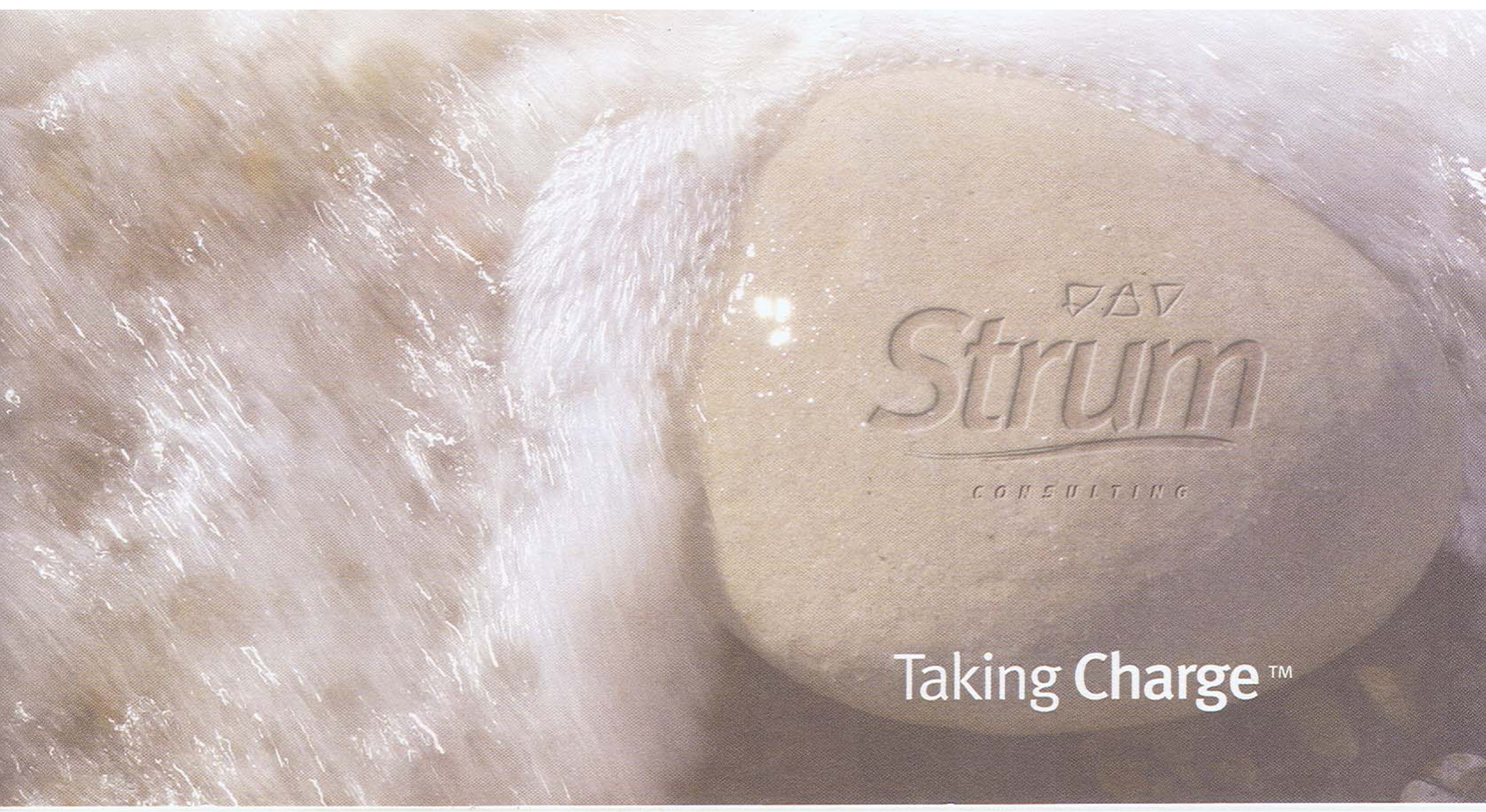
Attachment H

Strum

CONSULTING

MASTER STORMWATER MANAGEMENT PLAN
Penhorn Residential Development

December 8, 2020



December 8, 2020

Crombie REIT Limited & Clayton Developments Limited

Re: Master Stormwater Management Plan
Penhorn Residential Development

Attached is the Master Stormwater Management Plan prepared for the Penhorn Residential Development.

We trust this to be satisfactory at this time. Once you have had an opportunity to review this correspondence, please contact us to address any questions you may have.

Thank you,

Original Signed

Original Signed

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1.0 INTRODUCTION

This Master Stormwater Management Plan (MSWMP) has been prepared by Strum Consulting on behalf of Crombie REIT Limited (Crombie) and Clayton Developments Limited (Clayton), for consideration by Halifax Regional Municipality (HRM) staff. This report presents a stormwater management strategy for the site and demonstrates how it will meet the stormwater management goals and objectives set forth in the Regional Centre Secondary Municipal Planning Strategy (Package A) and Morris-Russell Lake Secondary Planning Strategy as provided by Halifax Regional Municipality (HRM).

This report has also been completed in reference to HRM Stormwater Management Guidelines (Dillon, 2006) and previous MSWMPs for areas with similar sensitivities to stormwater management within the HRM. These areas include West Bedford Sub-Area 2, West Bedford Sub-Areas 7 & 8, and Bedford South.

1.1 Background

In accordance to the Halifax Regional Centre Plan (Package A), "A Community Vision for the Penhorn Mall site was approved in principle by Regional Council in October of 2009 as a mixed-use area clustered around the transit terminal on Portland Street. The redevelopment concept includes pedestrian and transit oriented spaces and corridors, a range of medium to high density housing choices. Public amenity spaces including Penhorn Lake and Brownlow Park will support the development of this community, and additional open spaces and open space connections will be provided. Protection of the water quality of Penhorn Lake is a key goal of future development on this site, and shall be considered during the development and construction of the site."

The Penhorn residential development being considered will consist of a combination of multi-unit apartment buildings and single-family townhouse units. Exterior site development will include public open space and walking trails. The Penhorn development is expected to be fully serviced with water, wastewater, and stormwater systems connected to existing local municipal systems.

The sensitive nature of the natural environment surrounding the proposed development has been documented through previous watershed and water quality studies completed in the area. If not properly maintained, impacts to stormwater variations as a result of the proposed development will be directly transferred downstream to lakes which are already experiencing the effects of urbanization. Areas downstream of the proposed development include sensitive environmental habitats and public use areas, which are at risk of being impacted from both a stormwater quality (nutrient) and quantity (flooding) perspective.

Additionally, Penhorn Lake, a prominent water body adjacent to the proposed development lands, was identified as having significant water quality issues related to previous development and urbanization of the surrounding watershed. Special considerations will be discussed to ensure that further degradation will not occur as a result of the Penhorn residential development. It is anticipated that both temporary construction and permanent on-site stormwater management strategies will be implemented in order to maintain water balance and maintain or improve contaminant and nutrient levels for the benefit of the lake health.

1.2 Goals and Objectives

The purpose of this Master Stormwater Management Plan (MSWMP) is to address the potential effects on water quality and quantity from the proposed development on the surrounding lands and the downstream watershed. All development will generally be governed by HRM planning documents set forth in the Regional Centre Secondary Municipal Planning Strategy (Package A). This document specifically outlines objectives from the development of the Penhorn lands and contains general environmental protection and stormwater objectives, summarized in Section 3.6.3.2, policy 3-35 as follows:

i. Design on-site stormwater management that emphasizes low impact development measures as a means to maintain water quality in Penhorn Lake, with consideration given to the Analysis of Regional Lakes Water Quality Data (2006- 2011) prepared by Stantec in 2012.
ii. Consider a water quality monitoring program during and following development to ensure that the water quality objectives of the Regional Plan are satisfied;
iii. Prepare a landscaping and vegetation plan as part of site development to support the canopy target for the Manor Park Neighbourhood as referenced in the Urban Forest Masterplan.

In addition, Penhorn Lake and a significant portion of the development area is tributary to the Russel-Morris Lake Watershed. This area is generally governed by requirements the Dartmouth Municipal Planning Strategy and specifically, the Morris-Russel Lake Secondary Planning Strategy. HRM has presented objectives for stormwater management for new development in this document, with the relevant contained as policy ML-28 as follows:

> Within the Morris Lake Watershed, as illustrated on Map 9M, where applications are received for the expansion of existing or new commercial, institutional and multiple unit residential buildings, or for proposed grade alterations on such properties, it shall be the intention of Council to require the developer, where possible, to prepare and implement stormwater remediation measures to improve water quality entering the Morris Lake system.

This MSWMP will serve to address and outline the environmental and development objectives related to stormwater outlined in the HRM documents and the requirements for the on-site, low impact stormwater management systems, monitoring, and best management practices to be included in the development with the goal of minimizing impact to the surrounding area and maintaining or improving water quality of the downstream system.

2.0 ENVIRONMENTAL SETTING

2.1 Site Location

The subject site consists of PID 00222844 and 41331281, located on Portland Street, Dartmouth, also known generally as Penhorn Plaza. The site is approximately 17.05 hectares (42 acre), bounded by Penhorn Lake to the north, Highway 111 to the east, Portland Street to the south, and parkland and residential development to the west.

PID 00222844 is currently owned by Crombie Penhorn Mall (2011) Limited. The property contains an existing approximately 7,200 m^2 commercial building which was constructed in 1982 and underwent major renovations in 2009 when a large section of the former mall was demolished. The existing building underwent further redevelopment, transitioning to a primarily office building in 2018. PID 41331281 is a commercial property owned by Penhorn Plaza Holdings Limited. The two properties were subdivided in 2010 and the commercial property now contains multiple commercial units including a Sobeys grocery store, gas bar, and commercial strip plaza buildings. Figure A.1 included in Appendix A identifies the site boundary and current property ownership of the area included in this study.

The proposed Penhorn development is anticipated to consist of a combination of multi-unit residential and townhouse units, along with roadway, parking, and landscaped open space. A rendering of the proposed development layout is included as Figure A.2 in Appendix A.

This MSWMP will primarily focus on the development of the current open space on PID 00222844. There are no current plans on redevelopment of the existing commercial buildings, but future considerations for development and associated stormwater impacts, have been provided in this report.

2.2 Geology and Soil

2.2.1 Land Use and Topography

The subject site has been developed previously and contains large commercial buildings on the southern side of the site. The remainder of the site mainly consists of lands of the previously demolished Penhorn Mall, asphalt parking, and landscaped areas. In accordance to HRM planning documents (Halifax Regional Centre Plan Package A), the subject site is currently planned for mixed-use development.

The grading and sloping of the existing site was analyzed based on the topographic survey in combination with topographic LIDAR of the area. Detailed topographic survey has been completed throughout the subject site by SDMM in 2018 and DesignPoint in 2019.The topography of the site is mainly flat, with the majority of the site consisting of previously leveled pads of the former Penhorn Mall and asphalt parking areas. Steep landscaped and forested slopes, up to 50% grade, are located around the perimeter of previously developed pad areas. These slopes will generally remain undisturbed during development to maintain an essential natural riparian buffer to Penhorn Lake.

Generally, the finished site will be graded to minimize steep sloping to help promote infiltration and groundwater recharge. Existing site grades and sloping are indicated on the Pre-Development Site Drainage Plan, included as Figure A.3 in Appendix A.

2.2.2 Surficial and Bedrock Geology

A geotechnical investigation was completed as part of the preparation of the development of the subject site. Stantec completed an extensive geotechnical test pit program in June 2020 to assess geologic conditions of the subject site. Based on this investigation, subsurface conditions generally consist of a 1.0-4.0m thick layer of silty-sand and gravel fill, overlying silty-clay till and frequent cobbles and boulders. The majority of test pits were terminated upon encountering suspected large boulders, at depths between 2.0 to 6.0 m below the surface. Published Nova Scotia surficial geology data indicates the natural topography of the site area to be generally comprised of a silty till plain (ground moraine), which generally agrees with the data collected by Stantec.

According to the Nova Scotia Geoscience Atlas, the subject site is situated in the Halifax Formation of the Meguma Group. The Halifax Formation consists primarily of slate, siltstone, and minor sandstone. Based on the geotechnical investigations completed by Stantec, bedrock was not confirmed within the test pit depth. Groundwater levels were measured in each of the test pit locations. Groundwater was not encountered in the majority of the test pits, but was encountered in a small percentage of the total test pits with levels as high as 1.5 m below surface elevation. Based on the variation of groundwater elevations measured, there is possible groundwater mounding at the site, causing an apparent groundwater flow divide, to the north and southeast. Generally, deep bedrock elevations and low groundwater table will help to encourage infiltration, groundwater recharge, and be more conducive to the BMP approach and associated use of stormwater BMPs.

Stantec completed subsurface infiltration testing at select test pit locations during the investigation. Based on these tests, a medium to low infiltration rate of 6-8 mm/hour was estimated for the existing fill and till. The soil parameters and conditions outlined above will be used in the stormwater management design for optimal results and will be further assisted by the integration of imported permeable topsoil and fill for increased effectiveness of surface BMPs and infiltration.

2.3 Watershed Overview

Based on topographic data, historical record drawings, and previous watershed analysis completed in the area, it was determined that the Penhorn residential development area is primarily tributary to the Russel-Morris Lake Watershed, with a small portion tributary to the Lake Banook Watershed. The majority of the existing subject site flows directly into Penhorn Lake which is tributary to the Russel/Morris Lake Watershed.

A portion of the existing site flows directly into an existing underground stormwater system to the southeast which eventually drains into Morris Lake. The Morris/Russel watershed is a large watershed consisting of extensive residential development. Refer to Figure A.5 included in Appendix A, for the approximate limits of the Morris/Russel Lake watershed area, taken from HRM's Morris-Russel Lake Secondary Planning Strategy. Clayton Developments has a thorough understanding of the sensitivities around the Morris/Russel watershed, based on extensive previous community development in Russel Lake West.

A small portion of the southwestern site (approximately 15% of the total site area) flows west into the municipal storm system on Peddars Way, which eventually runs into Lake Banook. The Lake Banook watershed consists of a large catchment area which includes significant areas of existing development. This includes areas of previous and ongoing development of residential, commercial, and industrial lands, including a portion of Burnside Industrial Park, Dartmouth Crossing, and downtown Dartmouth. A map of the approximate catchment area for Lake Banook and the contributing land uses is provided as Figure A.6 in Appendix A, taken from the AECOM Hydraulic Modeling and Flood Plain Mapping Report (2013).

In accordance with previous environmental site assessments (Strum Consulting, 2010), the subject site contains no natural wetlands and watercourses within the site boundaries.

2.3.1 Penhorn Lake

Penhorn Lake is an approximately 4.3 hectare lake located just northeast of the subject site and is the primary receiving water body for the proposed Penhorn development. The lake is separated from the subject site by an approximately 50 m wide forested municipal parcel, which will act as a buffer zone. The lake includes an outlet control structure near the crossing of Highway 111 to manage lake discharge to the downstream system to Morris and Russel Lake. The Penhorn Lake watershed has been extensively developed with inflow from surrounding residential housing, commercial, and highway properties. The lake sees frequent public use with ongoing fishing and swimming activity. Preliminary plans for a public beach have been suggested by HRM staff. A new public trail is currently being constructed by HRM on the eastern side of Penhorn Lake.

Concern regarding nutrient levels and trophic status, in relation for natural plant and fish species have been previously expressed by HRM and local community groups such as the Banook Area Residents Association. According to a study provided by the group, emerging anoxic conditions have been identified in the deep water, caused by excessive nutrients and higher temperatures. As a result of these concerns, a solar-powered aerator was installed in 2019, lead primarily by the Association, with partial funding provided by Crombie REIT Limited.

In accordance with the HRM Regional Centre Secondary Municipal Planning Strategy (Package A), protection of the water quality of Penhorn Lake is a key goal of future development on this site, and shall be considered during the development and construction of the site. HRM has identified Penhorn Lake as one of the high-priority lakes in the Regional Plan Centre, in regards to water quality analysis. All planned development (with the possible exception of a public walking trail) will be contained on the subject site and will be constructed to avoid direct disruption to the neighbouring public parcel and lake.

2.4 Water Quality Monitoring

In accordance with general stormwater objectives Regional Centre Secondary Municipal Planning Strategy (Package A), on-site stormwater management systems will be included as a means to maintain water quality in Penhorn Lake, with consideration given to the Analysis of Regional Lakes Water Quality Data (2006- 2011) prepared by Stantec in 2012.
As part of an extensive water quality monitoring program conducted on HRM lakes between 2006 and 2011, Stantec was commissioned to prepare a report to compare measured water quality data to established water quality guidelines and to identify water quality trends within the selected lakes. This report provided Water Quality Index (WQI) and phosphorus-indicative trophic status of each of the water bodies sampled based on Canadian Council of Ministers of the Environment (CCME) Protection of Freshwater Aquatic Life (FAL) guidelines and field measurements.

The CCME WQI analyzes specific water quality parameters against the established CCME guidelines, resulting in a water quality index value ranging from 0 (poor) to 100 (excellent). In accordance with the Stantec report, six parameters were included in the customized WQI program: nitrate, nitrite, phosphorus, pH, ammonia, and chloride.

In accordance with the Stantec report, trophic status can be used in conjunction with WQI as an indicator of water quality in areas where nutrient enrichment has the potential to result from development activities. For determination of the trophic status in water bodies, the CCME Phosphorus Framework outlines the natural phosphorus ranges recommended by the CCME and is based on phosphorus being the limiting nutrient in the aquatic environment. Total Phosphorous (TP) is generally considered the most meaningful measurement of phosphorus in the aquatic environment and therefore is recommended by CCME as a predictor of the trophic state. A lake can be generally classified as being in one of three possible statuses based on concentration of phosphorus in surface water: oligotrophic (<10 µg/L), mesotrophic (10 – 20 µg/L), or eutrophic (>20 µg/L).

Water quality sampling and analysis included the relevant lakes downstream of the proposed development area, including Penhorn Lake, Morris Lake, Russel Lake, and Lake Banook. The results of the sampling and analysis are summarized in the following sections.

2.4.1 Penhorn Lake

Penhorn Lake was sampled seasonally for water quality between 2006 and 2011 at a monitoring station near the outlet at the Highway 111 crossing. In accordance with the 2012 Stantec report, Penhorn Lake was measured to have a CCME WQI rating of 78, or “Fair”. The CCME WQI Technical Report (2001) defines “Fair” as follows: “Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.” Penhorn Lake was also measured to have an average TP concentration of 12 µg/L, classifying the lake as Mesotrophic in accordance with the CCME phosphorus framework.

Further sampling and analysis in Penhorn Lake was completed by AECOM in 2017. Based on the AECOM report, measured phosphorus levels ranged between 14 to 25 µg/L, with an

average of 20 µg/L for samples taken in the spring, summer, and fall. These results would suggest that the trophic status of the lake would be on the higher end of the mesotrophic range (10 to 20 µg/L) and into the eutrophic (>20 µg/L) range, however, due to the limited testing period and available results, it is suggested the previous Stantec historical results and classification of the lake would still govern.
Testing of other indicative nutrients were also completed in Penhorn Lake including nitrate, nitrite, phosphorus, pH, ammonia, and chloride. From the 2012 Stantec report, all measured parameters fell below CDWQG PAL and Health Canada guidelines, with the exception of chloride, which exceeded the CDWQG limit of 120 mg/L in 11 out of 16 tests completed. A compilation of the historical water quality testing results for Penhorn Lake from the Stantec analysis is provided as Appendix B. Based on the 2017 AECOM report, CDWQG exceedances for nitrate and pH were observed in the spring, and exceedances for chloride were observed in the spring, summer, and fall.

2.4.2 Russel Lake, Morris Lake, and Lake Banook
In accordance with the 2012 Stantec Water Quality Monitoring Report, Morris Lake, Russel Lake and Lake Banook were sampled seasonally between 2006 and 2011.

Morris Lake was measured to have a CCME WQI rating of 80, or “Good” at both locations. The CCME WQI Technical Report (2001) defines “Good” as follows: “Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.” Morris Lake was also measured to have an average TP concentration of 14 µg/L at the northern monitoring station and 13 µg/L at the southern monitoring station, classifying the lake as Mesotrophic in accordance with the CCME phosphorus framework. Russel Lake was measured to have a CCME WQI rating of 70, or “Fair”. Russel Lake was also measured to have an average TP concentration of 12 µg/L, classifying the lake as Mesotrophic in accordance with the CCME phosphorus framework.

In accordance with the 2012 Stantec report, a TP management threshold has been set at a concentration of 15 µg/L for Morris and Russell Lakes. Through the implementation of on-site LID stormwater management practices on the proposed site, phosphorous contribution to the downstream watershed will be maintained or reduced in an attempt to achieve these requirements.

Lake Banook was measured to have a CCME WQI rating of 70, or “Fair”. Lake Banook was also measured to have an average TP concentration of 11 µg/L, classifying the lake as Mesotrophic in accordance with the CCME phosphorus framework.

In accordance with Water Quality Objectives from the Shubenacadie Lakes Subwatershed Study – Final Report prepared by AECOM in 2013, a TP management threshold has been set at a concentration of 20 µg/L for Lake Banook to maintain its current trophic status. The study also indicated historical high levels of chloride in the lake, which should be considered as part of any new development. It is anticipated that because of the limited portion of the site which flows towards the Lake Banook system (approximately 15% of subject site), and through proper implementation of on-site LID stormwater management practices, phosphorous and chloride contribution to the downstream watershed will be maintained or reduced to achieve these requirements.

