Porters Lake Watershed Servicing Study

Final Report

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ISO 9001
Registered Company

Prepared for:
HALIFAX
REGIONAL MUNICIPALITY

Prepared by:
CBCL LIMITED
Consulting Engineers

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List of Acronyms

BOD_5	Biochemical Oxygen Demand - 5 day
C.BOD	Carbonaceous Biological Oxygen Demand
CCME	Canadian Council of Ministers of the Environment
CDD	Comprehensive Development District
CDWQGs	Canadian Drinking Water Quality Guidelines
CSD	Conservation Sub-division Design
DAF	Dissolved Air Floatation
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
FC	Fecal coliform
F/M	Food to Micro-organism ratio
GIS	Geographical Information System
HAA	Haloacetic acid
HRM	Halifax Regional Municipality
HRT	Hydraulic Residence Time
MBR	Membrane Bioreactor
MLD	Million liters per day
MLSS	Mixed Liquor Suspended Solids
MPS	Municipal Planning Strategy
NOM	Non-organic Molecule
NSE	Nova Scotia Environment
NSTIR	Nova Scotia Transportation and Infrastructure Renewal
pH	Potency of Hydrogen Ion
ppt	Parts per Thousand
RCAP	Rapid Chemical Analysis Program
SBR	Sequencing Batch Reactor
SRT	Solids Residence Time
TDS	Total Dissolved Solids
THM	Trihalomethane(s)
TOC	Total Organic Carbon
TP	Total Phosphorus
TSS	Total Suspended Solids
TWL	Top Water Level
UV_{254}	Ultraviolet light – wavelength 254
WHPA	Well Head Protection Area

EXECUTIVE SUMMARY

Introduction

The community of Porters Lake is located in the Halifax Regional Municipality (HRM) east of Halifax as shown in Figure ES1.1. There is considerable residential development as well as commercial development occurring in the area. The existing community comprises:

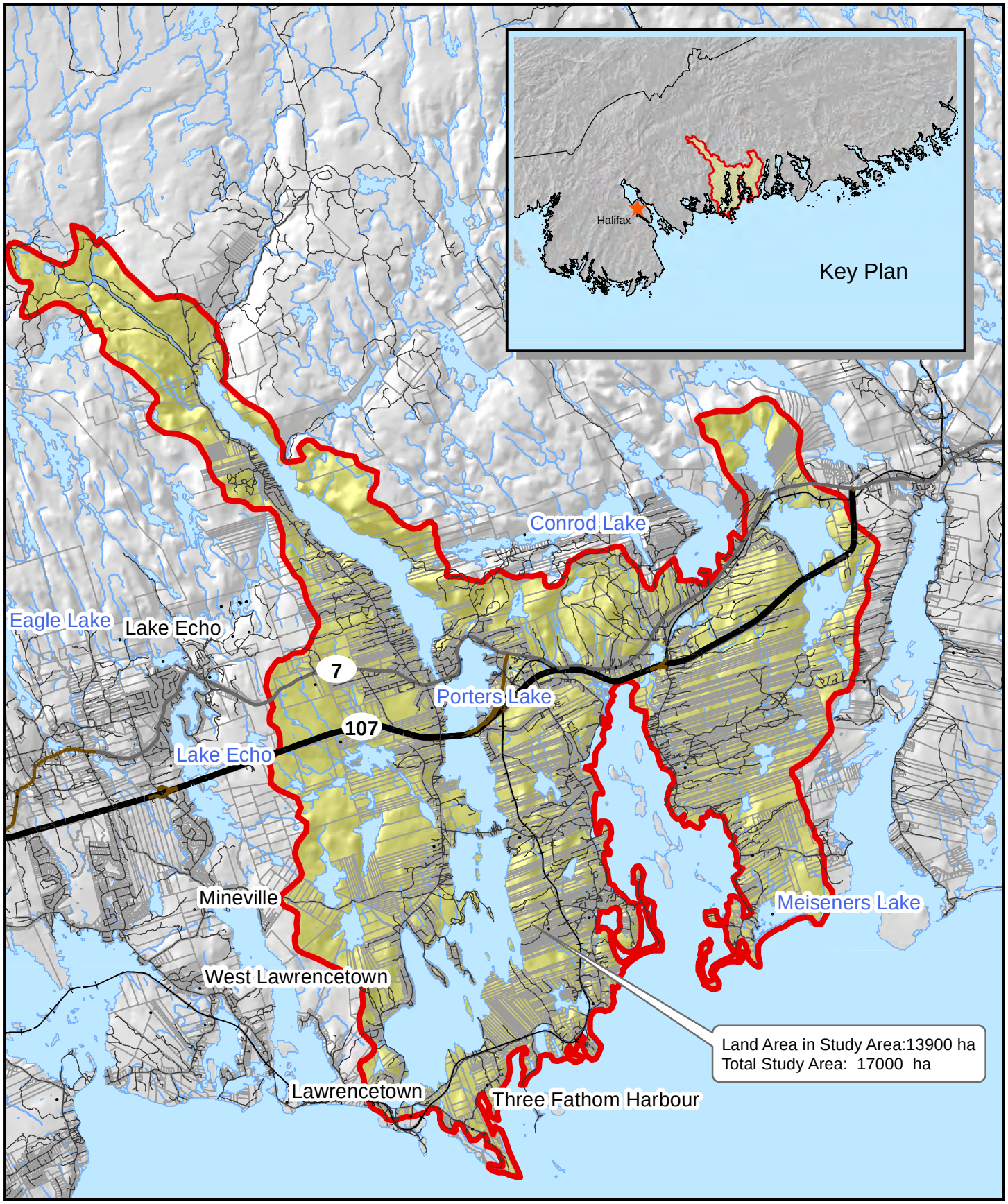
- 1,450 residences in several small communities and in strip developments along the main roads (typically older development) and in several subdivisions with large lots (newer development);
- Commercial development and small businesses centred along Highway 7;
- Three schools:
  - Porters Lake Elementary School- 40 Inspiration Drive;
  - The old Elementary School on Highway 7; and
  - Gaetz Brook Junior High School.

Existing development is serviced by onsite wastewater treatment systems, wells for water supply and roadside ditches for stormwater drainage. Receiving waters for storm runoff include streams and Porters Lake for development in the community of Porters Lake as well as streams and Chezzetcook Inlet for surrounding communities in the study area.

In the Halifax Regional Municipality's Regional Municipal Planning Strategy (HRM Regional MPS), Porters Lake is designated as a Rural Commuter Centre, which is defined as a low to medium density residential development with open space design subdivisions and a mix of convenience commercial, institutional and recreational uses. The HRM Regional MPS envisions the provision of express bus facilities connected to downtown Halifax and shared parking facilities for park and ride and commercial uses.

This study provides a means to evaluate opportunities for the provision of services required for planned development including, wastewater treatment and disposal, stormwater management and potable water while minimizing negative impacts on the natural environment. In order that HRM may promote and direct development that best suits requirements for developable land and minimizes negative impacts on the environment, the objectives of this study are to:

- Identify opportunities for development within the Porters Lake Study Area (identified in Figure ES1.1);
- Provide a range of servicing schemes for wastewater collection, treatment and disposal, stormwater management and water supply for those lands;



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Porters Lake Watershed/Servicing Study
Figure ES1.1 Study Area Location
May 2012

0 1,400 2,800 5,600 Meters

Study Area

CBCL Project # 101015
Data Sources: HRM, NSDNR
Coordinate System: NAD 1983 UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

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- Discuss the "level of development" various schemes will support and the impacts on the surrounding environment of various servicing schemes; and
- Develop a site specific plan showing all land suitable for development complete with potential development densities and the services required to allow these densities to be realized.

Objectives for this study are established by policy E-17 in the HRM Regional MPS.

Results of Component Studies

Several component studies were undertaken to address the study objectives, gather baseline information and understand site conditions and system requirements of each aspect of municipal servicing infrastructure and potential development patterns and densities. The results of these component studies are outlined below.

Wastewater Collection and Treatment

Existing wastewater collection and disposal systems in the Study Area are predominantly onsite wastewater systems comprised of:

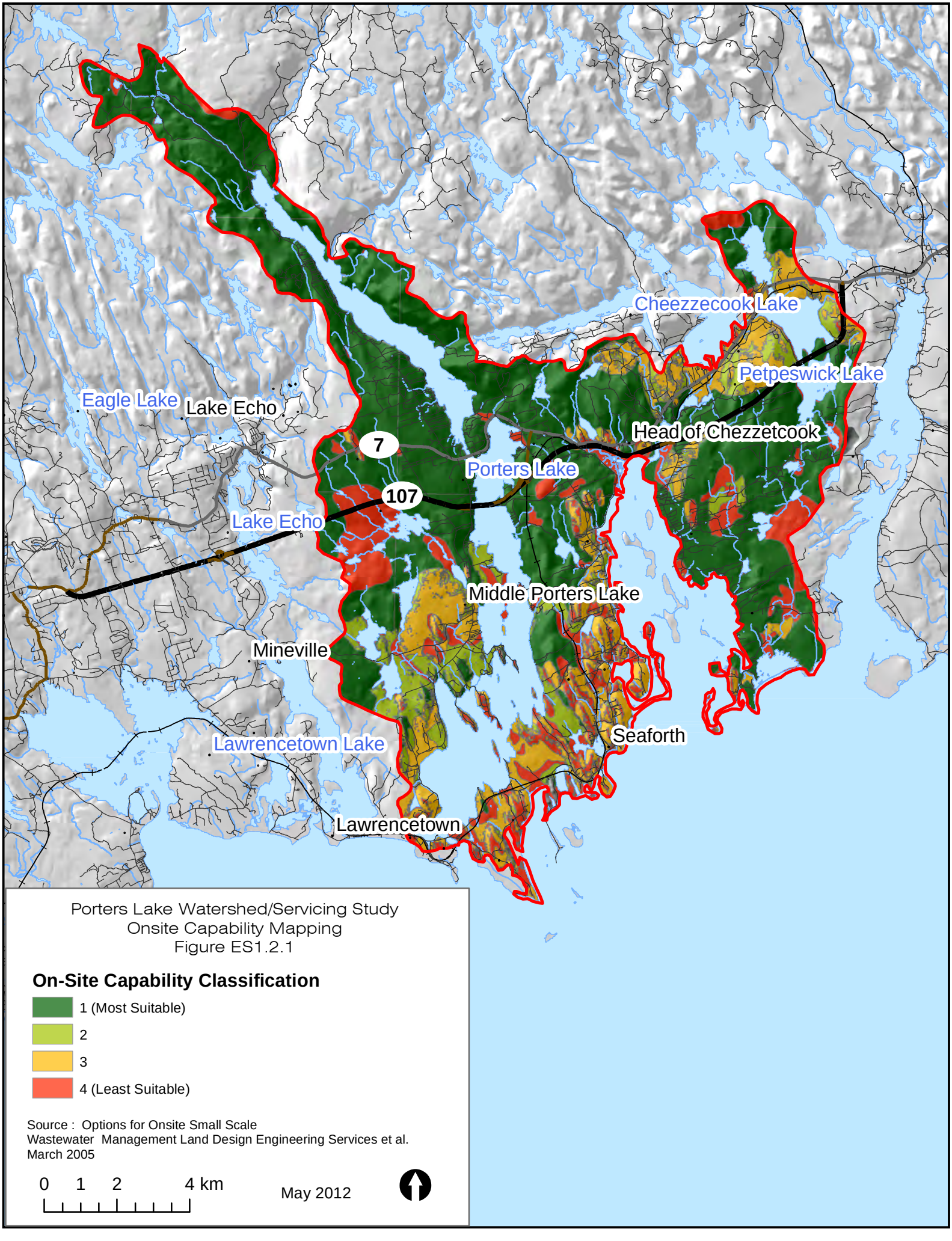
- A septic tank for solids removal; and
- An effluent dispersal system such as an area bed or contour system. Some original systems have failed and have been replaced with various alternatives including peat filters.

Figure ES 1.2.1, reproduced from the onsite study completed by Land Design Engineering in 2005[1], indicates that in general the soils in most of the Study Area are considered most suited for onsite wastewater treatment systems. The general exceptions are the lands between Chezzetcook Inlet and Porters Lake and between Porters Lake and Lawrencetown Lake. Discussions with local installers indicate that the failed systems have been in these areas and in pockets of unsuitable soils and on lots that do not meet current Nova Scotia Environment standards for the design of onsite wastewater treatment systems.

Water Supply, Treatment, and Distribution

Water is typically supplied to individual properties by onsite wells dug into locally recharged surficial aquifers and deeper wells that are drilled into the bedrock, supplied by regional aquifers. Water balance calculations were completed for the Study Area to determine, at a screening level, typical groundwater recharge rates in the community. Water demands for existing development were estimated based on typical average daily demands. These account for 7 percent of the overall recharge to local aquifers. It is estimated that the potential increase in demand generated by a high growth scenario in the community could account for up to 16 percent of the local area recharge which the aquifers are likely able to provide, this must be monitored as development proceeds.

[1] Land Design Engineering Services et al. March 2005. Options for Onsite & Small Scale Wastewater Management.



Porters Lake Watershed/Servicing Study
Onsite Capability Mapping
Figure ES1.2.1

On-Site Capability Classification

- 1 (Most Suitable)
- 2
- 3
- 4 (Least Suitable)

Source : Options for Onsite Small Scale Wastewater Management Land Design Engineering Services et al. March 2005

0 1 2 4 km

May 2012

Figure ES 1.2.2, reproduced from the onsite study completed by Land Design Engineering[2], indicates that in general the bedrock in the Study Area can supply well water of suitable quality. The general exception areas are similar to the areas considered less suitable for on-site wastewater treatment. In these areas treatment to remove common contaminants, such as iron, manganese and possibly arsenic is likely required. In practice, many residents do not treat their water to remove these contaminants and the water is considered unsuitable for drinking in these cases. Some residents use it anyway, others import drinking water.

The infiltration area required to supply groundwater to meet water demands for a single family from existing as well as potential future development is estimated to be 5,971 square metres, based on typical groundwater infiltration rates for the area and the assumptions that all permeable areas contribute equally to groundwater recharge throughout the Study Area.

The greatest risk to using groundwater from local surficial aquifers for potable water is the potential for groundwater contamination from local sources. The locations of potential sources of contamination were investigated and are documented in the main report and appendices.

Water Quality Objectives

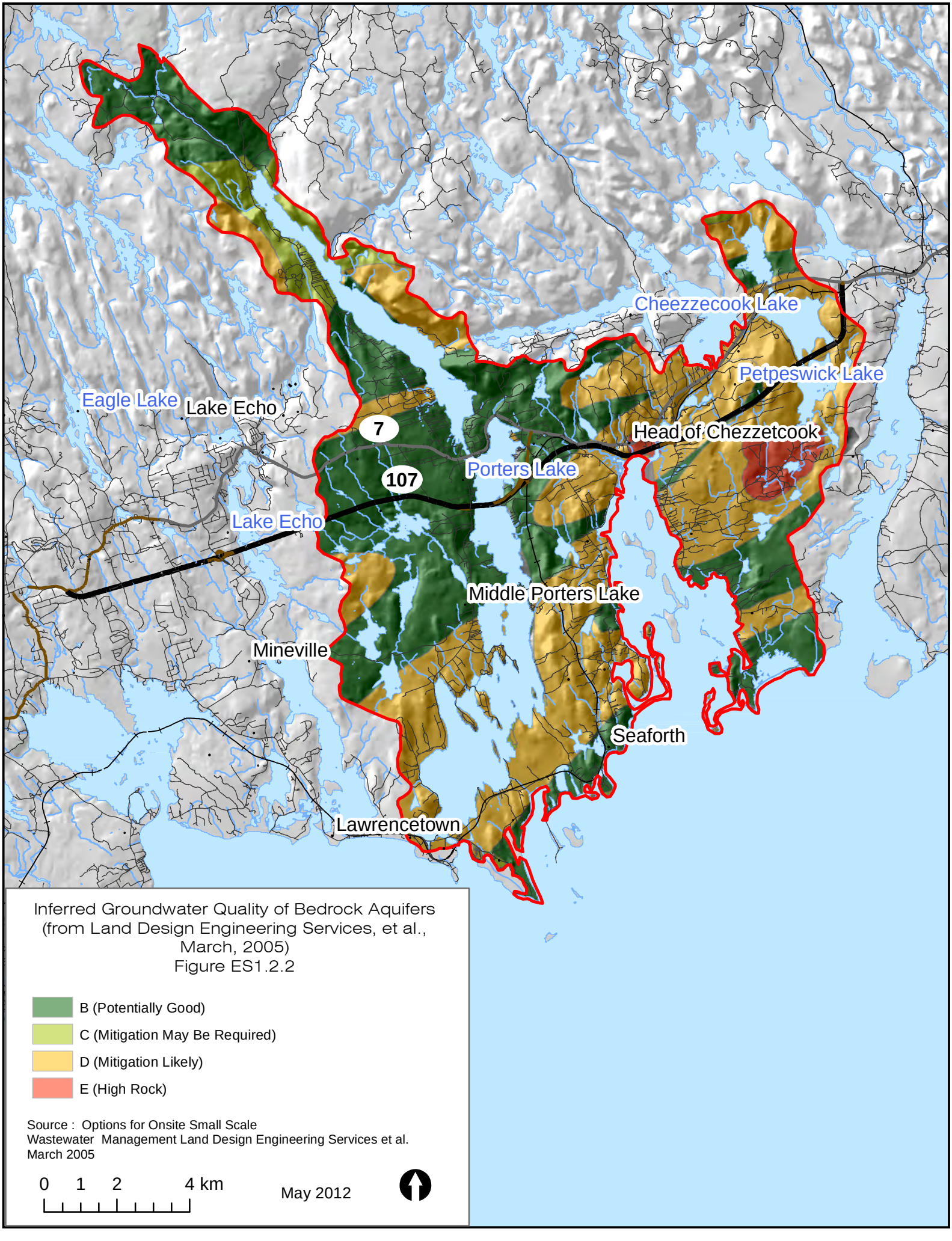
Minimum water use objectives for this study are based on the objectives described in the HRM Regional MPS indicating a desire to achieve public health standards for body contact recreation and to maintain the existing trophic status of our lakes and waterways to the extent possible.

An online survey of interested stakeholders was completed to assess the importance of water quality in local water bodies and to determine desired uses of them. A questionnaire was developed and made available online from August 5th to November 10th, 2010. There were 197 responses to the survey. In response to the question, **"Are you concerned about the water quality of the water bodies?"** more than 50 percent of the respondents were concerned with the water quality in the lakes in the watershed.

When asked: **"At what level would you be satisfied with future water quality?"** almost 90 percent of those responding indicated that the lakes should at least be suitable as fish and wildlife habitat and of those 20 to 25 percent indicated that the waters should be of the highest possible quality. More than 90 percent indicated similar desires for Chezzetcook Inlet and the ocean.

To meet HRM water use objectives E coli concentrations should be below 200 counts per 100 mL sample and have a trophic status of mesotrophic or better. To meet the water use objectives defined by the majority of respondents to the survey, water quality in the lakes should meet the CCME Guidelines for Protection of Aquatic Life (Freshwater), Chezzetcook Inlet and the ocean in the vicinity of the Study Area should meet the CCME Guidelines for Protection of Aquatic Life (Marine). In addition, to be suitable for human consumption of fish from these waters, it is recommended that mean E coli concentrations be below 14 counts.

[2] Ibid.



Inferred Groundwater Quality of Bedrock Aquifers
(from Land Design Engineering Services, et al., March, 2005)
Figure ES1.2.2

- B (Potentially Good)
- C (Mitigation May Be Required)
- D (Mitigation Likely)
- E (High Rock)

Source : Options for Onsite Small Scale Wastewater Management Land Design Engineering Services et al. March 2005

0 1 2 4 km

May 2012

When asked about willingness to pay more than the typical cost of onsite services for community based wastewater treatment systems to achieve the desired water quality in the area lakes and inlets, the answer was **"no"** for a majority (66.5 %) of respondents.

Receiving Water Quality

A receiving water sampling program was completed for this study based on the following parameters:

- Water samples were collected in spring, summer and fall of 2010, during dry conditions as well as following rain events at 5 sampling locations in Porter Lake;
- Samples were analysed for evidence of sewage (E-Coli and Fecal coliform, CBOD and Total Suspended Solids) and typical indicators of trophic status (nitrogen, phosphorus, Chlorophyll a and dissolved oxygen); and
- Additional samples were collected at the same 5 locations in the spring, summer and fall of 2012 and analysed for total phosphorus concentrations.

Results of sampling and modelling indicate:

- On the basis of data collected in the HRM 2006 to 2011 Sampling Program and data collected in 2012 by CBCL Limited, average total phosphorus concentrations at the upper end of Porters Lake are in the mesotrophic range for the 6 years of record, at the upper end of the mesotrophic range for 2010 to 2012 values and in the meso-eutrophic range for 2 of 3 samples taken in 2012. Chlorophyll a concentrations measured in the HRM program in the upper part of Porters Lake were all in the oligotrophic range;
- All of the total phosphorus samples taken at the 5 sample location in Porters Lake collected for this study in 2010 were below 0.02 mg/L, indicating oligotrophic to mesotrophic conditions with one exception, 0.03 mg/L was measured at site furthest downstream following a significant rainfall in late October, indicating meso-eutrophic conditions at that time. Chlorophyll a concentrations ranged from 0.82 to 1.37 micrograms/L in the oligotrophic range from spring to fall. In 2012 the average total phosphorus concentrations were all in the upper mesotrophic range or into the meso-eutrophic range. TP concentrations measured in the spring were all in the meso-eutrophic range, they were in the mesotrophic range at the lower end of the lake in the summer and in the oligotrophic range across the lake in the late fall;
- Porters Lake typically experienced E coli concentrations below 200 counts, making it suitable for swimming but there are incidents of E coli concentrations higher than 14 counts, typically during and following rainfall events. It is questionable whether it is suitable for consumption of fish. E coli and Fecal coliform concentrations are in excess of 14 counts according to Environment Canada; and
- Low oxygen concentrations were measured in a deep part of Porters Lake near the community of Porters Lake. The development of low oxygen concentration may be natural, but is also likely to be enhanced by the effects of human activities. The deepwater oxygen concentration should be monitored in the future, as growth of the affected area may affect the health of fish and invertebrates in Porters Lake.

These conditions can change with changes in climate and land use in the tributary areas.

Assimilative Capacity in Receiving Waters

Comparison of existing water quality to desired water uses indicates that:

- Measured E coli concentrations were below 200 counts but frequently above 14 counts, and concentrations of Chlorophyll a are typically in the oligotropic range. Therefore Porters Lake in general has assimilate capacity available to accept additional nutrient loads but no additional E coli loads; and
- Chezzetcook Inlet does not have capacity for additional E coli loads, based on the high E coli concentrations in the inlet. Fisheries and Oceans have closed the upper inlet and sheltered areas along the west coast of the inlet to shellfish harvesting for human consumption as a result.

Meetings with Focus Group of Community Representatives

Several Porters Lake community and business leaders as well as HRM Councillor David Hendsbee were contacted and asked to meet with the study team to discuss their vision for the community. The meeting took place at the community centre on January 31, 2011, 19 residents of Porters Lake attended. Population forecasts, existing water quality in receiving waters, water use objectives and associated water quality objectives from the survey were discussed as well as options for servicing future development in the community. The representatives listened to the presentations provided by the study team and were then asked to consider future development in the community and to answer two (2) questions based on their opinions of the information presented:

- What type of development should occur, low density development serviced by onsite systems as has generally occurred in the community or dense development serviced by central water, wastewater and stormwater systems?
- If there is dense development with central services, where should it be located? Participants were asked to draw the locations on the maps.

Responses from the three groups formed at the meeting were similar. Generally they agreed that:

- There should be a Core Area with denser development serviced by central systems located in the area around the existing commercial development on Highway 7 extending over to the undeveloped lands south of Highway 107 at Exit 20 and that additional expansion of the Core Area would be appropriate behind the Fire Hall. Figure ES1.2.6 shows the location and general extents of the Core Area as defined by the Focus Group at the meeting. Smaller lots and even small apartment building developments could be acceptable in appropriate locations within this area;
- The area around the O'Connell Drive School would also be appropriate for more dense smaller lot



Figure ES1.2.6 Location and General Extents of the Core Area

development suitable for young families and seniors that wish to live in Porters Lake but can't afford to purchase or do not wish to maintain large properties; and

- Large lots with on-site systems or cluster developments are suitable for the rest of the area beyond the Core.

Desirability for Residential Development

Figure ES1.2.7 shows the relative suitability and desirability of the land in the Study Area for residential development. Desirability does not imply it is technically feasible to develop the lands. Factors such as slopes could make building difficult. Factors used to determine suitability and desirability are explained in the main report.

Certain areas within the Study Area are considered unsuitable for development on the basis of their capability to support on-site water and wastewater systems, regulatory restrictions or their environmental sensitivity. All areas outside the "No Go" areas (shown in Figure ES1.2.7) are considered available for development.

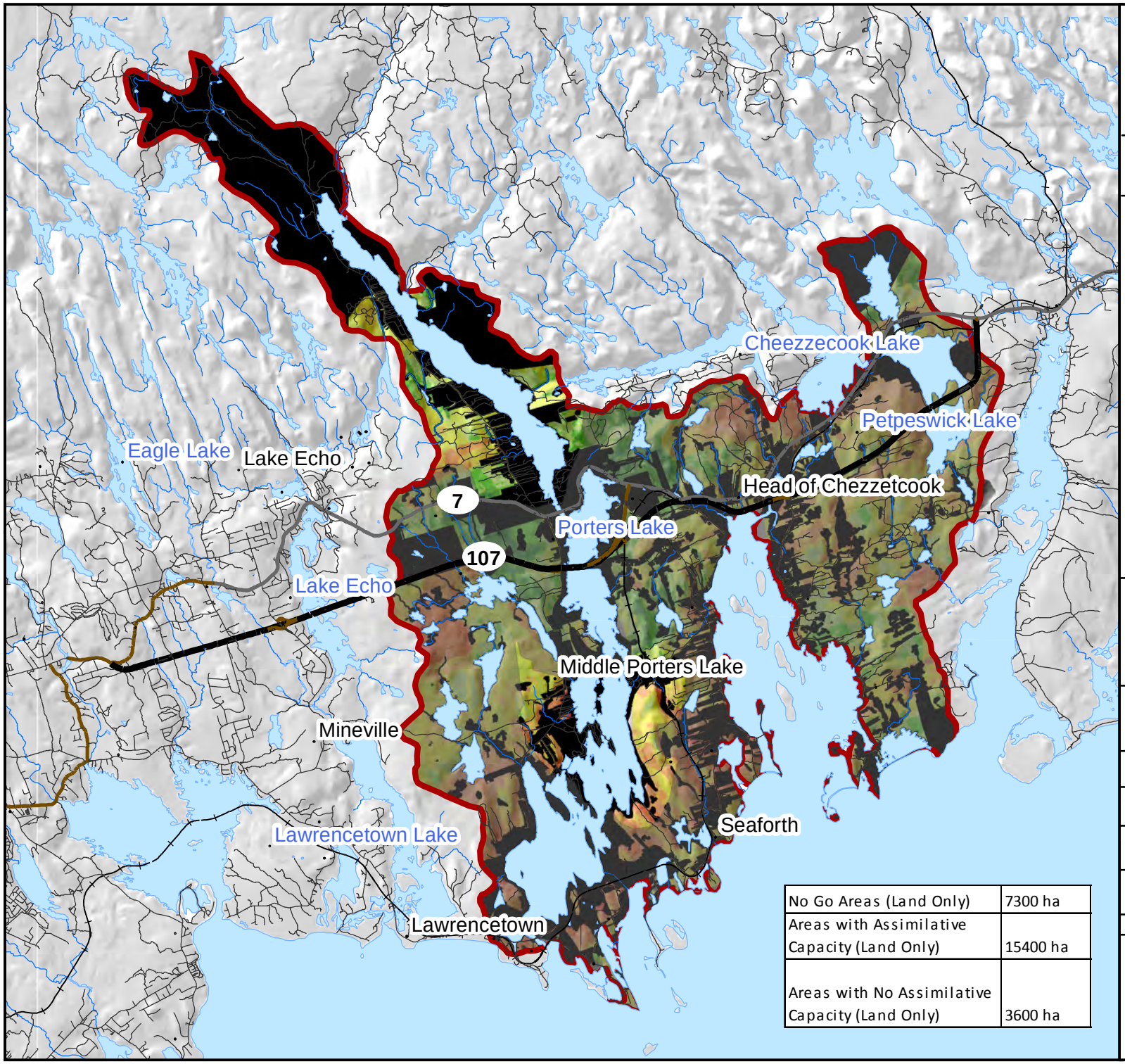
Demographics and Potential Development Densities

A low growth scenario for the Porters lake area was developed based on the provincial Community Counts data. A high-range growth scenario is based on the projection in the Transit Study. A mid-range growth scenario splitting the difference between the high and low projections was also established. Changes in population and housing units are summarized in Table ES1.2.8 (below).

Table ES1.2.8: Population Projections for Porters Lake Study Area

Year	Low (Community Counts)	High (Transit Plan)	Mid-Range (between Transit Plan and Community Counts)
2010 Population	3,200	6,100	
2010 Units	1,200	2,300	
2030 Population	5,100	11,300	8,200
2030 Units	2,200	4,900	3,600
Population Growth 2010-2030	1,900	5,200	3,200
Unit Growth 2010-2030	1,000	2,600	1,800

Note: 2010 population and number of units were different in the two studies referenced. This study takes this range into consideration in any assessments that utilize population and unit counts. Manual counts of existing units to be serviced in the Core Area were undertaken as part of the servicing assessment.



No Go Areas (Land Only)	7300 ha
Areas with Assimilative Capacity (Land Only)	15400 ha
Areas with No Assimilative Capacity (Land Only)	3600 ha

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Porters Lake Watershed/Servicing Study

- Streets
- Trunk Highway
- Divided Highway
- Arterial
- Collector
- Railroad
- Study Area Boundary
- No Go Areas

No Assimilative Capacity Available
- Best Suitability and Desirability
- Worst Suitability and Desirability

Assimilative Capacity Available
- Best Suitability and Desirability
- Worst Suitability and Desirability

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Land Available for Development with Existing Assimilative Capacity

Drawn: YO	Date: March 2012
Checked: GS	CBCL Project # 101015.00
Approved: MD	

Figure ES1.2.7

Notes:

Map Parameters

Projected Coordinate System: NAD_1983_UTM_Zone_20N
Projection: Transverse_Mercator
False Easting: 500000.00000000
False Northing: 0.00000000
Central Meridian: -63.00000000
Scale Factor: 0.99960000
Latitude Of Origin: 0.00000000
Linear Unit: Meter

N W E S

0 900 1,800 3,600 Meters

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For assessment purposes it was assumed that half of the population increases would be in the Core Area with a development density in the order of 40 persons per hectare to support central services. The remainder would be dispersed across the Study Area, with new development at an average density of 2.9 persons per hectare.

Conclusions and Recommendations

Conclusions about the state of existing development and its impacts on the environment as well as recommendations to improve existing conditions and to reduce the risks of additional negative impacts on the environment of potential future development are summarized as follows:

Water Quality

- Minimum water use objectives for the water bodies in the Study Area include:
  - All lakes should be mesotrophic or better and suitable as fish and wildlife habitat; and
  - Chezzetcook Inlet should be suitable for shellfish harvesting and human consumption.
- Existing water quality makes:
  - The lakes generally suitable for fish and wildlife habitat, sections of Porters Lake may not be suitable due to average E coli concentrations above 14 counts and total phosphorus concentrations in Mill Lake in the meso-eutrophic range; and
  - Chezzetcook Inlet unsuitable for shellfish harvesting for human consumption.

For the water bodies in the Study Area to be used as per the preferences indicated in the water quality survey, measures must be taken to improve existing water quality in Chezzetcook Inlet, portions of Porters Lake and Mill Lake. Attention should be paid to the trophic status of Porters Lake to ensure that it is oligotrophic and remains in this state. Future development in the Study Area should minimize the risk of generating additional sources of pollutants and improve existing water quality where feasible.

Recommended measures to reduce pollutant loads from existing development and minimize potential loads from future development to improve existing water quality in the Study Area include:

- Implement **public education programs** relating property owners' actions to water quality to reduce pollutant loads from individual properties;
- Encourage and assist with the development of **stewardship programs** for the lakes in the community as well as the adjacent shoreline;
- Identify **deficiencies** with existing wastewater and stormwater systems and design and construct retrofits to these systems;
- Design, construct, operate and maintain wastewater management and stormwater management systems to **minimize potential pollutant loads** released to the receiving environment by these systems; and
- **Continue monitoring water quality** in Porters Lake and additional lakes closest to proposed development on a quarterly basis to establish baseline conditions in the Study Area and to follow development progress and its impacts. Assessment of the ongoing data should be used to verify that the plan is achieving the desired reduction in pollutant loads and to modify development plans in response to unpredicted impacts. The monitoring program should **include vertical profiles of dissolved oxygen** at several locations in the lakes, particularly the deepest areas of Porters Lake.

Servicing

Recommended changes to traditional servicing to reduce potential pollutant loads to the water bodies in the Study Area include:

WASTEWATER COLLECTION, TREATMENT AND DISPERSAL

- Effluent discharge from any wastewater treatment plant should be carefully sited to avoid future environmental problems. Due to the bathymetry and hydrodynamics of Porters Lake, much of the lake is likely to be unsuitable to receive wastewater. The most southern section of Porters Lake has the greatest potential for dispersion and dilution of effluent, but is not close to centers of development. A wastewater treatment facility near the community of Porters Lake should not discharge into the deep cove adjacent to the community due to restricted flushing and stagnant deep water. Outfalls near the central axis of the lake south of the Highway 107 bridge may be considered if nutrient removal is included as part of the wastewater treatment;
- Ensure routine maintenance and monitoring of onsite wastewater treatment systems. This may be facilitated through formation of a wastewater management district with HRM as the party responsible for management of the district; and
- Routine maintenance and monitoring of cluster wastewater treatment systems. This is already required for each system under current provincial regulations but may be more efficiently provided by a wastewater management district.

STORMWATER COLLECTION, TREATMENT AND DISPERSAL

Objectives for Stormwater Management Plans to rectify existing water quality issues and limit the risks of creating new risks should include:

- Minimize changes in runoff at source, including each building site;
- Maintain peak runoff flows at or below existing flows from all areas;
- Promote infiltration of the cleanest runoff (from rooftops, etc.) for groundwater recharge; and
- Provide treatment of all other runoff and additional infiltration facilities before the excess enters the local natural drainage systems.

Low impact development should be considered for all new developments and modifications of existing development. In any servicing situation, to achieve stormwater water quality objectives, the following should be considered:

- Low impact site development, minimizing the affected footprint and providing measures to minimize the collection of stormwater. Where it is necessary to collect stormwater, decrease the efficiency of the collection systems, particularly on private properties;
- Decrease the efficiency of local collection systems using swales with flow limiting culverts between them to encourage detention and infiltration. Filling of ditches should not be allowed; and
- Treatment of remaining runoff in centralized wet ponds and constructed wetlands with built in infiltration and detention capacity. Co-use of detention with other public use lands such as parkland or recreation fields will lower the overall costs of this requirement as the costs of land can be significant.

WATER

- Groundwater supplies to service individual properties as well as clusters systems to service ten (10) properties are feasible. Wells in bedrock are the most suitable for this purpose to protect against surface contamination. Treatment of these supplies may be required for removal of naturally occurring iron, manganese and possibly arsenic;
- Groundwater supplies for central systems to service some portion of existing development plus future development may be achievable. Locating a well field with source water that requires minimal treatment should be investigated; and
- Potential surface water supplies investigated in the Study Area included the Porters Lake system. This should be further investigated if suitable wells cannot be developed.

GENERAL

- Monitoring of construction activities with particular attention paid to assuring that erosion prevention and sediment control plans are implemented and components are maintained during construction and properly retired at the end of construction activities;
- Condominium associations are required for ongoing responsibility of clustered water and wastewater services where these are considered; and
- To ensure proper operation and maintenance of all onsite wastewater systems, wastewater management district(s) are recommended. They will need to be formed as there are none currently in operation in the community and should manage onsite wastewater treatment systems in the Study Area most likely at risk of failure as a minimum, described in section 3.11. HRM is the likely manager of these systems.

Future Development

AREAS SUITABLE FOR DEVELOPMENT

Certain areas within the Study Area are considered unsuitable for development on the basis of their capability to sustain onsite systems, regulatory restrictions or their environmental sensitivity. Generally development should avoid the areas designated as “No Go” areas, including:

- Areas that are already developed;
- Water bodies, watercourses and designated wetlands;
- Watercourse, wetland and coastal buffers;
- Provincial parks, reserves, and provincial crown lands;
- Cemeteries;
- All lands below elevation 2.5m;
- Significant wildlife habitat and endangered species as per map 5 of the Regional Municipal Planning Strategy;
- Areas of elevated archaeological potential as per map 11 of the Regional Municipal Planning Strategy; and
- Lands of high cultural significance as per category 5 on map 10 in the Regional Municipal Planning Strategy.

All areas outside the “No Go” areas are considered available for development with the exception of the lands tributary to Mill Lake, Sections 2, 3 and 5 of Porters Lake and the upper end and west side of

Chezzetcook Inlet. Figure ES1.2.7 illustrates the relative suitability and desirability for residential development of areas within the Study Area outside of the "No Go" areas. The low growth scenario requires approximately 234 hectares to accommodate the projected new development outside of the Core Area, approximately 3.5% of the area available for development in the Study Area. The medium growth scenario requires approximately 394 hectares (5.8%) and the high growth requires approximately 640 hectares (9.4%).

Location of Development

The assumption that growth in the areas outside of the Core Area will be based on the use of cluster systems creates a large degree of flexibility in the location of future development. Unlike central systems that require a certain level of density to be concentrated in one area to make the systems cost effective, cluster systems can be cost-effectively developed separately in a variety of areas allowing developments throughout the Study Area to come on-line as desired.

If a Wastewater Management District is established to improve monitoring, maintenance and cost-effectiveness through sharing of resources, the use of cluster systems is easily scale-able. Since each subdivision/condominium corporation will build and own the infrastructure, the Wastewater Management District will only need to add additional staff and their supporting equipment for which it will be compensated by the additional condominium corporations. No large investments in infrastructure or new plants will be required.

Form of Development

Any additional development should ensure minimal degradation of stormwater or preferably, improved stormwater quality in an effort to improve receiving water quality. Improving the design and construction as well as maintenance and monitoring of onsite wastewater and stormwater systems will produce improvements in water quality. Additional improvements may be made by improving the process of locating and laying out development and selecting appropriate types of development.

In keeping with the proposal developed by area residents, a Core Area or community centre, serviced by central services, is envisioned with a center located near the intersection of the William Porter Connector and Highway 7.

Area residents envisioned the rest of the Study Area being developed as open space subdivisions. It is recommended that classic open space subdivision designs be used to keep a significant portion of the Study Area free of development. Based on the *Conservation Design (CSD) Workshop Discussion Paper* distributed at a session hosted by HRM on 5 November 2010, classic open space design allows an overall density of one lot per 0.4 hectares (one lot per acre) with the requirement that the landowner preserves culturally and environmentally significant lands by retaining at least 60% of the parcel as open space. Within an overall development parcel, development may occur in the areas outside the "No Go" areas defined above.

Within individual house lots, responsible site planning, design and construction should be encouraged to mitigate the creation of impermeable surfaces (such as paved driveways, rooftops) through a variety of approaches such as the provision of multiuse land areas for recharge. Lawn areas, for example, can be

designed to act as surface runoff detention areas, as well as aesthetic and recreational areas. Driveways can be designed to be more permeable through the use of unit pavers, and roof drains can be designed to discharge into soft landscaped areas or "rain gardens". In other cases, it may be more desirable to have impermeable surfaces directing runoff to recharge areas depending on the situation. The point is that in each case the question of stormwater runoff and recharge needs to be addressed at the community level as well as on each property in the community. Responsible design also incorporates the use of native landscape, topography and native vegetation into the site development. Rather than stripping a site bare and completely reforming the topography, buildings should be placed in the landscape and the areas disturbed for construction should be limited to the smallest reasonable footprint.

MINIMUM LOT SIZE

Based on the screening level assessment for water supply by wells, the minimum lot size for residential development should generally be based on a requirement for a minimum of 5,971 square metres of permeable area for each 1 cubic metre per day of demand, which is approximately equivalent to the demand for one dwelling unit. This should be added to the area taken by all impermeable surfaces on the property and the total compared to the minimum lot size required for the onsite wastewater treatment and dispersal system. The larger size should be used to establish a minimum property size on a site by site basis.

This minimum area of 5,971 square metres of permeable surface plus impermeable surfaces is for areas with a soil depth exceeding 300 mm. In locations with soil depths of 150 to 299 mm, the minimum lot size should be 6,800 square metres and in locations with soil depths less than 149mm, the minimum lot size should be 9,000 square metres to meet Nova Scotia Environment technical guidelines for onsite sewage disposal systems[3].

Costs of Services

Table ES1.4 provides a cost summary for provision of services in the Study Area, including the Core Area (the community centre as defined by the residents' Focus Group). In this table a range of costs is presented on-site services to represent a range of site and geologic conditions as well as alternative technologies (see Appendix F -Table 7.1 for details).

An increase in residential development density cannot be achieved in the Core Area without providing some form of central services. It is interesting to note that the cost per service of central services is lowest for the high growth scenarios but is still more than the costs of clustered services and the costs of onsite systems to service a single unit. In areas outside of the Core Area, clustered systems may allow some increase in population density to be achieved to minimize development footprints and costs of other municipal services.

[3] Nova Scotia Environment, April 2009. *On-Site Sewage Disposal Systems Technical Guideline: Minimum Lot Size requirements For Development Utilizing On-Site Sewage Disposal Systems.* Table 2.4.

Table ES1.4: Cost of Services

	Design Number of Units Serviced	Wastewater Services	Stormwater	Water Supply	Overall Servicing Capital Costs	Capital Cost ($/ Unit Serviced)	Life Cycle Costs of Core Area Servicing Plan	Life Cycle Cost ($/ Unit Serviced)
Central Services in Porters Lake Core Area								
High Growth	1,267	$ 18,260,968	$ 3,837,724	$ 15,059,035	$ 37,157,727	$ 33,204	$ 50,301,215	$ 39,689
Medium Growth	711	$ 16,895,458	$ 3,837,724	$ 7,810,136	$ 32,267,656	$ 55,698	$ 39,417,734	$ 55,465
Low Growth	592	$ 12,125,745	$ 2,451,998	$ 6,371,586	$ 23,660,998	$ 39,080	$ 34,937,593	$ 59,007
On-site Services - Outside of Core Area								
Individual Systems - assumes systems are constructed in suitable areas (see Figure 4.1)	1	$ 14,400	$ 2,500	$ 15,200	$ 32,100	$ 32,100	$ 64,158	$ 64,158
Cluster Systems - assumes systems are constructed in suitable areas (see Figure 4.2)	10	$ 186,400	$ 25,000	$ 129,000	$ 340,400	$ 34,040	$ 875,651	$ 87,565

CHAPTER 1 INTRODUCTION

1.1 Background

1.1.1 Porters Lake

The community of Porters Lake is located in the Halifax Regional Municipality (HRM) east of Halifax as shown in Figure 1.1. There is considerable residential development as well as commercial development occurring in the area. The existing community comprises:

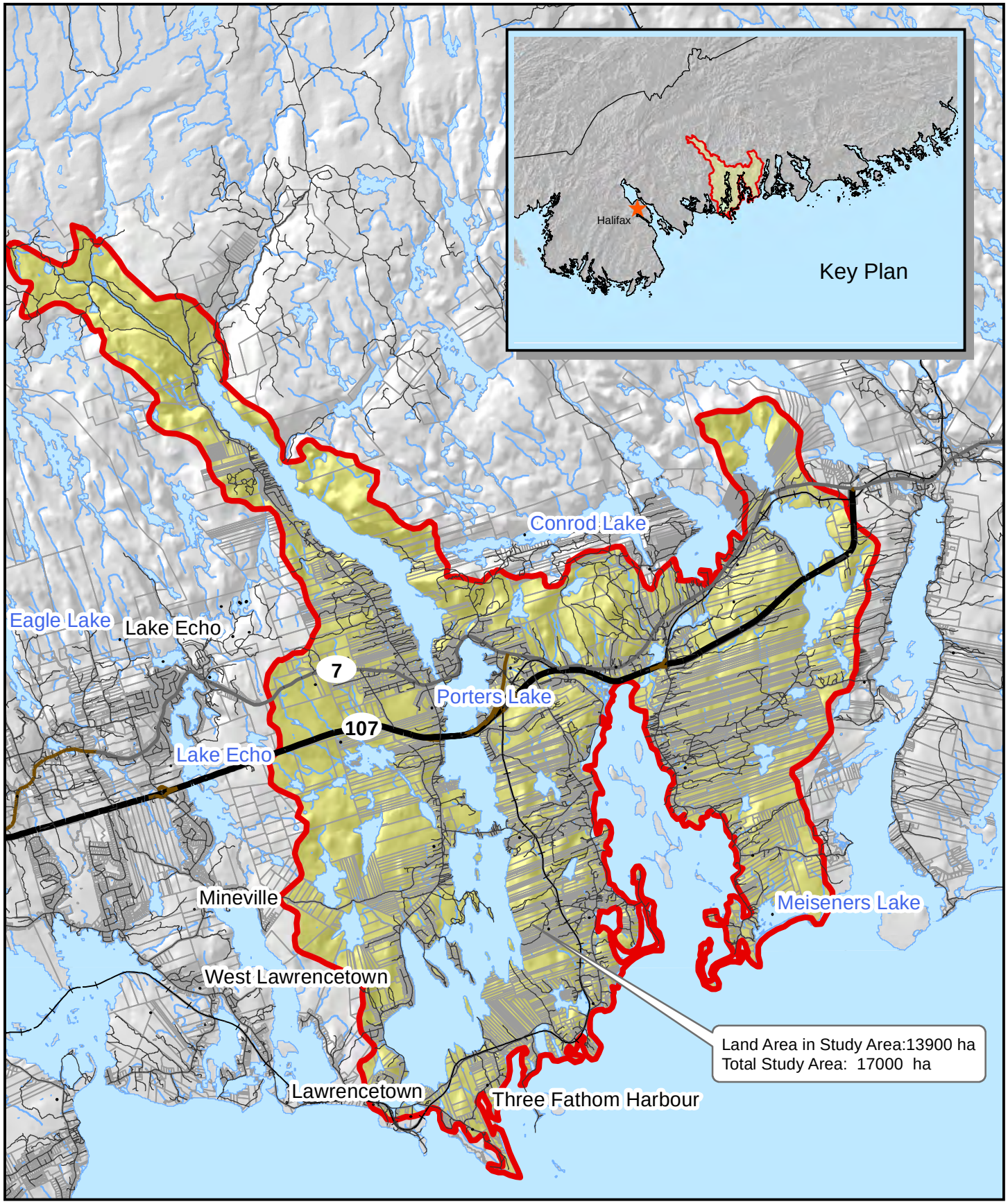
- 1,450 residences in several small communities and in strip developments along the main roads (typically older development) and in several subdivisions with large lots (newer development);
- Commercial development and small businesses centred along Highway 7;
- Three schools:
  - Porters Lake Elementary School- 40 Inspiration Drive;
  - The École des Beaux-Marais on Highway 7 now used by the French School Board; and
  - Gaetz Brook Junior High School.

Existing development is serviced by onsite wastewater treatment systems, wells for water supply and roadside ditches for stormwater drainage. Receiving waters for storm runoff include streams and lakes (Porters Lake receives most of the runoff, Little Lake, Chezzetcook Lake and Petpeswick Lake each receive runoff from a small amount of development) as well as Chezzetcook Inlet.

1.1.2 Context of the Study within the HRM Regional Plan

The Halifax Regional Municipality's Regional Municipal Planning Strategy (HRM Regional MPS) has been created to ensure that development within the Municipality proceeds in an effective and efficient manner. Watershed studies are part of comprehensive secondary planning processes and form the basis of community planning strategies. These studies shall determine the carrying capacity of the watersheds to meet the water quality objectives"[4] and are required before any other secondary planning processes are advanced.

[4] Halifax Regional Municipality. (2006 with amendments to 8 May 2010). Regional Municipal Planning Strategy. p. 31 of digital copy.



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Porters Lake Watershed/Servicing Study
Figure 1.1 Study Area Location
May 2012

0 1,400 2,800 5,600 Meters

Study Area

CBCL Project # 101015
Data Sources: HRM, NSDNR
Coordinate System: NAD 1983 UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

CBCL LIMITED

File Path: L:\101015 Lake Echo\101015_Layout\101015 - Porters Lake\101015 Porters Lake - Study Area.mxd

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1.1.3 Watershed Studies

This watershed study will determine the carrying capacity of the lands and water systems in the watershed areas tributary to Porters Lake and the west side of Chezzetcook Inlet with respect to suburban development. Its objective is to assess how currently undeveloped land in this community can be developed without negatively impacting water quality objectives for the inlet, lakes and watercourses in the watershed areas. Carrying capacity is determined by two factors in this case:

- Ability of the environment to ameliorate the effects of land development; and
- The form that the land development takes.

The ability of the environment to ameliorate the effects of land development is influenced by two factors:

1. The capacity of watercourses and lakes to accept pollutant loading without exceeding water quality objectives.
2. The location of development which influences the ability of the land to ameliorate pollutants before they reach the watercourses and lakes.

The form of development can influence the type and quantity of wastes that changes in land cover can produce. Careful consideration of the overall layout of development can preserve areas that:

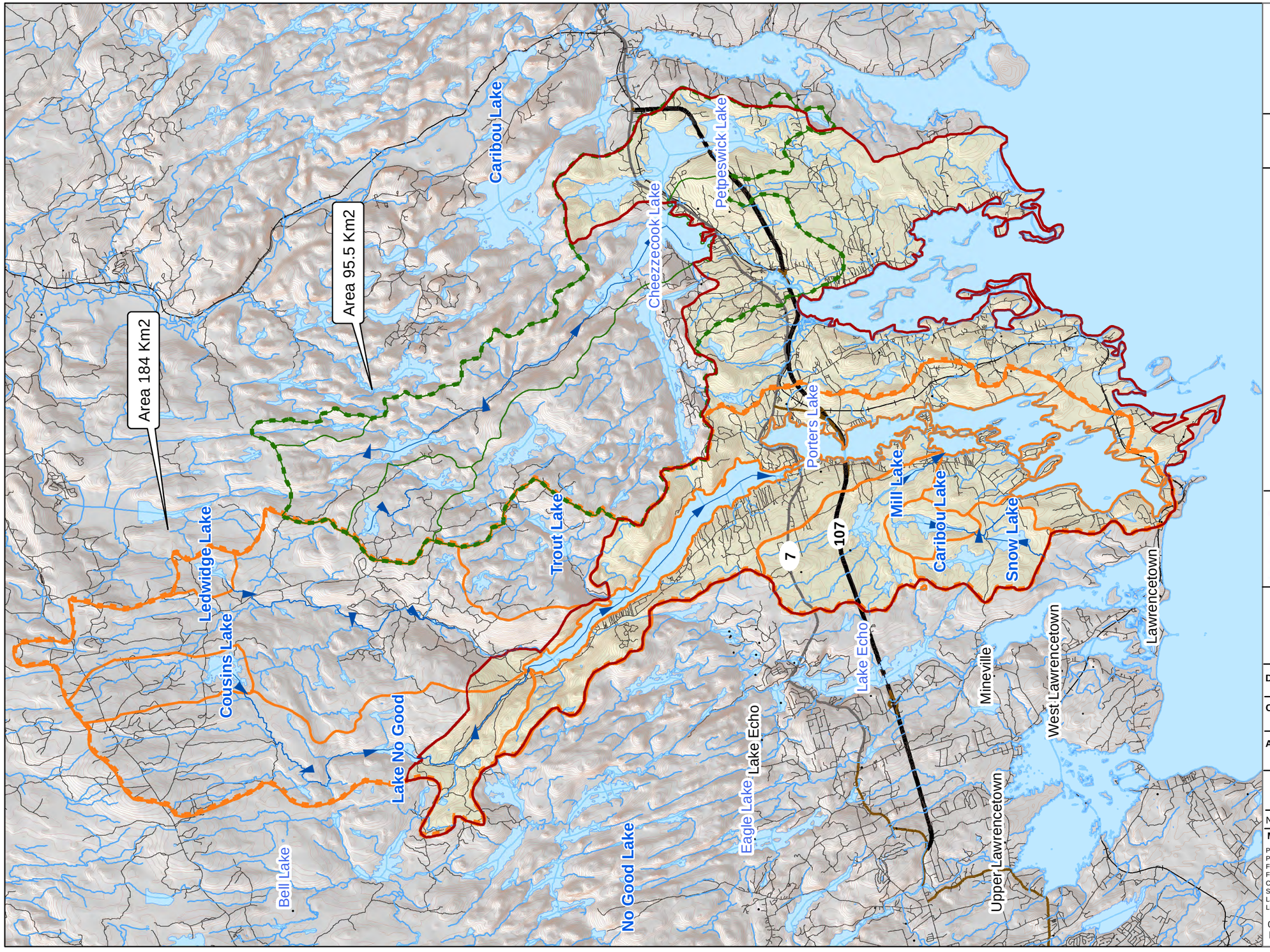
- Have the best ability to mitigate pollutants; or
- Can absorb surface water to recharge groundwater and reduce runoff; as well as
- Reduce erosion with existing vegetation on sloped areas.

Watershed plans should result in land development and provision of services for development with much less negative impact on the surrounding environment than have resulted from current development approaches. The overall process involves:

- Determining the existing condition of natural systems in the Study Area based on site specific scientific and engineering studies and careful analysis;
- Setting objectives for allowable impacts on these natural systems; and
- Defining appropriate development where locations, density and form of development are matched to the capability of the surroundings to accept the development.

However, the plan developed as part of this study affects development of only a part of the Porters Lake watershed, see Figure 1.1.3. Actions taken upstream in the watersheds that contribute flows through the community may impact the surface and ground water quality as it enters the Study Area. HRM is able to implement development policies that affect the area within its boundaries but does not have full control of water quality in the waters that enter or surround it. It must be realized in the planning process that these limitations exist and should be accounted for with appropriate contingency plans.

Terms of Reference for the study were received from HRM in January 2010, outlining a number of specific tasks to be completed as part of the overall evaluation of the development potential for this Study Area. The study was awarded to CBCL Limited in April 2010 and field work was completed from April until October 2010 and again from April until November 2012.



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Porters Lake Watershed/Servicing Study

- STudy Area
- Cheezzetcook Lake Subwatersheds
- Cheezzetcook Lake Watershed
- Porters Lake Subwatersheds
- Porters Lake Watershed
- Flow Direction
- Contour Lines
- Streets
- Trunk Highway
- Divided Highway
- Arterial
- Collector
- Railroad

CBCL LIMITED
Consulting Engineers

Watersheds Tributary to the Porters Lake Study Area

Drawn: YO	Date: May 2012
Checked: GS	CBCL Project # 101015.00
Approved: MD	

Figure 1.1.3

Notes:

Map Parameters

Projected Coordinate System: NAD_1983_UTM_Zone_20N
Projection: Transverse_Mercator
False Easting: 500000.00000000
False Northing: 0.00000000
Central Meridian: -63.00000000
Scale Factor: 0.99960000
Latitude Of Origin: 0.00000000
Linear Unit: Meter

0 750 1,500 3,000 Meters

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1.2 Study Scope and Objectives

The general objectives of this study included:

- Identify opportunities for development within the Study Area defined around the existing community of Porters Lake; and
- Develop a site specific plan showing all land suitable for development complete with potential development densities and the services required to allow these densities to be realized.

Specific objectives for this study as set out under Policy E-17 of the HRM Regional MPS and the Request for Proposals were:

- Assess quantity and quality of groundwater resources;
- Determine receiving water quality;
- Estimate the quantity and quality of surface water (freshwater and marine), including limiting the potential of eutrophication of potential receiving waters from stormwater and sewage treatment plant effluent;
- Identify strategies for minimizing the loss of existing watershed features and attributes;
- Compile an inventory of sources of contamination;
- Recommend strategies to specifically adapt HRM's Stormwater Guidelines to meet the water quantity and quality objectives for this watershed;
- Identify natural corridors and critical habitats for terrestrial and aquatic species and recommended measures to protect them;
- Identify appropriate riparian buffers based on watershed specific sites, issues and parameters; and
- Evaluate development potential in the Study Area based on these assessments.

In addition, the Terms of Reference for this study included a sanitary survey of the most densely developed areas within the existing community to assess well water quality and performance of existing on-site wastewater systems. This information will contribute to an assessment of the most suitable servicing schemes for the community.

1.3 Organization of the Report

The report is organized as follows:

- Chapter 2 described the methodology followed in the study;
- Chapter 3 provides a brief description, including relevant findings and recommendations, for the studies completed to address the specific objectives listed in Section 1.2 that required significant investigations;
- Chapter 4 outlines alternatives for servicing potential development; and
- Chapter 5 describes a preferred development plan for this Study Area.

CHAPTER 2 PROJECT METHODOLOGY

2.1 Methodology

Generally, the study methodology was as follows:

- Mapping and other relevant data were collected and assembled in a GIS map and database of the Study Area;
- Several sub-studies necessary to address each objective listed in Section 1.2 were completed. These studies were used to define:
  - A range in potential future development (the number of additional people and the number of additional buildings) expected in the Study Area;
  - Limitations and constraints on development within the Study Area; and
  - Best methods for development with limited impacts on the surrounding environment.
- Study findings were compiled on the mapping and identified areas suitable for future development in the Porters Lake Study Areas;
- Various development density scenarios were evaluated, required densities in the Core Area where some development will tend to be concentrated as well as reasonable development densities for areas outside of the Core, areas where the remaining expected development will occur;
- Facilities needed to provide wastewater, stormwater and water services consistent with current design guidelines were identified; and
- Findings and recommendations developed to address environmental issues resulting from existing development as well as to guide future development of the Study Area were reported in a Draft report and this Final report as well as through presentations to a focus group and then the community.

Details of the individual tasks completed for the study are described in a set of component study reports in the appendices, summaries of the work are presented in the next chapter.

2.2 Background Information Particular to Porters Lake

In order to develop a clear understanding of local conditions and to establish watershed specific targets for development, information from available sources was gathered and collated. Sources included the following:

- HRM GIS;
- Personal communication with the steering committee;

- Formation of a Focus Group of community representatives that met to explore their vision of the Community of Porters Lake and their thoughts on future development in the community;
- Previous reports completed for HRM including:
  - HRM -*Options for Onsite & Small Scale Wastewater Management Study*, Land Design, March 2005 – including copies of suitability mapping; and
  - Halifax Regional Development Agency - *Chezzetcook Harbour Pollution Control Study* - ABL ENVIRONMENTAL CONSULTANTS LTD., January, 1998.
- Provincial and Federal agencies.

Data gathered from these sources included:

- Federal and provincial regulations regarding discharges to surface waters, and water withdrawal as well as CCME water quality guidelines necessary to sustain various uses;
- Topographic mapping complete with delineated watershed boundaries;
- Watercourse and wetland locations and types;
- Soil types and areas;
- Native and non-native vegetation;
- Environmentally sensitive areas;
- Available information on levels of site contamination and any dangerous/hazardous materials;
- Existing servicing systems and utilities;
- Existing developed areas and general conditions;
- Property boundaries and ownership;
- Environment Canada - Shellfish Closure Areas for Chezzetcook Inlet;
- Watershed boundaries on the larger scale from NSEL Watershed Mapping for the Porters Lake watershed as well as a portion of the watershed tributary to Chezzetcook Inlet; and
- Assessment of areas most suitable (as well as those areas less suitable) for onsite wastewater services as well as the groundwater potential in the study area. This information was derived from the 2005 study of Options for onsite and small scale wastewater management done for HRM as well as knowledge of local conditions based on previous investigations by the study team in the area.

2.3 Visions of Future Development

Potential future development within the Study Area was investigated by:

- Reviewing the HRM Regional Municipal Planning Strategy;
- Meeting with community representatives;
- Reviewing estimates of future population developed in recent studies in the area; and
- Assessing the desirability and suitability for development of various sections of the Study Area.

2.3.1 HRM Regional Municipal Planning Strategy

The HRM Regional MPS states that "Establishing new municipal wastewater systems may be an option in areas not located adjacent to an existing Urban Service Area. Consideration of such new systems should be given to those centres situated along the coast which have the potential to discharge into a marine environment. In cases where a wastewater system is provided, a water distribution system should also

be provided. Further study of these centres is required to determine the potential of wastewater and water systems and the associated costs to HRM and affected residents if provided."[5]

In the MPS, HRM has established Porters Lake as a Rural Commuter Centre. The Municipality's has established Comprehensive Development District (CDD) zoning in an area near the intersection of Highway 7 and the William porter Connector. The CDD zoning will protect the area as a focal point for transit-oriented design development by requiring new development to proceed by development agreement, except for the continuation and expansion of existing uses. The parameters of the development agreement are quite broad, allowing for mixed use and development controls related to buildings heights, signage, building massing, architectural design, parking facilities, etc.

The HRM Regional MPS proposes future land use in these areas as low to medium density residential with a mix of commercial, institutional and recreational uses. It also states that central wastewater collection and treatment as well as water may be considered in Porters Lake. Large scale as-of-right residential development is discouraged in these areas. Provisions allow small scale infill development on existing roads that were under consideration at the time of implementation of the plan. Provisions also allow limited development on new roads. Large-scale residential development may be considered through a development agreement if it is in some form of Open Space Design that protects important conservation areas. The Regional MPS outlines the issues that HRM shall consider in approving Open Space Design developments.

2.3.2 Meeting with Focus Group

Several local community and business leaders were identified to the study team by HRM and other members of the community. A meeting was held with several representatives on the evening of January 31st 2011. Population forecasts, existing water quality in receiving waters, water use objectives and associated water quality objectives from the water quality survey were discussed as well as options for servicing future development in the community. The presentation included a discussion of the costs of servicing and indicated that in other studies it was determined that a development density of forty (40) persons per hectare or more was required for the unit cost of central services to be in the same order as the unit costs with onsite water and wastewater services.

Following the presentation and discussions that arose on various points during the presentation, the attendees were asked to gather in groups and to consider future development in the community. Each group was to answer two (2) questions based on their options of the information presented:

- What type of development should occur, low density development serviced by onsite systems as has generally occurred in the community or dense development serviced by central water, wastewater and stormwater systems?
- If there is dense development with central services, where should it be located?

[5] HRM Regional Plan with amendments to 08 May 2010.

Following the meetings of the individual groups, all attendees gathered to discuss the outcomes. Generally, the attendees agreed that:

- There should be a Core Area with denser development serviced by central services. The Core Area should be located in the commercial area on Highway 7 extending over to the lands south of Highway 107 and Exit 20 and that additional expansion of the Core Area would be appropriate behind the Fire Hall. Figure 2.3.2 shows the location and general extents of the Core Area as defined by the Focus Group at the meeting. Smaller lot and even small apartment building developments could be acceptable in appropriate locations within this area;
- The area around the O'Connell Drive School would also be appropriate for more dense smaller lot development suitable for young families and seniors that wish to live in Porters Lake but can't afford to purchase or do not wish to maintain large properties; and
- Large lots with on-site systems or cluster developments are suitable for the rest of the area beyond the Core Area.

A summary of discussions was prepared following the meeting with the Focus Group and is included in Appendix A.

2.3.3 Demographics and Potential Development Densities

Population allocations prepared for the HRM Regional Plan for the period of 2006 to 2026 allow for a population increase of 3,800 people within the community of Porters Lake[6]. However, because of downward trends in household size from 2.87 people per unit in 2001 to 2.37 people per unit in 2026 (generalized across HRM's rural commuter-shed), it is expected that there would be at least 1,800 new housing units created in the community.

To determine a range of possible future development scenarios, growth projections related to the Transit Plan[7] were reviewed and alternate projections related to "straight-line" extrapolations from the Nova Scotia Community Counts web site[8] and Statistics Canada[9] were developed. Based on this range of possible growth scenarios, the projections from the Transit Plan are selected as the high growth scenario. Projections based on calculations using data obtained from the Nova Scotia Community Counts website are used to create the low growth scenario. A medium growth scenario mid-way between the high and low growth scenarios is also provided. Potential changes in population and housing units are summarized in the following table.

[6] Marcus Garnett, Planner, HRM, personal communication 12 July 2010.
[7] Entra Consultants. 2007. Halifax Regional Municipality Regional Transit Plan – Park and Ride Express and Rural Transportation Services.
[8] Nova Scotia Community Counts, http://www.gov.ns.ca/finance/communitycounts/, accessed on 8 September 2010.
[9] Statistics Canada. 2006 Census Tract and Dissemination Area Population Data.



Figure 2.3.2: Location and General Extents of the Core Area

Table 2.3.3: Population Projections for the Porters Lake Study Area

Year	Low (Community Counts)	High (Transit Plan)	Mid-Range (between NS Community Counts and Transit Plan)
2010 Population	3,200	6,100	
2010 Units	1,200	2,300	
2030 Population	5,100	11,300	8,200
2030 Units	2,200	4,900	3,600
Pop Growth 2010-2030	1,900	5,200	3,200
Unit Growth 2010-2030	1,000	2,600	1,800

Note: High and low scenarios selected on basis of population change

2.3.4 Population to be Serviced

The total area included in the defined Core Area is approximately 360 hectares. Approximately 172 hectares are available for future development. At a design development density of 40 people per hectare (the minimum development density needed to make central services economically feasible), the area required for the projected range of people that are expected to move into the community in the next 20 years is as follows:

Table 2.3.4: Population Projections for the Core Area

Growth Scenario	100 Percent of Growth in Core Area			50 Percent of Growth in Core Area		
Additional	People	Units[(1)]	Hectares[(2)]	People	Units[(1)]	Hectares[(2)]
High	5200	2250	163	2600	1125	83.3
Medium	3200	1385	100	1600	693	51.3
Low	1900	823	59.4	950	412	30.5

(1) Assumes 2.37 persons per unit

(2) Assumes 40 persons per hectare

Based on discussions at the Focus Group meeting, it is expected that only a portion of the new residents would choose to move into the Core Area. The remainder will either choose to live in the smaller settlements in the study area or in new developments in rural areas. For planning purposes, it has been assumed that half of those moving to the community in the next 20 years will move to the Core Area, the remainder will be distributed in the Study Area outside of the Core Area.

CHAPTER 3 COMPONENT STUDIES

Studies were conducted to determine the following:

- Groundwater availability and quality conditions and the potential for using groundwater to supply water to the community;
- Existing water quality in local surface water bodies;
- Desired water uses for the streams, lakes and costal inlets in the community;
- Assimilative capacity and opportunities for stormwater and wastewater treatment effluent discharge to surface waters;
- Potential sources of contamination for surface waters and groundwater;
- Opportunities for improving existing water quality, including stormwater best management practices most applicable in Porters Lake;
- Valuable environmental functions in the Study Area and opportunities for retaining them through the development process;
- Constraints on development exerted by natural conditions and existing uses including a limited survey of existing on-site wastewater treatment systems and wells; and
- Servicing requirements. Typical municipal services provided in HRM include wastewater treatment and disposal, stormwater management and water.

Descriptions of the studies conducted and generalized results considered in isolation are summarized in this section. Where component studies were extensive, the details of these component studies are presented in Component Study Reports in the appendices. Results of these studies are synthesized in subsequent chapters to develop results and recommendations.

3.1 Groundwater Availability and Quality

The full groundwater component study can be found in Appendix B.

3.1.1 Existing Wells

Drinking water needs in Porters Lake and surrounding communities are supplied by individual water wells in the surficial and bedrock aquifers of the area. Groundwater supply wells may be drilled or dug into surficial aquifers, or drilled into metamorphic bedrock units (or plutonic rocks in the extreme northeast and northwest). Surficial deposits in ice contact till plains may function as unconfined aquifers, but the presence of finer material in thicker sequences of till should provide a degree of

protection in most areas. Unconfined bedrock is most likely to be encountered in areas underlying the coarsest slate tills, and a limited area to the east of Lower East Chezzetcook.

3.1.1.1 Surficial Material

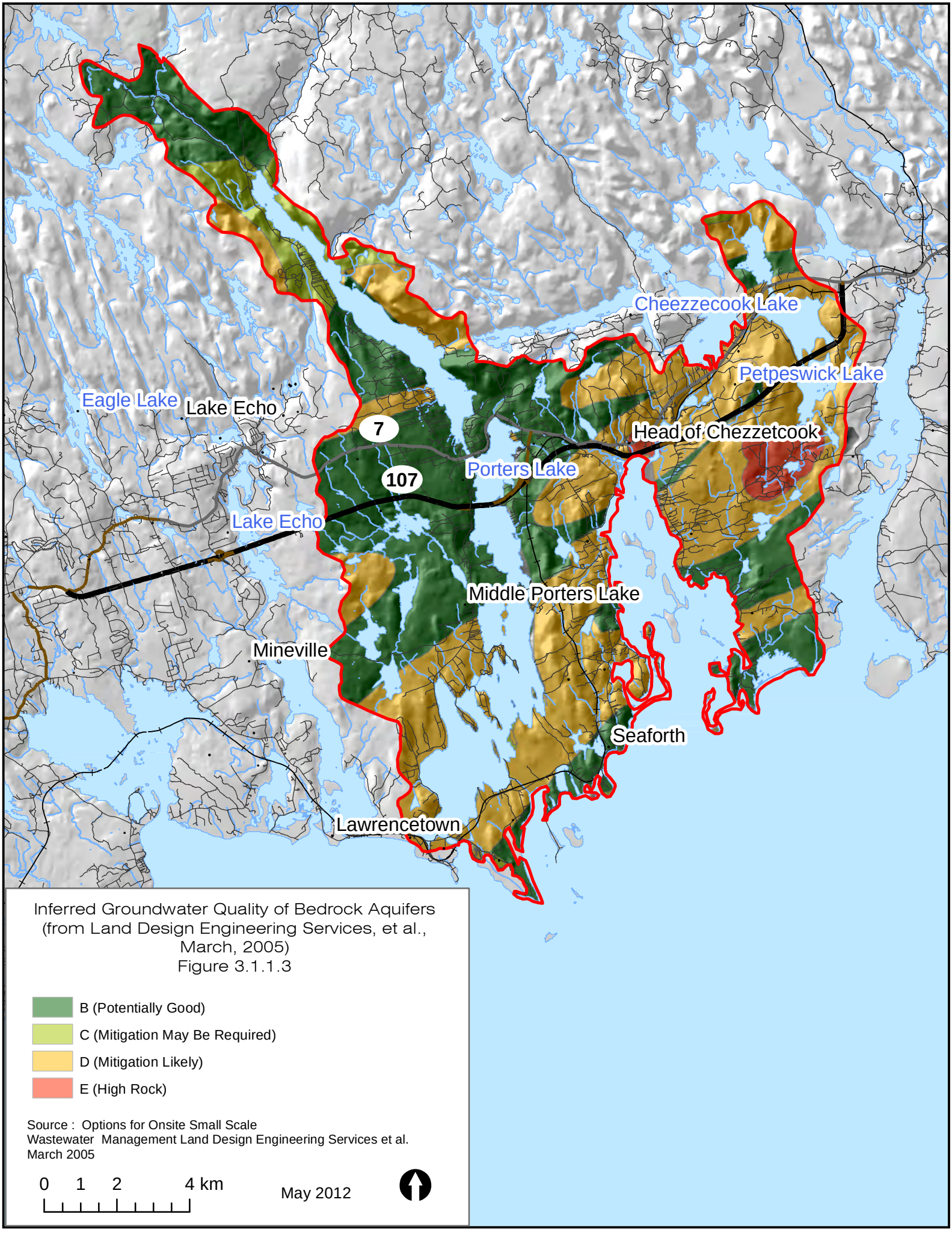
Wells installed in surficial deposits are typically 6 m deep or less, but can reach up to 29 m in selected locations, with a maximum reported depth of 87 metres. Many wells drilled into the surficial deposits reported yields adequate to supply light industry and small commercial developments. The well yields are variable, ranging from 32 L/min in lower producing areas up to 318 L/min where yields are most favourable. The maximum reported yield for a well installed in surficial material was 2,270 L/min. The source of water to many surficial wells is described as sand lenses or gravel, referring either to localized gravel beds within till material, or to the quartzite tills that predominate in Porter's Lake Centre and in the southeast arm. Many wells also reported finer grained materials, suggesting that many wells are equipped with extensive storage, or intercept fine sand seams not identified in the drilling logs.

3.1.1.2 Bedrock

Wells installed in the bedrock unit generally reach a depth of 40 m, with over 100 wells in the study area exceeding a depth of 100 m. The well yields are variable, depending directly on the number and size of fracture sets encountered. Deeper wells are generally required when shallow fracture sets do not intersect the borehole. Well yields are moderate to low, tending to fall between 7 and 27 L/min, with 230 wells reporting yields over 100 L/min and 31 wells over 500 L/min. This frequency of high yield wells (needed for central or shared supply), suggests that several test holes would be required to locate a major fracture zone. Wells reporting the highest yields are distributed throughout the study area.

3.1.1.3 Groundwater Quality Potential of Bedrock Aquifers

The inferred quality of water that could be supplied by wells installed in bedrock was investigated at a screening level in the "Onsite and Small Scale Wastewater Management Study" completed for HRM by Land Design Engineering Services in March 2005. Figure 3.1.1.3 was developed with information presented in the report for that study. It suggests that bedrock underlying most of the Study Area is Class B (Potentially Good) and Class D, (treatment to address water quality issues are likely). Bedrock underlying the proposed Core Area is mostly Class B. There are pockets of Class C, (treatment to address water quality issues may be required) and Class E, (High Risk that treatment is required) throughout the Study Area. Based on this assessment, planning should include allowances for treatment to remove contaminates listed previously. If suitable wells can be sited northeast of the Core Area, the need for treatment may be reduced. Location of wells and the need for treatment will be determined through a Hydrogeological Assessment, as part of a subdivision application.