2.5 Existing Stormwater Management Facilities

As the subject site has been previously developed, some stormwater management facilities are currently incorporated. In accordance with record drawings and information from the current property managers, facilities on the existing site mainly include traditional stormwater infrastructure, consisting of a combination of roof and catch basin conveyance and traditional underground piped infrastructure. The existing commercial development also contains multiple operational flow stormwater treatment units, which are reportedly maintained on an annual basis.

During the demolition of the existing Penhorn Mall in 2009, much of the surrounding underground stormwater infrastructure was removed, but a portion of it was left in place and/or capped and abandoned. As part of the demolition, surface flow diversion ditches were constructed to direct and disperse runoff off-site. Considerations for the continued maintenance and integration of the existing stormwater treatment units will be critical to the implementation of new stormwater infrastructure and phasing of the new development. Design considerations will be investigated to utilize existing infrastructure, such as remaining ditches or piping, for temporary or long term stormwater management.

Considerations for the potential future redevelopment of the existing commercial lands, and the associated impacts on stormwater management, is further discussed in Section 3.4 of this report.

3.0 CONCEPTUAL STORMWATER MANAGEMENT PLAN FACILITIES

The strategy for the development of the subject site is to provide an integrated approach to stormwater management. This approach has been developed based on a hierarchy of stormwater management practices that begin at the source of runoff and nutrient creation. The hierarchy of stormwater management practices is as follows:

- Re-establishment and integration of natural vegetation;
- Source controls;
- Conveyance controls; and
- End-of-pipe controls.

3.1 Re-establishment and Integration of Natural Vegetation

Reintroducing natural vegetation throughout the development area is a key factor to improving natural water balance. Based on historical land use on the subject site, the majority of the site had been completely hardscaped in the 1970's with very limited green areas and natural vegetation. As a result, water quality in Penhorn Lake and the surrounding watershed has deteriorated through the introduction of increased nutrient levels and increased runoff rates. Native vegetation on the Penhorn lands shall be integrated into the development to act as a natural resource for runoff treatment, tree protection, ecological habitat, and public green space. Careful detailing during the design development phase will be completed to evaluate the capability of treatment and runoff quantity balancing.

Some of the benefits of re-establishing natural vegetation in green spaces are as follows:

- Natural cleansing and filtration of stormwater runoff;
- Promotion of evapotranspiration from trees and natural ground cover;
- Promotion of natural infiltration from undisturbed soils;
- Increased groundwater recharge;
- Preserving native plant communities;
- Providing natural buffers and green space as amenities;
- Maintaining the natural ecology for fish and waterfowl species; and
- Control runoff temperature.

The Integration of natural riparian buffers will provide natural water quality and quantity improvements before discharge to Penhorn Lake. Vegetation will reduce runoff quantities by minimizing stormwater velocities and promoting infiltration and aid in the removal of pollutants such as total suspended solids and phosphorus from the stormwater runoff, and reduce runoff temperature.

After the construction of each phase, guidelines will be utilized to encourage continued efficient nutrient removal within the green areas and stormwater BMPs. To ensure the vegetation will survive without heavy fertilizer applications, a topsoil recommendation specification has been provided as Appendix C, which provides the developers with detailed information on the topsoil requirements to produce healthy and sustainable planting. Using adequate depth and quality topsoil is helpful in promoting healthy lawn and plant growth as it provides a good growing base for root structures and in turn mitigates the need for fertilizer application. Additionally, acceptable plant species will be outlined as to closely resemble pre-development conditions. The use of native planting species encourages sustained growth as it is understood that these species already thrive in their natural habitat, this mitigates the need for fertilizer application and promotes sustained growth.

The Master Stormwater Management Plan intends to fully integrate landscaping design with recommendations in the HRM Urban Forestry Guide along with preserved natural forested areas around the development. Special consideration will be made along the eastern side of the site adjacent to Penhorn Lake, to eliminate significant point source discharge over the steep slopes, through the use of stormwater BMP facilities. All pre/post stormwater flows will be balanced at all critical discharge points to preserve the natural water balance in these areas.

3.2 Proposed BMP Description

Stormwater BMPs are features included in a stormwater system with the goal of improving water quality and quantity. Typically, BMPs are introduced in areas that experience a change in land use and have an increased percentage of impervious area, causing more direct runoff and nutrient transfer to occur. The performance of various BMPs has been monitored in studies across North America and published values for removal efficiency are widely available. Removal efficiency values quantify the BMPs ability to remove nutrients, such as TP and TSS. BMP removal efficiencies used in this study have been compiled from the following sources:

- Halifax Regional Municipality Stormwater Management Guidelines prepared by Dillon Consulting (2006);
- Standard and Guidelines for Municipal Waterworks, Wastewater, and Storm Drainage Systems published by Alberta Environment (2013);
- Credit Valley Conservation – Low Impact Development Guidance Documents; and
- New Jersey Stormwater Best Management Practices Manual published (2004)

BMP strategies will be integrated into the stormwater management system throughout the development area to reduce the post-development runoff rates and nutrient loads. BMPs will be implemented in series wherever possible to obtain a higher level of runoff reduction and the highest potential removal rates of nutrients. Stormwater BMPs will be designed to be low-maintenance and be cost comparable over their lifecycle relative to traditional municipal facilities. Specific BMPs as discussed in this section can decrease capital and maintenance costs by reducing or eliminating traditional infrastructure such as asphalt pavement, curbing, and piped infrastructure. Additionally, integrating the functional aspect of BMPs with the development of parks and green spaces can provide major savings for both capital and maintenance costs as well as enhances aesthetics with more natural looking infrastructure. Further detail on specific BMP integration is provided in the following sections.

BMP strategies, as outlined in HRM Stormwater Management Guidelines (2006), can be divided into three primary categories: source controls, conveyance controls, and end-of-pipe controls. The following sections outline the BMP strategies which are being considered in the proposed development area.

<u>3.2.1 Stormwater Source Control</u>
Stormwater source controls are on-site measures which control runoff at the source of generation. This would include all BMP measures utilized to store and treat stormwater before it reaches the conveyance system or downstream BMPs. Source control BMPs can exist within both public and private property. Some general BMPs which will be considered within the private development areas include:

- Minimizing impervious areas (travel ways, driveways, walkways, etc.) and maximizing green space;
- Roof leaders directed to lawns and vegetated areas rather than the street / storm system; and
- Roof and parking lot stormwater storage.

Additional examples of source control BMP’s that can be implemented into public and private development areas are as follows:

Reduced Travel Ways
In accordance with design guidance included in the latest addition of the Transportation Association of Canada (TAC) manual, narrowing drive lanes will naturally result in lower operating speeds and improve pedestrian safety. In addition to traffic calming and safety benefits, reducing the paved travel ways on local roads also has significant benefits to improving stormwater runoff. The increase in permeable green space and decrease in the amount of impermeable area within the right-of way will increase levels of infiltration and filtration.

Historically in HRM, design of roads has been governed by a standard approved cross-section differentiated by road type (i.e. local, collector, arterial etc.) and not the expected traffic volumes they carry. This often results in local roads with little traffic volume to be significantly over-designed. It is recommended that the roads within the subject site be individually designed in consultation with HRM, based on expected road use, traffic volumes, and requirements for parking in the local area.

Brownstone Townhouses
Residential layout alternatives which can function with shared exterior spaces while still maintaining privacy and resident independence. These layout styles encourage social interaction using communal parking, communal green/open spaces, and increased housing proximity.

By providing centralized parking over individual private driveways, the overall impermeable area of this type of development is smaller than traditional residential development. This type of development also allows for narrower travel ways, which decreases impermeable area and associated maintenance and replacement costs that may require public funding.

Green Roofs
Green roofs generally consist of a thin layer of vegetation and growing medium installed on top of a conventional flat or sloped roof. Green roofs provide water quality, water balance, and peak flow control benefits in urban areas where open green space may be limited. Green roofs function by storing rainwater in the growing medium and ponding areas. Excess rainfall enters underdrains and overflow points and is conveyed in the building drainage system. After the storm, a large portion of the stored water is removed through evapotranspiration through the plants, evaporation into the air, or slowly drains away through the medium. The removal of stormwater decreases the demand on the downstream system, and provides natural contaminant removal.

Other benefits of green roofs include improvement of energy efficiency through the insulating properties of the media, reduction of urban heat island effects, and creation of greenspace for passive recreation or aesthetic enjoyment. Green roofs come with some limiting design constraints such as increased structural loads, potential for water damage, and limiting roof sloping and layout of amenities. Green roofs will be considered as a potential stormwater management option for multi-unit residential buildings and be investigated further during the detailed design phase.

Rain Barrels/Rainwater Harvesting

Rainwater harvesting is the process of intercepting, conveying, and storing rainwater for future use. Stormwater is typically gathered on a catchment surface, such as a roof, and is collected into a storage tank or rain barrel. Implementation of rainwater harvesting units or rain barrels can provide benefits of both conserving water for reuse and reducing stormwater runoff rates. With minimal pre-treatment, the captured rainwater can be reused for outdoor non-potable water uses such as irrigation systems, or in the building to flush toilets or urinals. In accordance with the Credit Valley Conservation (CVC) estimates, household municipal water consumption rates can be reduced by up to 55% with full system implementation.

When utilized in irrigation systems, the water is either evapotranspired by vegetation or infiltrated into the soil, which can significantly reduce stormwater runoff rates and pollutant loads. The capture and use of rainwater provides a reliable and renewable source of water to end users, and also helps reduce demand from the municipal water supply. By reducing demand on water resources, rainwater harvesting can result in significant cost savings.

Permeable Pavement and Pavers

Permeable pavement or pavers is an alternative to traditional pavement in urban areas to encourage infiltration and groundwater recharge in locations where open or green space is limited. Permeable pavement allows stormwater to drain through the hardscape structure through gaps or pours, into a stone reservoir where it is infiltrated into the underlying native soil or temporarily detained. Permeable paving allows for filtration, storage, or infiltration of runoff, and can reduce or eliminate surface stormwater flows compared to traditional impervious paving surfaces like concrete and asphalt.

Typical application of permeable pavement is on low traffic roads, parking lots, driveways, pedestrian plazas, and walkways. Permeable pavement types can vary and can include the following:

- Permeable interlocking concrete pavers (i.e., block pavers);
- Plastic or concrete grid systems (i.e., grid pavers);
- Pervious concrete; and
- Porous asphalt.

The permeable pavement system may be designed with no underdrain for full infiltration, with an underdrain for partial infiltration, or with an impermeable liner and underdrain for a no infiltration or detention and filtration only practice. Design consideration will need to include winter snow clearing and salting operations, and maintenance to prevent clogging.

Bio-Infiltration Planters

Surface bio-infiltration units are an emerging surface treatment alternative which can be integrated with natural landscaping and tree plantings. Units typically consist of pre-constructed planter frames, surface tiles, stormwater inlet, filter media, and subsurface drains. Typical application would be in walkway areas adjacent to landscaped or hardscaped areas such as parking lots, used in combination with traditional catch basins.

Bio-infiltration units use a fine-gradation of sand and filter media to treat stormwater runoff at its source to achieve a relatively high infiltration rate and stormwater treatment for small storm events.

3.2.2 Stormwater Conveyance Control

The stormwater conveyance in the development will include both traditional stormwater infrastructure and stormwater BMPs. Where possible, runoff will be directed to vegetated areas to promote infiltration and groundwater recharge. This overland flow conveyance practice serves to reduce peak runoff rates, infiltrate water, and filter nutrients. Conveyance control BMPs which are being considered for the development are as follows:

Permeable Storm Sewer and Soak-Away Structures

Permeable pipes and soak-away structures (manholes, catch basins) can be integrated into grassed medians, landscaped islands, bioswales, and hard-surfaced areas with low traffic volumes. Permeable stormwater infrastructure serves to help infiltrate stormwater into the ground, while still providing conveyance in significant rainfall events. Traditional piped conveyance would only be utilized when overland or underground pathways (i.e. surface swales and piped infiltration) do not provide sufficient capacity to handle the required rain events.

Open bottom or perforated manholes give opportunity for stormwater to infiltrate into the surrounding soils while still conveying a portion of stormwater so as not to flood unwanted areas. Furthermore, placing the conveyance conduit (perforated pipes) at a higher elevation than the bottom (i.e. sump) of the structure, provides an opportunity for additional water storage when stormwater flow exceeds infiltration rates.

Vegetated Swales / Bioswales

Vegetated swales or bioswales are linear landscape features consisting of a drainage channel with gently sloping sides. Underground, they may be filled with engineered soil and/or contain a water storage layer of coarse gravel material. Vegetated swales help to detain runoff, filter sediment and nutrients, and promote infiltration.

Typical applications for vegetated swales will be along the edges of roads and paved areas, replacing conventional curb and gutter configurations. Other applications will include collection systems capturing runoff from yards and conveyance from pipe outfalls to existing wetlands, watercourses, and natural drainage features. Check dams installed in the swale reduce water velocities and are necessary to prevent severe erosion on slopes greater than 4%. Vegetated swales and bioswales are proposed for use throughout the development where applicable. See Figure 3.1 below for an example of a successful bioswale installed in the Parks of West Bedford, Sub-Area 7.

Figure 3.1: Bioswale Outlet, (Parks of West Bedford, Sub-Area 7, 2020)

Infiltration Trenches
Infiltration trenches are underground linear stormwater BMP features typically comprised of a channel of clean permeable stone surrounded by geotextile fabric or sand filter. Trenches can include perforated drainpipes and be integrated with traditional piped stormwater system in certain scenarios. Infiltration trenches help convey and recharge groundwater and help maintain or restore the site's natural hydrology. Infiltration trenches store runoff stormwater in the stone void spaces, and filter as it slowly percolates downward into the subsoil. Infiltration trenches can be constructed as a stormwater conveyance alternative to vegetative swales and bioswales throughout the development area.

3.2.3 End of Pipe Control

CDS Units (Hydro-Dynamic Separators)
Continuous Deflective Separation (CDS) units are treatment units which can be integrated into the underground piped stormwater system for water quality protection. A CDS unit is typically a vertically-oriented separator that removes oil, sediment, and other potential contaminants in urban runoff. A CDS unit typically contains an emergency bypass system that allows runoff in major storm events to directly bypass the lower chamber and prevent the disruption of settled pollutants.

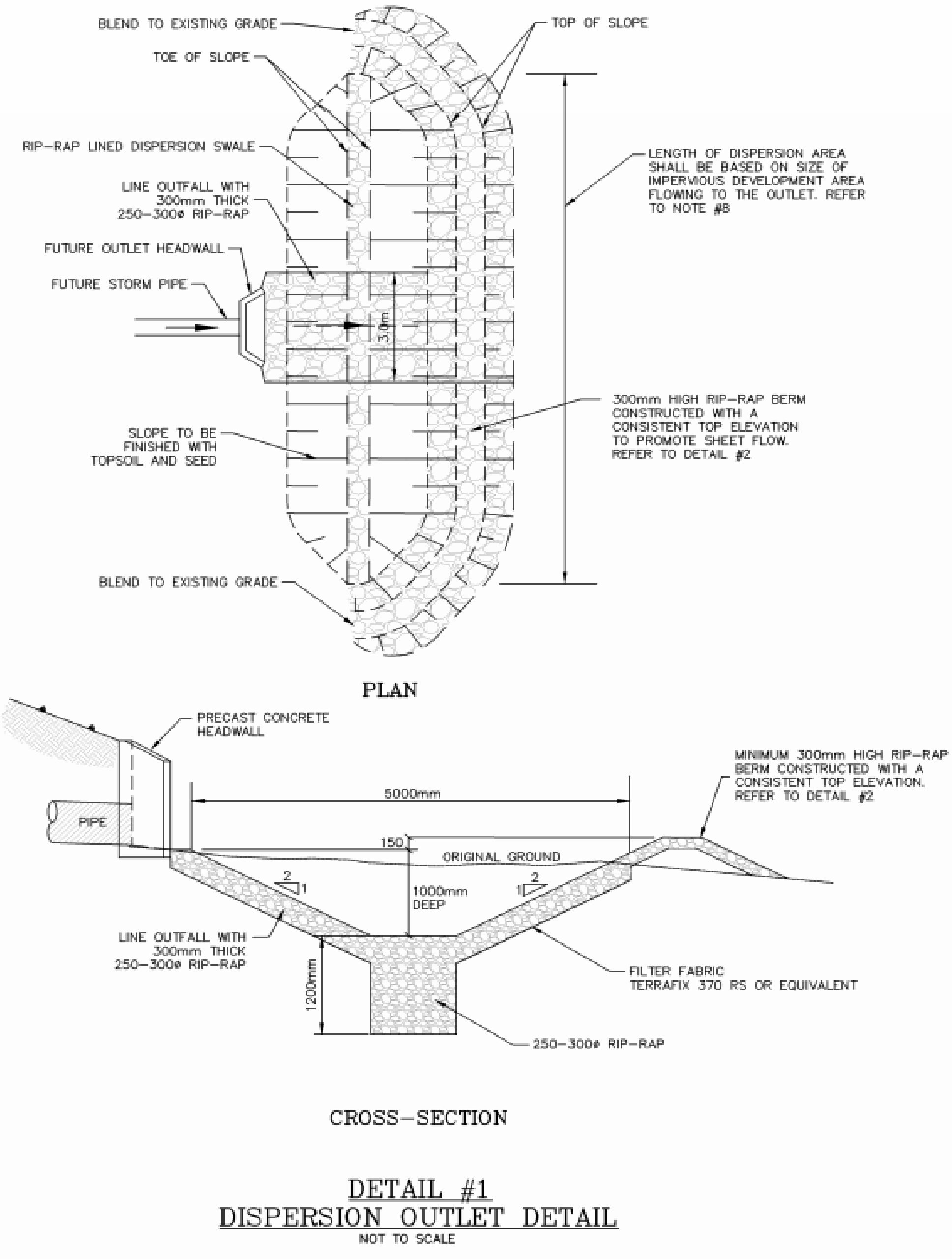
According to the US Environmental Protection Agency Fact sheet on CDS units: The CDS stormwater applications include removal of trash, debris, vegetative material, and coarse sediments prior to discharges to receiving waters and wetlands. Where higher levels of treatment are desired, CDS provides the essential pre-treatment as the initial step in a treatment train that may employ ultra-fine filtration and/or adsorption/absorption for removal of very small particulates, dissolved pollutants and oil/water separators.

Flow Dispersion Outlets / Vegetative Filter Strips

Dispersion features and vegetative filter strips can be constructed at piped outfalls to disperse runoff over a large area and promote sheet flow and infiltration to the downstream area. Vegetated filter strips are gently sloping, vegetated areas that treat runoff as sheet flow from adjacent impervious areas. They function by limiting runoff velocity and filtering out suspended sediment and pollutants, and by providing some infiltration into underlying soils. Vegetation included in filter strips may be comprised of a variety of trees, shrubs, and native plants to add aesthetic value as well as water quality benefits. With proper design and maintenance, filter strips can provide relatively high pollutant removal.

Dispersion outlet structures will consist of a perpendicular trench and berm configuration. Permeable media such as clearstone or rip-rap will be installed below the trench to provide storage and promote infiltration and groundwater recharge. The flow dispersion structures will be individually sized to handle volume from the estimated 95th percentile-24hr annual rainfall event (+/-25mm) within the constructed trench. Any storm event which exceeds this limit will filter through and overtop the rip-rap berm along its length, promoting sheet flow into a vegetative filter strip. Refer to Figure 3.2 below regarding construction detail of the dispersion outlet. Further detailing and sizing of filter strips is indicated on drawing D02, included in Appendix A.

Figure 3.2: Dispersion Outlet Detail



3.3 Stormwater Modeling Results

In accordance with the objectives proposed in the Regional Centre Secondary Municipal Planning Strategy (Package A) and Morris-Russel Lake Secondary Planning Strategy, the primary goal of the MSWMP will be to maintain or improve water quality in the surrounding watersheds and downstream water bodies. This goal will be achieved through implementing on-site stormwater BPM's into the development to maintain or improve post-development stormwater conditions both in terms of stormwater quantity and quality.

3.3.1 Stormwater Quantity Design Criteria

The intent of stormwater quantity control is to manage flood hazards and prevent or reduce damages associated with large, infrequent storm events. Significant increase in water levels, volumes, and flow velocities associated with land development can also directly affect water quality, through the disturbance of sediment and soils surrounding which can lead to increased turbidity, suspended solids, and other harmful nutrients into the water system.

The stormwater objectives outlined in the HRM Regional Centre Secondary Municipal Planning Strategy (Package A), can be supported by typical water quantity objectives from local authorities including HRM Stormwater Management Guidelines (Dillon, 2006), Halifax Regional Water Commission (HRWC) Standard Specifications (2020), and NSE. As per local guidelines, estimated post-development peak flows must be controlled for the 2, 5, 10, 25, 50, and 100-year, 24-hr design storm event, and peak flows at all critical discharge points must be balanced within 10% of the pre-development condition.

3.3.2 Stormwater Quantity Hydrological Model

Water quantity and peak flow rate modeling for the proposed development was completed through a desktop study analysis. The pre-development and post-development sites were modelled in HydroCAD Version 10.00, using the SCS TR-20 Unit Hydrograph runoff method and Dynamic-Storage-Indication reach routing method. This analysis has considered all areas which are tributary to each discharge point from the development area.

Design storms were taken from published storm data provided in the latest edition of the HRWC Standard Specification (2020). Rainfall depths for each design storm is listed in Table 3.1 below.

Table 3.1: Halifax Regional Water Commission – Design Storm Rainfall Depths

Design Storm	24-hr Rainfall Depth
2-yr	83 mm
5-yr	124 mm
10-yr	145 mm
25-yr	169 mm
50-yr	188 mm
100-yr	204 mm

Catchments were delineated using AutoCAD Civil 3D and available LiDAR contour mapping blended with field survey data completed by SDMM and DesignPoint. Multiple catchments areas and outlets points were carefully selected to suit the natural drainage characteristics and conditions (refer to Figure A.3 and A.4 in Appendix A).

Runoff coefficients are used in determining the portion of rainfall that runs off the site during the prescribed storm events. For the SCS model, the runoff coefficient is referred to as an "SCS curve number" or "CN" and is a number between 0 and 100, which approximates the relationship between rainfall and runoff. Further information on the SCS curve numbers utilized in our stormwater analysis can be found on Figure A.3 and A.4 in Appendix A. SCS curve numbers have been selected with careful consideration of the native soil's ability to accept and infiltrate stormwater, based on previous geotechnical studies and analysis of the study area.

3.3.3 Stormwater Quantity Modeling Results

The pre-development modeling results are summarized in Table 3.2 for the Penhorn residential development area. Pre-development catchment areas and critical drainage points in the table are indicated on drawing D01, included in Figure A.3 in Appendix A. The post-development modeling results are summarized in Table 3.3. Post-development catchment areas and critical drainage points in the table are indicated on Figure A.4 in Appendix A.

The post-development runoff results reflect site conditions with some minor typical stormwater management facilities such as rooftop and parking lot storage. Results are generally conservative as integrated stormwater BMPs, which will contribute to additional flow reduction, are not reflected in the model. These BPMs will be further detailed and included at the design development stage.

Table 3.2: Pre-Development Model Results - Stormwater Quantity Summary

POINT	AREA (Hectares)	CN	TC (Min.)	FLOW (cms)					
				2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
A	5.60	84	20	0.365	0.647	0.779	0.942	1.063	1.180
B	0.92	98	7	0.148	0.224	0.261	0.307	0.340	0.375
C	1.87	94	15	0.202	0.310	0.359	0.420	0.465	0.510

Table 3.3: Post-Development Model Results - Stormwater Quantity Summary

POINT	AREA (Hectares)	CN	TC (Min.)	FLOW (cms)					
				2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
A	5.81	87	20	0.364	0.635	0.748	0.881	0.976	1.067
B	1.02	90	7	0.124	0.203	0.242	0.291	0.326	0.362
C	1.93	89	15	0.172	0.277	0.327	0.389	0.434	0.480

Peak-flow balancing was achieved on the subject site through the introduction of additional open green space and design features including cluster-style unit layouts and reduced travel lane widths. For the majority of the site, runoff coefficients (CN) were reduced from the pre-development condition (asphalt parking lot), through the use of landscaping and vegetative site finishes which are more conducive to infiltration. Through the implementation of these BMPs, pre/post peak flow balancing was achieved for each of the design storms as required by local authorities. In addition, flow capacity of the existing piped stormwater system directly downstream of the development area was analysed and confirmed to be acceptable based on the anticipated peak runoff rates from the proposed development.

3.3.4 Stormwater Quality Design Criteria

The primary goal of the stormwater quality management system, in accordance with water quality objectives proposed in the Regional Centre Secondary Municipal Planning Strategy (Package A) and Morris-Russel Lake Secondary Planning Strategy, is to maintain or improve water quality in the surrounding watersheds and downstream water bodies, which include Penhorn Lake, Morris/Russel Lake, and Lake Banook.

The general approach to maintaining or improving water quality will be to maintain or decrease total phosphorus (TP) and total suspended solids (TSS) levels from the development area such that the lakes do not experience an increase in trophic state. This approach is consistent with the general objective of the HRM Regional Planning Strategy, which seeks to "maintain existing trophic status of our lakes and waterways to the extent possible" (HRM, 2014). For the purposes of the development area, the approach of providing no net increase in TP or TSS load from the development area will be utilized to ensure the quality and trophic status of the downstream water bodies remains unchanged.

3.3.5 Stormwater Quality Model

Through the use of desktop modeling processes and empirical data presented in the HRM Stormwater Management Guidelines (2006), a concentration-based mass-balance nutrient loading model was created. This model simulated anticipated TP and TSS transported from the site through stormwater runoff in the 1 in 2, 5, 10, 25, 50, and 100-year storm events. This accepted methodology was previously used in Bedford South and the Parks of West Bedford, with analysis for those projects previously completed by Stantec. Considerations in the model include:

- Accurately identifying ground surface and soil characteristics;
- Assigning TP and TSS nutrient loading values; and
- Nutrient removal rates for a range of different stormwater BMPs.

The majority of nutrient transport occurs in what is known as the first flush. The first flush is identified as the initial stages of a rainfall event, usually when rainfall intensities are low but steady. Nutrients that are situated at the surface are easily removed by the first flush and transported downstream. As the rainfall event increases in intensity it is understood that a large majority of the surface nutrients have already been removed and that the latter parts of the rainfall event only transport a small amount of nutrients downstream. In addition to the first flush, light rains that happen more regularly, with a short duration and lower intensity will transport sediment much in the same way. These storms are referred to as low intensity, high frequency storms and represent approximately 90% of the annual rainfall. Designing stormwater quality measures that consider these storms and encourage infiltration is considered a proactive approach to stormwater management and is one of the fundamental elements of stormwater BMPs.

Similar to proven methodology employed for Bedford South and The Parks of West Bedford, a concentration-based loading mass-balance water quality model has been utilized for this analysis. This model was initially run in the pre-development scenario to determine the base-line, or budget, TP and TSS values. Then, a post-development model was created that ran uncontrolled with no allowance for nutrient loading attenuation features (BMPs). This provided an understanding of how the expected nutrient loading would be affected by a developed site. The equations below were used in calculating the concentration-based nutrient loads.

$$L = (R * \rho) / 1000$$ **Equation 3-1**

Where,
L = Nutrient load (kg)
R = Site runoff volume (m^3)
ρ = Total phosphorus concentration (mg/L)

$$R = A * C * P$$ **Equation 3-2**

Where,
R = Site runoff volume (m^3)
A = Tributary area (m^2)
C = Runoff coefficient (unitless)
P = Depth of precipitation (m)

In accordance with Halifax Regional Municipal Planning Strategy (2006), “Rational C” runoff coefficients were used in the water quality model. The runoff coefficient is essentially a ratio of rainfall to runoff and varies based on land use, soil type, infiltration ability, and land slope. Runoff coefficients are a value between 0 and 1 that can be taken from published tables or used aggregately as a weighted value to represent an area which incorporates multiple land uses.

It is standard practice to increase the rational runoff coefficient during a high intensity, low frequency storm to account for the response to a rainfall of increased intensity. The anticipated percent increase can vary depending on the expected runoff coefficient during lower frequency storm events. The lower the runoff coefficient, the larger the change is expected.

3.3.6 BMP Selection

Throughout the preliminary design process for this development, several stormwater BMPs were selected based on their potential application to the site. The general description of these BMPs are outlined in Section 3.2 of this report. Generally, some combination of the indicated BMP will be required to maintain or improve water quality discharge from the site. Exact layout and location requirements for the BMPs will be finalized during the design development stage and will be required to be considered for each portion of the development.

Table 3.4 below outlines the primary stormwater BMPs selected for this project and their associated TP and TSS removal efficiencies. The values presented below have been compiled from the HRM Stormwater Management Guidelines and alternative resources indicated below. Other BMPs to be included in the development, as indicated in Section 3.2, will have associated removal efficiencies, and will be analyzed in further detail at the design development stage.

Table 3.4: BMPs and Related TP and TSS Removal Efficiencies

Best Management Practice (BMP)	TP Removal Efficiency (%)	TSS Removal Efficiency (%)
Vegetative Grass Swale	40	85
Vegetated Filter Strip	50*	85*
Infiltration Basins and Trenches	70	90
CDS Units	30**	70**
Green Roof	N/A	N/A
Permeable Pavement	Negligible	80
Permeable Storm Sewer and Soak-Away Structures	80***	70***
Bio-infiltration Planters	50****	85****

*Based on New Jersey BMP Manual – 2004

**Based on study by the Cooperative Research Centre for Catchment Hydrology, as noted in the CDS Technologies brochure. Actual removal efficiencies will depend on model chosen.

***Based on average removal rates in combination with additional BMPs (Grass swale or infiltration trench) found in Credit Valley Conservation Low Impact Development Stormwater Management Planning and Design Guide.

****Based on the International BMP Database estimates on similar sand media filters with similar dimensions.

The BMPs listed above are anticipated to be incorporated into the site design and natural topography of the development but require special consideration for placement due to size or soil characteristic requirements (i.e. a vegetated filter strip may require a minimum flow length or maximum slope for effective removal or an infiltration trench may require a minimum soil infiltration rate to achieve the published removal efficiency). Table 3.5 below outlines some special considerations required for each BMP presented above.

Table 3.5: BMPs Design Requirements and Considerations

Best Management Practice (BMP)	Design Considerations
Vegetative Grass Swales	• Contributing drainage <2 ha. • Maximum 2.5:1 interior side slopes. • Minimum depth of 750 mm. • Minimum bottom width of 750 mm. • Use of natural and native vegetation. • Effective for stormwater treatment if length is at least 60 m. • Requires permanent check dams at 60 m spacing. • Longitudinal sloping should range between 0.5-5%. • Requires regular inspection and maintenance of vegetation.
Vegetated Filter Strips	• Contributing drainage <2 ha. • Minimum flow length of 10 m. • Sloping should range between 0.5-5%.

Best Management Practice (BMP)	Design Considerations
Infiltration Basins and Trenches	• Contributing Drainage <2 ha. • Requires pre-treatment to protect groundwater quality (grassed channels, sedimentation basins, ponds, wetlands). Recommended volume of pre-treatment 25% of the design runoff volume. • Soils to have clay content <20%, and silt/clay content <40%. • Slopes less than 15%. • Must have safe overflow facility designed to take flows in excess of the design event. • Requires an observation well. • Soil percolation rate >15 mm/h. • High water table level and bedrock > 1m below trench bottom.
Green Roofs	• Choice of Extensive (thin soil) vs. Intensive (deep soil) Green Roof. • Extensive green roofs are limited in plant species options and are lower maintenance. • Intensive green roofs have a greater weight loading and better insulation properties. • Considerations for waterproofing and maintenance are important.
Permeable Pavement	• Very limited experience in Canada. • Use only in low vehicle traffic areas. • Requires moderately permeable soils, with depth at least 1 m above high water table or bedrock. • Only effective for small drainage areas. • Should not be applied in parking areas where sanding or salting is used in the winter. • Soil permeability >16 mm/hour. • Longitudinal slopes <15%. • Require frequent inspection and maintenance.
Permeable Storm Sewer and Soak-Away Structures	• Pipe diameter >200 mm. • Slope of pipe <0.5% to encourage infiltration. • Implemented in soils >15 mm/h percolation rate. • High water table or bedrock >1 m below pipe. • Geotextile fabric installed between pipe bedding and the native soil. • Pipe bedding using clear stone 50 mm diameter with 40% void ratio.
CDS Units	• Installed in accordance to the manufacturer's specification. • Select model based on design flow rate and level of pollutant removal required. • Requires annual inspection and maintenance. • Typically more effective for low flows, medium and high flows are bypassed.

*Based on data provided in HRM Stormwater Management Guidelines – 2006

3.3.7 Treatment Trains

BMPs can act as stand-alone features that work to remove a defined percentage of waterborne nutrients, but they can also be arranged in a treatment train to increase the overall removal efficiency. When stormwater BMPs are laid out in series, each successive BMP sees water with a greatly reduced nutrient load. The downstream BMP removes its "target" percentage of nutrients from what remains in the water that it receives. Credit Valley Conservation has recommended the use of treatment trains, when combining source, conveyance, and end of pipe control measures to produce a more efficient nutrient removal system. BMPs provided in a train cannot simply have their removal efficiencies added together, but rather they require a specific equation to determine the cumulative, aggregate, removal efficiency. The total removal rate of the BMP treatment train is based on applying the removal rate of the second BMP to what results from the application of the first BMP, and so on. Equation 3-3 below describes this relationship and is used to determine the removal efficiency of BMPs in series:

$$R_{train} = R_a + R_b - (R_a R_b/100) \qquad \textbf{Equation 3-3}$$

Where,
R_{train} = Total aggregate removal rate of train (%)
R_a = Removal rate of the upstream BMP (%)
R_b = Removal rate of the downstream BMP (%)

3.3.8 Stormwater Quality Modeling Results

The water quality model has been completed using a concentration-based loading mass-balance approach that is widely accepted and originally adopted for use in Bedford South and The Parks of West Bedford by Jacques Whitford (Stantec). The concentration-based loading mass-balance approach is used to estimate the proposed development's generation of TP and TSS in kilograms during prescribed storm events. Anticipated TP loading is dependent on the land use of a particular area and the stormwater management design. Land use and corresponding TP concentrations are outlined below and were selected from the HRM Stormwater Management Guidelines and other relevant literature. Using the provided TP and TSS concentrations, a mass of TP and TSS in kilograms was calculated using the estimated rainfall that falls on a given area during the different return period storm events. The anticipated pre-development TP and TSS masses were used as the target values during post-development balancing.

The following land use scenarios were used during analysis:

- Scenario 1: Pre-development conditions
- Scenario 2: Post-development conditions, no BMPs (uncontrolled)
- Scenario 3: Post-development conditions, with BMPs

Pre and post-development land use and corresponding TP and TSS loading concentrations were assigned using the information presented in Table 5-5 of the HRM Stormwater Management Guidelines. Table 3.6 below summarizes the land uses and corresponding TP and TSS loading values utilized throughout the modelling process. Refer to Stormwater Drainage Plans included as Figure A.3 and A.4 in Appendix A for reference.

Table 3.6: Summary of Pre and Post-Development Land Uses

Development Condition	Drainage Area	Land Use	Area (ha)	TP Loading (mg/L)	TSS Loading (mg/L)	Notes
Pre-Development	A	Urban Open	5.81	0.20	20.0	Abandoned mall site/parking area
	B	Urban Open	1.02	0.20	20.0	Abandoned mall site/parking area
	C	Commercial	1.93	0.30	54.2	Parking lot
Post-Development	A	Residential (Medium Density)	1.40	0.20	30.5	Townhouse development
		Residential (High Density)	4.41	0.20	47.7	Multi-unit development
	B	Residential (High Density)	1.02	0.30	47.7	Multi-unit development
	C	Residential (High Density)	1.93	0.30	47.7	Multi-unit development

For consistency with the water quantity analysis (peak flow attenuation), event specific concentration-based loading mass-balance calculations were completed. Tables 3.7 to 3.12 summarize the pre and post-development TP and TSS values as well as the anticipated percent reduction required to provide balanced nutrient loads for the whole project site area.

Table 3.7: TP Loading for Project Site - Pre and Post-Development Drainage Area "A"

Development Scenario	Total Project Site TP Loading (kg)					
	2 Year Storm	5 Year Storm	10 Year Storm	25 Year Storm	50 Year Storm	100 Year Storm
Pre-Development	0.606	0.905	1.058	1.233	1.372	2.253
Post-Development (Uncontrolled)	0.638	0.954	1.115	1.300	1.446	2.617
Percent Reduction Required	5.4%	5.4%	5.4%	5.4%	5.4%	16.1%

Table 3.8: TP Loading for Project Site - Pre and Post-Development Drainage Area "B"

Development Scenario	Total Project Site TP Loading (kg)					
	2 Year Storm	5 Year Storm	10 Year Storm	25 Year Storm	50 Year Storm	100 Year Storm
Pre-Development	0.116	0.173	0.202	0.236	0.262	0.416
Post-Development (Uncontrolled)	0.114	0.171	0.200	0.262	0.259	0.452
Percent Reduction Required	-1.1%*	-1.1%*	-1.1%*	-1.1%*	-1.1%*	8.7%

*Negative value indicates that reduction in anticipated TP loading has been achieved naturally through change in land use and reduction in impervious area.

Table 3.9: TP Loading for Project Site - Pre and Post-Development Drainage Area "C"

Development Scenario	Total Project Site TP Loading (kg)					
	2 Year Storm	5 Year Storm	10 Year Storm	25 Year Storm	50 Year Storm	100 Year Storm
Pre-Development	0.356	0.532	0.623	0.726	0.807	1.180
Post-Development (Uncontrolled)	0.205	0.307	0.359	0.418	0.465	0.855
Percent Reduction Required	-42.3%*	-42.3%*	-42.3%*	-42.3%*	-42.3%*	-27.5%*

*Negative value indicates that reduction in anticipated TP loading has been achieved naturally through change in land use and reduction in impervious area.

Table 3.10: TSS Loading for Project Site - Pre and Post-Development Drainage Area "A"

Development Scenario	Total Project Site TP Loading (kg)					
	2 Year Storm	5 Year Storm	10 Year Storm	25 Year Storm	50 Year Storm	100 Year Storm
Pre-Development	60.57	90.49	105.81	123.32	137.19	225.30
Post-Development (Uncontrolled)	100.75	150.52	176.01	205.15	228.21	413.08
Percent Reduction Required	66.4%	66.4%	66.4%	66.4%	66.4%	83.3%

Table 3.11: TSS Loading for Project Site - Pre and Post-Development Drainage Area "B"

Development Scenario	Total Project Site TP Loading (kg)					
	2 Year Storm	5 Year Storm	10 Year Storm	25 Year Storm	50 Year Storm	100 Year Storm
Pre-Development	11.57	17.28	20.21	23.56	26.21	41.55
Post-Development (Uncontrolled)	18.20	27.19	31.79	37.05	41.22	71.85
Percent Reduction Required	57.3%	57.3%	57.3%	57.3%	57.3%	72.9%

Table 3.12: TSS Loading for Project Site - Pre and Post-Development Drainage Area "C"

Development Scenario	Total Project Site TP Loading (kg)					
	2 Year Storm	5 Year Storm	10 Year Storm	25 Year Storm	50 Year Storm	100 Year Storm
Pre-Development	64.38	96.19	112.48	131.09	145.83	213.11
Post-Development (Uncontrolled)	32.67	48.80	57.07	66.51	73.99	135.97
Percent Reduction Required	-49.3%*	-49.3%*	-49.3%*	-49.3%*	-49.3%*	-36.2%*

*Negative value indicates that reduction in anticipated TSS loading has been achieved naturally through change in land use and reduction in impervious area.

Based on the loading models results, it was determined that integration of on-site stormwater BMPs is required in "Area A" (tributary to Penhorn Lake) and "Area B" (tributary to Morris Lake) in the development in order to achieve no net increase of TP and TSS generation following project completion. Because of the pre-existing conditions (commercial parking lot), development of the "Area C" (tributary to Banook Lake) actually results in a decrease in TP and TSS loading and thus no additional BMPs are required to achieve nutrient balance. A plan indicating preliminary location of all primary BMP facilities is provided as Figure A.7 in Appendix A. To ensure "no net increase" of TP and TSS during construction, proper application of the erosion and sediment control measures, as well as any required modifications, will be monitored and enforced by the Site Engineer.

3.4 Considerations for Potential Future Redevelopment of Existing Commercial Lands

It has been requested by HRM for this MSWMP to include analysis of the potential impacts of redevelopment of the existing commercial units which are part of the subject site. These commercial units include the existing office building owned by Crombie Penhorn Mall (2011) Limited (PID 00222844), and the existing commercial units contained on Penhorn Plaza Holdings Limited (PID 41331281) property, including Sobeys, Mr. Lube, Needs, Starbucks, commercial strip mall, etc. There are no current plans to redevelop these lands, but any future changes to land use and impervious area will have a direct effect on stormwater quantity and quality leaving the site and would need to be considered in the overall impact to the downstream watershed. Clayton Developments Limited has provided a high-level conceptual blocking for this area, which has been used to estimate the potential impact area for the stormwater analysis. Conceptual future blocking is indicated on the proposed development layout included as Figure A.2 in Appendix A.

There are two primary stormwater discharge locations for the existing commercial lands. Discharge locations are indicated as critical point “D” and “E” on drawing D01, included in Figure A.3 in Appendix A. Critical point “D” discharges into the ditch system adjacent to Portland Street and Highway 111. Critical point “E” discharges into the municipal storm sewer system which crosses Highway 111. Both of these discharge points are believed to be tributary to the Russel/Morris Lake watershed.

3.4.1 Existing Commercial Stormwater Quantity Analysis

Stormwater quantity design criteria has been outlined in Section 3.3.1 of this report. As per local guidelines, estimated peak flows must be controlled for the 2, 5, 10, 25, 50, and 100-year, 24-hr design storm event, and peak flows at all critical discharge points must be balanced within 10% of the pre-development condition. For the purposes of analysing the existing commercial development area, the approach of achieving flow balance at critical discharge points will be utilized, based on the current development conditions.