Inferred Groundwater Quality of Bedrock Aquifers
(from Land Design Engineering Services, et al., March, 2005)
Figure 3.1.1.3

- B (Potentially Good)
- C (Mitigation May Be Required)
- D (Mitigation Likely)
- E (High Rock)

Source : Options for Onsite Small Scale Wastewater Management Land Design Engineering Services et al. March 2005

0 1 2 4 km

May 2012

3.1.2 Effects of Groundwater Yields on Future Development

Projected demands were compared to the available water budget for the Porter's Lake area. Current demand is estimated at 7% of local groundwater recharge. The calculation assumes that all water is drawn from infiltrating precipitation falling within the study area, which implies a focus on withdrawals from surficial aquifers. Additional components of regional flow may be available in the bedrock aquifer. Calculations indicate that under a high growth scenario, groundwater use would more than double to 16% of recharge to area aquifers. The remaining 84% of recharge local to the study area would remain available as base flow to streams, lakes, coastlines, and regional recharge. Although this amount is likely sufficient to maintain the function of natural systems and aquifers, the increase may represent a threshold for measureable changes (e.g., a decline in the water table or reduction of stream flow near a new subdivision).

Reliance on groundwater to service new developments in the Porter's Lake area is likely to be focused on locating productive zones of the surficial and bedrock aquifers, and on treatment for arsenic, manganese, and iron. As subdivision developments progress, an increasing density of septic systems will also become a factor. The intensity of use of individual aquifers, and the water budgets for new subdivisions should become the focus of further investigations. With increasing development there will be a need for evaluation of sustainability on a case by case basis. Whereas the regional water budget suggests that projected development will be sustainable, local water budgets should be considered.

Production characteristics of existing surficial wells suggest that a central municipal supply could be accomplished with four large diameter wells, with the assumption that an extensive quaternary deposit can be located, and that several additional test wells would likely be a part of the exploration program. Ideally the well field would be located in an area apart from future residential, commercial, industrial, and coastal areas, potentially in the extreme centre-north, to the northeast of East Chezzetcook, or in the drumlin field on the southwest arm.

Treatment prior to distribution could be a requirement to address arsenic, iron, and manganese concentrations. The data suggest that aquifer yields would be adequate to develop a central water supply provided that the yields in the water well database could be reproduced (i.e. if exploration succeeded in locating these high yield zones). Although potentially viable from a yield perspective, central services based on groundwater could be cost prohibitive pending the costs of treatment and exploration. A more detailed investigation for the potential to provide a central water supply is warranted.

As groundwater resources in the Porter's Lake area do not appear to be overexploited, additional development of groundwater resources should be sustainable. Although traditional open space lots are likely to be viable, widespread installation of individual water wells and on-site sewage disposal systems would not provide the most effective option for source water protection. With an increasing density of groundwater users, single wells supplying clusters of up to 10 homes would provide improved protection to area aquifers. This option has several advantages from a supply and aquifer vulnerability perspective including:

- Yields are generally adequate;
- Both surficial and bedrock wells can be incorporated, balancing well interference effects; and

- The introduction of bedrock wells reduces the potential for contamination by on-site sewage disposal systems in higher density subdivisions.

Existing high-yield water supplies suggest that the yields of selected aquifers in the Porter's Lake area are adequate to provide central servicing. Additional investigation would be required to locate an extensive deposit of granular material, preferably in a remote area where a Well Head Protection Area (WHPA) could eventually be designated. If future development is to encourage growth of a centralized urban area, a detailed hydrogeological investigation is recommended.

Outlying parts of the Porter's Lake area are expected to develop as traditional open space lots or according to the principles of Conservation Sub-division Design (CSD). The HRM Guidelines for Groundwater Assessment and Reporting (2006) provide instruction and requirements for new developments. As part of and in addition to this document, developers should be required to provide the following site specific information for assessment by HRM and other potential reviewers:

- Depth of till or surficial aquifer in the location to be developed;
- Presence or absence of silty material in the location to be developed;
- Proximity to existing wells;
- Known problems with water quality or quantity in neighbouring wells;
- Projected density of residences; and
- Plan for best use of both bedrock and surficial wells.

If the population of the Porter's Lake area is to approach 11,300 (high growth scenario), water supply planning measures should be implemented prior to further development. Measures to mitigate potential supply problems include:

- Drilling of test wells for central water supply;
- Implementation of water conservation strategies (watering restrictions, low-flow appliances, rainwater cisterns);
- Promotion of well stewardship, casing maintenance, and regular water quality testing;
- Upgrades to existing wells;
- Incentives and requirements for developers to establish a binding lot plan showing well and on-site sewage disposal system locations;
- Incentives or requirements for developers to implement cluster supplies for groups of 10 (or more) single family homes;
- Establishment of guidelines for well maintenance and treatment for cluster supplies; and
- Monitoring and reassessment of the development of surficial aquifers.

3.2 Existing Surface Water Quality

The full surface water quality component study can be found in Appendix C.

3.2.1 Background

Water samples were collected at 5 sites on Porters Lake. Each site was sampled six times between June and November 2010. Sampling was scheduled to coincide with seasonal changes in weather and precipitation

conditions. Surface sampling was conducted to capture pollution-carrying runoff. Vertical profiles of in situ parameters (temperature, salinity, dissolved oxygen) were also taken to assess lake stratification.

3.2.2 Objectives

- To assess existing water quality of surface water bodies in the Study Area;
- To assess the existing trophic status of these water bodies; and
- To develop a baseline for assimilative capacity assessments under various development scenarios.

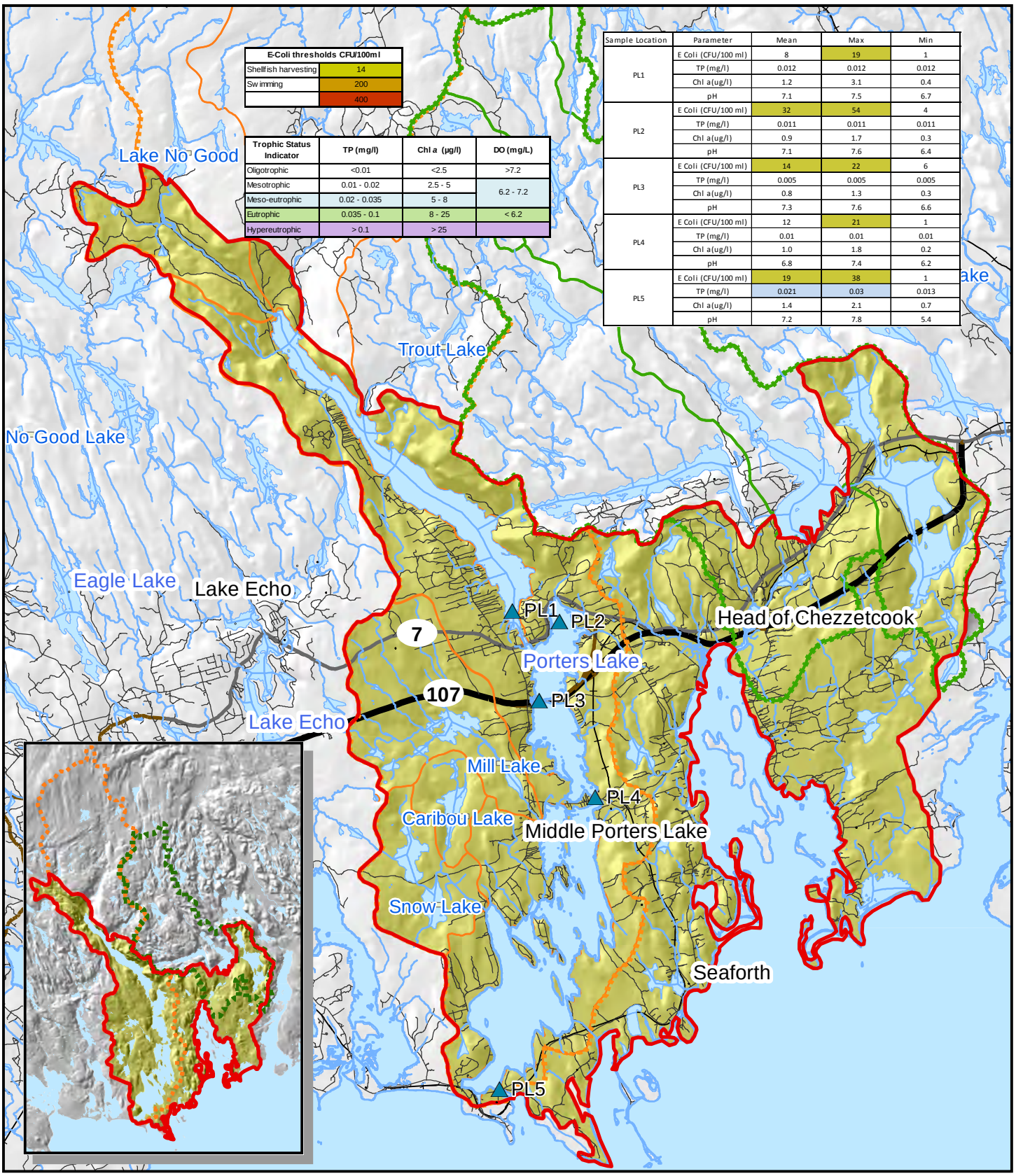
3.2.3 Water Sampling and Analysis Program

Surface water samples were collected at the locations shown on Figure 3.2.3. Fourteen (14) water quality parameters were measured for each sample, listed in Table 3.2.3.

Table 3.2.3: Water Quality Parameters

Parameter	Symbol	Units	Detection Limit Applied	Description
Dissolved Oxygen	DO	mg/L		Measured *in situ*
Water temperature		°C		Measured *in situ*
pH	pH			Measured *in situ*
Salinity		%		Measured *in situ*
Concentration of *Escherichia coli*	E. coli	CFU/100 ml	1	CFU (Colony Forming Units): the number of colonies on the incubation plate
Concentration of fecal coliform bacteria*	FC	MPN/ml	100	MPN (Most Probable Number): an approximation of the number of bacteria from a count of the number of colonies.
Total Phosphorus	TP	mg/L	0.02	Laboratory measurement
Carbonaceous Biological Oxygen Demand	C.BOD	mg/L	5	Laboratory measurement
Chlorophyll a	Chl *a*	µg/L		Laboratory measurement
Nitrate	Nitrate	mg/L	0.05	Laboratory measurement
Nitrate + Nitrite	Nitrite	mg/L	0.05	Laboratory measurement
Ammonia	Ammonia	mg/L	0.05	Laboratory measurement
Total Kjeldahl Nitrogen	TKN	mg/L	0.1	Laboratory measurement
Total suspended solids	TSS	mg/L	2	Laboratory measurement

* Historically Fecal Coliform (FC) have been used in some jurisdictions as the primary bacterial indicator.



E-Coli thresholds CFU/100ml	
Shellfish harvesting	14
Swimming	200
	400

Trophic Status Indicator	TP (mg/l)	Chl a (µg/l)	DO (mg/L)
Oligotrophic	<0.01	<2.5	>7.2
Mesotrophic	0.01 - 0.02	2.5 - 5	6.2 - 7.2
Meso-eutrophic	0.02 - 0.035	5 - 8	
Eutrophic	0.035 - 0.1	8 - 25	< 6.2
Hypereutrophic	> 0.1	> 25	

Sample Location	Parameter	Mean	Max	Min
PL1	E Coli (CFU/100 ml)	8	19	1
	TP (mg/l)	0.012	0.012	0.012
	Chl a(ug/l)	1.2	3.1	0.4
	pH	7.1	7.5	6.7
PL2	E Coli (CFU/100 ml)	32	54	4
	TP (mg/l)	0.011	0.011	0.011
	Chl a(ug/l)	0.9	1.7	0.3
	pH	7.1	7.6	6.4
PL3	E Coli (CFU/100 ml)	14	22	6
	TP (mg/l)	0.005	0.005	0.005
	Chl a(ug/l)	0.8	1.3	0.3
	pH	7.3	7.6	6.6
PL4	E Coli (CFU/100 ml)	12	21	1
	TP (mg/l)	0.01	0.01	0.01
	Chl a(ug/l)	1.0	1.8	0.2
	pH	6.8	7.4	6.2
PL5	E Coli (CFU/100 ml)	19	38	1
	TP (mg/l)	0.021	0.03	0.013
	Chl a(ug/l)	1.4	2.1	0.7
	pH	7.2	7.8	5.4

HALIFAX
REGIONAL MUNICIPALITY

Porters Lake Watershed/Servicing Study
Figure 3.2.3 Surface Water Sample Location
May 2012

NTDB_Toponyms_Water_ANNO
Surface Water Sample Location
Study Area
Chezzetcook Lake Watershed
Subwatersheds
Watershed Limit
Porters Lake Watershed
Subwatersheds
Watershed Limits

0 1,300 2,600 5,200 Meters

CBCL Project # 101015
Data Sources: HPM, NSDNR
Coordinate System: NAD 1983 UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

CBCL LIMITED

File Path: L:\101015 Lake Echo\101015_Layout\101015 - Porters Lake\101015 Porters Lake - Surface Water Sample Location.mxd

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Recently E-coli (a subgroup of FC) was established as the preferred indicator (CCME 2004), because it is reported to correlate best with bather illnesses in sewage impacted recreational waters (Noble et al. 2003, Water Research 37 1637-1643). The samples were analysed for both E-coli and FC. For this dataset, the E-Coli measurements are likely a more reliable indicator for the following reasons. There is a vast spread in the measured FC range (and often questionably high values) reported by Maxxam Analytics using the MPN-Isogrid method (Most Probable Number - an approximation of the number of bacteria from a count of the number of colonies). The Isogrid filters used being large, they are capable of detecting large numbers of FC, including those that grow poorly or ferment lactose slowly while in other methods sometimes used FC that are poor growing or ferment lactose slowly may not provide a positive reaction during the specified incubation time (source: Maxxam Analytics). Results for E-Coli using the CFU method exhibit less variability and are within a range that is consistent with other local studies (HRM Lake sampling program at Porters Lake).

3.2.4 Results

Results of the measurements and analysis of the water samples are presented in Table 3.3 in Appendix C and are summarized in the table on Figure 3.2.3. Pertinent results include:

3.2.4.1 E-COLI

- Concentrations at all sites sampled were below 200 CFU/100 mL, i.e. suitable for primary recreational contact, with values ranging from 1 to 54 CFU/100 mL;
- Concentrations were greater than 14 CFU/100 mL for 50% of the samples, i.e. not suitable for shellfish harvesting; and
- Highest concentrations were observed during wet weather in late summer and fall, and at sites impacted by development.

3.2.4.2 TROPHIC STATUS INDICATORS

The process of eutrophication is defined as the loading of inorganic and organic dissolved and particulate matter, including nutrients, to waterbodies at rates sufficient to increase the potential for high biological production, decrease basin volume and deplete dissolved oxygen (Cooke *et al*., 2005). For the purpose of this report the trophic status of each lake has been assessed by examining the concentrations of nutrients: total phosphorus (TP) and total nitrogen (TN), the levels of algal biomass (as Chlorophyll a present in the lake), and the state of oxygenation of the water column. The results allow for the classification of the lakes into oligotrophic, mesotrophic, meso-eutrophic, eutrophic or hypereutrophic (see Table 3.2.4.2).

Table 3.2.4.2: Indicators of Trophic State

	TP (mg/L)	TN (mg/L)	Chl a (µg/L)	DO (mg/L)
Oligotrophic	<0.01	<0.35	<2.5	>7.2
Mesotrophic	0.01 - 0.02	0.35 – 0.65	2.5 - 5	6.2 - 7.2
Meso-eutrophic	0.02 - 0.035		5 - 8	
Eutrophic	0.035 - 0.1	0.65 – 1.2	8 - 25	< 6.2
Hypereutrophic	> 0.1	> 1.2	> 25	

Note: Values in Table3.2.4.2 are based on the following sources:

- *Range indicator values for TP and Chl a are from Vollenweider and Kerekes (1982) as recommended by Brylinski (2004) for NS Lake Phosphorus Loading Models;*
- *There are no Federal or Nova Scotian guideline values for these parameters, below which nuisance algae can be avoided. The Province of Ontario suggests an annual average of less than 0.020 mg/L. For the purposes of this assessment, a Chl a concentration of greater than 5 µg/L, indicates nuisance algae;*
- *Range indicator values for DO and TN are from Cooke et al. (2005);*
- *Phosphorus and nitrogen are required in specific ratios for plant growth. TP and TN concentrations are of concern if the particular nutrient is limiting. Typically P is the limiting nutrient in freshwater, and therefore a TN concentration in the eutrophic range is not as much of a concern as a TP concentration in the eutrophic range (the opposite is typical in marine water); and*
- *Total nitrogen can be calculated from the parameters measured in this study as the sum of TKN and Nitrate+Nitrite.*

- **Total Phosphorus** concentrations were generally below the detection limit of 0.02 mg/L employed by Maxxam Analytics for the 2010 program, except at PL5 on October 28, 2010 when a value of 0.03 mg/L was recorded. Strong rainfall preceded this sample and may have caused this higher concentration. Total phosphorus concentrations were measured again in the spring, summer and fall of 2012. All sites show average total phosphorus concentrations in the mesotrophic to meso-eutrophic range, with the exception of the bottom measurement at site PL2 (see Trophic Status Indicators in Table 3.2.4.2). This is consistent with HRM 2006 to 2011 sampling data in the upper section of Porters Lake showing an average concentration of total phosphorus for the 5 years of available data of 0.0147 mg/L, in the mesotrophic range;
- **Total nitrogen** concentrations measured at the Porters Lake sites in 2010 were typically in the oligotrophic range during the summer and early fall, the exceptions were at sites 4 and 5 in the lower end of the lake where TN was in the mesotrophic range on September 29th. In late October the TN concentrations were in the mesotrophic range for all of the sites except PL5 at the lower end of the lake;
- Average **Chlorophyll a** concentrations at the 5 sites ranged from 0.82 to 1.37 micrograms/L for 2010. The average concentration measured in the HRM 2006 to 2011 program for the upper end of the lake is 1.0 micrograms/L. Both sets of results are in the oligotrophic range; and
- **Dissolved oxygen:** while the surface area of the lake is well aerated, there is oxygen depletion in deep areas likely due to the consumption of oxygen by microbes during decomposition of organic material and limited vertical mixing of water, due to the density stratification.

3.2.4.3 DENSITY STRATIFICATION

Temperature and salinity profiles indicate significant density stratification over deeper sections of the lake, indicating limited vertical mixing. High salinity was found at depth at all stations, except the most upstream (PL1) on all occasions. The salinities at the bottom of station PL2 (15 m deep) were the highest recorded during this program. The water in this deep pocket of the lake is more stagnant trapped by density stratification and bottom topography. These areas are not well mixed and are therefore sensitive to potential pollutant loads.

3.2.4.4 OTHER PARAMETERS

- **TSS:** concentration of total suspended solids in all water samples was low, typically less than 5 mg/L, which did not raise particular concerns;
- **C.BOD:** carbonaceous biological oxygen demand is a measure of organic substances in the water. The levels are below the detection limit; and
- **pH:** The relatively low pH values for freshwater are not unusual in such environments with acidic soils and acidic precipitation, typical of this region.

3.3 Surface Water Use Objectives

The full surface water use objectives component study can be found in Appendix D.

3.3.1 Summary of Water Quality Questionnaire

A water quality questionnaire was created to gather community input on future water use objectives for the Porters Lake study area. The questionnaire was available to any interested individuals in the community on-line from August 5th to November 10th, 2010. The questionnaire was publicized through email distribution lists, posters, and an advertisement in the Eastern Gazette. The objective of the questionnaire was to find out how residents of the area use water bodies now and how they want to be able to use them in the future. A copy of the questionnaire used in the survey is available as part of the component report in Appendix D.

There were one hundred and ninety-seven (197) responses to the questionnaire. The survey presented a list of water bodies in the area and respondents were asked to indicate the ways in which these water bodies were important to them. Overall, the most responses were provided for Porter's Lake, both north and south of Highway 7 and the ocean.

3.3.2 Water Use Objectives

Minimum water use objectives for this study are based on the objectives described in the HRM Regional MPS indicating a desire to achieve public health standards for body contact recreation and to maintain the existing trophic status of our lakes and waterways to the extent possible.

Figure 3.3.2 shows the most important water use objectives for each water body in the study area as provided by respondents to the survey, the height of each colour band indicates the portion (%) of the respondents that felt each water use objective was the most important to them. Visual enjoyment, swimming, boating, and habitat were the popular choices for most important water use objectives for

Porter's Lake. Visual enjoyment, leisure on beaches, swimming, and shoreline trails were the most important water use objectives for the ocean.

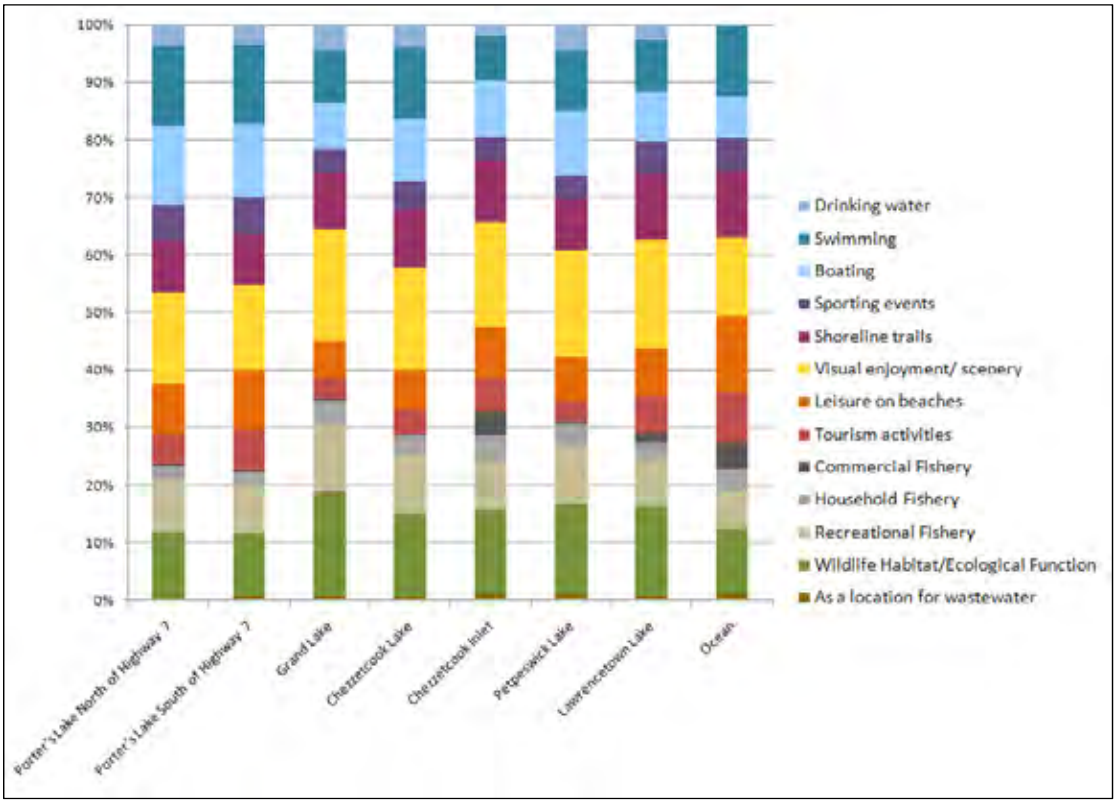


Figure 3.3.2: Water Use Objectives Indicated for Each Water Body

3.3.3 Water Quality Objectives

Respondents were asked what level of water quality they desired for each water body. The questionnaire showed respondents a scale that showed a movement from the LEAST stringent water quality requirements (left) to the MOST stringent water quality requirements (right). Respondents were asked to indicate the level of water quality they would be satisfied with in the future.

Figure 3.3.3 shows the level of water quality respondents would be satisfied with in the future for each water body. The ocean and Chezzetcook Inlet were the water bodies respondents indicated the need for the most stringent water quality requirements. The majority of responses for fresh water bodies indicated a desire for high requirements (see level 4 in Figure 3.3.3). Very few respondents would be satisfied with level one or two water quality requirements. Respondents provided additional comment expressing the desire for highest (see level 5 in Figure 3.3.3) protection for other water bodies in the area including Petpeswick Lake, Three Fathom Harbour and Conrods Lake, and high (see level 4 in Figure 3.3.3) protection for Meisners Lake, Lake Echo, and all water bodies north of Porters Lake.

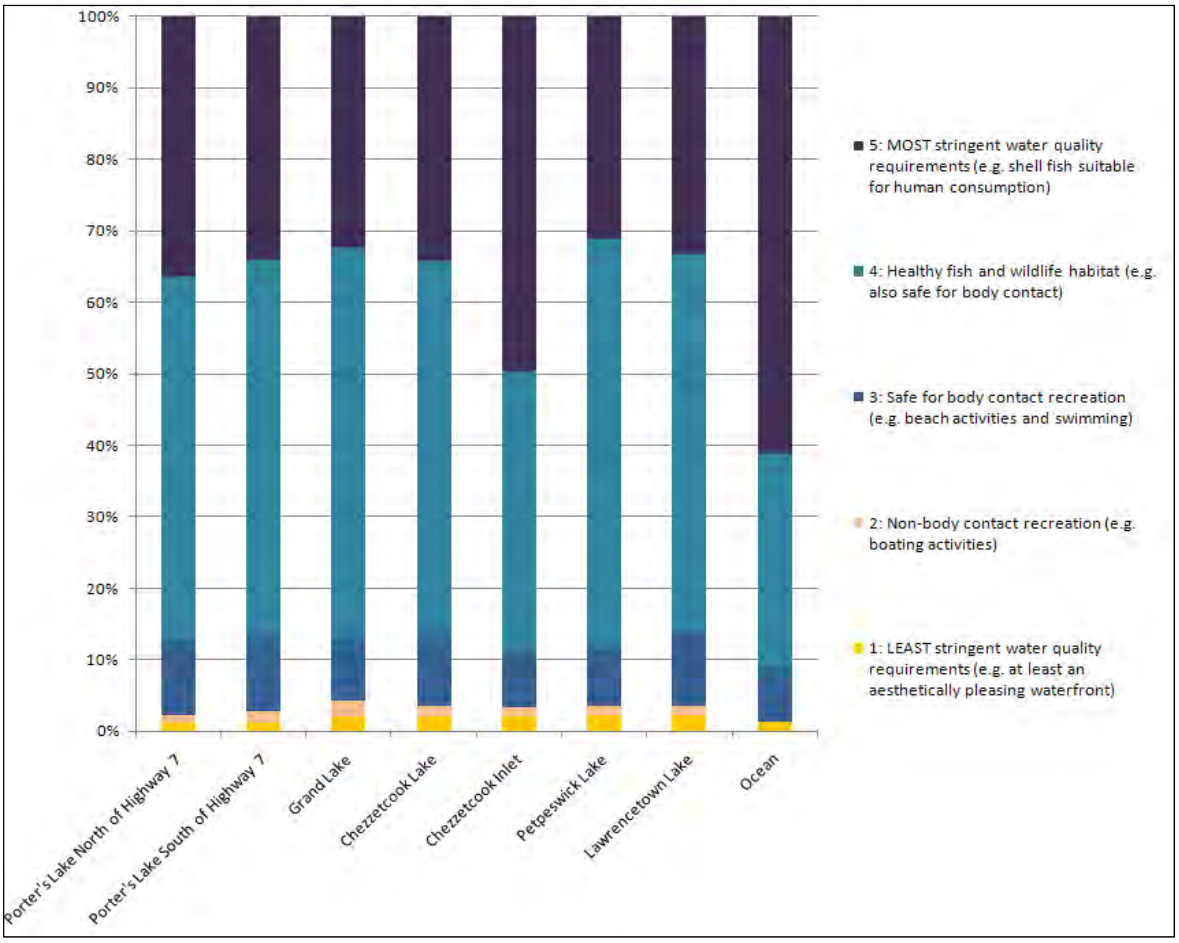


Figure 3.3.3: Respondents Desired Future Water Quality for Each Water Body

In water bodies near urban development, there are typically two areas of paramount interest:

1. Public health and habitat - E coli concentrations are used to assess conditions with respect to public health and potential for habitat.
2. Aesthetics - Concentrations of nutrients (nitrogen and phosphorus), algal biomass (Chlorophyll a), and dissolved oxygen as well as silt and organic matter are used to assess the trophic status of a water body.

There are CCME guidelines for concentrations of E coli below which experience has shown that use of the water has a relatively low probability of causing illness.

Although one of the essential parameters in the production of algae, there are no federal or Nova Scotian guidelines related to total phosphorus concentration limits *below which nuisance algae can be avoided.* Guidelines from Ontario were presented in section 3.2.4.6. However, these guideline concentrations do not preclude algae growth; as algae growth depends on many parameters that can vary significantly during the ice free period. Experience has shown that by limiting phosphorus, the amount of algae that can be produced is limited.

Table 3.3.3 outlines the water quality objectives required for desired uses for water bodies in the Study Area.

Table 3.3.3: Water Quality Objectives for Desired Water Uses

Use	Water Quality Required to Sustain the Water Use
Health	*Concentration of E coli*
Drinking Water	*Guidelines for Canadian Drinking Water Quality (GCDWQ)* should be met. To allow consumption of water it must have an E coli count of 0 per 100 mL sample. All water used for water supplies must be treated to meet GCDWQ guidelines by current Provincial requirements.
Fishing	To preserve habitat, CCME Guidelines should be met. To allow consumption, an E coli count of <14 per 100 mL sample is suggested
Shellfish Gathering	To preserve habitat, CCME Guidelines should be met. To allow consumption, a long term median an E coli count of <14 per 100 mL sample is required by Environment Canada
Swimming	To allow primary contact associated with this activity, an E coli count < 200 per 100 mL sample is required
Boating	To allow secondary contact associated with this activity, an E coli count < 1000 per 100 mL sample is required
Habitat and Aesthetics	*Trophic Status*
Oligotrophic	TP < 0.010 mg/L; Chl a<2.5 micrograms/L;TN<0.35 mg/L; DO>7.2 mg/L; pH> 5.5
Mesotrophic	TP < 0.020 mg/L; 2.5<Chl a< 5 micrograms/L; 0.035<TN<0.65 mg/L; 6.2<DO<7.2 mg/L; pH> 5.5

Recommended water quality objectives for all of the waterbodies in the Study Area include:

- Average mean annual E coli concentrations should be below 14 per 100 mL sample for all waterbodies in the study area: freshwater and salt water;
- All waterbodies that are currently not impacted by development should be Oligotrophic or better. To achieve this requires compliance with the stipulated values for the parameters listed in Table 3.3.3; and
- Any water body that is currently impacted by development including portions of Porters Lake and Mill Lake should be mesotrophic or better to be considered for habitat or as aesthetically acceptable. To achieve this requires compliance with the stipulated values for the parameters listed in Table 3.3.3.

3.4 Assimilative Capacity of Surface Waters

Assimilative capacity of surface waters is discussed in the component report in Appendix C.

Assimilative capacity is an indication of the amount of additional loads of various pollutants a water body may receive without exceeding water quality objectives. Assessment of the assimilative capacity of the lakes and streams in the Study Areas was completed by comparing existing water quality to water quality objectives required to sustain various water uses as listed in Table 3.3.3. Two conditions exist:

- Concentration of measured water quality parameter is below the guideline level for the desired use, the water may be used as desired and there is some assimilative capacity available; and
- Concentration of measured water quality parameter is at or above the guideline level, the water is not suitable for the desired use and there is no assimilative capacity available in the water body for the limiting pollutant(s).

3.4.1.1 OBJECTIVES

- Assess the assimilative capacity of Porters Lake and other water bodies in the Study Area; and
- Identify waterbodies currently impacted by development, those that receive stormwater runoff and potentially receive septic tank effluent.

3.4.1.2 PHOSPHORUS LOADING MODELS

Assessments of assimilative capacity based on current trophic status of the lakes were completed using a standard phosphorus loading model, Brylinski (2004), developed with Nova Scotia Environment for use in Nova Scotia. This model was used to simulate mean annual Total Phosphorus concentrations in the main lakes in the Study Area. The model uses information on land-uses in the tributary areas and typical phosphorus generation rates for each land-use to estimate the flow of phosphorus into each lake, the amount retained in each lake and the amount discharged to the downstream based on typical values that have been developed based on experience gained in this region.

Phosphorus concentrations measured in the upper end of Porters Lake as part of HRM's 2006 - 2011 Sampling Program and concentrations measured as part of this study were used to confirm that the estimated parameters were reasonable. The sampling data collected as part of HRM's program provided the best information for calibration of the models as it is:

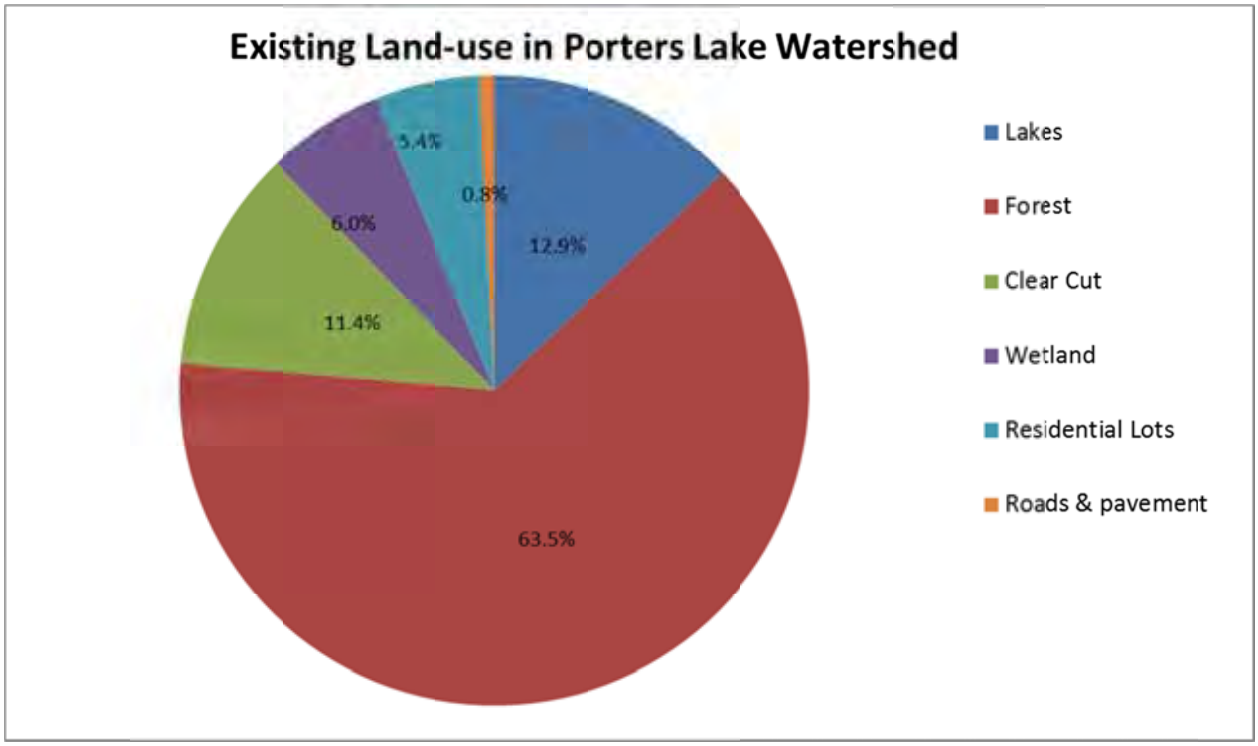
- Multi-year, long-term; and
- Low TP detection limit analyses were completed.

However, there is only data for the upper end of Porters Lake available from this program. Additional samples were collected for this study and the information collected was used to assess:

- Conditions in several locations in Porters Lake that are not included in the HRM program; and
- Differences in water quality that result from varying weather conditions.

3.4.1.3 PHOSPHORUS LOADING MODEL RESULTS

Results of the land use and phosphorus loading assessments for the lakes in the Study Area are presented in Appendix C.2. This information is summarized for Porters Lake in Figure 3.4.1.3. The top pie chart indicates the portion of various lands-uses in the Porters Lake watershed. The pie chart on the bottom indicates the amount of phosphorus these land uses contribute to Porters Lake.



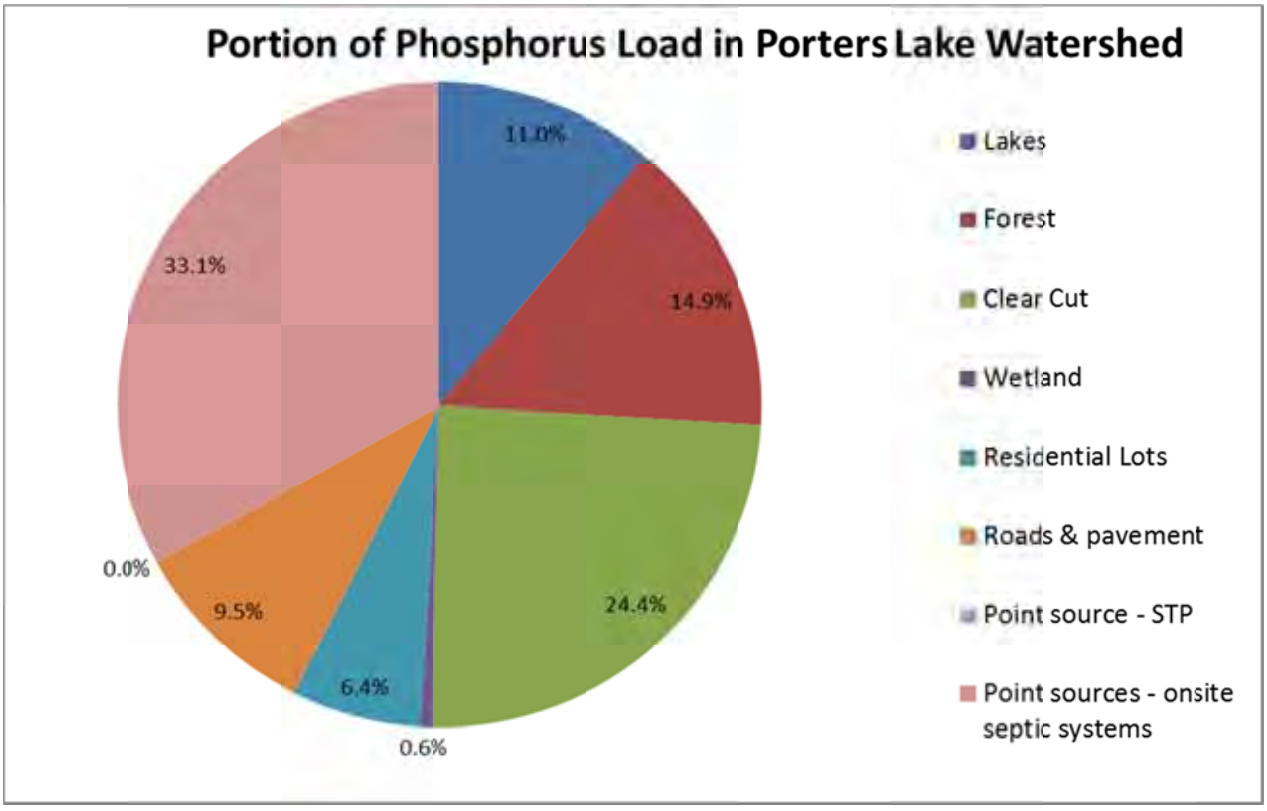


Figure 3.4.1.3: Land-use and Estimated Total Phosphorus Loads Generated in Porters Lake

Currently developed areas cover slightly more than 6.2% of the watershed but contribute approximately 49% of the annual phosphorus load to the lake. It was estimated that this load is contributed by a combination of point sources (including partially treated septic tank effluent) and non-point sources

such as runoff from landscaped areas and road rights of way. Another significant contributor is clear cutting of the forest. Clear cutting accounts for 11.4% of the watershed area but contributes 24.4% of the phosphorus load to Porters Lake. On the other hand, forests cover 63.5% and wetlands make-up 6% of the watershed but contribute 14.9% and 0.6 % of the annual phosphorus loads.

Table 3.4.1.5 shows the results of the phosphorus loading model assessments. Based on the estimated phosphorus loads, it appears that most of the lakes are in the mesotrophic range, exceptions include some of the head water lakes that would be in the oligotrophic range and Mill Lake with TP concentrations estimated to be in the meso-eutrophic range.

3.4.1.4 Assessment of Existing Assimilative Capacity

Porters Lake

Figure 3.4.1.4(a) summarizes the information used to assess the trophic status of Porters Lake.

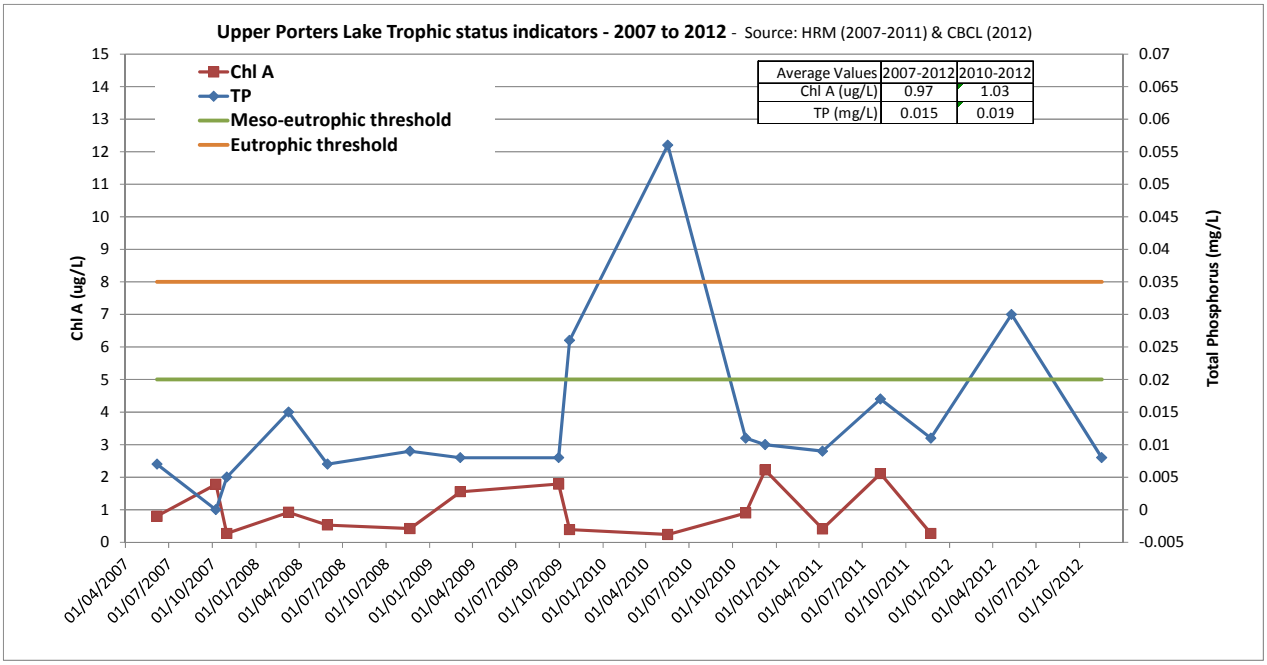


Figure 3.4.1.4(a): Measured Trophic Status Indicators – Upper Porters Lake

Total phosphorus concentrations for 2012 were above the upper end of the mesotrophic range and average mean annual concentrations for the HRM 2006 to 2011 program were in the mesotrophic range. The average mean annual total nitrogen concentrations for the HRM 2006 to 2011 program were also in the mesotrophic range. However, chlorophyll a concentrations were in the middle of the oligotrophic range. While the contributing nutrient concentrations are in the mesotrophic range, plant growth, as measured by the concentration of chlorophyll a, is indicative of oligotrophic conditions, and typically in the middle of the range. On this basis it appears that although the measured TP concentrations are above the range considered for oligotrophic conditions, there is assimilative capacity available most of the time in all sections of Porters Lake based on chlorophyll a concentrations. The exception to this generalization is in the deeper areas of the Lake, particularly in the upstream sections, where dissolved oxygen concentrations are low under existing conditions.

Table 3.4.1.5: Predicted Average Annual Total Phosphorous Concentration in Study Area Lakes with Central Tertiary Wastewater Treatment in Core Area

Development Scenario		Sub-Watershed												Total to Outlet of Porters Lake
		Lake No Good	Cousins Lake	Ledwidge Lake	Trout Lake	Mill Lake	Snow Lake	Caribou Lake	Porters Lake Section 1 Upstream	Porters Lake Section 2	Porters Lake Section 3	Porters Lake Section 4	Porters Lake Section 5 Downstream	
Existing Conditions														
Drainage Basin Area (Excl. of Lake Area)	Ha	2306.5	886.9	161.6	879.4	1182.1	446.7	265.5	7478.2	364.4	501.3	907.3	709.7	16089.7
Percent Clear Cut	%	16.2%	15.2%	1.3%	14.5%	19.2%	20.4%	9.1%	11.4%	5.5%	23.4%	8.9%	8.6%	13.1%
Percent Developed	%	0.6%	0.0%	0.0%	0.0%	7.5%	1.9%	0.0%	5.0%	56.4%	15.8%	15.1%	32.8%	7.1%
Number of Residences Directly Draining to Lake	# Units	8.0	0.0	0.0	5.0	28.0	7.0	0.0	523.0	305.0	76.0	133.0	476.0	1561.0
Average Annual Total Phosphorous Concentration	mg/L	0.0145	0.0110	0.0050	0.0107	0.0219	0.0096	0.0068	0.0149	0.0175	0.0170	0.0157	0.0159	
Trophic Status Based on Total Phosphorous		Mesotrophic	Mesotrophic	Oligotrophic	Mesotrophic	Meso-eutroph	Oligotrophic	Oligotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	
Growth Scenarios Considered														
Assumed Portion of Develpopment in Each Sub-watershed		0%	0%	0%	0%	0%	0%	0%	30%	0%	35%	20%	15%	
Low Growth Scenario														
Percent Clear Cut	%	16.2%	15.2%	1.3%	14.5%	19.2%	20.4%	9.1%	11.1%	0.0%	17.7%	7.1%	6.8%	12.5%
Percent Developed	%	0.6%	0.0%	0.0%	0.0%	7.5%	1.9%	0.0%	5.7%	85.1%	27.3%	18.7%	36.3%	8.8%
Number of Residences	# Units	8.0	0.0	0.0	5.0	28.0	7.0	0.0	584.7	152.5	148.0	174.2	506.9	1614.3
Average Annual Total Phosphorous Concentration	mg/L	0.0143	0.0110	0.0050	0.0106	0.0216	0.0095	0.0068	0.0145	0.0163	0.0166	0.0155	0.0154	
Predicted Increase	%	-1%	0%	0%	-1%	-1%	-1%	0%	-3%	-7%	-2%	-1%	-3%	
Trophic Status Based on Total Phosphorous		Mesotrophic	Mesotrophic	Oligotrophic	Mesotrophic	Meso-eutroph	Oligotrophic	Oligotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	
Medium Growth Scenario														
Percent Clear Cut	%	16.2%	15.2%	1.3%	14.5%	19.2%	20.4%	9.1%	10.9%	0.0%	13.8%	5.9%	5.6%	12.2%
Percent Developed	%	0.6%	0.0%	0.0%	0.0%	7.5%	1.9%	0.0%	6.2%	85.1%	35.1%	21.2%	38.7%	9.5%
Number of Residences	# Units	8.0	0.0	0.0	5.0	28.0	7.0	0.0	626.9	152.5	197.2	202.3	527.9	1754.8
Average Annual Total Phosphorous Concentration	mg/L	0.0143	0.0110	0.0050	0.0106	0.0216	0.0095	0.0068	0.0147	0.0164	0.0170	0.0158	0.0157	
Predicted Increase	%	-1%	0%	0%	-1%	-1%	-1%	0%	-1%	-6%	0%	1%	-1%	
Trophic Status Based on Total Phosphorous		Mesotrophic	Mesotrophic	Oligotrophic	Mesotrophic	Meso-eutroph	Oligotrophic	Oligotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	
High Growth Scenario														
Percent Clear Cut	%	16.2%	15.2%	1.3%	14.5%	19.2%	20.4%	9.1%	10.5%	0.0%	7.7%	4.0%	3.8%	11.6%
Percent Developed	%	0.6%	0.0%	0.0%	0.0%	7.5%	1.9%	0.0%	6.8%	85.1%	47.2%	25.0%	42.3%	10.5%
Number of Residences	# Units	8.0	0.0	0.0	5.0	28.0	7.0	0.0	691.8	152.5	272.9	245.5	560.4	1971.0
Average Annual Total Phosphorous Concentration	mg/L	0.0143	0.0110	0.0050	0.0106	0.0216	0.0095	0.0068	0.0150	0.0167	0.0176	0.0164	0.0162	
Predicted Increase	%	-1%	0%	0%	-1%	-1%	-1%	0%	1%	-5%	4%	4%	2%	
Trophic Status Based on Total Phosphorous		Mesotrophic	Mesotrophic	Oligotrophic	Mesotrophic	Meso-eutroph	Oligotrophic	Oligotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	

Assumptions:

50% of new development occurs in areas that are currently forests, and 50% occurs in areas that are currently clear cut

Shading indicates a change in trophic status

Estimated using the phosphorous loading model - should be validated with sampling

Average mean annual Total Phosphorous concentration based on results of HRM's 2006 - 2011 Sampling Program

Table 3.4.1.5 indicates that most of the other lakes in the Study Area have assimilative capacity for additional phosphorus loads; the exception is Mill Lake with a phosphorus concentration in the meso-eutrophic range. Other lakes to watch include Trout Lake and Snow Lake with TP concentrations in the vicinity of the lower range of mesotrophic to the upper range oligotrophic. It should be noted that this assessment is based on estimates of average mean annual total phosphorus concentrations (based on the phosphorus loading model) and these estimates should be confirmed with actual measurements.

Additional phosphorus loads that could be assimilated to meet the objective phosphorus concentrations for oligotrophic or mesotrophic ranges are readily estimated. However, quantification of the amount of additional phosphorus that the lakes can assimilate without exceeding the chlorophyll a objectives for oligotrophic or mesotrophic ranges is difficult. Table 3.4.1.5 indicates that with the assumptions described, including the assumed distribution of new units in areas tributary to each section of Porters Lake, the expected phosphorus concentrations should remain within the mesotrophic range for all of the growth scenarios considered, with some flexibility.

Chezzetcook Inlet

Bacteria concentrations are the limiting parameter in Chezzetcook Inlet. Although not measured as part of this study, Environment Canada and Department of Fisheries and Oceans have extensive measurements of E coli and Fecal coliform in Chezzetcook Inlet and as a result of their measurements have closed a portion of the area to shellfish harvesting. Concentrations regularly exceed the objective of less than 14 counts per 100 mL sample. Based on this assessment there is no assimilative capacity in Chezzetcook Inlet for additional E coli loads. Any additional development with potential to increase E-coli loads should be discouraged without measures to reduce current loads.

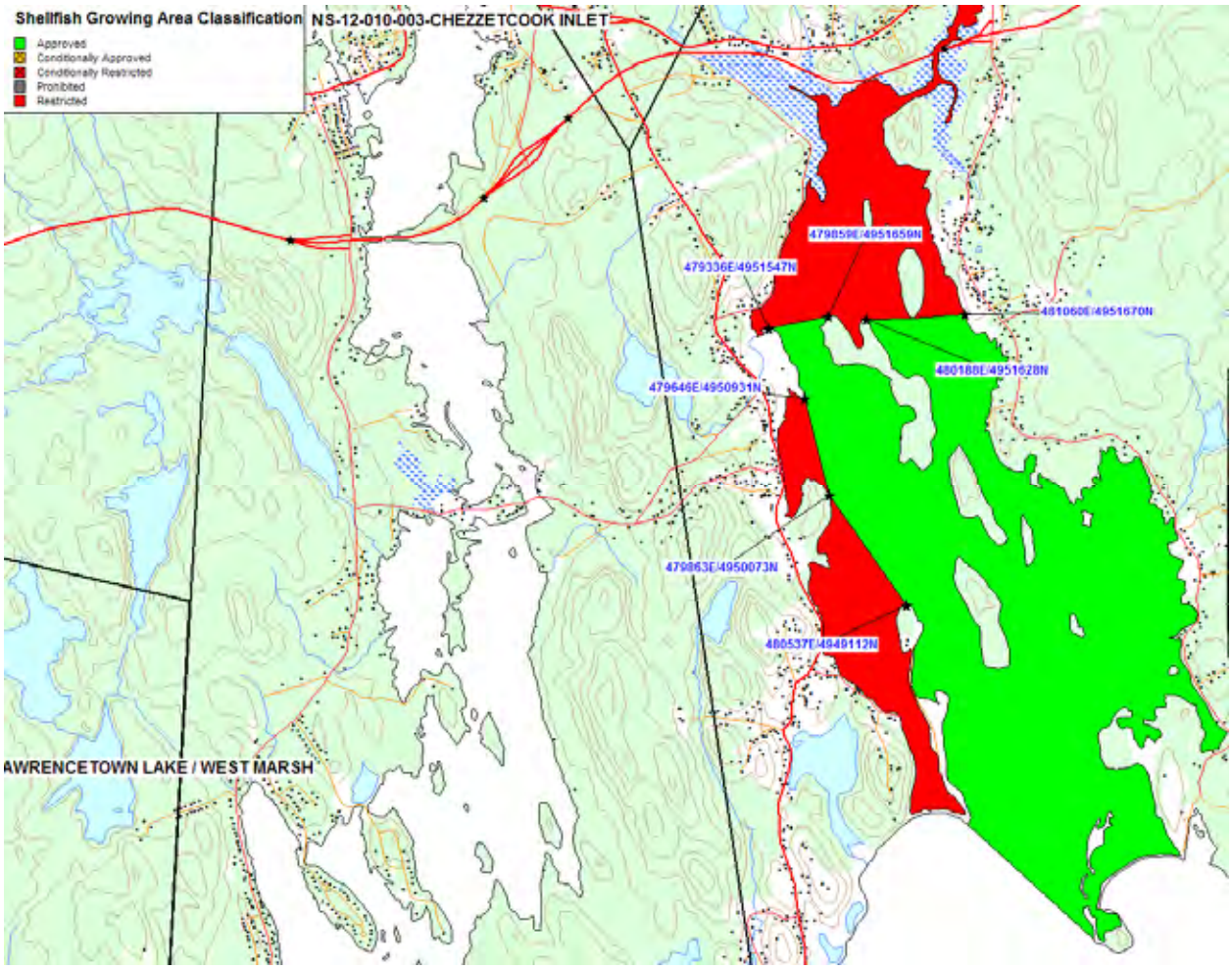
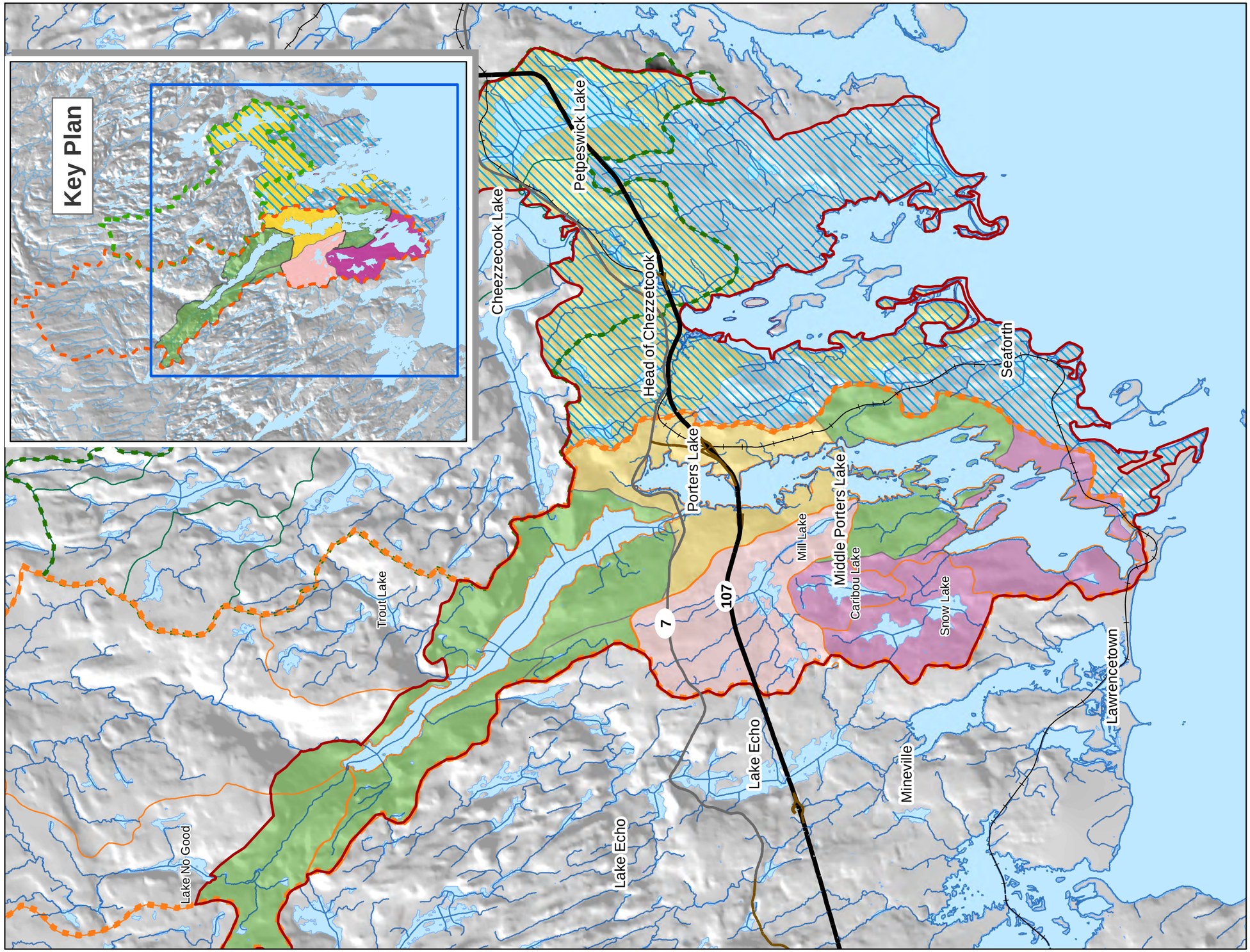


Figure 3.4.1.4(b): Environment Canada Shellfish Growing Area Classification - Chezzetcook Inlet 2010

Results of this assimilative capacity assessment are summarized in Figure 3.4.1.5. There is assimilative capacity in most of the Porters lake watershed for additional phosphorus loads, except for the areas tributary to Mill Lake. There were no E coli measurements above 200 counts so there is assimilative capacity with respect to E coli based on the HRM objective. There were individual E coli measures above 14 counts in all sections of Porters Lake but estimated average E coli concentrations were below 14 counts in the upper end of the lake (upstream of Highway 7) and at sample location PL 4, near the outlet from Section 3 to Section 4, the bridge on the Bellefontaine Road. There appears to be some assimilative capacity for additional E coli loads in these sections of Porters Lake based on the average of 14 counts objective suggested to ensure a safe habitat for fish and wildlife.



HALIFAX
REGIONAL MUNICIPALITY

Porters Lake Watershed/Servicing Study

- Study Area
- Porters Lake Subwatersheds
- Porters Lake Watersheds
- Cheezzetcook Subwatershed
- Cheezzetcook Watershed
- Area with High E. Coli Concentration in Receiving Waters
- Area with High TP Concentration in Receiving Waters
- Area with High TP and E. Coli Concentration in Receiving Waters
- Water Quality Characterization Required
- Areas Closed for Shellfish Harvesting by Environment Canada (2010)
- Area with Available Assimilative Capacity
- Rivers
- Hihgway
- Divided Highway
- Arterial
- Collector
- Railroad

CBCL LIMITED
Consulting Engineers

Assimilative Capacity Assessment

Drawn: YO	Date: May 2012
Checked: GS	CBCL Project # 101015.00
Approved: MD	

Figure 3.4.1.5

Notes:

Map Parameters

Projected Coordinate System: NAD_1983_UTM_Zone_20N
Projection: Transverse_Mercator
False Easting: 500000.00000000
False Northing: 0.00000000
Central Meridian: -63.00000000
Scale Factor: 0.99960000
Latitude Of Origin: 0.00000000
Linear Unit: Meter

0 750 1,500 3,000 Meters

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3.4.1.5 Development Scenarios and Associated Impacts

Projections for the development of the Porters Lake area were presented in Section 2.3.3. The impact that this development will have on the water quality of Porters Lake depends in part on the method of wastewater treatment and disposal. Some of the proposed development will proceed under the current practice of on-site septic systems on a household-by-household or cluster basis. In addition it has been assumed that half of the proposed development will be in the Core Area which will be serviced by a central wastewater collection and treatment system with an outfall for treated effluent that discharges into Porters Lake.

The impacts of the three growth scenarios for future development were considered. Estimated average mean annual total phosphorus concentrations in all five sections of Porters Lake for a range of wastewater treatment scenarios were generated, using the Nova Scotia Phosphorus Loading Model, Brylinski (2004). The results for tertiary treatment (including phosphorus removal) of wastewater generated in the Core Area with effluent discharging into Section 3 are provided in Table 3.4.1.5. It has been assumed that some of the on-site septic systems in Section 2 will be serviced by the proposed central system. This lowers the number of residences draining directly to Section 2 of Porters Lake and moves treated effluent to Section 3.

It is expected that effluent discharged from a treatment system serving 5200 people without phosphorus removal will lead to meso-eutrophic conditions on average in Sections 2 and 3 of the lake. Treatment with phosphorus removal is predicted to increase total phosphorus concentrations but is not expected to change the trophic status of any sections of Porters Lake.

3.4.1.6 Outfall Site Hydrodynamic Modelling

The topography of Porters Lake is characteristic of a long, narrow and, along some sections, deep estuary that is separated into distinct sections by road bridges. Flushing is limited due to the bridge constrictions, including the two bridges at its outlet that significantly restrict tidal passage. The upper section is deep and mostly freshwater, with virtually no tidal flushing. The middle section, between Highways 7 and 107, is strongly stratified. Measurements suggest that stagnant and anoxic water may occur in deep sections of the lake. A hydrodynamic model was developed to investigate effluent dilution patterns for potential outfall sites in Porters Lake, for development options that may include centralised wastewater treatment. The results of the investigations are presented in Figure 3.4.1.6

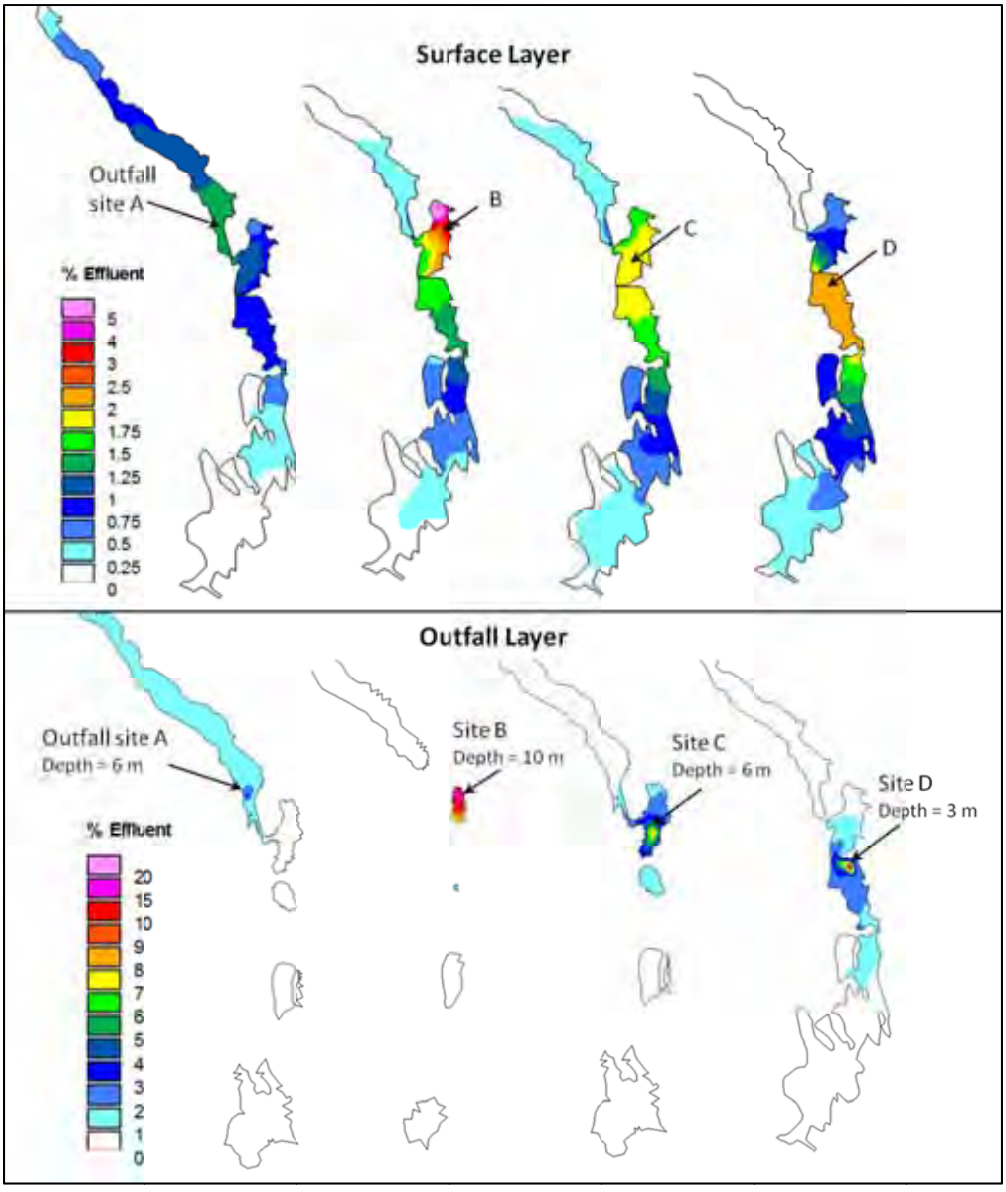


Figure 3.4.1.6: Modeled Maximum Effluent Concentrations for Various Outfall Sites

Notes: Assumed Effluent Flow = 7,690 m3/day (design peak rate);
Outfall Sites A, B, C, and D are approximate. A detailed siting study would be required as part of the design of the outfall.

A treated wastewater outfall should be placed as far downstream as possible and close to the main axis of the lake (sites C or D on Fig. 3.4.1.6). The outfall should not be placed in areas with long residence time, including the upper section of Porters Lake or deep areas that experience density stratification. For the assessment of the requirements for effluent water quality the receiving waters should be regarded as a freshwater lake. Provided that disinfection can bring down end-of-pipe concentrations of coliform bacteria to 200 CFU/100 ml, dilution and natural mortality will result in acceptable levels for primary contact. However, tertiary treatment and significant nutrient removal before discharge are recommended to minimize the risks of eutrophication in the outfall area and downstream.

3.5 Sources of Contamination

Sources of contamination are discussed in Chapter 4.4 of the component report in Appendix B.

Potential sources of contamination of surface waters and groundwater were investigated. Possible sources of water pollution and/or contamination, which may be of concern, include the following:

- Malfunctioning and failing sewage disposal systems, constructed on lots that are considered undersized for local site conditions by current standards. Of particular concern are the small lots around the lakes and on the western side of Chezzetcook Inlet. A 1983 report by the province of Nova Scotia states that "There is much evidence that many malfunctions of on-site systems are due to improper or inadequate maintenance. There are no regulations requiring such maintenance and many homeowners are unaware that periodic removal of solids from the septic tanks is even necessary."[10]
- Wastewater treatment plant treated effluent. Previous investigations identified a piped system along part of Highway 7 that conveys treated effluent from wastewater treatment plant(s) to the cove on Porters Lake adjacent Meadow View Drive and Highway 7. Although it is treated, the effluent may impact water quality in this cove, near water quality monitoring station PL2;
- Runoff and leachates from a variety of potential sources that are periodically washed off the land and discharged to the surface water systems as well as potentially infiltrate into the groundwater. Potential contributors to some of the most significant water quality issues observed include:
  - Phosphorus and nitrogen released from decaying and rotting vegetation or directly applied to urban areas as fertilizers; and
  - Pet wastes.

Other potential sources of contamination were identified by respondents to the water quality survey and by a windshield survey of the Study Area. These are described in the following paragraphs.

3.5.1 Surface Waters

Potential sources of contamination of surface water sources were investigated by asking respondents to the water quality questionnaire as well as by reviewing previous water quality investigations.

[10] Government of Nova Scotia. *Wastewater Management Districts*, 1983. As quoted in *Halifax Regional Municipality Municipal Planning Strategy for Planning Districts 8 & 9* with amendments to 18 November 2006.

3.5.1.1 RESPONSES FROM THE WATER QUALITY QUESTIONNAIRE

Respondents to the water quality questionnaire were asked to describe any potential past or current sources of contamination in each water body. Respondents described the following potential sources of contamination.

Potential Contaminants in Chezzetcook Inlet/Atlantic Ocean

- **Effluent from malfunctioning or failed septic systems;**
- **Construction/excavation/development too close to the water;**
- **Runoff from roads / road salt / NSTIR activities;**
- Proposed clam plant near Seaforth;
- Chemical fertilizers and pesticides;
- Tree cutting;
- Landfill/ dumping;
- Gas and oil leaks from boats;
- Automotive mechanic land use / works yards;
- Mineral extraction;
- Old cars/other machinery;
- Horses/livestock;
- Commercial uses near water; and
- Contaminated water flowing from inland into the inlet.

Potential Contaminants in Fresh Water Bodies

While there were some differences between lakes and certain residential developments, the majority of potential contaminants described in fresh water bodies included:

- **Failing or malfunctioning septic systems in general (domestic and school);**
- **Construction/excavation/development too close to the water;**
- **Runoff from roads / road salt / NSTIR activities;**
- **Chemical fertilizers and pesticides;**
- **Gas and oil leaks – domestic, from boats, old vehicles;**
- Tree cutting;
- Landfills / informal “dumps”;
- Automotive mechanic land use / works yards;
- Erosion and sedimentation;
- ATV use close to water;
- Gas stations;
- Run-off from exposed shale;
- Old mines / sawmills / gravel pits; and
- Commercial uses near lake (e.g. shopping centre businesses, marina).

3.5.1.2 REVIEW OF RESULTS FROM PREVIOUS INVESTIGATIONS

The Chezzetcook Harbour Pollution Control Study – ABL Environmental Consultants Limited, 1998 found a strong relationship between the occurrences of wastewater related pollutants in small water courses and the surficial soils in the areas tributary to the water courses. Pollutant concentrations were highest in the vicinity of West Chezzetcook and Grand Desert, on the western shores of the Harbour where the

soils are restrictive to infiltration. Additional problems occur with property sizes and arrangements. Properties in the areas where the problems are greatest are long and narrow, which doesn't allow for adequate separation of on-site systems and wells from property to property. The report indicated that approximately 25 % of the lots would meet the standard of the day for lot width.

3.5.2 Groundwater

Figure 3.5.2, illustrates locations and land uses that could be potential sources of contamination within the Study Area. Relative risk to source water are ranked from least risk to greatest risk, based on the *Nova Scotia Environment's Developing a Municipal Source Water Protection Plan: A Guide for Water Utilities and Municipalities, Step 3 Identify Potential Contaminants and Assess Risk*.

The terrain is a blend of softwood forest, mixed forest and wetlands. Low density housing and little industrial activity leads to generally local potential sources of contamination.

3.5.2.1 Agricultural Areas

There are two larger farms in the southwest corner of the study area and three smaller farms in the central and eastern part of the study area to the north of Highway 107. Hobby farms and livestock are the most likely uses of farms in the area, but limited crop production may be possible in the southwest. The requirement for irrigation and/or spraying is unknown. If water supply wells were to be located near farms, more detailed site reconnaissance would be required. Each of the farms could under specific conditions propose a threat to local shallow groundwater supplies under the direct influence of surface water (GUDI wells).

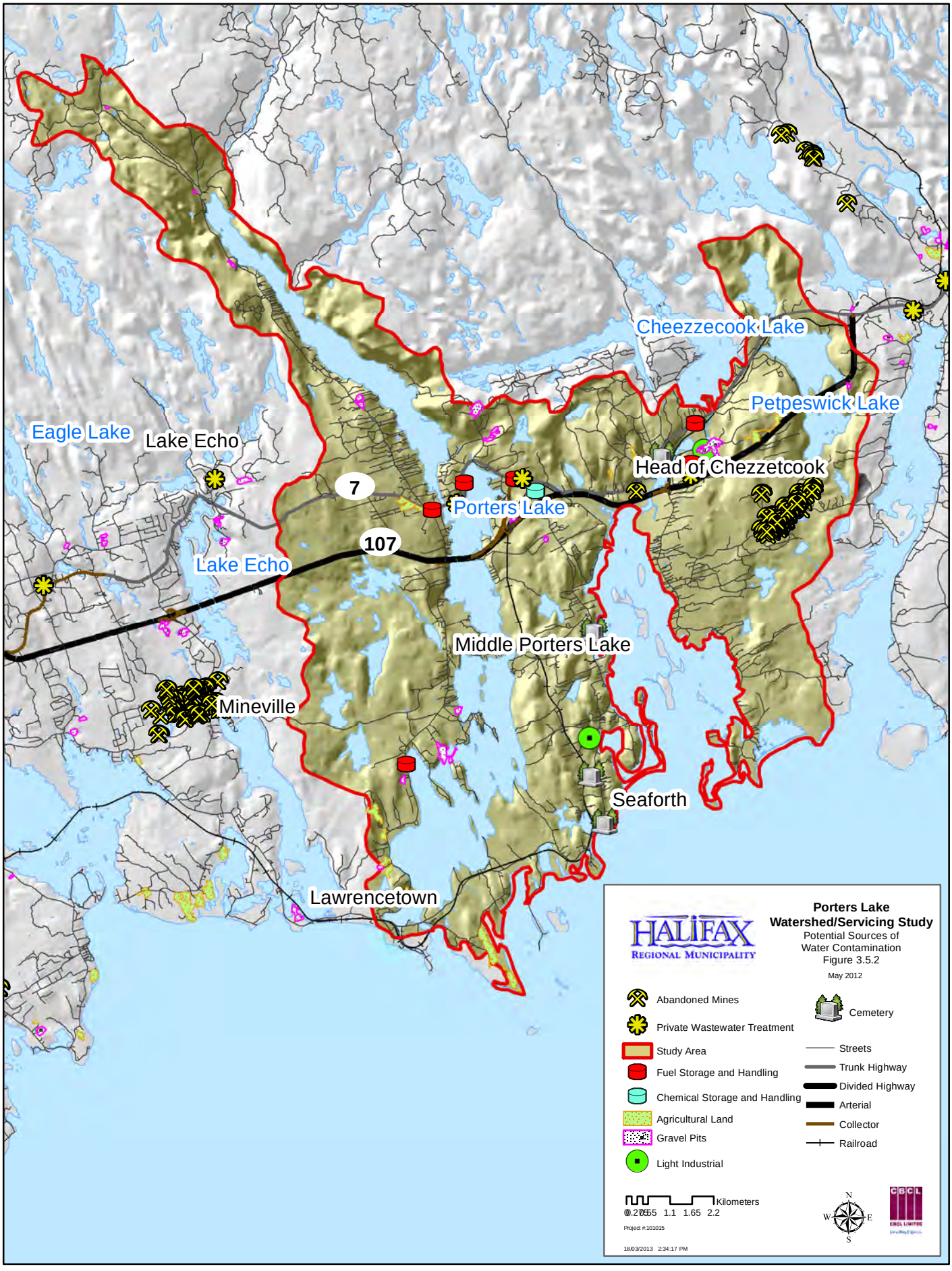
3.5.2.2 Pits and Quarries

Provincial mapping shows two smaller borrow pits near Porter's Lake Centre, and a larger inactive pit to the northwest. A large inactive quarry is located adjacent to the industrial park, and there is an active quarry on Alps Road, in the northwest boundary of the study area. Pits and quarries represent areas where contaminants released at the surface could short-circuit into the groundwater regime. High risk land uses should be prohibited near pits and quarries.

3.5.2.3 Light Industrial Activity

There are two small areas in the Porter's Lake Area supporting light industrial activity. The province of Nova Scotia operates the Eastern Shore Industrial Park adjacent to Highway 107, in the eastern half of the study area. This park operates on a private sewage disposal system, and hosts a chemical testing laboratory for industrial cleaners and degreasers. These chemicals could include dense non-aqueous phase liquids, posing a serious potential hazard to the underlying groundwater regime. Chemical storage and handling at this facility represents the greatest concern for a point source of contamination in the study area. The Chezzetcook Harbour Pollution Control Study indicated that the treatment plant was not operational at the time of that report and that it appeared that the majority of the flow into the lagoon system infiltrated to groundwater.

Zoning mapping from HRM indicates that there is a salvage yard in the community of Grand Desert, at the end of Bonin Road, to the west of Highway 207. Salvage yards have the potential to release gasoline, diesel, lube oil, paint, solvents, metals, and battery acid to the underlying groundwater regime.



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Siting of groundwater supplies should avoid both of these industrial zones, including the areas down gradient.

3.5.2.4 Cemeteries

There are four known cemeteries in the study area, all associated with churches located on main routes. Three of these are located on Highway 207, on the southwest arm of the study area. The cemeteries in the study area would be expected to affect local shallow groundwater supplies.

3.5.2.5 Abandoned Mines Within the Study Area

The Catcha Lake area on Mines Road is host to a historically significant gold mining district of Nova Scotia. There are over 170 abandoned mine shafts, open cuts, and pits located between East Chezzetcook and West Petpeswick. One additional shaft is located at the Head of Chezzetcook. Gold deposits are commonly associated with elevated concentrations of arsenic.

Tailings deposited near the shafts and at gold ore processing sites can generate significant source zones of arsenic. Process streams are also associated with elevated concentrations of cyanide. Arsenic originating in flooded tailings ponds or flooded shaft may be present in its reduced form (AsIII), which is relatively mobile in aquifers. This mining district could present an obstacle to obtaining a reliable groundwater supply in the area.

3.5.2.6 Sand/salt storage facilities

There is a NSTIR operations site located on Highway 207 near its intersection with Highway 107 that includes equipment storage and maintenance sheds and a salt storage dome. Contingent on effective containment measures and safe handling practices, this site may serve as a source of elevated chloride concentrations. Chloride, although not a health-related contaminant, is persistent and mobile in groundwater environments, and can render water supplies unusable.

3.5.2.7 Fuelling and Service Stations

There are two active gas stations located on the Porter's Lake strip mall, on Highway 7. Two former garages or gas stations were noted at other locations along Highway 7. The industrial park appeared to host an equipment shed or machine shop. The presence of the gas station in Porter's Lake Centre, where development is likely to be most intense, could pose a threat to water supplies obtained locally.

Fuelling stations are equipped with one or more underground storage tanks (UST) for gasoline and diesel fuel. Older tanks can deteriorate and develop perforations, releasing fuel to the subsurface environment and generating significant source zones for groundwater contamination. Garages may use and store lube oil, degreasers, and paint. Older garages often have oil change pits and sumps excavated directly into the underlying soil, creating a direct conduit for flow of contaminants into the subsurface.

3.5.2.8 Private Sewage Disposal Systems

There are three known private sewage disposal systems in the study area: the Marina Mobile Home Park, the Lakeview Consolidated School, and the Eastern Shore Industrial Park. Gaetz Brook Junior High School was noted on Highway 7, near the northwest shore of Petpeswick Lake. The school is on a septic tank and conventional septic bed.

Sewage treatment systems can impart elevated concentrations of bacteria, viruses, dissolved organic carbon, biological oxygen demand, chloride, nitrogen compounds, phosphates, pharmaceuticals, and personal care products (e.g. acetaminophen, caffeine, codeine, nicotine, antidepressants, antibiotics, and estrogenic steroids). High rates of extraction in areas where the density of sewage treatment systems is relatively high could impart contaminants to drinking water.

3.5.2.9 SEAWATER INTRUSION

Development to the south of Porter's Lake Centre is focused along two main roads, Highway 207 to the west of Chezzetcook Inlet, and Chezzetcook Road to the east of Chezzetcook Inlet. Large scale use of groundwater in these coastal areas could lead to seawater intrusion. High pumping rates in coastal areas draw the freshwater-seawater interface inland. This effect could compromise existing wells closer to the coastline and eventually compromise the pumping well itself.

3.5.2.10 LOCATION OF PAST SPILL EVENTS

In order to determine the location of past spill events within the Study Area, an Environmental Registry Search must be requested from Nova Scotia Environment and Labour. A Search must be requested for each property in question at a cost of $21.30 per civic address. This Search can also provide information on:

- Approvals issued under the *Environment Act*;
- Certificates of qualification issued under the *Environment Act*;
- Certificates of variance issued under the *Environment Act*;
- Orders, appeals, decisions and hearings made under the *Environment Act*;
- Notices of designation given pursuant to the *Environment Act*;
- Notices of a charge or lien given pursuant to the *Environment Act*; S.132;
- Policies, programs, standards, codes of practice, guidelines, objectives,
- Directives and approval processes established under the *Environment Act*;
- Convictions, penalties and other enforcement actions brought under the *Environment Act*;
- Information or documents required by the regulations to be included in the registry;
- Annual reports;
- Petroleum storage tank registration information; and
- Well log information.

When potential areas for groundwater supply are confirmed it will be necessary to request a search for registered storage tanks and other point sources. The results of each Environmental Registry Search are available two to four weeks after the request is made.

3.6 Stormwater Management

HRM's stormwater management guidelines describe stormwater best management practices to improve water quality in the water bodies in the Study Area affected by existing development as well as to minimize the risk of further degradation of water quality by future development.

3.6.1 Measures to Improve Existing Water Quality

Receiving water assessments indicated that E. coli concentrations in Porters Lake are at times above the 14 counts objective in sections 2, 3 and 5. Maximum measured results in the summer and fall are highest and suggest that monitoring should be conducted during these periods. As shown in Figure

3.4.1.4(b) E coli concentrations in Chezzetcook Inlet have led to the closure of areas of the inlet for shellfish harvesting.

Sources of these bacteria are typically failing onsite wastewater treatment systems and stormwater from urban development as well as direct deposits from local lake residents such as ducks and other waterfowl. While there is not much that can be done to deter the waterfowl, investigations can be undertaken to locate the other sources.

The second water quality concern is the trophic status of portions of Porters Lake. The assimilative capacity assessment (section 3.4.1.5) indicated that the risk will increase as development in the tributary watershed continues. Sources of phosphorus associated with development are typically failed onsite wastewater systems, surface runoff that has come in contact with lawn fertilizers etc. as well as discharges from existing and potential wastewater treatment plants.

To identify the sources requires the following measures:

- Sampling and analysis of tributary drainage systems;
- Identification of point sources of the pollutants in suspect areas; and
- Testing of onsite wastewater systems as well as local water supply wells as described in section 3.11.

Once point sources are located, failed onsite systems may be replaced or reconstructed with systems designed to meet current standards for those located outside of the Core Area, or by central services in the Core Area. Non-point sources may be reduced by:

- Education of residents in the community at large and in particular residents in the areas with significant sources of bacteria or other pollutants;
- Development of stewardship programs for local residents to encourage them to identify the sources and work to remove them; and
- Design and implementation of stormwater treatment systems to remove the remaining pollutants to a level that can be assimilated by the lakes and still meet the receiving water objectives. Locating facilities to accomplish treatment of stormwater is very difficult in areas where development has already occurred; some innovation is typically required.

3.6.2 Measures to Reduce the Risk of Further Degradation of Water Quality

Given current water quality in Porters Lake and Chezzetcook Inlet, stormwater management plans should include measures to minimize additional pollutant loads to all receiving waters and to reduce the current loads to these water bodies. This requires the following measures for any new development prior to discharging to the environment:

- Reduction of stormwater flows at source;
- Attenuation of peak runoff flows; and
- Treatment of stormwater.

These objectives can be achieved by:

- Implementing low impact site development, minimizing the affected footprint, and providing measures to:
  - Promote infiltration, particularly infiltration of the cleanest runoff;
  - Attenuate flows from individual properties and developments;

  - Maintain dispersed stormwater systems, minimize the concentration of stormwater;
  - Decrease the efficiency of the stormwater collection systems on private properties;
  - Minimize erosion potential; and
  - Provide treatment to remove pollutants;
- Decreasing the efficiency and increasing potential for infiltration in local stormwater collection systems;
- Treating runoff from the local drainage systems; and
- Enacting current guidelines that require deep storm sewers or clear water sewers be provided where sanitary sewers are provided. In Porters Lake, central wastewater collection systems are only envisioned in the Core Area. Clear water sewers to convey foundation drainage away from each property will be required in the Core Area. These will discharge relatively constant clean flows directly to the local drainage systems with minimal impact.

Groundwater is currently the main source of water in the community and will play a significant role in water supply for future development in the community. Groundwater quantity and quality must not be compromised. Erosion prevention measures for protection of "clean" sources of runoff and stormwater best management practices including, treatment of stormwater with potential contaminants and infiltration of the cleanest water to recharge the surficial aquifer should be promoted, including:

- Rain gardens;
- Permeable pavements;
- Sediment, oil and grease separators; and
- Infiltration systems.

These measures are considered further in Chapter 4.

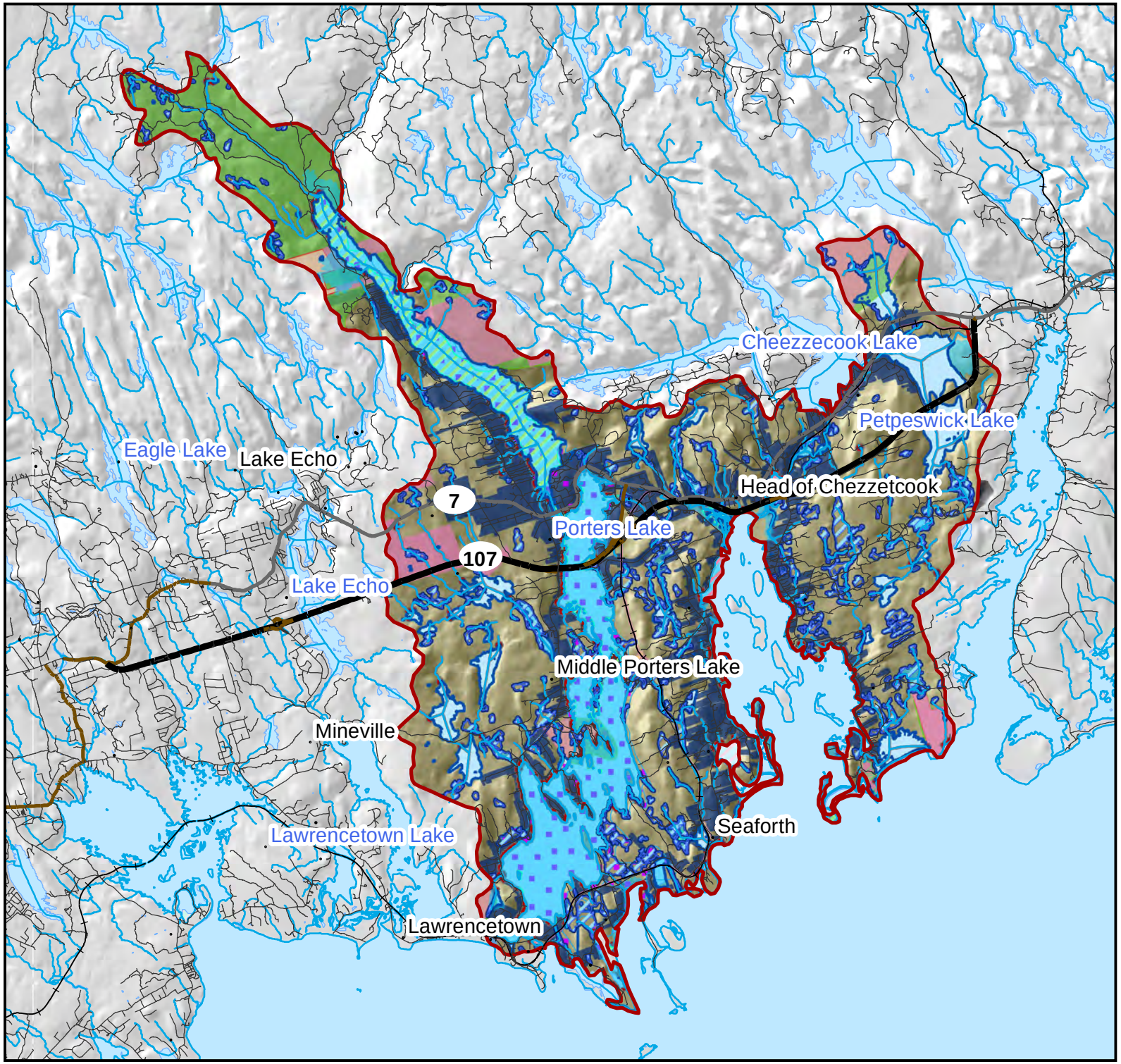
3.7 Means to Reduce and Mitigate Loss of Important Environmental Functions

A key method to reduce and mitigate the loss of permeable surfaces, native plants and native soils, groundwater recharge areas, and other important environmental functions within the watershed is to concentrate development in appropriate areas reducing the footprint of the area impacted and leaving larger areas unaffected by development. This approach is applicable at two scales: one related to the overall locating of development and the other dealing with detailed site planning.

3.7.1 Locating Development

Certain areas within the Study Area are considered unsuitable for development on the basis of their capability, regulatory restrictions or their environmental sensitivity. Figure 3.7.1 illustrates **"No Go" areas** based on the following criteria adapted from *A Guide to Open Space Design Development in Halifax Regional Municipality* (HRM, 2007) and other sources:

- Existing development;
- Water bodies, watercourses and designated wetlands;
- Watercourse, wetland and coastal buffers;
- Provincial parks, reserves, and provincial crown lands;
- Cemeteries;
- All lands below elevation 2.5m;



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- Streets
- Trunk Highway
- Divided Highway
- Arterial
- Collector
- Railroad
- Wetlands
- Wetlands 20m Buffer
- Lakes 20m Buffer
- Salt Marshes
- Less Than 2pt5m ASL
- Nondesignated Park Reserve
- Rivers 20m Buffer
- Existing Regional Parks
- Areas of Elevated Archaeological Potential
- Areas of Elevated Cultural Significance
- Provincial Crown Land
- Protected Areas
- Protected Beaches
- Provincial Parks
- OpenSpace and Natural Resources Network
- Developed Areas
- Study Area

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Areas that Should Not Be Developed (No-Go Areas)

Drawn: YO	**Date: May 2012**
Checked: GS	**CBCL Project # 101015.00**
Approved: MD	

Figure 3.7.1

Notes:

Map Parameters

Projected Coordinate System: NAD_1983_UTM_Zone_20N
Projection: Transverse_Mercator
False Easting: 500000.00000000
False Northing: 0.00000000
Central Meridian: -63.00000000
Scale Factor: 0.99960000
Latitude Of Origin: 0.00000000
Linear Unit: Meter

N W E S

0 1,000 2,000 4,000 Meters

File Path: L:\101015 Lake Echo\101015_Layout\101015 - Porters Lake\101015 Porters Lake - Areas that should not be developed (No_Go).mxd Last Saved: 18/05/2012 5:12:52 PM

- Significant wildlife habitat and endangered species as per map 5 of the Regional Municipal Planning Strategy;
- Areas of elevated archaeological potential as per map 11 of the Regional Municipal Planning Strategy; and
- Lands of high cultural significance as per category 5 on map 10 in the Regional Municipal Planning Strategy.

The HRM Regional MPS proposes the development of a new regional park northwest of Porter Lake. While the proposed boundaries of the park have not been established, the Regional MPS states that lands within the Porters Lake park will be publically owned[11]. Therefore in this study, all publicly owned lands in the area of the proposed park are set as "No-Go" areas.

3.7.2 Detailed Site Planning

The HRM Regional MPS allows large-scale residential development by development agreement if it is in some form of Open Space Subdivision Design in order to limit development in environmentally sensitive areas and preserve a connected system of open space. Within an overall development site, development may occur in the areas outside the "No-Go" areas defined above. Where "No-Go" areas exist within an overall site, development should be located so that the "No-Go" areas remain undeveloped (see Figure 3.7.2(a)).

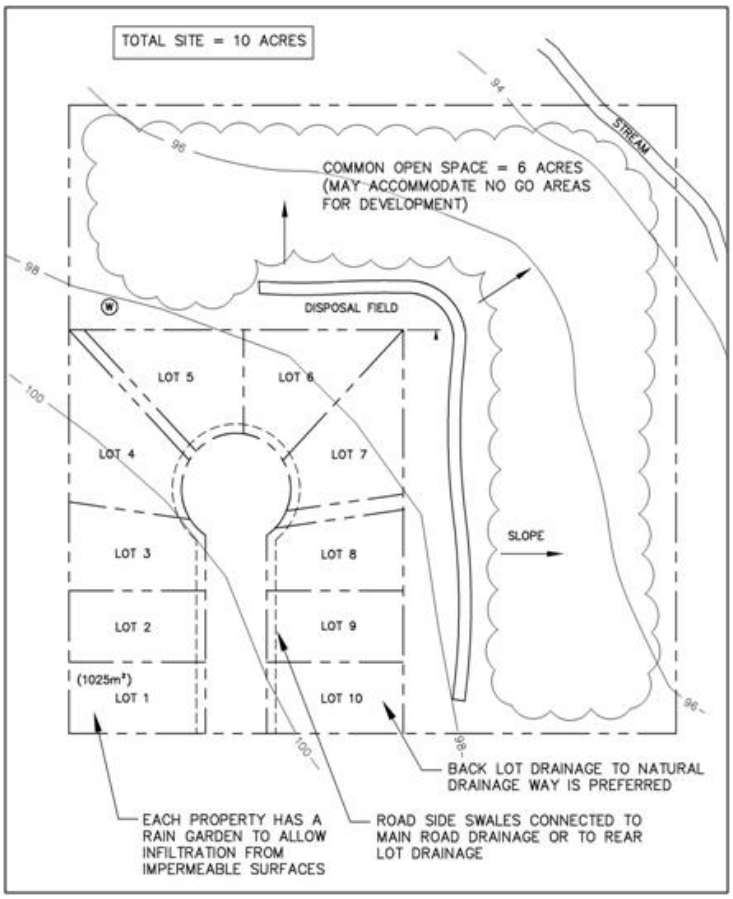


Figure 3.7.2(a): Schematic Drawing of an Open Space Subdivision Design

In the Core Area, open space subdivision design will not allow the density of development that is required to create a walk-able, transit oriented centre. A development style in line with older small town areas in Nova Scotia is appropriate. The provision of central services will enable this density of development.

In both the denser Core Area and the more rural outlying areas, land development should be done through responsible design –a process that takes into consideration and addresses the environmental functionality of the landscape. There are many references to this concept; three well known texts include McHarg's, *Design with Nature (1969)*; Hough's, *City Form and Natural Process (1984)*, and Forman and Gordon's, *Landscape Ecology (1986)*. All three texts refer to the idea that design, in order to be successful, must acknowledge, understand and respond to the ecological processes of the land.

[11] HRM Regional Plan with amendments to 08 May 2010.

More recent texts include Randall Arendt's *Growing Greener (1999)* and *Envisioning Better Communities (2010)*. These works provide guidance on site planning and design approaches that will assist in reducing and mitigating the loss of permeable surfaces, native plants and native soils, groundwater recharge areas, and other important environmental functions.

Responsible site planning and design can mitigate the loss of permeable surfaces (such as paved driveways, rooftops) through a variety of approaches such as the provision of multiuse land areas for recharge. Lawn areas, for example, can be designed to act as surface runoff detention areas, as well as aesthetic and recreational areas. Driveways can be designed to be more permeable through the use of unit pavers, and roof drains can be designed to discharge into soft landscaped areas or "rain gardens". In other cases, it may be more desirable to have impermeable surfaces directing runoff to recharge areas depending on the situation. The point is that in each case the question of recharge needs to be addressed at the community level as well as on each property in the community.

Good design should incorporate the use of native landscape, topography and native vegetation into the site development (see Figure 3.7.2(b)). Rather than stripping a site bare and completely reforming the topography, buildings should be placed in the landscape and the areas disturbed for construction should be limited to the smallest reasonable area. Open space or conservation subdivision design should make this easier to achieve because the smaller footprint of development will allow development areas to be placed strategically within the site enabling the preservation of important natural and cultural features.



Figure 3.7.2(b): Schematic of Development that Reflects Natural Conditions

Using the natural landscape and vegetation reduces the requirement of artificial irrigation, maintains natural infiltration areas and helps to conserve native soils, the wildlife and its habitats that all help to define the place. Since the permeability of the surrounding landscape is directly related to groundwater recharge and well water, homeowners, and developers alike, should be aware of the potential impacts associated with unnecessarily large construction footprints. Clearing a lot for ease of construction purposes does nothing to conserve the surrounding environment. Landscaping to re-establish the vegetation once lost after construction further mystifies the very intention of the development in the first place. Through responsible design, however, successful land development can be both conscientious of the environment and at the same time provide safe and healthy communities in which to live, work and play.

3.8 Methods to Reduce Cut and Fill and Overall Grading

To reduce cut and fill and overall grading of development sites, the use of open space subdivision designs enables a significant portion of the site to remain undisturbed. Developers should be

encouraged to work with the land to strategically place developed portions of the site in areas where cut and fill can be minimized.

Respect should be given to slopes. Contour development should be practised in roadway design to reduce cuts and fills and steep grades.

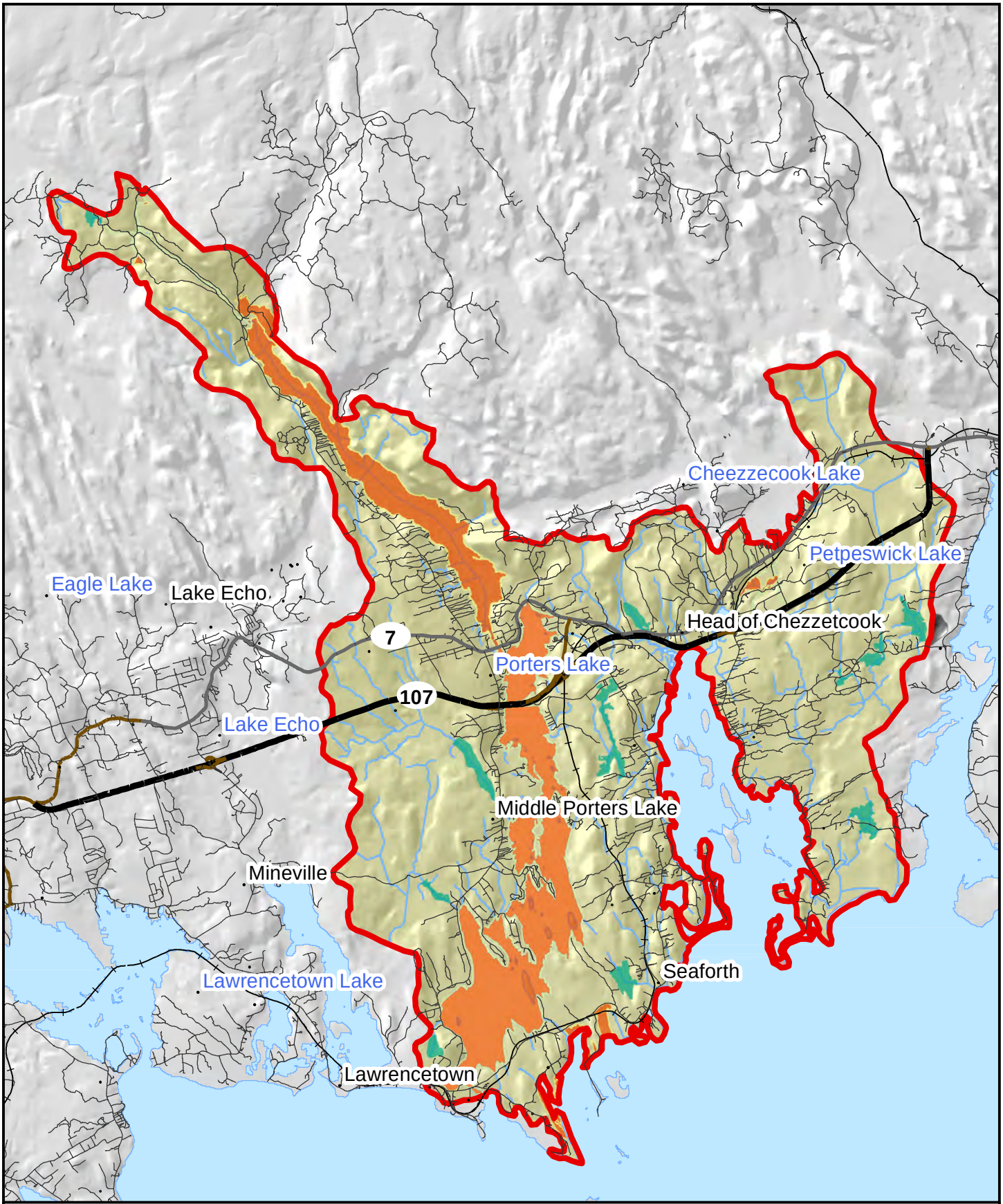
Lower areas of the site and drainage-ways should be preserved. Development should be placed on higher ground where run-off can be directed to these natural drainage-ways. Run-off does not always have to be directed to the street. Where appropriate, run-off can be directed to the backs of lots where slopes enable this and natural drainage-ways exist. To reduce its erosive force as much as possible, run-off should be dispersed and not concentrated.

3.9 Identify and Recommend Measures to Protect and Manage Natural Corridors and Critical Habitats

Habitats and species at risk are described in Appendix E.

As mentioned above, the use of open space subdivision designs should more easily enable the preservation of undisturbed areas and the establishment of the upland buffers along watercourses and wetlands. The “No-Go” areas identified on Figure 3.7.1 include natural corridors and critical habitats as identified though the HRM Regional Plan. Development should be setback from identified critical habitat areas and buffers appropriate to the species being protected need to be established. For example, certain birds may need buffers of up to 100 metres from road noise to preserve nesting habitat, while a stationary plant could have a much smaller buffer. Habitat fragmentation can have a major impact on species viability. It is therefore recommended that as far as possible, contiguous blocks of undisturbed lands be preserved across multiple properties and that only extremely limited road crossings of these areas be allowed. This is especially critical for Red Species and Yellow Species areas identified on Map 5 of the Regional Municipal Planning Strategy (see Figure 3.9).

Erosion and sedimentation can also have a significant impact on habitat. In addition to preserving undisturbed portions of the site, specific building sites should only be cleared when construction is ready to proceed. Large swaths of land should not be cleared months or years in advance and left without groundcovers that limit erosion.



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Figure 3.9 Significant Habitats and Endangered Species in the Study Area
May 2012

CBCL Project # 101015
Data Sources: HRM, NSDNR
Coordinate System: NAD 1983 UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

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3.10 Identify Appropriate Riparian Buffers and Recommend Other Methods for Protection of Critical Habitats

It is recommended that buffers along all watercourses be brought in line with the Nova Scotia Department of Natural Resources *Wildlife and Watercourses Protection Regulations*, which states that for watercourses with channel widths over 50 cm, upland buffers are to be a minimum of 20 metres on either side of the watercourse and where average slopes within that area exceed 20%, the width is to be increased by one metres for each 2% of slope, up to a maximum of 60 metres in width. These buffers should also be established for wetlands over 1 hectare. Measurements of the upland buffers should start at the top of bank or edge of wetlands associated with the watercourses.

Stormwater management and the maintenance of existing flow conditions including quantity, quality, temperature, time of concentration, etc. are critical to the protection of aquatic habitats. Erosion and sedimentation controls as per Nova Scotia Environment requirements should be implemented. Limiting of areas to be cleared and only clearing sites when construction is imminent will also serve to reduce run-off and erosion issues that could affect water quality.

Specific concerns regarding erosion and sedimentation along Porters Lake have been mentioned by residents of the area. Given that there are sensitive areas in the lake, including the deep, stagnant areas, it is recommended that the buffer along the lake be increased to a minimum of 30 metres. A continuous strip of natural vegetation, a minimum of 10 metres wide, is recommended on both sides of all water courses and around all lakes and wetlands.

The use of open space subdivision designs should more easily enable the preservation of undisturbed areas and the establishment of the upland buffers.

3.11 Sanitary Survey

A sanitary survey was completed in the study area to assess the make-up and performance of existing on-site wastewater treatment and dispersal systems as well as onsite water supply systems. Details of the assessment and the findings are provided in the component study report in Appendix H.

The sanitary survey was not intended to be an all inclusive program, only a sampling program of onsite systems in the study area. Locations for the survey were selected based on the findings of the surface water quality assessments. These assessments determined that the greatest concerns with water quality were in the system tributary to the cove adjacent Station Road in Section 2 of Porters Lake and in Chezzetcook Inlet. Areas tributary to these systems became the focus of the sanitary survey; to determine how much the onsite wastewater systems might be contributing to the water quality issues in these water bodies.

Onsite systems are considered to have failed when they discharge untreated or partially treated wastewater to surface waters or groundwater. Factors such as the type of system, the slope of the land, the nature and depth of surficial soils were considered in the generation of the onsite suitability mapping for HRM.

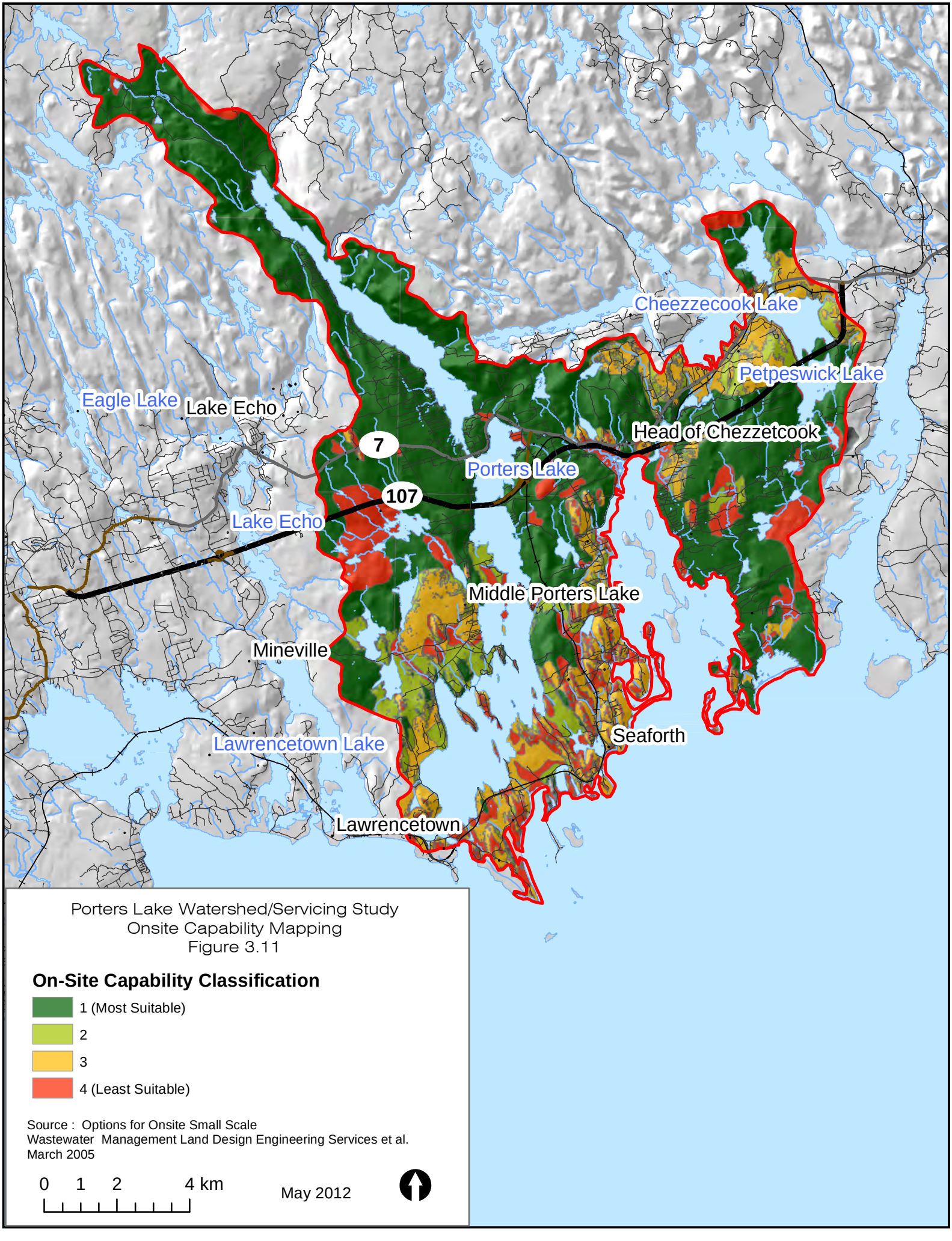
Figure 3.11, reproduced from the onsite study completed by Land Design Engineering in 2005[12], indicates that in general the soils in the eastern portions and northwest sections of the Study Area are considered most suited for onsite systems. Sites on the western shores of Chezzetcook Inlet and Porters Lake are less suitable. Other factors, including the size of the lot and the arrangement of the system on the lot, affect the capacity of an onsite system to successfully treat sewage before it is released to the environment. Discussions with local installers indicated that the failed systems they have replaced have been in areas of unsuitable soils and on lots that do not meet current Nova Scotia Environment standards for the design of onsite wastewater systems.

Properties with the greatest potential for onsite wastewater systems to fail were visited in an effort to confirm suspicions that these were the systems that generated pollutant loads to the receiving waters. Residents were asked to voluntarily participate in the survey at the level where they felt comfortable. Some agreed to fill out a questionnaire with the survey team. Each property owner that completed this phase was asked to allow the team to complete a dye test on the wastewater system (dye is flushed and the area monitored for a two week period for signs of the dye (and septic tank effluent) at the surface).

Table 3.11: Summary of the Sanitary Survey Findings

Survey Results	Number	
Total Visits	282	
Surveys Completed	85	30.1%
Dye Tests Completed	6	2.1%
Suspect or Inadequate Systems	34	40.0%
Systems that Failed the Dye Test	0	
Onsite Wastewater System Types		
Area Bed	60	70.5%
Contour Systems	13	15.3%
No Septic	5	5.9%
Chambers	3	3.5%
Holding Tanks	2	2.4%
Peat Filter	1	1.2%
Cesspool	1	1.2%
Water Source		
Dug Well	45	52.9%
Drilled Well	31	36.5%
No Water	5	5.9%
Lake Water	4	4.7%
Do Not Drink Water =	16	18.8%
Water Treatment =	34	40.0%
Water Samples Collected	6	2.1%
Positive Results for E coli	0	0.0%
Aesthetic Parameter Concerns identified in the sampled wells	10	

[12] Land Design Engineering Services et al. March 2005. Options for Onsite & Small Scale Wastewater Management.



Porters Lake Watershed/Servicing Study
Onsite Capability Mapping
Figure 3.11

On-Site Capability Classification

- 1 (Most Suitable)
- 2
- 3
- 4 (Least Suitable)

Source : Options for Onsite Small Scale Wastewater Management Land Design Engineering Services et al. March 2005

0 1 2 4 km

May 2012

There was a very low participation rate in the dye testing program, 6 dye tests were allowed out of 85 surveys completed. Although assured that the results would remain confidential, property owners were reluctant to participate, fearing that neighbours would observe the dye and know that their system failed as well as the financial repercussions of a failed system. No failed systems were identified by the dye testing program. This is not proof that the existing systems provide suitable treatment; only that at the time the dye tests were completed none of the wastewater flows came to the surface.

All of the sampled wells had measured water quality parameters that exceeded guideline values for drinking water. These are summarized as follows:

- Water quality issues with the 5 dug wells sampled included elevated concentrations of:
  - Iron and manganese in all but one well;
  - Aluminum in a couple of the wells; and
  - Lead, likely related to the plumbing system, almost 5 times the guideline concentration. The owners indicate that they do not drink the water.
- Water quality issues with the single drilled well sampled in Porters Lake included elevated concentrations of iron and manganese.

CHAPTER 4 ALTERNATIVES FOR SERVICING THE STUDY AREA

Wastewater, stormwater and water servicing needs in the community were investigated and the results are summarized in this chapter. Additional information from contributing assessments may be found in the Servicing Study Report in Appendix F.

4.1 Services in the Core Area

The terms of reference for this study states that "the objective of the servicing component study will be to assess in greater detail, options for servicing the lands within the Porters Lake Centre with central water and sewer." Services considered include:

- Wastewater collection and treatment;
- Stormwater management, includes a deep storm sewer where sanitary sewers are located; and
- Water supply, treatment and distribution.

Figure 4.1 shows undeveloped blocks of land in the Core Area. These were used to develop potential schemes for progression of development in the Core Area. It was assumed that the first areas to develop would be those closest to a potential transit centre located near the intersection of Highway 7 and the William Porter Connector from Highway 107. As development continues it would progress away from this centre, ideally it would be symmetrically about the centre.

4.1.1 Wastewater Collection and Treatment

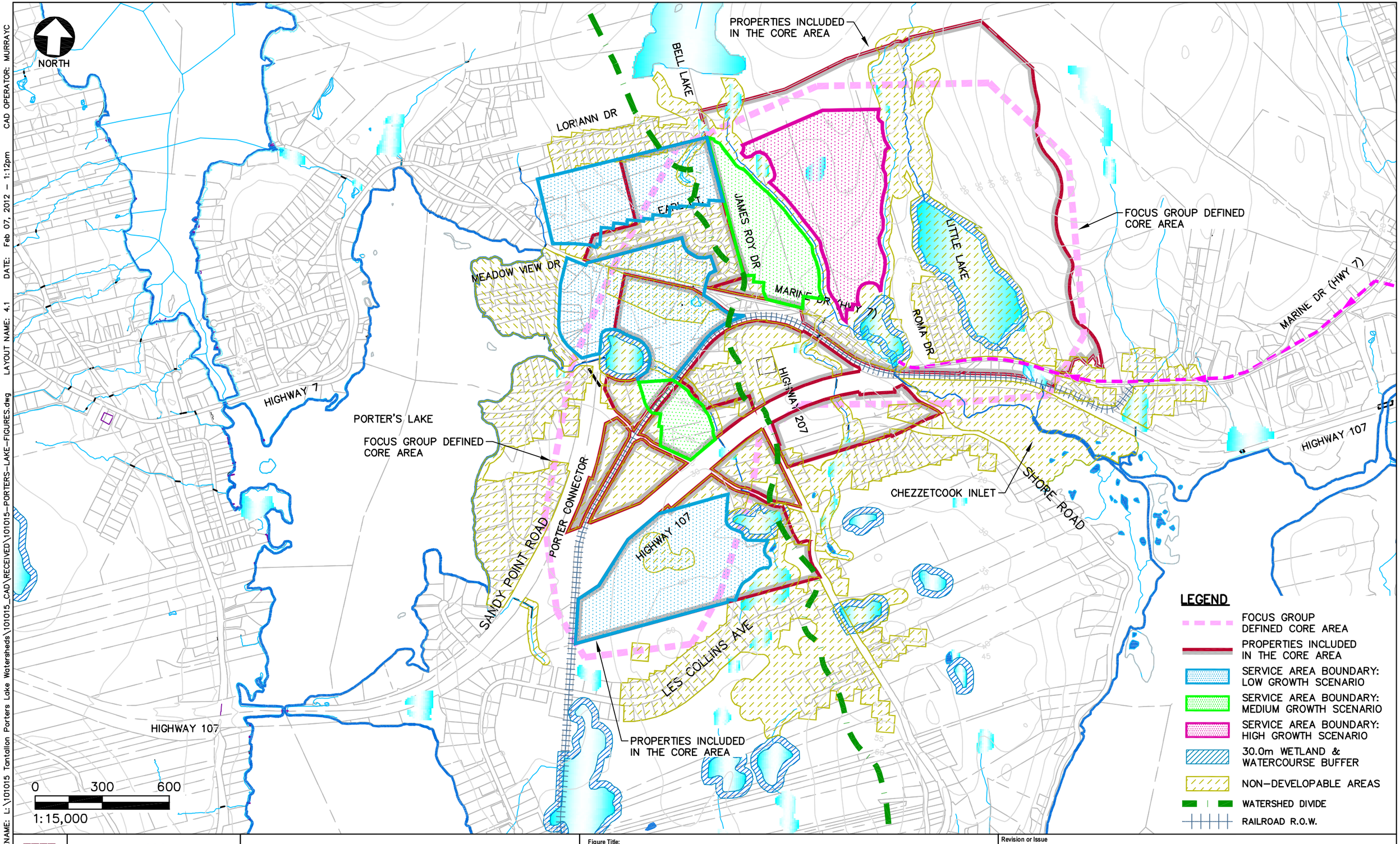
As shown on Figure 4.1, the Core Area is divided by topography into two sections:

- Areas tributary to Porters Lake- all areas west of the watershed divide that runs parallel to Highway 207 and James Roy Drive; and
- Areas tributary to Chezzetcook Inlet including all areas east of the watershed divide.

4.1.1.1 AREAS TO SERVICE

Initially two schemes were considered for wastewater services in the Core Area, based on the topography:

- Collect all wastewater to a single treatment plant with a single outfall to one of the potential receiving water bodies, Porters Lake or Chezzetcook Inlet; and
- Collect wastewater from the two tributary systems and discharge treated effluent into both potential receiving waters.



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Porters Lake Watershed/Servicing Study

Figure Title:

Phased Development of Undeveloped Land in the Core Area

Revision or Issue			
Drawn: MEC	Designed: EMD	Checked: GS	Approved: EMD
Scale: 1:15,000	Project No: 101015.00	Date: JAN 2012	Figure No.: 4.1

A feasible arrangement of the components necessary to service existing development and provide capacity for additional inputs from future development is shown on Figure 4.1.1(a) for a single plant scenario, on Figure 4.1.1(b) for the duel wastewater treatment plants scenario.

A cursory assessment of the alternative with two treatment plants indicates that treatment costs (capital and operation) would be almost double compared to the costs for a system with a single treatment plant. These are major costs, making the costs of this concept much higher than the costs of a concept with a single wastewater treatment plant. Therefore, this concept was not considered further.

4.1.1.2 Wastewater Collection and Treatment Systems Considered

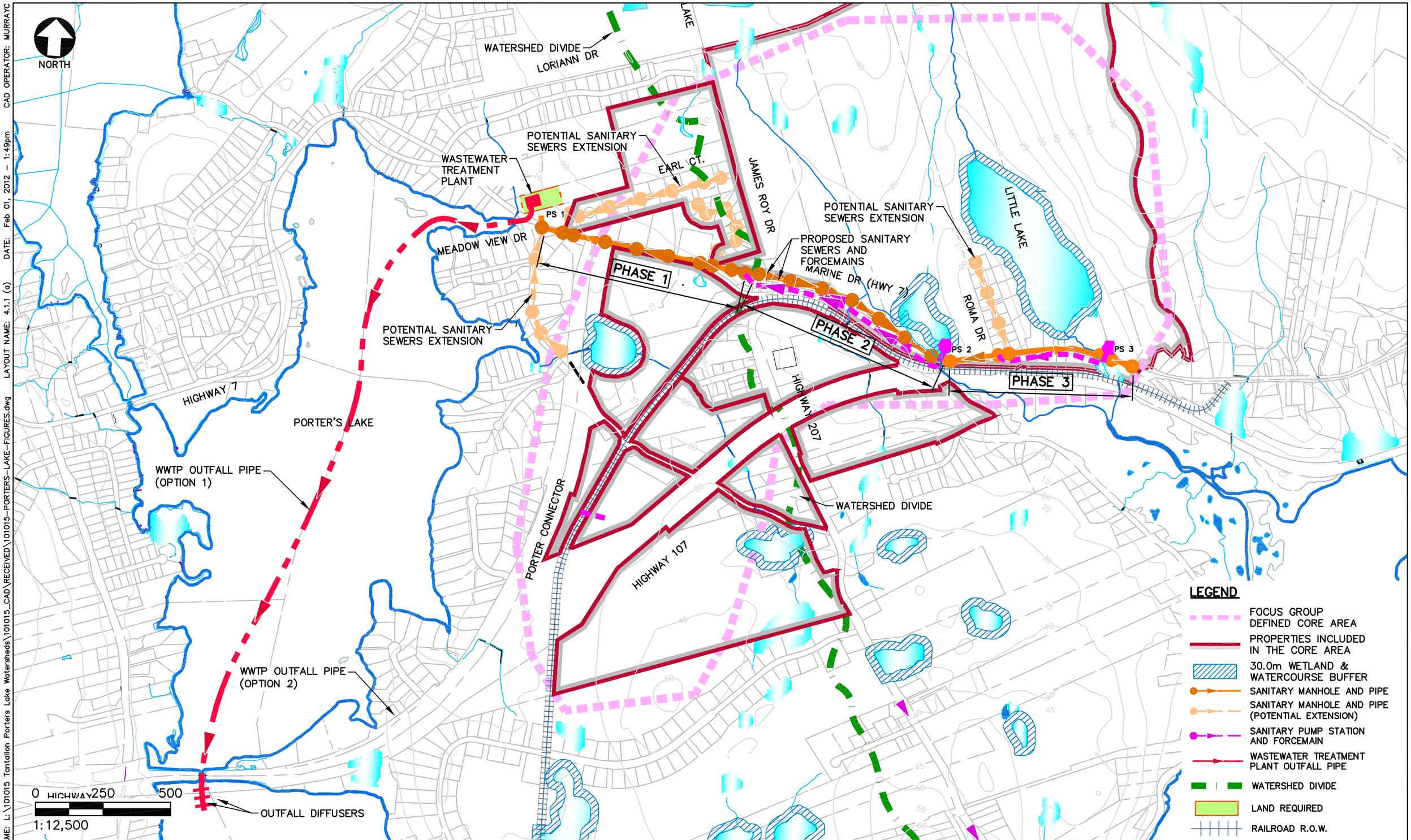
Existing wastewater treatment is typically provided by onsite wastewater systems, as described in section 3.11. A review of lot sizes in the study area indicates that:

- Many of the existing lots in the Core Area are smaller than 4,500 square metres, the minimum lot size required by today's standards for typical onsite systems in good soils that are a minimum of 600 mm deep. Several lots on a waterway, or with lake or ocean frontage are less than 3,716 square meters, which is the minimum size for waterfront lots required by today's standards for typical onsite systems servicing waterfront lots. (see Figure 4.1.1(c)); and
- Within the overall Study Area, out of a total of 6,750 lots, 4,110 are currently developed. Of these 3,229 lots are less than 4,500 square metres and there are 1,059 lots with water frontage that are less than 3,716 square metres (see Figure 4.1.1(d)).

If existing systems fail, they would likely need to be replaced by an onsite filter system or a central system of some type.

Two types of central wastewater collection and treatment systems were considered for servicing the Core Area:

- Conventional wastewater collection and treatment systems designed according to the Halifax Water Design & Construction Specifications. Each system would include the following components:
  - Gravity sewer service laterals from each currently developed property along the trunk sewer alignments;
  - Gravity trunk sewers to collect all of the wastewater that will eventually be generated in the tributary areas with a minimum diameter of 250 mm and minimum slope of 0.6 percent;
  - Wastewater pumping stations located at the low areas in the community to move accumulated flows along the trunk sewer system and eventually discharge them to the wastewater treatment plant;
  - A wastewater treatment plant to reduce pollutant loads to levels that are acceptable in the receiving waters. From the water quality and assimilative capacity assessment it was determined that the treatment plant must remove BOD5, Suspended Solids and pathogens as well as nitrogen and phosphorus for discharges to fresh waters including Porters Lake. This requires a tertiary level of treatment (including phosphorus removal);



DRAWING FILENAME: L:\101015 Tantallon Porters Lake Watersheds\101015_CAD\RECEIVED\101015-PORTERS-LAKE-FIGURES.dwg LAYOUT NAME: 4.1.1 (a) DATE: Feb 01, 2012 - 1:49pm CAD OPERATOR: MURRAYC

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Porters Lake Watershed/Servicing Study

Figure Title:

Plan of Central Wastewater Collection, Treatment and Outfall in Porters Lake - Original Arrangement

Revision or Issue			
Drawn: MEC	Designed: EMD	Checked: GS	Approved: EMD
Scale: 1:12,500	Project No: 101015.00	Date: JAN 2012	Figure No.: 4.1.1 (a)

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NORTH

WATERSHED DIVIDE

LORIANN DR

POTENTIAL SANITARY SEWERS EXTENSION

WASTEWATER TREATMENT PLANT

PS 1

EARL CT.

JAMES ROY DR

MEADOW VIEW DR

PHASE 1

POTENTIAL SANITARY SEWERS EXTENSION

PROPOSED SANITARY SEWERS AND FORCEMAINS

MARINE DR (HWY 7)

LITTLE LAKE

ROMA DR

PS 2

PS 3

WASTE WATER TREATMENT PLANT

PHASE 2

PHASE 3

OUTFALL DIFFUSERS

HIGHWAY 207

HIGHWAY 7

PORTER'S LAKE

WWTP OUTFALL PIPE (OPTION 1)

PORTER CONNECTOR

HIGHWAY 107

WATERSHED DIVIDE

0 HIGHWAY250 500

1:12,500

OUTFALL DIFFUSERS

LEGEND

- FOCUS GROUP DEFINED CORE AREA
- PROPERTIES INCLUDED IN THE CORE AREA
- 30.0m WETLAND & WATERCOURSE BUFFER
- SANITARY MANHOLE AND PIPE
- SANITARY MANHOLE AND PIPE (POTENTIAL EXTENSION)
- SANITARY PUMP STATION AND FORCEMAIN
- WASTEWATER TREATMENT PLANT OUTFALL PIPE
- WATERSHED DIVIDE
- LAND REQUIRED
- RAILROAD R.O.W.

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Porters Lake Watershed/Servicing Study

Figure Title:

Plan of Central Wastewater Collection, Treatment and Outfall in Porters Lake and at the Head of Chezzetcook Inlet

Revision or Issue			
Drawn: MEC	Designed: EMD	Checked: GS	Approved: EMD
Scale: 1:12,500	Project No: 101015.00	Date: JAN 2012	Figure No.: 4.1.1 (b)

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Porters Lake Watershed/Servicing Study

- Property Area<3,716m2
- Property Area<4,500m2
- Core Area Boundary
- Property Boundary
- County Lines
- Rivers
- Other Roads
- Highway
- Collector
- Railroad

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Lot Size Assessment in the Core Area

Drawn: YO	**Date: January 2013**
Checked: GS	**CBCL Project # 101015.00**
Approaved: MD	

Figure 4.1.1(c)

Notes:

Total Lots in Core Area	**241**
Developed Lots	**220**
Lots Less than 4500 m2	**139**
Lots Less than 3716 m2	**126**

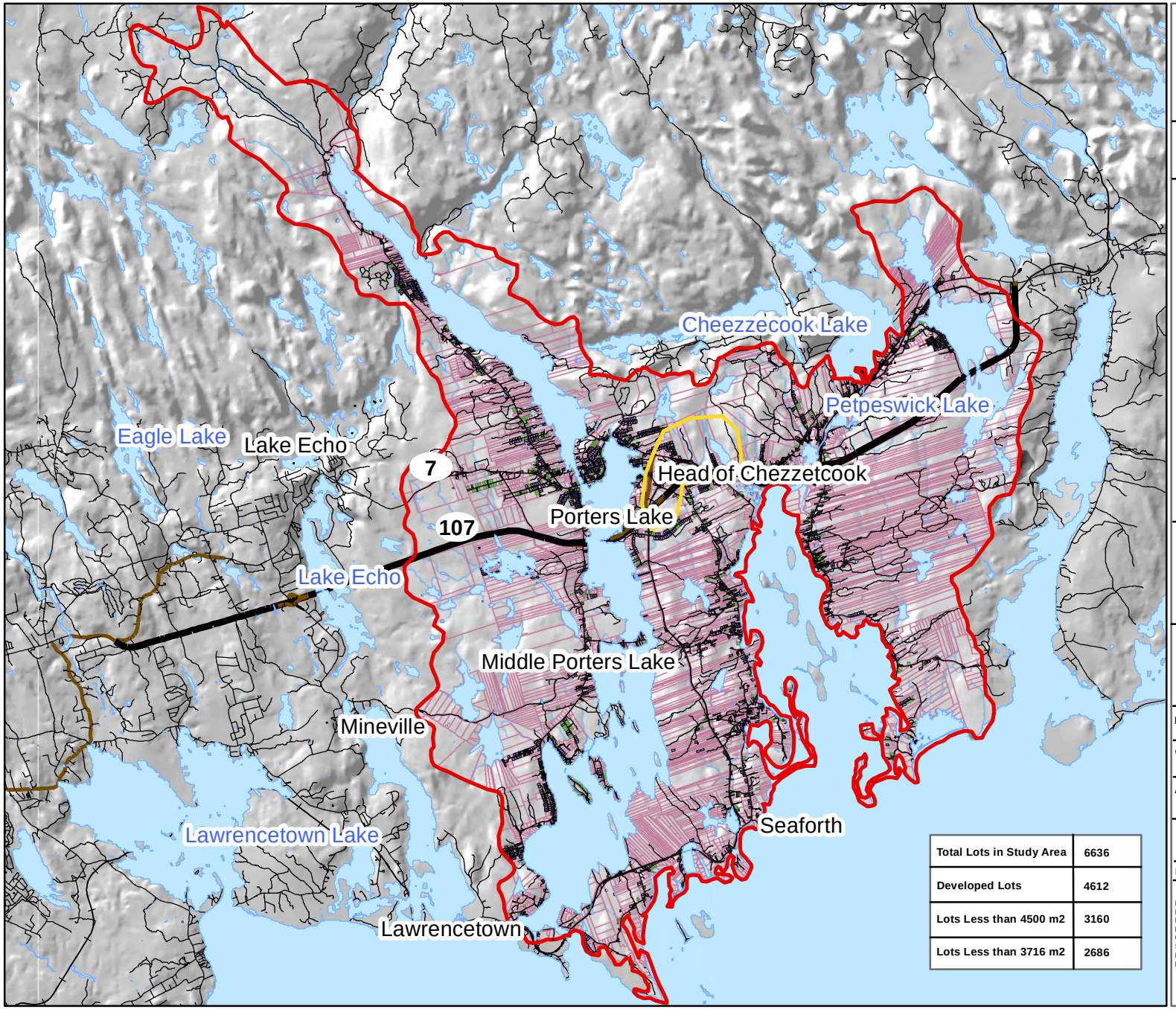
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False Northing: 0.00000000
Central Meridian: -63.00000000
Scale Factor: 0.99960000
Latitude Of Origin: 0.00000000
Linear Unit: Meter

N W E S

0 187.5 375 750 Meters

L:\101015 Lake Echo\101015_Layout\101015 - Porters Lake\101015.00 Porters Lake_Lots Assessment_Core Area.mxd Saved: 13/03/2013 5:00:07 PM



Total Lots in Study Area	6636
Developed Lots	4612
Lots Less than 4500 m2	3160
Lots Less than 3716 m2	2686

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- Property Area<3,716m2
- Property Area<4,500m2
- High Density Areas
- Property Boundary
- Study Area
- County Lines
- Rivers
- Other Roads
- Highway
- Collector
- Railroad

CBCL LIMITED
Consulting Engineers

Lots Size Assessment in the Study Area

Drawn: YO	Date: May 2012
Checked: GS	CBCL Project # 101015.00
Approved: MD	

Figure 4.1.1 (d)

Notes:

Map Parameters

Projected Coordinate System: NAD_1983_UTM_Zone_20N
Projection: Transverse_Mercator
False Easting: 500000.00000000
False Northing: 0.00000000
Central Meridian: -63.00000000
Scale Factor: 0.99960000
Latitude Of Origin: 0.00000000
Linear Unit: Meter

0 750 1,500 3,000 Meters

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- An outfall to suitable receiving waters. Assessments of potential outfall sites in Porters Lake were completed as part of this study. Assessment of suitable discharge locations in Chezzetcook Inlet was not part of the scope of this study but the assessment completed in the 1998 Chezzetcook Harbour Pollution Control Study was reviewed. In that study it was determined that to minimize the risk of clam bed closures, the outfall would need to located as far out the inlet as possible, beyond Grand Desert, close to Seaforth. Discharges would only be on the outgoing tide to minimize the risk of bringing effluent back in on the rising tide.

- Hybrid wastewater collection and treatment, designed to standards for on-site wastewater systems and including:
  - A septic tank at each property, including a pump and filter for all low services and a lateral connection to the sewer mains on the streets;
  - Small (50, 100 and 150 mm) diameter gravity and pressure sewers to collect septic tank effluent;
  - A recirculating filter for treatment of the septic tank effluent;
  - Disinfection of the treated septic tank effluent; and
  - An outfall to a surface water or land dispersal of the treated effluent.

Assessment of these systems indicates that if a development density of 40 persons per hectare can be achieved, the most cost effective wastewater services will be provided using conventional collection systems. The hybrid system will be more cost effective than conventional collection systems for servicing existing development where the density is less than 40 persons per hectare. Potential areas where the hybrid systems may be most applicable include:

- Extensions of the central services from the Core Area to provide an alternate to replacement of onsite systems where these fail; and
- In the undulating topography along the shores of Porters Lake or Chezzetcook Inlet, particularly where the existing septic tanks are newer and may be used as part of the system.

Cluster wastewater treatment systems were considered for servicing of new development or re-development within the Core Area where the development would be isolated from the central system. Designs generally applicable to the Study Area are presented in the next section.

4.1.1.3 WASTEWATER EFFLUENT

The biggest concern with a central system to accommodate flows from the entire Core Area is disposal of the treated effluent. Options for discharge of treated effluent to various receiving environments were considered including the following:

Land Application

Ideally, the effluent would be dispersed on a sufficiently large piece of land in close proximity to the treatment facility, suitable for land application of the effluent. This would minimize impacts on Porters Lake and / or on Chezzetcook Inlet. The difficulty of finding sufficient land increases as the capacity of the treatment facility increases and as the permeability of the soil decreases.

For typical soils on the north side of the Core Area (as defined in the HRM Options for On-site & Small Scale Wastewater Management Study, Land Design Engineering Services, March 2005), it is expected that in the order of 7 hectares would be required for the low growth scenario, 11 hectares for the

medium growth scenario and 17 hectares for the high growth scenario. Figure 4.1.1(e) shows the size of the parcel of land required to accommodate the wastewater treatment plant effluent developed by each growth scenario on a potential site. Some of the existing onsite wastewater systems in the area are currently having problems or have experienced problems in the past, indicating that the soils in the vicinity of the Core Area may not be typical. There are similar concerns with the soils to the south of the Core Area. The size of the property required for land application may need to be much larger than the sizes estimated using soil characteristics typical of the soils to the north of the Core Area. Design of the dispersal system would require detailed insitu permeability and infiltration testing to determine actual conditions at any potential sites and as a result, the actual land requirements.

Porters Lake

If land application is not an option, discharge to a surface receiving water would be considered. The assimilative capacity assessment of Porters Lake indicated that it has assimilative capacity available to accept treated effluent from the entire Core Area for the high growth scenario, provided a tertiary level of wastewater treatment is included, including phosphorus removal.

Four sites for an outfall diffuser were evaluated in Porters Lake. The potential outfalls were located and the diffusers were designed to achieve a minimum dilution of effluent at the diffuser of 5 to 1 and at the surface layer of 50 to 1. The dilution achieved at the alternative outfall locations (as a percentage of the concentration of pollutants in the effluent) are shown on Figure 3.4.1.6. Based on this assessment, the most appropriate locations were identified in section 3.4 as locations C (in the main channel of Porters Lake downstream of the Highway 7 Bridge) and D (on the downstream side of the Highway 107 Bridge). Site D is preferred as it produces the lowest concentrations of pollutants discharged in the effluent at the beach adjacent Highway 107 but it is the furthest from the center of the Core Area. Discussions with the steering committee indicated a preference to locate the effluent discharges in the area downstream of the Highway 107 Bridge; far enough away that the effluent will not pass under the bridge on the rising tide.

Chezzetcook Inlet

There are concerns with Fecal coliform and E coli counts in Chezzetcook Inlet. There is a desire in the community to have Chezzetcook Inlet reopened for shellfish harvesting. Chezzetcook Inlet does not have assimilative capacity to accept additional pollutant loads.

To consider discharging treated effluent to Chezzetcook Inlet requires a decrease in current pollutant loads to the inlet. Additional pollutant loads, even from well treated effluent cannot be accepted without reducing the other loads from the community adjacent Chezzetcook Inlet, particularly the west side of the inlet. To produce no net degradation of water quality requires locating and upgrading enough of the existing sources to reduce the wastewater pollutant loads in an amount equal to the pollutant loads associated with any planned effluent discharges.

However, “No Net Degradation” may not be a suitable objective. Respondents to the water use objectives survey desire reopening of the area shellfish beds. This requires locating and reducing enough pollutant sources so that the concentration of E coli in the Inlet is less than 14 counts per 100 mL, including treatment plant effluent if it is discharged to this receiving water. Major reductions in existing pollutant sources would be required.

NORTH

WWTP OUTFALL PIPE (OPTION 4)

WATERSHED DIVIDE

LORIANN DR

BELL LAKE

POTENTIAL SANITARY SEWERS EXTENSION

EARL CT.

JAMES ROY DR

WASTEWATER TREATMENT PLANT

PS 1

MEADOW VIEW DR

PHASE 1

POTENTIAL SANITARY SEWERS EXTENSION

PROPOSED SANITARY SEWERS AND FORCEMAINS

MARINE DR (HWY 7)

PHASE 2

POTENTIAL SANITARY SEWERS EXTENSION

LITTLE LAKE

ROMA DR

PS 2

PS 3

PHASE 3

HIGHWAY 7

0 - 250 - 500

1:12,500

LEGEND

- FOCUS GROUP DEFINED CORE AREA
- PROPERTIES INCLUDED IN THE CORE AREA
- 30.0m WETLAND & WATERCOURSE BUFFER
- SANITARY MANHOLE AND PIPE
- SANITARY MANHOLE AND PIPE (POTENTIAL EXTENSION)
- SANITARY PUMP STATION AND FORCEMAIN
- WASTE WATER TREATMENT PLANT OUTFALL PIPE
- WATERSHED DIVIDE
- LAND REQUIRED (low 7Ha)
- LAND REQUIRED (med 11Ha)
- LAND REQUIRED (high 17Ha)
- RAILROAD R.O.W.

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Porters Lake Watershed/Servicing Study

Figure Title:

Potential Sites for Land Application of Wastewater Treatment Plant Effluent in Porters Lake

Revision or Issue			
Drawn: MEC	Designed: EMD	Checked: GS	Approved: EMD
Scale: 1:12,500	Project No: 101015.00	Date: JAN 2012	Figure No.: 4.1.1 (e)

Alternatively, the effluent from a treatment plant located in the Chezzetcook Inlet watershed could be piped past the areas of the inlet where the concentrations exceed the guideline as discussed in the 1998 Chezzetcook Harbour Pollution Control Study.

4.1.1.4 Alternative Wastewater Collection and Treatment Arrangements Considered

To address all of these constraints, two schemes for wastewater collection trunk systems, treatment plants and outfalls were considered in detail:

- Trunk sewers and pumping stations along Highway 7, a tertiary treatment plant located as close as possible to Porters Lake and an outfall located on the old railway alignment that discharges to Porters Lake south of the Highway 107 bridge; and
- Trunk sewers and pumping stations along Highway 7 and Highway 207 to Grand Desert, a secondary treatment plant located in Grand Desert and an outfall located along Highway 207 and the Dyke Road that discharges to the mouth of Chezzetcook Inlet.

Treatment Plant in Porters Lake

The original arrangement for this concept was presented in Figure 4.1.1(a). Discussions with the steering committee resulted in modifications to the arrangement (shown in Figure 4.1.1(f)) which is intended to:

- Include the undeveloped areas along Station Road in Phase 1 for residential development. This required rearrangement of the phased development in the Core Area. The trunk sewer on Highway 7 would be extended to the end of Station Road and Pumping Station 1, as shown on Figure 4.1.1(f);
- Include the undeveloped areas south of the Highway 107 interchange (Exit 20) in Phase 1 for commercial development. The treatment plant would be located at the lower end of this property and would accept pumped wastewater flows from Pumping Station 1 as well as the new school and the commercial development; and
- Discharge treated effluent to Section 3 of Porters Lake through an outfall located on the old railway alignment to a point well downstream of Highway 107 and then overland to the lake on an available piece of land that would need to be acquired. The diffuser for the outfall would be located near the main flow through the lake.

Treatment Plant in Grand Desert

Figure 4.1.1(g) shows a scheme for pumping wastewater collected in the Porters Lake Core Area to a treatment plant in Grand Desert located in the vicinity of the Dyke Road. The outfall would be at the end of the Dyke Road and discharge treated effluent to a diffuser in the main channel at the mouth of Chezzetcook Inlet.

To service the same areas serviced by the treatment plant in Porters Lake:

- Pumping Station 2 would pump to the high point on Highway 7, into the trunk sewer that discharges to Pumping Station 1;
- Additional pumping stations would be required at the new school and the proposed commercial development south of Highway 107 interchange. These would pump into a common forcemain with Pumping Station 1;
- The forcemain alignment would be through the proposed commercial development to Highway 207 and along Highway 207 to the treatment plant;

NOTES:
1. THE TRUNK SEWERS, TREATMENT PLANT AND OUTFALL ARE SIZED TO ACCOMMODATE WASTEWATER FROM ONLY THE AREAS INCLUDED IN THE SERVICE AREA BOUNDARIES HIGHLIGHTED IN THE BLUE, GREEN AND PINK SHADING IN THE CORE AREA.

2. ONLY THOSE PROPERTIES ADJACENT THE TRUNK SEWERS ON HIGHWAY 7 WILL BE SERVICED WITH THE SEWERS SHOWN. ADDITIONAL COLLECTION SEWERS WILL BE REQUIRED TO SERVICE ALL PROPERTIES WITHIN THE SERVICE AREA BOUNDARIES.

NORTH

PROPOSED PUMP STATION #2

PHASE 2

PHASE 1

LOCAL PUMP STATION: HIGH SCHOOL

LOCAL PUMP STATION: COMMERCIAL DEVELOPMENT

PROPOSED PUMP STATION #1

WASTEWATER TREATMENT PLANT

WWTP OUTFALL AND DIFFUSERS

0 250 500

1:12,500

LEGEND

- FOCUS GROUP DEFINED CORE AREA
- WATERSHED DELINEATION
- SERVICE AREA BOUNDARY: LOW GROWTH SCENARIO
- SERVICE AREA BOUNDARY: MEDIUM GROWTH SCENARIO
- SERVICE AREA BOUNDARY: HIGH GROWTH SCENARIO
- 30.0m WETLAND & WATERCOURSE BUFFER
- NON-DEVELOPABLE AREAS
- PROPOSED SANITARY PUMP STATION AND FORCEMAIN
- PROPOSED SANITARY MANHOLE AND SEWER
- PROPOSED OUTFALL AND DIFFUSERS
- RAILROAD R.O.W.
- PROPOSED SANITARY PS TRIBUTARY AREA (POTENTIAL)
- TRIBUTARY EXISTING ONSITE SYSTEMS

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Porters Lake
Watershed/Servicing Study

Figure Title:

Plan of Central Wastewater Collection, Treatment and Outfall in Porters Lake - Only Core Area Serviced

Revision or Issue			
Drawn: MEC	Designed: EMD	Checked: GS	Approved: EMD
Scale: 1:25,000	Project No: 101015.00	Date: JAN 2012	Figure No.: 4.1.1(f)

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NORTH

NOTES:
1. THE TRUNK SEWERS, TREATMENT PLANT AND OUTFALL ARE SIZED TO ACCOMMODATE WASTEWATER FROM ONLY THE AREAS INCLUDED IN THE SERVICE AREA BOUNDARIES HIGHLIGHTED IN THE BLUE, GREEN AND PINK SHADING IN THE CORE AREA.

2. ONLY THOSE PROPERTIES ADJACENT THE TRUNK SEWERS ON HIGHWAY 7 WILL BE SERVICED WITH THE SEWERS SHOWN. ADDITIONAL COLLECTION SEWERS WILL BE REQUIRED TO SERVICE ALL PROPERTIES WITHIN THE SERVICE AREA BOUNDARIES.

WWTP OUTFALL AND DIFFUSERS

WASTEWATER TREATMENT PLANT

PROPOSED PUMP STATION #2

LOCAL PUMP STATION: HIGH SCHOOL

LOCAL PUMP STATION: COMMERCIAL DEVELOPMENT

PROPOSED PUMP STATION #1

LEGEND

- FOCUS GROUP DEFINED CORE AREA
- WATERSHED DELINEATION
- SERVICE AREA BOUNDARY: LOW GROWTH SCENARIO
- SERVICE AREA BOUNDARY: MEDIUM GROWTH SCENARIO
- SERVICE AREA BOUNDARY: HIGH GROWTH SCENARIO
- 30.0m WETLAND & WATERCOURSE BUFFER
- NON-DEVELOPABLE AREAS
- PROPOSED SANITARY PUMP STATION AND FORCEMAIN
- PROPOSED SANITARY MANHOLE AND SEWER
- PROPOSED OUTFALL AND DIFFUSERS
- RAILROAD R.O.W.
- PROPOSED SANITARY PS TRIBUTARY AREA (POTENTIAL)
- TRIBUTARY EXISTING ONSITE SYSTEMS

DRAWING FILENAME: L:\101015 Tantallon Porters Lake Watersheds\101015_CAD\January 2012 Updates Figures\101015-PORTERS-LAKE-FIGURES_Opt_3.dwg LAYOUT NAME: 4.1.1 (g) DATE: Feb 07, 2012 - 1:06pm

CBCL LIMITED Consulting Engineers

HALIFAX REGIONAL MUNICIPALITY

Porters Lake
Watershed/Servicing Study

Figure Title:

Plan of Central Wastewater Collection in Porters Lake with Treatment and Outfall in Grand Desert - Only Core Area Serviced

Revision or Issue			
Drawn: MEC	Designed: EMD	Checked: GS	Approved: EMD
Scale: 1:25,000	Project No: 101015.00	Date: JAN 2012	Figure No.: 4.1.1 (g)

- The treatment plant would be located as close to the mouth of Chezzetcook Inlet as possible, based on availability of land for siting the treatment plant; and
- The outfall would be located along roadways where possible and underwater to a diffuser located near the mouth of the Inlet.