Based on a review of record drawings, there is limited on-site stormwater retention currently being utilized on the existing commercial lands. Stormwater runoff is generally conveyed through traditional stormwater infrastructure directly into the municipal stormwater piped system. Stormwater hydraulic analysis was completed on the existing commercial lands as outlined in Section 3.3.2 of this report. Estimated existing peak flow rates for the critical discharge points have been calculated as per Table 3.13 below based on the current land use.

Table 3.13: Existing Commercial Model Results - Stormwater Quantity Summary

POINT	AREA (Hectares)	CN	TC (Min.)	PEAK FLOW (cm)					
				2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
D	3.57	93	7.0	0.514	0.818	0.966	1.151	1.281	1.418
E	3.20	96	7.0	0.498	0.765	0.895	1.059	1.173	1.295

As per local guidelines, and to provide a “no net increase” in stormwater flow, it is recommended that for any future redevelopment of the existing commercial lands, the peak design flow shall not exceed these quantities. Any future redevelopment planning should consider the requirements of adhering to the stormwater quantity targets above.

3.4.2 Existing Commercial Stormwater Quality Analysis

Stormwater quality design criteria has been outlined in Section 3.3.4 of this report. The general approach for maintaining or improving water quality will be to maintain or decrease total phosphorus (TP) and total suspended solids (TSS) levels from the development area such that the downstream lakes do not experience an increase in trophic state. For the purposes of analysing the existing commercial development area, the approach of providing no net increase in TP or TSS load based on the current development will be utilized to ensure the quality and trophic status of the downstream water bodies remains unchanged.

Based on compiled record drawings from the existing commercial properties, some nutrient/sediment mitigation strategies have been implemented into the existing stormwater management system. Several stormwater treatment units have been identified to be operating on the commercial lands, covering approximately 2.7 hectares of developed area. Treatment coverage includes portions of buildings and paved areas surrounding Sobeys (2008), commercial strip mall (2009), Needs (2012), Mr. Lube (2013), and Starbucks (2014).

Stormwater treatment units are reportedly a combination of traditional CDS, Stormceptor, and oil separator units, but the exact make and models are unknown. For the purposes of this water quality analysis, it is assumed that the existing stormwater treatment units have an average removal efficiency of 30% for TP and 70% for TSS as outlined in Table 3.4 of this report. Known locations of existing stormwater treatment units are indicated on drawing D01, included in Figure A.3 in Appendix A.

Stormwater quality analysis was completed for the existing commercial lands as outlined in Section 3.3.5 of this report. Pre-development TP and TSS loading rates for the critical discharge points have been calculated as per Table 3.14 and Table 3.15 below based on the current land use, and currently installed treatment units.

Table 3.14: TP Loading for Existing Commercial Site

Critical Drainage Point	TP Loading (kg)					
	2 Year Storm	5 Year Storm	10 Year Storm	25 Year Storm	50 Year Storm	100 Year Storm
D	0.619	0.925	1.081	1.260	1.402	2.090
E	0.493	0.737	0.861	1.004	1.117	1.528

Table 3.15: TSS Loading for Existing Commercial Site

Critical Drainage Point	TSS Loading (kg)					
	2 Year Storm	5 Year Storm	10 Year Storm	25 Year Storm	50 Year Storm	100 Year Storm
D	105.40	157.46	184.13	214.60	238.73	355.39
E	54.07	80.78	94.46	110.09	122.47	172.56

As per local guidelines, and to provide a “no net increase” in nutrient loading, it is recommended that for any future redevelopment of the existing commercial lands, estimated TSS and TP loadings shall not exceed these quantities. Any future redevelopment planning should consider the requirements of adhering to the storm water quality targets above.

4.0 PROTECTION MEASURES DURING AND AFTER SITE DEVELOPMENT

Temporary and long-term effect of sedimentation and erosion can be minimized by appropriate prevention and control measures. All development will comply with applicable environmental laws, regulations, standards and practices, permits, approvals, and requirements of federal, provincial, and municipal authorities. All land developers involved will have established guidelines that are enforced through the tender/contract period. Appendix D of this report includes a detailed Sedimentation and Erosion Minimization Plan that will be utilized during construction for the Penhorn lands. All developers within the project area will be required to adopt similar on-site procedures. Clear and concise guidelines and site-specific erosion control plans must be provided to all contractors.

The geology of the site consists mainly of silt and granular fill, which, if exposed, would potentially be susceptible to erosion. Imported material will generally be limited to gravels and topsoil needed for landscaping. Standard erosion and sedimentation control measures will be employed for all erodible soils. In addition, site-specific salt and snow management plans will be developed in collaboration with HRM at the time of development application.

4.1 Temporary Protection Measures

Temporary erosion and sedimentation protection measures used during construction will generally include:

- Phased construction approach, limiting amount of exposed soil at any one time;
- Utilizing existing diversion ditches as management and dispersion features;
- Silt fences installed downstream of impacted areas before construction;
- Clean run-on water controlled/diverted by installation of channels, berms, and grading;
- Rip-rap rumble strips installed at all construction entrances to prevent tracking of sediment and fines;
- Silt sacs installed in all surrounding catch basins to prevent migration of fines into stormwater system;
- Exposed soil minimized via rapid cover by mulch, gravel, hay, etc.;
- Controlled exposure relative to forecasted weather conditions;
- Conscious site grading to minimize steep slopes;
- Continuous site monitoring and inspection of temporary sedimentation and erosion control measures; and,
- Limited transportation and testing of materials off-site.

4.2 Permanent Protection Measures

The erosion and sedimentation control plan for permanent stabilization should include:

- Immediate stabilization of all disturbed surfaces during and after construction;
- Periodic inspection and maintenance of erosion and sedimentation control measures to ensure continued effectiveness;

- Provide vegetative buffers between all development and natural wetlands and watercourses; and
- Installation of permanent dispersion features to disrupt concentrated point source discharge.

4.3 Ongoing Protection Measures

There are a variety of other "soft" protection measures that will be adopted by the community to further aid in stormwater quality and quantity management. The Halifax Regional Municipality Bedford West Master Planning Study (HRM, 2006) provides the following suggestions, which will also be applied to the Penhorn development area:

- Public education. Educate individuals in the development about the effects of poor stormwater management and the methods by which they can minimize their impact (e.g. the protection measures listed in the following bullets). Methods of education can include billing inserts, school and community programs, pamphlets, etc.
- Litter control and recycling programs. Litter control and recycling programs reduce the potential for clogging of stormwater management facilities and can be implemented through the use of no-littering bylaws.
- Animal waste control. Clean-up and proper disposal of household pet waste through the use of bylaws reduces the release of nutrients and pathogenic bacteria to downstream receiving waters.
- Spill response plans. The implementation of emergency spill response plans can help limit pollutants and hazardous chemicals from entering downstream receiving waters.
- Proper storage and use of chemicals, fertilizers, and pesticides. The decreased use and proper application of fertilizers can greatly decrease the nutrient and chemical loading to downstream watercourses. Common control measures include applying fertilizers to minimize potential for runoff and hand-weeding as opposed to controlling weeds with chemicals.
- Vacant lot clean-up. Lot clean-up can prevent the accumulation of debris and other material which may pollute downstream watercourses.
- Identification and prohibition of illegal/illicit storm drain connections and discharges. This is another way to minimize pollutant load to receiving waters.
- Street sweeping and catch basin cleaning. Street sweeping and catch basin cleaning can reduce oil and grease runoff as well as decrease the potential for clogging of stormwater management facilities.
- Road salt management. Properly managed road salt application programs minimize the load of salt and sediment in stormwater runoff.
- Pollution prevention lawn care. Utilization of proper fertilizer and pesticide application will reduce the release of nutrients and chemicals that typically contribute to downstream receiving water impairments. Also, guidelines will require a minimum of 6" of topsoil on lawn areas prior to seeding and/or sodding.

To address the issues outlined in the HRM study, Clayton will prepare a Home Owner's Guide to address Lawn Care Best Management Practices. A reference guide, which was provided in the Parks of West Bedford, is provided as Appendix E. The document outlines the developer's environmental commitment for the development as well as the management practices that the homeowner can undertake to contribute to that commitment.

5.0 STORMWATER FACILITY MAINTENANCE

Stormwater BMPs will be designed to be low-maintenance and be cost-comparable to traditional municipal stormwater facilities. Specific BMPs as discussed in this section can decrease capital and maintenance costs by reducing or eliminating traditional infrastructure such as asphalt pavement, curbing, and underground piped infrastructure.

5.1 Stormwater BMP Maintenance

In order to provide BMPs that maintain their optimal TP and TSS removal potential throughout their lifespans, it is important that regular maintenance be completed. For natural BMPs such as vegetated filter strips and enhanced grass swales, making sure they are free of debris and excess sediment will help them operate at their full potential. Ultimately, maintenance schedules are the responsibility of the owner but it is imperative that regular maintenance be performed to ensure peak operational efficiency of any BMP implemented.

Credit Valley Conservation (CVC) in Ontario, Canada has published literature on typical maintenance and inspection activities for BMPs. Table 5.1, 5.2, and 5.3 presents typical recommendations below.

Table 5.1: Typical Maintenance Activities for Vegetative Filter Strips and Grass Swales (Source: Credit Valley Conservation)

Activity	Schedule
• Inspect for vegetation density (at least 80% coverage), damaged by foot or vehicular traffic, channelization, accumulation of debris, trash and sediment, and structural damage to pre-treatment devices.	After every major storm event (>25 mm) in the first year, quarterly for the first two years, and twice annually thereafter.
• Regular watering may be required during the first two years while vegetation is becoming established. • Mow grass to maintain height between 75 to 150 mm. • Remove trash and debris from pre-treatment devices, the swale surface and inlet and outlets.	At least twice annually. More frequently if desired for aesthetic reasons.
• Remove accumulated sediment from pre-treatment devices, inlets and outlets. • Replace dead vegetation, remove invasive growth, dethatch, remove thatching and aerate (PDEP, 2006). • Repair eroded or sparsely vegetated areas. • Replace mulch in spring. • Trim trees and shrubs. • Remove accumulated sediment on the swale surface when dry and exceeds 25 mm depth (PDEP, 2006). • If gullies or pools of standing water are observed along the swale, regrading and revegetating may be required.	Annually or as needed.

Table 5.2: Typical Maintenance Activities for Permeable Storm Sewer and Soak-Away Structures (Source: Credit Valley Conservation)

Activity	Schedule
• Inspection via manholes should be performed to ensure the facility drains within the maximum acceptable length of time (typically 72 hours)	After every major storm event (>25 mm) in the first year, and at least annually.
• Cleaning out leaves, debris and accumulated sediment caught in pre-treatment devices	Annually or as needed.

Table 5.3: Typical Maintenance Activities Green Roofs (Source: Credit Valley Conservation)

Activity	Schedule
• Irrigation and/or watering • Leak Detection: Electronic leak detection is recommended with particular attention should be paid in the first few months following installation.	Regularly as needed
• Weeding and removal of volunteer seedlings of trees and shrubs. • Remove debris and dead vegetation. In particular, the overflow conveyance system should be kept clear	At least twice per year

Table 5.4: Typical Maintenance Activities CDS Units (Source: CDS Technologies)

Activity	Schedule
• Visual inspection - ensure that the system components are in working order and that there are no blockages or obstructions in the inlet and separation screen. • Inspection should also quantify the accumulation of hydrocarbons, trash, and sediment in the system. • Inspect level of discoloration of the sorbent material, if, used.	At least twice per year
• Cleaning - when the level of sediment has reached 75% of capacity in the isolated sump or when an appreciable level of hydrocarbons and trash has accumulated. • Cleaning shall be completed with vacuum truck or other approved method. • If absorbent material is used, it should be replaced when significant discoloration has occurred.	As needed as determined by inspection

5.2 Erosion and Sedimentation Control Maintenance

The maintenance program to ensure the effectiveness of the erosion and sedimentation control plan will generally include:

- Daily (and during precipitation events) inspection of temporary erosion and sedimentation control measures to check for damage. Damaged structures will be repaired.
- Maintenance of environmental protection structures (including removal of silt material) until disturbed areas have been completely stabilized. Following

stabilization of disturbance areas, environmental protection structures will be removed and the area will be re-graded and stabilized.

Further maintenance measures are outlined in the Sedimentation and Erosion Minimization Plan that will be utilized during construction for the Penhorn development is included as Appendix D.

6.0 STORMWATER MANAGEMENT SUMMARY

All critical aspects of the proposed development, existing site constraints and site features have been considered in the management of stormwater. A stormwater management design, through the implementation and integration of on-site BMP features has been adopted that focuses on achieving the stormwater objectives for new development contained within the Regional Centre Secondary Municipal Planning Strategy (Package A) and Morris-Russell Lake Secondary Planning Strategy provided by HRM.

The design of the proposed development was thoughtfully prepared to minimize development impact and utilize Stormwater BMP strategies where possible. Stormwater quantity and quality balancing have been jointly achieved through the measures outlined in this document. Based on the data presented in this report, it is anticipated that stormwater BMPs are required to be incorporated throughout the site design to achieve stormwater quantity (peak flow) and quality (TSS and TP) balance as required by HRM documents. It is anticipated that BMP treatment trains will be utilized to achieve water balance and will likely include a combination of green roofs, permeable pavers, rain barrels, vegetative grass swales, bio-infiltration planters, permeable stormwater infrastructure, filter strips, and CDS treatment units. Detailed design and selection of specific units will be further detailed during the design development stage.

Stormwater peak flow management for this project will be achieved through the use of increased green space to aid in attenuating the anticipated peak runoff from the developed area along with traditional flow management and green stormwater BMP features. A balanced peak-flow site is anticipated to be achieved as required as per local authorities. In addition, flow capacity of the existing piped stormwater system directly downstream of the development area was analysed and confirmed to be acceptable based on the anticipated peak runoff rates from the proposed development.

Both private and publicly owned BMPs and erosion and sediment control measures outlined will been designed to achieve a negligible impact on the existing surface flows from the development to any receiving watercourses or bodies of water. This is to be accomplished through the re-establishment and integration of natural vegetation, maintaining appropriate riparian buffers to existing water features, and providing flow dispersion BMP’s at all outfalls to eliminate concentrated point discharge. Proposed sedimentation and erosion control measures have been provided to outline all measures to be completed before, during, and after construction to mitigate possible disturbances to the surrounding area.

The development will intend to integrate and re-establish native natural vegetation throughout the site. Landscaping design will focus on integrating local native plantings and will generally seek opportunities to implement measures outlined in the HRM Urban Forestry Plan.

The trophic status of the primary receiving body, Penhorn Lake, and additional receiving bodies, Lake Banook and Morris/Russel Lake, have been reviewed through historical testing compiled by Stantec and AECOM. It is anticipated that, through the measures outlined in this report, the current trophic status of the Lakes will be maintained by achieving the water quality/quantity balance of the developed site and managing any potential disturbance of sediment in and around Penhorn Lake during and after construction.

Hydraulic stormwater and nutrient loading analysis was also completed for the existing commercial lands to evaluate potential impacts of redevelopment. Estimated peak flow and nutrient loading rates were determined at critical discharge points, and are recommended for use as stormwater targets for any future redevelopment activities. Any future redevelopment planning should consider the requirements of adhering to the storm water quantity and quality targets as indicated.

Chloride levels, which were identified as being a concern for the receiving lakes, will be managed by implementing specific BMP features near roads and parking areas and by implementing snow and salt management strategies which are to be developed with consultation with HRM throughout the development application process. The Developers involved in this project would be generally prepared to enhance the existing water quality monitoring program for Penhorn Lake and would be open to working with HRM for the potential development of a public beach on Penhorn Lake.

7.0 STATEMENT OF QUALIFICATIONS AND LIMITATIONS

This Report (the “Report”) has been prepared by Strum Consulting (“Consultant”) for the benefit of Crombie REIT Limited and Clayton Developments Limited (“Client”) in accordance with the agreement between Consultant and Client, including the scope of work detailed therein (the “Agreement”).

The information, data, recommendations, and conclusions contained in the Report (collectively, the “Information”):

- is subject to the scope, schedule, and other constraints and limitations in the Agreement and the qualifications contained in the Report (the “Limitations”)
- represents Consultant’s professional judgement in light of the Limitations and industry standards for the preparation of similar reports
- may be based on information provided to Consultant which has not been independently verified
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued
- must be read as a whole and sections thereof should not be read out of such context
- was prepared for the specific purposes described in the Report and the Agreement
- in the case of subsurface, environmental, or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time

Consultant shall be entitled to rely upon the accuracy and completeness of information that was provided and has no obligation to update such information. Consultant accepts no responsibility for any events or circumstances that may have occurred since the date on which the Report was prepared and, in the case of subsurface, environmental, or geotechnical conditions, is not responsible for any variability in such conditions, geographically or over time.

Consultant agrees that the Report represents its professional judgement as described above and that the Information has been prepared for the specific purpose and use described in the Report and the Agreement, but Consultant makes no other representations, or any guarantees or warranties whatsoever, whether express or implied, with respect to the Report, the Information or any part thereof.

The Report is to be treated as confidential and may not be used or relied upon by third parties, except:

- as agreed in writing by Consultant and Client
- as required by law
- for use by governmental reviewing agencies

Consultant accepts no responsibility, and denies any liability whatsoever, to parties other than Client who may obtain access to the Report or the Information for any injury, loss, or damage suffered by such parties arising from their use of, reliance upon, or decisions or actions based on the Report or any of the Information ("improper use of the Report"), except to the extent those parties have obtained the prior written consent of Consultant to use and rely upon the Report and the Information. Any damages arising from improper use of the Report or parts thereof shall be borne by the party making such use.

This Statement of Qualifications and Limitations forms part of the Report and any use of the Report is subject to the terms hereof.

Should additional information become available, Strum requests that this information be brought to our attention immediately so that we can re-assess the conclusions presented in this report. This report was prepared by Ben Crouse, P.Eng., Civil Engineer, and was reviewed by Chris Boudreau, P.Eng., Manager Engineering.