Two scenarios were considered for the design of this wastewater collection, treatment and outfall system:

1. The system would have capacity to accommodate only the wastewater flows in the proposed Core Area of Porters Lake. The forcemain would be continuous from Pumping Station 1 to the treatment plant in Grand Desert. Additional flows generated at the new school and at the proposed commercial development south of Highway 107 would be pumped into the common forcemain. No other areas would be serviced along the alignment.
2. The system would have capacity to accommodate wastewater flows generated in West Chezzetcook and/or Grand Desert (to follow the recommended plan in the 1998 Chezzetcook Inlet Study) as well as the flows generated in the Core Area of Porters Lake. In this arrangement two options were considered for the trunk system along Highway 207:
    a. The forcemain from the high point on Highway 207 to the treatment plant would be upsized to provide capacity for properties adjacent the alignment to pump into the same forcemain.
    b. The trunk sections would consist of forcemain as well as gravity sewers and additional pumping stations located at the 3 low points along Highway 207. A forth pumping station and forcemain would collect wastewater from a portion of the Shore Road and pump it up to the system on Highway 207. This system is shown in Figure 4.1.1(h).

4.1.1.5 WASTEWATER TREATMENT

Secondary treatment will meet the minimum effluent requirements stated in the CCME Guidelines for an ocean discharge. A secondary treatment for the wastewater generated in the Porters Lake Core Area, that is typically acceptable to NSE, is a system based on a Sequencing Batch Reactor (SBR).

As discussed previously, tertiary treatment is required for discharge of effluent into Porter's Lake and should include nutrient removal. This level of treatment may be achieved by:

- Providing chemical addition and filtration following the secondary process; and
- Using a different type of process such as a Membrane Bioreactor (MBR) that utilizes membrane filters to limit pollutants in the effluent stream.

Flow Estimates

Wastewater treatment plant design flow estimates for the Core Area were developed using the population projections presented in section 2.3.4 for a twenty year period from 2010 to 2030 and published estimates for wastewater flows from residential development. Published data was used from both the *Atlantic Canada Wastewater Guidelines Manual for Collection, Treatment and Disposal* (CBCL Limited 2006) and Environment Canada's (2004) *Municipal Water and Wastewater Survey* (MWWS).

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PROPOSED PUMP STATION #1

PROPOSED PUMP STATION #2

PROPOSED PUMP STATION #3

HIGH SCHOOL PROPOSED PUMP STATION

PROPOSED PUMP STATION #4

PROPOSED PUMP STATION #5

PROPOSED PUMP STATION #6

PROPOSED PUMP STATION #7

PROPOSED PUMP STATION #8

WASTEWATER TREATMENT PLANT

WWTP OUTFALL AND DIFFUSERS

LEGEND

- FOCUS GROUP DEFINED CORE AREA
- WATERSHED DELINEATION
- SERVICE AREA BOUNDARY: LOW GROWTH SCENARIO
- SERVICE AREA BOUNDARY: MEDIUM GROWTH SCENARIO
- SERVICE AREA BOUNDARY: HIGH GROWTH SCENARIO
- POTENTIAL ADDITIONAL SERVICE AREAS
- 30.0m WETLAND & WATERCOURSE BUFFER
- NON-DEVELOPABLE AREAS
- PROPOSED SANITARY PUMP STATION AND FORCEMAIN
- PROPOSED SANITARY MANHOLE AND SEWER
- PROPOSED OUTFALL AND DIFFUSERS
- RAILROAD R.O.W.
- PROPOSED SANITARY PS TRIBUTARY AREA (POTENTIAL)
- TRIBUTARY EXISTING ONSITE SYSTEMS
- POLLUTION RISK PROPERTIES

CBCL LIMITED Consulting Engineers

HALIFAX REGIONAL MUNICIPALITY

Porters Lake Watershed/Servicing Study

Figure Title:

Plan of Central Wastewater Collection in Porters Lake with Treatment and Outfall in Grand Desert - Core Area as well as West Chezzetcook and Grand Desert Serviced

Revision or Issue

Drawn	Designed	Checked	Approved
MEC	EMD	GS	EMD
Scale	**Project No**	**Date**	**Figure No.**
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The average daily flow (ADF) for the Core Area will be generated from a combination of residential, institutional and commercial development. A combined wastewater generation of 532 L/p/d was used to estimate the average wastewater design flows for the three growth scenarios. A peak factor based on population (Harmon) was used to estimate the peak flow rates for the service area, based on the requirements of the *Atlantic Canada Wastewater Guidelines Manual* (2006). These estimates provide only approximate future flows which are appropriate for use in a planning level study such as this. The actual wastewater flows produced in each community is expected to vary depending on the amount of commercial growth experienced in the service area.

Treatment flow estimates are presented in Table 4.1.2 for the three growth scenarios discussed.

Table 4.1.2: Wastewater Treatment Plant Design Flows

Development Scenario	Average Daily Flow (cubic metres/day)	Peak Flow (cubic metres/day)
High Growth	1383	4840
Medium Growth	850	3150
Low Growth	505	1920

Wastewater Treatment

Preliminary Treatment

Preliminary treatment requirements for SBR treatment systems typically include screening and grit removal.

All influent will flow through a bar screen and aerated grit chamber prior to the wet well for the SBR influent pumps. Ground screenings and grit will settle in the grit chamber with the remainder of the flow pumped to the SBR's which will be controlled by the level in the tank. Screening and grit will be cleaned out on a regular basis.

Secondary Treatment - Sequencing Batch Reactor

The main treatment components of the plant are the Sequencing Batch Reactors. Preliminary designs of the SBR's were based on the wastewater loading rates presented as well as the design parameters listed below:

Design Parameter

Hydraulic Residence Time (HRT)	= 20 h
Solids Residence Time (SRT)	= 15 days
MLSS at TWL	= 2,500 mg/L
F/M	= 0.10

Control Strategy

The SBR will be operated based on a 6.0 hour cycle during average flow. This will result in 8 batches per day of 173 m^3 each in the treatment plant designed to accommodate the high growth scenario. During periods of peak flow operating parameters will be altered to allow for a 3.0 hour cycle resulting in 16 batches per day of 303m^3 each. Operation will be controlled by a PLC operating on timer control with a

level override. Operation during average flow will contain fill, fill/react, react, settle, decant, and idle cycles. Operation during peak flows will contain fill, fill/react, react, settle, decant, and fill/decant cycles.

Floating Decanter

The decanter is designed for the removal of 173 m^3 of effluent over a 30 minute period. This results in an average decanter flow rate of 5.8 m^3/min. The decanter will also be designed to exclude scum and solids. Scum that accumulates in the SBR tanks may be either sprayed down or physically skimmed off and placed in the aerobic solids holding tanks. Depending on the configuration of the decanter, peak decant rates may be considerably higher than the average rate.

Tertiary Treatment – Upflow Filter

Tertiary treatment includes the removal of solids and nutrients to below secondary levels (in the order of 25 percent of the load with secondary treatment). Typically a pump station is required to lift the flow from the SBR units through the tertiary treatment processes.

Sand filtration is typically utilized to remove TSS and subsequently BOD levels to less than 10 mg/L. Addition of coagulant is required for removal of phosphorus. A number of different configurations exist, the most common is a moving bed or continuous clean sand filter. This system would be enclosed within a small building.

Continuous clean filters provide a continuous supply of filtered water without the interruption of backwash cleaning cycles. In the upflow mode, influent enters the bottom of the filter and flows upward through the sand bed. Clean filtrate exits the sand bed and overflows a weir as it leaves the filter. Simultaneously, the sand bed, with the accumulated solids, is drawn downward into the suction of an airlift pipe positioned at the center of the filter. A small volume of compressed air is introduced into the bottom of the airlift causing a turbulent upward flow of sand, dirt, air, and water. This turbulence scours impurities from the sand. At the top of the airlift dirty slurry spills over into a central reject compartment. Sand returns to the bed through a gravity washer/separator and reject water is returned to the primary clarifiers.

Alternate – Combined Secondary – Tertiary Treatment

An alternative treatment train considered is the membrane bioreactor. This technology combines a biological treatment process with a membrane system to provide for the removal of organics, nutrients, and suspended solids. Installation of the membrane system within a biological reactor system typically replaces sedimentation and filtration as a means of separating mixed liquor or suspended solids from treatment effluent. Flow passes through the membrane, while solids remain in the biological treatment process. A typical MBR process schematic is provided in Figure 4.1.1.5.

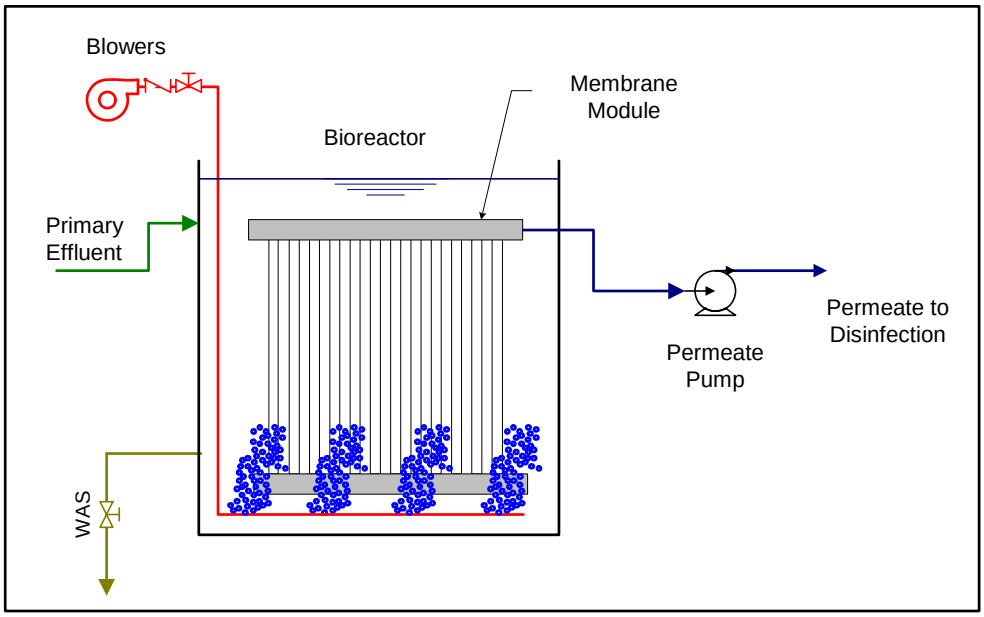


Figure 4.1.1.5: Typical Membrane Bioreactor (MBR) Process Schematic

The advantage of membrane biological reactors is that they eliminate the need for secondary clarification and can operate at higher MLSS concentrations allowing for:

- Higher volumetric loading rates and thus shorter reactor hydraulic retention times;
- Longer SRTs resulting in less sludge production;
- Operation at low DO concentrations with the potential for simultaneous nitrification-denitrification in long SRT designs;
- High quality effluent in terms of low turbidity, bacteria, TSS, and BOD; and
- Less space required for wastewater treatment.

Potential disadvantages of a MBR process include:

- Extensive and complex cleaning processes are required to prevent inorganic and organic fouling of the membranes;
- Typically higher operating costs due to power requirements of the permeate pumping, air scouring of membranes, membrane replacement costs (life of membranes typically 7-10 years);
- Typically higher capital costs;
- Relatively new technology; and
- Requires fine screening (1 to 2 mm) to prevent hair and other stringy materials from being entangled with the membranes.

Utilization of the MBR process would require the construction of a small building to house the fine screens, membrane modules, aeration tankage, and permeate pumps. While capital costs may be similar to more conventional processes, operating costs could increase fairly significantly due to increased aeration, pumping, and membrane replacement costs. However, depending upon land availability, proximity to adjacent development, and geotechnical conditions the smaller footprint MBR process could be the preferred option.

Waste Activate Sludge
Waste activated sludge will be removed on an automated cycle and pumped to the aerated solids holding tank. This tank will be sized for one month sludge production at the peak design flow rate with the decant overflowing and returning to the preliminary treatment tank by gravity.

Ultraviolet Disinfection
Effluent will require disinfection to meet a discharge criterion of 200 fecal coliform per 100 mL. Ultraviolet disinfection is typically selected as the means to achieve this limit. Advantages of an UV disinfection system include eliminating safety concerns associated with chlorine gas and some associated problems such as dechlorination stock supply, storage and feed pumps.

Disinfection will take place in a single concrete channel located in the first floor of the control building. The UV system will consist of a single reactor containing two banks of low pressure, high intensity UV lamps. The lamps will be oriented horizontally and parallel to the direction of flow.

SCADA
Operation of the treatment plant will be monitored by a supervisory control and data acquisition (SCADA) system designed to be monitored from the plant. This system will monitor all process equipment status as well as process variables such as dissolved oxygen concentrations, wastewater flow rates, and tank water levels.

4.1.2 Stormwater Management
Receiving water assessments indicated that the existing water quality in lakes in the study area (including parts of Porters Lake) is generally suitable for desired uses. The assessments also indicate that there is a potential for higher phosphorus concentrations in the lakes as well as higher E coli concentrations from future development.

Existing Fecal coliform and E coli concentrations in Chezzetcook Inlet are a concern. Current levels must be reduced and future development must produce no additional loads if the inlet is to be open to shellfish harvesting as desired by the community representatives that responded to the survey of water quality objectives.

Stormwater management plans should include measures to minimize additional pollutant loads to these receiving waters and to reduce the risks of increasing pollutant loads where possible. This requires attenuation of peak flows and treatment of stormwater from any new development prior to discharging to the environment.

These objectives can be achieved by utilizing stormwater best management practices to minimize the impacts of development on the receiving environment, including:

- Siting buildings on high land and retaining low lands for stormwater detention and treatment as demonstrated in Figure 3.7.2(b);
- Low impact site development, utilizing stormwater best management practices such as:
  - Rain gardens and rain barrels;
  - Porous pavements; and

- Low slope swales along the property perimeter complete with vegetated filter strips adjacent impermeable areas. These should be directed to undeveloped back lots where this is possible without affecting neighbours;

- Local stormwater collection swales with flow limiting culverts between them to encourage detention and infiltration rather than piped stormwater collection systems;
- Treatment of remaining runoff in centralized wet ponds and constructed wetlands with built in retention capacity. Co-use of stormwater detention with other public use lands such as parkland or recreation fields will lower the overall costs of this requirement as the costs of land can be significant; and
- Current Halifax Water design guidelines require that deep storm sewers or clear water sewers are provided where sanitary sewers are provided. Clearwater sewers to convey foundation drainage away from each property will need to be included where central wastewater collection systems are considered. These will discharge relatively constant clean flows directly to the environment with minimal impact on flows and quality. Discharge may be to surface receiving waters but groundwater recharge should be considered, particularly outside the Core Area where groundwater is used as the water supply. Locations of clearwater sewers adjacent the trunk sanitary sewers for the Core Area are shown on Figure 4.1.2.

4.1.3 Water Supply Treatment and Distribution

Two arrangements for central water supply systems were developed:

- Figures 4.1.3(a) shows the arrangement developed based on a groundwater supply; and
- Figures 4.1.3(b) shows the arrangement considered for water supply from Porters Lake.

4.1.3.1 WATER SUPPLY BY WELLS

Yields of existing wells in surficial soils range depending on the locations of the wells. An exploration program would be required to locate and develop sufficient capacity. There is a risk of contamination from surface sources and elevated concentrations of iron and manganese were concerns in the dug wells sampled as part of the sanitary survey (see section 3.11). Wells in bedrock are somewhat protected from surface contaminants but are subject to natural contaminants. Iron and manganese concentrations were elevated in the drilled well sampled. Yields of existing wells in bedrock are considered moderate to low.

Supply of water to the Core Area by four (4) large diameter wells appears feasible in the right location. The area suggested is in the north of the study area, in the vicinity of Bell Lake, see Figure 4.1.3(a). Development in this area should be limited and monitored for protection of the well field.

4.1.3.2 WATER SUPPLY FROM PORTERS LAKE

The feasibility of using surface water from the Porters Lake watershed to supply water for the central system was assessed by comparing maximum day water demands to low flows in local water courses. The maximum day demands for existing development account for 25% of the 1 in 50 year low flow in the Porters Lake system. Preliminary assessments indicate that drought flows are less than future water demands for the Core Area under the medium and high growth scenarios. Potential future development would require withdrawal of all of the low flows as well as withdrawal of some water stored in the lake, resulting in lower lake levels.

NORTH

LORIANN DR

WATERSHED DIVIDE

SUB–WATERSHED DIVIDE

PROPOSED STORM OUTFALL (TYP)

EMERALD CT

JAMES ROY DR

MEADOW VIEW DR

PROPOSED STORM SEWERS

MARINE DR (HWY 7)

LITTLE LAKE

FOCUS GROUP DEFINED CORE AREA

ROMA DR

PHASE 1

PHASE 2

HIGHWAY 7

PORTER'S LAKE

HIGHWAY 207

PORTER CONNECTOR

HIGHWAY 107

WATERSHED DIVIDE

SUB–WATERSHED DIVIDE

0 HIGHWAY 250 500

1:12,500

LEGEND

- FOCUS GROUP DEFINED CORE AREA
- PROPERTIES INCLUDED IN THE CORE AREA
- SERVICE AREA BOUNDARY: LOW GROWTH SCENARIO
- SERVICE AREA BOUNDARY: MEDIUM GROWTH SCENARIO
- SERVICE AREA BOUNDARY: HIGH GROWTH SCENARIO
- 30.0m WETLAND & WATERCOURSE BUFFER
- NON–DEVELOPABLE AREAS
- STORM MANHOLE AND PIPE
- WATERSHED DIVIDE
- SUB–WATERSHED DIVIDE
- PROPERTY LINE
- RAILROAD R.O.W.

DRAWING FILENAME: L:\101015 Tantallon Porters Lake Watersheds\101015_CAD\RECEIVED\101015–PORTERS–LAKE–FIGURES.dwg LAYOUT NAME: 4.1.2 DATE: Feb 07, 2012 – 1:50pm CAD OPERATOR: MURRAYC

CBCL LIMITED Consulting Engineers

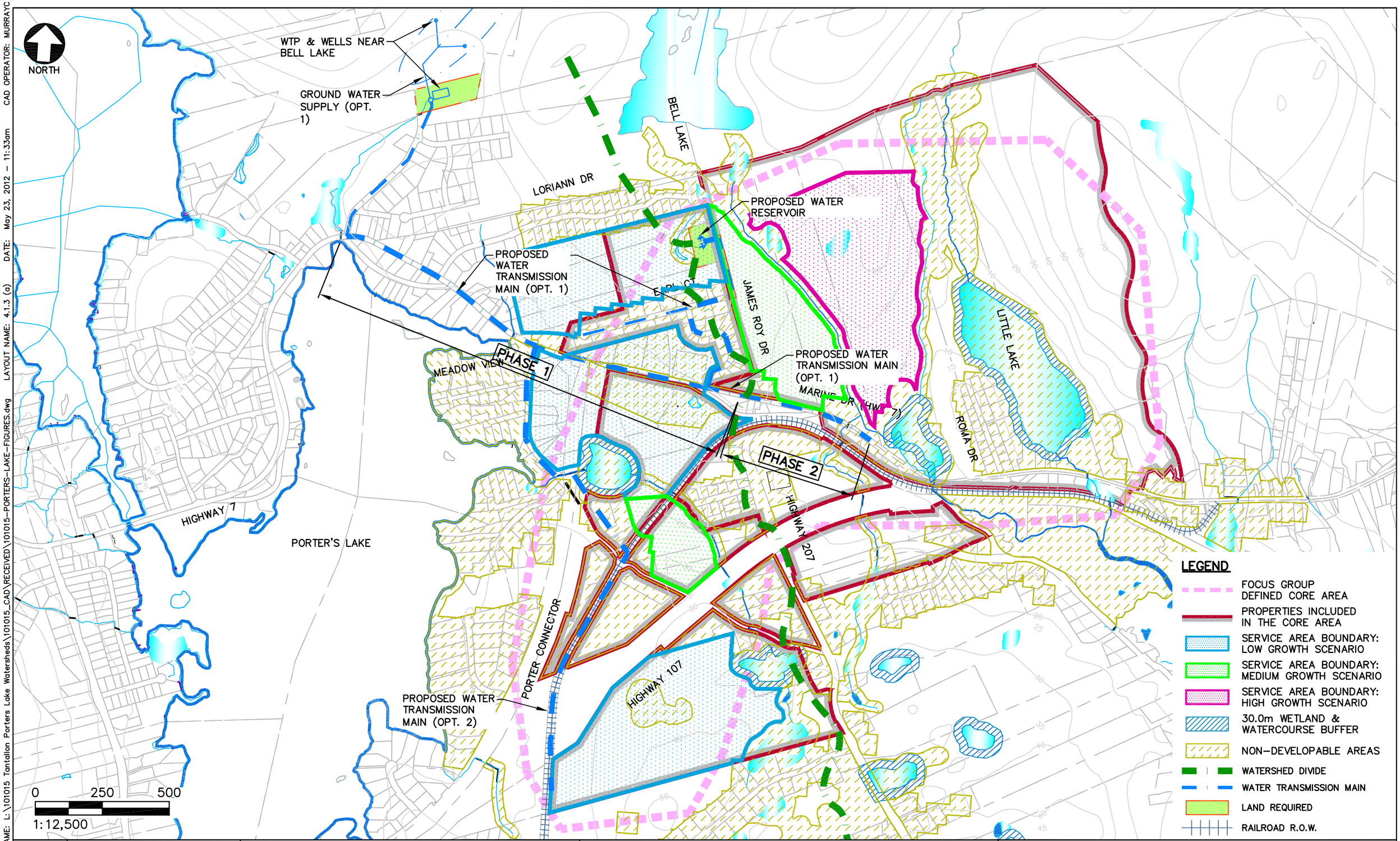
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Porters Lake Watershed/Servicing Study

Figure Title:

Clearwater Sewers in the Core Area

Revision or Issue			
Drawn: MEC	Designed: EMD	Checked: GS	Approved: EMD
Scale: 1:12,500	Project No: 101015.00	Date: JAN 2012	Figure No.: 4.1.2



DRAWING FILENAME: L:\101015 Tantallon Porters Lake Watersheds\101015_CAD\RECEIVED\101015-PORTERS-LAKE-FIGURES.dwg LAYOUT NAME: 4.1.3 (a) DATE: May 23, 2012 - 11:33am CAD OPERATOR: MURRAYC

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Porters Lake Watershed/Servicing Study

Figure Title:

Plan of Central Groundwater Supply, Water Treatment and Transmission System

Revision or Issue			
Drawn: MEC	Designed: EMD	Checked: GS	Approved: EMD
Scale: 1:12,500	Project No: 101015.00	Date: JAN 2012	Figure No.: 4.1.3 (a)

DRAWING FILENAME: L:\101015 Tantallon Porters Lake Watersheds\101015_CAD\RECEIVED\101015-PORTERS-LAKE-FIGURES.dwg LAYOUT NAME: 4.1.3 (b) DATE: Feb 07, 2012 - 1:53pm CAD OPERATOR: MURRAYC

NORTH

LAKE WATER SUPPLY INTAKE (OPT. 2)

WATER TREATMENT PLANT (OPT. 2)

PROPOSED WATER TRANSMISSION MAIN (OPT. 2)

PROPOSED WATER RESERVOIR

PROPOSED WATER TRANSMISSION MAIN (OPT. 2)

PHASE 1

PHASE 2

BELL LAKE

LORIANN DR

EARL CT

JAMES ROY DR

MEADOW VIEW DR

MARINE DR (HWY 7)

LITTLE LAKE

ROMA DR

HIGHWAY 7

PORTER'S LAKE

HIGHWAY 207

PORTER CONNECTOR

HIGHWAY 107

0 250 500

1:12,500

LEGEND

- FOCUS GROUP DEFINED CORE AREA
- PROPERTIES INCLUDED IN THE CORE AREA
- SERVICE AREA BOUNDARY: LOW GROWTH SCENARIO
- SERVICE AREA BOUNDARY: MEDIUM GROWTH SCENARIO
- SERVICE AREA BOUNDARY: HIGH GROWTH SCENARIO
- 30.0m WETLAND & WATERCOURSE BUFFER
- NON-DEVELOPABLE AREAS
- WATERSHED DIVIDE
- WATER TRANSMISSION MAIN
- LAND REQUIRED
- RAILROAD R.O.W.

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Porters Lake Watershed/Servicing Study

Figure Title:

Plan of Central Water Supply from Porters Lake, Water Treatment and Transmission System

Revision or Issue			
Drawn: MEC	Designed: EMD	Checked: GS	Approved: EMD
Scale: 1:12,500	Project No: 101015.00	Date: JAN 2012	Figure No.: 4.1.3 (b)

Although the change in water levels due to withdrawal for water supply may be considered minor, (1 mm for the low growth 2 mm for the medium growth and 4 mm for the high growth scenario) it may impact fish habitat. This may not be acceptable for all stakeholders. As a result it may not be feasible to supply the community with water solely from local surface waters. It is recommended that the acceptability of such changes be investigated as part of a water withdrawal permit application, prior to proceeding further.

4.1.3.3 WATER TREATMENT

Design Flows

According to the MWWS (2006), Nova Scotia municipalities distribute approximately 60% of their treated water to residential users, 20% to commercial users, 5% to industrial users and list the remainder as 'water loss'. The percentage of the demand caused by residential users affects the maximum daily flow that must be treated at the water treatment plant. In the absence of more detailed information about the future commercial, institutional and industrial profile of the community of Porters Lake, it is recommended that a conservative per capita flow rate of 532 L/person/day combined with typical maximum day peaking be used to calculate the anticipated maximum daily flow required for each growth scenario. This would result in a treatment plant sized to treat 1.3MLD in the low growth scenario, 1.8MLD in the medium growth scenario and 2.9 MLD in the high growth scenario.

Source Water Quality

Lake Water Source

Water quality results from the lake water sampling program indicate that the surface water near the proposed intake is slightly acidic, high in organics, low in turbidity and alkalinity, and moderate in minerals. Metals, including iron, manganese, and aluminum are at or near the regulatory limit. Some small systems in the HRM, including Bennery Lake, have similar organic matter and metals source water characteristics as Porter's Lake.

Consideration has been given to whether the lake water at the proposed intake location is influenced by brackish water or seawater. The analysis results for sodium and chloride indicate there are higher mineral values in the lake water than for typical surface water in Nova Scotia. Further, the total dissolved solids (TDS) and conductivity are elevated for a common fresh water source in the region. Common fresh water lake concentrations of sodium and chloride in Nova Scotia are in the ranges of 20-40 mg/L, or lower. The chloride concentration at 330 mg/L exceeds the Health Canada Aesthetic Objective of 250 mg/L, which is considered a regulatory limit for drinking water in Nova Scotia. The sodium objective is 200 mg/L which is met in the sample collected. There are no upper limits for conductivity and TDS but the values do indicate the presence of elevated minerals.

During the broader water quality monitoring work for Porter's Lake the water salinity at the same location (i.e. PL1) was monitored over a longer period of time (at varying depths) and is described more completely in section3.2. The salinity at PL1 varied from 0.08 ppt to 0.15 ppt with one reading at 0.64 ppt over the course of 5 sampling events. The threshold for brackish water is 0.5 ppt by most definitions. Therefore it remains unclear whether the lake water at the location indicated would consistently meet the requirements as a fresh water source for conventional drinking water treatment, or whether enhanced treatment would be required for the partial removal of minerals.

Well Water Source

Drilled wells (excluding dug wells, or improperly constructed drilled wells) in and around the Porter's Lake area commonly have elevated levels of either iron, manganese, arsenic or some combination thereof. This is typical of many groundwater supplies in Nova Scotia. Hardness levels are moderate to elevated but other parameters such as pH, fluoride, TDS, chloride etc. appear to be within acceptable limits.

Summary of Water Treatment Options for Potential Porter's Lake Water Supplies

The water treatment process for Porter's Lake will have to provide for the removal of manganese (and likely iron) and disinfection by-product precursors. Thus, it will have to include some form of oxidation process combined with a process optimized to remove the organic molecules that react with chlorine to form THMs and HAAs. There are a number of alternatives for natural organic matter (NOM) removal including conventional sedimentation, or proprietary clarification systems. For this report DAF has been used based on a past history of installations in Nova Scotia on similar water but more study is needed to identify the optional NOM removal process for those comparable to DAF (i.e. coagulant-based with multi-media filtration).

If the outcome of additional source water monitoring shows that levels of minerals including sodium and chloride are at or above the regulatory limits the treatment of Porter's Lake water for municipal water supply becomes more complicated. The same treatment processes identified for removal of natural organic matter NOM, metals, and disinfection are still considered applicable, however there would be an added need for partial demineralization. This would require further unit processes for removal of unwanted ions from the water to reach concentrations below the prescribed limits. Candidate treatment processes would most likely include side-stream reverse osmosis or ion exchange. Considering that only slight reductions in mineral content would likely be needed in any event, the capacity of a unit process designed for mineral removal would be a fraction of the total treatment plant capacity such that the final blended water quality is within acceptable limits. The addition of any demineralization to the treatment process adds significant cost and complexity and is likely to make surface water supply less feasible. Therefore, more effort to study groundwater or other surface water alternatives is warranted in this case.

There is little detailed information of the quality of water from drilled wells. Treatment processes for water from existing drilled wells includes a range of small-scale or point-of-use devices designed for removal of iron and manganese, or softening. These include ion exchange, media filtration, and reverse osmosis.

Three general categories of treatment were developed based upon the typical parameters of concern which may be encountered in the area. Each category ranges in complexity and cost and can be considered as follows:

1. Chlorination/disinfection only – no additional treatment required.
2. Iron and manganese treatment plus chlorination/disinfection.
3. Iron and manganese treatment plus arsenic treatment plus chlorination/disinfection.

4.1.3.4 WATER DISTRIBUTION

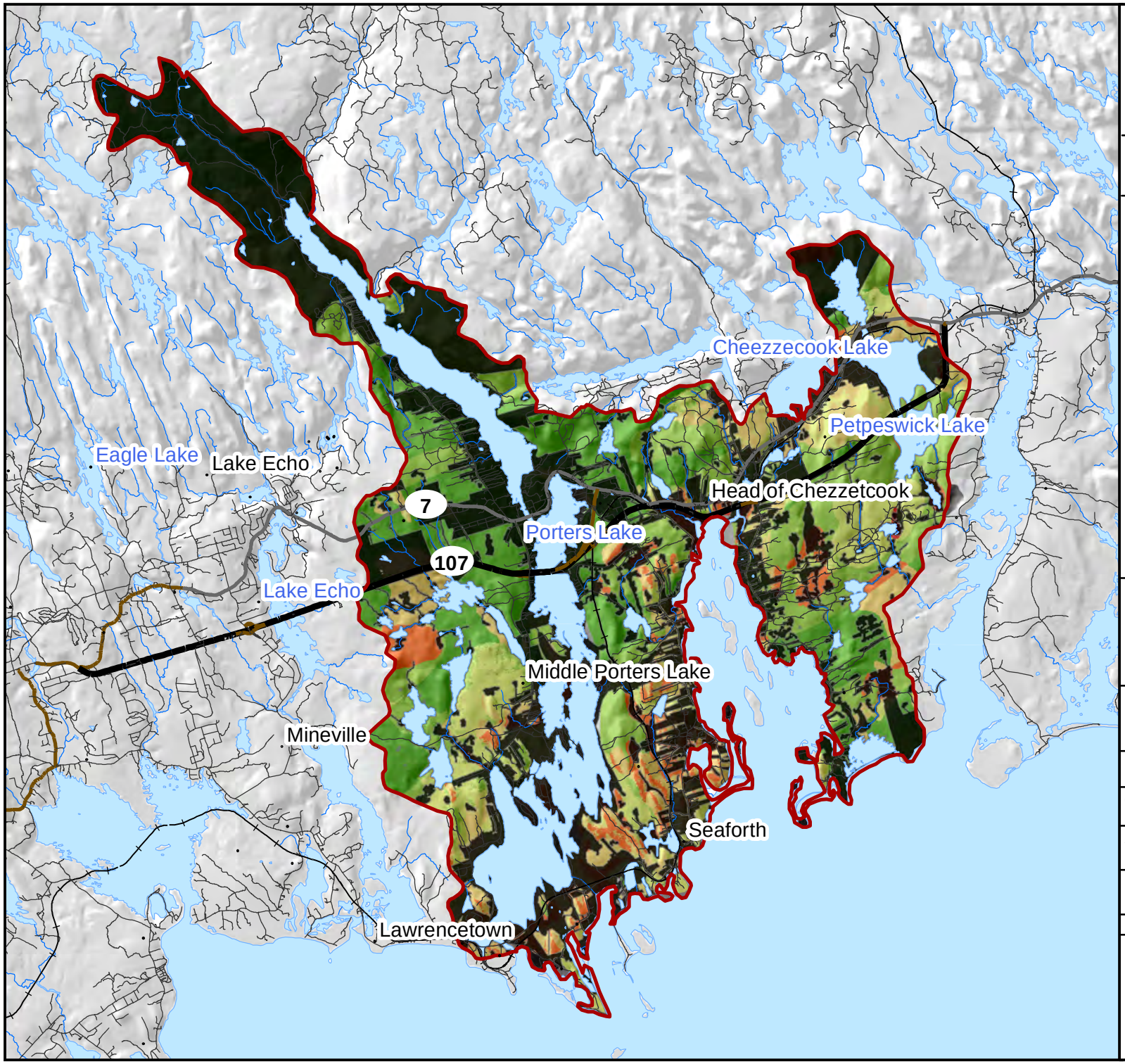
The trunk distribution system for the community is shown on Figures 4.1.3 (a and b). Based on discussions with the steering committee, the distribution watermains are sized only to provide water to existing and future domestic users as well as existing commercial and institutional users. The watermains shown have not been sized to provide fire flows.

The minimum system would include:

- Raw water supply from the source to the treatment plant:
  - Approximately 100 metres of water main from an intake in the lake, north of the Highway 7 bridge where the salinity concentrations are lowest (see Figure 4.1.3(a)) to the water treatment plant; or alternatively
  - Approximately 1,400 metres of water main from the wellfield, northwest of the Core Area. At a preliminary level, the source water supply pipes would need to be in the order of 300 mm in diameter to supply the high growth scenario.
- Approximately 2000 metres of water main from the treatment plant to the reservoir;
- A reservoir to accommodate peak demands on the maximum demand day. It should be:
  - Located in the vicinity of the highest point in the area to be serviced, at the top of Earl Court and James Roy Drive at an elevation in the order of 39 metres;
  - Have active capacity in the order of the maximum day demand; and
  - The maximum water level should be in the order of elevation 70 metres and the minimum water elevation should be in the order of elevation 54 metres.
- Water distribution piping in the Core Area to service existing and proposed development:
  - Phase 1 – 800 metres of watermain on Highway 7 as well as 550 metres on Station Road. An additional 1200 metres of watermain along the old railway alignment and across the Highway 107 overpass would be required to service the lands on the south side of the highway. This has not been included at this point but it would be located beside the forcemain from wastewater pumping station 1; and
  - Phase 2 – 850 metres on Highway 7.

4.2 Areas Outside of the Core Area

Areas outside of the Porters Lake Core Area (and potentially the areas to be serviced in West Chezzetcook and Grand Desert) should be serviced with on-site systems for individual residences or commercial properties and small clusters of properties. Figure 4.2(a) is a compilation of the information presented in Figures 3.1.1.3 and 3.11 and shows in green the areas that are best suited for on-site wastewater and well water. Development in less suitable areas typically requires the more complex onsite wastewater treatment options (see Appendix F) and/or treatment of well water. These assessments are considered screening level; all onsite systems should be designed and constructed to meet current standards based on site specific measurements of site conditions.



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- Study Area Boundary
- No Go Areas
- Streets
- Trunk Highway
- Divided Highway
- Arterial
- Collector
- Railroad

Relative Suitability - Onsite Services

- Most Suitable
- Least Suitable

CBCL LIMITED
Consulting Engineers

Lands Most Suitable for Onsite Water and Wastewater Services

Drawn: YO	**Date: May 2012**
Checked: GS	**CBCL Project # 101015.00**
Approved: MD	

Figure 4.2(a)

Notes:

Map Parameters

Projected Coordinate System: NAD_1983_UTM_Zone_20N
Projection: Transverse_Mercator
False Easting: 500000.00000000
False Northing: 0.00000000
Central Meridian: -63.00000000
Scale Factor: 0.99960000
Latitude Of Origin: 0.00000000
Linear Unit: Meter

N W E S

0 900 1,800 3,600 Meters

File Path: L:\101015 Lake Echo\101015_Layout\101015 - Porters Lake\101015 Porters Lake - Lands most Suitable for Onsite Water and Wastewater Services.mxd Last Saved: 14/03/2013 3:16:23 PM

Design of onsite systems requires consideration of property size and dimensions. For general planning purposes, a minimum of 5,971 square metres of permeable area is required for every one cubic metre of daily water demand, based on the groundwater suitability mapping and an assumption that ground cover has a low demand for water. Generally, one cubic metre per day of water can supply one dwelling unit. The actual land area required for water supply will be determined during the hydrologic assessment required as part of HRM's subdivision approval process. Minimum lot sizes for onsite wastewater system are set by Nova Scotia Environment technical guidelines for onsite sewage disposal systems[13]. Minimum lot sizes for both onsite wastewater and onsite wells should be compared for each property and the larger lot size used as the minimum lot size. As demonstrated in Figure 4.1.1(d) future development in some areas, particularly on the west side of Chezzetcook Inlet, may require reconfiguration of lots to meet current dimensional requirements.

Onsite services should include:

- Onsite septic tanks and effluent dispersal systems sized to match site soil conditions;
- Onsite water supplies including drilled wells to supply a sufficient amount of water. The hydrogeological assessment (section 3.1) indicated that the percentage of water taken to service existing development is relatively small (7%) compared to the flow through the tributary aquifers. This more than doubles to 16% as development continues with the high growth scenario. Withdrawal to supply this type of development may be feasible if minimum lot sizes for water supply and well separation distances are considered;
- Supply of water by wells that provide water for up to 10 units in a cluster appears feasible in the Study Area. This must be confirmed on a site by site basis;
- Assessments of the need for treatment of all sources are required on a site by site basis. Treatment is likely required in about half of the study area (see Figure 3.1.1.3). Where required, water treatment should include:
    - At source treatment systems for removal of iron and manganese; and
    - At point of use treatment for removal of the arsenic and any other parameters exceeding health related guidelines.

A typical arrangement of services for a property in a cluster is shown in Figure 4.2(b).

[13] Nova Scotia Environment, April 2009. *On-Site Sewage Disposal Systems Technical Guideline: Minimum Lot Size requirements For Development Utilizing On-Site Sewage Disposal Systems.* Table 2.4.

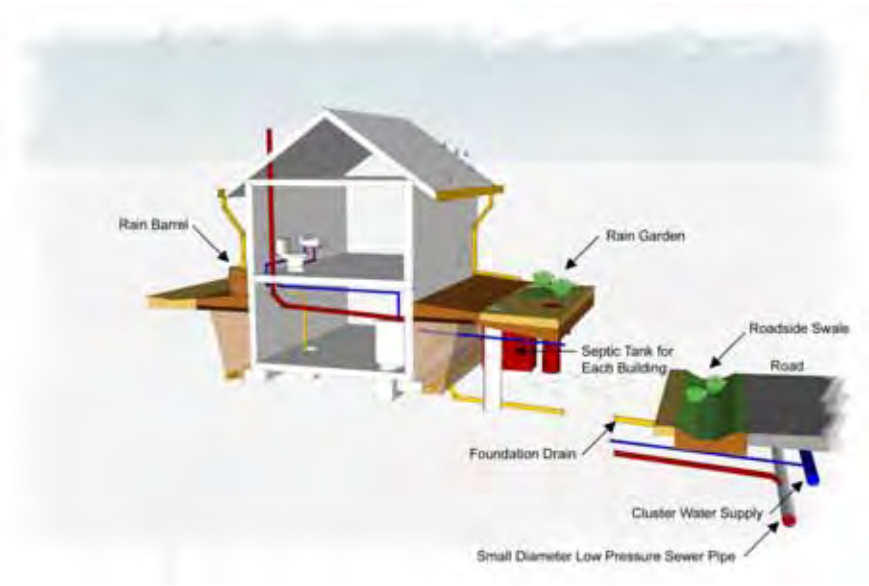


Figure 4.2(b): Illustration of Typical Cluster Services

4.3 Costs of Services

4.3.1 Wastewater

A summary of the probable costs for the range of wastewater collection and treatment systems discussed in this chapter is provided in this section.

4.3.1.1 Core Area Serviced at a Treatment Plant in Porters Lake

The proposed system is shown on Figure 4.1.1(f) and comprises the following:

- Sewer laterals from each property - costs included are for the section from the property line to the sewer in the street for all existing services. It is assumed that the property owner would have the section from the property line to the building constructed and pay for it;
- Sanitary trunk sewers constructed along Highway 7 and Station Road. These would be constructed in phases as development proceeds in the Core Area. It is assumed that development would start closest to the transit centre and proceed away from this centre. The Phase 1 trunk sewers would allow all existing development adjacent the pipe plus the development expected in the low growth scenario to be connected. It could be sized to potentially accept some additional development. The medium growth scenario requires expansion into area C3 by constructing the trunk system identified as Phase 2, see Figure 4.1.1(f). Areas serviced by the Phase 2 system will service sufficient area for the high growth scenario as well at the expected average development density of 40 people per hectare;
- Pumping Station 1, located near the southern end of Station Road would receive wastewater flows from all of the serviced area in Porters Lake. It would pump these flows to the treatment plant in a forcemain that crosses the highway connector and follows the old rail alignment to Highway 107 where it crosses on the overpass bridge. It would be sized to accept wastewater flows from the new school that would be pumped into the common forcemain;

- To achieve the desired effluent quality for discharge to Porters Lake, a tertiary level treatment plant based on a membrane bio reactor was assumed. This could potentially be located on the large parcel of land south of the Highway 107 interchange (Exit 20). In this location it could service the planned residential development as well as the new school and the planned commercial development in the vacant property labelled as area P6 in Figure 4.1; and
- It was assumed that the outfall would be located on the old railway alignment from the treatment plant to a point where access to the lake could be arranged, on one of the long narrow lake front properties. The underwater portion of the outfall would be laid on the bottom of Porters Lake. The outfall would end in a diffuser located approximately 1600 metres downstream of the Highway 107 Bridge.

4.3.1.2 Core Area Serviced at a Treatment Plant in Grand Desert

Figure 4.1.1(g) shows a scheme for moving the treatment plant and outfall from Porter's Lake to Grand Desert. In this concept Pumping Station 1 and its forcemain, the treatment plant and outfall would be sized to only accept wastewater flows from the Porters Lake Core Area. The cost estimates include the following:

- The Phase 1 and 2 trunk sewers in Porters Lake are as described in section 4.3.1.1;
- Pumping Station 1 would be larger than in the previous arrangement to pump to a long forcemain along Highway 207 to the wastewater treatment plant and outfall in Grand Desert;
- The forcemain from Pumping Station 1 would follow the same alignment to the proposed commercial development south of Highway 107. It would then cross the property to Highway 207 and follow this road to the treatment plant. In its simplest form, the forcemain would be a single, continuous pipe without the need for additional pumping stations shown on Figure 4.1.1(g);
- To service the commercial development south of Highway 107, a local pumping station would be required that would pump into the common forcemain with Pumping Station 1 as well as a local pumping station at the new school;
- The level of treatment required to meet current guidelines would be secondary. A process based on sequencing batch reactors was assumed;
- The treatment plant would discharge to an outfall including:
  - An overland section along the Dyke Road;
  - An underwater section to the main channel; and
  - A diffuser to achieve an initial dilution of 25 to 1 in the vicinity of the diffuser.

4.3.1.3 Core Area, West Chezzetcook and Grand Desert Serviced at a Treatment Plant in Grand Desert

A regional approach was considered, including allowances for additional services in West Chezzetcook and Grand Desert to mitigate failed onsite systems as recommended in the 1998 Chezzetcook Harbour Study. Modifications to the previous scheme to facilitate this approach include:

- The forcemain would be increased from 375 mm diameter to 450 mm diameter from the high point of land on Highway 207 to the treatment plant. The section would act as a pressure sewer;
- Additional flows from West Chezzetcook and Grand Desert would be pumped into the pressure sewer using sewage pumps at each property;
- The capacity of the secondary treatment plant would be increased to accommodate wastewater flows from the regional system; and
- The capacity of the outfall and diffuser would be increased to match the treatment plant capacity.

4.3.1.4 Core Area, West Chezzetcook and Grand Desert Serviced at a Treatment Plant in Grand Desert

Rather than pumping all of the additional services into a pressure sewer, a series of gravity sewers complete with pumping stations at the three low areas along the alignment and forcemains to the next high point were considered. Modifications to the previous arrangement for this scheme include:

- Forcemain sections 2, 4 and 6 would be gravity sewers;
- Additional pumping stations and forcemains to convey flows along the alignment to the treatment plant are required but only a fraction of the potential services along the alignment would need to be pumped; and
- An additional pressure sewer may be added in the future to collect septic tank effluent from the properties with suspected failed systems on Shore Road.

4.3.1.5 Costs of the Alternative Arrangements for Wastewater Services in the Core Area

Estimates of probable costs for the design and construction of the wastewater collection, treatment and outfall systems considered in this section are presented in Table 4.3.1. These estimates are based on construction costs of similar systems experienced at the time these estimates were developed in 2011. All cost estimates presented in this report include a contingency allowance of 25% and an allowance of 10% of the construction cost for engineering.

The probable costs presented for the four arrangements considered are for the high growth scenario for comparison purposes. They show the relative differences in costs between the alternatives for overall costs. The lowest overall costs are for the system described in section 4.3.1.1 with a tertiary treatment plant in Porters Lake.

The most cost effective arrangement for a system with a treatment plant in Grand Desert is using pressure connections from properties along the Highway 207 alignment and a common pressure sewer (described in Section 4.3.1.3). The cost per service for this arrangement is still 20 percent higher than the cost per service for the system in the Core Area only. It should be noted that the costs per service are for only the components shown on the figures. Additional costs for each service in the new subdivisions that will contribute to these trunk systems will include costs of:

- Local collector sewers;
- Local pumping stations; and
- Service laterals.

When these are included for the trunk systems shown, the costs for individual services will still be higher than the costs per service using onsite or cluster services.

4.3.1.6 Costs of On-site and Cluster Wastewater Services

A summary of requirements and probable construction costs for septic tanks and contour systems for a range of capacities is also provided in Table 4.3.1.

4.3.2 Stormwater

Estimates of probable costs of the clearwater trunk sewers on Highway 7 and on Station Road shown in Figure 4.1.2, including services to existing properties are presented in Table 4.3.2.

Table 4.3.1: Capital Costs of Sanitary Sewers, Treatment and Outfall Alternatives

	Component	Existing Services	High Growth Scenario Ultimate Number of Services	Estimate of Probable Cost (1)	Cost / Existing Service (2)	Cost / Ultimate Service (3)
In Core Area						
Sanitary Alt 1	**Tertiary STP in Porters Lake**					
	Phase 1 - Highway 7	14	1267	$ 1,195,347	$ 85,382	$ 943
	Phase 1 - Station Road	12	168	$ 576,031	$ 48,003	$ 3,423
	Phase 2 - Highway 7	9	1267	$ 2,457,867	$ 273,096	$ 1,939
	Existing Services	35	1267	$ 120,609	$ 3,446	$ 95
	PS#1	35	1267	$ 1,486,995	$ 42,486	$ 1,173
Figure 4.1.1(f)	PS#1 Forcemain	35	1267	$ 1,627,288	$ 46,494	$ 1,284
	Treatment - Tertiary in Porters Lake	35	1267	$ 7,440,551	$ 212,587	$ 5,871
	Land Portion of Outfall	35	1267	$ 2,135,815	$ 61,023	$ 1,685
	Outfall to Porters Lake Site D	35	1267	$ 1,220,466	$ 34,870	$ 963
	Sub- total Sanitary - Tertiary STP in Porters Lake	35	1267	**$ 18,260,968**	$ 521,742	$ 14,408
Sanitary Alt 2	**Secondary STP in Grand Desert for Porters Lake**					
	PS#1	35	1267	$ 1,776,995	$ 50,771	$ 1,402
	PS#1 Forcemain - Only Porters Lake	35	1267	$ 7,818,067	$ 223,373	$ 6,169
	Treatment - Secondary in Grand Desert	35	1267	$ 5,750,413	$ 164,298	$ 4,537
	Land Portion of Outfall	35	1267	$ 1,779,846	$ 50,853	$ 1,404
Figure 4.1.1(g)	Outfall to Mouth of Chezzetcook Inlet	35	1267	$ 10,984,193	$ 313,834	$ 8,667
	Total Sanitary - Secondary STP in Grand Desert	35	1267	**$ 32,459,367**	$ 927,410	$ 25,611
Sanitary Alt 3	**Secondary STP in Grand Desert for Porters Lake, West Chezzetcook and Grand Desert - Forcemain Size Increases**					
	PS#1 - Only Porters Lake	35	1267	$ 1,776,995	$ 50,771	$ 1,402
	PS#1 Forcemain - Sect 1	35	1267	$ 3,205,970	$ 91,599	$ 2,530
	PS#1 Forcemain - Sect 2	65	1317	$ 1,574,862	$ 24,229	$ 1,195
	PS#1 Forcemain - Sect 3	150	1603	$ 384,185	$ 2,561	$ 240
Figure 4.1.1(g)	PS#1 Forcemain - Sect 4	150	1653	$ 896,431	$ 5,976	$ 542
	PS#1 Forcemain - Sect 5	245	1773	$ 768,369	$ 3,136	$ 433
	PS#1 Forcemain - Sect 6	245	1823	$ 576,277	$ 2,352	$ 316
	PS#1 Forcemain - Sect 7	261	1883	$ 832,400	$ 3,189	$ 442
	Existing Services	0	1823	$ -	$ -	$ -
	Pumped Wastewater Services	226	556	$ 2,249,829	$ 9,955	$ 4,046
	Treatment - Secondary in Grand Desert	261	1823	$ 7,705,998	$ 29,525	$ 4,226
	Land Portion of Outfall	261	1823	$ 1,779,846	$ 6,819	$ 976
	Outfall to Mouth of Chezzetcook Inlet	261	1823	$ 10,984,193	$ 42,085	$ 6,024
	Total Sanitary - Secondary STP in Grand Desert	261	1823	**$ 37,085,207**	$ 142,089	$ 20,339
Sanitary Alt 4	**Secondary STP in Grand Desert for All Communities - Combination of Forcemain and Gravity Sewers**					
	PS#1 - Only Porters Lake	35	1267	$ 1,776,995	$ 50,771	$ 1,402
	PS#4 - West Chezzetcook	150	1603	$ 1,753,963	$ 11,693	$ 1,094
	PS#5 - West Chezzetcook	245	1773	$ 1,955,856	$ 7,983	$ 1,103
	PS#6 - Grand Desert	261	1883	$ 2,033,380	$ 7,791	$ 1,080
Figure 4.1.1(h)	Pressure Sewer on Shore Road	20	20	$ 1,221,717	$ 61,086	$ 61,086
	Pumped Wastewater Services	20	20	$ 199,100	$ 9,955	$ 9,955
	FM PS#1 to High Land on Hwy 207	35	1267	$ 3,205,970	$ 91,599	$ 2,530
	GS - High land on Hwy 207 to PS#4	65	1317	$ 2,173,358	$ 33,436	$ 1,650
	FM - PS#4 to High land on Hwy 207 in West Chezzetcook	150	1603	$ 384,185	$ 2,561	$ 240
	GS - West Chezzet at Petain Sta Rd to PS#5	150	1653	$ 1,310,821	$ 8,739	$ 793
	FM - PS#5 to High Point before Grand Desert	245	1773	$ 768,369	$ 3,136	$ 433
	GS - High point before Grand Desert to PS#6	245	1823	$ 842,671	$ 3,439	$ 462
	FM - PS#6 to Grand Desert STP	261	1883	$ 832,400	$ 3,189	$ 442
	Existing Services	188	1823	$ 647,841	$ 3,446	$ 355
	Pumped Wastewater Services	18	556	$ 179,190	$ 9,955	$ 322
	Treatment - Secondary in Grand Desert	261	1823	$ 7,555,999	$ 28,950	$ 4,144
	Land Portion of Outfall	261	1823	$ 1,968,578	$ 7,542	$ 1,080
	Outfall to Mouth of Chezzetcook Inlet	261	1823	$ 4,274,626	$ 16,378	$ 2,344
	Total Sanitary - Secondary STP in Grand Desert	261	1823	**$ 34,856,396**	$ 133,549	$ 19,116
On-site Systems - Individual Units and Typical Cluster Development						
	Individual Residential Unit					
	Sepic Tank and Contour for Individual Property	1	1	$ 12,000	$ 12,000	$ 12,000
	Sepic Tank and RTF for Individual Property	1	1	$ 25,000	$ 25,000	$ 25,000
	Wastewater Treatment for a 10 Unit Cluster					
	Sepic Tank and RTF for 10 Unit Cluster	10	10	$ 114,400	$ 11,440	$ 11,440
	Sepic Tank and Contour for 10 Unit Cluster	10	10	$ 112,400	$ 11,240	$ 11,240
	Wastewater Treatment for a 20 Unit Cluster					
	Sepic Tank and RTF for 10 Unit Cluster	20	20	$ 227,500	$ 11,375	$ 11,375
	Sepic Tank and Contour for 10 Unit Cluster	20	20	$ 199,700	$ 9,985	$ 9,985

Probable costs include 10% engineering allowance and 25%contingency allowance.

Highlight denotes a change from the preceeding scheme

Table 4.3.2: Probable Costs of Recommended Stormwater Measures

Stormwater Component	Size	Quantity (m)	Existing Services	Ultimate Services	Estimate of Probable Costs	Cost / Existing Service	Cost / Ultimate Service
Required with Sanitary Sewers for Core Area							
Phase 1 - Highway 7	450 mm dia	820	14	191	$ 1,535,534	$ 109,681	$ 8,030
Phase 1 - Station Road	450 mm dia	520	12	160	$ 973,753	$ 81,146	$ 6,072
Phase 1 - Existing Services		26	26	352	$ 39,309	$ 1,512	$ 112
Phase 1 - Total			26	352	$ 2,548,596	$ 98,023	$ 7,249
Phase 2 - Highway 7	450 mm dia	520	9	714	$ 973,753	$ 108,195	$ 1,363
Phase 2 - Existing Services		9	9	714	$ 33,694	$ 3,744	$ 47
Phase 2 - Total			9	714	$ 1,007,447	$ 111,939	$ 1,410
Total			35	1066	$ 3,556,043	$ 101,601	$ 3,336
All Residential Development - Inside and Outside of Core Area							
Rain Barrels for Each Residential Unit	0.2 m^3	1			$500 – $1,000		
Rain Garden for Each Residential Unit	2 m^3	1			$2,000 –		

Probable costs include 10% engineering allowance and 25%contingency allowance.

Typically the costs of the recommended measures on individual properties, including a portion of the costs of the roadside swales, may be incorporated into the costs of lot grading and landscaping for new construction. Similarly, the costs of the collection swales may be incorporated into the typical cross sections for new rural roads and be included in the costs of their construction. This would require a change in the subdivision design standards.

Estimates of probable costs of typical measures recommended for use on individual properties or in cluster development are summarized in Table 4.3.2.

4.3.3 Water Supply

Estimates of probable costs of the two alternative water supply, treatment and transmission systems considered are presented in Table 4.3.3. The overall costs of the two alternatives for central water supply are similar; however both are more than 50 percent higher than the cost of individual supplies. Wells to supply clusters of 10 units should be considered where appropriate well spacing can be achieved and well water quality is such that treatment is not required. If central water supply is considered in the Core Area, additional investigations are warranted before selecting a water supply including:

- Range of salinity at the proposed withdrawal point from Porters Lake;
- Location of a suitable well field and test wells.

As presented in the next chapter, estimates of operating and maintenance costs and replacement costs were used to assess the present worth (2011 dollars) of the 100 year life cycle costs of the two alternatives. The life cycle cost assessment indicates that lower costs will be incurred over the life of the groundwater based system, so long as a suitable source can be located as discussed in section 4.1.3. If the source includes arsenic over the recommended maximum concentrations, the treatment plant will need to be category 3 with higher capital as well as operating costs and the life cycle costs will be higher.

Surficial aquifers in lowland areas are composed primarily of granular deposits within quartzite and slate tills. Thicknesses of granular deposits commonly reach 8 metres, with a maximum reported thickness of 110 m. A well serving a single home in Porters Lake should on average be 55 metres deep. Individual wells in the surficial aquifer are capable on average of providing 32 to 318 L/min. Wells installed in surficial aquifers are expected to be capable of supplying clusters of 10 homes or more. A high density of shallow wells could cause a decline in the local water table, potentially interrupting the supply to the shallowest wells. A balanced approach is recommended including wells drawing water from both the bedrock and surficial aquifers.

The bedrock unit is composed of metamorphic rock with an upper weathered zone and limited fracture partings at greater depths. Individual wells are on average drilled 37 to 75 m into the bedrock, and provide water at 7 to 27 L/min, which should satisfy a peak demand of around 3 L/min.

Most wells installed in the bedrock should be capable of supplying clusters of up to 10 homes. The bedrock transmissivity and storativity are low, indicating that drawdown cones will be deep with a moderate radius of influence. Careful consideration must be paid to providing adequate well spacing.

Table 4.3.3: Capital Costs of Water Supply, Treatment and Distribution

Component		Existing Services	High Growth Scenario		Cost / Existing Service	Cost / Ultimate Service
			Ultimate Services	Capital Cost		
Central Water Services in the Core Area						
Water Supply Alt 1 - Porters Lake with Surface Water Treatment Plant						
	Interconnecting Piping in Wellfield	47	1300	$ 407,239	$ 8,665	$ 313
	Wells	47	1300	$ 200,000	$ 4,255	$ 154
	Well Pumps	47	1300	$ 250,000	$ 5,319	$ 192
	Water Treatment - Category 2 assumed	47	1300	$ 4,648,000	$ 98,894	$ 3,574
	Total Water Supply and Treatment	47	1300	$ 5,505,239	$ 117,133	$ 4,234
Figure 4.1.3(a)	Reservoir	47	1300	$ 4,663,710	$ 99,228	$ 3,586
	TM From WTP to Stn Rd	12	1300	$ 1,185,065	$ 98,755	$ 911
	WM P1-Highway 7	14	1267	$ 627,148	$ 44,796	$ 495
	Phase 1 - Station Rd	12	168	$ 1,486,671	$ 123,889	$ 8,833
	TM to Reservoir	0	1300	$ 1,071,039		$ 824
	Phase 2 - Highway 7	9	705	$ 394,193	$ 43,799	$ 559
	Existing Services	47	705	$ 101,847	$ 2,167	$ 144
	Total Distribution	47	705	$ 4,865,964	$ 103,531	$ 6,899
	Total Water	47	705	$ 15,034,913	$ 319,892	$ 21,317
Water Supply Alt 2 - Porters Lake with Surface Water Treatment Plant						
	Intake Structure and Piping	47	1300	$ 360,825	$ 7,677	$ 277
Figure 4.1.3(b)	Water Treatment	47	1300	$ 6,049,000	$ 128,702	$ 4,652
	Total Water Supply and Treatment	47	1300	$ 6,409,825	$ 136,379	$ 4,929
	Reservoir	47	1300	$ 4,663,710	$ 99,228	$ 3,586
	TM From WTP to Stn Rd	12	1300	$ 1,185,065	$ 98,755	$ 911
	WM P1-Highway 7	14	1300	$ 627,148	$ 44,796	$ 482
	P1-Station Rd	12	1267	$ 1,486,671	$ 123,889	$ 1,173
	TM to Reservoir	0	168	$ 1,071,039		$ 6,364
	P2-Highway 7	9	1300	$ 394,193	$ 43,799	$ 303
	Existing Services	47	705	$ 101,847	$ 2,167	$ 144
	Total Distribution	47	705	$ 4,865,964	$ 103,531	$ 6,899
	Total Water	47	705	$ 15,939,499	$ 339,138	$ 22,600
On-site Systems - Individual Units and Typical Cluster Development						
	Individual Residential Unit					
	Well	1	1	$ 10,000	$ 10,000	$ 10,000
	Well Pump	1	1	$ 1,000	$ 1,000	$ 1,000
	Water Treatment	1	1	$ 2,000	$ 2,000	$ 2,000
	Total for Water Supply	1	1	$ 13,000	$ 13,000	$ 13,000
	Well Water Supply for a 10 Unit Cluster					
	Well	10	10	$ 38,000	$ 3,800	$ 3,800
	Well Pump	10	10	$ 5,000	$ 500	$ 500
	Water Treatment	10	10	$ 20,000	$ 2,000	$ 2,000
	Total for Water Supply	10	10	$ 63,000	$ 6,300	$ 6,300
	Well Water Supply for a 20 Unit Cluster					
	Well	20	20	$ 76,000	$ 3,800	$ 3,800
	Well Pump	20	20	$ 10,000	$ 500	$ 500
	Water Treatment	20	20	$ 40,000	$ 2,000	$ 2,000
	Total for Water Supply	20	20	$ 126,000	$ 6,300	$ 6,300

Probable costs include 10% engineering allowance and 25%contingency allowance.

An analysis of potential servicing scenarios indicates that all approaches can be sustained at the projected rate of growth. The costs for the wells described should fall in the standard $3000-$6000 range for a domestic water well. A well serving ten (10) homes would be required to produce 30 L/min. A deeper or larger diameter well could be required, or a second well would be needed where the yield of a single well does not meet demand. It would be wise to budget at least $10,000 per well, with this figure increasing to $30,000 or more for a worst-case. It is worth noting that if there are more than twenty-five (25) people on the well that it will need to be registered as a public drinking water supply.

A summary of costs of the alternative water supply schemes is presented in Table 4.3.3.

CHAPTER 5 PREFERRED DEVELOPMENT IN THE PORTERS LAKE STUDY AREA

The previous chapters summarize:

- Information related to the watershed study objectives set out in Policy E-17 in the HRM Regional MPS regarding protection and enhancement of environmental functions in the Study Area;
- Constraints to development including assimilative capacity of surface waters; and
- Extents of municipal services required in various development scenarios and the best systems to use to provide these services in a cost effective manner.

This chapter integrates the results of these studies and analyzes that information to discuss options for development in the Study Area.

5.1 Development Considered

Populations and development densities were discussed in section 2.3. Based on those discussions it is expected that future development in the Porters Lake Study Area over the next 20 years will include:

- Between 900 and 2600 additional people will move into the Core Area and 400 to 1100 additional dwelling units will be constructed in the Core Area of Porters Lake to develop a community centre; and
- It is expected that between 900 and 2600 additional people and 400 to 1100 additional dwelling units will be constructed in the Study Area outside of the Core Area.

5.2 Areas Available for Development

5.2.1 Desirability for Residential Development

Development will occur on suitable lands that are considered desirable and that have the ability to be serviced in a cost-effective manner.

"No Go" areas for development are defined in Section 3.7.1. Figure 5.2.1 shows the relative desirability of the land base within the Study Area for residential development based on the criteria outlined in Table 5.2.1. Soil type and site conditions determine ease of building and the ability to install onsite septic systems. Residential development can be built on slopes up to 30%. Preferred aspects are southeast, southwest, south, and west. Generally, areas with mature vegetation are more desirable to purchasers, although it may be desirable for the Municipality to encourage redevelopment of disturbed areas as a means of preserving less-disturbed areas and controlling erosion. Lands on the oceanfront or lakefront or with ocean views tend to be more valuable than inland areas. Development outside of the Core Area will not be serviced by central services, so it is important that the areas selected for development be able to supply sufficient good-quality groundwater and be suitable for onsite wastewater systems. The amalgamation of information from the component maps (see Appendix G) creates a relative scale with the lower numbered areas on the plan denoting areas that can be considered more desirable for residential development.

Desirability does not imply it is technically feasible to develop the lands; factors such as slopes and soil conditions could make building difficult or prohibitively expensive.

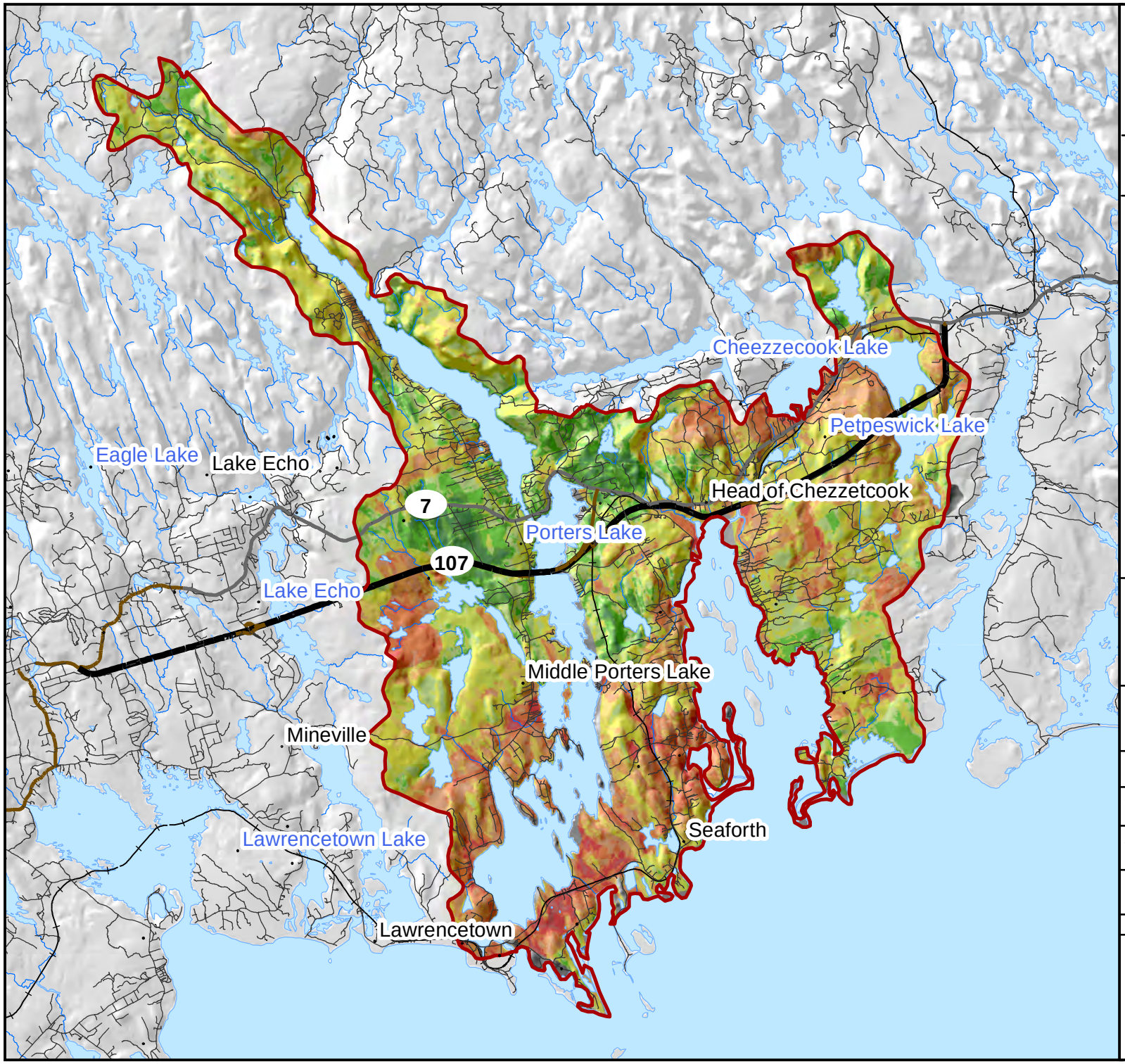
Table 5.2.1: Suitability and Desirability Criteria

	Best	Middle	Worst
Soil Type	Dry Soil	Imperfectly Drained	Wet and Wet Organic
Soil Conditions	Thick Till	Thin till	Disturbed and Bedrock
Slope	0-8%	8-20%	>20%
Vegetation	Mature	Immature	Other
Aspect	South, southwest	Southeast, west	Other
School Access	within 1 km	1-2 km	>2 km
Views	Oceanfront/lakefront	ocean/water view or riverfront	No water views
Groundwater Resource Potential of Bedrock	Class B (potentially good)	Class C and D (may require treatment)	Class E (high risk of contamination)
Acid Slate Potential	No	-	Yes

5.2.2 Development Pattern

Denser development and central services is preferred in the Community Centre or Core Area. This is expected to occur by infilling of currently vacant areas and development of additional lands around the commercial development on Highway 7 and extending to the south side of Highway 107.

Classic open space subdivisions are the preferred pattern of development for residential areas outside of the Core Area. These subdivisions will be fashioned to place residences in desired developable areas while preserving lands that provide significant environmental functions. Servicing of single properties will utilize on-site systems. New sub-divisions will be serviced by clustered on-site systems. The number of units in a cluster system will be determined during the detailed design stage using site specific information including the results of a hydrogeological investigation.



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Porters Lake Watershed/Servicing Study

Relavite Suitability and Desirability

Relavite Suitability and Desirability

Study Area Boundary
Streets
Trunk Highway
Divided Highway
Arterial
Collector
Railroad

CBCL LIMITED
Consulting Engineers

Relative Suitability and Desirability of Land for Residential Development

Drawn: YO	**Date: March 2012**
Checked: GS	**CBCL Project # 101015.00**
Approved: MD	

Figure 5.2.1

Notes:

Map Parameters

Projected Coordinate System: NAD_1983_UTM_Zone_20N
Projection: Transverse_Mercator
False Easting: 500000.00000000
False Northing: 0.00000000
Central Meridian: -63.00000000
Scale Factor: 0.99960000
Latitude Of Origin: 0.00000000
Linear Unit: Meter

N
W E
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0 900 1,800 3,600 Meters

File Path: L:\101015 Lake Echo\101015_Layout\101015 - Porters Lake\101015 Porters Lake - Relative Desirability.mxd Last Saved: 23/05/2012 3:53:22 PM

5.2.3 Potential Development Locations

The low growth scenario requiring approximately 234 hectares to accommodate the projected new development is fairly easily accommodated within a reasonable distance of the Core Area. The medium growth scenario requires approximately 394 hectares using on site systems and the high growth scenario requires approximately 640 hectares to be developed using on site systems. Given that these new developments will be open space subdivisions serviced by clustered onsite wastewater systems and wells, they can be located anywhere within the Study Area.

The assumption that growth in the area will be based on the use of cluster systems creates a large degree of flexibility in the location of future development. Unlike central systems that require a certain level of density to be concentrated in one area to make the systems cost effective, cluster systems can be cost-effectively developed separately in a variety of areas allowing developments throughout the Study Area to come on-line as desired.

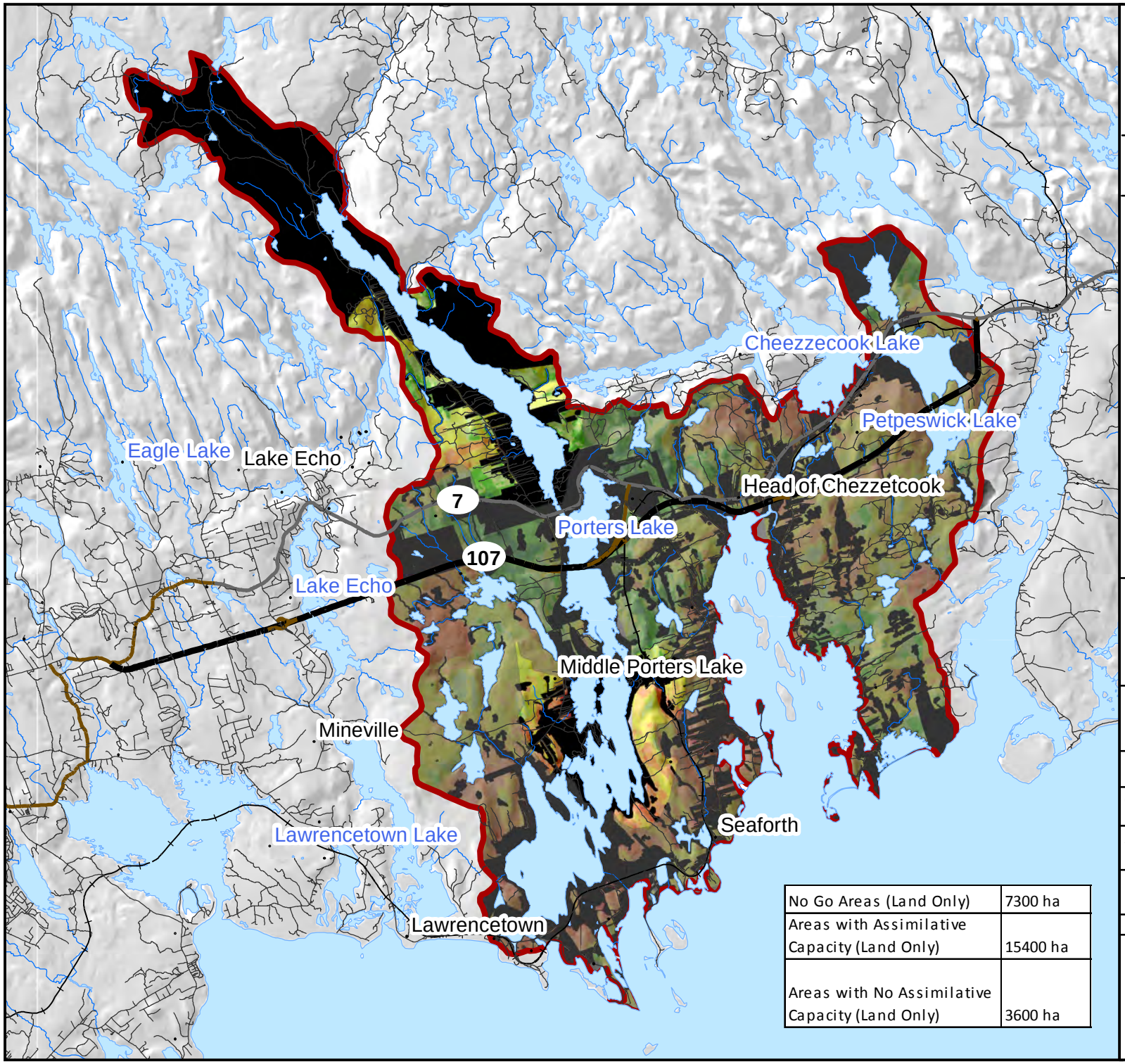
Policy S-10 of the Regional Municipal Planning Strategy outlined the objective of creating sufficient population density to support a viable walk-able transit-oriented centre in Porters Lake. This transit centre is to be located in the vicinity of the intersection of Highway 7 and the William Porter Connector from Highway 107. The furthest point in the Core Area to the south is in the order of 1500 metres (19 minute walk) and to the east is 1800 metres (23 minute walk). Most of the people in the Core Area will have a walk that is less than 15 minutes to the transit centre as will existing residences to the west of the Core Area and on Highway 7.