8.0 REFERENCES

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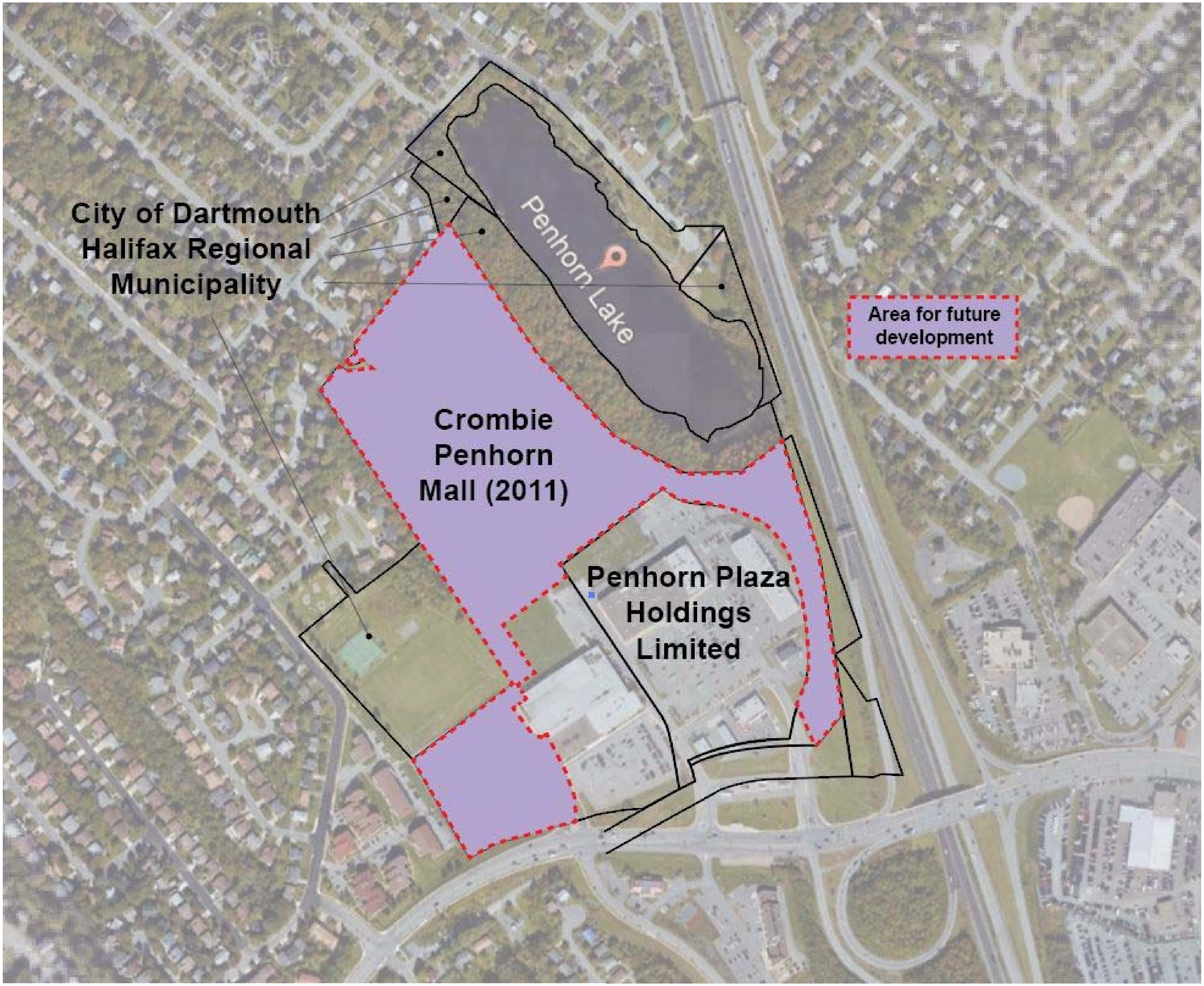
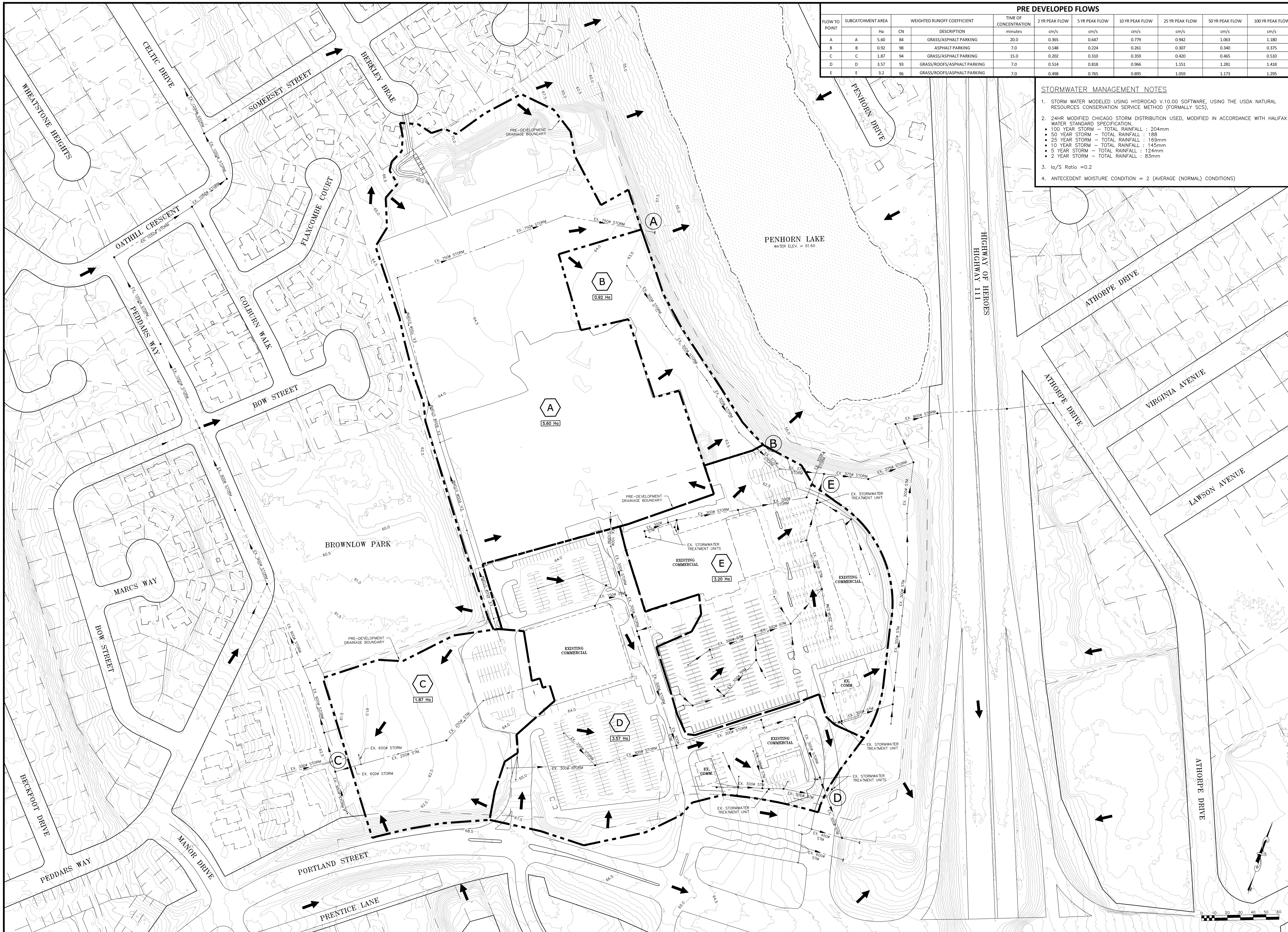
APPENDIX A
SITE MAP FIGURES



A.1 – Penhorn Property Ownership Map

A.2 - Penhorn Residential Concept Plan

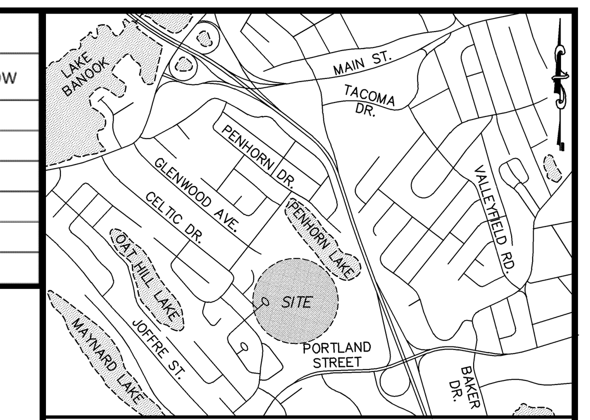


PRE DEVELOPED FLOWS

FLOW TO POINT	SUBCATCHMENT AREA		WEIGHTED RUNOFF COEFFICIENT		TIME OF CONCENTRATION	2 YR PEAK FLOW	5 YR PEAK FLOW	10 YR PEAK FLOW	25 YR PEAK FLOW	50 YR PEAK FLOW	100 YR PEAK FLOW
		Ha	CN	DESCRIPTION	minutes	cm/s	cm/s	cm/s	cm/s	cm/s	cm/s
A	A	5.60	84	GRASS/ASPHALT PARKING	20.0	0.365	0.647	0.779	0.942	1.063	1.180
B	B	0.92	98	ASPHALT PARKING	7.0	0.148	0.224	0.261	0.307	0.340	0.375
C	C	1.87	94	GRASS/ASPHALT PARKING	15.0	0.202	0.310	0.359	0.420	0.465	0.510
D	D	3.57	93	GRASS/ROOFS/ASPHALT PARKING	7.0	0.514	0.818	0.966	1.151	1.281	1.418
E	E	3.2	96	GRASS/ROOFS/ASPHALT PARKING	7.0	0.498	0.765	0.895	1.059	1.173	1.295

STORMWATER MANAGEMENT NOTES

1. STORM WATER MODELED USING HYDROCAD V.10.00 SOFTWARE, USING THE USDA NATURAL RESOURCES CONSERVATION SERVICE METHOD (FORMALLY SCS),
2. 24HR MODIFIED CHICAGO STORM DISTRIBUTION USED, MODIFIED IN ACCORDANCE WITH HALIFAX WATER STANDARD SPECIFICATION.
   - 100 YEAR STORM – TOTAL RAINFALL : 204mm
   - 50 YEAR STORM – TOTAL RAINFALL : 188
   - 25 YEAR STORM – TOTAL RAINFALL : 169mm
   - 10 YEAR STORM – TOTAL RAINFALL : 145mm
   - 5 YEAR STORM – TOTAL RAINFALL : 124mm
   - 2 YEAR STORM – TOTAL RAINFALL : 83mm
3. Ia/S Ratio =0.2
4. ANTECEDENT MOISTURE CONDITION = 2 (AVERAGE (NORMAL) CONDITIONS)



Key Plan NOT TO SCALE

LEGEND

- DRAINAGE AREA IDENTIFIER
- CRITICAL CALCULATION POINT
- OVERLAND FLOW DIRECTION
- DRAINAGE BOUNDARY
- W.X WETLAND IDENTIFIER
- XX.XX Ha DRAINAGE AREA VOLUME IDENTIFIER
- S## VOLUME RATE IDENTIFIER
- STORMWATER MANAGEMENT AREA
- BODY OF WATER
- EXISTING LOTS
- EXISTING ROW
- LOW POINT — LOW POINT IN ROADWAY
- HIGH POINT — HIGH POINT IN ROADWAY
- PROPOSED LOTS
- PROPOSED ROW
- SILT FENCE

NOTES:

1. Contour interval is 0.5 Metre, based on LRIS mapping blended with actual field data provided by Servant Dunbrack Limited.
2. For storm drainage calculations refer to Strum Consulting storm drainage calculation sheets.
3. Peak flows for critical discharge point "D" and "E" have been indicated for the purposes of setting maximum flow targets for the potential future redevelopment of these existing commercial lands.

No	Description	Date	By
0.	XXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX	XXX

Revision or Issue

Strum CONSULTING

Project: PENHORN PLAZA DARTMOUTH NOVA SCOTIA

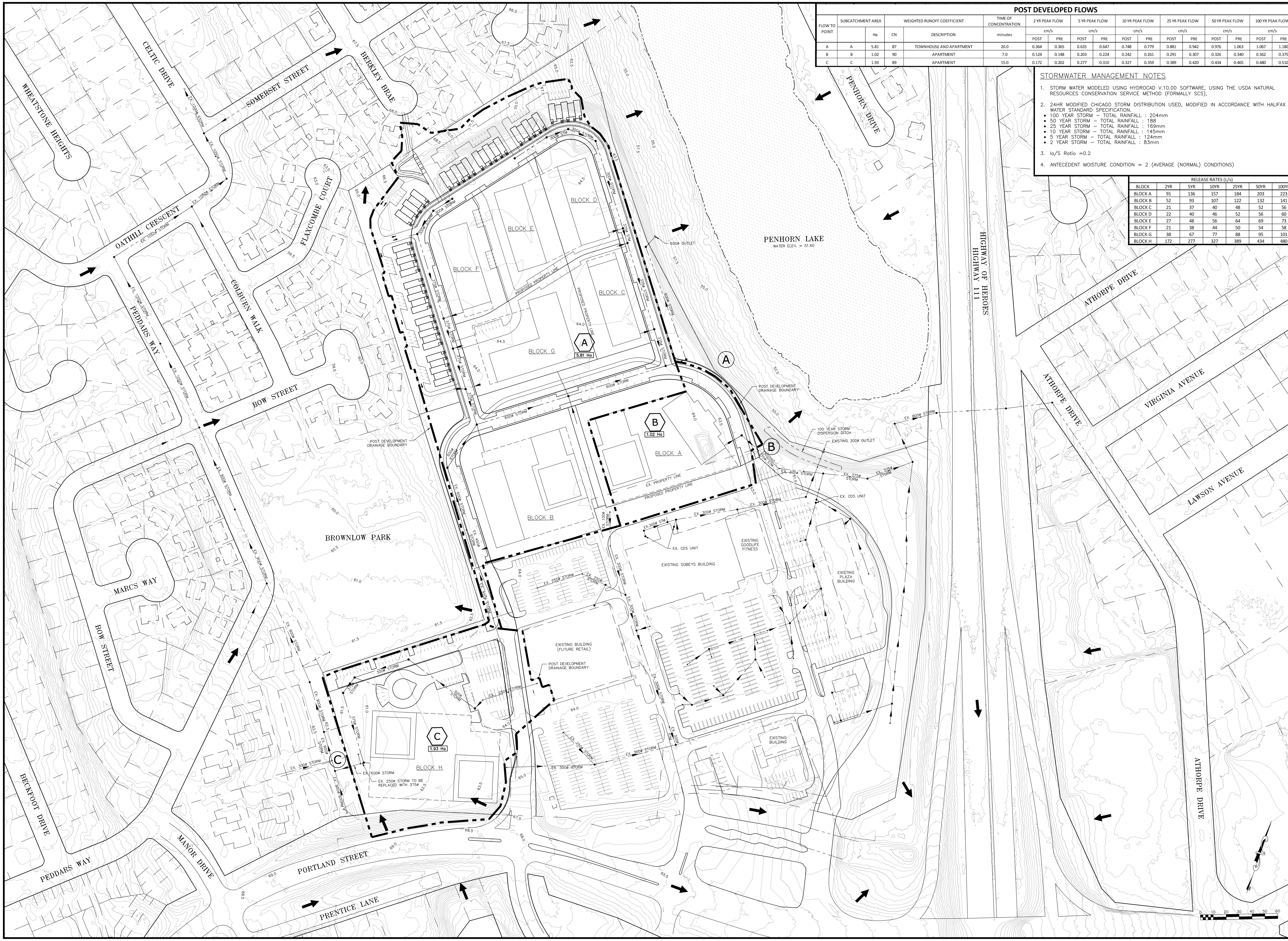
Drawing: PRE-DEVELOPMENT DRAINAGE CONDITIONS

DRAFT NOT FOR CONSTRUCTION PRINTED JUN 30/20

Scale 1:1250

Date		Drawn
XXXX-XX-XX		MMH
Design CTP	Check CNB	Approv. CNB
Project No. 20-7306		Sheet 1 Of 1
Drawing No. D01		Rev. 0

A.3 - Pre-Development Site Drainage Plan



POST DEVELOPED FLOWS

FLOW TO POINT	SUBCATCHMENT AREA		WEIGHTED RUNOFF COEFFICIENT		TIME OF CONCENTRATION	2 YR PEAK FLOW		5 YR PEAK FLOW		10 YR PEAK FLOW		25 YR PEAK FLOW		50 YR PEAK FLOW		100 YR PEAK FLOW	
						cm/s		cm/s		cm/s		cm/s		cm/s		cm/s	
		Ha	CN	DESCRIPTION	minutes	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE
A	A	5.81	87	TOWNHOUSE AND APARTMENT	20.0	0.364	0.365	0.635	0.647	0.748	0.779	0.881	0.942	0.976	1.063	1.067	1.180
B	B	1.02	90	APARTMENT	7.0	0.124	0.148	0.203	0.224	0.242	0.261	0.291	0.307	0.326	0.340	0.362	0.375
C	C	1.93	89	APARTMENT	15.0	0.172	0.202	0.277	0.310	0.327	0.359	0.389	0.420	0.434	0.465	0.480	0.510

STORMWATER MANAGEMENT NOTES

1. STORM WATER MODELED USING HYDROCAD V.10.00 SOFTWARE, USING THE USDA NATURAL RESOURCES CONSERVATION SERVICE METHOD (FORMALLY SCS),

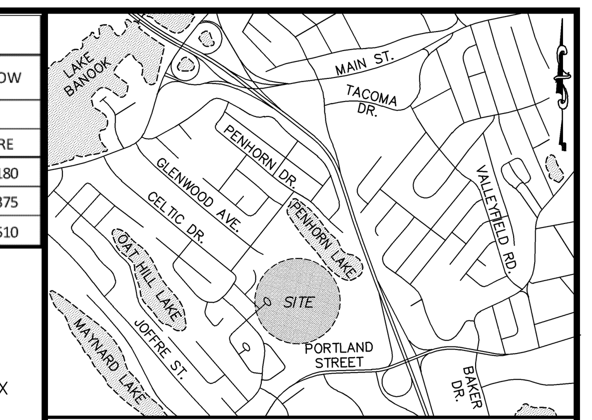
2. 24HR MODIFIED CHICAGO STORM DISTRIBUTION USED, MODIFIED IN ACCORDANCE WITH HALIFAX WATER STANDARD SPECIFICATION.
   - 100 YEAR STORM – TOTAL RAINFALL : 204mm
   - 50 YEAR STORM – TOTAL RAINFALL : 188
   - 25 YEAR STORM – TOTAL RAINFALL : 169mm
   - 10 YEAR STORM – TOTAL RAINFALL : 145mm
   - 5 YEAR STORM – TOTAL RAINFALL : 124mm
   - 2 YEAR STORM – TOTAL RAINFALL : 83mm

3. Ia/S Ratio =0.2

4. ANTECEDENT MOISTURE CONDITION = 2 (AVERAGE (NORMAL) CONDITIONS)

RELEASE RATES (L/s)

BLOCK	2YR	5YR	10YR	25YR	50YR	100YR
BLOCK A	91	136	157	184	203	223
BLOCK B	52	93	107	122	132	141
BLOCK C	21	37	40	48	52	56
BLOCK D	22	40	46	52	56	60
BLOCK E	27	48	56	64	69	73
BLOCK F	21	38	44	50	54	58
BLOCK G	38	67	77	88	95	101
BLOCK H	172	277	327	389	434	480



Key Plan — NOT TO SCALE

LEGEND

- DRAINAGE AREA IDENTIFIER
- CRITICAL CALCULATION POINT
- OVERLAND FLOW DIRECTION
- DRAINAGE BOUNDARY
- WLX — WETLAND IDENTIFIER
- XX.XX Ha — DRAINAGE AREA VOLUME IDENTIFIER
- S## — VOLUME RATE IDENTIFIER
- STORMWATER MANAGEMENT AREA
- BODY OF WATER
- EXISTING LOTS
- EXISTING ROW
- LOW POINT — LOW POINT IN ROADWAY
- HIGH POINT — HIGH POINT IN ROADWAY
- PROPOSED LOTS
- PROPOSED ROW
- SILT FENCE

NOTES:

1. Contour interval is 0.5 Metre, based on LRIS mapping blended with actual field data provided by Servant Dunbrack Limited.
2. For storm drainage calculations refer to Strum Consulting storm drainage calculation sheets.
3. All post developed flows are based on Release Rates shown in the table.

No	Description	Date	By
0.	XXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX	XXX

Revision or Issue

Strum CONSULTING

Project
PENHORN PLAZA
DARTMOUTH
NOVA SCOTIA

Drawing
POST–DEVELOPMENT
DRAINAGE CONDITIONS

Scale 1:1250

Date XXXX–XX–XX		Drawn MMH
Design CTP	Check CNB	Approv. CNB
Project No. 20–7306		Sheet 1 Of 1
Drawing No. D02		Rev. 0

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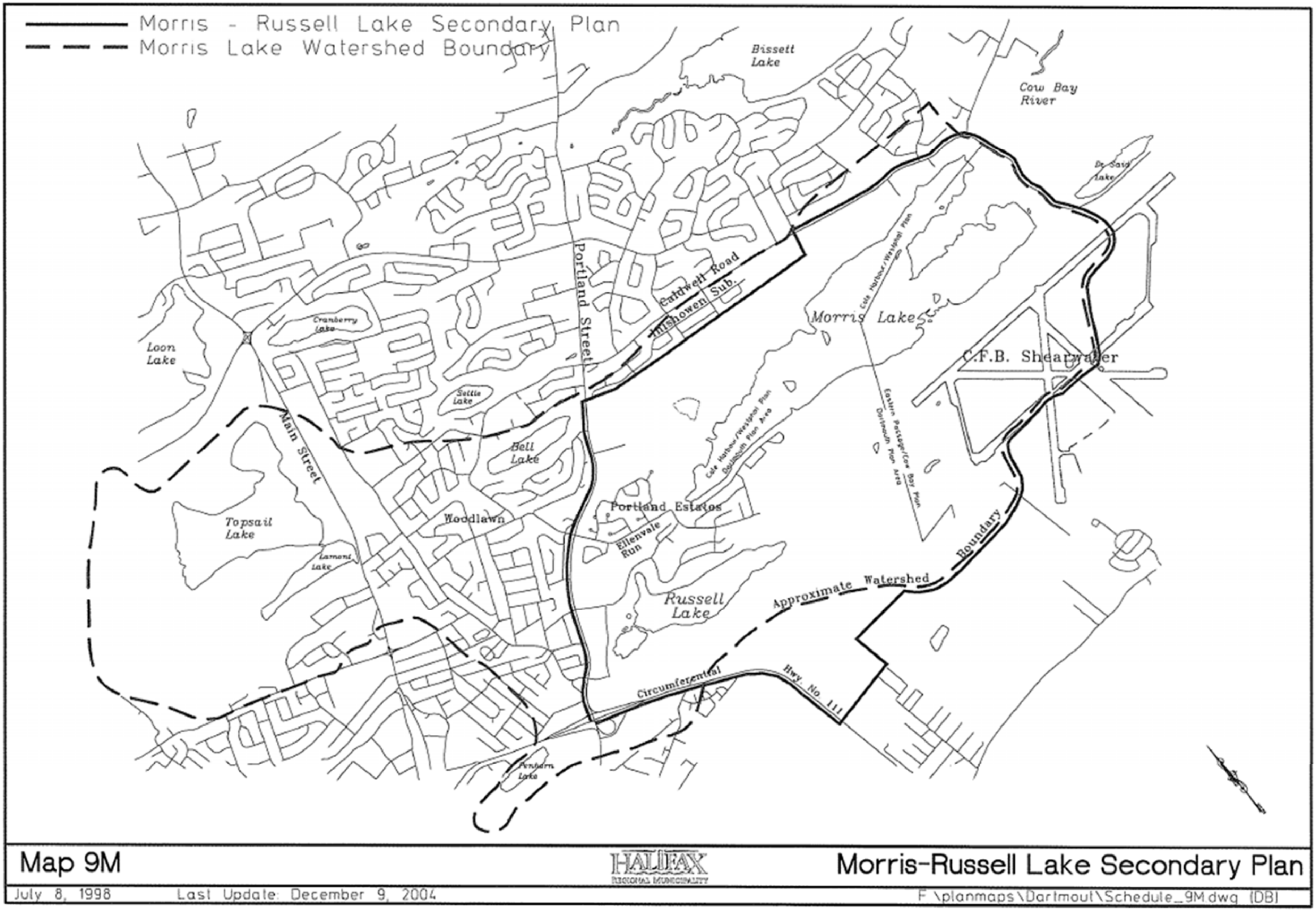
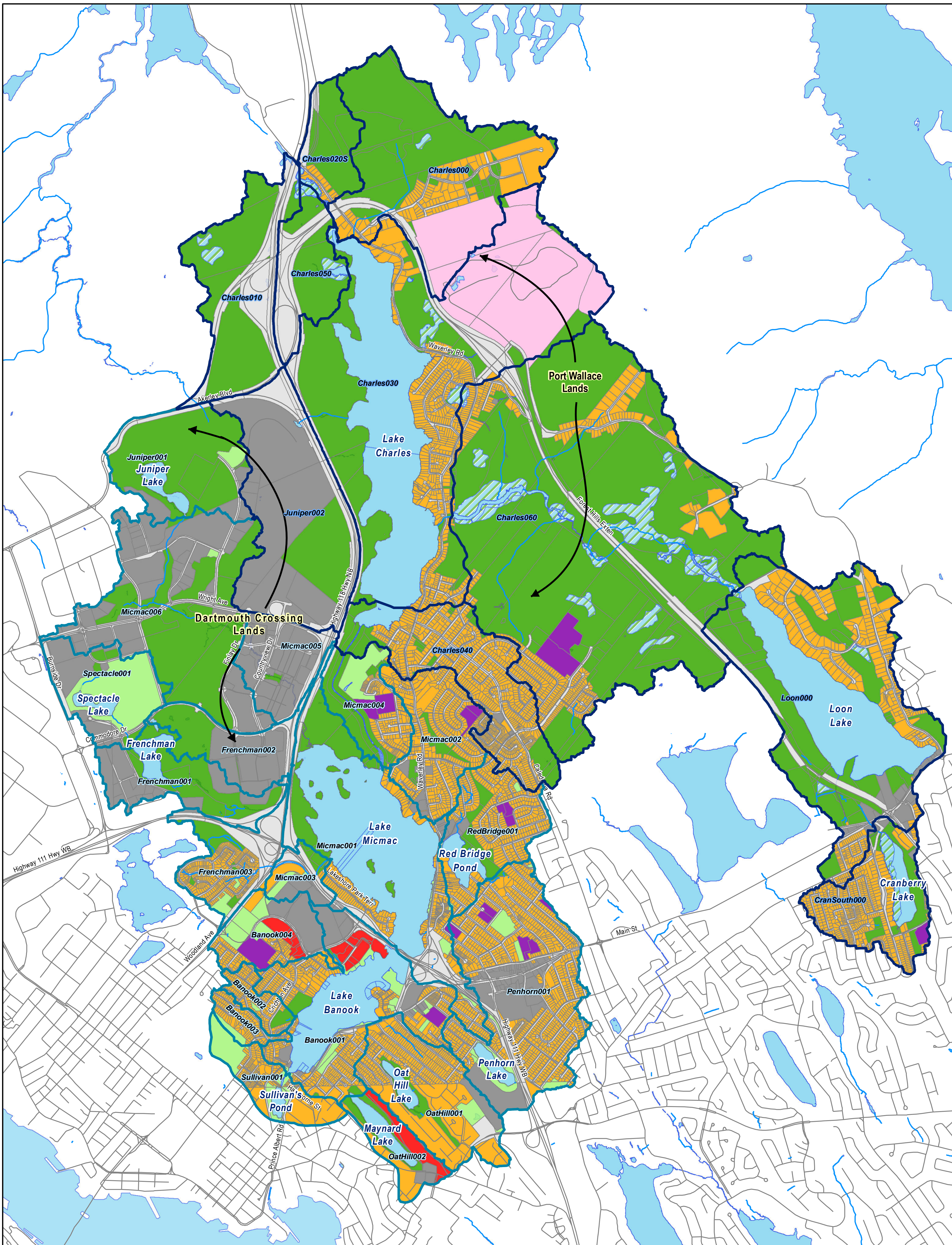
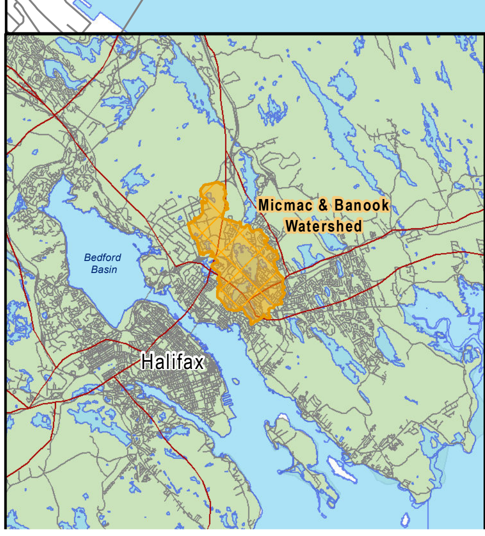
A.4 - Post-Development Site Drainage Plan



A.5 – Morris-Russell Lake Watershed





Legend

Existing Land Use

- High Density Residential
- Medium Density Residential
- Commercial
- Industrial
- Institutional
- Roadway
- Forest
- Open Space
- Wetland
- Water

- Watercourses
- Roads
- Lakes
- Lake Charles Subwatershed and Subcatchment Boundaries
  Charles010 : Subcatchment name
- Micmac & Banook Subwatershed and Subcatchment Boundaries
  Banook002 : Subcatchment name

N

Hydraulic Modeling & Flood Plain Mapping of Lake Micmac, Lake Banook, Red Bridge Pond & Sullivans Pond

Existing Land Use and Hydrologic Subcatchment Boundaries

August 2013	1:30,000	Datum: ATS 1977 MTM 5 NS Source: HRM
P#: 60299928	V#: 001	Figure 2

AECOM

0 0.5 1 2
Kilometers

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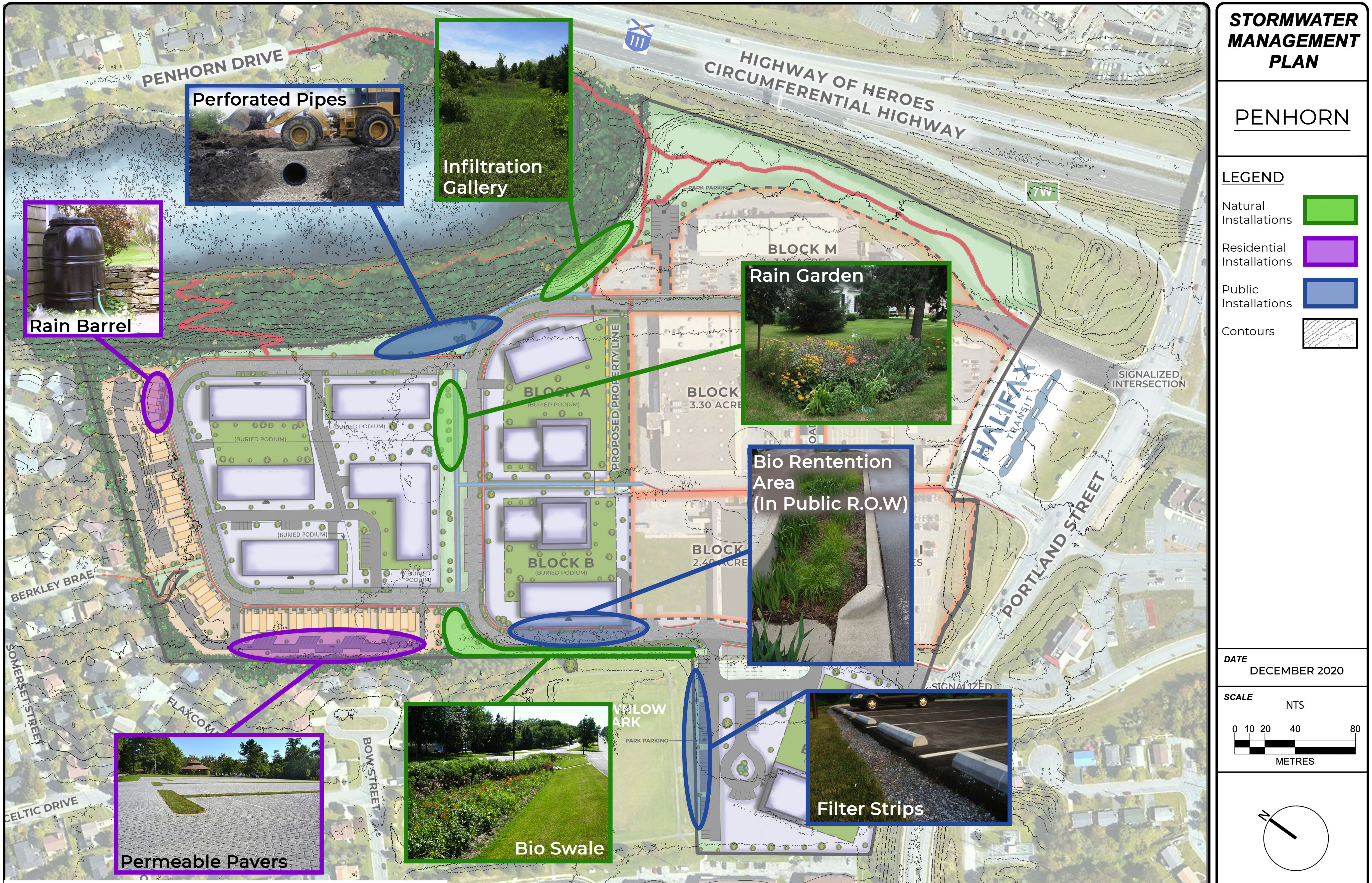
Map Location: P:\60299928 Sullivan's Pond\900-CAD-GIS\920 GIS-Graphics\Design\Report Figures

A.6 - Lake Banook Watershed



A.7 - Prenhorn Residential Conceptual BMP Plan

APPENDIX B
PENHORN LAKE WATER QUALITY TESTING RESULTS

Penhorn Lake

WATER QUALITY ANALYSES - HRM LAKE SAMPLING PROGRAM

See NOTES below

	Units	RDL	Spring 2006	Fall 2006	Spring 2007	Summer 2007	Fall 2007	Spring 2008	Summer 2008	Fall 2008	Spring 2009	Summer 2009	Fall 2009	Spring 2010	Summer 2010	Fall 2010	Spring 2011	Summer 2011	Fall 2011
Community			Dartmouth	Dartmouth	Dartmouth	Dartmouth	Dartmouth	Dartmouth	Dartmouth	Dartmouth	Dartmouth	Dartmouth	Dartmouth	Dartmouth	Dartmouth	Dartmouth	Dartmouth	Dartmouth	Dartmouth
Sampling Date & Time	DD/MM/YYYY 24hr time		5/17/2006 0:00	10/11/2006 0:00	5/8/2007 9:40	8/14/2007 11:14	10/24/2007 9:02	5/6/2008 10:31	8/13/2008 10:35	10/20/2008 11:40	6/1/2009 8:35	7/27/2009 10:35	10/20/2009 11:20	5/10/2010 10:25	8/10/2010 11:00	10/19/2010 11:50	4/7/2011 0:00	8/7/2011 11:40	11/14/2011 12:10
FIELD DATA																			
Secchi Depth	Meters	N/A	3.8	2.5	5.5 (bottom)	3	2.25	4.6	3.7	2.4	2.3	2	1.8	4.7	4.9	3.9	--	4.4	--
Temp	Celsius	N/A	14.35	15.19	10.33	22.08	14.97	12.67	22.03	11.29	16	22.04	9.24	13.27	22.62	11.4	--	21.99	9.14
Dissolved Oxygen	mg/L	0.2	10.34	8.99	10.57	8.04	9.29	11.65	8.22	9.76	11.28	8.63	10.44	11.3	8.65	10.74	--	8.75	10.66
pH (Field)	pH	N/A	7.51	7.41	7.17	7.3	7.07	7.52	7.92	8.03	6.93	7.07	7.71	7.77	7.13	7.56	--	7.4	7.43
Specific Conductance	mS/cm	0.001	0.446	0.385	0.606	1.04	0.417	0.781	0.666	0.649	0.941	0.835	0.749	0.693	0.616	0.627	--	0.531	0.401
TDS	g/L	0.01	--	--	0.394	0.676	0.271	0.508	0.433	0.422	0.612	0.543	0.487	0.45	0.401	0.407	--	0.345	0.261
Salinity	ppt	0.01	--	--	0.3	0.51	0.2	0.39	0.32	0.32	0.47	0.41	0.37	0.34	0.3	0.31	--	0.26	0.19
INORGANICS																			
Total Alkalinity (Total as CaCO3)	mg/L	5	--	--	25	--	26	24	26	30	27	30	29	29	30	31	25.1	35	33
Dissolved Chloride (Cl)	mg/L	1	110	90	160	--	100	200	170	170	260	246	218	308	168	166	159.1	134	91
Colour	TCU	5	--	6	5	ND	9	ND	9	7	16	52	9	ND	6	5	11	ND	16
Total Kjeldahl Nitrogen (TKN)	mg/L	0.4	0.2	0.3	0.3	--	2.8	ND	0.4	0.3	ND	1.1	0.9	ND	ND	0.4	--	ND	1
Nitrate + Nitrite	mg/L	0.05	--	--	2.1	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2	--	ND	ND
Nitrate (N)	mg/L	0.05	<0.05	ND	--	--	--	ND	ND	ND	ND	ND	ND	ND	ND	0.2	0.04	ND	ND
Nitrite (N)	mg/L	0.05	<0.01	ND	ND	--	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	ND	ND
Nitrogen (Ammonia Nitrogen)	mg/L	0.05	--	--	ND	--	ND	ND	ND	0.06	ND	0.06	ND	0.05	ND	ND	0	ND	0.21
Total Organic Carbon (C)	mg/L	0.5	--	--	1.8	--	2.9	2	2	2.2	3.2	7.7	4.5	4.3	3.6	3	--	3.9	5.3
Orthophosphate (P)	mg/L	0.01	--	--	ND	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.003	ND	0.01
pH (Lab)	pH	N/A	--	--	7.35	--	7.65	7.56	7.43	7.47	7.9	7.8	7.7	7.8	7.8	7.7	7.8	8	7.8
Total Phosphorus (1M depth)	mg/L	0.001	0.002	ND	0.007	0.004	0.018	0.006	0.012	0.021	0.011	0.019	0.005	0.025	0.021	0.02	0.006	0.009	0.019
Total Phosphorus (Deep)	mg/L	0.001	--	--	--	0.012	--	--	--	--	--	0.004	--	--	--	--	--	0.012	--
Reactive Silica (SiO2)	mg/L	0.5	--	--	ND	--	2.5	ND	1.4	2.6	ND	1	2	ND	1	1.9	--	0.7	1.7
Total Suspended Solids	mg/L	5	<2	ND	ND	1	2	1	1	2	ND	ND	ND	ND	ND	ND	--	ND	ND
Dissolved Sulphate (SO4)	mg/L	2	--	--	14	--	9	18	14	13	19	15	14	14	11	11	14.6	13	13
Turbidity	NTU	0.1	0.9	0.9	0.6	0.9	2.3	0.5	1	1	1.6	1.5	3.2	0.9	0.7	1.4	--	0.9	13.3
Conductivity	uS/cm	1	--	--	560	--	420	770	650	650	1030	855	797	688	630	607	654	505	385
Calculated Parameters																			
Anion Sum	me/L	N/A	--	--	5.38	--	3.58	6.61	5.7	5.76	8.27	7.84	7.01	5.63	5.56	5.55	5.29	4.75	3.49
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	1	--	--	25	--	26	24	26	30	27	30	29	29	30	31	--	35	33
Calculated TDS	mg/L	1	--	--	310	--	214	395	339	341	450	501	1200	1015	990	324	--	301	200
Carb. Alkalinity (calc. as CaCO3)	mg/L	1	--	--	ND	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	ND	ND
Cation Sum	me/L	N/A	--	--	55	--	3.85	7.07	6.01	5.97	6.86	10.12	6.93	5.7	7.25	5.69	5.22	5.93	3.5
Hardness (CaCO3)	mg/L	1	--	--	5.13	--	43	58	53	54	49	157	55	55	59	55.3	--	48	50
Ion Balance (% Difference)	%	N/A	--	--	2.38	--	3.63	3.36	2.65	1.79	9.4	12.7	0.6	0.6	13.2	1.3	--	11.1	0.1
Langelier Index (@ 20C)	N/A	N/A	--	--	-1.4	--	-1.17	-1.2	-1.33	-1.22	-1.1	-0.63	-1.26	-1.14	-1.1	-1.17	--	-0.89	-1.06
Langelier Index (@ 4C)	N/A	N/A	--	--	-1.65	--	-1.42	-1.45	-1.58	-1.47	-1.42	-0.95	-1.58	-1.46	-1.42	-1.49	--	-1.21	-1.38
Saturation pH (@ 20C)	N/A	N/A	--	--	8.75	--	8.82	8.76	8.76	8.69	9	8.43	8.96	8.94	8.9	8.87	--	8.89	8.86
Saturation pH (@ 4C)	N/A	N/A	--	--	9	--	9.07	9.01	9.01	8.94	9.32	8.75	9.28	9.26	9.22	9.19	--	9.21	9.18
METALS (ICP-MS)																			
Total Aluminum (Al)	ug/L	5	--	--	17	--	--	13	ND	ND	--	--	72	--	31	--	34	17	--
Total Antimony (Sb)	ug/L	2	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Arsenic (As)	ug/L	2	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Barium (Ba)	ug/L	5	--	--	26	--	--	28	34	35	--	--	40	--	30	--	--	29	--
Total Beryllium (Be)	ug/L	2	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Bismuth (Bi)	ug/L	2	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Boron (B)	ug/L	5	--	--	7	--	--	6	7	7	--	--	9	--	8	--	--	8	--
Total Cadmium (Cd)	ug/L	0.017	--	--	ND	--	--	ND	ND	ND			ND	--	ND	--	--	0.051	--
Total Calcium (Ca)	mg/L	0.1	--	--	19	--	15	20	18	19	16.5	60.5	18.9	19.2	20.6	19	18.8	15.8	17.3
Total Chromium (Cr)	ug/L	1	--	--	ND	--	--	ND	ND	ND	--	--	3	--	ND	--	--	ND	--
Total Cobalt (Co)	ug/L	1	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Copper (Cu)	µg/L	2	--	--	ND	--	ND	ND	ND	ND	6	ND	ND	ND	ND	ND	--	ND	2
Total Iron (Fe)	µg/L	50	--	--	ND	--	0.04	ND	ND	60	130	160	180	81	73	115	--	59	611
Total Lead (Pb)	ug/L	0.5	--	--	0.6	--	--	ND	ND	ND	--	--	ND	--	1.2			ND	
Total Magnesium (Mg)	mg/L	0.1	--	--	1.9	--	1.5	1.8	1.8	1.8	2	4.2	1.8	1.8	1.9	1.9	1.7	2.1	1.7
Total Manganese (Mn)	µg/L	2	--	--	32	--	0.22	75	91	190	123	127	319	87	52	73	--	67	38
Total Molybdenum (Mo)	ug/L	2	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Nickel (Ni)	ug/L	2	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Phosphorus (P)	mg/L	0.1	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Potassium (K)	mg/L	0.1	--	--	1.2	--	1.2	1.2	1.2	1.2	2.9	3	2.8	2.3	1.9	2.1	2	1.7	2.1
Total Selenium (Se)	ug/L	1	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Silver (Ag)	ug/L	0.1	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Sodium (Na)	mg/L	0.1	--	--	92	--	68	140	110	110	133	158	132	104	138	104	93.8	113	52.8
Total Strontium (Sr)	ug/L	5	--	--	52	--	--	60	59	62	--	--	65	--	63	--	--	59	--
Total Thallium (Tl)	ug/L	0.1	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Tin (Sn)	ug/L	2	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Titanium (Ti)	ug/L	2	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Uranium (U)	ug/L	0.1	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Vanadium (V)	ug/L	2	--	--	ND	--	--	ND	ND	ND	--	--	ND	--	ND	--	--	ND	--
Total Zinc (Zn)	µg/L	5	--	--	13	--	ND	7	ND	9	13	751	ND	ND	46	ND	--	ND	ND
MICROBIOLOGICAL																			
Total Coliform Lake	MPN/100mL	2	--	--	--	--	--	--	--	--	--	--	387	52	1961	613	--	--	--
Total Coliform Outlet	MPN/100mL	2	--	--	--	--	--	--	--	--	--	--	--	--	259	517	36	--	--
E. Coli Lake	MPN/100mL	2	--	ND	--	--	--	--	--	--	--	--	4	13	6	27	--	10	39
E. Coli Outlet	MPN/100mL	2	--		--	--	--	--	--	--	--	--	--	--	10	25	4	17	34
Fecal coliform Lake	CFU/100mL	2	72	2	13	240	260	2	1300	40	8	32	36	--	--	--	--	--	--
Fecal coliform Outlet	CFU/100mL	2	--	--	40	570	340	9	140	47	PRESENT	20	--	--	--	--	--	--	--
Fecal coliform Inlet	CFU/100mL	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chlorophyll A - Acidification method	µg/L	N/A	0.63	5.92	0.42	4.64	43.23	2.06	1.48	3.72	8.62	3.59	7.44	1.23	2.37	11.41	3.5	3.83	3.59
Chlorophyll A - Welschmeyer method	µg/L	N/A	--	--	0.41	4.14	44.8	2.13	1.58	3.71	8.35	3.72	7.75	1.1	2.29	9.95	--	3.64	3.42

Notes:

-- Not Analysed
NC Not Calculable
ND Not Detected
N/A Not Applicable
MPN Most Probable Number
RDL Reportable Detection Limit
ug Micrograms
mg Milligrams
L Litre
† Recreational Water Quality Guidelines
[1] Taken from South East end of Lake
[2] Taken from South West end of Lake

CCME - Canadian Council of Ministers of Environment Guidelines for the Protection of Aquatic Life
Fecal Coliform Guideline: for Contact Recreation
Dissolved Oxygen Guideline: lowest acceptable level depending on temperature and life stage
Bacterial level of concern for swimming
Bacterial level unsuitable for swimming

APPENDIX C
TOPSOIL RECOMMENDATION SPECIFICATION – JACQUES WHITFORD NAWE, INC.