If transit use is to be encouraged, most people in the community outside of the Core Area will need to drive their cars to the bus rapid transit terminal. This should be located near the intersection of the William Porter Connector and Highway 7.

5.2.4 Constraints on Development Locations

Provided measures are taken to improve existing conditions and minimize the impacts of future development, there should be sufficient assimilative capacity available in Porters Lake to accommodate the high growth scenario. Any opportunities to reduce existing pollutant loads to Porters Lake are good for the lake and should be considered when they arise.

On the other hand, there is no assimilative capacity available in Chezzetcook Inlet given that current levels of E coli are high enough that the federal department of Fisheries and Oceans has closed a significant portion of the head of the inlet and the western shore to shellfish harvesting. Additional development in any areas tributary to Chezzetcook Inlet has the potential to make matters worse. If it is considered, additional development must include measures to maintain existing pollutant loads as a minimum and should include measures to improve water quality in the Inlet wherever possible. If improvements to water quality in the areas tributary to Chezzetcook Inlet are not feasible, new development in the study area should be directed to other watersheds in the Study Area. Figure 5.2.4 shows where additional development could be located without affecting existing water quality in the systems with zero assimilative capacity.



No Go Areas (Land Only)	7300 ha
Areas with Assimilative Capacity (Land Only)	15400 ha
Areas with No Assimilative Capacity (Land Only)	3600 ha

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Porters Lake Watershed/Servicing Study

- Streets
- Trunk Highway
- Divided Highway
- Arterial
- Collector
- Railroad
- Study Area Boundary
- No Go Areas

No Assimilative Capacity Available
- Best Suitability and Desirability
- Worst Suitability and Desirability

Assimilative Capacity Available
- Best Suitability and Desirability
- Worst Suitability and Desirability

CBCL LIMITED
Consulting Engineers

Land Available for Development with Existing Assimilative Capacity

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Checked: GS	CBCL Project # 101015.00
Approved: MD	

Figure 5.2.4

Notes:

Map Parameters

Projected Coordinate System: NAD_1983_UTM_Zone_20N
Projection: Transverse_Mercator
False Easting: 500000.00000000
False Northing: 0.00000000
Central Meridian: -63.00000000
Scale Factor: 0.99960000
Latitude Of Origin: 0.00000000
Linear Unit: Meter

N W E S

0 900 1,800 3,600 Meters

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5.3 Services for New Development in the Core Area

Services to facilitate denser development with central services are described in this section.

5.3.1 Wastewater

The recommended approach for provision of wastewater services in the Core Area is with a treatment plant in Porters Lake as described in section 4.3.1.1 and shown in Figure 4.1.3(f). The overall capital costs of the system including a treatment plant in Porters Lake are much less than the capital costs of the alternatives with a treatment plant in Grand Desert. Unit service costs are also lowest for this arrangement. The unit service cost for the treatment plant in Grand Desert with capacity for the area serviced by a regional forcemain is in the order of 25 percent larger.

It should be noted however that the unit costs for the system sized to accommodate wastewater flows from West Chezzetcook and Grand Desert (described in section 4.3.1.3 and shown in Figure 4.1.3(g)) are much lower than the costs to replace a failed existing on-site system. Failed onsite systems on properties that do not meet current size and dimension requirements typically use recirculating filter systems (see the comparison in Table 4.3.1). In addition there is still the issue of unsuitability of the lands for onsite soils dispersal systems around Chezzetcook Inlet. For these reasons, HRM may wish to further consider the alternatives that include wastewater collection systems in West Chezzetcook and Grand Desert. For planning purposes, it is assumed that these systems will be replaced using cluster systems as described in the next section of this chapter.

5.3.2 Stormwater

Clearwater sewers are required where sanitary sewers are provided. Required Clearwater Sewers are shown in Figure 4.1.2. These sewers are used for foundation drainage only. Swales should be constructed in conjunction with sub-division street development. They should facilitate surface drainage from private properties.

5.3.3 Water Supply

A well field and treatment is the recommend water supply for a central water system in Porters Lake provided wells that produce the required quantity and quality of source water can be located. While capital costs of the two alternative water supply and treatment schemes are similar, life cycle costs are lower for the well water supply arrangement than for the Lake water supply and treatment alternative as shown in Table 5.3.3.

A preliminary program is required to:

- Confirm availability of the land (identified on Figure 4.1.4(a));
- Locate and drill test wells in the area;
- Complete pump tests to confirm the yield of the wells and of the aquifer; and
- Confirm water quality and complete treatability tests.

If water of suitable quantity is located and its quality is such that a category 2 treatment plant will be sufficient then the well water supply alternative should proceed. If additional treatment is required, a water withdrawal permits for Porters Lake and surface water supply and treatment should be considered further.

Table 5.3.3: 100 Year Life Costs of Water Supply and Treatment Alternatives for Porter Lake

Component	Growth Scenario	Capital Cost	Initial Installation Costs	Annual O&M Costs	Present Worth of 100 Year Life Cycle O&M Costs	Present Worth of 100 Year Life Cycle Replacement Costs	Present Worth of 100 Year Life Cycle
Wells and Connecting Piping, Ground Water Treatment Plant and Pipe to Station Road - **Figure 4.1.3(a)**	Low	$ 4,427,942	$ 4,627,942	$ 67,000	$ 2,309,931	$ 1,474,194	$ 8,019,348
	Medium	$ 5,510,838	$ 5,710,838	$ 94,000	$ 2,805,200	$ 1,871,223	$ 9,902,648
	High	$ 7,618,063	$ 7,818,063	$ 147,000	$ 4,331,863	$ 2,634,036	$ 14,120,534
Lake Water Intake, Treatment Plant and Pipe to Station Road - **Figure 4.1.3(b)**	Low	$ 6,297,944	$ 6,297,944	$ 113,000	$ 3,603,861	$ 2,442,891	$ 11,810,263
	Medium	$ 6,977,171	$ 6,977,171	$ 159,000	$ 4,635,587	$ 2,697,981	$ 13,718,667
	High	$ 8,149,178	$ 8,149,178	$ 250,000	$ 7,248,949	$ 3,109,098	$ 17,815,699

5.3.4 Costs of Recommended Central Services

Planning level estimates of the probable costs of central services for the Core Area were developed in Chapter 4. These are summarized for the recommended systems in Table 5.3.4.

5.4 Services for New Development Outside the Core Area

On-site services to facilitate future development comprising single property developments as well as open space sub-divisions with cluster services are described in this section.

5.4.1 Wastewater

Onsite wastewater treatment and dispersal systems are recommended for new single unit developments as well as for clusters of new development – Unit costs are similar for systems servicing single units and systems servicing multiple units. Assessments of site specific conditions (including the hydrogeological investigation) are required for selection of the most appropriate onsite systems for each application.

Failed onsite systems, identified by property owners and/or through sanitary surveys must be upgraded or replaced. Replacement system options should also be assessed based on site specific conditions described in section 3.11. In locations where several failed systems are in close proximity such as along Highway 207 or where space is limited, there may be opportunities for cluster systems to replace individual systems.

5.4.2 Stormwater

Onsite infiltration systems and storage systems should be used to limited runoff volume and peak flows from new development or redevelopment to predevelopment levels – Creation of additional storage/treatment/infiltration systems to address existing stormwater related issues within the community should also be considered.

5.4.3 Water Supply

Wells may be used to service individual lots or clusters of development in the order of 10 units - The number of units each well is able to service depends on many factors. Overall costs of the wells depends on the depth the well is drilled which depends on the geology at any particular site. Estimated costs for each unit serviced are similar for individual wells and cluster water systems.

5.4.4 Minimum Lot Sizes

Minimum lots size must consider restraints imposed by current design requirements for onsite wastewater treatment and dispersal systems as well as limitations imposed by infiltration requirements for well water supply and well locations for optimum siting of wells.

Table 5.3.4: Life Cycle Costs of Central Services **1/30/2012**

Component		Year of Installation	Capital Cost (1)	Annual Operating and Maintenance Costs	Replacement Costs	Present Worth of Life Cycle Costs	Capital Cost (1)	Annual Operating and Maintenance Costs	Replacement Costs	Present Worth of Life Cycle Costs	Capital Cost (1)	Annual Operating and Maintenance Costs	Replacement Costs	Present Worth of Life Cycle Costs
Sanitary	P1-Highway 7	2014	$ 1,195,347	$ 1,232	$ 1,016,045	$ 1,230,593	$ 1,090,699	$ 1,232	$ 927,094	$ 1,125,957	$ 1,090,699	$ 1,232	$ 927,094	$ 1,125,957
	P1-Station Rd	2014	$ 576,031	$ 760	$ 489,626	$ 597,791	$ 2,092,168	$ 3,320	$ 1,778,343	$ 597,791	$ 2,092,168	$ 3,320	$ 1,778,343	$ 597,791
	P2-Highway 7	2018	$ 2,457,867	$ 13,381	$ 2,106,070	$ 3,162,796	$ 2,211,793	$ 13,582	$ 1,896,377	$ 2,913,521	$ -	$ -	$ -	$ -
	Existing Services	2014	$ 120,609	$ 560	$ 102,517	$ 136,677	$ 120,609	$ 560	$ 102,517	$ 136,677	$ 120,609	$ 560	$ 102,517	$ 136,677
	Total Collection		$ 4,349,853	$ 15,933	$ 3,714,259	$ 5,127,858	$ 5,515,269	$ 18,694	$ 4,704,331	$ 4,773,946	$ 3,303,476	$ 5,112	$ 2,807,955	$ 1,860,425
	PS#1	2014	$ 1,486,995	$ 36,708	$ 1,232,966	$ 2,789,828	$ 9,939,839	$ 36,156	$ 8,481,568	$ 8,421,936	$ 1,021,902	$ 19,604	$ 856,241	$ 1,796,293
	PS#1 Forcemain	2014	$1,627,288	$2,560	$1,383,195	$1,851,460	$ 1,516,138	$ 2,560	$ 1,288,717	$ 1,730,020	$ 1,516,138	$ 2,560	$ 1,288,717	$ 1,730,020
	Treatment - Tertiary in Porters Lake	2014	$ 7,440,551	$ 300,023	$ 6,110,446	$ 5,843,670	$ 5,344,723	$ 212,697	$ 4,412,826	$ 5,460,374	$ 4,896,168	$ 194,007	$ 4,049,496	$ 11,239,824
	Outfall to Porters Lake Site D	2014	$ 3,356,281	$ 5,280	$ 2,852,839	$ 9,815,940	$ 3,127,034	$ 5,280	$ 2,657,979	$ 4,108,797	$ 2,904,199	$ 5,280	$ 2,468,569	$ 3,324,701
	Sub- total Sanitary - Tertiary STP in Porters Lake		$ 18,260,968	$ 360,505	$ 15,293,705	$ 25,428,756	$ 16,895,458	$ 256,693	$ 16,841,090	$ 19,721,126	$ 13,641,883	$ 226,563	$ 11,470,978	$ 19,951,263
Storm (1)	Clearwater Sewers and Laterals													
	P1-Highway 7	2014	$ 1,441,904	$ 1,232	$ 1,225,618	$ 1,477,121	$ 1,441,904	$ 1,232	$ 1,225,618	$ 1,477,121	$ 1,441,904	$ 1,232	$ 1,225,618	$ 1,477,121
	P1-Station Rd	2014	$ 889,486	$ 760	$ 756,063	$ 911,211	$ 889,486	$ 760	$ 756,063	$ 911,211	$ 889,486	$ 760	$ 756,063	$ 911,211
	P2-Highway 7	2018	$ 1,385,726	$ 1,184	$ 1,177,867	$ 1,419,571	$ 1,385,726	$ 1,184	$ 1,177,867	$ 1,419,571	$ -	$ -	$ -	$ -
	Existing Services	2014	$ 120,609	$ 560	$ 102,517	$ 136,677	$ 120,609	$ 560	$ 102,517	$ 136,677	$ 120,609	$ 560	$ 102,517	$ 136,677
	Sub- total Storm		$ 3,837,724	$ 3,736	$ 3,262,065	$ 3,944,581	$ 3,837,724	$ 3,736	$ 3,262,065	$ 3,944,581	$ 2,451,998	$ 2,552	$ 2,084,198	$ 2,525,010
Water (2)														
	Wells	2014	$ 200,000	$ -	$ 180,000	$ 183,028	$ 175,000	$ -	$ 157,500	$ 160,150	$ 125,000	$ -	$ 112,500	$ 114,393
	Well Pumps & Piping	2014	$ 657,239	$ 12,212	$ 596,153	$ 1,281,575	$ 500,338	$ 10,930	$ 455,287	$ 1,030,787	$ 250,169	$ 10,394	$ 227,644	$ 656,946
	Water Treatment	2014	$ 4,648,000	$ 147,000	$ 3,812,380	$ 9,457,734	$ 3,049,000	$ 94,000	$ 2,517,190	$ 6,208,607	$ 2,336,500	$ 67,000	$ 1,960,015	$ 4,754,332
	Sub-total Water Supply and Treatment		$ 5,505,239	$ 159,212	$ 4,588,533	$ 10,922,337	$ 3,724,338	$ 104,930	$ 3,129,977	$ 7,399,545	$ 2,711,669	$ 77,394	$ 2,300,159	$ 5,525,671
	Reservoir	2014	$ 4,663,710	$ 4,664	$ 3,964,154	$ 4,401,889	$ 2,969,048	$ 2,969	$ 2,523,691	$ 2,802,366	$ 2,100,957	$ 2,101	$ 1,785,814	$ 1,983,010
	TM From WTP to Stn Rd	2014	$ 1,185,065	$ 2,328	$ 1,066,559	$ 1,374,003	$ 1,185,065	$ 2,328	$ 1,066,559	$ 1,374,003	$ 1,092,478	$ 2,328	$ 983,230	$ 1,271,878
	WM P1-Highway 7	2014	$ 627,148	$ 1,232	$ 533,076	$ 720,590	$ 578,150	$ 1,232	$ 491,427	$ 667,056	$ 578,150	$ 1,232	$ 491,427	$ 667,056
	Phase 1 - Station Rd	2014	$ 1,486,671	$ 3,168	$ 1,263,671	$ 1,715,286	$ 1,486,671	$ 3,168	$ 1,263,671	$ 1,715,286	$ 1,486,671	$ 3,168	$ 1,263,671	$ 1,715,286
	TM to Reservoir	2014	$ 1,071,039	$ 2,104	$ 910,383	$ 1,230,618	$ 1,071,039	$ 2,104	$ 910,383	$ 1,230,618	$ 987,360	$ 2,104	$ 839,256	$ 1,139,192
	Phase 2 - Highway 7	2018	$ 394,193	$ 840	$ 335,064	$ 403,926	$ 394,193	$ 840	$ 335,064	$ 403,926	$ -	$ -	$ -	$ -
	Water Laterals	2014	$ 125,969	$ 752	$ 107,074	$ 159,227	$ 125,969	$ 752	$ 107,074	$ 159,227	$ 125,969	$ 752	$ 107,074	$ 159,227
	Total Distribution		$ 9,553,796	$ 15,088	$ 8,179,980	$ 10,005,540	$ 7,810,136	$ 13,393	$ 6,697,869	$ 8,352,482	$ 6,371,586	$ 11,685	$ 5,470,472	$ 6,935,649
	Sub- total Water		$ 15,059,035	$ 174,300	$ 12,768,513	$ 20,927,877	$ 11,534,473	$ 118,323	$ 9,827,846	$ 15,752,026	$ 9,083,255	$ 89,079	$ 7,770,631	$ 12,461,320
Total Servicing Costs			$ 37,157,727	$ 538,540	$ 31,324,283	$ 50,301,215	$ 32,267,656	$ 378,752	$ 29,931,001	$ 39,417,734	$ 25,177,136	$ 318,195	$ 21,325,807	$ 34,937,593

Note:

(1) Estimates of Probable Costs based on those provided in Table 4.3.1 for the components shown in Figures 4.1.1(f), 4.1.2 and 4.1.3(a).

Life Cycle Analysis - Criteria	
Pumping Stations &Treatment Plants	
Portion Funded by Others	0%
Date of Estimate	2011
Start of Construction	2014
Life Cycle Analysis	100
Civil - Concrete Structures	100
Civil - Gravity Sewers	75
Civil - Forcemains, Watermains	50
M & E - HVAC, Power Supply	40
M&E - Pumps, Motors and Instrumentation	25
Interest Rate	5.0%
Inflation	2.0%
Annual Cost of Money	3.0%

Based on the screening level assessment for water supply by wells, the minimum lot size for residential development should be set based on a requirement for a minimum of 5,971 square metres of permeable surface for each 1 cubic metre per day of demand. This should be added to the area taken by all impermeable surfaces on the property and the total compared to the minimum lot size required for the onsite wastewater treatment and dispersal system. The larger size should be used to establish a minimum property size on a site by site basis.

This minimum area of 5,971 square metres of permeable surface per lot is required to provide water for a single family residence under typical conditions in the Study Area. When added to the planned impermeable areas on each property, it forms the bases of the minimum lot size for areas with a soil depth exceeding 300 millimetres. In locations with soil depths of 150 to 299 millimetres, the minimum lot size should be 6,800 square metres and in locations with soil depths less than 149 millimetres, the minimum lot size should be 9,000 square metres to meet Nova Scotia Environment technical guidelines for onsite sewage disposal systems[14].

5.4.5 Costs of On-site Services

Estimates of the range of construction costs expected for the services described in this section are summarized in Table 5.4.5(a).

Table 5.4.5(a): Cost Summary for Provision of On-site Services in the Study Area

	Wastewater Services New or Reconstructed	Stormwater	Water Supply Surficial or Bedrock	Overall Servicing Costs	($/ Service)
Individual Onsite Systems	$4,000 - $12,000 **or** $15,000 - $25,000	$2,500 - $3,500	3,000 - $6,000 **or** $4,000 - $11,000		$9,500 - $21,500 **or** $21,500 - $39,500
Cluster Systems	$50,000 - $115,000	$25,000 - $35,000	$13,000 - $40,000	$88,000 - $190,000	$8,800 - $19,000

These are not the only costs expected for the provision of these services. Following is a list of additional costs:

- Operation and maintenance of the systems; and
- Costs for repair or replacement of components as their useful life is expended. Mechanical and electrical components typically have a shorter design life and need to be replaced after 20 years of service. Local installers indicate that failed soil dispersal systems in the area that need to be replaced are typically in the order of 25 years old. Other components such as piping and concrete structures typically last 50 to 100 years.

All of this information was used to assess the life cycle costs of the recommended services. These are summarized in Table 5.4.5(b).

[14] Nova Scotia Environment, April 2009. *On-Site Sewage Disposal Systems Technical Guideline: Minimum Lot Size requirements For Development Utilizing On-Site Sewage Disposal Systems.* Table 2.4.

Table 5.4.5(b): Life Cycle Costs of On-site and Cluster Services

Component	Capital Cost	Initial Installation Costs	Annual O&M Costs	Replacement Costs	Present Worth of 100 Year Life Cycle
On-site - Single Family	$ 27,500	$ 27,500	$ 502		$ 58,110
Well	$ 10,000	$ 10,000	$ -	$ 9,000	$ 9,151
Well Pump	$ 1,000	$ 1,000	$ 55	$ 1,200	$ 3,729
Water Treatment	$ 2,000	$ 2,000	$ 110	$ 2,000	$ 9,939
Rain Garden	$ 2,500	$ 2,500	$ 138	$ 2,500	$ 8,100
Septic Tank	$ 4,500	$ 4,500	$ 117	$ 4,050	$ 7,469
Pump	$ 1,500	$ 1,500	$ 83	$ 1,500	$ 5,285
Contour	$ 6,000	$ 6,000	$ -	$ 12,000	$ 14,437
	$ -	$ -	$ -	$ -	$ -
On-site - 10 Unit	$ 19,940	$ 19,940	$ 1,344	$ -	$ 70,986
On-site - 10 Unit	$ 199,400	$ 199,400	$ 13,444		$ 709,857
Well	$ 38,000	$ 38,000	$ -	$ 34,200	$ 34,775
Well Pump	$ 2,000	$ 2,000	$ 550	$ 1,500	$ 19,168
Water Treatment	$ 20,000	$ 20,000	$ 1,100	$ 20,000	$ 99,390
Rain Gardens	$ 25,000	$ 25,000	$ 1,375	$ 25,000	$ 81,004
Septic Tank	$ 20,500	$ 20,500	$ 9,594	$ 18,450	$ 294,295
Pump	$ 3,000	$ 3,000	$ 825	$ 3,000	$ 29,524
Contour	$ 90,900	$ 90,900	$ -	$ 91,900	$ 151,700
0	$ -	$ -	$ -	$ -	$ -
On-site - 20 Unit	$ 19,875	$ 19,875	$ 973	$ -	$ 62,047
On-site - 20 Unit	$ 397,500	$ 397,500	$ 19,464		$ 1,240,949
Well	$ 76,000	$ 76,000	$ -	$ 68,400	$ 69,551
Well Pump	$ 4,000	$ 4,000	$ 1,100	$ 4,000	$ 39,365
Water Treatment	$ 40,000	$ 40,000	$ 2,200	$ 40,000	$ 198,781
Septic Tank	$ 32,000	$ 32,000	$ 12,500	$ 28,800	$ 409,734
Pump	$ 4,500	$ 4,500	$ 1,650	$ 4,500	$ 51,503
Contour	$ 191,000	$ 191,000	$ -	$ 167,700	$ 347,283
Rain Gardens	$ 50,000	$ 50,000	$ 2,014	$ 2,750	$ 124,732

Life Cycle Cost Anaysis Criteria are as presented for Table 5.4.5(a)

5.4.6 Ownership, Operation Maintenance and Monitoring

5.4.6.1 Central Services

Traditionally, Halifax Water assumes ownership of the components of central wastewater, stormwater and water supply systems that are on street rights of way and on easements. Halifax Water operates and maintains these systems including monitoring and reporting as required for operation and by Nova Scotia Environment. Features of these systems that are on private property are operated and maintained by the property owners. This arrangement is assumed to be the case for central services for the Core Area in Porters Lake.

5.4.6.2 Individual Properties

Property owners traditionally own, operate, and maintain onsite wells and wastewater treatment systems. There are no provincial requirements for monitoring of onsite systems or for reporting on their performance. In cases where malfunctioning onsite wastewater systems are suspected, it may be desirable to have monitoring of individual onsite systems as part of an overall plan to manage surface water and groundwater quality in the Study Area.

5.4.6.3 Condominium Associations

In HRM, condominium associations typically own cluster water and wastewater services where they service multiple units with multiple owners and in some cases on multiple properties. Each condominium association would:

- Own all of the components of the water system (distribution piping, wells, pumps, treatment and storage) as well as the wastewater system (septic tanks, pumps, collection piping, treatment and land application piping). Capital costs to construct the facilities would be shared by the members of the Association, the property owners sharing the common facilities;
- Be the entity responsible to operate and maintain the common facilities and to monitor them and report to Nova Scotia Environment; and
- Pay the costs to operate, maintain, monitor and report. Typically these tasks are contracted out to a specialist contractor, familiar with the facilities and responsibilities of operating the systems and certified by Nova Scotia Environment. A number of these contractors currently work on these systems throughout the HRM.

5.4.6.4 Wastewater Management District

An alternative management approach is to form a wastewater management district in the Study Area. In other jurisdictions, the District owns all infrastructure associated with the collection and treatment of wastewater, including all infrastructure on private properties, one metre outside of the buildings serviced. The District is responsible for operation, maintenance, monitoring and reporting associated with the system for central collection and treatment in the community as well as the systems that treat wastewater from single properties.

These districts are formed to ensure that all systems in a community are properly constructed, operated, maintained and monitored by a single responsible entity that then reports to the municipal unit that owns the District and to Nova Scotia Environment. The municipal unit is then able to make changes to its system or operational procedures to improve the system and reduce potential impacts on

the receiving environments or improve conditions in the receiving environments as would be the case in the Study Area.

It is expected that the scope of responsibility could be expanded to include water supply systems and potentially to stormwater management systems although current regulatory framework, including the Halifax Charter, does not make provision for this. This would bring consistency to water supply and water quality in the community and allow an integrated approach to wastewater treatment, water supply and stormwater management with the overall objective of improving water quality in the lakes in this study area.

So that development can continue, the objective of the District would be improving water quality in the receiving waters with little or no assimilative capacity. In this study area, the greatest concern is with Chezzetcook Inlet. The District would need to include all lands in the watersheds tributary to the Inlet, the lands on the west side of the Inlet at the very least. If it is to be fashioned as in other Municipalities, the District would be responsibility for operation, maintenance, monitoring and reporting for all water, wastewater and stormwater systems in the District. HRM is a likely candidate for the role of manager of the Water – Wastewater Management District (District).

Each new subdivision, individual property development or redevelopment of an existing property would include specified infrastructure for all services. The District would take over these new facilities as well as all existing on-site services. All existing systems outside of the Core Area would need to be surveyed to determine their components, existing physical conditions and their ability to provide the required services. The District would then provide upgrades as necessary for proper operation.

Most of the required services could be contracted to qualified service providers. HRM would need to set up an administration group with responsibility for obtaining, overseeing and paying for the services as well as collecting fees from property owners to pay for the services. Estimates of the range of units serviced in the three growth scenarios are presented in Table 5.4.6.4. Also included in the table are estimates of the average annual costs for the water and wastewater management district that includes the cost to:

- Operate and maintain the systems;
- Inspect and report on the systems; and
- Replace components when they reach the end of their useful life.

5.5 Regulatory Controls and Management Strategies

Prior to any significant additional development in the Study Area, HRM should address the major constraints as outlined in the following plans. Input from various levels of government and all affected parties should be beneficial in the development and undertaking of these plans.

Table 5.4.6.4: Average Annual Costs for a Water and Wastewater Management District

Growth Scenario	Civic Units Participating Outside of Core Area		Average Annual Cost (1)			Average Unit Costs
	2014	2030	Outside of Core Area	In Core Area	Total	All Units Serviced
High	2511	3565	$ 3,490,000	$ 560,000	$ 4,050,000	$ 1,125
Medium	1900	2640	$ 2,690,000	$ 390,000	$ 3,080,000	$ 1,151
Low	1281	1665	$ 1,910,000	$ 330,000	$ 2,240,000	$ 1,318

(1) Annual Costs for Operation, Maintenance and Replacement of Onsite, Clustered and Central Services

5.5.1 Management of Water Supply

5.5.1.1 Local Aquifers

The largest available groundwater source for water supply is the local aquifers that supply existing wells. This source is limited in the quality of the water that it can supply. To facilitate the growing demand exerted by continuing development, groundwater recharge is required. Drainage plans submitted as part of development plans for subdivisions should include recharge components. Review of the plans should consider:

- Proposed infiltration systems and their locations; and
- Water selected for infiltration systems. Only "clean" sources should be considered so that groundwater quality is not compromised.

5.5.1.2 Water Treatment

Groundwater will require treatment for a central water supply and will likely require treatment prior to use in individual properties or clusters to ensure that it is aesthetically acceptable and free from pollutants that can be health concerns. The most appropriate treatment and the extent required will need to be defined by sampling, analysis and comparison of results to CCME Drinking Water Guidelines as well as treatability testing. This testing should be completed as individual wells are being developed.

5.5.2 Management of Receiving Water Quality

5.5.2.1 Minimize Impacts of Development

Minimizing Impacts of Effluent Discharges

The proposed on-site treatment systems include contour systems that are designed to allow treatment of septic tank effluent as it passes through unsaturated soils enroute to the groundwater aquifer. Alternative systems utilize recirculating filters to treat the effluent prior to discharge to the environment. The proposed recirculating filter systems also include a land application component so that the effluent is further treated prior to entering the aquifer, similar to the contour systems. In the event that the infiltration component fails, the effluent typically enters the surface water system.

CCME Guidelines for wastewater treatment plants require effluent discharges with maximum 25 mg/L for CBOD and suspended solids. Current design guidelines used by provincial regulators require 20 mg/L for rivers and estuaries, 5 mg/L for lakes and low flow streams or lower (depending on the ability of the potential receiving waters to provide dilution) for the same parameters. As a minimum, the proposed treatment systems will need to be able to achieve these Provincial objectives. Typically the recirculating filter systems should be able to achieve the limits for rivers and estuaries or better if designed and operated as required. Additional treatment is required for discharges to lakes. These systems are therefore recommended for cluster systems and replacement of failed systems.

In this study area, phosphorus loads are a concern. Although there are no specific limits imposed by NSE for phosphorus, the result of the receiving water assessment indicated that there should be for any treatment systems discharging effluent directly or indirectly into any waterbodies in the study area, including Porters Lake. Treatment systems must be able to retain most (90% or more) of the

phosphorus generated in wastewater flows. Then, if the soils are unable to accept and further treat the effluent, the impact of the effluent on the receiving environment will be greatly reduced.

As a minimum, the proposed treatment systems will need to be able to achieve these water quality objectives:

- A tertiary level wastewater treatment plant is recommended for Porters Lake. It will meet this minimum requirement; and
- Typically the recirculating filter systems should be able to achieve these limits or better if designed and operated as required, and are therefore recommended for cluster systems and replacement of failed systems.

Minimizing Other Impacts of Development

While wastewater treatment can deal with issues such as E coli, Fecal coliforms, biochemical oxygen demand, phosphorus, nitrogen, etc. other pollutants can enter the watershed through inappropriate disposal of chemicals such as solvents and paints. An education and enforcement program related to chemical disposal for local residents and businesses should be established.

The application of road salt during winter can also have a significant impact on water quality. Road salting should be limited as much as possible, and methods of treatment for stormwater impacted by road salt and sediment should be examined and utilized where possible.

To limit impacts of vegetation clearing, subdivision style development in the Study Area should be limited to Open Space Design Developments as defined in the HRM Regional MPS. Clustered sewage treatment systems as opposed to individual septic fields are preferred.

Clear cutting in the watersheds tributary to Porters Lake is significant, approximately 12 percent of the non-lake area in the study area watersheds were clear cut at the time of the study compared to 11% urbanized in the watersheds tributary to Porters Lake. Control of clear-cutting and runoff from clear cut areas is important to minimize erosion and sedimentation as well as nutrient loads in streams, lakes and Chezzetcook Inlet.

Mitigation for Additional Pollutant Discharges

The water quality in Chezzetcook Inlet as well as in some localized areas in Porters Lake does not support objective water uses. The poor water quality appears to be the result of the existing activities in the tributary watershed including improperly functioning onsite wastewater treatment systems, urban development and clear cutting.

This does not mean that development in the watersheds tributary to these water bodies should be halted. If development carries on as it has in the past, further development will make matters worse. A two-pronged approach to the problem is required:

- A reduction in current pollutant loads to these water bodies is required. The reduction must be at least equivalent to the loads that are expected to be generated by future development to have no net effect. Potential sources of existing pollutant loads and measures to reduce them were discussed in Section 3.6; and

- Measures should be taken to reduce the impacts of future development. HRM has the ability to control impacts due to future development through the subdivision approval process.

HRM must work with existing property owners, starting with the owners of the largest and potentially greatest contributors to develop plans to reduce existing pollutant loads into the receiving waters with the least assimilative capacity. An improvement in incoming water quality should result in an overall improvement to water quality in these receiving waters.

While working in conjunction with the Provincial and Federal governments is desirable and may allow for significant overall improvements, there is nothing to prevent HRM from working singly to achieve its desired goals.

Additional Improvements to Achieve Desired Water Uses

Watershed Management Plans involving all levels of government, private industry, special interest groups, individual citizens and other interested stewards have proven effective in the development and implementation of plans to improve conditions in watersheds and estuaries similar to these. A leader is required to initiate the planning process. In order to provide reduction in pollutants from upstream areas to offset pollutant loads from proposed development, it may be in HRM's best interest to step forward, take the lead and start the process. With such an organization, it may be feasible to achieve even greater reductions in pollutant loads than are required to offset the proposed development.

Generally, the rivers and streams in the area provide habitat for salmonid fish species such as brook and brown trout, and salmon. High phosphorus levels typical in runoff from urban areas can impact cold water fish species and should not exceed 0.035mg/L. Water temperature is also an issue and watercourse and wetland buffers should be preserved to provide shade for the water. Water and effluent releases to water bodies in the area should be within CCME guidelines for temperature as well as other water quality parameters.

5.5.3 Buffers

Land considered undevelopable in this study should be confirmed and if agreed, changes made to the land use bylaw should be implemented for the following:

- Watercourse, wetland and lake buffers of 20 metres in line with HRM's Regional MPS should be supplemented in areas of shallow slopes which fall within the 20 metre buffer with an additional one metre of buffer for every two percent of slope under 10 percent, to a maximum of a 60 metre wide buffer or as defined by a detailed floodplain delineation study. Similar increases in the buffer width are reasonable for slopes over 20 percent.

5.6 Monitoring the Impacts of Development

Monitoring is required to establish baseline conditions in the Study Area and to follow development progress and its impacts. Assessment of the ongoing data may be used to modify development plans in response to unpredicted impacts.

The assessments completed in this study are desktop studies based on limited field data for the most part. To be most reliable, field data should be collected to establish baseline or existing conditions with respect to groundwater levels and quality, surface water flood levels and quality, receiving water quality. Once established they can serve two purposes:

- To better estimate the impacts prior to expected development; and
- To compare with post development measurements to confirm that the actual impacts are as predicted prior to implementing mitigating measures if possible.

5.6.1 Surface Waters

Establishing reliable existing (baseline) conditions in the Lakes in the study area as well as Chezzetcook Inlet is important in the assessment of the impacts the proposed development may have on these systems. Long term monitoring of freshwater and marine water quality would be beneficial for comparison with monitoring results to determine if the management plans are producing the desired reductions in pollutant loads or if the plans need to be changed.

As a minimum, the program should consist of the following:

- **Locations of sample collection** – continue to sample locations used in this study (see Figure 3.2.3). Additional samples are suggested in Chezzetcook Inlet and in the lakes in the study area, including Mill Lake Chezzetcook Lake and Petpeswick Lake;
- **Sampling frequency** – samples should be collected as often as financial limitations allow but it would be most beneficial to quantify seasonal variations in the system. As a minimum, samples should be collected in spring, summer and fall during wet weather as well as dry weather. This program should be conducted for as long as possible prior to further development and should continue during development and for long enough after full development is complete to establish its impact on the system;
- **Analysis parameters** – all of the parameters analysed in this study would be beneficial for a long term program, including:
  - E coli and total coliforms;
  - Nitrogen in various forms, total phosphorus and Chlorophyll a;
  - BOD_5 and Total Suspended Solids; and
  - Salinity, Temperature, Dissolved Oxygen and pH.
- If other pollutants are suspected, grab samples may be collected intermittently and analysed for other parameters of concern including:
  - Heavy metals;
  - Hydrocarbons; and
  - Other potential pollutants.
- **Compilation and tracking requirements** – after analysis, results should be added to the existing results and plotted for each site against time as well as plotted against the other sampling sites for each sampling event. This provides an indication of areal and temporal changes in water quality through the drainage systems and this is useful in the determination of the location and sources of potential pollutants;

- **Analysis and reporting requirements** – depending on the changes noted or following completion of major developments, the data should be used to recalibrate the phosphorus loading models ant the hydro-technical model of Porters Lake and the results re-evaluated with respect to the impacts of development on water quality in the receiving waters; and
- **Action plans for findings that do not meet expectations** – where all possible measures are being implemented in the Study Area but the receiving waters are still being impacted more than is reasonable, alternate mitigation measures should be considered in the upstream tributary areas of the watershed. First, major sources of pollutants would need to be identified and then plans developed for reduction or elimination.

Additional monitoring in the form of grab samples collected during wet and dry weather conditions may be warranted to confirm the concentrations measured in the 1997 Study as well as to identify new sources of pollutants to the waters of Chezzetcook Inlet. This would be a first step in the process of reducing background concentrations of pollutants to offset the additional loads added by additional development.

5.6.2 Groundwater

There is limited data available on ground water quality from the Study Area. The well sampling program associated with this study has provided some indication of well water treatment requirements. This program should be continued during the operation of all water supply systems serving 25 people or more as part of the normal operating requirements for each water supply.

As a minimum, a recommended monitoring program for groundwater should consist of the following:

- **Locations of sample collection** – samples should be collected from each water well servicing a cluster system as well as at representative domestic wells in the Study Area;
- **Sampling frequency** – as a minimum for all treatment systems servicing cluster developments, samples should be collected quarterly during wet seasons of spring and fall as well as lower flow seasons in the winter and late summer. These samples should be collected for a minimum of 1 year to quantify seasonal variations in these systems. A well-defined program of sample collection and analysis is required by provincial and federal regulations and is part of the Permit to Operate for all water treatment plants. Annual samples from the wells servicing single units, collected in the drier parts of summer should suffice;
- **Analysis parameters** – parameters required as part of a treatability program would include as a minimum:
  - Turbidity;
  - pH;
  - Salinity;
  - Colour;
  - Metals (dissolved and total);
  - TOC/DOC;
  - THM formation potential;
  - UV254 absorbance;
  - Bacteriological testing (E. coli + organisms of concern);
  - Hardness;

  - Alkalinity; and
  - RCAP (ion balance, calcium, and inorganic minerals).
- **Compilation and tracking requirements** – after analysis, results should be added to the existing results and plotted for each site against time and sample location;
- **Analysis and reporting requirements** – the data should be re-evaluated with each set of new measurements with respect to the operation of any water treatment facilities. In addition, the data should be routinely compared to CCME Guideline values for drinking water; and
- **Action plans for findings that do not meet expectations** – Individual home and business owners should be informed of variations in their individual supplies. On clustered systems, adjustments to operation of treatment processes would be made to compensate for changes in well water quality and quantity as required. Where parameters not addressed by the treatment facilities are above guideline values it should be noted and reported and if this becomes routine, assessments must be made to address the issue, process modifications may be necessary if well water protection measures are not achievable.

Similar to the surface water system, monitoring of well water levels around the community should be completed to quantify seasonal variations as well as long term changes in levels as development in the community proceeds.

5.6.3 Estimated Costs of Monitoring

The estimated annual cost to sample at the locations in Porters Lake used in this study as well as 5 sampling locations proposed in the other lakes and in Chezzetcook Inlet 3 times each year during dry weather and wet weather is presented in Table 5.6.3.

The estimated average annual cost to sample wells that will be constructed to service future development in the Core Area as well as in clusters outside of the Core Area for the high growth scenario 4 times per year and to sample existing wells once per year is also presented in Table 5.6.3.

Table 5.6.3: Annual Costs of Proposed Sampling Programs

Surface Water Program	Sample Locations	Seasons Sampled	Wet	Dry	Annual Number of Samples	Sampling Costs	Analysis Costs	Reporting	Total Annual Cost
Porters Lake	5	3	1	1	30	$ 11,625	$ 15,249	$ 4,500	$ 31,374
Other Lakes	10	3	1	1	60	$ 11,625	$ 30,499	$ 4,500	$ 46,624
Chezzetcook Inlet	5	3	1	1	30	$ 11,625	$ 15,249	$ 4,500	$ 31,374
Total Surface Water Sampling Program									**$ 109,373**

Groundwater Program	Sample Locations	Seasons Sampled	Wet	Dry	Annual Number of Samples	Sampling Costs	Analysis Costs	Reporting	Total Annual Cost
Core Area	5	4	1	1	40	$ 15,500	$ 18,450	$ 6,000	$ 39,950
Outside of Core Area: Clusters	304	1	0	1	304	$ 1,938	$ 140,121	$ 25,000	$ 167,058
Total Groundwater Sampling Program									**$ 207,008**

APPENDIX A

Focus Group Meeting Summaries

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PORTERS LAKE WATERSHED / SERVICING STUDY

Community Focus Group Meeting

Porters Lake Community Centre, January 31 2011 from 6:30 to 9:30 pm.

Attendees were as follows:

- Nineteen (19) residents of Porters Lake and two (2) Lake Echo residents representing the Citizens for Responsible Development, invited by Councilor Hendsbee. A copy of the sign-up sheet is attached;
- Maureen Ryan HRM Planning, HRM Councilor David Hendsbee; and
- Gordon Smith and Mike DeLay, CBCL Limited

A presentation was made by CBCL Limited that included:

- Some findings of investigations in the Study Area, including the results of the Water Quality Sampling Program in Porters Lake and the Survey of Water Quality Objectives;
- General discussions of servicing options including typical costs; and
- Alternative development densities.

Following the presentation and discussions that arose on various points during the presentation, the attendees were asked to gather in three (3) groups around the three (3) large tables. They were asked to consider future development in the community and to answer two (2) questions based on their options of the information presented:

- What type of development should occur, low density development serviced by onsite systems as has generally occurred in the community or dense development serviced by central water, wastewater and stormwater systems?
- If there is dense development with central services, where should it be located? Each table was given a map of the Study Area and asked to draw the locations on the maps.

The attendees were advised that their opinions will be used to help the study team put together plans that would have the best chances of being accepted by the community. A public meeting would be held in late March or early April. All residents would have an opportunity to express their opinions at that time.

After approximately 45 minutes of discussion, each group presented their findings to all attendees. Summaries of their presentations are provided in the following paragraphs.

Group 1 Comments:

- Core of the community that could be serviced with central systems is the area around the Superstore and could extend over to the Sobeys lands and up back around behind the Fire Hall, a scanned copy of the drawing used at the meeting is attached;
- Large lots with on-site systems are suitable for the rest of the area beyond the core; and
- The area around the school could be appropriate for more dense smaller lot development suitable for young families and seniors that wish to live in Porters Lake but can't afford to purchase or do not wish to maintain large properties. Taxes are a concern.

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Group 2 Comments:

- Higher density would be appropriate in the same area outlined by Group 1, around the new school and the commercial district from Superstore to the intersection with the highway access road to resolve failing onsite systems. Apartment buildings seem appropriate in the core, as do senior's complexes, much needed in the community; and
- The Chezzetcooks and other small places should stay the same. Discussions in the group indicated an interest in Cluster Developments in areas where soils are less suitable for onsite systems.

Group 3 Comments:

- The core is the same as Groups 1 and 2, but with the new school as the centre of the area;
- Developments using on-site systems should only be put on areas with good soils;
- The area around the O'Connell Street school could also be an appropriate area for higher density development, for first time homeowners;
- The right of way for the old railway line running down the middle of the peninsula to Grand Desert could have a road developed alongside the trail to open up the area to development;
- The Old Mineville Road could be developed as a trail;
- Stay away from areas with poor soil conditions.

After the meeting, CBCL Limited reviewed the notes taken by the team members and summarized the discussions in this document.

Porters Lake Watershed Servicing Study.
31 Jan. 2011

Focus Group Mtg:

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21 Community input
+2 CBCL
+2 HRM
25 in total

Tantallon and Porters Lake Watershed Servicing Study
Porters Lake Study Area

HALIFAX
REGIONAL MUNICIPALITY

0 1.25 2.5 5 km

Study Area
Waterbodies
Property Boundaries
Wetlands
Rivers and Streams

Roads
Divided Highway
Arterial
Collector
Paved Road
TCH
Unpaved Road
Railroad
Lanes / Driveways
ROAD ruin/inactive/abandoned
Cart Track / Footpath
Ferry
Misc

CBCL Project # 101015
Data Sources: HRM, NSDNR
Coordinate System: NAD 1983 UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

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File Path: L:\101015 Tantallon Porters Lake Watersheds\101015_GIS\101015_Layout\101015 - Basemaps for Open Houses\101015 Open House Basemap 24 x 36.mxd Last Saved: 1/31/2011 1:47:55 PM

APPENDIX B

Component Study – Groundwater Assessment

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CHAPTER 1 AREA HYDROGEOLOGY

1.1 Surficial Unit

Quaternary material in the Porter's Lake study area is predominated by ice contact till plains, consisting of locally sourced stoney, sandy till and frequent boulders appearing at the ground surface. The buffering capacity of this soil is poor as a result of the local slate and quartzite source rock. Quartzite tills predominate in the northwest (including Porter's Lake Centre) and southeast arm of the study area, typically reaching thicknesses of up to 20 m. Slate tills cover the northeast parts of the study area, with a maximum thickness of 4 m. The southwest arm of the study area is covered largely by drumlins. Drumlin till shows improved buffering capacity and better suitability for farmland. Although dominated by fine grained material, this terrain can provide good local deposits of sand and gravel suitable for individual water supplies.

Figure 1.1 shows provincial mapping of quaternary features within the Porter's Lake area. There are over 20 silty drumlins concentrated in the southwest arm of the study area and within Chezzetcook Inlet. Till in these drumlins is similar to the surrounding plains, but may be of sufficient thickness to exhibit water bearing seams. Drumlins in the study area are composed of silt till and red clay derived from outside of the study area, with varying beds underlying the surface soils.

Well logs indicate that the thickness of surficial materials is typically 3 to 8 m, reaching up to 110 m in the most extensive units. Lower-lying areas predominate in the north and eastern parts of the study area. Shallow flow systems in these areas are likely to discharge locally to streams and lakes. A bog located near East Chezzetcook is expected to act as a local groundwater recharge area, constituting a shallow groundwater flow divide for the land lying between Chezzetcook Inlet and Petpeswick Inlet. Shallow groundwater flow in the northern parts of the site is expected to be closely associated with Petpeswick, Chezzetcook, Conrod, and Porter's Lakes. Flow to and from these lakes could contribute to local or more regional components of flow.

Groundwater in the southwest part of the study area is expected to be dominated by flow systems local to each of the drumlin features, controlled in part of the existence of sandier seams. Upward gradients or springs at the toes of drumlins can create suitable areas for the development of shallow wells for individual groundwater supplies. There is a bog situated in between several large drumlins which likely receives some flow from these drumlins, and could generate a vertical component that discharges to

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Trout Lake
Conrod Settlement
Gaetz Brook
Porter
Head of Chezzetcook
Porters Lake
West Petpeswick
Grand Lake
East Chezzetcook
West Chezzetcook
Mill Lake
Caribou Lake
Petain
Middle Porters Lake
Lower East Chezzetcook
Goose Lake
Grand Desert
Desert
Snow Lake
Seaforth
Three Fathom Harbour
Lawrencetown
Lloy
Terminal Beach
Lower Three Fathom Harbour

Figure 1.1: Quaternary Geology of the Porter's Lake Area

Porters Lake Study Area

Road

- Divide Highway
- Arterial
- Collector
- Paved Road
- TCH
- Unpaved Road
- Railroad
- Lanes / Driveways
- ROAD ruin/inactive/abandoned
- Cart Track / Footpath
- Ferry
- Misc
- County Lines

- Organi Deposits
- Hummocky Ground Morraine
- Stony Till Plain (Ground Moraine)
- Stony Drumlin (Drumlin Facies)
- Silty Till Plain (Ground Moraine)
- Silty Drumlin (Drumlin Facies)
- Bedrock

0 0.5 1 2 3 4 Kilometers

N W E S

Project #:101015
Project Name:Tantallon-St. Margarets Bay & Porters Lake - Lake Echo Watershed Studies

10/27/2010 11:45:51 AM

Data Sources:
NSGC Topographic Database
NSDNR Netlin

Datum: NAD83 UTM Zone 20N L:\101015 Tantallon Porters Lake Watersheds\101015_GIS\101015_Layout\101015 - Groundwater Layouts\101015 - Fig1.1 Surficial Geology.mxd

coastal or off-shore areas. Flow systems in the southwest, on the east shore of Porter's Lake are expected to be shallow and immediately local to coastal zones.

1.2 Bedrock Unit

Bedrock in the Porter's Lake area is metamorphic rock of the Meguma Group, lying to the south of the Musquodoboit Batholith (Figure 1.2). Rock types vary from sections of leucomonzogranite in the extreme northwest and northeast parts of the study area, to quartzite and slates over the remainder. Halifax Formation Slates occur primarily in the northeastern and southwestern parts of the study area, whereas quartzite and slate of the Goldenville Formation underlie Porter's Lake Centre and East Chezzetcook.

Groundwater flow in Halifax Formation slates can occur largely through a weathered zone occupying the upper 1 to 2 metres of the unit. Fracture partings bedding plains become less frequent, exhibit smaller openings, and decrease in connectivity with depth. Major water bearing features are nevertheless encountered at depth in selected locations. Quartzite and slate rock of the Goldenville Formation is similarly likely to exhibit greater hydraulic conductivity in the upper sequences, with water bearing features decreasing in frequency at depth. Fractures are frequently sub-vertical. Regional topographic patterns shown by provincial LiDAR mapping indicated that major structural features strike from north-northwest to south-southeast, and from east-northeast to west-southwest.

Flow in bedrock units is expected to include recharge to the shallower intervals of the bedrock by bog and lake areas, with flow and discharge to coastal areas and within the inlets. A local topographic low associated with Petpeswick Lake may result in intermediate components of flow recharging the local bedrock regime and discharging to Chezzetcook Inlet. Upland areas are located primarily to the north of the study area, in association with granitic rocks of the Muquodoboit Batholith. Regional flow originating in this zone would generate flow paths passing under the study area and discharging to inlets or off-shore areas. Deeper groundwater flow paths are expected to be generally to the south and southeast.

Poor fracture connectivity can lead to low yields, but can also limit interference between adjacent locations. Poor fracture connectivity will also result in low hydraulic conductivities and associated low bulk fluxes through the bedrock. By contrast groundwater velocities through individual fractures may be high. Higher groundwater velocities through discrete fractures have implications for contaminant transport. The gradient in the bedrock unit is expected to vary from downward to horizontal in the most northern parts of the study area, to upward closer to the inlets and coastlines. Flow patterns should reflect regional flow from inland areas, and local/intermediate flow within each of the peninsulas. Shallower intervals of the bedrock may transmit recharge from bog areas and larger lakes to coastal discharge zones.

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Trout Lake
Conrod Settlement
Gaetz Brook
Porter
Porters Lake
Head of Chezzetcook
West Petpeswick
Grand Lake
Mill Lake
Caribou Lake
Goose Lake
Snow Lake
West Chezzetcook
East Chezzetcook
Petain
Middle Porters Lake
Lower East Chezzetcook
Grand Desert
Desert
Seaforth
Three Fathom Harbour
Lawrencetown
Lloy
Terminal Beach
Lower Three Fathom Harbour

Figure 1.2: Bedrock Geology of the Porter's Lake Area

- Porters Lake Study Area

Road

- Divide Highway
- Arterial
- Collector
- Paved Road
- TCH
- Unpaved Road
- Railroad
- Lanes / Driveways
- ROAD ruin/inactive/abandoned
- Cart Track / Footpath
- Ferry
- Misc
- County Lines

- Windsor Group Evaporite
- Halifax Formation
- Goldenville Formation
- Granodiorite
- Biotite Monzogranite
- Muscovite Biotite Monzogranite
- Leucomonzogranite
- Fine Grained Leucomonzogranite
- Granitoid

0 0.5 1 2 3 4 Kilometers

Project #:101015
Project Name:Tantallon-St. Margarets Bay & Porters Lake - Lake Echo Watershed Studies

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Data Sources:
NSGC Topographic Database
NSDNR Netlin

N W E S

Datum: NAD83 UTM Zone 20N L:\101015 Tantallon Porters Lake Watersheds\101015_GIS\101015_Layout\101015 - Groundwater Layouts\101015 - Fig1.1 Bedrock Geology.mxd

CHAPTER 2 METHODOLOGY

2.1 Area Hydrogeology

A review of the regional topography, geology, and hydrogeological setting was used to develop a conceptual model of the groundwater flow systems throughout each study area. This conceptual model was developed based on principles of groundwater flow, scenarios for shallow and deeper flow systems, groundwater recharge and discharge areas, potential interaction with surface water features, pathways of contaminant transport, and local aquifer yields. The regional hydrogeology was examined from an integrated watershed perspective to develop an overall understanding of the relationship between surface and groundwater flow features in the study area.

The bedrock and surficial geology and the corresponding hydrostratigraphic units were described, including the hydraulic and hydrochemical characteristics of each unit, based on existing information. Data sources included geological and hydrogeological mapping, land ownership information, air photos, groundwater quality data, historical water level data from available groundwater monitoring stations, NSE pumping test and well record databases, diamond drill log records, applicable legislation and regulations, and relevant studies.

2.2 Groundwater Supply

Existing information on groundwater supplies in the study areas was compiled and analyzed. Data were drawn primarily from the NSE pumping test and well log databases. Additional groundwater quality and quantity information in the study area were drawn from registered Public Drinking Water Supplies (e.g. local schools), government buildings (e.g. Department of Transportation and Public Works buildings), and CBCL files.

The yields required for future development of each study area were based on other components of the HRM Watershed Servicing Study. Population growth scenarios were developed as part of the Planning Sub-study, and estimates of demand were drawn from the Water Supply and Distribution Sub-study. Methodologies for this work are described under the respective components of the HRM Watershed Servicing Study. Peak and average demands listed in Table 3.1 of the Groundwater Sub-study represent an aggregate of these two other components.

2.3 Groundwater Quality Mapping

Generalized water quality mapping was completed previously for HRM (Land Design Engineering Services, 2005). Presented as Groundwater Suitability Mapping, the work integrated bedrock geology mapping and mine shaft locations in an effort to predict groundwater quality. This mapping has been adopted by HRM as a screening level tool to assess suitable areas for development serviced by on-site systems, and has thus been incorporated by CBCL into the current the Watershed Servicing Study. The mapping/screening approach must, however, be treated with caution as the heterogeneity of groundwater environments is expected to exert a strong influence on observed groundwater quality. Any inferences based on the mapping approach must be tested and refined using site specific data collected under provincial and HRM guidelines (Level I and II Hydrogeological Investigations).

2.4 Analysis of Demand and Well Yield

Demand and yield were analyzed for the study area as a whole. The study area was in effect defined as a contributing watershed area. Water budget calculations based on this area assumed that no additional water is to be drawn from other basins via deeper groundwater flow paths, and that no water is released from aquifer storage. Allocations based on this data are considered conservative.

This approach allowed for infiltration over the development area as a whole to be considered in water budget calculations. Infiltration was set to 0.15 metres per year based on existing data from NSE and a groundwater flow model of the Annapolis Valley (Rivard et al., 2006). Water contributing to existing and new wells within the study area boundary is assumed to be drawn both from the lots on which the wells are located, and on land that remains undeveloped. This approach offers advantages over allocations based on individual lots and subdivisions, but it does not provide guidance on the minimum density of lots for a given subdivision. Further comments on lot density are provided below.

The number of wells required to meet the demand of central well field in the Porter's Lake study area was based on a well yield of 2270 L/min, as observed for a high capacity well installed in the surficial unit in the Porter's Lake study area. The number of wells required for clustered homes (Open Space Design) and individual lots was based on the projected number of housing units under each growth scenario.

2.5 Aquifer Vulnerability

The vulnerability of groundwater resources was evaluated according to the conceptual model of groundwater flow for each study area. Water well records and geology mapping provided information on the degree of confinement for local (surficial) and intermediate (bedrock) aquifers. The primary contaminants of concern associated with subdivision developments were defined as septic effluent, road salt, seawater intrusion, and constituents associated with groundwater under the direct influence of surface water (GUDI).

Additional potential sources of contamination were identified during a windshield survey of each study area. All accessible main routes and most side streets were surveyed to identify industrial, commercial, and institutional land uses associated with potential contaminants. GPS coordinates were recorded at each location. The provincial registry of On-Site Sewage Disposal Systems was also incorporated into contaminant source mapping. GIS data available from the Nova Scotia Department of Natural Resources provided the locations of mines / abandoned mines, landfills, pits and quarries.

CHAPTER 3 GROUNDWATER SUPPLY

3.1 Required Yields

Drinking water needs in the Porter's Lake area are supplied by individual water wells in the surficial and bedrock aquifers of the area. Many wells drilled into the surficial deposits reported yields adequate to supply light industry and small commercial developments. Options for additional groundwater supplies under scenarios for future development include the following:

- Individual wells (one well per household);
- Housing clusters (each well serving 10 households); and
- Central municipal supply (one well field serving the entire community).

Groundwater supply wells may be drilled or dug into surficial aquifers, or drilled into metamorphic bedrock units (or plutonic rocks in the extreme northeast and northwest). Surficial deposits in ice contact till plains may function as unconfined aquifers, but the presence of finer material in thicker sequences of till should provide a degree of protection in most areas. Unconfined bedrock is most likely to be encountered in areas underlying the coarsest slate tills, and a limited area to the east of Lower East Chezzetcook (indicated as exposed bedrock on Figure 1.1).

Projected water demands for the Porter's Lake area are shown in Table 2.1. Estimates are provided for three scenarios:

- The existing population / equivalent low-growth scenario;
- The estimated population under moderate development; and
- The anticipated population based on Statistics Canada estimated Unit Allocations (High Growth).

Table 2.1: Projected Water Demand for Porter's Lake, NS

	Low Growth	Moderate Growth	High Growth
Population in 2030	5100	8200	11 300
Housing Units in 2030	2200	3600	4900
Average Demand (m^3/day)	2713	4362	6012
Average Demand (L/min)	1884	3029	4175
Peak Demand (L/min)	4239	6059	8349
% increase		61	122

The existing demand (residential plus other uses) for the Porter's Lake area, under low growth, is estimated to be up to 2,713 m^3/day. A central municipal supply would be required to produce 1884 L/min on average, and up to 4,239 L/min at peak times. With moderate growth, demand would increase by 61% to 4,362 m^3/day. At the maximum proposed population, demand is estimated at 6,012 m^3/day. Flows from a central supply would require an average pumping rate of 4,175 L/min, and a peak pumping capability of 8349 L/min.

Conservation Subdivision Development (CSD) was considered as an alternative to single lot developments and central servicing. Clusters of households and other units would be serviced by single well or nest of wells and a single on-site sewage disposal system. For the purposes of example calculations a cluster of 10 households or other units was considered. A well serving 10 households would be required to supply 7.2 m^3/day, with an average pumping rate of 5 L/min, and peak flows of 10 L/min. A well serving a mixed cluster of residential, commercial, and light industrial users would be required to supply 12 m^3/day, requiring an average pumping rate of 8.5 L/min and peak flows of 17 L/min. Required pumping rates for clustered wells fall within expected ranges for existing wells (Sections 2.2 and 2.3).

3.2 Existing Drilled Wells in Surficial Units

3.2.1 Yield

Table 2.2 provides a summary of data from wells in the Porter's Lake area (Nova Scotia Water Well Logs database, 2009).

Table 2.2: Surficial Unit Well Characteristics for the Porter's Lake Area

	Well Depth (m) (n=83)	Static Water Level (m) n=(78)	Yield (L/min) (n=74)
95% Confidence Interval	13 to 22	3 to 4	142 to 337
First Quartile	5	2	32
Median	6	2	114
Third Quartile	29	4	318
Maximum	87	18	2270

Wells installed in surficial deposits are typically 6 m deep or less, but can reach up to 29 m in selected locations, with a maximum reported depth of 87 metres. The well yields are variable, ranging from 32 L/min in lower producing areas up to 318 L/min where yields are most favourable. The maximum reported yield for a well installed in surficial material was 2,270 L/min. The source of water to many surficial wells is described as sand lenses or gravel, referring either to localized gravel beds within till material, or to the quartzite tills that predominate in Porter's Lake Centre and in the southeast arm. Many wells also reported finer grained materials, suggesting that many wells are equipped with extensive storage, or intercept fine sand seams not identified in the drilling logs. This could be consistent with wells drilled through drumlins on the southwest arm of the study area. Dug wells are expected to provide the most favourable yields in the drumlin field in the southwest part of the study

area. When situated on the margin of natural groundwater discharge areas (near the base of hill slopes), dugs wells can provide favourable yields and good water quality.

3.2.2 Water Quality

The chemistry of water drawn from surficial material in the study area will be influenced by quartzite and slate tills which are in turn related to the chemistry of the local host rock. Provincial mapping provides till chemistry data for the Porter's Lake area (Stea and Dickie, 1979). Mean soil concentrations in area tills were: lead (68 mg/kg), arsenic (7.8 mg/kg), uranium (<0.4 mg/kg), iron (7.5 % by weight) and manganese (1730 mg/kg). The till geochemistry suggests that uranium poses a low concern in surficial wells, and that arsenic concentrations could be elevated in some wells. Surficial wells intersecting slate tills are more likely to be affected by the underlying Halifax Formation, where arsenic concentrations are frequently elevated. Soil iron, manganese, and lead concentrations are elevated with respect to other regions and tills derived from different host rocks. This condition could be reflected in well water quality. Provincial water quality data were not available for wells drilled in the surficial unit. A water quality sampling program of homes in the Porter's Lake area is planned for 2011 as part of this project.

Wells drawing water from surficial material can be at risk of contamination by surface sources. Older drilled wells with poor casings, areas where a confining unit is absent or discontinuous, and many dug wells are at highest risk. Influx of surface water can introduce bacteria, and shallow flow systems can transport nutrients, viruses, pharmaceuticals, and personal care products to nearby wells. Any emphasis on the use of screened wells in surficial material will require additional analysis of these factors, including an assessment of Groundwater Under the Direct Influence of surface water (GUDI).

3.2.3 Variability

The depth of surficial materials is less than 4 m over approximately half of the study area. Well records indicate that in other parts of the Porter's Lake area the overburden thickness reaches a maximum of 110 m. Till types vary across the study area, from extensive thicknesses of siltier till in the drumlins to the southwest, to moderate thicknesses of quartzite tills in the central and southeast areas, to silty slate tills in the northeast. Thick deposits of surficial material described as gravel in well logs suggests that there could be buried fluvial features, potentially in association with depressions in the bedrock surface.

Due to the variable nature of the aquifer material, water quality and quantity in these deposits can vary from good, where hardness is at a minimum, to poor where arsenic concentrations exceed drinking water standards. Conditions suggest that there is some potential for development of local surficial deposits, but that treatment and disinfection will be a requirement for many systems. The location of extensive granular deposits would furthermore require better mapping and delineation.

3.2.4 Interference

The development of water supplies in surficial deposits is subject to several constraints. Due to the nature of construction of shallow wells, they are vulnerable to bacteria introduced through surface inputs and on-site sewage disposal system use. An increasing density of on-site sewage disposal systems and shallow wells has the potential to exacerbate nutrient and bacteria loadings to drinking water. Due to the local variability of surficial deposits, developers of individual properties will not be able to guarantee a viable shallow water supply prior to exploration and test pitting.

Increasing urbanization in Porter's Lake Centre will decrease the available area for groundwater recharge, potentially lowering the local water table. The increased run-off resulting from land developments will affect the shallow aquifer, increasing contaminant loading, and short-circuiting natural filtration processes. Drawdown influences could be limited by controlling the density of shallow wells in centres of development. A combination of high permeability gravel, storage in the well, and physical separation of adjacent deposits will tend to minimize interference effects under most conditions. A high density of wells in a given deposit, decreasing recharge areas (due to increasing urban area and run-off), or extended periods of drought could cause the water table to decline, increasing the danger of well interference and interruption of water supply.

3.3 Existing Wells in Bedrock Unit

3.3.1 Yield

Table 2.3 provides a summary of data from wells in the Porter's Lake area (Nova Scotia Water Well Logs database, 2009).

Table 2.3: Bedrock Well Characteristics for the Porter's Lake Area

Date	Well Depth (m) (n=3153)	Casing Length (m) (n=3040)	Depth to Bedrock (m) (n=2701)	Static Water Level (m) (n=2160)	Yield (L/min) (n=3067)
95% Confidence Interval	53 to 55	10 to 10	7 to 8	5 to 5	38 to 48
First Quartile	37	6	3	3	7
Median	53	7	4	4	14
Third Quartile	75	10	8	5	27
Maximum	152	72	110	55	3632

Wells installed in the bedrock unit generally reach a depth of 40 m, with over 100 wells in the study area exceeding a depth of 100 m. The well yields are variable, depending directly on the number and size of fracture sets encountered. Deeper wells are generally required when shallow fracture sets do not intersect the borehole. Well yields are moderate to low, tending to fall between 7 and 27 L/min, with 230 wells reporting yields over 100 L/min and 31 wells over 500 L/min. This frequency of high yield wells (needed for central or shared supply), suggests that several test holes would be required to locate a major fracture zone. Figure 2.1 shows a sample of the well distribution in the study area (records showing a georeferencing accuracy of 100 metres or better were plotted). Wells reporting the highest yields are distributed throughout the study area. The number of wells with yields exceeding 50 L/min in a given area appears to be proportional to the number of wells drilled in that area.

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4960000 4955000 4950000 4945000 4940000

Trout Lake
Grand Lake
Mill Lake
Caribou Lake
Goose Lake
Snow Lake
Lawrencetown
Lloy
Terminal Beach
Three Fathom Harbour
Lower Three Fathom Harbour
Porters Lake
Middle Porters Lake
Porter
Petain
West Chezzetcook
Conrod Settlement
Gaetz Brook
Head of Chezzetcook
East Chezzetcook
Lower East Chezzetcook
West Petpeswick
Grand Desert
Desert
Seaforth

Figure 2.1: Sample Distribution of Water Wells in the Porter's Lake Area

Road
- Divide Highway
- Arterial
- Collector
- Paved Road
- TCH
- Unpaved Road
- Railroad
- Lanes / Driveways
- ROAD ruin/inactive/abandoned
- Cart Track / Footpath
- Ferry
- Misc
- County Lines
- Topographic Contour (5 m)

- Porters Lake Study Area
- Water Well
- Yields Exceeds 50 L/min

0 0.5 1 2 3 4 Kilometers

N W E S

Project #:101015
Project Name:Tantallon-St. Margarets Bay & Porters Lake - Lake Echo Watershed Studies

10/27/2010 1:24:03 PM

Data Sources:
NSGC Topographic Database
NSDNR Netlin

Datum: NAD83 UTM Zone 20N L:\101015 Tantallon Porters Lake Watersheds\101015_GIS\101015_Layout\101015 - Groundwater Layouts\101015 - Fig2.1 Wells.mxd

Pumping tests were available for Gaetz Brook School, Lakeview Consolidated School, the Atlantic Superstore (3 wells), a Tim Horton's restaurant, Martinique Beach Provincial Park, and a property owned by the Nova Scotia Housing Commission. Reported yields for the wells were moderate to good, ranging from 4.5 to 37 L/min, with long term safe yields from 1.2 to 13 L/min. Most wells appear to be generally capable of meeting required demands, and most of the tested wells could supply average (12 m^3/d) and peak (17 L/min) demands to cluster housing. Whereas two of the wells drilled for the Atlantic Superstore did not encounter major water bearing features (subsequently abandoned), one of the wells intersected a major fracture or fracture set. The yield of the latter well was 71 L/min, with a long term yield of 51 L/min, but an apparent transmissivity of just 2.5 m^2/d.

3.3.2 Water Quality

Bedrock in the study area, in particular Halifax Formation slates, can impart elevated concentrations of metals to groundwater. A survey of nine wells servicing community centres, fire departments, and registered water supplies in the Porter's Lake area showed arsenic concentrations exceeding the Canadian Drinking Water Quality Guideline (CDWQG) of 10 μg/L at four locations. Uranium concentrations were consistently below the CDWQG (<1 to 4 μg/L). Manganese (1 to 350 μg/L) and iron (10 to 1300 μg/L) concentrations varied, exceedingly the CDWQG at two out of nine locations for iron and six out of nine locations for manganese.

Seawater intrusion is a concern for residences on or near the coastline. Seawater intrusion could become a major concern for any single point large volume water takers, including a potential central supply well for the Porter's Lake area.

Shallower boreholes can intersect the upper weathered zones of the quartzite and slate formations in the study area. Where this upper zone is not cased off, water cascading from the upper interval can contribute a significant proportion of the well yield. Although increased yields are favourable, water entering a well in this fashion commonly shares a connection with water sources at or near the ground surface. Such a connection renders wells vulnerable to bacterial contamination and road salt.

3.3.3 Variability

Available data suggest that arsenic and manganese will be a common problem, but that there are localized aquifers that provide excellent water quality with lower arsenic and manganese concentrations. Bedrock yields can generally be expected to be at least 7 to 14 L/min, but yields exceeding 30 L/min were observed for just 24% of wells, and yields exceeding 100 L/min were observed for just 7.5% of wells. Fracture set connectivity and orientations are expected to vary across the study area. Metamorphic units are generally poorly transmissive (provincial median = 1.2 m^2/day), and contain few significant or highly producing fractures. Wells intersecting an upper sequence may benefit from a higher producing weathered zone, but are likely to be vulnerable to surface inputs. As wells are drilled deeper, the frequency of fracture partings tends to decrease, and deep wells will not always produce adequate yields in the Porter's Lake area. Deep wells are more likely to depend on a single, discrete fracture parting.

3.3.4 Interference

Pumping tests of local water supplies in the metamorphic bedrock provided apparent well transmissivities in the range 0.1 to 2.5 m^2/d. Low transmissivities are consistent with the nature of the deeper sequences of slate and quartzite aquifers, with few, poorly connected fracture partings, and occasional larger weathered partings along shear zones, bedding planes, and contacts with adjacent units. The storativity of metamorphic rocks in the study area is expected to be low. This type of environment is consistent with low yields, extensive drawdown within wells, and a moderate radius of influence. Contingent on fracture connectivity, there is a moderate potential for well interferences.

CHAPTER 4 ANALYSIS OF DEMAND AND WELL YIELD

4.1 Aquifer Yield Calculations

Development of groundwater resources may be assessed according to the concepts of aquifer yield and basin yield (Freeze, 1971). A complete analysis and calculation of yields for aquifers in the Porter's Lake area is beyond this scope of this study, however, preliminary calculations are shown in Table 3.1. Calculations are based on the following water balance equation (Freeze and Cherry, 1979):

$Q(t) = R(t) – D(t) + dS/dt$

Where:
Q(t) = total rate of groundwater withdrawal
R(t) = total rate of groundwater recharge to the basin
D(t) = total rate of groundwater discharge from the basin
dS/dt = rate of change of storage in the saturated zone of the basin

Table 3.1: Aquifer Yield Analysis

	Low Growth	Moderate Growth	High Growth
Infiltration (m/yr)	0.15	0.15	0.15
Area (m^2)	94 163 069	94 163 069	94 163 069
Recharge (m^3/yr) R(t)	14 124 460	14 124 460	14 124 460
Demand (m^3/yr) Q(t)	990 318	1 592 276	2 194 234
% of recharge pumped	7	11	16
Discharge (m^3/yr) D(t)	ki 134 142	12 532 184[1]	11 930 226[1]

[1] Discharge estimate does not include water released from storage

Projected demands were compared to the available water budget for the Porter's Lake area. Current demand is estimated at 7% of local groundwater recharge. The calculation assumes that all water is drawn from infiltrating precipitation falling within the study area, which implies a focus on withdrawals from surficial aquifers. Additional components of regional flow may be available in the bedrock aquifer. Calculations indicate that under a high growth scenario, groundwater use would more than double to 16% of recharge to area aquifers. The remaining 84% of recharge local to the study area would remain available as base flow to streams, lakes, coastlines, and regional recharge. Although this amount is

likely sufficient to maintain the function of natural systems and aquifers, the increase may represent a threshold for measureable changes (e.g., a decline in the water table or reduction of stream flow local to a new subdivision).

Reliance on groundwater to service new developments in the Porter's Lake area is likely to be focused on locating productive zones of the surficial and bedrock aquifers, and on treatment for arsenic, manganese, and iron. As subdivision developments progress, an increasing density of septic systems will also become a factor. The intensity of use of individual aquifers, and the water budgets for new subdivisions should become the focus of further investigations. With increasing development there will be a need for evaluation of sustainability on a case by case basis. Whereas the regional water budget suggests that projected development will be sustainable, local water budgets should be considered.

Table 3.2: Sourcing Options

Water Source	Number of Wells Needed to Meet Peak Demand	Formation	Comments
Central Municipal	4[1]	Surficial Unit	Exploration required
			Large tract of undeveloped land preferred
			Treatment for arsenic, iron and manganese may be required
			Moderate protection from surface influences
Cluster Supply (10 homes / well)	2560[2]	Surficial Aquifer	Yields are adequate
			Location of surficial deposits not well mapped
			Constraint on development - dwelling locations
			Constraint on development - potential contaminant sources
			Water supply vulnerable to surface contamination / septic influences
Cluster Supply (10 homes / well)	2560[2]	Bedrock and Surficial	Improved well spacing
			Better protection for bedrock wells
			Reduced well interference effects
			Reduced long-term drawdown in each aquifer
			Yields in bedrock wells commonly inadequate for peak demand
Individual Wells	4900	Bedrock and Surficial	Yields are adequate
			Well density becoming a factor
			Well interference effects may become a problem
			Some drawdown of water table, local water tables
			Dug wells affected by periods of drought
			Wells may draw groundwater affected by up gradient septic systems

[1] Based on large diameter high-yield wells installed in quaternary deposits.

[2] Total includes 2,300 existing units and 260 new cluster wells.

Supply options are presented in Table 3.2. Production characteristics of existing surficial wells suggest that a central municipal supply could be accomplished with four large diameter wells, with the assumption that an extensive quaternary deposit can be located, and that several additional test wells would likely be a part of the exploration program. Ideally the well field would be located in an area apart from future residential, commercial, industrial, and coastal areas, potentially in the extreme centre-north, to the northeast of East Chezzetcook, or in the drumlin field on the southwest arm.

Treatment prior to distribution could be a requirement to address arsenic, iron, and manganese concentrations. The data suggest that aquifer yields would be adequate to develop a central water supply provided that the yields in the water well database could be reproduced (i.e., if exploration succeeded in locating these high yield zones). Although potentially viable from a yield perspective, central services based on groundwater could be cost prohibitive pending the costs of treatment and exploration. A more detailed investigation for the potential to provide a central water supply is warranted.

As groundwater resources in the Porter's Lake area do not appear to be overexploited, additional development of groundwater resources should be sustainable. Although each of the scenarios presented in Table 3.2 is likely to be viable, widespread installation of individual water wells and on-site sewage disposal systems would not provide the most effective option for source water protection. With an increasing density of groundwater users, single wells supplying clusters of up to 10 homes would provide improved protection to area aquifers. This option has several advantages from a supply and aquifer vulnerability perspective including the following:

- Yields are generally adequate;
- Both surficial and bedrock wells can be incorporated, balancing well interference effects; and
- The introduction of bedrock wells reduces to potential for contamination by on-site sewage disposal systems in higher density subdivisions.

Cost sharing of a shared (cluster) system would require planning strategies consistent with Conservation Subdivision Design (e.g. open lot condominiums). A planning oriented investigation to assess the viability and promotion of shared wells and on-site sewage disposal systems in HRM is warranted.

4.2 Lot Density Calculations

Optimal lot densities of subdivision developments are affected by the availability and security of groundwater resources. Three primary factors for consideration are:

- Lot Water Budget / Allocation;
- Well Interference Effects; and
- Nutrient Loading (on-site sewage disposal systems).

Water budget calculations for the study area as a whole suggest that projected development for 2030 should be achievable. This assessment is based on the total water infiltrating in the study area compared to the projected demand in 2030. These calculations do not apply to individual subdivision developments. The "HRM Guidelines for Groundwater Assessment and Reporting" provide methodologies for the investigation of individual subdivision developments. This guide may be replaced in the near future by a similar guideline developed by NSE. The NSE guideline provides a Groundwater

Toolkit describing desktop methods to help in the prediction of groundwater budgets and well interferences associated with increasing development pressures.

Groundwater assessments are and will continue to be a requirement for future subdivision developments. These assessments will provide site specific information, and will provide the best means of predicting an appropriate lot size density for a given subdivision development. The individual investigations will furthermore provide the best possible information on water allocation, well interference effects, and nutrient loading.

It is strongly recommended that a Level 1 Groundwater Assessment is initiated as the first step in any subdivision approval process, and that preliminary water budget and well interference calculations are performed based on the proposed subdivision boundary and hydrogeological setting. These calculations can then be used to determine the optimal lot size, spacing, and layout. Following this initial assessment, a more detailed lot plan showing well locations, disposal beds, and required separation distances should be prepared in consultation with a qualified groundwater professional. The best available tool to assess groundwater budgets and interference effects is a Level 2 Groundwater Assessment. The installation and testing of actual water wells on the subject site will greatly improve the results of this screening process.

Consultations with NSE suggest that individual lot sizes may be used as a screening level water allocation tool. Groundwater resources allocated to a proposed lot would be equal to the estimated annual infiltration on the lot. Table 4.3 provides potential lot sizes for the Porter's Lake Area under varying scenarios for infiltration and allocation of water to the support of ecological systems. These lot sizes are provided for scale and reference purposes only. Actual lot sizes should be determined on a case by case basis, according the HRM Guidelines for Groundwater Assessment and Reporting (or NSE equivalent). **This Groundwater Sub-Study does not constitute a Groundwater Assessment Report under the HRM guidelines.**

Annual infiltration varies according to surface soil type, slope, and length/frequency of rain or melt-water events. A table of estimated regional average infiltration is in preparation by NSE. The estimate used in the Groundwater Sub-studies was 0.15 metres per year, which is in agreement with the draft estimates by NSE and other studies (ACVAS: Rivard et. al, 2006).

Table 4.3: Watershed Scale Lot Size Calculation Examples for the Porter's Lake Area

Total Infiltration (m/yr)	0.15	0.15	0.15	0.15	0.1	0.05
Baseflow Allocation	50%	60%	70%	80%	50%	50%
Demand (m^3/yr)	2 194 234	2 194 234	2 194 234	2 194 234	2 194 234	2 194 234
Infiltration - Baseflow (m/yr)	0.075	0.06	0.045	0.03	0.05	0.025
Infiltration Area (m^2)	29 256 453	36 570 567	48 760 756	73 141 133	43 884 680	87 769 360
Lots	4 900	4 900	4 900	4 900	4 900	4 900
Lot Size (m^2)	5 971	7 463	9 951	14 927	8 956	17 912
Lot Size (acres)	1.48	1.84	2.46	3.69	2.21	4.43

CHAPTER 5 AQUIFER VULNERABILITY

5.1 Surficial Unit

Wells installed in the surficial unit are expected to be divided between water table wells, where overburden thicknesses are less than 5 m, and wells intersecting deeper deposits. Where the thickness of the overburden is limited, unconfined conditions are likely to prevail. Unconfined aquifers can receive inputs from the ground surface by direct pathways, and interruptions in supply due to water table fluctuations can occur. Potential contaminant sources include on-site sewage disposal system, road salt, bacteria from storm water runoff, and localized spills of fuels or solvents. Careful planning is required to ensure that new and existing dug wells are not placed down gradient of septic systems.

As the density of on-site sewage disposal systems in a given area reaches a critical point, nutrient loading to the aquifer can overwhelm natural breakdown processes that attenuate effluent. As development proceeds, concentrations of NO_2^-, NO_3, NH_4^+, organic nitrogen, phosphates, pharmaceuticals, and other metabolites are expected to increase in the shallow groundwater and local water bodies. The mobility of pharmaceuticals and other metabolites (e.g., caffeine) in groundwater is not well characterized, but these compounds have been shown to be persistent and have been detected in drinking water.

Well logs indicate that extensive overburden thicknesses will allow for wells to be drilled deeper into the surficial unit. Where deeper sequences of overburden are present, drilled wells are preferred over dug wells. Shallow aquifers may be able to provide an adequate and moderately secure supply of drinking water provided that:

- Development pressures do not exceed the local aquifer yield;
- Widespread nutrient loading does not compromise the water quality;
- Well casings are properly constructed and/or upgraded; and
- Treatment needs are determined on a case by case basis.

5.2 Bedrock Unit

Conditions in the bedrock unit are expected to be semi-confined to confined where overlain by quartzite till, and confined where overlain by thicker silty deposits (e.g., drumlins). Quartzite and slate tills may provide adequate protection to the bedrock aquifer, as flow in the surficial sediments is assumed to be primarily horizontal, limiting interaction with the bedrock unit. Incoming contaminants are likely to

Low Risk Activities

- Land surrounding reservoir/well owned by water utility/municipality;
- Permanent open space dedicated to passive recreation; and
- Woodlands and managed forests.

Medium-Low Risk Activities

- Field crops: pasture, hay, grains, vegetables;
- Low-density residential: lots greater than 2 acres; and
- Churches, municipal buildings.

Medium Risk Activities

- Institutional uses: Hospitals, Universities;
- Medium-density residential: 0.5 to 1.0 acre lot sizes; and
- Commercial uses with limited hazardous material storage or underground chemical or fuel storage.

Medium-High Risk Activities

- Agricultural production: dairy, livestock, nurseries, orchards;
- Golf courses, quarries; and
- High-density housing: lots smaller than 0.5 acre.

High Risk Activities

- Retail commercial: gasoline, farm equipment, automotive, dry cleaners, photo labs, machine shops, furniture strippers;
- Industrial: all forms of manufacturing and processing;
- Underground chemical and fuel storage; and
- Waste disposal: pits, dumps, ponds, lagoons, landfills.

These categories provide an indication of the relative concern caused by potential sources of contamination to source water in the study area. More detailed studies would be required to assess the potential risk each of the surrounding land uses poses to the source water taking into account factors such as proximity to source water, specific type and scale of activity, longevity of activity, management practices employed, etc.

The following section details the potential sources of water contamination within the Porter's Lake Study Area. Locations of potential contaminant sources are shown on Figure 4.1. Development and potential sources of contamination are focused along main coastal roads. Low density housing and little industrial activity leads to generally local potential sources of contamination. Three fuel storage and handling facilities, two private sewage treatment facilities, and a chemical handling and storage facility in the Porter's Lake commercial centre pose the most concentrated threats to water quality in the study area.

Agricultural Areas

There are two larger farms in the southwest corner of the study area and three smaller farms in the central and eastern part of the study area to the north of Highway 107. Hobby farms and livestock are the most likely uses of farms in the area, but limited crop production may be possible in the southwest.

472000 476000 480000 484000

4960000 4955000 4950000 4945000 4940000

Trout Lake
Grand Lake
Mill Lake
Caribou Lake
Goose Lake
Snow Lake
Porters Lake
Porter
Middle Porters Lake
Petain
Conrod Settlement
Gaetz Brook
Head of Chezzetcook
West Chezzetcook
East Chezzetcook
West Petpeswick
Lower East Chezzetcook
Grand Desert
Desert
Seaforth
Three Fathom Harbour
Lower Three Fathom Harbour
Lawrencetown
Lloy
Terminal Beach

Figure 4.1: Potential Sources of Groundwater Contamination in the Porter's Lake Area

Legend

- Divide Highway
- Arterial
- Collector
- Paved Road
- TCH
- Unpaved Road
- Railroad
- Lanes / Driveways
- ROAD ruin/inactive/abandoned
- Cart Track / Footpath
- Ferry
- Misc
- Topographic Contour (5 m)
- Porters Lake Study Area
- Private Wastewater Treatment
- Cemetery
- Abandoned Mines
- Fuel Storage and Handling
- Chemical Storage and Handling
- Gravel Pits
- Agricultural Land

0 0.5 1 2 3 4 Kilometers

N W E S

Project #:101015
Project Name:Tantallon-St. Margarets Bay & Porters Lake - Lake Echo Watershed Studies

10/27/2010 4:18:06 PM

Data Sources:
NSGC Topographic Database
NSDNR Netlin

Datum: NAD83 UTM Zone 20N L:\101015 Tantallon Porters Lake Watersheds\101015_GIS\101015_Layout\101015 - Groundwater Layouts\101015 - Fig4.1 Contaminants.mxd

enter the shallow groundwater flow system and discharge to local water bodies. Where drumlins are present they generate secure conditions for the underlying sequences of bedrock, as the silty material and sloped ground surface will tend to discourage any large scale infiltration and downward flow of contaminants.

Proximity to the coastline is a disadvantage for deeper bedrock wells. Seawater intrusion is a concern in the Porter's Lake area, as development in the southern parts of the study area is focused along the coastline of Chezzetcook Inlet. Although projected developments are not expected to have widespread effects on the bedrock aquifer, any major water taking at a coastal site could draw the fresh water – seawater interface further inland. Development of bedrock wells for large scale water takings in coastal areas should be reviewed carefully on a case by case basis.

Some wells in the study area will be subject to GUDI classification. Factors such as proximity to surface water bodies, limited or absent confining layers, and observed coliform bacteria in existing wells indicate GUDI conditions. Any centralized water supplies, or supplies for public buildings would require GUDI investigations. Treatment would likely be required as mandated by the results of the GUDI study.

The bedrock aquifer may be able to provide a secure drinking water supply provided that:

- Development pressures do not exceed the aquifer yield;
- Excessive withdrawals do not occur close to coastal areas;
- Well casings are properly constructed and/or upgraded; and
- Treatment needs are met as required by GUDI studies and individual well water quality.

5.3 Well Head Protection Planning

If a centralized supply were to be developed to meet study area needs, the well field would require a Well Head Protection Plan (WHPP) under provincial legislation. A WHPP defines an area around the well field which is designated as protected land. Land uses within this area are restricted to ensure that activities do not compromise the aquifer which provides the water supply.

Ideally a well field and thus a Well Head Protection Area (WHPA) would be located in an undeveloped area, away from surface water bodies, with an adequate confining layer. Land which can be readily zoned and controlled by the municipality is preferable.

5.4 Potential Sources of Contamination

The following is a list of common land uses and their relative risk to source water, ranked from least risk to greatest risk (taken from Nova Scotia Environment and Labour's Developing a Municipal Source Water Protection Plan: A Guide for Water Utilities and Municipalities Step 3 – Identify Potential Contaminants and Assess Risk).

The requirement for irrigation and/or spraying is unknown. If water supply wells were to be located near farms, more detailed on-site reconnaissance would be required. Each of the farms could under specific conditions propose a threat to local shallow groundwater supplies under the direct influence of surface water (GUDI wells).

Pits and Quarries

Provincial mapping shows two smaller borrow pits near Porter's Lake Centre, and a larger inactive pit to the northwest. A large inactive quarry is located adjacent to the industrial park, and there is an active quarry on Alps Road, in the northwest boundary of the study area. Pits and quarries represent areas where contaminants released at the surface could short-circuit into the groundwater regime. High risk land uses should be prohibited near pits and quarries.

Light Industrial Activity

There are two small areas in the Porter's Lake Area supporting light industrial activity. The province of Nova Scotia operates the Eastern Shore Industrial Park adjacent to Highway 107, in the western half of the study area. This park operates on a private sewage disposal system, and hosts a chemical testing laboratory for industrial cleaners and degreasers. These chemicals could include dense non-aqueous phase liquids, posing a serious potential hazard to the underlying groundwater regime. Chemical storage and handling at this facility represents the greatest concern for a point source of contamination in the study area.

Zoning mapping from HRM indicates that there is a salvage yard in the community of Grand Desert, at the end of Bonin Road, to the west of Highway 207. Salvage yards have the potential to release gasoline, diesel, lube oil, paint, solvents, metals, and battery acid to the underlying groundwater regime. Siting of groundwater supplies should avoid both of these industrial zones, including the areas down gradient.

Cemeteries

There are four known cemeteries in the study area, all associated with churches located on main routes. Three of these are located on Highway 207, on the southwest arm of the study area. The cemeteries in the study area would be expected to affect local shallow groundwater supplies.

Abandoned Mines within the Study Area

The Catcha Lake area on Mines road is host to a historically significant gold mining district of Nova Scotia. There are over 170 abandoned mine shafts, open cuts, and pits located between East Chezzetcook and West Petpeswick. One additional shaft is located at the Head of Chezzetcook. Gold deposits are commonly associated with elevated concentrations of arsenic.

Tailings deposited near the shafts and at gold ore processing sites can generate significant source zones of arsenic and other metals. Process streams are also associated with elevated concentrations of cyanide. Arsenic originating in flooded tailings ponds or flooded shaft may be present in its reduced form (AsIII), which is relatively mobile in aquifers. This mining district could present an obstacle to obtaining a reliable groundwater supply in the area.

Sand/Salt Storage Facilities

There is a NSTIR operations site located on Highway 207 near its intersection with Highway 107 that includes equipment storage and maintenance sheds and a salt storage dome. Contingent on effective containment measures and safe handling practices, this site may serve as a source of elevated chloride concentrations. Chloride, although not a health-related contaminant, is persistent and mobile in groundwater environments, and can render water supplies unusable.

Fueling and Service Stations

There is one active gas station located on the Porter's Lake strip mall, on Highway 7. Two former garages or gas stations were noted at other locations along Highway 7. The industrial park appeared to host an equipment shed or machine shop. The presence of the gas station in Porter's Lake Centre, where development is likely to most intense, could pose a threat to water supplies obtained locally.

Fuelling stations are equipped with one or more underground storage tanks (UST) for gasoline and diesel fuel. Older tanks can deteriorate and develop perforations, releasing fuel to the subsurface environment and generating significant source zones for groundwater contamination. Garages may use and store lube oil, degreasers, and paint. Older garages often have oil change pits and sumps excavated directly into the underlying soil, creating a direct conduit for flow of contaminants into the subsurface.

Private Sewage Disposal Systems

There are three known classified private sewage treatment systems in the study area: the Marina Mobile Home Park, the Lakeview Consolidated School, and the Eastern Shore Industrial Park. The Gaetz Brook Junior High School and the Porter's Lake Community Centre are serviced by on-site sewage disposal systems.

Sewage treatment systems can impart elevated concentrations of bacteria, viruses, dissolved organic carbon, biological oxygen demand, chloride, nitrogen compounds, phosphates, pharmaceuticals, and personal care products (e.g., acetaminophen, caffeine, codeine, nicotine, antidepressants, antibiotics, and estrogenic steroids). High rates of extraction in areas where the density of sewage treatment systems is relatively high could impart contaminants to drinking water. Discharges of sewage effluent to salt water systems could help to alleviate this effect.

Seawater Intrusion

Development to the south of Porter's Lake Centre is focused along two main roads, Highway 207 to the west of Chezzetcook Inlet, and Chezzetcook Road to the east of Chezzetcook Inlet. Large scale use of groundwater in these coastal areas could lead to seawater intrusion. High pumping rates in coastal areas draw the freshwater-seawater interface inland. This effect could compromise existing wells closer to the coastline and eventually compromise the pumping well itself.

Location of Past Spill Events

In order to determine the location of past spill events within the study area, an Environmental Registry Search must be requested from Nova Scotia Environment and Labour. A Search must be requested for each property in question at a cost of $21.30 per civic address. This Search can also provide information on:

- Approvals issued under the *Environment Act;*

- Certificates of qualification issued under the *Environment Act;*
- Certificates of variance issued under the *Environment Act;*
- Orders, appeals, decisions and hearings made under the *Environment Act;*
- Notices of designation given pursuant to the *Environment Act;*
- Notices of a charge or lien given pursuant to the *Environment Act;* S.132;
- Policies, programs, standards, codes of practice, guidelines, objectives,
- Directives and approval processes established under the *Environment Act;*
- Convictions, penalties and other enforcement actions brought under the *Environment Act;*
- Information or documents required by the regulations to be included in the registry;
- Annual reports;
- Petroleum storage tank registration information; and
- Well log information

When potential areas for groundwater supply are confirmed it will be necessary to request a search for registered storage tanks and other point sources. The results of each Environmental Registry Search are available two to four weeks after the request is made.

5.5 Preliminary Nutrient Loading Calculations

With increasing density of onsite sewage disposal systems, the mass of nitrogen and phosphorus released to the study area will increase. Nitrogen enters the groundwater regime primarily as nitrate, and is transported conservatively (i.e. there is little degradation or adsorption along the groundwater flow path). Phosphorus is transported in the groundwater regime primarily as phosphate, and can be attenuated by adsorption along the groundwater flow path. These compounds are released to receiving water bodies with additional uptake and degradation in the organic rich sediments of stream and lake beds.

Transport along groundwater flow paths implies an opportunity for nitrate to be captured by water supply wells. In subdivision developments the density of on-site wells and sewage disposal systems can increase to a level where water supply wells are located downgradient of neighbouring sewage disposal systems. Minimum separation distances in Nova Scotia vary from 15 metres for drilled wells to 30 metres for dug wells, which is adequate for the attenuation of viruses and bacteria using properly functioning septic tanks and filtration beds, but nitrate plumes can extend for 60 metres or more in shallow aquifers (Ptacek et al., 1998).

Nitrate loading calculations generally assume that nutrients introduced by on-site systems are diluted by infiltrating precipitation. Standard practice is to consider the total area of a single property as the catchment area for dilution of nutrients. Table 5.1 shows example concentrations for nitrate loading and dilution on a single property in the Porter's Lake Study Area. Calculations are shown for varying lot sizes, including 5,971 m^2, the demand allocation area as calculated in Section 4.2. Calculations are based on an average nitrogen loading of 11.2 g/person/day (USEPA, 1992), and an average denitrification rate of 50% (Toor et al., 2011).

Table 5.1: Calculation of Average Nitrate (NO3-N) Concentration in Groundwater on a Single Lot within the Porter's Lake Study Area for Varying Lot Sizes and Infiltration Rates

Nitrogen Produced (g/pers/day)	11.2	11.2	11.2	11.2	11.2	11.2	11.2
Population	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Household Nitrogen Produced (g/day)	25.8	25.8	25.8	25.8	25.8	25.8	25.8
Denitrification Rate	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Annual Household Nitrogen Loading (kg/a)	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Annual Infiltration (m/a)	0.15	0.15	0.15	0.15	**0.1**	**0.08**	**0.05**
Lot size (m^2)	**5971**	**4047**	***3130***	**2023**	5971	5971	5971
Annual Recharge (m^3/a)	896	607	470	303	597	472	299
Lot Average Groundwater Nitrate Concentration (mg/L)	**5.2**	**7.7**	**10.0**	**15.5**	**7.9**	**10.0**	**15.7**

The calculations in Table 5.1 suggest that the average nitrate concentration in groundwater on a typical site would be approximately 5 mg/L, which is below the drinking water guideline of 10 mg/L (Health Canada Guidelines for Canadian Drinking Water Quality). As lot sizes decrease to 1 acre and 0.5 acres (4,047 m^2 and 2,023 m^2), the average nitrate concentrations would increase to 7.7 mg/L and 15.5 mg/L respectively. The minimum lot size of 3130 m^2 would result in a calculated average NO3-N concentration of 10 mg/L. Provided that the demand-allocation lot size of 5971 m^2 is used, new lot sizes should not approach this lower limit.

Calculations also indicate that if the local recharge rate falls below 0.08 m/a, average NO3-N concentrations would reach the drinking water limit. For example, lots in areas with steep slopes, largely impermeable services (such as paved parking lots), and groundwater discharge zones (fen type wetlands) are at higher risk for elevated groundwater nitrate concentrations. The screening calculations shown in Table 5.1 likely underestimate actual nitrate concentrations within plumes caused by on-site systems, and overestimate actual nitrate concentrations outside of these plumes.

In shallow aquifers narrow linear plumes are observed. The NO3-N concentration within a typical plume is 30 mg/L near the filtration bed, with concentrations decreasing along the groundwater flow path. Nitrate plumes can extend for 60 metres away from a typical infiltration bed, contributing additive loads to downgradient properties. A downgradient well on the flow path of a plume would be at risk of receiving nitrates and other constituents from a neighbour's waste stream.

The calculations in Table 5.1 do not account for additive loading. A plume intersecting a downgradient on-site sewage disposal system would contribute additional nitrate to the plume developing under that system. Depending on groundwater flow directions and lot orientations, several adjacent lots could combine to generate a larger nitrate plume that results in decreasing water quality for each successive neighbour.

Many parts of the Tantallon Study Area rely primarily on bedrock aquifers. The generally poor fracture connectivity and confined condition of these aquifers should act to off-set additive effects of nitrate plume formation. Limited soil cover, downward gradients and flow through discrete fractures could,

however, lead to additive effects in some areas. The calculations in Table 5.1 do not account for failed systems, which are expected to create the most immediate nutrient loading problems in the study area.

Mitigation

Additive nitrate loading and threats to downgradient wells must be addressed on a site by site basis using Level I and Level II Hydrogeological Assessments for subdivision development. Calculations should consider the number of on-site systems and wells along a groundwater flow path, and require that a detailed lot plan is prepared prior to assessment. If it is determined that nitrate concentrations are expected to exceed drinking water limits, additional or alternative sewage treatment strategies will be required.

Prior to projected development, existing groundwater conditions should be assessed through detailed nitrate loading calculations on a site by site basis, and supplemented with a well water sampling program for each subdivision. Work should begin in areas showing the greatest density of development, and those adjacent to areas of projected development. Some of the areas for projected development are in upgradient parts of the study area with respect to groundwater flow and recharge. Development of these areas has the potential to affect all downgradient users in commercial and residential areas.

CHAPTER 6 SUMMARY AND RECOMMENDATIONS

6.1 Summary

The groundwater resources evaluation of the Porter's Lake area is summarized as follows:

- Incoming precipitation in the study area is assumed to primarily recharge the surficial aquifer, components of recharge of deeper groundwater regimes could occur in upland areas;
- Flow in the bedrock aquifer is assumed to be regional, with gradients primarily horizontal or upward;
- Surficial aquifers in lowland areas are composed primarily of granular deposits within quartzite and slate tills;
- Thicknesses of granular deposits commonly reach 8 metres, with a maximum reported thickness of 110 m;
- Individual wells in the surficial aquifer are capable on average of providing 32 to 318 L/min;
- Wells installed in surficial aquifers are expected to be capable of supplying clusters of 10 homes or more;
- The bedrock unit is composed of metamorphic rock with an upper weathered zone and limited fracture partings at greater depths;
- Individual wells are on average drilled 37 to 75 m into the bedrock, and provide water at 7 to 27 L/min;
- Most wells installed in the bedrock should be capable of supplying clusters of up to 10 homes;
- Arsenic concentrations exceeded the CDWQG in samples from four of nine bedrock wells;
- Manganese concentrations exceeded the taste and odour guidelines in samples from six of nine bedrock wells;
- The depth and yield of drilled wells is variable. Many bedrock wells likely rely on single fractures near the base of the well;
- A high density of shallow wells could cause a decline in the local water table, potentially interrupting the supply to the shallowest wells;
- The bedrock transmissivity and storativity are low, indicating that drawdown cones will be deep with a moderate radius of influence;
- Under current conditions approximately 7% of potential recharge is pumped for water use in the Porter's Lake area;
- Under a high growth scenario up to 16% of potential recharge would be pumped as drinking water. This level of consumption could cause measurable decreases in the local water table or flows to local water courses;

- A balanced approach would include wells drawing water from both the bedrock and surficial aquifers;
- An analysis of potential servicing scenarios indicates that all approaches can be sustained at the projected rate of growth;
- CSD style development would encourage the development of water supplies and on-site sewage disposal systems serving clusters of homes, providing improved groundwater resources management with respect to traditional open-lot designs;
- Under increasing population density, surficial aquifers will be vulnerable to bacterial inputs, nutrient loading (septic effluent), pharmaceuticals / metabolites (septic effluent), and water table depletion;
- The bedrock aquifer receives some protection from the overlying tills, particularly in upland areas and where drumlins are present;
- Well casings must be maintained in excellent condition to minimize surface inputs to all wells; and
- Arsenic, iron and manganese treatment is likely to be required for many groundwater supplies in the study area.

6.2 Recommendations

Existing high-yield water supplies suggest that the yields of selected aquifers in the Porter's Lake area are adequate to provide central servicing. Additional investigation would be required to locate an extensive deposit of granular material, preferably in a remote area where a WHPA could eventually be designated. If future development is to encourage growth of a centralized urban area, a detailed hydrogeological investigation is recommended.

Outlying parts of the Porter's Lake area are expected to develop as traditional open space lots or according to the principles of CSD. The HRM Guidelines for Groundwater Assessment and Reporting (2006) provide instruction and requirements for new developments. As part of and in addition to this document, developers should be required to provide the following site specific information:

- Depth of till or surficial aquifer in the location to be developed;
- Presence or absence of silty material in location to be developed;
- Proximity to existing wells;
- Known problems with water quality or quantity in neighbouring wells;
- Projected density of residences; and
- Plan for best use of both bedrock and surficial wells.

If the population of the Porter's Lake area is to approach 11,300, water supply planning measures should be implemented prior to further development. Measures to mitigate potential supply problems include:

- Drilling of test wells for central water supply;
- Evaluation of a central surface water supply;
- Nutrient loading calculations to evaluate the need for central sewage collection;
- Implementation of water conservation strategies (watering restrictions, low-flow appliances, rainwater cisterns);
- Promotion of well stewardship, casing maintenance, and regular water quality testing;
- Upgrades to existing wells;

- Incentives and requirements for developers to establish a binding lot plan showing well and on-site sewage disposal system locations;
- Incentives or requirements for developers to implement cluster supplies for groups of 10 (or more) single family homes;
- Establishment of guidelines for well maintenance and treatment for cluster supplies; and
- Monitor and reassess development of surficial aquifers.

Use of CSD concepts in the implementation of cluster well and on-site sewage disposal systems in HRM should be investigated in more detail. The study should seek to clarify the logistics of designing and promoting (or requiring) shared wells and on-site sewage disposal systems in the context of advantages and constraints specific to HRM.

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APPENDIX C

Component Study – Surface Water Quality Survey

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EXECUTIVE SUMMARY

The waters and adjacent shores of Porters Lake in the Halifax Regional Municipality in Nova Scotia were studied to contribute to an informed discussion of the opportunities and constraints for future development in the area based on environmental water quality. The study's main components were a field sampling program to measure water quality parameters, a model-based phosphorus loading analysis of lakes in the greater Porters Lake watershed, and a numerical model to assess the hydrodynamics of effluent dispersion should an outfall be considered for centralized wastewater treatment. The phosphorus loading model is an eutrophication modeling tool based on hydrological, morphological and land-use characteristics.

Porters Lake itself is a large and elongated lake of about 2,000 ha surface area. The maximum depth of 23 m is found in the upper portion of the lake, and the second deepest depression is in the centre of the cove surrounded by the community of Porters Lake and measures 15 m. The remainder of Porters Lake is shallower than 10 m. At its southern end, Porters Lake is connected to the North Atlantic Ocean via two waterways which experience vigorous and reversing tidal currents. The connection to the ocean influences the hydrodynamics, water quality and ecology of the lake.

A suite of physical, chemical and biological water quality parameters was measured at five sites within the study region on six days between April and October 2010 under a variety of meteorological conditions.

Overall, the values for water quality parameters measured in this study are within the range of recommendations by the Canadian Water Quality Guidelines for the Protection of Aquatic Life from the Canadian Council of Ministers of the Environment. However, low oxygen concentrations were measured in a deep part of the lake near the community of Porters Lake. The development of low oxygen concentration is likely natural, due to poor mixing between a deep saline layer and a fresh surface layer. Care should be taken that human activities do not further decrease oxygen concentrations. The deepwater oxygen concentration should be monitored in the future, as growth of the affected area may affect the health of fish and invertebrates in Porters Lake. Bacteria concentrations are typically above the threshold for safe consumption of bivalves harvested from the area, but usually below the threshold for direct recreational contact with the water. The phosphorus loading model predicts on average mesotrophic conditions in terms of phosphorus concentration in the eight lakes modeled and this finding is confirmed for Porters Lake by water quality measurements. It is thus concluded that all lakes have assimilative capacity to deal with the current levels of nutrient loading.

Future developments with the continued use of single-home septic systems for wastewater disposal are likely to impact negatively on water quality of the receiving waters. To detect serious problems associated with eutrophication and low oxygen concentration it is therefore recommended that a monitoring program should measure vertical profiles of dissolved oxygen at several locations in the lake.

To protect the environment, further developments should follow stringent regulations for the protection of surface water and plans for growth of communities should consider centralized wastewater treatment facilities with removal of nutrients and disinfection. However, the discharge from any wastewater treatment plant should be carefully sited to avoid future environmental problems. Due to the bathymetry and hydrodynamics of Porters Lake, much of the lake is likely to be unsuited to receive wastewater and the most southern section of Porters Lake has the greatest potential for dispersion and dilution of effluent, but is not close to centers of development. A wastewater treatment facility near the community of Porters Lake should not discharge into the deep cove adjacent to the community due to restricted flushing and stagnant deep water. Outfalls near the central axis of the lake just north or south of the bridge of Highway 107 may be considered if effluent quality is according to guidelines and nutrient removal is strongly suggested.

CHAPTER 1 INTRODUCTION AND OBJECTIVE

Receiving waters are distinct bodies of water (lakes, estuaries and embayments) that are of concern because they are in the flow path for receipt of potential pollutants and contaminants that are derived from their watershed. This study focuses on the water quality in Porters Lake as the primary receiving water for surface runoff from the associated watershed. However, there are also a number of smaller lakes connected to Porters Lake by a system of streams and wetlands, which, with surrounding land amount to a watershed of approximately 18,487 ha in size, including the surface areas of the lakes. Porters Lake is valued for its recreational and aesthetic potential and the residential population is expanding. Most development has occurred around the center of the lake in the community of Porters Lake and along its western shore, yet much of the watershed is uninhabited and offers the potential for further development. As there is no service by centralized freshwater supply or communal wastewater collection system in the area, the quality of surface water, as well as the mode of wastewater treatment and discharge, are of paramount importance for the current and future population of the area and for the ecosystem.

The objectives of this study are to describe the current state of surface water quality in relation to past and ongoing development pressures, and to present an informed discussion of the constraints and opportunities given by the surface water characteristics of the study region with respect to new developments. To address these objectives CBCL Limited carried out a sampling program to determine a number of water quality parameters under varying environmental conditions at strategic locations within the study area. This report also describes the findings of a phosphorus loading model based on land use and precipitation to predict phosphorus concentration in key lakes of the study region. As phosphorus concentration is a primary water quality parameter, its prediction and evaluation is a useful indicator for establishing the boundaries for sustainable development within the water shed. This applies particularly for decision-making on centralized wastewater treatment systems and the management of surface water runoff patterns.

CHAPTER 2 DESCRIPTION OF STUDY AREA

2.1 The Main Watersheds and Lakes

The watershed of Porters Lake is about 8 km wide at its widest point, about 32 km long in the north-south direction and has a surface area of 16,107 ha (Figure 2.1). With just under 2,000 ha surface area, Porters Lake is the major body of water and it is fed by discharges from numerous small and mid-sized lakes (Table 2.1). The deepest part of Porters Lake is in its upper portion where a maximum depth of 23 m was measured by the Nova Scotia Department of Agriculture & Fisheries in 1967 (Appendix C.6). The maximum depth of the central portion of the Lake is in the centre of the cove surrounded by the community of Porters Lake and measures 15 m. The remainder of Porters Lake is shallower than 10 m.

Table 2.1: Most Important Lakes in the Porters Lake Study Area

Watershed and Lake	Area (ha)			Ratio of Lake Area to Drainage Basin Area	Volume 10^6 m^3
	Drainage Basin	Lake	Total		
Lake No Good	2,306	61	2,368	0.03	1.12
Cousins Lake	887	63	950	0.07	1.16
Ledwidge Lake	162	25	187	0.16	0.46
Trout Lake	879	75	955	0.09	1.38
Mill Lake	1,182	85	1,267	0.07	1.56
Snow Lake	447	92	539	0.21	1.69
Caribou Lake	265	46	312	0.17	0.84
Porters Lake	9,978	1,932	11,909	0.19	95.00
Total	**16,107**	**2,380**	**18,487**		**103**

Area is given in hectares (ha, 1 ha = 10,000 m^2)

At its southern end, Porters Lake is connected to the North Atlantic Ocean via two waterways. One is a narrow and straightened watercourse about 800 m long leading to Three Fathom Harbour, the other connection is a more natural stream of about 350 m length ending near Terminal Beach. Vigorous and reversing tidal currents run through the waterways, especially the shorter and wider one. The connection to the ocean influences the hydrodynamics, water quality and ecology of Porters Lake.

Figure 2.1:Porters Lake Watershed

Water Sampling Station
Contours
County Lines
Flow Direction
Watershed

Road

Divide Highway
Arterial
Collector
Paved Road
TCH
Unpaved Road
Railroad
Lanes / Driveways
ROAD ruin/inactive/abandoned
Cart Track / Footpath
Ferry
Misc

Land Use

Agriculture
Brush/Alder
Clear Cut
Forested
Rock/Barren
Urban
Wetland

N W E S

0 550 1,100 2,200 3,300 4,400 Meters

Data Sources:
NSGC Topographic Database
NSDNR Netlin

Project #:101015
Project Name:Tantallon-St. Margarets Bay & Porters Lake - Lake Echo Watershed Studies

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Datum: NAD83 UTM Zone 20N

Figure 2.1:Porters Lake Watershed

Water Sampling Station
Contours
County Lines
Flow Direction
Watershed

Road

Divide Highway
Arterial
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Land Use

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2.2 Fisheries

2.2.1 Recreational Fishery

Porters Lake is located within Recreational Fishing Area (RFA) 3 which is an area that encompasses Halifax and Lunenburg Counties. In RFA3 there are recreational fishing seasons for species such as brook trout, brown trout, lake trout, rainbow trout, smallmouth bass, chain pickerel, white perch, yellow perch, and landlocked salmon. Porters Lake was the location of the fourth largest tournament angling catch with a 14.73 lb smallmouth bass bag (5 fish) in 2006, signifying the ideal habitat found here for this species and the value of this area for recreational fishing (Nova Scotia fish registry, a database for large or record fish caught in the province). Other than small mouth bass, fish species confirmed to inhabit the Porters Lake system includes brook trout, white perch, rainbow smelt, white sucker, and golden shiner. There are also anecdotal reports from anglers that striped bass are present in this system (T. Marshall, personal comm., December, 2010).

2.2.2 Aquaculture

There is no aquaculture within Porters Lake, nor is there any occurring in the immediate coastal waters that the lakes drain into (J. Blakeney, personal comm., December 2010).

2.3 Definition of Assimilative Capacity

The so-called assimilative capacity refers to the ability of the environment or a portion of the environment (such as a stream, lake, or soil layer) to receive waste material without adverse effects on the environment or on users of its resources. The US EPA define assimilative capacity as "The ability of a body of water to cleanse itself; its capacity to receive waste waters or toxic materials without deleterious effects and without damage to aquatic life or humans who consume the water"[1]. Determining assimilative capacity of aquatic ecosystems is not straightforward, since a substance may potentially affect many different organisms in a variety of ways. In general it is accepted that symptoms of water pollution (e.g., high nutrient levels, algal blooms, high *E. coli* counts, and deoxygenation) are observed when the assimilative capacity is exceeded. Two other terms are also relevant: 1) *critical load;* and 2) *self purification*. The term critical load is synonymous with assimilative capacity and is commonly used to refer to the mass of a substance which, if exceeded, will result in adverse effects, i.e., pollution. Self purification refers to the natural process by which the environment cleanses itself of waste materials discharged into it.

Because of the technical complexity in accurately determining critical loads, preliminary assessment of the assimilative capacity of receiving waters is generally done by examining whether there is exceedance in the ambient levels of water quality variables that are indicators of water pollution. For this study the focus has been on levels of nutrients (nitrogen and phosphorus), algal biomass (measured as chlorophyll *a*), oxygen status, organic pollution (BOD) and microbial populations (fecal coliform and *E. coli*). The degree by which assimilative capacity has been exceeded or not can be assessed by relating concentrations at monitoring stations to water quality guideline levels published by the Canadian Council of Ministers of the Environment (CCME- http://ceqg-rcqe.ccme.ca/).

[1] U.S. Environmental Protection Agency (December 1997) Terms of Environment: Glossary, Abbreviations and Acronyms. [online] Washington, D.C. Available from: *http://www.epa.gov/OCEPAterms/* [accessed 18th October 2010]

CHAPTER 3 FIELD INVESTIGATIONS

3.1 Methodology

3.1.1 Sites and Parameters

The field sampling program was designed to cover a comprehensive suite of water-quality parameters (Table 3.1) in wet and dry weather conditions during spring, summer and fall season of 2010. Three sets of additional samples were collected in 2012. Five water sampling locations were strategically selected to provide baseline data for the most important locations within Porters Lake, as well as for the validation of the phosphorus model (Table 3.2). Details of the positioning of the sampling sites are shown in Figure 2.1.

In situ parameters of water temperature, pH and salinity were measured with a Horiba multi probe, Model W-21. The probe was lowered into the water column using a graduated cable for measurements at 1-m depth intervals where appropriate (see Photo 1). Water samples for biological and chemical analyses were collected in sterilized sampling bottles (see Photo 2) and analysis was performed by Maxxam Analytics (2010 samples) and AGAT Labs (2012 samples with lower detection limit for Phosphorus). All samples were stored on ice and delivered to the lab within six hours of taking the sample. Water samples for the determination of chlorophyll *a* were wrapped in metal foil to avoid degradation of pigment by sunlight.



Photo 1: Horiba water quality sensor W-21 measuring *in situ* parameters at station PL5 near the outflow of the lake.



Photo 2: Water quality sampling in Porters Lake from a boat.

Table 3.1: Water Quality Parameters Measured at Each Station

Parameter	Symbol	Units	Description
Water temperature		°C	Measured *in situ*
pH	pH		Measured *in situ*
Salinity		%	Measured *in situ*
Concentration of Escherichia coli	E. coli	CFU/100 ml	CFU (Colony Forming Units): the number of colonies on the incubation plate
Concentration of fecal coliform bacteria	FC	MPN/ml	MPN (Most Probable Number): an approximation of the number of bacteria from a count of the number of colonies.
Total Phosphorus	TP	mg/l	Laboratory measurement
Carbonaceous Biological Oxygen Demand	C.BOD	mg/l	Laboratory measurement
Chlorophyll *a*	Chl *a*	µg/l	Laboratory measurement
Nitrate	Nitrate	mg/l	Laboratory measurement
Nitrite	Nitrite	mg/l	Laboratory measurement
Ammonia	Ammonia	mg/l	Laboratory measurement
Total Kjeldahl Nitrogen	TKN	mg/l	Laboratory measurement
Total suspended solids	TSS	mg/l	Laboratory measurement

Table 3.2: Station IDs and Locations for Five Water Sampling Sites in the Porters Lake Study Area

ID	Easting	Northing	Description
PL1	475373	4954715	The northernmost sample in Porters Lake. Depth = 6 m The site allows for assessment of the influence of sea water on the higher reaches of the lake and serves as a control for the contribution of the less-developed northern half of the watershed.
PL2	476476	4954461	Mid-lake near the community of Porters Lake. Depth = 10 m. This site is provides an indication of the contribution of the community of Porters Lake to the water quality of the lake, as differentiated from site PL1.
PL3	476003	4952601	Just north of Highway 107 bridge in mid-lake. Depth = 5 m This site is valuable to indicate the degree of sea water influence in Porters Lake and possible effects of highway runoff on water quality
PL4	477319	4950318	Cove just north of Bellefontaine Road bridge. Depth = 3 m Information from this narrow section of Porters Lake serves to indicate a possible gradient in water quality from north to south and established an important baseline for future samples following changes in development and land use
PL5	475070	4943438	Sample from shore by the Highway 207 bridge. The southernmost sampling site on Porters Lake serves to illustrate the influence of sea water on the lake and establishes the contribution of the Lake to coastal water quality

Geographic coordinates are UTM NAD83 Zone 20. For a map showing the sampling locations, see Figure 2.1.

3.1.2 Technical Comments on Bacterial Counts

Fecal Coliform (FC) and E-Coli have been traditionally used in most jurisdictions as the primary bacterial indicators. Recently E-Coli (a subgroup of FC) was established as the preferred indicator (CCME 2004), because it is reported to correlate best with bather illnesses in sewage impacted recreational waters (Noble et al. 2003). For this study the samples were analysed for both E-Coli and FC. **For this dataset, the E-Coli measurements are deemed a more reliable indicator for the following reasons.**

In the 2010 samples there is a vast spread in the measured FC range (and often questionably high values) reported by Maxxam Analytics using the MPN-Isogrid method. Results for E-Coli using the CFU method exhibit less variability and are within a range that is consistent with other local studies (HRM Lake sampling program at Porters Lake).

The units of measurement for bacteria reported in this study, CFU versus MPN, are based on different methods to estimate the number of bacteria in a sample. CFU, i.e. Colony Forming Units, is the number of colonies on an incubation plate determined by direct count. MPN, i.e. Most Probable Number, is the result of a calculation based on a statistical model using the number of colonies as an input and yields an estimate of the actual number of bacteria. At low concentrations, i.e. less than 100 cells, CFU and MPN methods yield very similar results. At high cell concentrations, the method resulting in MPN yields higher counts compared with CFU, because the MPN calculation takes into account the probability that there are more than one bacterium per colony.

In addition, the results for FC bacteria reported in this study were determined by analysing the sample on large filters (ISOGRID) capable of detecting large numbers of FC, including those that grow poorly or ferment lactose slowly (source: Maxxam Analytics). This technique further contributes to the trend towards high values from the MPN method. In other methods sometimes used (e.g. A1 media techniques used by Environment Canada in the Canadian Shellfish Sanitation Program) FC that are poor growing or ferment lactose slowly may not provide a positive reaction during the specified incubation time. The results for E. coli reported in this study were determined by an E-Coli-specific membrane filtration technique with subsequent incubation.

Finally, we note that bacterial data from HRM at Upper Porters Lake (section 3.3) are comparable to the current E-Coli measurements.

3.1.3 Habitat Assessment

Characteristics of the freshwater and marine habitat for aquatic life, specifically important species of fish, were assessed either from a boat or on foot, as appropriate. Physical and chemical parameters from the water quality surveys were considered and habitat characteristics were assessed on September 29 2010. Habitat characteristics assessed included bottom substrate composition, water quality appearance, presence or absence of aquatic invertebrates, in-stream and surrounding vegetation, and land use. Parameters considered relevant to fish habitat included dissolved oxygen (DO), temperature, pH, salinity, E. coli, fecal coliform bacteria (FC), total phosphorus (TP), carbonaceous biological oxygen demand (C.BOD), and total nitrogen (TN).

3.2 Water Quality Measurements

All results are listed on Table 3.3. The weather conditions immediately prior to sampling days covered a range dry and wet periods at different parts of the sampling season. Precipitation, which can exacerbate water quality problems by flushing contaminants into the receiving waters, ranged from 0 to 52 mm of cumulative rainfall over the 48 hours prior to each of the sampling days. The sections below report the findings for each measured parameter and present a discussion of them in the context of the Canadian Water Quality Guidelines for the Protection of Aquatic Life from the Canadian Council of Ministers of the Environment (Canadian Council of Ministers of the Environment, 1999), hereafter referred to as the CCME Guidelines. This discussion follows the Update 7.1 (2007) of the CCME Guidelines Summary Table for water quality parameters (Appendix C.1).

3.2.1 Water Temperature

Temperatures in the water bodies tested ranged between 7 and 24°C over the sampling season. The warmest temperatures at all stations were measured on August 18, 2010 during a period of dry weather. Stations PL1 and PL4 showed mostly uniform temperature through the water column (Figure 3.1), with slight stratification due to solar warming in the August profile. Stations PL2 and PL3 showed marked temperature stratification which was most intense in August and began to break up in September and October, presumably due to wind mixing and lessening intensity of solar radiation.

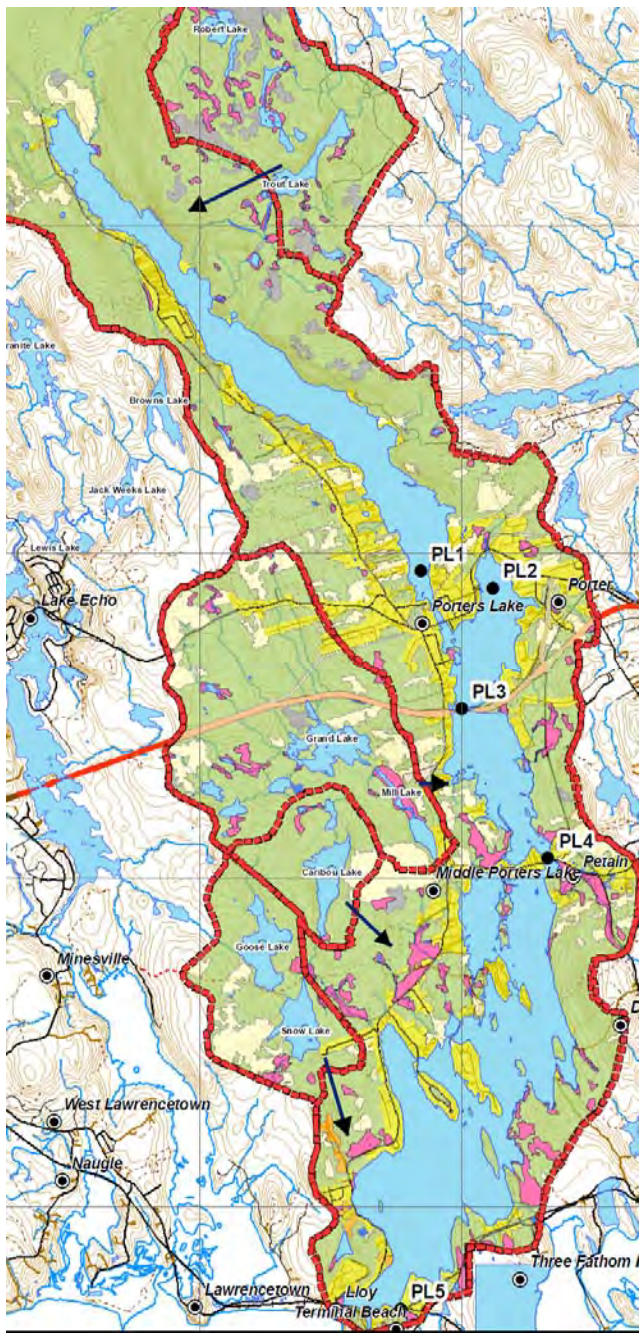
Temperature is a key physical parameter affecting life in marine and freshwater environments as apart from stratification it influences numerous other properties such as the solubility of gases in water, ionization constants, and the intrinsic growth rates of single celled organisms. Because temperature varies naturally in lakes both temporally and spatially CCME Guidelines, which are concerned about anthropogenic changes in ambient water temperature, are not relevant for this study's context.

Table 3.3: Water Quality Measurements

	Depth	DO	Water temp		salinity	E. Coli	FC	TP	C.BOD	Chl *a*	Nitrate (N)	Ammonia N	Nitrate + Nitrite	TKN	TSS	TN
	m below surface	mg/L	deg C	pH	ppt	CFU/100 ml	MPN/100 ml	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
22-Apr-10	**Dry, sunny**		Precipitation in last 48 hours = 0.4 mm													
PL1	0.2	11.5	7.8	7	0.8	<100	<100	<0.02	<5	0.37	0.07	<0.05	0.07		<1	
	2	11.6	7.7	6.8	0.8											
	4	11.7	7.7	6.6	0.8											
	6	11.6	8.2	6.4	1.4											
PL2	0.2	11.1	8.1	6.4	8.5	<100	<100	<0.02	<5	0.27						
	2	11.1	8.3	6.7	8											
	4	7.1	6.3	6.8	19.9	<100	<100	<0.02	<5	0.78						
	6	2.3	6.4	6.9	21.6											
	8	1.5	6.4	6.9	21.8											
	10	1.1	6.5	6.9	21.9	<100	<100	<0.02	<5	0.42						
PL3	0.2	11.3	7.3	6.6	2.8	<100	<100	<0.02	<5	0.33	0.07	<0.05	0.07		1	
	2	10.6	7.6	6.7	12.2											
	4	8.6	6.1	7.1	20.3											
	5	6.6	6.0	7.2	20.7											
PL4	0.2	10.9	7.2	6.2	7	<100	<100	<0.02	<5	0.23						
	2	10.7	7.2	6.7	7											
	3	9.6	7.1	7.1	18											
PL5	0.2	11.7	9.0	7.6	15	<100	<100	<0.02	<5	1.01						
20-May-10	**Rain**		Precipitation in last 48 hours = 20.2 mm													
PL1	0.2	10.97	12.3	7.46	0.8	<100	<100	<0.02	<5	0.44	0.09		0.09			
	2	11.06	12.3	7.19	0.8											
	4	11.09	12.3	6.89	0.8											
	6	11.5	12.2	6.68	0.9											
	7	11.06	12.2	6.54	0.9											
PL3	0	10.04	14.2	6.91	11.7	<100	<100	<0.02	<5	0.81	<0.05		<0.05			
	2	10.09	14.0	7.22	13.6											
	4	9.78	8.7	7.34	21.9											
18-Aug-10	**Dry, sunny**		Precipitation in last 48 hours = 0.9 mm													
PL1	0.2	9.44	24.1	7.05	0.8	1	300	<0.02	<5	3.05	0.07	<0.05	0.07	0.3	2	0.37
	0.5	9.37	23.5	7.12	0.8											
	1.5	9.28	23.1	7.18	0.8											
	2.5	9.27	22.8	7.23	0.8											
	3.5	9.43	22.4	7.35	0.8											
PL2	0.2	9.17	24.3	7.55	5.4	4	200	<0.02	<5	0.79	0.06	0.05	0.06	0.2	<2	0.26
	1	9.03	23.3	7.71	5.5											
	2	7.73	20.3	7.31	24											
	3	8.56	14.9	7.18	26.5											
	4	5.83	10.9	7.07	27.8											
	5	0.84	9.0	7.05	28.1											
	6	0.73	8.6	7.09	28.2											
PL3	0.2	9.11	24.0	7.39	4.1	16	600	<0.02	<5	0.66	0.06	0.06	0.06	0.2	3	0.26
	0.5	9.07	23.4	7.45	4.1											
	1.5	9.02	23.0	7.48	4.4											
	2.5	7.42	18.5	7.24	25.7											
	3.5	7.5	14.6	7.18	27.2											
PL4	0	8.4	24.2	7.16	8.8	<1	500	<0.02	<5	1.16	0.05	0.15	0.05	0.3	<2	0.35
	1	8.52	23.4	7.16	9.3											
	2	8.02	21.7	6.7	25.7											
PL5	0.2	9.14	23.0	7.84	22.4	<1	400	<0.02	<5	0.69	<0.05	0.07	<0.05	0.3	<2	0.3
29-Sep-10	**Showers**		Precipitation in last 48 hours = 5.3 mm													
PL1	0.2	9.28	17.8	6.71	1.5	3	<100	<0.02	<5	0.95	<0.01	<0.05	0.05	0.3	1	0.35
	1	9.47	17.8	6.73	1.5											
	2	9.64	17.8	6.74	1.5											
	3	9.72	17.8	6.76	1.5											
	4	9.85	17.7	6.77	1.5											
PL2	0.2	8.56	17.9	7.13	7.8	31	100	<0.02	<5	0.82	<0.05	<0.02	<0.05	0.3	<1	0.3
	1	8.36	17.9	7.13	7.8											
	2	7.23	18.0	7.13	8.3											
	3	5.3	18.6	6.7	20.8											
	4	4.6	17.3	6.6	21.8											
	5	3.65	13.7	6.55	22.5											
	6	3.4	11.3	6.51	24.8											
	7	3.39	10.5	6.48	24.8											
	8	3.3	10.1	6.32	27.6											
PL3	0.2	9.27	18.0	7.52	10.2	15	100	<0.02	<5	0.86	<0.05	<0.05	<0..05	0.3	1	0.3
	1	8.69	17.8	7.43	13.4											
	2	7.7	18.1	7.21	18.8											
	3	6.53	18.3	7.12	21.7											
	4	6.5	18.3	7.08	23.3											
PL4	0.2	9.09	17.7	7.39	15	1	<100	<0.02	<5	1.25	<0.05	<0.05	<0.05	0.4	2	0.4
	1	8.88	17.4	7.33	17.1											
	2	8.23	17.4	7.15	21.1											
	3	7.75	17.4	6.97	23.5											
PL5	0.2	7.79	16.8	7.27	26.2	1	<100	0.02	<5	2.14	<0.01	<0.05	<0.05	0.5	4	0.5
7-Oct-10	**Rain, windy**		Precipitation in last 48 hours = 1.3 mm													
PL1	0.2	9.34	17.6	7.26	1.7	<1	270	<0.02	<5	1.03	0.06	<0.05	0.06	0.2	<1	0.26
	1	9.41	17.6	7.31	1.7											
	2	9.75	17.6	7.44	1.7											
	3	9.84	17.5	7.63	1.8											
	4	9.67	17.4	7.36	6.4											
PL2	0.2	9.23	17.0	7.6	8.5	54	450	<0.02	<5	0.94	<0.05	<0.05	<0.05	0.2	1	0.2
	1	9.31	17.3	7.85	8.5											
	2	9.21	17.1	7.55	8.6											
	3	6.14	17.6	7.16	21.7											
	4	5.52	17.8	7.12	21.6											
	5	5	16.2	7.09	21.9											
	6	4.51	13.9	7.04	22.6											
	7	2.5	11.2	7.03	23.7											
	8	2.48	10.5	7.06	23.9											
	9	3.6	9.8	7.1	22.4											
PL3	0.2	8.56	17.0	7.6	13.6	10	61	<0.02	<5	0.92	<0.05	<0.05	<0.05	0.3	<1	0.3
	1	7.99	17.4	7.5	15.1											
	2	7.48	17.8	7.38	18											
	3	5.58	18.1	7.25	22.2											
	4	5.45	18.2	7.22	23.1											
	4.25	5.77	18.2	7.22	23.1											
PL4	0.2	9.04	17.0	7.65	14.7	9	12	<0.02	<5	0.69	<0.05	<0.05	<0.05	0.2	3	0.2
	1	9.09	17.0	7.66	15.6											
	2	8.87	17.2	5.59	19.7											
	3	8.68	17.5	5.71	21.1											
PL5	0.2	8.49	16.5	7.78	26.3	38	1100	<0.02	<5	1.5	<0.05	<0.05	<0.05	0.2	23	0.2
28-Oct-10	**Rain**		Precipitation in last 48 hours = 52.3 mm													
PL1	0.2	9.78	13.5	6.88	<2	19	54	<0.02	<5	1.25	0.09	<0.05	0.09	0.3	<2	0.39
PL2	0.2	10.24	13.0	6.67	4	48	100	<0.02	<5	1.7	0.13	<0.05	0.13	0.3	<2	0.43
PL3	0.2	10.28	13.0	6.69	5	22	16	<0.02	<5	1.32	0.08	<0.05	0.08	0.4	<2	0.48
PL4	0.2	10.47	13.0	6.45	9	18	18	<0.02	<5	1.75	0.06	<0.05	0.06	0.3	<2	0.36
PL5	0.2	9.62	11.0	5.42	25	35	20	0.03	<5	1.51	<0.05	<0.05	<0.05	0.2	4	0.2
30-Nov-11	**Rain** (27 mm over the whole day, plus ongoing snowmelt) - Samples taken from shoreline															
PL1 shoreline	0.2	7.96	8.1	7.15		<1	<2	0.012								
PL2 shoreline	0.2	9.83	7.0	7.45		22	24	0.011								
PL3 shoreline	0.2	9.18	8.0	7.52		6	26	0.005								
PL4 shoreline	0.2	8.80	8.0	6.94		21	<2	0.010								
PL5 shoreline	0.2	8.97	6.8	7.23		2	<2	0.013								
10-May-12	**Rain** (39 mm from May 9 to May 10)															
PL1	0.2		10.6	6.53	0			0.029								
PL2 - surface	0.2		11.9	6.67	3			0.030								
PL2 - mid-depth	4		9.5	6.55	21			0.030								
PL2 - bottom	8		9	6.78	22			0.124								
PL3	0.2		12.1	6.85	6			0.027								
PL4	0.2		12.4	6.96	12			0.027								
PL5	0.2		9.9	7.23	26			0.034								
16-Nov-12	**Dry, overcast**															
PL1	0.2							0.008								
PL2 - surface	0.2							0.008								
PL2 - mid-depth	4							0.007								
PL2 - bottom	8							0.020								
PL3	0.2							0.007								
PL4	0.2							0.009								
PL5	0.2							0.018								

E-Coli thresholds CFU/100ml	
Shellfish harvest	14
Swimming	200
	400

Trophic status indicators	TP (mg/l)	Chl *a* (ug/l)	DO (mg/L)
Oligotrophic	<0.01	<2.5	>7.2
Mesotrophic	0.01 - 0.02	2.5 - 5	6.2 - 7.2
Meso-eutrophic	0.02 - 0.035	5 - 8	
Eutrophic	0.035 - 0.1	8 - 25	< 6.2
Hypereutrophic	> 0.1	> 25	



Water Quality Sampling Sites

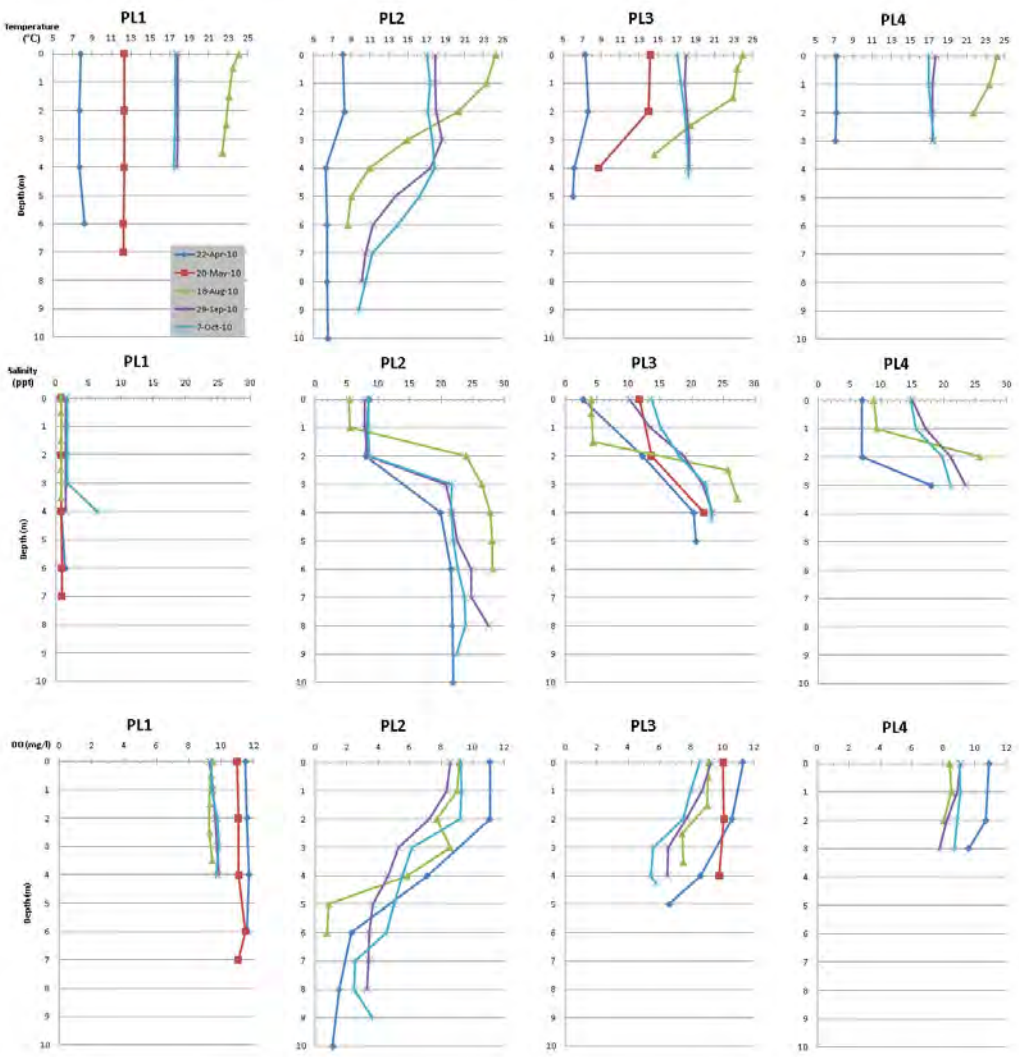


Figure 3.1: Vertical Profiles of Temperature, Salinity and Dissolved Oxygen as Measured at Four Sites in Porters Lake

3.2.2 Salinity

The salinity of the surface water shows a clear horizontal gradient in Porters Lake with low values upstream (mean of 1.1 ppt at PL1) and high values near the outlet of Porters Lake (mean of 23 ppt at PL5). The signature of salinity in the surface indicates the presence of estuarine circulation in which saltier, heavier seawater flows upstream in lower layers and gradually mixes with the fresher surface water. In lower Porters Lake, the freshwater layer is between 1 and 2 m deep after which salinity increases to a maximum at depth. High salinity was found at depth at all stations, except the most upstream (Station PL1) on all occasions (Figure 3.1). At PL1 only the April profile shows elevated salinity near the bottom. This suggests that salt water reaches upper Porters Lake only occasionally. The salinities at the bottom of station PL2 were the highest recorded during this program. With a maximum depth of 15 m, this site is also the deepest among our stations. The high salinity and temperatures below 10°C in all of our profiles suggest that the water in this deep pocket of the lake is more stagnant trapped by density stratification and bottom topography. Exchange of this water likely occurs, but at a much slower rate than in most other parts of the lake with consequences for other water quality parameters, e.g., oxygen (see below). Similar conditions may occur in upper Porters Lake where depths

reach 20 m and greater. Salt water intrusions of sufficient density to flush these deep parts in the upper reaches of the lake are likely less frequent than intrusions to station PL2. Thus, we can expect older, less frequently flushed water there and possibly lower concentrations of dissolved oxygen. These observations are consistent with a detailed oceanographic survey conducted by the Bedford Institute of Oceanography in the 1970's (Elliott 1978).

CCME Guidelines for salinity do not exist for freshwater. For marine systems, interim guidelines recommend that anthropogenic perturbations to salinity should be below 10% of ambient levels. The natural variability of salinity in Porters Lake is large and there is no obvious anthropogenic perturbation to the salt content.

3.2.3 pH

The pH in Porters Lake shows relatively little variability with values typically between 6.5 and 7.5. Variations of pH with depth are not systematic, or demonstrate any increasing or decreasing pattern in an inconclusive fashion. The lowest pHs were measured at site PL4 at 2 and 3 m depth on October 7 2010 (5.59 and 5.71, respectively). The CCME Guidelines recommend a pH range of 6.5 to 9. Slightly acid water is not unusual for Nova Scotia, where most watersheds have an environment with acidic soils, because of humic material.

3.2.4 Carbonaceous Biological Oxygen Demand (C.BOD)

C.BOD values were below the detection limit of 5 mg/l in all samples. These low values indicate that there is little loading of lakes with dissolved organic matter. This has minimal effect on the oxygen levels, as confirmed by uniformly high values of dissolved oxygen concentrations in surface samples (see next section).

3.2.5 Dissolved Oxygen

The concentration of dissolved oxygen in surface waters at all locations and times was between 9 and 10 mg/l with a minimum of 7.79 mg/l at station PL 5 on September 29 2010. These values are within the CCME Guidelines, which are 5.5 to 9.5 mg/l for freshwater and >8 mg/l for marine aquatic life.

Vertical profiles of dissolved oxygen correspond to those for temperature. Stations PL1 and PL4 showed relatively uniform oxygen concentration with depth, while vertical gradients existed at the other two stations. At PL3, dissolved oxygen reached a minimum between 5 and 7 mg/l at depths deeper than about 3 m. At PL2 low levels of between 0.73 and 3.3 mg/l were observed, with concentrations consistently lower than the lower limit of the CCME Guidelines (5.5 mg/l) at depths deeper than 4 m. The low oxygen concentrations in deeper parts of the lake are likely to be a consequence of the consumption of oxygen by microbes during decomposition of organic material and limited vertical mixing of water, due to the density stratification.

Oxygen concentration between 2 and 5 mg/l causes biological stress and hypoxia (DO 2 mg /l or less) can be tolerated only by a limited number of animals. Low oxygen conditions are common in waters with restricted deep circulation, such as fjords and deep lakes, where autochthonous biomass, i.e., biomass produced within the lake system, sinks and decomposes at depth. However, anthropogenic input of organic material and nutrients can increase the oxygen demand and further lower the

concentration of dissolved oxygen and enlarge affected areas. Without further study it is impossible to say whether hypoxic conditions in Porters Lake are caused by human activities. The oxygen profiles in the deep parts of Porters Lake should be monitored over the long term to allow for a better assessment of the health of the lake.

3.2.6 Total Suspended Solids (TSS)

The concentration of total suspended solids in all water samples was low, typically less than 5 mg/l. On October 7 2010, a concentration of 23 mg/l was measured at station PL5. A cause for the high concentration could not be found, but it is likely to be natural, e.g. suspension of sediment by wave action. CCME Guidelines recommend that anthropogenic activity not increase the concentration of suspended sediments by 25 mg/l at any time when background levels are between 25 and 250 mg/l. Hence, TSS concentration has not been found to be of concern in the water bodies sampled.

3.2.7 Eutrophication Status (Phosphorus, Nitrogen, Chlorophyll)

The process of eutrophication is defined as the loading of inorganic and organic dissolved and particulate matter, including nutrients, to lakes at rates sufficient to increase the potential for high biological production, decrease basin volume and deplete dissolved oxygen (Cooke *et al*., 2005).
For the purpose of this report the trophic status of each lake has been assessed by examining the concentrations of nutrients (P and N), the levels of algal biomass (as chlorophyll a present in the lake, and the state of oxygenation of the water column. The results allow for the classification of the lakes into oligotrophic, mesotrophic, eutrophic or hypereutrophic (see Table 3.4).

Table 3.4: Trophic State Indicators

	TP (mg/L)	Chl *a* (µg/l)	DO (mg/L)	TN (mg/L)
Oligotrophic	<0.01	<2.5	>7.2	<0.35
Mesotrophic	0.01 - 0.02	2.5 - 5	6.2 - 7.2	0.35 – 0.65
Meso-eutrophic	0.02 - 0.035	5 - 8		
Eutrophic	0.035 - 0.1	8 - 25	< 6.2	0.65 – 1.2
Hypereutrophic	> 0.1	> 25		> 1.2

Values in Table 3.4 are based on the following sources:

- Boundary values for TP and Chl A are from Vollenweider and Kerekes (1982) as recommended by Brylinski (2004) for NS Lake Phopshorus Loading Models;
- The boundary between mesotrophic and meso-eutrophic represents the threshold to avoid nuisance algae as defined by the Province of Ontario who use a TP limit of 0.020 mg/L. The equivalent Chl A is estimated at 5 µg/L, as supported by Figure 3.2;
- Boundary values for DO and TN from Cooke et al. (2005);
- TP and TN thresholds apply if the particular nutrient is limiting. Typically P is the limiting nutrient, and therefore a TN concentration in the eutrophic range has no impact if the TP concentration is limiting; and
- Total nitrogen can be calculated from the parameters measured in this study as the sum of TKN and Nitrate+Nitrite.

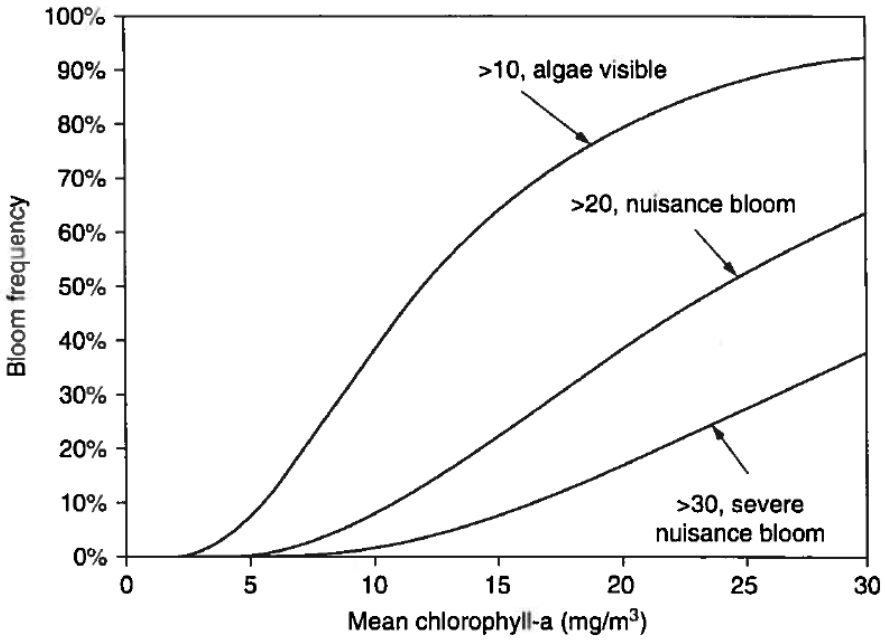


Figure 3.2: Frequency of algal blooms (defined as Chl A > 10, 20 or 30 mg/L) related to summer mean Chl A

Source: Walker 1985 (Reproduced from Cooke et al). The mean Chl A threshold for the onset of nuisance blooms is 5 µg/L.

3.2.7.1 PHOSPHORUS

Values of total P in 2010 were generally below the detection limit of 0.02 mg/l employed by Maxxam Analytics, except at PL5 on October 28 2010 when a value of 0.03 mg/l was recorded. Strong rainfall preceded this sample and may have caused this higher concentration. The findings demonstrate that all sites show total phosphorus concentrations in the oligotrophic to mesotrophic range, with the exception of one measurement at site PL5.

In 2011 and 2012, samples were analyzed by AGAT Labs using a low detection limit of 0.002 mg/l. the results confirm the oligotrophic to mesotrophic range, with the exception of the post-rainfall samples on 10 May 2012 where surface TP concentrations were in the vicinity of 0.03 mg/l. This illustrates the importance of runoff on lake phosphorus levels.

In terms of water quality guideline, one cannot use the eutrophic trigger (0.035 mg/l) as an annual mean guideline because eutrophic conditions typically occur in the summer, when the annual mean value would be lower than the trigger range. There is no Federal or Nova Scotia guideline on recommended annual mean values. The Province of Ontario recommends an average value of 0.020 mg/l for the ice-free period to avoid nuisance algae, while a high level of protection against aesthetic deterioration provided by a TP less than 0.010 mg/l (should apply to all lakes naturally below this value (Source: Ontario 1994). An example application of these guidelines to guide development in the study area is provided in section 4.1.

3.2.7.2 NITROGEN

Total nitrogen values in the watershed varied between 0.2 and 0.48 mg N/l (recorded at station PL3 on October 28 2010). Mean values of total N ranged between 0.30 mg N/l to 0.34 mg N/l. Nitrate, nitrite and ammonia were almost always below detection limit indicating that most of the nitrogen in the water is in organic form. Ammonia levels were generally <0.05 mg N/l indicating that pollution from domestic waste is almost non-existent. The ratio TN/TP can be used to assess which nutrient is controlling plant biomass growth due to its lower concentrations (Brylinski 2004). Except on one occasion (most downstream site PL5 on 28 October 2010), the ratio TN/TP is greater than 10 at all sites, indicating that phosphorus is the limiting nutrient. Therefore TN concentrations in the mesotrophic range have no impact on plant growth because of TP limitations. This is typical of large watersheds where nutrient loadings are predominantly from non-point sources.