Memo

Jacques Whitford NAWE, Inc
4444 Centerville Road, Suite 140 • White Bear Lake, MN • 55127
Phone: 651-255-5050 • Fax: 651-255-5060 • www.nawe-pa.com

To: Scott MacCallum

From: Shane Sparks

Date: July 31st, 2008

Re: Topsoil Recommendations

Scott,

Good quality topsoil is critical to the establishment of a low maintenance landscape. If the topsoil has sufficient amounts of air, water, and nutrients, it will reduce the need for maintenance activities such as aeration, irrigation, and fertilizer application. The purpose of this memo is to provide guidelines for the selection and installation of topsoil for future developments. Recommendations are divided into chemical and physical characteristics of the recommended topsoil.

Physical Characteristics:

1. *Texture* - Ideal topsoil contains a mixture of sand, silt, and clay. Acceptable soil textures are loam, sandy loams and loamy sands. These soil types have good permeability to prevent saturation, but also hold a significant amount of moisture to supply to the landscape.
2. *Organic Matter* – High quality topsoil typically has a minimum of 4% organic matter. Higher percentages are preferred for the soil as the organic matter supplies critical nutrients to the landscape above.
3. *Structure/Consistency* – Soil should crush/crumble easily when pressure is applied.
4. *Topsoil Thickness* – The minimum thickness for topsoil is 10 centimeters (cm). However, a range of 15-20 cm is ideal as all topsoil will compact following installation to approximately 50% of its original thickness

Chemical Characteristics:

1. *Salts* – High levels of salt, as measured by soil electrical conductivity (EC), can cause toxic effects on lawn vegetation. Sodium and chloride levels below 100 mg/kg of soil are recommended.
2. *pH* – Turfgrass tends to grow in slightly more acidic soils. Therefore, a pH of 6.3-6.8 is recommended for the topsoil.

3. *Nutrients* – Several nutrients are critical to reduce the need for fertilizer addition to lawn topsoil. Any potential topsoil sources should be tested by a certified soils lab before application to ensure that they meet the following nutrient requirements:
    a. Nitrogen: greater than 30 mg N/kg of soil (more organic matter = more nitrogen)
    b. Phosphorus: greater than 30 mg P/kg of soil
    c. Potassium: 120 to 250 mg K/kg of soil
    d. Calcium: 2,000 to 4,000 mg Ca/kg of soil
    e. Magnesium: 150 to 300 mg Mg/kg of soil
    f. Trace Elements: boron, cobalt, iron, copper, molybdenum, sulfur, manganese and zinc should be present in trace amounts

High quality topsoil is well balanced, rich in microbial life, and high in the essential nutrients for basic plant nutrition. The application of the guidelines above will result in the installation of high quality topsoil that is critical to a low maintenance landscape. If you have any questions regarding this document, or would like more information, please contact Shane Sparks at 651-255-5045.

Sincerely,

Original Signed

Shane Sparks
Hydrogeologist/Soil Scientist

APPENDIX D
SEDIMENTATION AND EROSION MINIMIZATION PLAN

Sedimentation and Erosion Minimization Plan
Penhorn Residential Development Area

1.0 INTRODUCTION

This Sedimentation and Erosion Minimization Plan for the Penhorn Residential Development Area has been prepared by Strum Consulting on behalf of Crombie REIT Limited and Clayton Developments Limited, for consideration by Halifax Regional Municipality (HRM) staff. This Plan has been developed to provide a general summary of the runoff, erosion, and sedimentation controls that are anticipated to be implemented before, during, and after construction activities.

This Plan does not serve to meet the formal requirements for an Erosion and Sedimentation Control Plan (ESCP) for any particular construction activity or work phase on the site. All development will be required to comply with all applicable environmental laws, regulations, standards, and practices, permits, approvals, and requirements of federal, provincial, and municipal authorities. This Plan presented will be provided to all land developers involved and will establish guidelines that will be enforced through all stages of development. This Plan will be based on the following principles:

- Prevent runoff and migration of sediment from disturbed areas to adjacent undisturbed areas through the installation of perimeter controls prior to commencement of work.
- Intercept and divert clean surface runoff away from the work site to prevent it from mixing with sediment laden water resulting from ongoing construction activities.
- Prevent concentrated point discharge by installing flow dispersion features at the outlet of work areas.
- Dewater excavation by pumping sediment laden water to highly controlled areas.
- Stabilize areas of exposed soil as soon as final grade is achieved.
- Maintain control measures until the site is stabilized.

1.1 Background

The subject site is a property located at 535 Portland Street, Dartmouth, NS (PID 00222844). The site is an approximately 12.53 hectare (31 acre) property bounded by Penhorn Lake to the north, Highway 111 to the east, Portland Street to the south, and parkland and residential development to the west. The subject site is currently owned by Crombie Penhorn Mall (2011) Limited. The site contains an existing approximately 7,200m2 commercial building which was constructed in 1982 and underwent a major renovations in 2009 when a large section of the former mall was demolished. The existing building underwent further redevelopment, transitioning to primarily office building in 2018.

The Penhorn residential development being considered will consist of a combination of multi-unit apartment buildings and single-family townhouse units with public open space and walking trails. The Penhorn development is to be fully serviced with water, wastewater, and stormwater systems connected to existing local municipal systems. The sensitive nature of the natural environment surrounding the proposed development has been documented through previous watershed and water quality studies completed in the area. If not properly maintained, impacts to stormwater variations as a result of the proposed development will be directly transferred downstream to lakes which are already experiencing the effects of urbanization. Areas downstream of the proposed development include sensitive environmental habitats and public use areas, which are at risk of being impacted from both a stormwater quality (nutrient) and quantity (flooding) perspective.

Additionally, Penhorn Lake, a prominent water body adjacent to the proposed development lands, was identified as having significant water quality issues related to previous development and urbanization of the surrounding watershed. Special considerations will be discussed to ensure that further degradation will not occur as a result of the Penhorn residential development. It is anticipated that both temporary construction and permanent on-site stormwater management strategies will be implemented in order to maintain water balance and maintain or improve contaminant and nutrient levels for the benefit of the lake health.

The surface/subsurface conditions at test pit locations generally subsurface conditions generally consists of a 1.0-4.0m thick layer of silty-sand and gravel fill, overlying silty-clay till and frequent cobbles and boulders. The geology of the site is such that, if exposed, has to potential to be susceptible to erosion.

As part of each Penhorn development phase, a specific Erosion & Sediment Control Plan shall be developed to ensure that any sensitive areas are considered. Special efforts are anticipated to be required around Penhorn Lake to ensure that the currently stable sediment layers are maintained. A key focus shall be the minimization of point source discharges to sensitive areas coupled with an emphasis on not creating any turbidity within Penhorn Lake

2.0 GENERIC REQUIREMENTS

1. The controls included in this plan are anticipated to be the most effective approach during the execution of work on this project, based on background review of the site and measures completed for similar projects. Site conditions encountered during construction may require that controls be modified. It may be necessary for additional controls to be implemented.
2. All controls must be installed in compliance with specifications and manufacturer's instructions.
3. All work shall be in accordance with the latest revision of the Nova Scotia Environment's Erosion and Sedimentation Control Handbook for Construction Sites.
4. All temporary environmental controls must be maintained until the site has been stabilized.
5. The amount of exposed soil areas in this development must always remain at a minimum.

6. The release of sediment to watercourses, wetlands, and land adjacent to the development area must be prevented.
7. All necessary precautions shall be taken to prevent or minimize the spillage, misplacement or loss of fuels and other hazardous materials. All Acts and Regulations pertaining to controlled products shall be followed.
8. The delivery, storage, use, and disposal of hazardous materials shall only be undertaken by trained personnel in accordance with provincial and federal laws and regulations.
9. The Contractor shall always keep an emergency spill containment kit on site. Any spilled fuel or lubricants shall be promptly reported and cleaned up and disposed of in accordance with NSE regulations.
10. Fuelling, storage, and servicing of vehicles and construction equipment is not allowed within 30 m of a watercourse, wetland, drainage ditch, and areas with a high-water table or exposed or shallow bedrock.
11. All equipment used on the development site shall be mechanically sound with no oil or gas leaks. Frequent inspections shall be carried out on all equipment and repairs to leaks shall be immediately addressed.

3.0 BEST MANAGEMENT PRACTICES

For construction projects, there are generally three categories of erosion and sediment control measures: water controls, erosion controls, and sediment controls. Water controls limit or contain soil movement from the construction site, minimizing rainfall impact on the soil and reducing runoff volume and runoff velocities. Erosion controls are implemented to reduce or eliminate the detachment of soil particles by rainfall or to resist sheet or channel flow. Sediment controls work to capture detached sediment and prevent mitigation to the surrounding undisturbed areas. Details regarding specific controls which will be implemented is provided below.

3.1 Water Controls

3.1.1 Diversion Ditches

Temporary Diversion Ditches shall be used to intercept and direct any surface runoff away from the work site. Diversion ditches may be used in combination with Sandbag Berms and Check Dams if conditions warrant.

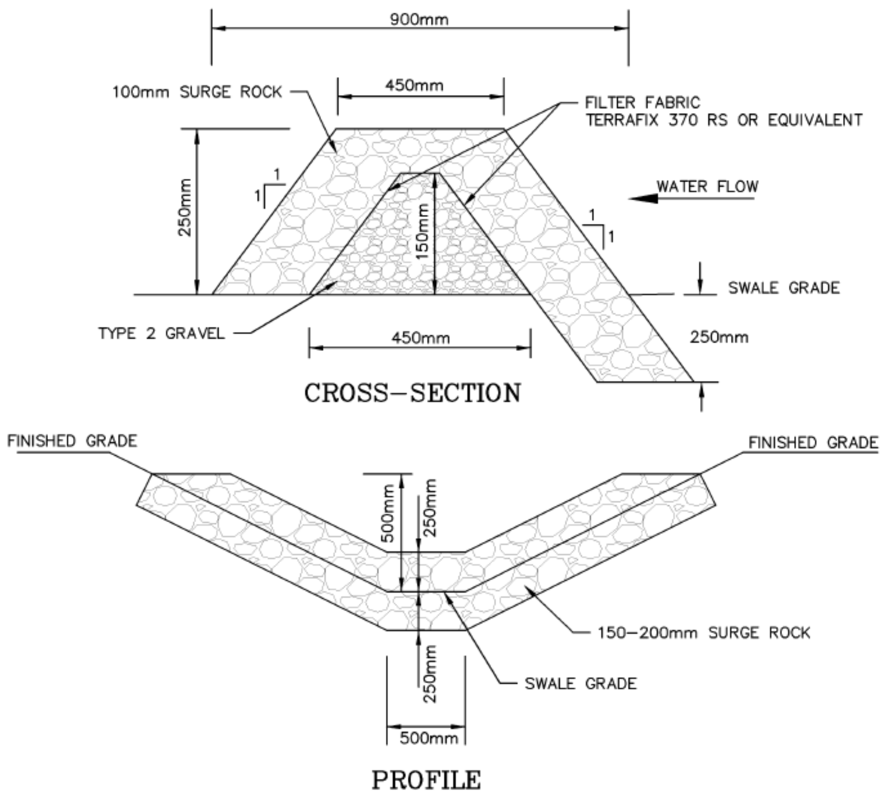
- Install upstream of work areas to prevent clean runoff from entering the work area.
- If the material in the diversion ditches is erodible then ditch shall be lined with Riprap or Clear Stone as specified by the Project Engineer.

3.1.2 Check Dams

Check Dams shall be installed in temporary or permanent ditches or stormwater conveyance features to reduce the velocity of surface runoff and promote the deposition of suspended sediment.

- Rock Flow checks shall be constructed with Clear Stone or Surge Rock in compliance with Division 3, Section 4 of NSTIR's Standard Specification or a directed by the Project Engineer.
- The Contractor shall maintain a quantity of Clear Stone and/or surge rock on site at all times.
- Rock check dams shall be installed at intervals such that the top of the next dam is less than 100 mm below the bottom of the previous dam.
- Refer to Figure 3.1 below for details on Rock Flow Check Dam construction

Figure 3.1: Check Dam Detail



3.1.3 Sandbag Dams and Barriers

Temporary Sandbag Dams shall be used to block or divert flow so that work within water features can be completed in dry conditions. Sandbag Berms shall be used to divert surface runoff to vegetated areas or be used as a barrier around salvaged and stockpiled material.

- Dams will be installed prior to any soil disturbance and will consist of sandbags of approximate dimensions 150 mm x 150 mm x 450 mm.
- Sandbags to be filled with sand or pea gravel, containing no silt or clay material.
- Sandbags to be installed in rows, tightly abutted against one another.
- The sandbags in each layer shall uniformly overlap the layer below.

- The sandbag dam shall be constructed of sufficient height and width to handle a 2-year rainfall event.

3.1.4 Dewatering

Dewatering during construction on the site will include pumping and discharging of sediment-laden water through the following options:

- Discharge to a Filter Bag placed on a 300 mm layer of Clear Stone. The dimensions of the filter bag shall be based on the size of the discharge pump. The Filter Bag shall be located more than 30 m from any watercourse, wetland, or drainage ditch and be in an area of dense vegetation.
- Discharge to constructed temporary settling ponds. Pond shall be maintained throughout the period of use (including drainage of 'clean water' and accumulated sediments: water outlets should be protected with 200 mm-250 mm stone or other protective cover). Take special care prior to storm events to avoid over-filling the pond (flocculants and pumping maybe required to direct to other storage areas or via tanker to an off-site location).
- Dewatering discharge points should be routinely monitored and maintained. Concentrated flow discharge should be avoided through the use of dispersion method approved by the Project Engineer.

3.2 Erosion Controls

3.2.1 Rip-rap Lining

Rip-rap protection shall be installed in locations where erosion may be caused by surface runoff or subsurface seepage. This may include steep slopes, stream, or ditch banks. Rip-rap lining shall also be used to dissipate concentrated flow and prevent downstream erosion in culvert outfalls/inlets and drainage channels.

- Rip-rap stone should be blocky, angular shape, and by sized of a mixed gradation so that smaller stones fill the voids between the larger ones.
- A layer of filter stone or fabric may be required depending on the nature of the underlying soil the size of protective riprap above.
- Riprap should be sized by the Project Engineer, to resist the erosive forces, based on the volume and velocity of anticipated flow.
- Riprap should be applied at a thickness of at least 1.5 times the maximum stone size and not less than 300 mm thick.
- Riprap should be placed as not to restrict the design width of the ditch or channel.
- The Contractor should maintain a quantity of riprap on site at all times as part of his Contingency Plan.

3.2.2 Vegetative Lining

Vegetative lining shall be installed, once grading operations have completed, to achieve natural, self-regenerating cover, for protection of exposed sediment from erosive action of runoff (overland flow and open channel flow). This can be achieved using suitable soil or imported topsoil with a combination of seed, sod, and/or other approved plantings.

- Imported topsoil shall be minimum 150 mm thick as directed and approved by the Design Engineer.
- Seed mixture to be approved by the Design Engineer and in accordance with Government of Canada "Seeds Act" and "Seeds Regulations".
- Sod to be approved by the Design Engineer and nursery grow and free of diseased plants, pest infestations and noxious or invasive species as listed in the Nova Scotia Weed Control Act.
- Fertilizers type and application in accordance with Canada "Fertilizers Act" and "Fertilizers Regulations" and approved by Design Engineer.
- Seeding shall be completed in conjunction with dry mulching for temporary stabilization if required.

3.2.3 Dry Mulching

Application of Dry Mulching will consist of the spreading of locally procured straw or hay mulch by hand or blower on areas of exposed soil or stockpiled material.

- Dry mulching shall be applied at a rate of 4,000 kg/ha ± 10% (20 kg/100 m2) as a temporary measure prior to a precipitation event or if permanent stabilization is delayed.
- The Contractor should maintain a quantity of straw/hay bales on site at all times as part of his Contingency Plan.

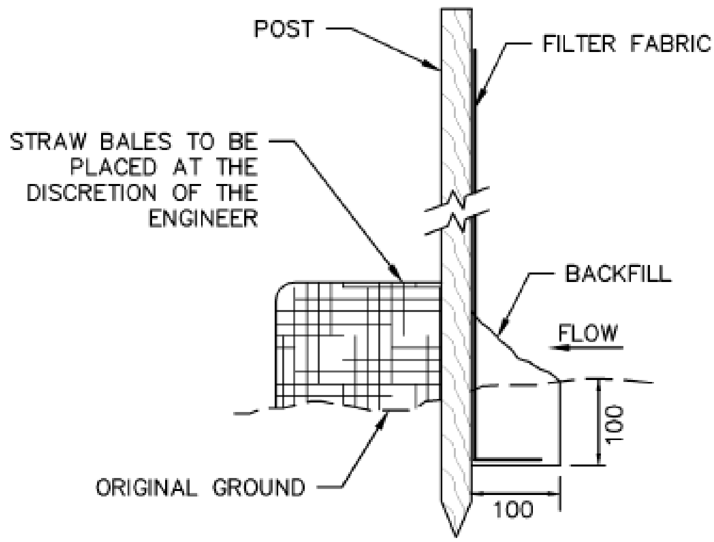
3.3 Sediment Controls

3.3.1 Silt Fence

Silt Fence shall be used as a perimeter control around selected excavated stockpiled material or toe of embankment to prevent the release of sediment from the work site. Silt fence must be erected prior to clearing and grubbing operations and remain in place until site stabilization is achieved.

- Silt fence shall be erected along the entire down-gradient perimeter of the work areas and of stockpiles.
- A backhoe working from the edge of the road may have to gently pull organic material back to displace a corridor so that the silt fence can be installed.
- Sandbags shall be used to toe in the bottom of the fence fabric.
- Refer to Figure 3.2 below for construction detail of the Silt Fence.

Figure 3.2: Silt Fence Detail



3.3.2 Construction Entrances, Access Roads, and Work Platforms

A stable, clean surface material shall be used applied and maintained in the work area to mitigate sedimentation of fine material throughout construction operations.

- Construction driveways and entrances to work areas are to be maintained with clean rock, applied periodically to cover muddied areas. Rip-rap or stone to be a minimum thickness of 150 mm. If necessary, filter fabric will be laid under the rock if fines are encountered. This surface will be maintained during construction.
- Cleaning of adjacent Public Streets is to be performed as needed in accordance with Streets By-Law S-300 Section 43, as directed by the Project Engineer and/or local authority.
- Rock Fill shall be used to construct access roads and work platforms for equipment working around watercourses and wetlands.
- Rock Fill shall be in compliance with Division 4, Section 9 of NSTIR's Standard Specification, or as specified by the Project Engineer.

3.3.3 Silt Sac and Filters

Silt bags shall be installed in all existing nearby catch basins before starting construction, as well as new catch basins as soon as possible.

- Silt bags to be maintained/cleaned as needed throughout construction.
- Fabric material shall be approved by Project Engineer.

4.0 SEQUENCING OF WORK

4.1 Clearing and Grubbing

Clearing and grubbing activities can cause the disturbance of soils and sediment within the work area which can cause the land to become susceptible to sedimentation and erosion. Additionally, clearing and grubbing activities near water features and wetlands can cause disturbance of the protective vegetative buffer or riparian zones and could lead to erosion of the bank slopes and sedimentation and obstruction of the water feature. The following Best Management Practice will be required to be implemented prior to the start of construction.

- Clearing limits, easements, setbacks, sensitive/critical areas and their buffers, trees and drainage courses will be delineated with flagging tape prior to any clearing or grubbing operations.
- No clearing or grubbing will occur within the protective green/belts/protected sensitive areas as identified on the development plans.
- Crop residues, plants, and rough soil surfaces shall be installed to help control velocity of runoff and promote sheet flow.
- Silt fencing shall be erected along the entire down-gradient perimeter of the work areas and around stockpiles as directed by the Project Engineer.
- Diversion berms and channels shall be installed on slopes to intercept sheet flow on exposed surfaces and to reroute clean flow into undisturbed areas. Locations shall be directed by the Project Engineer.
- Check dams shall be constructed in drainage ditches and swales to control the flow velocity.
- The work site will not be cleared or grubbed prior to commencement of construction and implementation of all required control features.
- Cleared and graded areas will be limited to minimize the area of exposed soil.
- Minimal amount of natural vegetation and topsoil will be removed at each construction site
- Mulches consisting of hay, wood chips or stone will be used to limit erosion on exposed areas.
- Non-mercantile timber may be chipped on site and used as temporary protective cover over exposed and disturbed areas.
- Grubbed material, will be properly managed and reused on site where possible. Disposal off-site will be limited and be in accordance with Nova Scotia Environment legislation and Halifax Regional Municipal Bylaws.
- The contractor and developer will maintain a stockpile of erosion control materials onsite.