3.2.7.3 CHLOROPHYLL

Chlorophyll levels in the waters of the lakes give a measure of the size of their resident phytoplankton populations, and provide one of the best indicators of eutrophication status. Mean chloprophyll levels for all stations ranged between 0.82 and 1.37 µg/l, and the highest chlorophyll levels (3.05 and 2.14 µg/l) were recorded at stations PL1 (August) and PL5 (September), respectively. These chlorophyll concentrations are indicative of oligotrophic habitats.

3.2.8 Bacterial Indicators

The samples were analyzed for two bacterial indicators, fecal coliform (FC) and *Escherichia coli* (E. coli). The fecal coliform bacteria group is indicative of contamination from the intestinal tract of humans and other animals and includes other, more definite groups such E. coli. A commonly used standard based on E-Coli bacteria is 200 MPN/100 ml for primary recreational contact and 14 MPN/100 ml for shellfish harvesting. For this dataset, the E-Coli measurements are deemed a more reliable indicator for reasons outlined in section 3.1.2.

Ecoli

E-Coli concentrations at all sites sampled were below 200 CFU/100 ml, i.e. suitable for primary recreational contact, with values ranging from 1 to 54 CFU/100 ml. Concentrations were greater than 14 CFU/100 ml for 50% of the samples, i.e. not suitable for shellfish harvesting. Highest concentrations were observed during wet weather in late summer and fall, and at sites impacted by development. The range of measured E. coli concentrations is consistent with data collected by HRM at Upper Porters Lake (Chapter 5).

Fecal Coliform

Fecal coliform concentrations in the study area are moderate to high. During August, the warmest month of the year, concentrations were at or above 200 MPN/100 ml. Concentrations of bacteria in September were lower than in August, and increased again in October. The September decrease may be due to declining water temperatures, while the October increase may reflect the input of bacteria from enhanced microbial activity due to the decomposition of leaf litter and surface water runoff from rainfall. In terms of spatial patterns, fecal coliform concentrations are highest near the most populated region of the lake. The high mean concentration at station 5 is due to two high measurements, 400 and 1100 MPN/100 ml, both measured during ebb tidal flow. Conversely, at times when water was flowing

into Porters Lake, bacterial concentrations were lower, suggesting a source for sanitary contamination along the lake rather than from the adjacent ocean coast. Potential sources for fecal coliform bacteria in this area are houses, although the land there is developed sparsely with houses on large properties, but there is some evidence of fields that may be used for animals or hay harvest.

3.3 Observations from HRM Lakes Water Quality Sampling Program

The Halifax Regional Municipality (HRM) has reported on three sampling events per year, spring, summer and winter, in Porters Lake since 2007. The HRM sampling site is located near the northern end of the lake closest to site PL1. Several water quality parameters were measured by HRM, including those determined in this study. Measured parameters are presented in Table 3.5.

There are no great discrepancies between the values of water quality parameters measured by HRM and those found in this study (from site PL1). Temperature, dissolved oxygen, Nitrate+Nitrite, total phosphorus, E. coli and chlorophyll *a* are in good agreement. Salinity is higher at station PL1 from this study, which is to be expected due its location closer to the ocean-end of the lake. Furthermore, pH is lower in the HRM dataset compared with all stations measured here. Like salinity, a lower pH could be explained by the greater influence of freshwater upstream in the lake, since slightly acid freshwater is not unusual for Nova Scotia, an environment with acidic soils. The mean concentration of total phosphorus in the HRM samples was 0.0147 mg/l which is consistent with measurements taken for this study. Finally, total Kjeldahl nitrogen was higher in the HRM samples (0.8 mg/l) than in this study (0.18 mg/l). This difference appears to indicate an input of organic nitrogen near the northern end of the lake.

Bacterial counts by HRM at the northern end of Porters Lake average 49 CFU/100 ml of fecal coliforms. At station PL1, the mean fecal coliform was 104 MPN/100 ml. It is noted that in the range of bacterial concentration considered here, the units of measurement for bacteria, CFU versus MPN, can be used interchangeably. For this reason, a discrepancy between 49 CFU/100 ml and 104 MPN/100 ml of fecal coliform must be attributed to temporal and spatial variability in fecal contamination and not to the analysis technique.

Table 3.5: Selected Water Quality Parameters Measured Through the HRM Lakes Water Quality Sampling Program in Upper Porters Lake

	Units	RDL	CCME Guideline Level	Upper Porters Lake														
Sampling Date & Time				22/11/2011	08/08/2011	08/04/2011	28/10/2010	08/12/2010	17/05/2010	22/10/2009	29/09/2009	06/03/2009	20/11/2008	09/03/2008	30/05/2008	31/10/2007	08/10/2007	06/06/2007	
FIELD DATA																			**Average**
Secchi Depth	Meters	N/A		1.3	1.45		2.1	2.8	--	1.4	2.0	2.0	1.4	1.3	2.1	1.50	2.5	2.0	**1.8**
Temp	Celsius	N/A		9.05	20.67		12.37	22.16	11.41	10.98	23.18	14.76	9.04	19.06	13.14	12.56	19.18	14.77	**15.17**
Dissolved Oxygen	mg/L	0.2	6-9.5	11.42	8.64		11.25	8.31	12.04	10.11	8.66	10.78	11.40	9.40	10.99	8.81	8.21	9.69	**9.98**
pH	pH	N/A	6.5-9.0	5.34	7		7.33	6.76	7.80	6.66	6.56	6.60	5.45	5.45	5.32	5.47	5.51	5.84	**6.22**
Specific Conductance	mS/cm	0.001		0.765	0.714		2.533	1.389	1.275	0.461	0.521	0.582	0.950	0.528	0.468	0.736	2.026	1.027	**0.998**
TDS	g/L	0.01		0.498	0.461		1.673	0.903	0.828	0.299	0.338	0.378	0.618	0.343	0.304	0.480	1.318	0.667	**0.651**
Salinity	ppt	0.01		0.38	0.35		1.33	0.70	0.64	0.22	0.25	0.28	0.47	0.26	0.23	0.36	1.04	0.56	**0.51**
INORGANICS																			
Total Alkalinity (Total as CaCO3)	mg/L	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	**ND**
Dissolved Chloride (Cl)	mg/L	1		205	199	392	557	421	373	128	143	122	270	140	130	200		280	**254.3**
Colour	TCU	5		114	97	63	60	71	75	108	66	72	130	110	84	60	40	34	**78.9**
Total Kjeldahl Nitrogen (TKN)	mg/L	0.4		1	ND	ND	0.9	ND	0.9	1.3	ND	0.4	0.3	0.5	ND	1.5		0.5	**0.8**
Nitrate + Nitrite	mg/L	0.05		ND	ND	0.09	ND	ND	0.08	ND	ND	ND	0.09	ND	ND	ND		ND	**0.09**
Nitrate (N)	mg/L	0.05	13	ND	ND	0.09	ND	ND	0.08	ND	ND	ND	0.09	ND	ND				**0.09**
Nitrite (N)	mg/L	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND			ND	**ND**
Nitrogen (Ammonia Nitrogen)	mg/L	0.05	19	0.08	ND	0.06	ND	ND	0.09	0.07	ND	ND	ND	ND	ND	0.05		ND	**0.07**
Total Organic Carbon (C)	mg/L	0.5		14.1	10.8	8.5	11.7	9.9	8.5	12.3	8.4	7.4	8.7	9.4	6.3	8.8		5.5	**9.3**
Orthophosphate (P)	mg/L	0.01		0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	**ND**
pH (Lab)	pH	N/A	6.5-9.0	5.8	5.9	6.3	6.1	6.3	6.2	5.6	5.9	6	5.52	5.38	5.74	5.67		6.05	**5.89**
Total Phosphorus (1M depth)	**mg/L**	**0.002**		**0.011**	**0.017**	**0.009**	**0.011**	**0.010**	**0.056**	**0.026**	**0.008**	**0.008**	**0.009**	**0.015**	**0.007**	**0.005**	**ND**	**0.007**	0.014
Reactive Silica (SiO2)	mg/L	0.5		3.1	2.3	3	3.2	2.3	2.8	2.8	2.1	2.1	2.8	2.4	2.1	2.9		2	**2.6**
Total Suspended Solids	mg/L	5		ND	ND	ND	ND	ND	50	ND	ND	ND	1	2	ND	ND	1	ND	**13.5**
Dissolved Sulphate (SO4)	mg/L	2		29	27	55	77	55	52	19	20	24	40	22	18	29		42	**36.4**
Turbidity	NTU	0.1		2.1	1	0.8	1.6	0.8	0.8	0.8	0.7	1.2	0.7	1.2	0.5	0.8	0.4	0.6	**0.9**
Conductivity	µS/cm	1		743	679	1370	1970	1370	1330	496	504	613	930	520	470	740		990	**909**
MICROBIOLOGICAL																			
Fecal coliform Lake	CFU/100mL	2	200				ND	ND	74	ND	4	4	1	26	ND	2	63	220	**49.3**
Chlorophyll A - Acidification method	µg/L	0.05		0.24	2.36	0.41	1.05	2.30	0.23	0.32	1.92	1.50	0.37	0.94	0.54	0.23	1.88	ND	**1.02**
Chlorophyll A - Welschmeyer method	µg/L	0.05		0.27	2.11	0.41	0.90	2.22	0.24	0.39	1.79	1.55	0.42	0.92	0.53	0.27	1.78	0.8	**0.97**
E. Coli Lake	MPN/100mL			4	13	ND	9	4	2										**6.4**
Total coliform (Lake)	MPN/100mL					68	1200	237		143									**412**

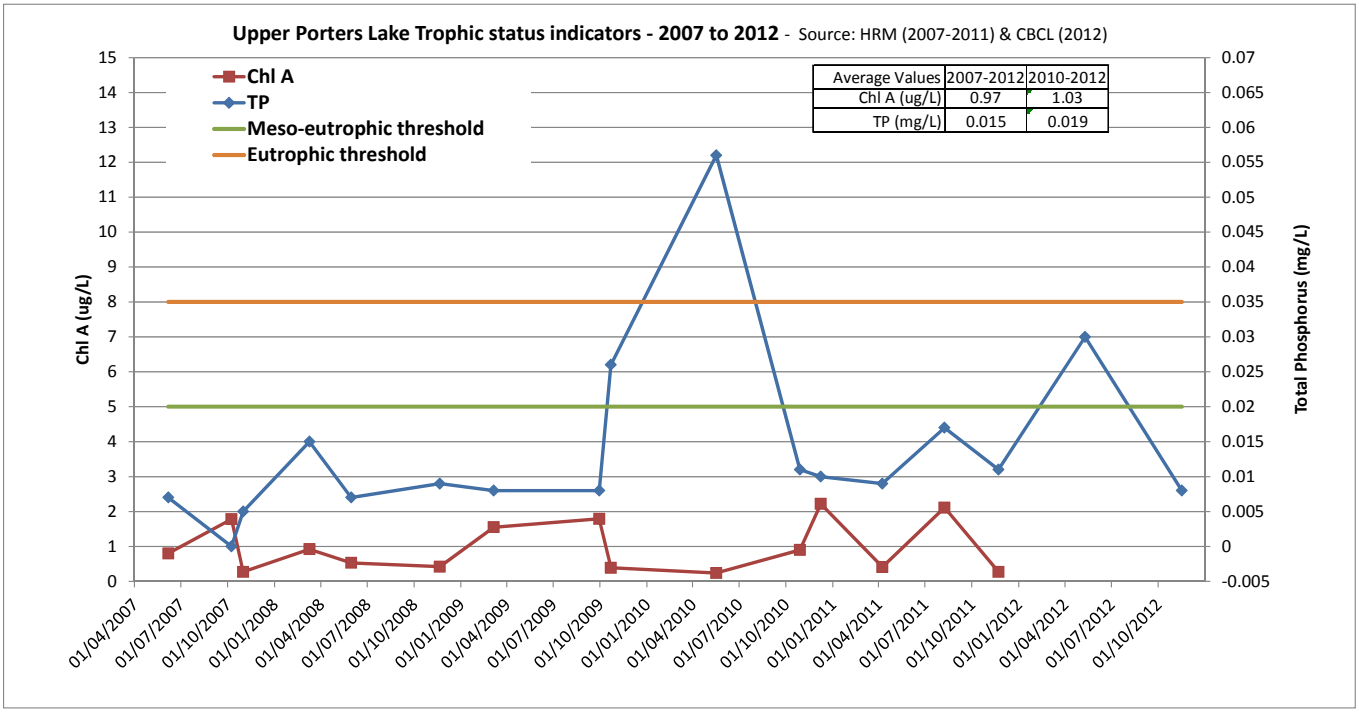


Figure 2.3: Porters Lake Trophic Status Indicators from 2007 to 2011

Data sources: HRM sampling program (2007 to 2011)

3.4 Habitat Assessment

This section summarizes the results and conclusions of an assessment of key locations within the study area with respect to fish habitat. The full habitat assessment is found in Appendix C.2.

The middle and lower sections of Porters Lake that were the subject of this study generally represent good habitat for fish. Low concentrations of dissolved oxygen occur in some deeper parts of the lake, which are unsuitable for most fish and invertebrate species. Most mobile organisms have developed mechanisms to avoid such areas. The available data indicate that the low oxygen is brought about by a lack of circulation in deeper waters due to salinity stratification. However, zones of low oxygen concentration are prone to grow with increasing loads of organic material or nutrients, for example, as a consequence of increasing residential and commercial development. The temperature of surface water during August reaches values above the optimum for salmonids such as brook trout. Especially at this time of the year, the extent of areas with low oxygen concentration can be critical, as such waters do not represent a viable refuge for fish seeking cooler temperatures in deeper waters. As a consequence, future development should follow stringent criteria to minimize the input of organic substances and nutrients into the lake where low-oxygen zones are likely, e.g., near PL2.

CHAPTER 4 WATER QUALITY MODELLING

4.1 Lake Phosphorus Loading Model

4.1.1 Model Description

The Brylinski model is a simple eutrophication modelling tool that is widely used in Nova Scotia to predict the annual average phosphorus (P) concentration in a lake (receiving water body) based on its hydrological, morphological and watershed characteristics (Brylinski, 2004). It is a black box model that inputs estimated export loads of phosphorus from various land use activities in a watershed and calculates the average annual P concentration in the receiving lake. The P concentration can then be related to an expected trophic status (water quality) and allows for an assessment as to whether the system has any additional assimilative capacity to receive loading of P from developments in the watershed.

The model has to be used with caution as it is based on several assumptions that are not met by most Nova Scotian water bodies. These assumptions are:

- There is complete mixing of the P throughout the lake – this situation is rarely met as most Nova Scotian lakes stratify during summer and winter;
- There is a steady state situation which implies that P and hydrological loading are constant and there is no fluctuation in inputs;
- Loss of P to lake sediments is proportional to its concentration in the lake;
- Export coefficients from various land uses in the watershed are based on theoretical estimates that are not always verifiable;
- Internal loading of P from sediments is ignored; and
- Complex physical and biological nutrient dynamics taking place in a lake are ignored.

Despite this, the model has been useful to this study, and others, in providing a tool for:

- Preliminary screening of receiving waters in order to predict whether there might be any possible eutrophication problems;
- Providing a conceptual and theoretical check on the results of water quality analyses;
- Planning of the survey for water quality monitoring;
- Assessing the potential impacts of any development in a watershed that might release additional loading of P into a receiving water;
- Assisting in making recommendations on watershed planning and management;

- Assessing the potential of lakes to receive additional loads of P before exceedance of assimilative capacity is observed; and
- Linking with other models (e.g. phosphorus-chlorophyll-water transparency models) in order to predict the level of phytoplankton populations that can be expected in a lake. This then gives an idea of the water quality for recreational and drinking water purposes.

For this study, the land use patterns for each watershed were obtained from provincial data sources. Specifically, the watershed boundary layer was provided by the NS Geomatics Centre, the vegetation cover is derived from a province-wide inventory of air-photo digitized forest stand polygons, and associated descriptors from the NS Department of Natural Resources, and the number of dwellings comes from the NS Geomatics Centre 1:10,000 topographic database.

These land use categories included: agriculture, clearcut, forested, plantation, wetland, urban, lake, rock/barren, brush/alder and roads/pavement (Appendix C.3). Due to its size and many narrow sections Porters Lake was divided into five parts and the phosphorus loading was calculated for each part. Due to the influence of salt water on the vertical structure of Porters Lake, the volume of the lakes was not calculated using the full depth of the lake, but rather the depth of the freshwater layer under the assumption that the density of effluent is similar to the surface water in the lake and deep mixing is negligible. The depth of the surface layer was derived from our measurements of salinity and temperature profiles (Figure 3.1 and Table 4.1 for assumed mixing depths). The resulting lake volumes and drainage areas as used in the model are presented in Table 4.1.

After integrating and totalling the estimated P loading from each land use area, an expected P concentration for each lake was calculated using the model, thereby allowing for an assessment of its theoretical expected eutrophication status. Input and output parameters for the model are given in Appendix C.4.

Table 4.1: Lakes Used in the Phosphorus Model. In Porters Lake, the Depth of Mixing was Used for Calculation of Volume

Watershed and Lake	Area (ha)			Mixing Depth (m)	Ratio of Lake Area to Drainage Basin Area	Volume 10^6 m^3
	Drainage Basin	Lake	Total			
Lake No Good	2,306	61	2,368	n/a	0.03	1.12
Cousins Lake	887	63	950	n/a	0.07	1.16
Ledwidge Lake	162	25	187	n/a	0.16	0.46
Trout Lake	879	75	955	n/a	0.09	1.38
Mill Lake	1,182	85	1,267	n/a	0.07	1.56
Snow Lake	447	92	539	n/a	0.21	1.69
Caribou Lake	265	46	312	n/a	0.17	0.84
Porters Lake 1 (Upper)	7,478	619	8,098	10	0.08	1.84

Watershed and Lake	Area (ha)			Mixing Depth (m)	Ratio of Lake Area to Drainage Basin Area	Volume 10^6 m^3
	Drainage Basin	Lake	Total			
Porters Lake Part2	364	172	536	2	0.47	2.84
Porters Lake Part3	501	180	681	2	0.36	3.84
Porters Lake Part4	907	411	1,318	2	0.45	4.84
Porters Lake 5 (Lower)	710	549	1,259	10	0.77	5.84

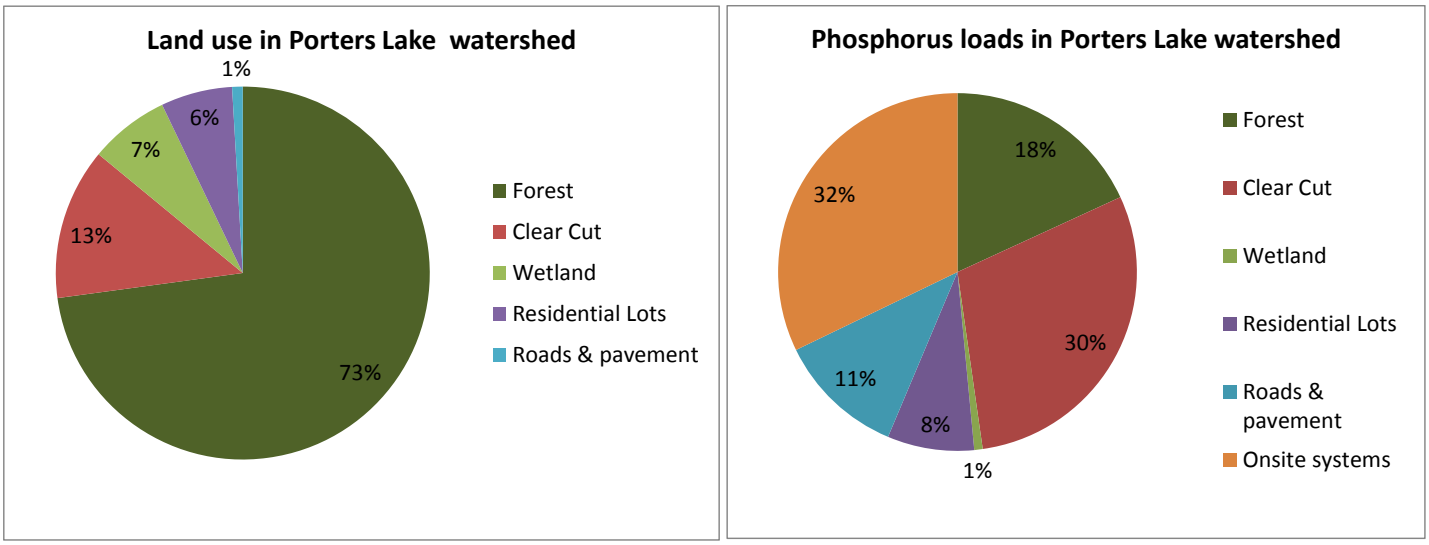


Figure 4.1: Phosphorus Loading Model Land Use and Loading Inputs

4.1.2 Results and Implications for Development

Estimates of P concentrations from the eutrophication model of Brylinski (2004) for selected lakes of the Porters Lake area are shown in Table 4.2 and calculations using the detailed model are presented in Appendix C.4. All lakes are predicted to have oligotrophic to mesotrophic phosphorus loadings, i.e., equal to or below 0.02 mg P/l over an annual mean. This is confirmed by measurements (Figure 2.3) showing a 2007-2012 average of 0.015 mg/l, which compares well with the predicted value of 0.014 mg/l.

Projections for the development of the Porters Lake area predict a maximum population growth of 5200 people over the next 15 years. The impact this development will have on the water quality of Porters Lake depends on the method of wastewater treatment and disposal. Development may proceed under the current practice of on-site septic systems on a household-by-household basis, wastewater treatment may occur in a central facility with a discharge into Porters Lake. Five scenarios for the development were modeled to predict the impact of increasing population on Porters Lake. The scenarios are:

Scenario 1 – Assumes on-site septic system, one per household. The only land available for this type of development with impact on Porters Lake is the eastern shore of upper Porters Lake (Porters Lake Part 1). It is assumed that the new population along the eastern shore of the lake is identical to the number of dwellings along the western shore, i.e. 422. Thus, Scenario 1 assumes an increase of population in the watershed of Porters Lake 1 to 945 dwellings from 523.

Scenario 2 - Assumes a population increase of 5200 people which will be serviced by a centralized treatment system with outfall into Porters Lake 2. Primary treatment without phosphorus removal is assumed, leading to a per capita annual phosphorus effluent load of 624.2 g/yr/person (Table 7.5 in Brylinski 2004).

Scenario 3 - As Scenario 2, but assuming primary treatment with phosphorus removal (phosphorus effluent load of 273.5 g/capita/yr, see Table 7.5 in Brylinski 2004).

Scenario 4 - As Scenario 2, but assuming secondary treatment with phosphorus removal (phosphorus effluent load of 153.3 g/capita/yr).

Scenario 5 - As Scenario 2, but assuming tertiary treatment with phosphorus removal (phosphorus effluent load of 54.8 g/capita/yr).

The estimated annual mean phosphorus concentration in all five parts of Porters Lake for each of the five wastewater treatment scenarios is given in Table 4.2. On-site septic systems in 422 dwelling along upper Porters Lake are not expected to impact lake phosphorus levels significantly (Scenario 1). Effluent discharge from a treatment system serving 5200 people without phosphorus removal is predicted to lead to eutrophic conditions over an annual average in parts 2 and 3 of the lake (Scenarios 2). Assuming annual phosphorus effluent load between 153 and 273 g/yr/person (Scenarios 3 and 4), treatment with typical phosphorus removal is predicted to increase tropic levels from mesotrophic to meso-eutrophic on an annual average basis, which is undesirable. For centralized wastewater treatment with outfall in Porters Lake Part 2, the maximum annual phosphorus effluent load required to keep P levels in the lake at or below 0.02 mg/l is 85 g/yr/person, which would be met by a tertiary treatment system with phosphorus removal (Scenario 5).

Table: 4.2: Predicted Phosphorus Concentration in the Lakes Under Five Scenarios of Wastewater Treatment

Lake		Existing P conc. Unit: mg/l	Assimilative capacity to keep P<0.02 mg/l throughout Porters Lake Unit: kg P/year Note: loads are not cumulative - Only 1 load assumed throughout the 5 lake parts	Modelled average P concentrations for various development scenarios at Porters Lake - Unit: mg/l				
				Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Undeveloped upstream lakes	Lake No Good	0.014		On-site treatment for Upper Porters Lk development	Centralized WW treatment for 5200 people with outfall in Porters Lake Part 2			
	Cousins Lake	0.012						
	Ledwidge Lake	0.005						
	Trout Lake	0.011			Primary treatment No P removal 624 g P/cap/yr	Primary treatment With P removal 273 g P/cap/yr	Secondary treatment With P removal 153 g P/cap/yr	Tertiary treatment With P removal 55 g P/cap/yr
	Mill Lake	0.022						
	Snow Lake	0.009						
	Caribou Lake	0.007						
Porters Lake	Porters Lake Part1	0.014	755	0.017	0.014	0.014	0.014	0.014
	Porters Lake Part2	0.016	505	0.019	0.040	0.027	0.023	0.019
	Porters Lake Part3	0.016	608	0.018	0.037	0.025	0.021	0.018
	Porters Lake Part4	0.015	996	0.016	0.029	0.021	0.018	0.016
	Porters Lake Part5	0.015	1174	0.016	0.025	0.019	0.017	0.016

Trophic status indicators	
	TP (mg/l)
Oligotrophic	<0.01
Mesotrophic	0.01 - 0.02
Meso-eutrophic	0.02 - 0.035
Eutrophic	0.035 - 0.1
Hypereutrophic	> 0.1

4.2 Porters Lake Hydrodynamic Model

A hydrodynamic model was developed to investigate effluent dilution patterns for potential outfall sites in Porters Lake, for development options that may include centralised wastewater treatment.

4.2.1 Methodology

A numerical model was set-up to investigate the hydrodynamics of Porters Lake based on tidal and river flow inputs. Currents from hydrodynamic simulations were used to drive time-dependent far-field effluent dispersion simulations for a number of discharge scenarios. The model was calibrated to salinity observations from the field program and run under summer freshwater discharge conditions for a period of 10 weeks to account for variations in the lunar tidal cycle. The model system is MIKE3 (Danish Hydraulic Institute), which has a wide base of users worldwide and extensive recognition from the coastal science and engineering community. MIKE3 solves the momentum and continuity equations over a finite-element mesh to simulate hydrodynamic circulation. The model also features a coupled advection-diffusion algorithm to simulate the transport of dissolved effluent away from the initial mixing zone at the outfall.

The model mesh consists of triangular cells of variable size and seven vertical layers to resolve the density structure of the lake (Figure 4.2). Bathymetric data from the Province of Nova Scotia was used as lake bathymetry.

4.2.2 Model Inputs, Assumptions and Limitations

4.2.2.1 HYDRODYNAMICS

The critical model input parameters included:

- Tidal predictions from DFO's 'WebTide' model;
- Bathymetry from the Province of Nova Scotia;
- Bridge cross-sections – these are an important parameter in determining the amount of exchange between each section of the lake. Cross sections for the two bridges at the tidal inlet were estimated during the field program, while those for the middle and upstream sections of the lake were estimated from high-resolution satellite imagery and depth contours from the Provincial bathymetric map; and
- Freshwater flows – summer average values used in modelling are shown on Figure 4.2. The flows total 3.7 m^3/s, as per DFO estimates for August (Figure 4.3). The total value was divided between each sub-watershed as per the method developed for the phosphorus loading models.

Based on the above set-up, the model accounts for the large-scale tidal and freshwater flushing mechanisms that prevail in the summer. Wind-driven circulation is not included. A more detailed modelling effort (which is not within the scope of the present conceptual study) would require:

- Higher resolution bathymetry including detailed surveying of all bridge cross-sections;
- River flow measurements concurrent to the salinity observations;
- Tide gauge measurements in each section of the lake; and
- Current and wind measurements for model validation.

4.2.2.2 EFFLUENT DISPERSION MODELING

An assessment of the patterns of effluent dispersion was conducted for four potential outfall sites in the vicinity of the conceptual future wastewater treatment plant (Figure 4.2). Two types of model simulations were performed:

1. Mixing was assessed using conservative tracers to predict the effect of purely physical dispersion of effluent.
2. Tracers were subject to first-order exponential decay function to parameterize natural bacterial mortality.

In nature, mortality of coliform bacteria increases primarily with light intensity, temperature and salinity. Typical mortality rates for fecal coliform bacteria range from about 0.2 day^{-1} for cool weather conditions to 3 day^{-1} for warm weather conditions (US EPA, 1985). A mortality rate of 1 day^{-1} was chosen, corresponding to a $T_{90\%}$ of 55 hours (the time by which 90% of the pollutant load has decayed), which is considered conservative. Each effluent simulation started with initial conditions of zero effluent concentration. Results show the state of the model after the initial effluent build-up period, which can last up to 2 months, until the concentrations stabilize due to die off and/or exit of pollutants through the model boundaries.

The model assumes total mixing upon discharge in the model cell containing the outfall. Near field, initial mixing processes are not well represented (these are generally studied at a later stage during outfall design).

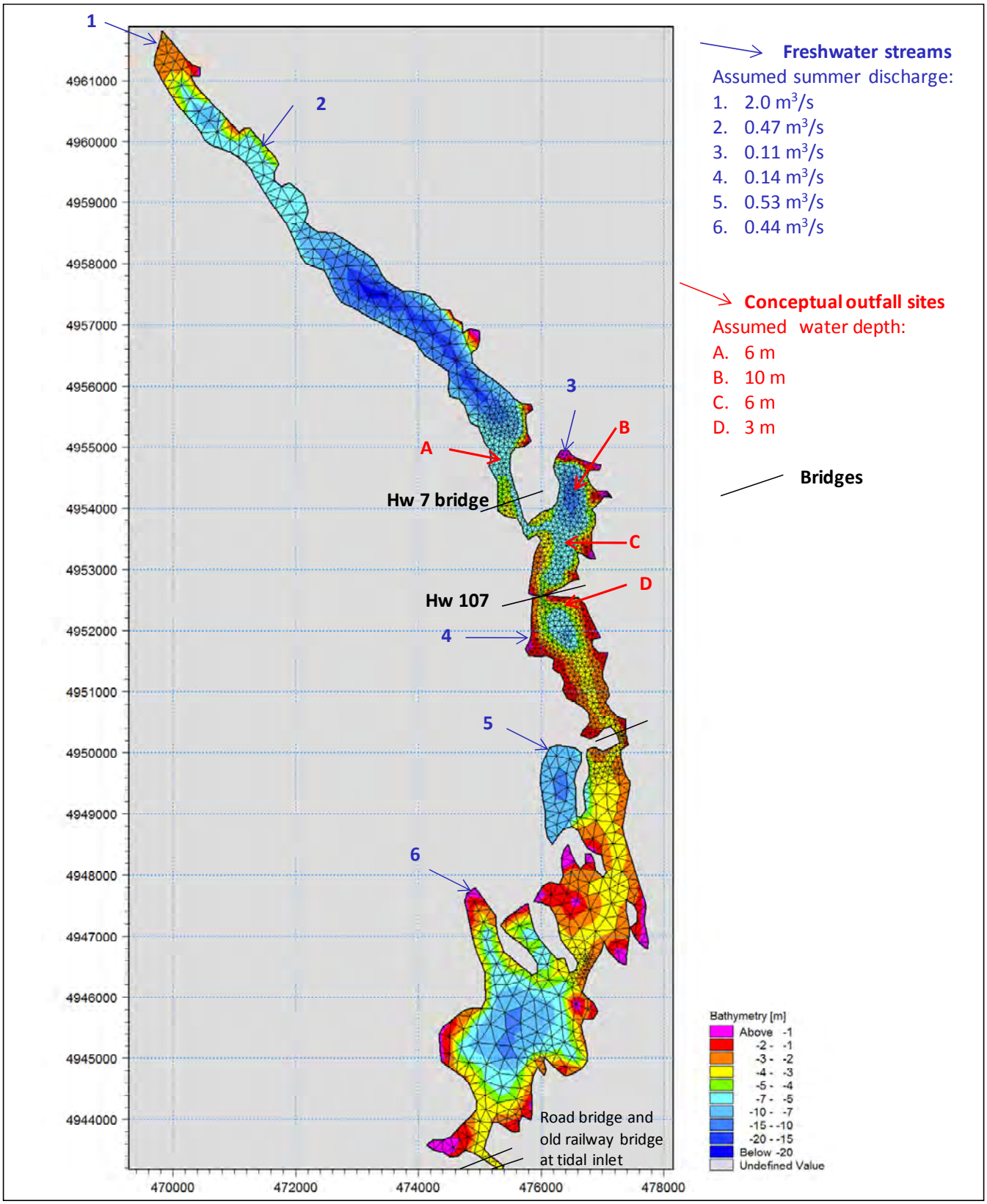
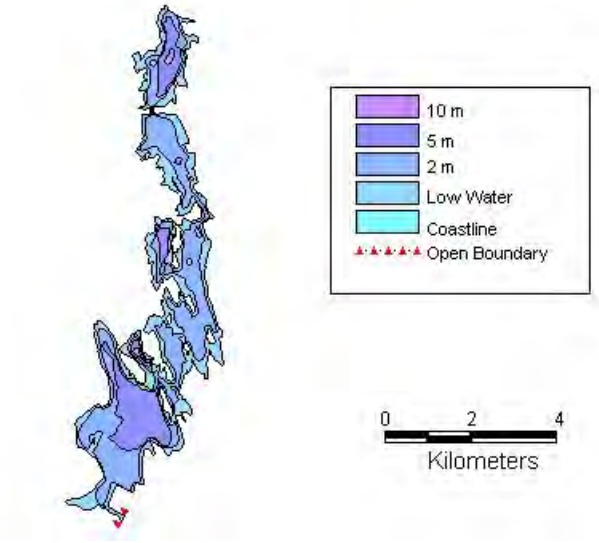


Figure 4.2: Hydrodynamic Model Bathymetry



HW Area (sq. km.)	13.3	**CD Area (sq. km.)**	13.2
Perimeter (km)	57.6	**CD Vol. (mill.cu.m.)**	40.0
Axis Length (km)	12.9	**Max. Depth (m)**	11.9
Section Width (km)	0.1	**Section Area (sq. m.)**	86.8

-

Tidal Range(m.)		**Tid. Vol ($10^6 m^3$)**	**Tidal Current(m/s)**	
Mean	**Large**	**Mean Tide**	**Mean**	**Peak**
0.3	0.6	3.99	2.05	3.23

-

Flushing Time (hours)	130.7
Tidal / Freshwater Volume Ratio	22.7
Watershed Drainage Area (sq. km.)	192.6

-

Freshwater Discharge

	cu. m/s	**std. dev.**		**cu. m/s**	**std. dev.**
Jan	9.3	48.3 %	**Jul**	3.5	73.9 %
Feb	7.1	56.7 %	**Aug**	3.7	64.6 %
Mar	10.5	42.6 %	**Sep**	3.2	63.4 %
Apr	14.5	31.3 %	**Oct**	6.1	59.9 %
May	9.8	65.3 %	**Nov**	10.3	56.8 %
Jun	4.9	66.8 %	**Dec**	11.4	36.8 %

Figure 4.3: Summary of Tidal Parameters and Freshwater Discharge for Lower Porters Lake
Source: DFO Classification of Maritime Inlets (Gregory et al 1993)
Note: flushing time, calculated assuming complete mixing at each tide, is much overestimated because of density stratification.

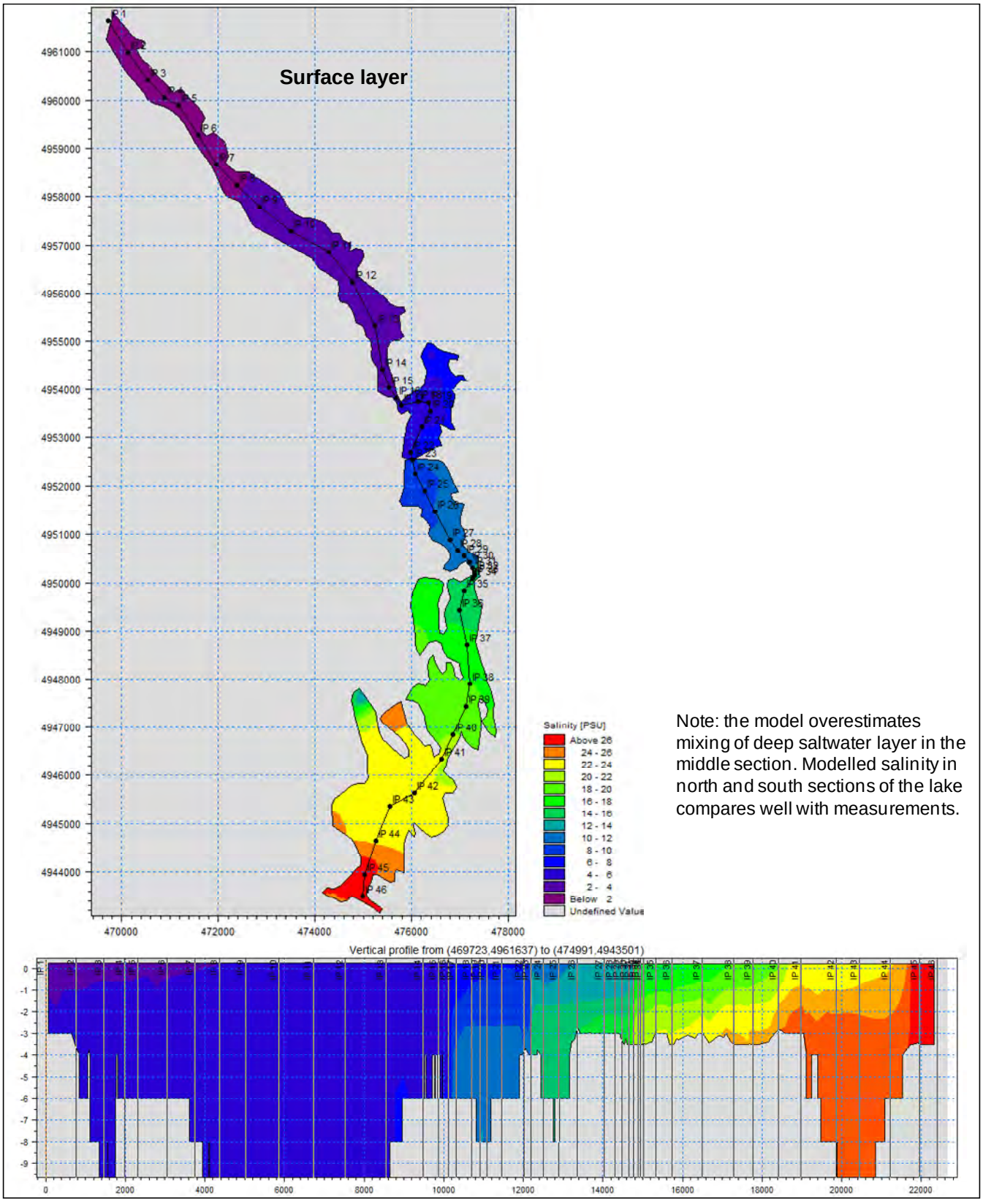
4.2.3 Model Calibration

Salinity is an important calibration parameter because it is a measure of the water exchange and flushing processes under investigation. The model's vertical diffusion coefficient was adjusted to yield reasonable agreement with salinity measurements. In the absence of current data, bottom friction and horizontal mixing coefficients were set at typical values for comparable applications. The modelled salinity structure is shown on Figure 4.3. While the upper and lower portions of the lake show satisfactory results, modeled stratification in the middle section is generally underestimated for the deeper areas.

4.2.4 Effluent Dispersion

Results without mortality using conservative tracers, and with mortality are shown in Figures 4.5.a-b and Figures 4.6.a-b, respectively, for surface (a) and at-outfall-depth (b) concentrations. Each figure represents a composite picture (as opposed to a snapshot) of maximum concentrations over the model run of sufficient duration to allow for effluent build-up and stabilization of concentrations. Results are given assuming an effluent flow rate of 7690 m^3/day (89 l/s), which presently stands as the best estimate for the future peak flow. Not surprisingly, the attainable dilution increases when placing the outfall along the main axis of the lake.

At site A, the absence of density stratification from a saltwater layer and the significant depth of this lake section allow mixing of the effluent within a large volume of water, thus reducing the maximum effluent concentration. At site B, the outfall is placed in a deep and stagnant cove where flushing is limited. In all outfall locations, mortality reduces the spatial footprint of effluent in areas away from the outfall where the travel time from the outfall would be more than the time period over which most decay occurs.



Note: the model overestimates mixing of deep saltwater layer in the middle section. Modelled salinity in north and south sections of the lake compares well with measurements.

Figure 4.3: Modelled Average Salinity for Summer Conditions

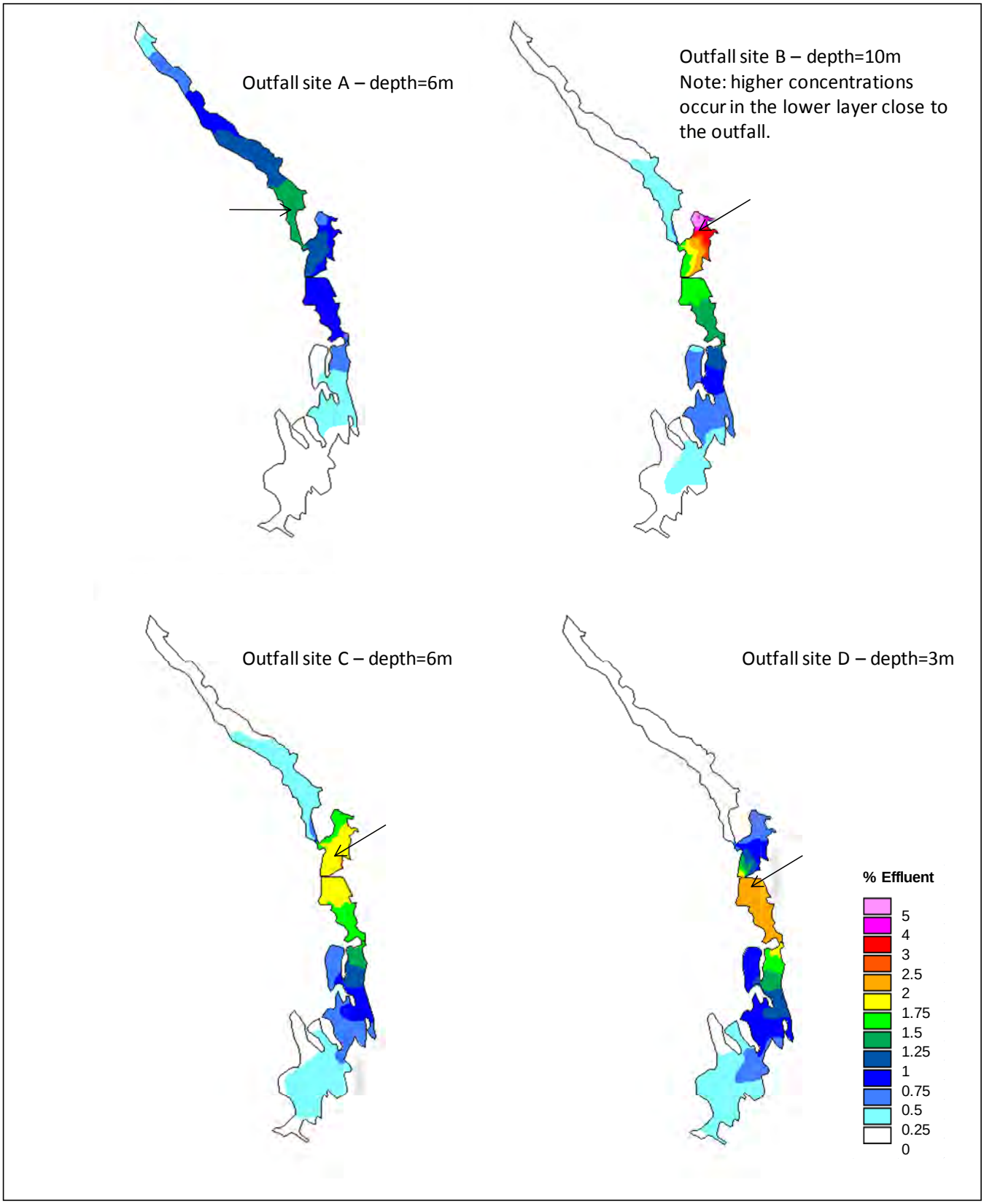


Figure 4.5.a: Modeled Maximum Effluent Concentrations in the Surface Layer Assumed Effluent Flow Rate = 7,690 m^3/day

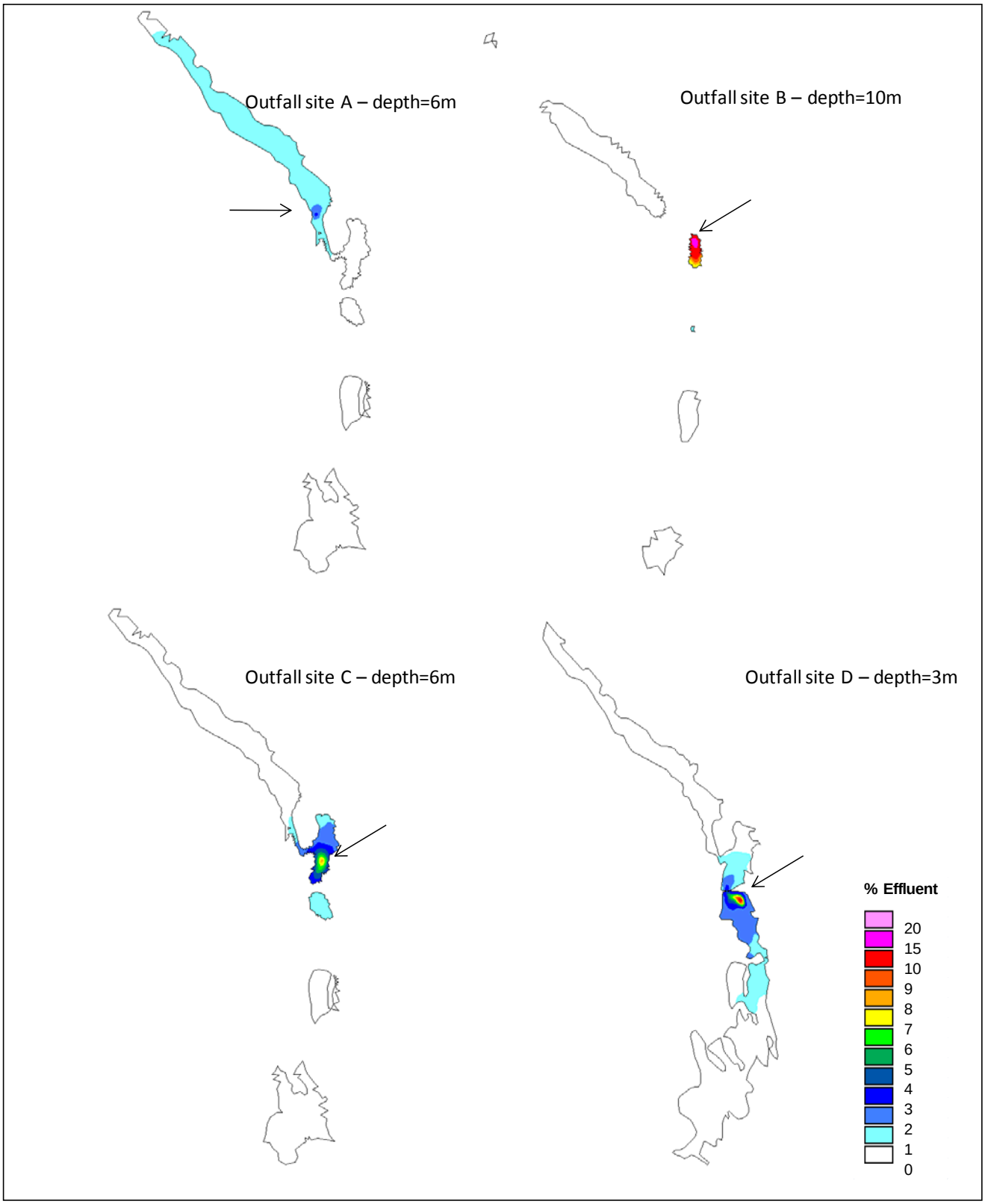


Figure 4.5.b: Modeled Maximum Effluent Concentrations at Outfall Depth Assumed Effluent Flow Rate = 7,690 m^3/day

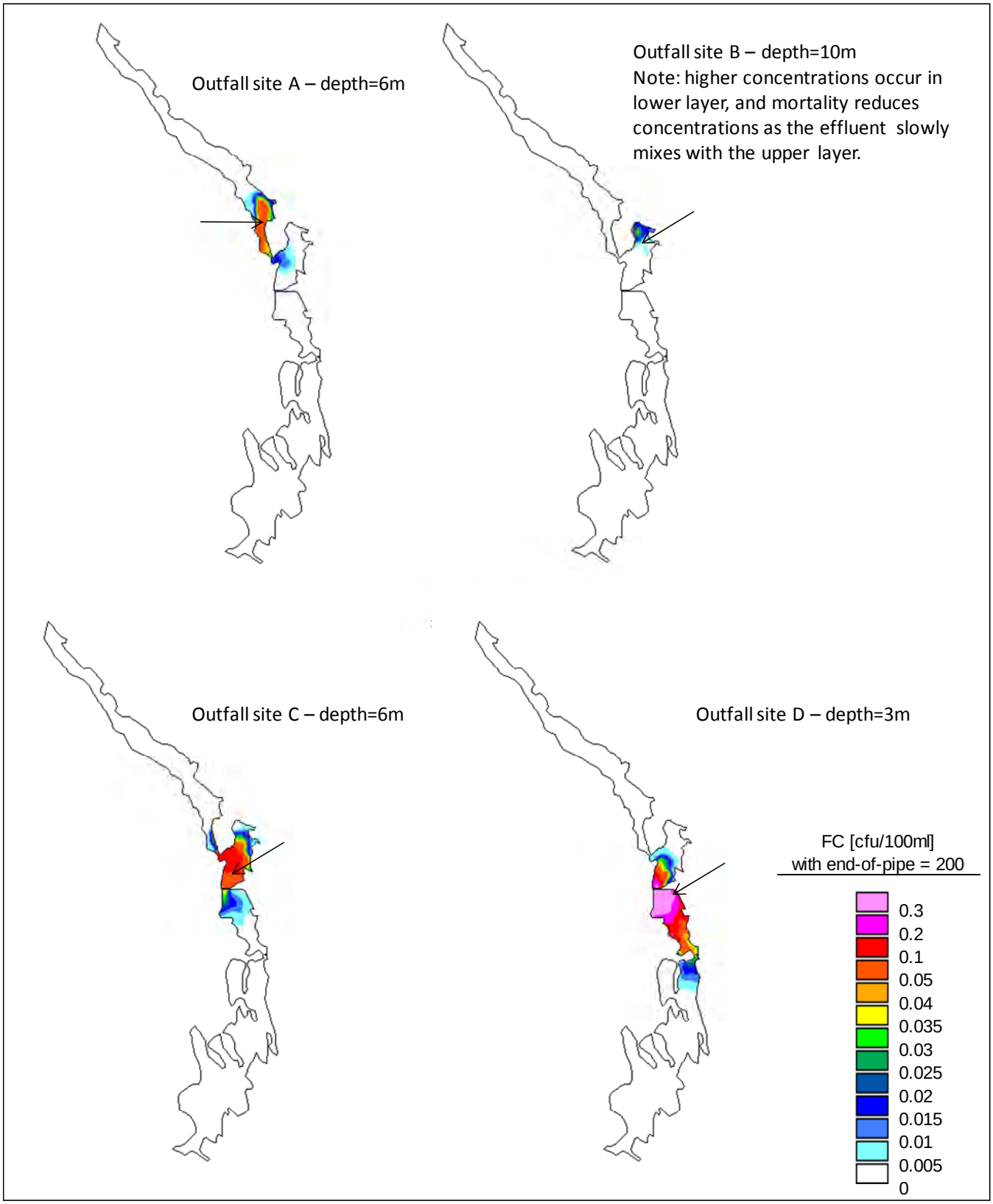


Figure 4.6.a: Modeled Maximum FC Concentrations in the Surface Layer Assumed Effluent Flow Rate = 7,690 m^3/day

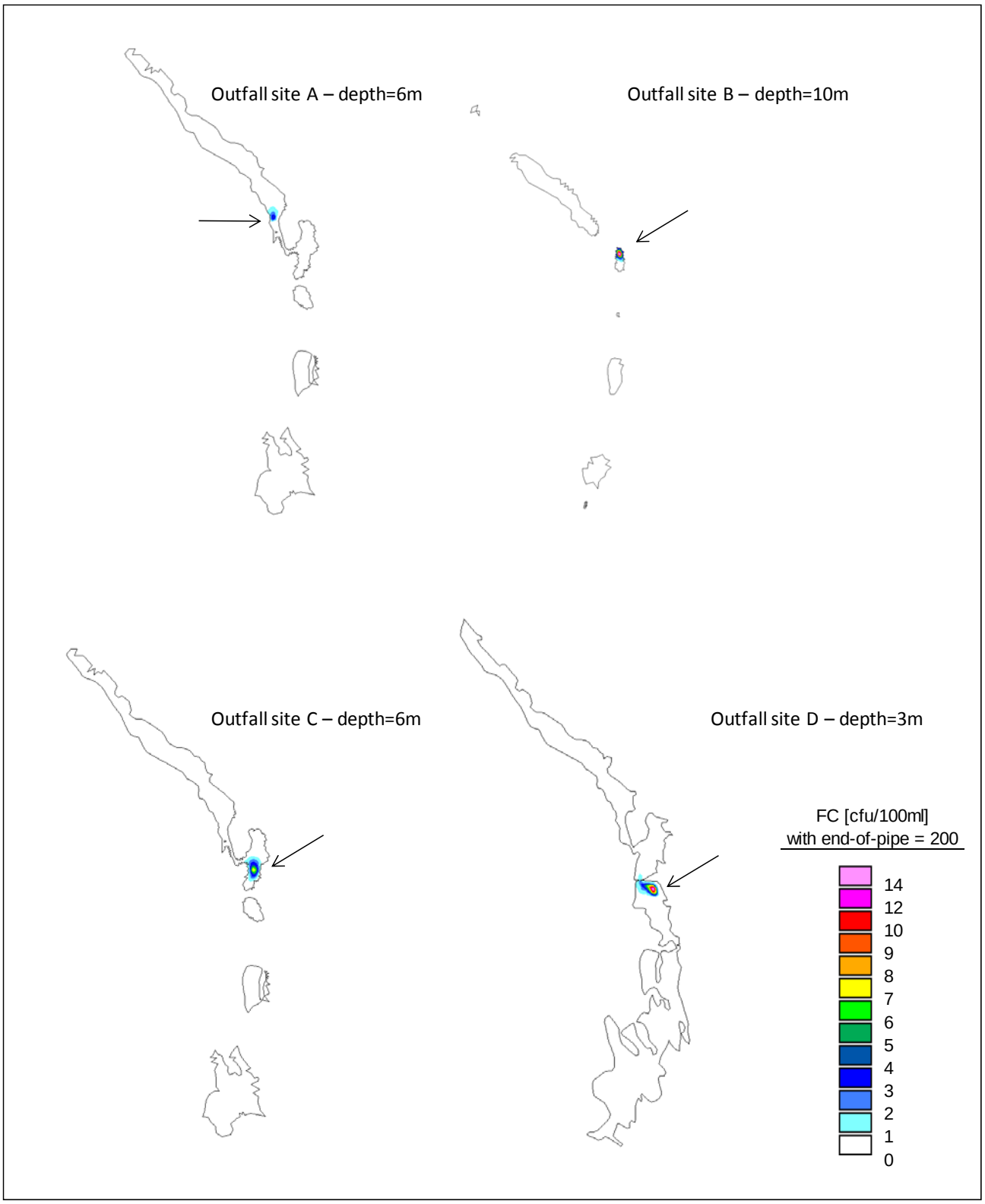


Figure 4.6.b: Modeled Maximum FC Concentrations at Outfall Depth Assumed Effluent Flow Rate = 7,690 m^3/day

4.2.5 Implications of Effluent Discharge on Water Quality

The results of the modeling of wastewater discharge into Porters Lake should be examined in the light of Environment Canada's "Atlantic Canada Standards and Guidelines Manual for the Collection, Treatment, and Disposal of Sanitary Sewage" (2006). The stipulated effluent requirements for a point discharge are reproduced in Table 4.4.

While upper Porters Lake should be considered a freshwater lake, the lower section is an estuary. The definition of the middle section, the most likely location for a future outfall, is more complicated. Analysis of the model simulations suggests that, for the purposes of effluent dilution, this area should be considered a freshwater lake, because its saline bottom layer is too stagnant to offer much additional dilution, as shown for site B. Based on an order-of-magnitude agreement of mixing ratios obtained from model simulation with those estimated from bulk freshwater input estimates: at a flow rate of effluent of 7690 m^3/day, the far-field dilution obtained at sites C and D ranges from less than 10:1 in the bottom layer close to the outfall to approximately 30:1 at the surface. This makes order-of-magnitude sense, as the freshwater flow assumed in the model upstream of the conceptual outfall sites is 2.5 m^3/s, or 28:1 relative to the effluent flow rate. Tidal flushing in the middle section of the lake is very limited.

Table 4.4 : Environment Canada Effluent Requirements

Point of discharge	Fecal Coliform (MPN /100 ml)	Required effluent quality CBOD5/SS (mg/l)
Fresh water lakes and low flow streams (5-10 times dilution)*	200	0-20/0-20 (dependent upon results of receiving water assessment)
Rivers and estuaries	200	20/20
Open coastline	200	25/25
A) Effluent quality may be stipulated as a result of a receiving water assessment. Under no circumstances will less than secondary treatment be acceptable for a fresh water discharge or primary for a coastal discharge. (The receiving water study may indicate that no discharge is permissible). B) Nutrient removal may also be specifically required. * <5 times dilution may require periods of no discharge.		

Bacteria

The effluent requirement for estuaries is 200 MPN/100 ml for coliform bacteria, and 20/20 for CBOD5 and SS (Atlantic Canada Wastewater Guidelines, Environment Canada 2006). Assuming end-of-pipe concentration of 200 /100ml and accounting for mortality, results indicate that maximum far field concentrations of fecal coliform bacteria at outfall sites C and D would be less than 12 CFU/100 ml near the bottom and 0.3 CFU/100 ml at the surface, which meets water quality standards for primary contact and shellfish harvesting. The relatively low FC concentrations obtained are due to mortality of bacteria rather than dilution.

Nutrients

There are currently no guidelines for end-of-pipe concentrations in nutrients (nitrogen and phosphorus). Typical nutrient inputs from municipal wastewaters are 7 mg/l for total phosphorus without detergent, and 8 mg/l for inorganic nitrogen (Thomann and Mueller, 1987). A dilution of 350:1 would be required

to reduce an end-of-pipe concentration of total phosphorus 7 mg/l down to 0.02 mg/l (the assumed objective). For the design flow rate considered (7690 m^3/day), such a dilution is not achieved in the vicinity of any outfall site, so nutrient removal options have to be considered to bring down end-of-pipe concentrations to less than 0.2 mg/l (10:1 bottom dilution x 0.02 mg/l) at outfall sites C and D.

In conclusion, if centralized wastewater treatment is considered:

- Criteria for choosing outfall sites should include proximity to the treatment plant and dispersive capacity of the receiving body of water. Outfall site A appears to show the strongest potential for dispersion of effluent. However, sites C and D offer better potential for exchange of effluent with seawater in the lower section of Porters Lake. Deep areas of the lake are naturally stagnant and anoxic, which is not appropriate for any outfall; and
- Nutrient removal is recommended to the maximum extent possible.

CHAPTER 5 SUMMARY AND CONCLUSIONS

5.1 Existing Water Quality

This report presents the results of a water quality study of Porters Lake in Nova Scotia to establish a baseline of surface water quality and to assess the effect of future development in the study area. The study included a field sampling program, a habitat assessment, a phosphorus loading model and hydrodynamic dispersion modeling. Field investigations took place at five sites on six days between spring and fall of 2010. Phosphorus loading was modeled for nine lakes in the study area, and the hydrodynamic model examined the dispersion of effluent discharged from several potential locations. The key findings are:

- There are acceptable values of nutrient concentrations, dissolved oxygen, algal biomass and biological oxygen demand suggesting that the quality of water at the sampling sites in Porters Lake is suitable for aquatic life as defined by the Canadian Water Quality Guidelines for the Protection of Aquatic Life from the Canadian Council of Ministers of the Environment;
- Low oxygen concentrations were measured in a deep part of the lake near the community of Porters Lake. The development of low oxygen concentration may be natural, but is also likely to be enhanced by the effects of human activities. The deepwater oxygen concentration should be monitored in the future, as growth of the affected area may affect the health of fish and invertebrates in Porters Lake;
- A phosphorus loading model predicts oligotrophic to mesotrophic conditions in terms of phosphorus, i.e. <0.02 mg/l of total phosphorus, for eight lakes in the study area, including Porters Lake. This is confirmed by water quality measurements;
- Phosphorus modeling and observations suggest that all lakes have an assimilative capacity to deal with the current levels of nutrient loading; and
- Bacteria concentrations are typically above the threshold for safe consumption of bivalves, but usually below the threshold for direct recreational contact with the water.

Based on these findings it is concluded that the quality of the water of Porters Lake is generally good. Signs of possible contamination from septic sources was found and should be monitored in areas where there is frequent recreational use of the lake. Future development with the continued use of single-home septic systems for wastewater disposal are likely to impact negatively on water quality of the receiving waters. To detect serious problems associated with eutrophication and low oxygen concentration it is therefore recommended that a monitoring program should measure water quality parameters and vertical profiles of dissolved oxygen at several locations in the lake as development

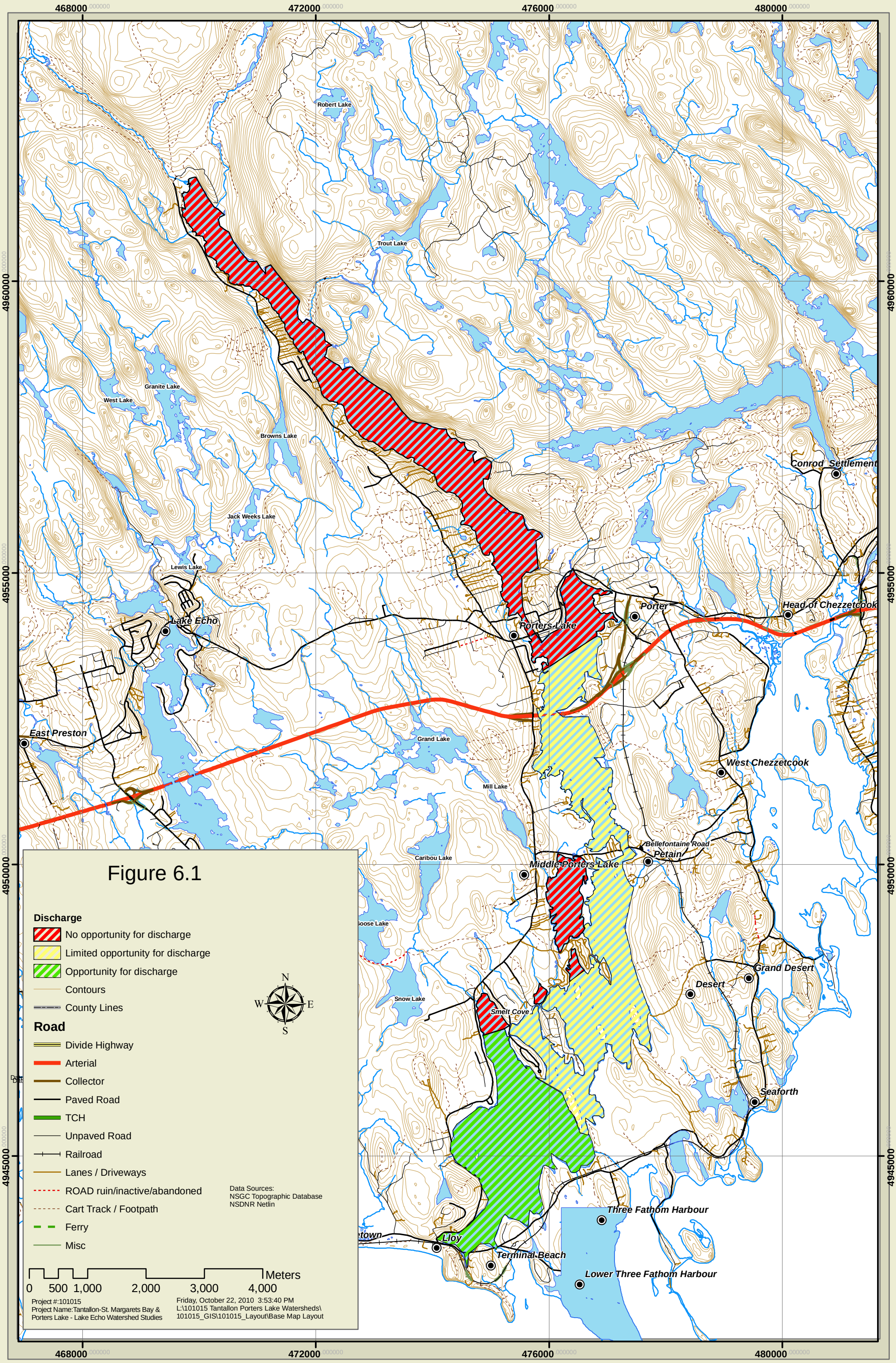
occurs. To protect the environment, developments should follow stringent regulations for the protection of surface water and plans for growth of communities should consider centralized wastewater treatment facilities with removal of nutrients and disinfection.

5.2 Constraints for Wastewater Disposal into Porters Lake

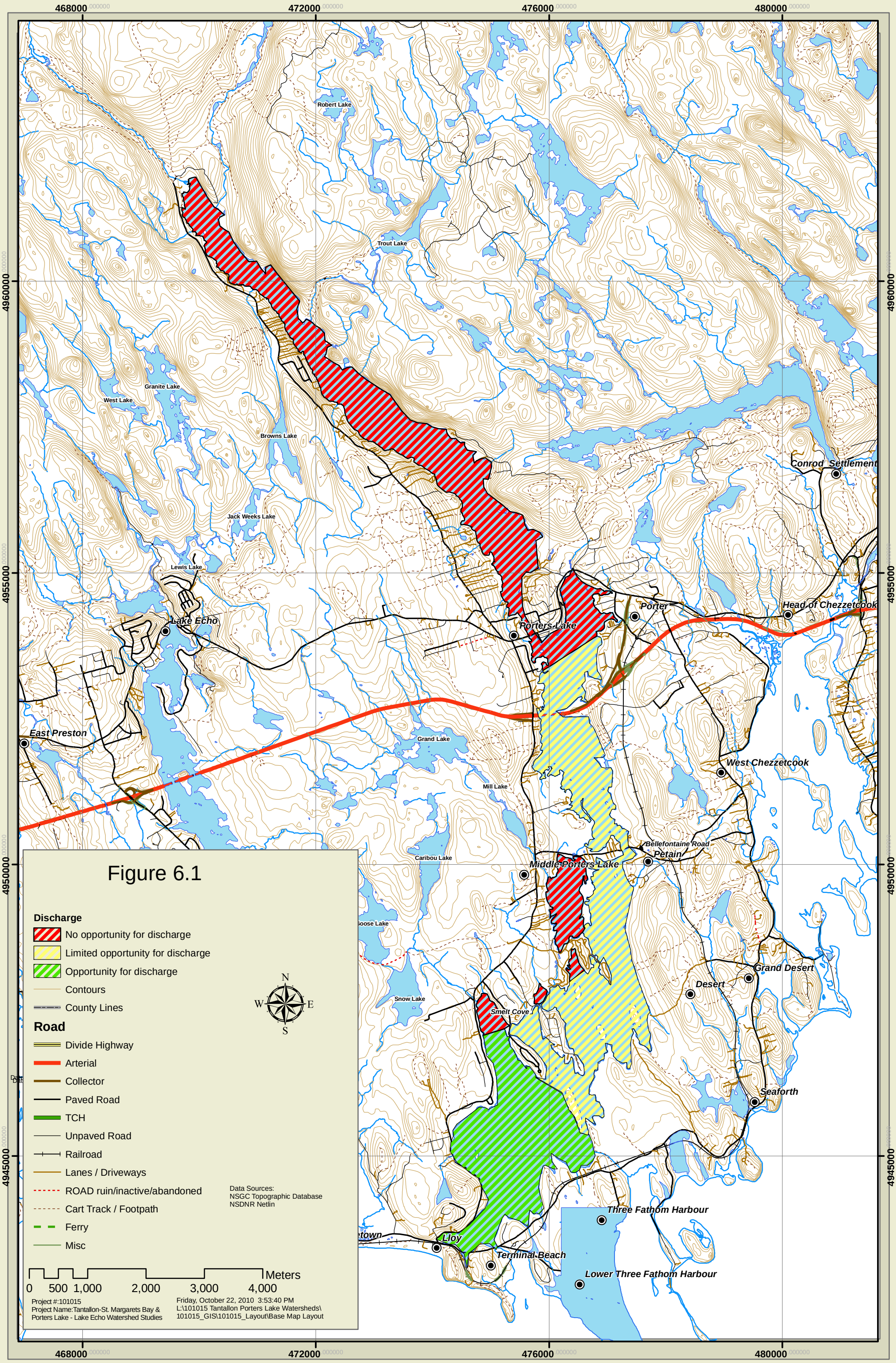
Generally, wastewater discharge should not occur into an area with a low residence time of water, such as stagnant coves and deep sections of a lake. In addition, estuarine circulation patterns, with salty water flowing inland along the bottom and fresh water flowing seaward at the surface, means that any pollutants which enter the deep, salty layer can flow inland and eventually mix with surface water before finally flushing out to sea.

Preliminary hydrodynamic and effluent dispersion modelling in Porters Lake was conducted to estimate dilution ratios, identify potential outfall sites and flag important treatment considerations. The topography of Porters Lake is characteristic of a long, narrow and, along some sections, deep estuary that is separated into distinct sections by road bridges. Flushing is limited due to the bridge constrictions, including the two bridges at its outlet that significantly restrict tidal passage. The upper section is deep and mostly freshwater, with virtually no tidal flushing. The middle section, between Highways 7 and 107, is strongly stratified. Measurements suggest that stagnant and anoxic water may occur in deep sections of the lake.

For these reasons, a treated wastewater outfall should be placed as far downstream as possible and close to the main axis of the lake (Figure 6.1). For the assessment of the requirements for effluent water quality the receiving waters should be regarded as a freshwater lake. Provided that disinfection can bring down end-of-pipe concentrations of coliform bacteria to 200 CFU/100 ml, dilution and natural mortality will result in acceptable levels for primary contact. However, tertiary treatment and significant nutrient removal before discharge are recommended to minimize the risks of eutrophication in the outfall area and downstream.