4.2 Leveling and Grading

Grading and leveling requirements will be extensive in the development area to accommodate the construction of lots and roads. Grading and leveling will include the disturbance of soil and sediment, which must be managed and limited within the work area.

Site contouring and sloping will be completed, which can be particularly susceptible to erosion and sedimentation.
Soil loss from slopes may occur even with the implementation of erosion and runoff control measures. If this soil can enter a waterbody, mitigative measures will be required to intercept it. Methods used to trap sediment include installation of vegetated filter strips, silt fencing, filter berms, and sediment traps.

- Construction will be sequenced such that each stage of the development is to be completed and stabilized before proceeding to the next stage unless overlapping work is approved by the Project Engineer.
- Work along the public streets will not exceed 500 m. The contractor will work continuously until the streets are completed. If work is halted for 5 days, temporary stabilization structures and material will be installed.
- A clean rock construction entrance will be installed to prevent tracking of mud off-site and through the new and adjacent areas.
- Construction driveway entrances will be limited to a select number of locations, especially along Waverley Road, to prevent migration of sediment off-site.
- Lot grading will initially involve construction of the lot driveway with clear stone or gravel to a thickness of 75 mm to 150 mm. If necessary, filter fabric will be laid under the stone if fines are encountered. This surface will be maintained during construction.
- Vehicular travel to the lot will be restricted to the driveway. Access to each lot will be restricted to one driveway.
- Once the house pad is graded, the exposed pad, unless prepared from rock fill, will be graveled with clear stone. All exposed soil or unworked home sites will be stabilized no more than 5 days upon completion of the construction.
- No mud, debris, or other excavation material will be placed on the street. Fill material will not be stored next to the curb. Fill will be piled within the perimeter of the cleared lot (no more than 3 m around the house pad) until needed for cut lots or landscaping.
- Imported fill material will be assessed to ensure that material is not composed of high percentage of fines.
- All stockpiled fill material will be covered with tarps or other material, which are secure, to protect it from rainfall.
- Diversion features will be constructed at the top of each fill slope at the end of each workday, as needed. Diversions will be located at least 0.6 m uphill from the tope edge of each fill. The outlet of diversions, if free of sediment, will be located on undisturbed or stabilized areas when possible. Otherwise, sediment laden runoff must be diverted to a sediment retention structure.

4.3 Post Construction and Long-term Control Management

The final restoration phase is critical for minimizing the long-term impacts to water features and the surrounding area. The developer will incorporate all appropriate mitigative measures to ensure proper restoration of the development area. Implementation of permanent protection measures into a stormwater management plan will minimize the impact to the sensitive downstream area.

- The work site will be stabilized immediately to limit sustained erosion.
- Wood chips, vegetative growth, or rock facing (riprap) on steep slopes and exposed sediment will be installed.
- Establishment of vegetation will reduce the need for costly remedial measures caused by erosion damage to slopes.
- The targets to minimize and reduce contaminant input into the Penhorn Lake system will be achieved through implementation of BMP facilities. The strategy recommended for this site is to provide an integrated approach to stormwater management that is premised on controlling surface runoff and pollution at the source. An integrated series or treatment train, of stormwater management practices may include:
    - Source Controls: Rain barrels, green roofs, rain gardens, reduced travel ways, permeable pavers, grass alternatives, etc.
    - Conveyance Controls: Green ROW cross sections, permeable storm systems, vegetative swales, infiltration trenches, etc.
    - End-of-Pipe Controls: Flow dispersion outlets, vegetative filter strips, CDS units, selective native plantings, etc.

5.0 CONTROL MONITORING AND MAINTENANCE

Routine maintenance of all temporary and permanent erosion and sediment control measures will be enforced to ensure the integrity of surrounding area. Effective monitoring, including frequent inspections of environmental control measures, is critical to demonstrating due diligence and for managing the consequences of the project. All maintenance and monitoring is to be completed to the satisfaction of the Project Engineer, HRM, and Environmental Inspectors.

- The effectiveness of control measures will be inspected and monitored during rain events and maintained and upgraded as necessary or as directed by the Project Engineer or Environmental Inspectors.
- The Contractor and Project Engineer will incorporate a routine end-of-day check to ensure the integrity of the protection measures.
- Monitoring of meteorological conditions and forecasts will be conducted to minimize the potential for erosion. Weather forecasts should be consulted daily during site preparation. In the event of a forecasted precipitation event ≥ 25 mm, environmental controls should be inspected in the field and preventative maintenance carried out in advance of the storm.
- Control structures require maintenance (removal of sediment) when the deposition reaches a height of one-half of the effective height of the control or a depth of 300 mm immediately upstream of the control device.

- Environmental control measures will be reviewed during construction and any deficiencies will be corrected as soon as possible. If the environmental controls included in the ESCP must be replaced or adapted, the process should be recorded in a written addendum to the ESCP.

6.0 CONTINGENCY PLAN AND DOCUMENTATION

Extreme storm events can result in extensive erosion and sedimentation due to heavy rainfall impact and the associated stormwater runoff. Excessive runoff can be mitigated or controlled using additional diversion berms, straw-bale check dams, sediment fences, sediment traps, and/or sandbag barriers. The Contractor will ensure that equipment, personnel, and required materials will be available for application as required. A Contingency Plan will be required to be developed by the Contractor and should include the following information:

- Quantity and location of stored erosion and sediment control materials on site.
- Instructions on how construction equipment can be made available on short notice (including owner/operator details).
- Plan for preventing the offsite discharge of sediment-laden runoff from the site.
- A plan for emergency shutdown of the site, including the sequence of activities.

Following extreme storm events, Environmental Inspectors, will conduct environmental monitoring in those area deemed at risk. Recommendations regarding erosion control will be made by the Environmental Inspectors as required. To establish due diligence in the event of the release on sediment-laden runoff during extreme events, it is important to demonstrate that all reasonable actions have been undertaken to prevent such an occurrence. All ESCP activities will be recorded to demonstrate that a process was followed. Copies of these documents will be kept on site for reference by the Contractor. This documentation should include:

- The original ESCP;
- Any revisions to the ESCP;
- Regular inspection and maintenance reports;
- ESCP related incident reports; and
- ESCP decommissioning report.

7.0 DECOMMISSIONING

Temporary sediment controls are to be maintained throughout construction and only be removed when appropriate and with approval of the Project Engineer and HRM Site Supervisor. Controls will only be removed after site inspection has concluded that areas are sufficiently stabilized and that downstream controls are no longer required. This will be determined when:

- The disturbed area is sufficiently stabilized;
- No areas of active erosion are observed; and
- Control monitoring indicates stable conditions;

8.0 SUMMARY

This Erosion and Sedimentation Minimization Plan is based on the current assessment of the site and the anticipated requirements necessary to best minimize offsite impacts during construction activities on this site. This Plan does not serve to meet the requirements for a formal ESCP for any particular construction activity on the site. All development will be required to comply with applicable environmental laws, regulations, standards, and practices, permits, approvals, and requirements of federal, provincial, and municipal authorities.

APPENDIX E
LAWN CARE BEST MANAGEMENT PRACTICES – HOME OWNERS GUIDE

The Parks of West Bedford

Lawn Care Best Management Practices

Home Owners' Guide

THE PARKS
OF WEST BEDFORD
EMBRACING NATURE. ENJOYING LIFE

THE PARKS
OF WEST BEDFORD
EMBRACING NATURE. ENJOYING LIFE

West Bedford Holdings Limited – Our Commitment

West Bedford Holdings Limited is dedicated to developing residential communities that are sensitive to low impact and sustainable development. Our goal is to not only plan and design residential communities that are responsible, sustainable and functional, but to inspire our homeowners in the Community to learn from their decisions and to develop a greater appreciation for the environment and its resources. For this reason we challenge you the homeowner to better understand your environmental responsibility within the Papermill Lake watershed.

The following Homeowner's Best Management Guideline will serve as a critical educational tool that each family should review and understand in order to preserve and enhance our most precious natural resource....Water!

Stop Runoff

Use a Rain Barrel

Rain barrel usage can be important to the overall success of the stormwater management system. The benefits of using a rain barrel include:

- Stormwater that washes off rooftops and into downspouts is caught and retained.
- Homeowners use the water in the rain barrel as needed during the growing season.
- Water can be reused as needed in the garden or lawn landscape.
- Reduces stormwater runoff and pollution by providing treatment to the "first flush" of contaminants.
- Easy Installation – suitable for all property types.
- Reduces water bills by not using potable water for irrigation.
- Water generated is very soft (low in minerals), which is good for plant growth.

The proper design, siting and maintenance practices are necessary to ensure that the rain barrel is functioning appropriately and not becoming a nuisance or mosquito breeding ground in the development. The following guidance is intended to provide the proper siting, mosquito control and maintenance practices for your rain barrel.

Finding the best location for your rain barrel

To find the best location for your rain barrel, the following techniques are recommended:

- Place rain barrel on a hard, level, and pervious surface. Concrete blocks, bricks, decorative blocks, or flagstones work well as a base.
- Locate rain barrel at downspout nearest to the garden you want to irrigate.
- Rain barrels work using gravity to drain – The garden to be irrigated should be lower in elevation that the rain barrel.
- Ensure that the rain barrel overflow location directs water towards your yard and not your neighbors.

What about those pesky mosquitoes?

Many homeowners worry that rain barrels will create a breeding ground for mosquitoes. The following is a list of tried and trusted techniques that can be employed to control mosquitoes:

- Ensure that the mosquito proof screen on the rain barrel is installed and functioning correctly.
- Ensure that the base is pervious, so overflow does not collect and leave standing water for mosquito breeding.
- Inspect rain barrel weekly – ensure that the lid is securely closed and the water is free of organic material.
- Mosquito larvae require 6-9 days to hatch. Completely drain the barrel once per week and clean if necessary to prevent the formation of stagnant water.

When properly encased with a mosquito proof screen, rainbarrels will keep out any mosquitoes from breeding.

How do I take care of my rain barrel?

To properly care for your rain barrel, the following techniques are recommended:

- Keep spigot closed when not using water.
- Routinely inspect gutters, downspouts, rain barrel intake and mosquito screens for debris.
- Keep lid secured and screens clear of debris. Make sure the overflow tube and hose are functioning correctly.
- If odours develop, drain the rain barrel and spray with a hose until clean.
- Completely drain rain barrel before winter – leave spigot open during the cold months so water does not accumulate and freeze.
- Ensure that the overflow is draining properly and not causing erosion of the rain barrel base. An example overflow valve is shown in the above figure.
- Rain barrel water is not potable – *do not drink the water.*

Go-Toxic Free

Lawn Fertilizer

There are many natural ways to fertilize a lawn before reaching for a store-bought fertilizer. Compost and grass clippings are a cost-effective and environmentally friendly way to provide your lawn with nutrients. If you feel the need to purchase a fertilizer to care for your lawn, use organic fertilizers or slow release fertilizers.

- Clean Nova Scotia indicates that generally a 4:1:2 (the ratio of nitrogen to phosphorous to potassium) fertilizer applied at rate of 1 kilogram nitrogen per 100 square metres (2 pounds per 1000 square feet) provides the proper balance of nutrients.
- Combine the fertilizer with organic material (a mixture of good-quality soil, sand and a source of humus) and add this to your lawn's surface.
- Use a slow release or organic fertilizer before a rain (follow labels). If rain is not expected, water the lawn prior to fertilizing.
- Know your nutrient needs by understanding your soil and lawn conditions (most people apply too much fertilizer and this impacts water quality as well as lawn health).
- Go natural! Forget chemical fertilizers and replace your lawn with native plantings. There are over 1,500 to choose from for our region!

Organic fertilizers are often overlooked as an effective method for lawn care and maintenance.

Create Rain Gardens

A rain garden is a landscaping feature you can build to manage runoff. A rain garden will collect rain water and slowly filter water into the ground. They are usually a constructed depression (10-20 cm deep) that is designed to look like a natural area, but it will accept, infiltrate and clean stormwater. The rain garden will typically fill up with a few inches of water after a storm and within 1-2 days, the water will slowly filter into the ground. It is planted with wet and dry tolerant plants to absorb rain water. This technique encourages the recharge of the groundwater aquifer and uses the soil filters out any pollutants before the infiltrating water reaches the local groundwater table. When combined with a disconnected roof leader (downspout), the stormwater can be conveyed into the rain garden via a vegetated swale creating a high value natural landscape.

Rain gardens serve both a practical and aesthetic purpose; to clean and manage water run off, while creating a more beautiful landscape.

Keep it Green

Lawn Irrigation

One of the key ways you can help to keep lawn care more sustainable is by thinking about how you keep your lawn irrigated. Turf grasses and other plants in a native landscape need water for growth and development. By implementing proper irrigation practices, lawn quality and aesthetics will be improved, while at the same time, lowering water bills. By watering infrequently and deeply you can help improve the health of your lawn. The following techniques will put you on the path to proper lawn irrigation practices and prevent over watering:

- A typical turfgrass requires 2.5 cm of water per week (through rainfall or irrigation), which will soak the upper 10 cm of soil.
- Monitor your irrigation by placing a can in path of sprinkler flow and stop irrigation once 2.5 cm of water has accumulated in the can.
- Ideal irrigation times are when temperatures are cooler in the early morning or early evening and when wind speeds are low.
- Let lawn completely dry out between irrigation intervals. The soil should be difficult to penetrate before irrigation.
- Lawns require water when the grass turns light-green to brown in colour and the stalks remain bent over after being walked on.
- Stop irrigation when puddling or runoff occurs. Excessive moisture can potentially cause fungal disease in grasses and also prevents grasses from extending deep roots.
- Where possible, reuse collected stormwater from rain barrels for irrigation of gardens or smaller areas.
- Use sprinklers with uniform water application patterns. Do not aim sprinklers in a pattern that will water sidewalks, driveways, or the sides of homes.
- Without watering, most lawn grasses will go dormant over the hot summer months. This should not be a concern and the grasses will begin growing again during the cool season months.

Pet Clean-Up

Pet waste is a health hazard and a pollutant as it contains excess phosphorus and harmful bacteria which can harm lake water quality. The following guidelines will provide for the proper cleanup of pet waste and the elimination of any health concerns due to contact concerns:

- Clean up all animal waste whether on your lot or on trails or other places in the community.
- During walks, bring a bag and dispose of the waste in the toilet, garbage, or a designated pet compost area.
- In your yard, encourage pets to use one location. This will make clean-up easier and this area can be isolated from the rest of yard, which can prevent accidental contact with the pet waste.
- Do not feed Geese - It encourages them to frequent your yard and generate waste in your yard, driveway, or sidewalks.
- Pick up after pets before cleaning patios, sidewalks or driveways. Do not spray waste onto streets or into gutters.

Pesticide Use

Pesticides should be applied only as a last resort, or not at all. The major source of pesticides in urban streams is home applications to kill insects and weeds in the lawn and garden. If you need pesticides, certain pesticides may be permitted. Visit the HRM website, http://www.halifax.ca/pesticides/rules.html for more information.

Naturalize

Use Native Species

Many native species are suited to growing in a wide range of ecological conditions and they are usually best suited to the Nova Scotia climate. Because of this, once they are established they usually require less care and are a key element in creating a low maintenance and sustainable landscape. The species listed below are considered to be the types of species that would most usually found in the Parks of West Bedford area, however, use of other native species may also be appropriate. Final planting decisions should be made based on specific site conditions, species availability, and advice from landscape specialists.

Native Trees & shrubs best suited for certain site conditions:

- Dry/Poor Sites: Black Spruce, Balsam Fir, White Pine, Red Pine, White Birch, Grey Birch, Red Oak, Trembling Aspen, and Largetooth Aspen.
- Moist/Poor Sites: Black Spruce, Red Maple, Eastern Larch, and Balsam Fir.
- Average Sites: Red Spruce, White Spruce, Eastern Hemlock, White Pine, White Birch, Yellow Birch, Red Oak, Red Maple, and Sugar Maple.
- Moist/Rich Sites: Red Spruce, White Spruce, Eastern Hemlock, Yellow Birch, Red Maple, Sugar Maple, White Ash, and Ironwood.
- Native Shrubs: Wild Raisin, Serviceberry, False Holly, Canada Holly, Velvetleaf Blueberry, Lowbush Blueberry, Lambkill, Bush Honey Suckle, Huckleberry, Witch Hazel, Speckled Alder, Labrador Tea, Rhodora, Mountain Ash, Teaberry, Spirea, Striped Maple, Mountain Maple, and Beaked Hazelnut.

Lawn Mowing

The frequency, height, pattern and condition of a lawn mower can impact the quality and sustainability of a lawn landscape. The following items provide a recommendation for maintaining your lawn through proper lawn mowing practices:

- Always use a sharp blade – A dull blade will damage the remaining grass blades, potentially stunting future growth.
- Always mow when the grass is dry
- Mow at regular intervals (every 5-7 days).
- Cut grasses to a height of 6-8 cm. Higher cut grass will shade out weeds and encourages deep root growth.
- Never mow more than 1/3 of the grass blade – This puts additional stress on the grass, potentially stunting growth.
- Use a mulching lawn mower and leave grass clippings on yard. The cut grass will contribute nitrogen to the soil and reduce fertilizer use on the yard.
- Avoid mowing when turf is under heat and drought stress.
- Alter the pattern with each mowing event to reduce wear on the grass surface.
- Wear appropriate safety gear, which includes long pants and shirt and eye/ear protection.
- Use a low emission lawn mower. According to Canada's **Clean Air Foundation**, a standard gas mower will emit the same amount of air pollutants in one hour as driving a new car for over 550 kilometers.

Keep it Green

Dethatching

Thatch is a layer of living and dead organic material that lies on top of the soil that can be a home to insects and fungus spores as well as prevent water, fertilizer and air from reaching the soil. The information below provides information how to avoid thatch formation and the removal of thatch should it become a problem:

- Avoid over fertilization and excess pesticide application. Thatch buildup is typically due to excess nitrogen and pesticide in the growing zone.
- Mulching lawnmowers do not cause thatch buildup. If thatch buildup becomes a problem, maintenance will be required on a yearly basis. The following options are available for thatch removal/control:
  - Aeration - Mechanical aeration equipment will break up the thatch, allowing air to penetrate the soil and enhance thatch decomposition.
  - Heavy Raking- A manual removal method for thin thatch layers.

Regular ground aeration is vital for a long-lasting and healthy lawn.

Manage your downspouts

Roof leaders (downspouts) at the Parks of West Bedford where ever possible are directed to lawns and vegetated areas to recharge groundwater. The installation of a downspout diverter can help you to direct water to certain areas on your lot. Benefits of this technique include:

- Low cost alternative that directly reduces stormwater runoff.
- Allow management/use of stormwater on the property.
- Reduce water bills by using stormwater to irrigate lawns and gardens.
- Reduce the volume of stormwater runoff to end of pipe facilities.

Downspouts should drain the water away from any impervious areas, such as the foundation or driveway, and into vegetated zones.

Get with the Program

Get to know your site

Getting to know your site is critical in helping you to create a more sustainable landscape. Consider the following options in caring for your land:

- Be sure you are not removing desirable native plants that are already well adapted to your site.
- Consider how much sunlight your site gets over the course of a day.
- Know your soil type! Does your soil hold moisture? How quickly does it drain? This can help you in choosing the right species and stormwater management techniques.
- Plant a diverse mix of native species and understand how your chosen plants might 'creep' into adjacent areas.
- Over time, the cost of using native plants for landscaping is less than non-native plants. Think of our plants as long-term investments that can be phased in as your budget allows.
- Make sure plants are not dug from the wild. This depletes the resource and many species do not thrive after transplanting.
- Consider interseeding (no till) or plugging plants into existing vegetation in places such as thin lawns, or sparsely vegetated old fields. This can result in fewer new weeds.
- Consider using shade trees to screen your home from the sun. They help keep you comfortable, and save money on air conditioning.

Green Bin Composting

We are lucky in HRM to have an advanced recycling program than can help us in managing our waste. Significant accumulations of grass clippings, leaves, pruned branches, and other vegetative material are typically produced during the growing season. The following guidelines outline the proper handling of these materials to help sustain a low maintenance landscape:

- Use your green bin for leaves & brush, and house & garden plant waste.
- Excess leaf & yard material can be placed alongside the cart using orange or clear plastic bags or heavy paper bags - 20 bag limit, 25 kg (55 lb) maximum weight per bag.
- Branches should be tied in armload - sized bundles - maximum 5 bundles. Each bundle not exceeding 34 kg (75 lb) and no individual piece in the bundle more than 4 feet long (1.2 m) or larger than 8 inches (0.2m) in diameter.
- Create your own compost for your landscape needs. Learn more from HRM at http://www.halifax.ca/wrms/backyardcompost.html or the Resource Recovery Fund Board at www.putwasteinitsplace.ca
- Leave grass clippings on the grass. If possible, use a mulching mower, which will spread the grass clippings through the grass and put nutrients back into the soil.
- If a mulching mower is not available, dispose of grass clippings in your green bin or compost, or spread clippings in a vegetable or flower garden, as a mulch under bushes or add to the soil.
- Rake leaves, seeds, and grass clippings out of the street and gutter.
- Do not dispose of organic debris by dumping it in or near water bodies or sewers.

THE PARKS
OF WEST BEDFORD
EMBRACING NATURE ENJOYING LIFE

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