Datum: NAD83 UTM Zone 20N



Datum: NAD83 UTM Zone 20N

CHAPTER 6 REFERENCES

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APPENDIX C.1

Summary of Canadian Water Quality Guidelines for the Protection of Aquatic Life

Canadian Environmental Quality Guidelines Summary Table

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,1,1-Trichloroethane **CASRN** 71556	Organic Halogenated aliphatic compounds Chlorinated ethanes	*No data*	Insufficient data	1991	*No data*	Insufficient data	1991
1,1,2,2-Tetrachloroethene PCE (Tetrachloroethylene) **CASRN** 127184	Organic Halogenated aliphatic compounds Chlorinated ethenes	*No data*	110	1993	*No data*	Insufficient data	1993
1,1,2,2-Tetrachlorethane **CASRN** 79345	Organic Halogenated aliphatic compounds Chlorinated ethanes	*No data*	Insufficient data	1991	*No data*	Insufficient data	1991
1,1,2-Trichloroethene TCE (Trichloroethylene) **CASRN** 79-01-6	Organic Halogenated aliphatic compounds Chlorinated ethenes	*No data*	21	1991	*No data*	Insufficient data	1991
1,2,3,4-Tetrachlorobenzene **CASRN** 634662	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	1.8	1997	*No data*	Insufficient data	1997
1,2,3,5-Tetrachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997

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Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,2,3-Trichlorobenzene **CASRN** 87616	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	8	1997	*No data*	Insufficient data	1997
1,2,4,5-Tetrachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997
1,2,4-Trichlorobenzene **CASRN** 120801	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	24	1997	*No data*	5.4	1997
1,2-Dichlorobenzene **CASRN** 95501	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	0.7	1997	*No data*	42	1997
1,2-Dichloroethane **CASRN** 1070602	Organic Halogenated aliphatic compounds Chlorinated ethanes	*No data*	100	1991	*No data*	Insufficient data	1991
1,3,5-Trichlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997
1,3-Dichlorobenzene **CASRN** 541731	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	150	1997	*No data*	Insufficient data	1997
1,4-Dichlorobenzene **CASRN** 106467	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	26	1997	*No data*	Insufficient data	1997
1,4-Dioxane		NRG	NRG	2008	NRG	NRG	2008
3-Iodo-2-propynyl butyl carbamate IPBC **CASRN** 55406-53-6	Organic Pesticides Carbamate pesticides	*No data*	1.9	1999	*No data*	*No data*	*No data*
Acenaphthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	5.8	1999	*No data*	Insufficient data	1999

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Acenaphthylene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	No data	No data	1999	No data	No data	1999
Acridine PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	No data	**4.4**	1999	No data	Insufficient data	1999
Aldicarb **CASRN** 116063	Organic Pesticides Carbamate pesticides	No data	**1**	1993	No data	**0.15**	1993
Aldrin	Organic Pesticides Organochlorine compounds	No data	**~~0.004~~**	1987	No data	No data	No data
Aluminium	Inorganic	No data	**Variable**	1987	No data	No data	No data
Ammonia (total)	Inorganic Inorganic nitrogen compounds	No data	**Table**	2001	No data	No data	No data
Ammonia (un-ionized) **CASRN** 7664417	Inorganic Inorganic nitrogen compounds	No data	**19**	2001	No data	No data	No data
Aniline **CASRN** 62533	Organic	No data	**2.2**	1993	No data	Insufficient data	1993
Anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	No data	**0.012**	1999	No data	Insufficient data	1999
Arsenic **CASRN** none	Inorganic	No data	**5**	1997	No data	**12.5**	1997
Atrazine **CASRN** 1912249	Organic Pesticides Triazine compounds	No data	**1.8**	1989	No data	No data	No data
Benzene **CASRN** 71432	Organic Monocyclic aromatic compounds	No data	**370**	1999	No data	**110**	1999
Benzo(a)anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	No data	**0.018**	1999	No data	Insufficient data	1999

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Benzo(a)pyrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	**0.015**	1999	*No data*	Insufficient data	1999
Boron	Inorganic	29,000µg/L or 29mg/L	1,500µg/L or 1.5mg/L	2009	NRG	NRG	2009
Bromacil **CASRN** 314409	Organic Pesticides	*No data*	**5**	1997	*No data*	Insufficient data	1997
Bromoxynil	Organic Pesticides Benzonitrile compounds	*No data*	**5**	1993	*No data*	Insufficient data	1993
Cadmium **CASRN** 7440439	Inorganic	*No data*	**Equation**	1996	*No data*	**0.12**	1996
Captan **CASRN** 133062	Organic Pesticides	*No data*	**1.3**	1991	*No data*	*No data*	*No data*
Carbaryl **CASRN** 63252	Organic Pesticides Carbamate pesticides	3.3	0.2	2009	5.7	0.29	2009
Carbofuran **CASRN** 1564662	Organic Pesticides Carbamate pesticides	*No data*	**1.8**	1989	*No data*	*No data*	*No data*
Chlordane	Organic Pesticides Organochlorine compounds	*No data*	**~~0.006~~**	1987	*No data*	*No data*	*No data*
Chloride	Inorganic	**640,000 µg/L or 640 mg/L**	**120,000 µg/L or 120 mg/L**	2011	**NRG**	**NRG**	2011
Chlorothalonil **CASRN** 1897456	Organic Pesticides	*No data*	**0.18**	1994	*No data*	**0.36**	1994
Chlorpyrifos **CASRN** 2921882	Organic Pesticides Organophosphorus compounds	0.02	0.002	2008	NRG	0.002	2008
Chromium, hexavalent (Cr(VI)) **CASRN** 7440473	Inorganic	*No data*	**1**	1997	*No data*	**1.5**	1997
Chromium, trivalent (Cr(III)) **CASRN** 7440473	Inorganic	*No data*	**8.9**	1997	*No data*	**56**	1997
Chrysene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	Insufficient data	1999	*No data*	Insufficient data	1999

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Colour **CASRN** N/A	Physical	*No data*	**Narrative**	1999	*No data*	**Narrative**	1999
Copper	Inorganic	*No data*	**Equation**	1987	*No data*	*No data*	*No data*
Cyanazine **CASRN** 2175462	Organic Pesticides Triazine compounds	*No data*	**2**	**1990**	*No data*	*No data*	*No data*
Cyanide	Inorganic	*No data*	**5 (as free CN)**	1987	*No data*	*No data*	*No data*
Debris **CASRN** N/A	Physical	*No data*	*No data*	*No data*	*No data*	**Narrative**	1996
Deltamethrin **CASRN** 52918635	Organic Pesticides	*No data*	0.0004	1997	*No data*	Insufficient data	1997
Deposited bedload sediment	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	Insufficient data	1999	*No data*	Insufficient data	1999
Di(2-ethylhexyl) phthalate **CASRN** 117817	Organic Phthalate esters	*No data*	**16**	1993	*No data*	Insufficient data	1993
Di-n-butyl phthalate **CASRN** 84742	Organic Phthalate esters	*No data*	**19**	1993	*No data*	Insufficient data	1993
Di-n-octyl phthalate **CASRN** 117840	Organic Phthalate esters	*No data*	Insufficient data	1993	*No data*	Insufficient data	1993
Dibromochloromethane	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	**Insufficient data**	1992	*No data*	**Insufficient data**	1992
Dicamba **CASRN** 1918009	Organic Pesticides Aromatic Carboxylic Acid	*No data*	**10**	1993	*No data*	*No data*	*No data*
Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane DDT (total)	Organic Pesticides Organochlorine compounds	*No data*	**~~0.001~~**	1987	*No data*	*No data*	*No data*
Dichlorobromomethane	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	**Insufficient data**	1992	*No data*	**Insufficient data**	1992
Dichloromethane Methylene chloride **CASRN** 75092	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	**98.1**	1992	*No data*	Insufficient data	1992

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Dichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	**0.2**	1987	*No data*	*No data*	*No data*
Diclofop-methyl **CASRN** 51338273	Organic Pesticides	*No data*	6.1	1993	*No data*	*No data*	*No data*
Didecyl dimethyl ammonium chloride DDAC **CASRN** 7173515	Organic Pesticides	*No data*	**1.5**	1999	*No data*	Insufficient data	1999
Diethylene glycol **CASRN** 111466	Organic Glycols	*No data*	**Insufficient data**	1997	*No data*	Insufficient data	1997
Diisopropanolamine DIPA **CASRN** 110974	Organic	*No data*	**1600**	**2005**	*No data*	**Insufficient data**	2005
Dimethoate **CASRN** 60515	Organic Pesticides Organophosphorus compounds	*No data*	**6.2**	1993	*No data*	Insufficient data	1993
Dinoseb **CASRN** 88857	Organic Pesticides	*No data*	0.05	1992	*No data*	*No data*	*No data*
Dissolved gas supersaturation **CASRN** N/A	Physical	*No data*	Narrative	1999	*No data*	Narrative	1999
Dissolved oxygen DO **CASRN** N/A	Inorganic	*No data*	**Variable**	1999	*No data*	**>8000 & Narrative**	1996
Endosulfan	Organic Pesticides Organochlorine compounds	0.06	0.003	2010	0.09	0.002	2010
Endrin	Organic Pesticides Organochlorine compounds	*No data*	**~~0.0023~~**	1987	*No data*	**No data**	*No data*
Ethylbenzene **CASRN** 100414	Organic Monocyclic aromatic compounds	*No data*	**90**	1996	*No data*	**25**	1996
Ethylene glycol **CASRN** 107211	Organic Glycols	*No data*	**192 000**	1997	*No data*	Insufficient data	1997
Fluoranthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	**0.04**	1999	*No data*	Insufficient data	1999

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Fluorene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	**3**	1999	*No data*	Insufficient data	1999
Fluoride	Inorganic	*No data*	**120**	2002	*No data*	**NRG**	2002
Glyphosate **CASRN** 1071836	Organic Pesticides Organophosphorus compounds	**27,000**	**800**	**2012**	**NRG**	**NRG**	**2012**
Heptachlor Heptachlor epoxide	Organic Pesticides Organochlorine compounds	*No data*	**~~0.01~~**	1987	*No data*	*No data*	*No data*
Hexachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	**Insufficient data**	1997	*No data*	**Insufficient data**	1997
Hexachlorobutadiene HCBD **CASRN** 87683	Organic Halogenated aliphatic compounds	*No data*	**1.3**	1999	*No data*	*No data*	*No data*
Hexachlorocyclohexane Lindane	Organic Pesticides Organochlorine compounds	*No data*	**0.01**	1987	*No data*	*No data*	*No data*
Imidacloprid **CASRN** 13826413		*No data*	**0.23**	2007	*No data*	**0.65**	2007
Iron	Inorganic	*No data*	**300**	1987	*No data*	*No data*	*No data*
Lead	Inorganic	*No data*	**Equation**	1987	*No data*	*No data*	*No data*
Linuron **CASRN** 41205214	Organic Pesticides	*No data*	**7**	1995	*No data*	*No data*	1995
Mercury **CASRN** 7439976	Inorganic	*No data*	**0.026**	2003	*No data*	**0.016**	2003
Methoprene **CASRN** 40596698		*No data*	**0.09 (Target Organism Management value: 0.53)**	2007	*No data*	Insufficient data	2007
Methyl tertiary-butyl ether MTBE **CASRN** 1634044	Organic Non-halogenated aliphatic compounds Aliphatic ether	*No data*	**10 000**	2003	*No data*	**5 000**	2003

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Methylchlorophenoxyacetic acid (4-Chloro-2-methyl phenoxy acetic acid; 2-Methyl-4-chloro phenoxy acetic acid) MCPA **CASRN** 94746	Organic Pesticides	*No data*	2.6	1995	*No data*	4.2	1995
Methylmercury	Organic	*No data*	0.004	2003	*No data*	NRG	2003
Metolachlor **CASRN** 51218452	Organic Pesticides Organochlorine compounds	*No data*	7.8	1991	*No data*	*No data*	*No data*
Metribuzin **CASRN** 21087649	Organic Pesticides Triazine compounds	*No data*	1	1990	*No data*	*No data*	*No data*
Molybdenum	Inorganic	*No data*	73	1999	*No data*	*No data*	*No data*
Monobromomethane Methyl bromide	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Monochlorobenzene **CASRN** 108907	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	1.3	1997	*No data*	25	1997
Monochloromethane Methyl chloride	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Monochlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	7	1987	*No data*	*No data*	*No data*
Naphthalene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	1.1	1999	*No data*	1.4	1999
Nickel	Inorganic	*No data*	Equation	1987	*No data*	*No data*	*No data*
Nitrate **CASRN** 14797-55-8	Inorganic Inorganic nitrogen compounds	550,000 µg/L or 550 mg/L	13,000 µg/L or 13 mg/L	2012	1,500,000 µg/L or 1500 mg/L	200,000 µg/L or 200 mg/L	2012

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Nitrite	Inorganic Inorganic nitrogen compounds	No data	60 NO_2-N	1987	No data	No data	No data
Nonylphenol and its ethoxylates **CASRN** 84852153	Organic Nonylphenol and its ethoxylates	No data	1	2002	No data	0.7	2002
Nutrients		No data	Guidance Framework	2004	No data	Guidance framework	2007
Pentachlorobenzene **CASRN** 608935	Organic Monocyclic aromatic compounds Chlorinated benzenes	No data	6	1997	No data	Insufficient data	1997
Pentachlorophenol PCP	Organic Monocyclic aromatic compounds Chlorinated phenols	No data	0.5	1987	No data	No data	No data
Permethrin **CASRN** 52645531	Organic Pesticides Organochlorine compounds	No data	0.004	2006	No data	0.001	2006
Phenanthrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	No data	0.4	1999	No data	Insufficient data	1999
Phenols (mono- & dihydric) **CASRN** 108952	Organic Aromatic hydroxy compounds	No data	4	1999	No data	No data	No data
Phenoxy herbicides 2,4 D; 2,4-Dichlorophenoxyacetic acid	Organic Pesticides	No data	4	1987	No data	No data	No data
Phosphorus	Inorganic	No data	Guidance Framework	2004	No data	Guidance Framework	2007
Picloram **CASRN** 1918021	Organic Pesticides	No data	29	1990	No data	No data	No data
Polychlorinated biphenyls PCBs	Organic Polyaromatic compounds Polychlorinated biphenyls	No data	~~0.001~~	1987	No data	~~0.01~~	1991
Propylene glycol **CASRN** 57556	Organic Glycols	No data	500 000	1997	No data	Insufficient data	1997
Pyrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	No data	0.025	1999	No data	Insufficient data	1999

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
pH	Inorganic Acidity, alkalinity and pH	*No data*	**6.5 to 9.0**	**1987**	*No data*	**7.0 to 8.7 & Narrative**	1996
Quinoline PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	**3.4**	1999	*No data*	Insufficient data	1999
Reactive Chlorine Species total residual chlorine, combined residual chlorine, total available chlorine, hypochlorous acid, chloramine, combined available chlorine, free residual chlorine, free available chlorine, chlorine-produced oxidants	Inorganic Reactive chlorine compunds	*No data*	**0.5**	1999	*No data*	**0.5**	1999
Salinity	Physical	*No data*	*No data*	*No data*	*No data*	**Narrative**	1996
Selenium	Inorganic	*No data*	**1**	1987	*No data*	*No data*	*No data*
Silver	Inorganic	*No data*	**0.1**	1987	*No data*	*No data*	*No data*
Simazine **CASRN** 122349	Organic Pesticides Triazine compounds	*No data*	**10**	1991	*No data*	**No data**	*No data*
Streambed substrate	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	**Narrative**	1999	*No data*	**Narrative**	1999
Styrene **CASRN** 100425	Organic Monocyclic aromatic compounds	*No data*	**72**	1999	*No data*	*No data*	*No data*
Sulfolane Bondelane **CASRN** 126330	Organic Organic sulphur compound	*No data*	**50 000**	2005	*No data*	Insufficient data	2005
Suspended sediments TSS	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	**Narrative**	1999	*No data*	**Narrative**	1999
Tebuthiuron **CASRN** 34014181	Organic Pesticides	*No data*	**1.6**	1995	*No data*	Insufficient data	1995
Temperature	Physical Temperature	*No data*	**Narrative**	1987	*No data*	**Narrative**	1996

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Tetrachloromethane Carbon tetrachloride **CASRN** 56235	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	**13.3**	1992	*No data*	Insufficient data	1992
Tetrachlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	**1**	1987	*No data*	*No data*	*No data*
Thallium	Inorganic	*No data*	**0.8**	1999	*No data*	*No data*	*No data*
Toluene **CASRN** 108883	Organic Monocyclic aromatic compounds	*No data*	**2**	1996	*No data*	**215**	1996
Toxaphene	Organic Pesticides Organochlorine compounds	*No data*	**~~0.008~~**	1987	*No data*	*No data*	*No data*
Triallate **CASRN** 2303175	Organic Pesticides Carbamate pesticides	*No data*	**0.24**	1992	*No data*	*No data*	*No data*
Tribromomethane Bromoform	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	**Insufficient data**	1992	*No data*	**Insufficient data**	1992
Tributyltin	Organic Organotin compounds	*No data*	**0.008**	1992	*No data*	**0.001**	1992
Trichloromethane Chloroform **CASRN** 67663	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	**1.8**	1992	*No data*	Insufficient data	1992
Trichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	**18**	1987	*No data*	*No data*	*No data*
Tricyclohexyltin	Organic Organotin compounds	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Trifluralin **CASRN** 1582098	Organic Pesticides Dinitroaniline pesticides	*No data*	**0.2**	1993	*No data*	*No data*	*No data*

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Triphenyltin	Organic Organotin compounds	*No data*	0.022	1992	*No data*	*No data*	1992
Turbidity	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	Narrative	1999	*No data*	Narrative	1999
Uranium **CASRN** 7440-61-1	Inorganic	33	15	2011	NRG	NRG	2011
Zinc	Inorganic	*No data*	30	1987	*No data*	*No data*	*No data*

Chemical name	Chemical groups
No Chemicals with Data	

Recreational Water Quality Guidelines and Aesthetics

Recreational water refers to surface waters that are used primarily for activities in which the user comes into frequent direct contact with the water, either as part of the activity or incidental to the activity. Examples include swimming, windsurfing, waterskiing, white water sports, scuba diving, and dinghy sailing. Secondary recreational uses include boating, canoeing, and fishing, which generally have less frequent body contact with water.

General Requirements

Health and Safety

Water used primarily for recreational purposes should be sufficiently free from microbiological, chemical, and physical hazards, e.g. poor visibility, to ensure that there is negligible risk to the health and safety of the user. Recreational water quality guidelines, summarized in Table 1, were prepared by the Federal–Provincial Advisory Committee on Environmental and Occupational Health and published by Health and Welfare Canada (1992).

These guidelines deal mainly with potential health hazards related primarily to recreational water use, but also relate to aesthetics and nuisance conditions. Health hazards associated with direct recreational contact with water include infections transmitted by pathogenic microorganisms and injuries resulting from impaired visibility in turbid waters. The determination of the risk of infection is based on a number of factors, including results of environmental health assessments, results of epidemiological studies, levels of indicator organisms, and the presence of pathogens. Sampling and enumeration of microbiological indicators and pathogens in recreational waters are also discussed. New guidelines for safe recreational water environments are currently being prepared by the World Health Organization with the assistance of Health Canada.

Aesthetics

The local setting of recreational water bodies is also important, as the surrounding countryside has a strong visual effect on the enjoyment of lakes and rivers, whether the activity is physically active or passive, such as gazing on the scenery.

In northern waters, swimming is not a major recreational activity, and factors other than microbiological are major components when determining the suitability of lakes and rivers and their environments as recreational areas. Visual impact of the whole area is as important as the quality of the water.

Impacts on a water source come from many activities. These include logging, mining, drainage of wetlands, dredging, dam construction, agricultural runoff, industrial and municipal wastes, land erosion, road construction, and land development. These factors all have to be considered in areas of natural beauty that are used for the many recreational activities engaged in by Canadians and visitors to Canada.

References

Health and Welfare Canada. 1992. Guidelines for Canadian recreational water quality. Cat. No. H49-70/1991E. Minister of Supply and Services Canada, Ottawa.

Moody, R.P., and I. Chu. 1995. Dermal exposure to environmental contaminants in the Great Lakes. Environ. Health Perspect. 103(Suppl. 9):103–114.

Recreational Water Quality Guidelines and Aesthetics

Summary — Guidelines for Canadian recreational water quality.

Parameter	Guideline
Microbiological	
Escherichia coli (fecal coliforms)	The geometric mean of at least five samples taken during a period not to exceed 30 d should not exceed 2000 *E. coli* per litre. Resampling should be performed when any sample exceeds 4000 *E. coli* per litre. See Health and Welfare Canada (1992) for additional information on application of guideline.
Enterococci	The geometric mean of at least five samples taken during a period not to exceed 30 d should not exceed 350 enterococci per litre. Resampling should be performed when any sample exceeds 700 enterococci per litre. See Health and Welfare Canada (1992) for additional information on application of guideline.
Coliphages	Limits on coliphages can not be specified at this time. See Health and Welfare Canada (1992) for additional information.
Waterborne pathogens	The pathogens most frequently responsible for diseases associated with recreational water use are described in Health and Welfare Canada (1992), i.e., *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Salmonella*, *Shigella*, *Aeromonas*, *Campylobacter jejuni*, *Legionella*, human enteric viruses, *Giardia lamblia*, and *Cryptosporidium*.
Cyanobacteria (blue-green algae)	Limits have not been specified. Health Canada is in the process of developing a numerical guideline for microcystin, a cyanobacterial toxin. Water with blue-green surface scum should be avoided because of reduced clarity and possible presence of toxins.
Chemical characteristics	Limits for chemicals have not been specified because of lack of data. Decisions for use should be based on an environmental health assessment and the aesthetic quality. Dermal exposures to environmental contaminants has recently been reviewed by Moody and Chu (1995).
Temperature	The thermal characteristics of water should not cause an appreciable increase or decrease in the deep body temperature of bathers and swimmers.
Clarity	The water should be sufficiently clear that a Secchi disc is visible at a minimum of 1.2 m.
pH	When the buffering capacity of the water is very low,6.5 to 8.5; range of 5.0 to 9.0 is acceptable.
Turbidity	A limit of 50 Nephelometric Turbidity Units (NTU) is suggested.
Oil and grease	Oil or petrochemicals should not be present in concentrations that • can be detected as a visible film, sheen, or discoloration on the surface; • can be detected by odour; or • can form deposits on shorelines and bottom deposits that are detectable by sight and odour.
Aquatic plants	Bathers should avoid areas with rooted or floating plants; very dense growths could affect other activities such as boating and fishing.
Aesthetics	All water should be free from • materials that will settle to form objectionable deposits; • floating debris, oil, scum, and other matter; • substances producing objectionable colour, odour, taste, or turbidity; and • substances and conditions or combinations thereof in concentrations that produce undesirable aquatic life.
Nuisance organisms	Bathing areas should be as free as possible from nuisance organisms that • endanger the health and physical comfort of users or • render the area unusable. Common examples include biting and nonbiting insects and poisonous organisms, for example jelly-fish.

This page revised 2004

Reference listing:

Canadian Council of Ministers of the Environment. 1999. Recreational water quality guidelines and aesthetics. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

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Canadian Environmental Quality Guidelines Summary Table

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,1,1-Trichloroethane **CASRN** 71556	Organic Halogenated aliphatic compounds Chlorinated ethanes	*No data*	Insufficient data	1991	*No data*	Insufficient data	1991
1,1,2,2-Tetrachloroethene PCE (Tetrachloroethylene) **CASRN** 127184	Organic Halogenated aliphatic compounds Chlorinated ethenes	*No data*	110	1993	*No data*	Insufficient data	1993
1,1,2,2-Tetrachlorethane **CASRN** 79345	Organic Halogenated aliphatic compounds Chlorinated ethanes	*No data*	Insufficient data	1991	*No data*	Insufficient data	1991
1,1,2-Trichloroethene TCE (Trichloroethylene) **CASRN** 79-01-6	Organic Halogenated aliphatic compounds Chlorinated ethenes	*No data*	21	1991	*No data*	Insufficient data	1991
1,2,3,4-Tetrachlorobenzene **CASRN** 634662	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	1.8	1997	*No data*	Insufficient data	1997
1,2,3,5-Tetrachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
1,2,3-Trichlorobenzene **CASRN** 87616	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	8	1997	*No data*	Insufficient data	1997
1,2,4,5-Tetrachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997
1,2,4-Trichlorobenzene **CASRN** 120801	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	24	1997	*No data*	5.4	1997
1,2-Dichlorobenzene **CASRN** 95501	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	0.7	1997	*No data*	42	1997
1,2-Dichloroethane **CASRN** 1070602	Organic Halogenated aliphatic compounds Chlorinated ethanes	*No data*	100	1991	*No data*	Insufficient data	1991
1,3,5-Trichlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	Insufficient data	1997	*No data*	Insufficient data	1997
1,3-Dichlorobenzene **CASRN** 541731	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	150	1997	*No data*	Insufficient data	1997
1,4-Dichlorobenzene **CASRN** 106467	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	26	1997	*No data*	Insufficient data	1997
1,4-Dioxane		NRG	NRG	2008	NRG	NRG	2008
3-Iodo-2-propynyl butyl carbamate IPBC **CASRN** 55406-53-6	Organic Pesticides Carbamate pesticides	*No data*	1.9	1999	*No data*	*No data*	*No data*
Acenaphthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	5.8	1999	*No data*	Insufficient data	1999

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Acenaphthylene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	No data	No data	1999	No data	No data	1999
Acridine PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	No data	**4.4**	1999	No data	Insufficient data	1999
Aldicarb **CASRN** 116063	Organic Pesticides Carbamate pesticides	No data	**1**	1993	No data	**0.15**	1993
Aldrin	Organic Pesticides Organochlorine compounds	No data	**~~0.004~~**	1987	No data	No data	No data
Aluminium	Inorganic	No data	**Variable**	1987	No data	No data	No data
Ammonia (total)	Inorganic Inorganic nitrogen compounds	No data	**Table**	2001	No data	No data	No data
Ammonia (un-ionized) **CASRN** 7664417	Inorganic Inorganic nitrogen compounds	No data	**19**	2001	No data	No data	No data
Aniline **CASRN** 62533	Organic	No data	**2.2**	1993	No data	Insufficient data	1993
Anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	No data	**0.012**	1999	No data	Insufficient data	1999
Arsenic **CASRN** none	Inorganic	No data	**5**	1997	No data	**12.5**	1997
Atrazine **CASRN** 1912249	Organic Pesticides Triazine compounds	No data	**1.8**	1989	No data	No data	No data
Benzene **CASRN** 71432	Organic Monocyclic aromatic compounds	No data	**370**	1999	No data	**110**	1999
Benzo(a)anthracene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	No data	**0.018**	1999	No data	Insufficient data	1999

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Benzo(a)pyrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	**0.015**	1999	*No data*	Insufficient data	1999
Boron	Inorganic	29,000µg/L or 29mg/L	1,500µg/L or 1.5mg/L	2009	NRG	NRG	2009
Bromacil **CASRN** 314409	Organic Pesticides	*No data*	**5**	1997	*No data*	Insufficient data	1997
Bromoxynil	Organic Pesticides Benzonitrile compounds	*No data*	**5**	1993	*No data*	Insufficient data	1993
Cadmium **CASRN** 7440439	Inorganic	*No data*	**Equation**	1996	*No data*	**0.12**	1996
Captan **CASRN** 133062	Organic Pesticides	*No data*	**1.3**	1991	*No data*	*No data*	*No data*
Carbaryl **CASRN** 63252	Organic Pesticides Carbamate pesticides	3.3	0.2	2009	5.7	0.29	2009
Carbofuran **CASRN** 1564662	Organic Pesticides Carbamate pesticides	*No data*	**1.8**	1989	*No data*	*No data*	*No data*
Chlordane	Organic Pesticides Organochlorine compounds	*No data*	**~~0.006~~**	1987	*No data*	*No data*	*No data*
Chloride	Inorganic	**640,000 µg/L or 640 mg/L**	**120,000 µg/L or 120 mg/L**	2011	**NRG**	**NRG**	2011
Chlorothalonil **CASRN** 1897456	Organic Pesticides	*No data*	**0.18**	1994	*No data*	**0.36**	1994
Chlorpyrifos **CASRN** 2921882	Organic Pesticides Organophosphorus compounds	0.02	0.002	2008	NRG	0.002	2008
Chromium, hexavalent (Cr(VI)) **CASRN** 7440473	Inorganic	*No data*	**1**	1997	*No data*	**1.5**	1997
Chromium, trivalent (Cr(III)) **CASRN** 7440473	Inorganic	*No data*	**8.9**	1997	*No data*	**56**	1997
Chrysene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	Insufficient data	1999	*No data*	Insufficient data	1999

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Colour **CASRN** N/A	Physical	*No data*	**Narrative**	1999	*No data*	**Narrative**	1999
Copper	Inorganic	*No data*	**Equation**	1987	*No data*	*No data*	*No data*
Cyanazine **CASRN** 2175462	Organic Pesticides Triazine compounds	*No data*	**2**	**1990**	*No data*	*No data*	*No data*
Cyanide	Inorganic	*No data*	**5 (as free CN)**	1987	*No data*	*No data*	*No data*
Debris **CASRN** N/A	Physical	*No data*	*No data*	*No data*	*No data*	**Narrative**	1996
Deltamethrin **CASRN** 52918635	Organic Pesticides	*No data*	0.0004	1997	*No data*	Insufficient data	1997
Deposited bedload sediment	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	Insufficient data	1999	*No data*	Insufficient data	1999
Di(2-ethylhexyl) phthalate **CASRN** 117817	Organic Phthalate esters	*No data*	**16**	1993	*No data*	Insufficient data	1993
Di-n-butyl phthalate **CASRN** 84742	Organic Phthalate esters	*No data*	**19**	1993	*No data*	Insufficient data	1993
Di-n-octyl phthalate **CASRN** 117840	Organic Phthalate esters	*No data*	Insufficient data	1993	*No data*	Insufficient data	1993
Dibromochloromethane	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	**Insufficient data**	1992	*No data*	**Insufficient data**	1992
Dicamba **CASRN** 1918009	Organic Pesticides Aromatic Carboxylic Acid	*No data*	**10**	1993	*No data*	*No data*	*No data*
Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane DDT (total)	Organic Pesticides Organochlorine compounds	*No data*	**~~0.001~~**	1987	*No data*	*No data*	*No data*
Dichlorobromomethane	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	**Insufficient data**	1992	*No data*	**Insufficient data**	1992
Dichloromethane Methylene chloride **CASRN** 75092	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	**98.1**	1992	*No data*	Insufficient data	1992

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Dichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	**0.2**	1987	*No data*	*No data*	*No data*
Diclofop-methyl **CASRN** 51338273	Organic Pesticides	*No data*	6.1	1993	*No data*	*No data*	*No data*
Didecyl dimethyl ammonium chloride DDAC **CASRN** 7173515	Organic Pesticides	*No data*	**1.5**	1999	*No data*	Insufficient data	1999
Diethylene glycol **CASRN** 111466	Organic Glycols	*No data*	**Insufficient data**	1997	*No data*	Insufficient data	1997
Diisopropanolamine DIPA **CASRN** 110974	Organic	*No data*	**1600**	**2005**	*No data*	**Insufficient data**	2005
Dimethoate **CASRN** 60515	Organic Pesticides Organophosphorus compounds	*No data*	**6.2**	1993	*No data*	Insufficient data	1993
Dinoseb **CASRN** 88857	Organic Pesticides	*No data*	0.05	1992	*No data*	*No data*	*No data*
Dissolved gas supersaturation **CASRN** N/A	Physical	*No data*	Narrative	1999	*No data*	Narrative	1999
Dissolved oxygen DO **CASRN** N/A	Inorganic	*No data*	**Variable**	1999	*No data*	**>8000 & Narrative**	1996
Endosulfan	Organic Pesticides Organochlorine compounds	0.06	0.003	2010	0.09	0.002	2010
Endrin	Organic Pesticides Organochlorine compounds	*No data*	**~~0.0023~~**	1987	*No data*	**No data**	*No data*
Ethylbenzene **CASRN** 100414	Organic Monocyclic aromatic compounds	*No data*	**90**	1996	*No data*	**25**	1996
Ethylene glycol **CASRN** 107211	Organic Glycols	*No data*	**192 000**	1997	*No data*	Insufficient data	1997
Fluoranthene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	**0.04**	1999	*No data*	Insufficient data	1999

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Fluorene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	**3**	1999	*No data*	Insufficient data	1999
Fluoride	Inorganic	*No data*	**120**	2002	*No data*	**NRG**	2002
Glyphosate **CASRN** 1071836	Organic Pesticides Organophosphorus compounds	**27,000**	**800**	**2012**	**NRG**	**NRG**	**2012**
Heptachlor Heptachlor epoxide	Organic Pesticides Organochlorine compounds	*No data*	**~~0.01~~**	1987	*No data*	*No data*	*No data*
Hexachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	**Insufficient data**	1997	*No data*	**Insufficient data**	1997
Hexachlorobutadiene HCBD **CASRN** 87683	Organic Halogenated aliphatic compounds	*No data*	**1.3**	1999	*No data*	*No data*	*No data*
Hexachlorocyclohexane Lindane	Organic Pesticides Organochlorine compounds	*No data*	**0.01**	1987	*No data*	*No data*	*No data*
Imidacloprid **CASRN** 13826413		*No data*	**0.23**	2007	*No data*	**0.65**	2007
Iron	Inorganic	*No data*	**300**	1987	*No data*	*No data*	*No data*
Lead	Inorganic	*No data*	**Equation**	1987	*No data*	*No data*	*No data*
Linuron **CASRN** 41205214	Organic Pesticides	*No data*	**7**	1995	*No data*	*No data*	1995
Mercury **CASRN** 7439976	Inorganic	*No data*	**0.026**	2003	*No data*	**0.016**	2003
Methoprene **CASRN** 40596698		*No data*	**0.09 (Target Organism Management value: 0.53)**	2007	*No data*	Insufficient data	2007
Methyl tertiary-butyl ether MTBE **CASRN** 1634044	Organic Non-halogenated aliphatic compounds Aliphatic ether	*No data*	**10 000**	2003	*No data*	**5 000**	2003

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		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Methylchlorophenoxyacetic acid (4-Chloro-2-methyl phenoxy acetic acid; 2-Methyl-4-chloro phenoxy acetic acid) MCPA **CASRN** 94746	Organic Pesticides	*No data*	2.6	1995	*No data*	4.2	1995
Methylmercury	Organic	*No data*	0.004	2003	*No data*	NRG	2003
Metolachlor **CASRN** 51218452	Organic Pesticides Organochlorine compounds	*No data*	7.8	1991	*No data*	*No data*	*No data*
Metribuzin **CASRN** 21087649	Organic Pesticides Triazine compounds	*No data*	1	1990	*No data*	*No data*	*No data*
Molybdenum	Inorganic	*No data*	73	1999	*No data*	*No data*	*No data*
Monobromomethane Methyl bromide	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Monochlorobenzene **CASRN** 108907	Organic Monocyclic aromatic compounds Chlorinated benzenes	*No data*	1.3	1997	*No data*	25	1997
Monochloromethane Methyl chloride	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Monochlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	7	1987	*No data*	*No data*	*No data*
Naphthalene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	1.1	1999	*No data*	1.4	1999
Nickel	Inorganic	*No data*	Equation	1987	*No data*	*No data*	*No data*
Nitrate **CASRN** 14797-55-8	Inorganic Inorganic nitrogen compounds	550,000 µg/L or 550 mg/L	13,000 µg/L or 13 mg/L	2012	1,500,000 µg/L or 1500 mg/L	200,000 µg/L or 200 mg/L	2012

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Nitrite	Inorganic Inorganic nitrogen compounds	No data	60 NO_2-N	1987	No data	No data	No data
Nonylphenol and its ethoxylates **CASRN** 84852153	Organic Nonylphenol and its ethoxylates	No data	1	2002	No data	0.7	2002
Nutrients		No data	Guidance Framework	2004	No data	Guidance framework	2007
Pentachlorobenzene **CASRN** 608935	Organic Monocyclic aromatic compounds Chlorinated benzenes	No data	6	1997	No data	Insufficient data	1997
Pentachlorophenol PCP	Organic Monocyclic aromatic compounds Chlorinated phenols	No data	0.5	1987	No data	No data	No data
Permethrin **CASRN** 52645531	Organic Pesticides Organochlorine compounds	No data	0.004	2006	No data	0.001	2006
Phenanthrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	No data	0.4	1999	No data	Insufficient data	1999
Phenols (mono- & dihydric) **CASRN** 108952	Organic Aromatic hydroxy compounds	No data	4	1999	No data	No data	No data
Phenoxy herbicides 2,4 D; 2,4-Dichlorophenoxyacetic acid	Organic Pesticides	No data	4	1987	No data	No data	No data
Phosphorus	Inorganic	No data	Guidance Framework	2004	No data	Guidance Framework	2007
Picloram **CASRN** 1918021	Organic Pesticides	No data	29	1990	No data	No data	No data
Polychlorinated biphenyls PCBs	Organic Polyaromatic compounds Polychlorinated biphenyls	No data	~~0.001~~	1987	No data	~~0.01~~	1991
Propylene glycol **CASRN** 57556	Organic Glycols	No data	500 000	1997	No data	Insufficient data	1997
Pyrene PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	No data	0.025	1999	No data	Insufficient data	1999

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
pH	Inorganic Acidity, alkalinity and pH	*No data*	**6.5 to 9.0**	**1987**	*No data*	**7.0 to 8.7 & Narrative**	1996
Quinoline PAHs	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	*No data*	**3.4**	1999	*No data*	Insufficient data	1999
Reactive Chlorine Species total residual chlorine, combined residual chlorine, total available chlorine, hypochlorous acid, chloramine, combined available chlorine, free residual chlorine, free available chlorine, chlorine-produced oxidants	Inorganic Reactive chlorine compunds	*No data*	**0.5**	1999	*No data*	**0.5**	1999
Salinity	Physical	*No data*	*No data*	*No data*	*No data*	**Narrative**	1996
Selenium	Inorganic	*No data*	**1**	1987	*No data*	*No data*	*No data*
Silver	Inorganic	*No data*	**0.1**	1987	*No data*	*No data*	*No data*
Simazine **CASRN** 122349	Organic Pesticides Triazine compounds	*No data*	**10**	1991	*No data*	**No data**	*No data*
Streambed substrate	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	**Narrative**	1999	*No data*	**Narrative**	1999
Styrene **CASRN** 100425	Organic Monocyclic aromatic compounds	*No data*	**72**	1999	*No data*	*No data*	*No data*
Sulfolane Bondelane **CASRN** 126330	Organic Organic sulphur compound	*No data*	**50 000**	2005	*No data*	Insufficient data	2005
Suspended sediments TSS	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	**Narrative**	1999	*No data*	**Narrative**	1999
Tebuthiuron **CASRN** 34014181	Organic Pesticides	*No data*	**1.6**	1995	*No data*	Insufficient data	1995
Temperature	Physical Temperature	*No data*	**Narrative**	1987	*No data*	**Narrative**	1996

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Tetrachloromethane Carbon tetrachloride **CASRN** 56235	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	**13.3**	1992	*No data*	Insufficient data	1992
Tetrachlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	**1**	1987	*No data*	*No data*	*No data*
Thallium	Inorganic	*No data*	**0.8**	1999	*No data*	*No data*	*No data*
Toluene **CASRN** 108883	Organic Monocyclic aromatic compounds	*No data*	**2**	1996	*No data*	**215**	1996
Toxaphene	Organic Pesticides Organochlorine compounds	*No data*	**~~0.008~~**	1987	*No data*	*No data*	*No data*
Triallate **CASRN** 2303175	Organic Pesticides Carbamate pesticides	*No data*	**0.24**	1992	*No data*	*No data*	*No data*
Tribromomethane Bromoform	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	**Insufficient data**	1992	*No data*	**Insufficient data**	1992
Tributyltin	Organic Organotin compounds	*No data*	**0.008**	1992	*No data*	**0.001**	1992
Trichloromethane Chloroform **CASRN** 67663	Organic Halogenated aliphatic compounds Halogenated methanes	*No data*	**1.8**	1992	*No data*	Insufficient data	1992
Trichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	*No data*	**18**	1987	*No data*	*No data*	*No data*
Tricyclohexyltin	Organic Organotin compounds	*No data*	Insufficient data	1992	*No data*	Insufficient data	1992
Trifluralin **CASRN** 1582098	Organic Pesticides Dinitroaniline pesticides	*No data*	**0.2**	1993	*No data*	*No data*	*No data*

Users are advised to consult the Canadian Environmental Quality Guidelines introductory text, factsheet, and/or protocols for specific information and implementation guidance pertaining to each environmental quality guideline.

		Water Quality Guidelines for the Protection of Aquatic Life					
		Freshwater			Marine		
		Concentration (µg/L)	Concentration (µg/L)	Date	Concentration (µg/L)	Concentration (µg/L)	Date
Chemical name	Chemical groups	Short Term	Long Term		Short Term	Long Term	
Triphenyltin	Organic Organotin compounds	*No data*	0.022	1992	*No data*	*No data*	1992
Turbidity	Physical Turbidity, clarity and suspended solids Total particulate matter	*No data*	Narrative	1999	*No data*	Narrative	1999
Uranium **CASRN** 7440-61-1	Inorganic	33	15	2011	NRG	NRG	2011
Zinc	Inorganic	*No data*	30	1987	*No data*	*No data*	*No data*

Chemical name	Chemical groups
No Chemicals with Data	

Recreational Water Quality Guidelines and Aesthetics

Recreational water refers to surface waters that are used primarily for activities in which the user comes into frequent direct contact with the water, either as part of the activity or incidental to the activity. Examples include swimming, windsurfing, waterskiing, white water sports, scuba diving, and dinghy sailing. Secondary recreational uses include boating, canoeing, and fishing, which generally have less frequent body contact with water.

General Requirements

Health and Safety

Water used primarily for recreational purposes should be sufficiently free from microbiological, chemical, and physical hazards, e.g. poor visibility, to ensure that there is negligible risk to the health and safety of the user. Recreational water quality guidelines, summarized in Table 1, were prepared by the Federal–Provincial Advisory Committee on Environmental and Occupational Health and published by Health and Welfare Canada (1992).

These guidelines deal mainly with potential health hazards related primarily to recreational water use, but also relate to aesthetics and nuisance conditions. Health hazards associated with direct recreational contact with water include infections transmitted by pathogenic microorganisms and injuries resulting from impaired visibility in turbid waters. The determination of the risk of infection is based on a number of factors, including results of environmental health assessments, results of epidemiological studies, levels of indicator organisms, and the presence of pathogens. Sampling and enumeration of microbiological indicators and pathogens in recreational waters are also discussed. New guidelines for safe recreational water environments are currently being prepared by the World Health Organization with the assistance of Health Canada.

Aesthetics

The local setting of recreational water bodies is also important, as the surrounding countryside has a strong visual effect on the enjoyment of lakes and rivers, whether the activity is physically active or passive, such as gazing on the scenery.

In northern waters, swimming is not a major recreational activity, and factors other than microbiological are major components when determining the suitability of lakes and rivers and their environments as recreational areas. Visual impact of the whole area is as important as the quality of the water.

Impacts on a water source come from many activities. These include logging, mining, drainage of wetlands, dredging, dam construction, agricultural runoff, industrial and municipal wastes, land erosion, road construction, and land development. These factors all have to be considered in areas of natural beauty that are used for the many recreational activities engaged in by Canadians and visitors to Canada.

References

Health and Welfare Canada. 1992. Guidelines for Canadian recreational water quality. Cat. No. H49-70/1991E. Minister of Supply and Services Canada, Ottawa.

Moody, R.P., and I. Chu. 1995. Dermal exposure to environmental contaminants in the Great Lakes. Environ. Health Perspect. 103(Suppl. 9):103–114.

Recreational Water Quality Guidelines and Aesthetics

Summary — Guidelines for Canadian recreational water quality.

Parameter	Guideline
Microbiological	
Escherichia coli (fecal coliforms)	The geometric mean of at least five samples taken during a period not to exceed 30 d should not exceed 2000 *E. coli* per litre. Resampling should be performed when any sample exceeds 4000 *E. coli* per litre. See Health and Welfare Canada (1992) for additional information on application of guideline.
Enterococci	The geometric mean of at least five samples taken during a period not to exceed 30 d should not exceed 350 enterococci per litre. Resampling should be performed when any sample exceeds 700 enterococci per litre. See Health and Welfare Canada (1992) for additional information on application of guideline.
Coliphages	Limits on coliphages can not be specified at this time. See Health and Welfare Canada (1992) for additional information.
Waterborne pathogens	The pathogens most frequently responsible for diseases associated with recreational water use are described in Health and Welfare Canada (1992), i.e., *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Salmonella*, *Shigella*, *Aeromonas*, *Campylobacter jejuni*, *Legionella*, human enteric viruses, *Giardia lamblia*, and *Cryptosporidium*.
Cyanobacteria (blue-green algae)	Limits have not been specified. Health Canada is in the process of developing a numerical guideline for microcystin, a cyanobacterial toxin. Water with blue-green surface scum should be avoided because of reduced clarity and possible presence of toxins.
Chemical characteristics	Limits for chemicals have not been specified because of lack of data. Decisions for use should be based on an environmental health assessment and the aesthetic quality. Dermal exposures to environmental contaminants has recently been reviewed by Moody and Chu (1995).
Temperature	The thermal characteristics of water should not cause an appreciable increase or decrease in the deep body temperature of bathers and swimmers.
Clarity	The water should be sufficiently clear that a Secchi disc is visible at a minimum of 1.2 m.
pH	When the buffering capacity of the water is very low,6.5 to 8.5; range of 5.0 to 9.0 is acceptable.
Turbidity	A limit of 50 Nephelometric Turbidity Units (NTU) is suggested.
Oil and grease	Oil or petrochemicals should not be present in concentrations that • can be detected as a visible film, sheen, or discoloration on the surface; • can be detected by odour; or • can form deposits on shorelines and bottom deposits that are detectable by sight and odour.
Aquatic plants	Bathers should avoid areas with rooted or floating plants; very dense growths could affect other activities such as boating and fishing.
Aesthetics	All water should be free from • materials that will settle to form objectionable deposits; • floating debris, oil, scum, and other matter; • substances producing objectionable colour, odour, taste, or turbidity; and • substances and conditions or combinations thereof in concentrations that produce undesirable aquatic life.
Nuisance organisms	Bathing areas should be as free as possible from nuisance organisms that • endanger the health and physical comfort of users or • render the area unusable. Common examples include biting and nonbiting insects and poisonous organisms, for example jelly-fish.

This page revised 2004

Reference listing:

Canadian Council of Ministers of the Environment. 1999. Recreational water quality guidelines and aesthetics. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

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APPENDIX C.2

Habitat Assessment

Freshwater Environment

There are several key lacustrine habitats present within the vicinity of the study area. Water quality measurements were taken on six different occasions between June and November of 2010. Table F1.1 shows results for water quality measurements taken on August 18th and September 29th. Habitat assessments were conducted during the September visit only. Sites visited include:

- Site PL1 Porters Lake (most Northern site);
- Site PL2 Porters Lake (main body - North);
- Site PL3 Porters Lake (main body – South);
- Site PL4 Porters Lake (middle Porters Lake); and
- Site PL5 Porters Lake (most Southern site).

Lacustrine Habitats

Lacustrine habitats present within the watershed of the study area include Cousins Lake, Lake No Good, Trout Lake, Grand Lake, Caribou Lake, Goose Lake, Snow Lake, and Porters Lake, among others. Water quality samples were taken at five sites, four being within the main portions of Porters Lake (Sites PL1 – PL4) and the remainder (PL5) being at the very southern edge of the Lake where exchange with the coastal waters of the North Atlantic occurs.

Site PL1 is the furthest north of all sample sites in this study area. It is located on Porters Lake with moderate to heavy residential development along the shoreline. Many properties here have manicured lawns that extend to the shoreline and some are armored. Tree species in the area of this site appear to be an even mixture of hardwood and softwood. Water quality parameters fall within the Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life and are generally favorable for important fish species such as trout. Water temperature at PL1 during August was around 23°C, which is on the upper limit of the tolerance range for brook trout and in September it did not fall within the optimum range for growth (Raleigh, R.F., 1982).





Sites PL2 and PL3 are both located on a section of the main portion of Porters Lake between the Highways 7 and 107, with PL3 being just adjacent to the roadway bridge for Highway 107 while PL2 is located some distance from shore. PL2 is central to moderate and heavy residential development with patches of vegetation varying from sparse to plentiful hardwood and softwood tree species. Vegetation at PL3 consisted of approximately 65% softwood species, 30% hardwood, and 5% grasses.

The water at both sites appeared clear and there was armoring present along some of the shoreline at site PL3, most notably being the fill located at the bridge and along a nearby property. Water quality parameters measured at both sites had values that are within the CCME Guidelines, but temperatures during August were above optimum for the growth of salmonids such as brook trout. When comparing temperatures at different depths at this time, both sites appeared to be thermally stratified, with temperatures decreasing with increasing depth. By contrast, in September temperatures at PL3 did not vary greatly at different depths, but there were some variations at site PL2 with lower temperatures at greater depths. Dissolved oxygen concentrations for both sampling times were also lower at greater depths, with limiting values for fish species occurring in August and September at 6 m and 2 m depths, respectively. pH values decreased slightly with depth at both sites, but did not go below acceptable values for supporting fish species.

Site PL4 is located further south on Porters Lake and is also adjacent to an armored roadway bridge. This area is slightly more developed, but maintains natural vegetation along most of the shoreline with about 50% hardwood tree species and 50% softwood. Some residential properties have an armored shoreline with lawns extending to the water. Dissolved oxygen concentrations and pH values here both fall within the CCME Guidelines, however high temperatures during the height of summer (August) suggest suboptimal conditions for fish species such as trout, which cannot live and thrive in temperatures above 20°C (Raleigh, R.F., 1982).

Site PL5 is influenced by tidal exchange with the coastal ocean. Water quality samples were taken on the upstream side of the roadway bridge with little residential development in the vicinity. Bottom substrate is mixed muck and rock with heavy seaweed and algae growth. Bank vegetation consists mostly of grasses, shrubs, and mixed hardwood and softwood tree species. Water quality parameters were similar to site PL4, with dissolved oxygen concentrations and pH values within the CCME Guidelines and water temperature in August higher than optimal for important salmonid species such as brook trout.



Carbonaceous biological oxygen demand (C.BOD) values for all sites were below the detection limit of 5 mg/l except PL4 and PL5 during the September sampling run. Low values indicate that oxygen levels are minimally affected by the loading of dissolved organic matter.

Based on the water quality samples collected in August and September of 2010, most of the sites have water quality values that fall within the CCME Guidelines for Aquatic Life. It is noted that naturally high temperatures in surface waters during August are outside the ideal range for trout.

When considering the development of areas near fish habitat it is important to ensure that human activities do not impact the habitat negatively. Fish habitat, according to the *Fisheries Act*, includes all "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes". If impacts to fish habitat are expected, authorization under the *Fisheries Act* is required. Likewise, it is important to keep areas of fish passage open to ensure their migration routes are accessible. This is important to consider in areas where watercourses need to be crossed for the development of roadways or properties, which often involves the installation of culverts. Culverts must be properly placed or baffled to allow fish passage.

In summary, the middle and lower sections of Porters Lake that were the subject of this study generally represent good habitat for fish. Low concentrations of dissolved oxygen occur in some deeper parts of the lake, which are unsuitable for most fish and invertebrate species. While this study has not established whether the low oxygen concentrations are driven primarily by natural or man-made inputs of organic material, most mobile organisms have developed mechanisms to avoid such areas. However, zones of low oxygen concentration are prone to grow with increasing loads of organic material or nutrients, for example, as a consequence of increasing residential and commercial development. The temperature of surface water during August reaches values above the optimum for salmonids such as brook trout. Especially at this time of the year, the extent of areas with low oxygen concentration can be critical, as such waters do not represent a viable refuge for fish seeking cooler temperatures in deeper waters. As a consequence, future development should follow stringent criteria to minimize the input of organic substances and nutrients into the lake where low-oxygen zones are likely, e.g. near PL2.

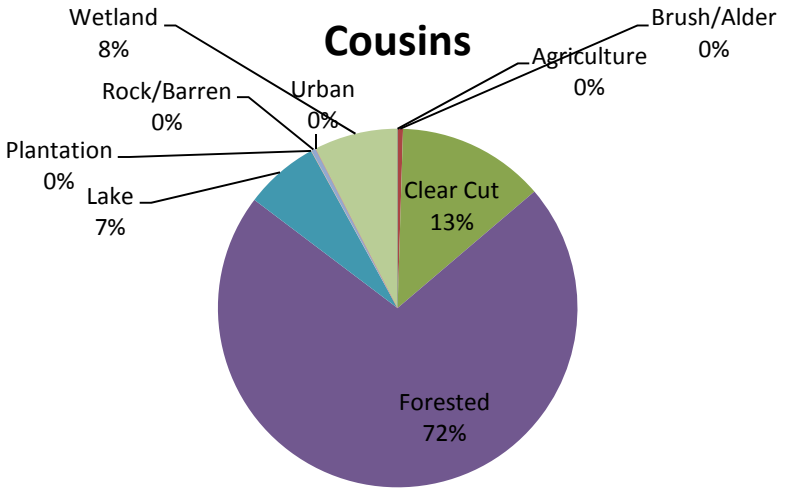
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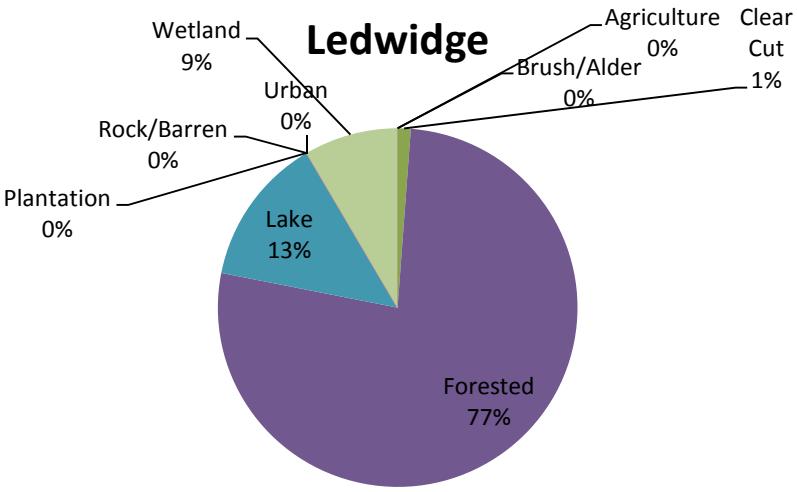
Canadian Council of Ministers of the Environment (CCME), 2007. Canadian Water Quality Guidelines for the Protection of Aquatic Life, summary table. Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment.

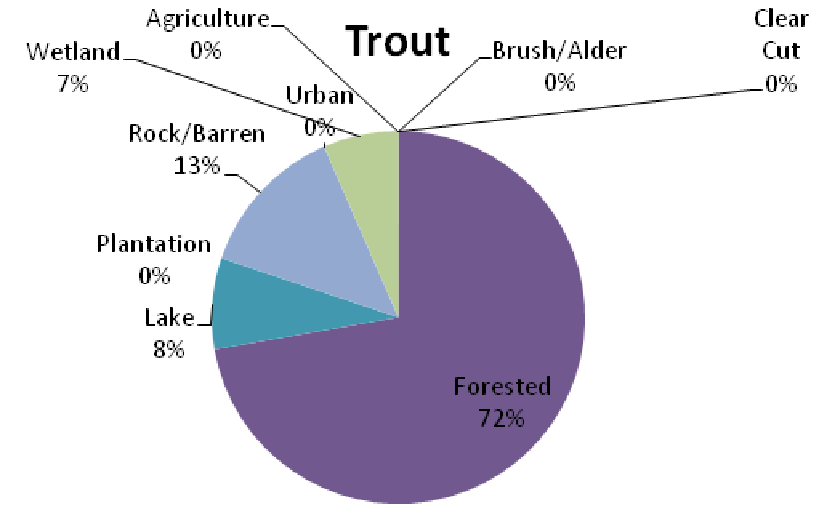
Raleigh, R. F., 1982. Habitat Suitability Index Models: Brook trout. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.24. 42pp.

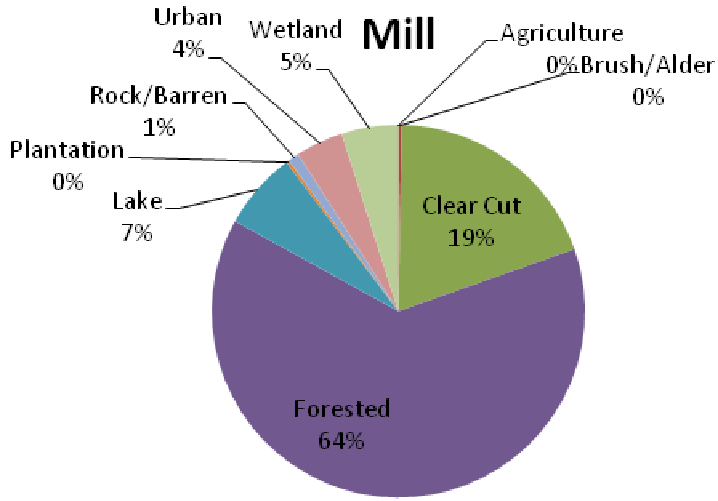
APPENDIX C.3

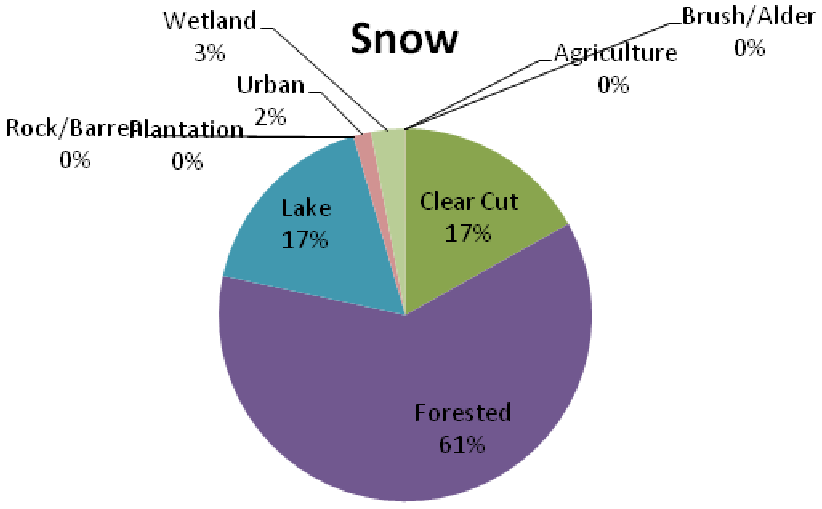
Land Use Summary for Lake Watersheds

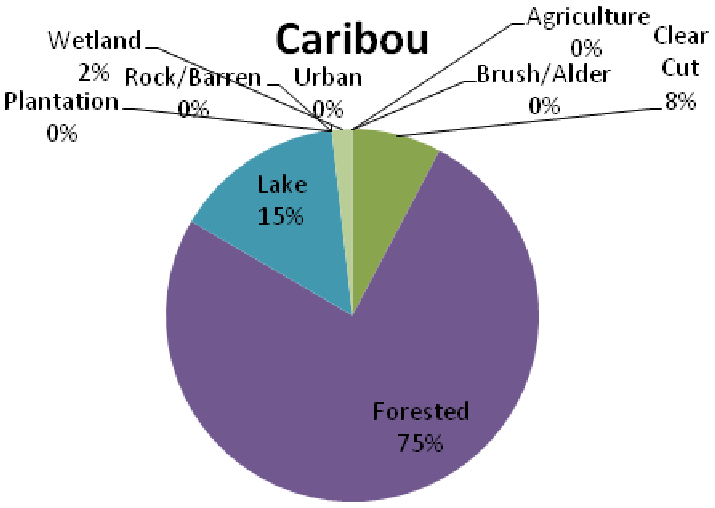


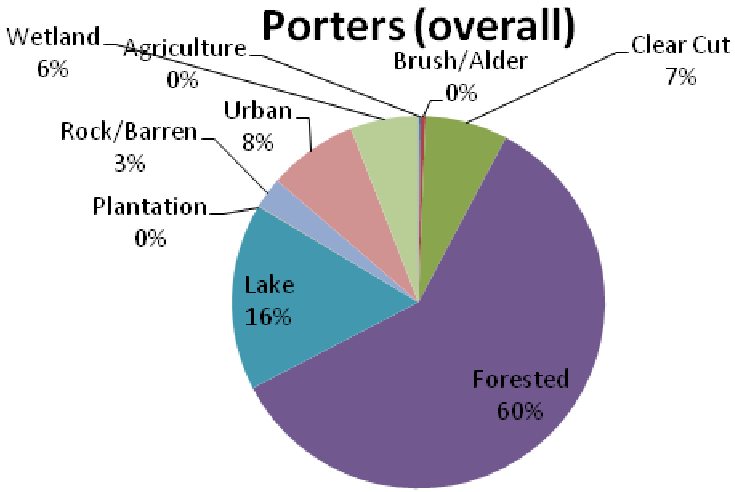


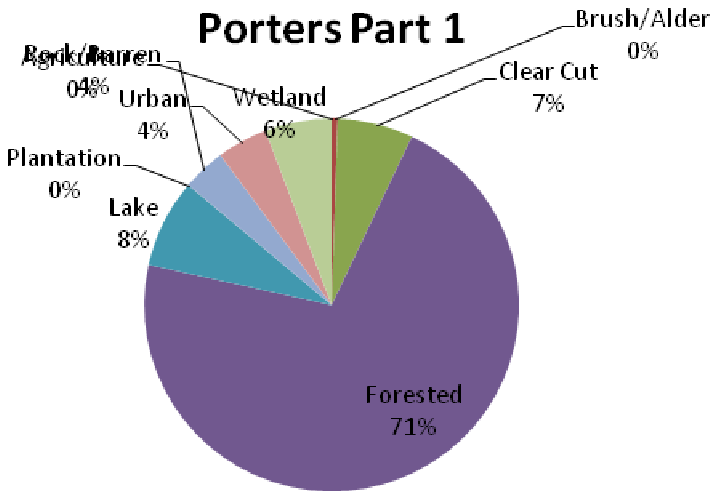

Trout
Agriculture 0%
Wetland 7%
Urban 0%
Brush/Alder 0%
Clear Cut 0%
Rock/Barren 13%
Plantation 0%
Lake 8%
Forested 72%

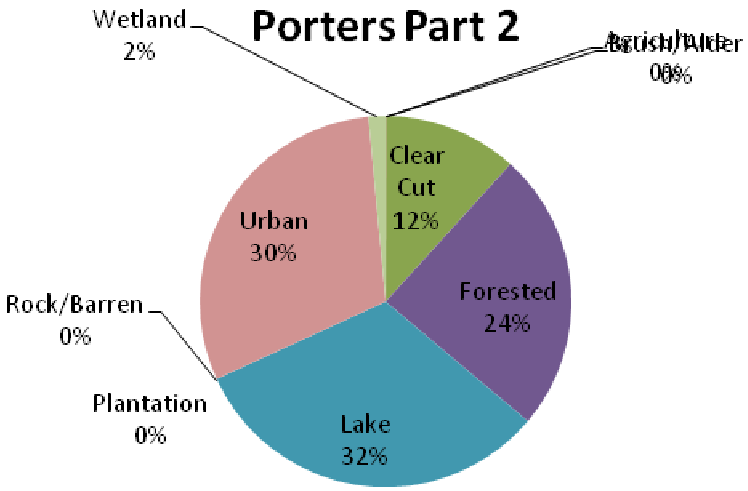

Mill
Urban 4%
Wetland 5%
Agriculture 0%
Brush/Alder 0%
Rock/Barren 1%
Plantation 0%
Lake 7%
Clear Cut 19%
Forested 64%

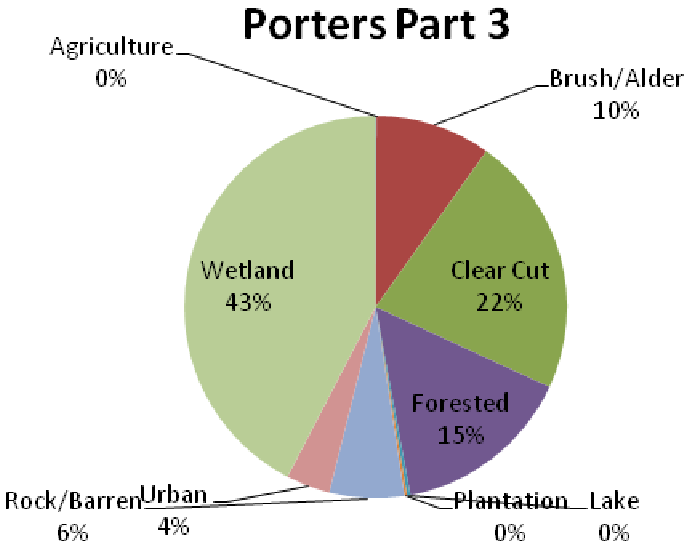

Snow
Wetland 3%
Brush/Alder 0%
Agriculture 0%
Urban 2%
Rock/Barren 0%
Plantation 0%
Lake 17%
Clear Cut 17%
Forested 61%

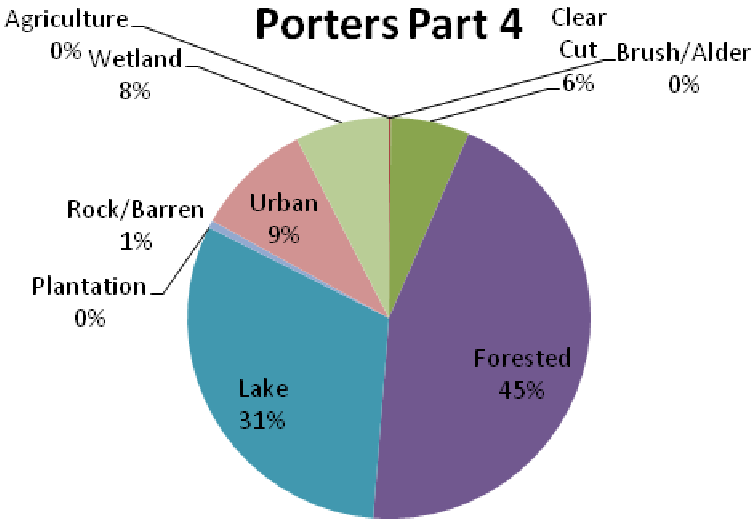

Caribou
Wetland 2%
Rock/Barren 0%
Urban 0%
Agriculture 0%
Brush/Alder 0%
Clear Cut 8%
Plantation 0%
Lake 15%
Forested 75%

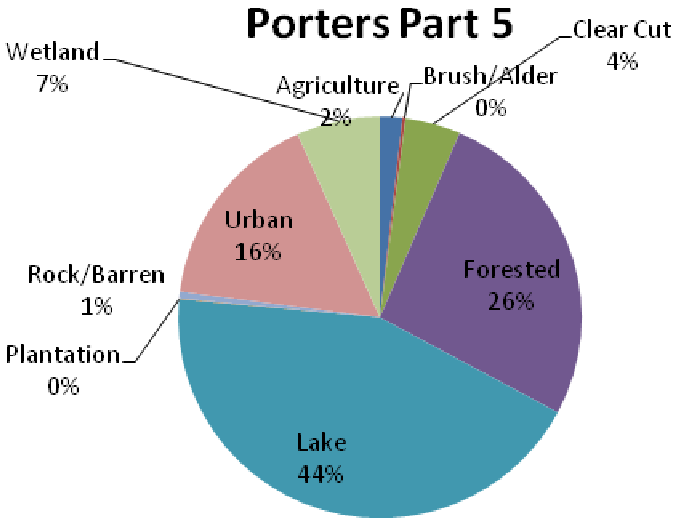

Porters (overall)
Wetland 6%
Agriculture 0%
Brush/Alder 0%
Clear Cut 7%
Urban 8%
Rock/Barren 3%
Plantation 0%
Lake 16%
Forested 60%


Porters Part 1
Brush/Alder 0%
Clear Cut 7%
Urban 4%
Wetland 6%
Plantation 0%
Lake 8%
Forested 71%


Porters Part 2
Wetland
2%
Clear
Cut
12%
Urban
30%
Forested
24%
Rock/Barren
0%
Plantation
0%
Lake
32%


Porters Part 3
Agriculture
0%
Brush/Alder
10%
Wetland
43%
Clear Cut
22%
Forested
15%
Rock/Barren
6%
Urban
4%
Plantation
0%
Lake
0%


Porters Part 4
Agriculture 0%
Wetland 8%
Clear Cut 6%
Brush/Alder 0%
Rock/Barren 1%
Urban 9%
Plantation 0%
Forested 45%
Lake 31%


Porters Part 5
Wetland 7%
Agriculture 2%
Clear Cut 4%
Brush/Alder 0%
Urban 16%
Rock/Barren 1%
Plantation 0%
Forested 26%
Lake 44%

Phosphorus Loading Models

Lake No Good model (headwater lake)						
Input Parameters	**Symbol**	**Value**	**Units**	**Budgets**		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	2306.5	ha			**%Total**
Area Land Use Category 1 (Forest)	Ad1	1744.5	ha	Upstream Inflow	0	0
Area Land Use Category 2 (Clear Cut & Barren)	Ad2	373.4	ha	Precipitation	836212.42	3.75
Area Land Use Category 3 (Wetland)	Ad3	175.1	ha	Surface Run Off	21450136	96.25
Area Land Use Category 4 (Hay Land)	Ad4	0.0	ha	Evaporation	-110366.8	0.5
Area Land Use Category 5 (Residential Lots)	Ad5	13.6	ha	Total Outflow	22175981	99.5
Area Land Use Category 6	Ad6	0.0	ha	Total Check		100.00
Area Land Use Category 7	Ad7	0.0	ha			
Area Land Use Category 8	Ad8	0.0	ha			
Area Land Use Category 9	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10	Ad10	0.0	ha			**%Total**
Lake Surface Area	Ao	61.3	ha	Upstream Inflow	0	0
Lake Volume	V	1.12	$10^6 m^3$	Atmosphere	15329	4.04
Hydrology				Land Run Off	363874	95.96
Upstream Hydraulic Inputs	Qi	0	$m^3 yr^{-1}$	Development	0	0.00
Annual Unit Precipitation	Pr	1.36	m yr^{-1}	Sedimentation	-64465	17.00
Annual Unit Lake Evaporation	Ev	0.18	m yr^{-1}	Total Outflow	314738	83.00
Annual Unit Hydraulic Runoff	Ru	0.93	m yr^{-1}	Total Check		100.00
P Loading						
Upstream P Input	Pi	0	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0250	gm P $m^{-2} yr^{-1}$			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P $m^{-2} yr^{-1}$			
Land Use Category 2 P Export Coefficient	E2	0.0625	gm P $m^{-2} yr^{-1}$			
Land Use Category 3 P Export Coefficient*	E3	0.0031	gm P $m^{-2} yr^{-1}$	*based on Dillon & Molot (1997)		
Land Use Category 4 P Export Coefficient	E4	0.0081	gm P $m^{-2} yr^{-1}$			
Land Use Category 5 P Export Coefficient	E5	0.0350	gm P $m^{-2} yr^{-1}$			
Land Use Category 6 P Export Coefficient	E6	0.0000	gm P $m^{-2} yr^{-1}$			
Land Use Category 7 P Export Coefficient	E7	0.0000	gm P $m^{-2} yr^{-1}$			
Land Use Category 8 P Export Coefficient	E8	0.0000	gm P $m^{-2} yr^{-1}$			
Land Use Category 9 P Export Coefficient	E9	0.0000	gm P $m^{-2} yr^{-1}$			
Land Use Category 10 P Export Coefficient	E10	0.0000	gm P $m^{-2} yr^{-1}$			
Number of Dwellings	N_d	0	#			
Average number of Persons per Dwelling	N_u	0.00	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	0	yr^{-1}			
Phosphorus Load per Capita per Year	Si	800	gm P $cap^{-1} yr^{-1}$			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1	0				
Point Source Input 2	PS2					
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	7.2	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppt_i	836212.4224	$m^3 yr^{-1}$			
Total Evaporation Hydraulic Loss	Eo	110366.7957	$m^3 yr^{-1}$			
Total Hydraulic Surface Run Off	Ql	21450135.79	$m^3 yr^{-1}$			
Total Hydraulic Input	Qt	22286348	$m^3 yr^{-1}$			
Areal Hydraulic Load	q_s	36.17	m yr^{-1}			
Total Hydraulic Outflow	Qo	22175981.41	$m^3 yr^{-1}$			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	15329	gm yr^{-1}			
Total Overland Run Off P Input	Je	363874	gm yr^{-1}			
Total Development P Input	Jd	0	gm yr^{-1}			
Total P Input	Jt	379203	gm yr^{-1}			
Lake P Retention Factor	Rp	0.17	n/a			
Lake Phosphorus Retention	Ps	64465	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0142**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	314738	gm yr^{-1}			
Lake Mean Depth	z	1.8	m			
Lake Flushing Rate	FR	19.8	times yr^{-1}			
Lake Turnover Time	TT	0.05	yr			
Lake Response Time	RT(1/2)	0.03	yr			

Cousins Lake model (headwater lake)						
Input Parameters	**Symbol**	**Value**	**Units**	**Budgets**		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	886.9	ha			
Area Land Use Category 1 (Forest)	Ad1	680.1	ha			**%Total**
Area Land Use Category 2 (Clear Cut & Barren)	Ad2	135.2	ha	Upstream Inflow	0	0
Area Land Use Category 3 (Wetland)	Ad3	71.6	ha	Precipitation	865091.79	9.49
Area Land Use Category 4 (Hay Land)	Ad4	0.0	ha	Surface Run Off	8248391.8	90.51
Area Land Use Category 5 (Residential Lots)	Ad5	0.0	ha	Evaporation	-114178.42	1.25
Area Land Use Category 6	Ad6	0.0	ha	Total Outflow	8999305.2	98.75
Area Land Use Category 7	Ad7	0.0	ha	Total Check		100.00
Area Land Use Category 8	Ad8	0.0	ha			
Area Land Use Category 9	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10	Ad10	0.0	ha			
Lake Surface Area	Ao	63.4	ha			**%Total**
Lake Volume	V	1.16	10^6 m^3	Upstream Inflow	0	0
Hydrology				Atmosphere	15858	10.13
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}	Land Run Off	133669	85.37
Annual Unit Precipitation	Pr	1.36	m yr^{-1}	Development	7040	4.50
Annual Unit Lake Evaporation	Ev	0.18	m yr^{-1}	Sedimentation	-53233	34.00
Annual Unit Hydraulic Runoff	Ru	0.93	m yr^{-1}	Total Outflow	103334	66.00
P Loading				Total Check		100.00
Upstream P Input	Pi	0	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0250	gm P m^{-2} yr^{-1}			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}			
Land Use Category 2 P Export Coefficient	E2	0.0625	gm P m^{-2} yr^{-1}			
Land Use Category 3 P Export Coefficient*	E3	0.0031	gm P m^{-2} yr^{-1}	*based on Dillon & Molot (1997)		
Land Use Category 4 P Export Coefficient	E4	0.0081	gm P m^{-2} yr^{-1}			
Land Use Category 5 P Export Coefficient	E5	0.0350	gm P m^{-2} yr^{-1}			
Land Use Category 6 P Export Coefficient	E6	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 7 P Export Coefficient	E7	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 8 P Export Coefficient	E8	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 9 P Export Coefficient	E9	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 10 P Export Coefficient	E10	0.0000	gm P m^{-2} yr^{-1}			
Number of Dwellings	N_d	8	#			
Average number of Persons per Dwelling	N_u	2.20	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}			
Phosphorus Load per Capita per Year	Si	800	gm P cap^{-1} yr^{-1}			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1	0				
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	7.2	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppt_i	865091.7939	m^3 yr^{-1}			
Total Evaporation Hydraulic Loss	Eo	114178.4154	m^3 yr^{-1}			
Total Hydraulic Surface Run Off	Ql	8248391.777	m^3 yr^{-1}			
Total Hydraulic Input	Qt	9113484	m^3 yr^{-1}			
Areal Hydraulic Load	q_s	14.19	m yr^{-1}			
Total Hydraulic Outflow	Qo	8999305.156	m^3 yr^{-1}			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	15858	gm yr^{-1}			
Total Overland Run Off P Input	Je	133669	gm yr^{-1}			
Total Development P Input	Jd	7040	gm yr^{-1}			
Total P Input	Jt	156567	gm yr^{-1}			
Lake P Retention Factor	Rp	0.34	n/a			
Lake Phosphorus Retention	Ps	53233	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0115**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	103334	gm yr^{-1}			
Lake Mean Depth	z	1.8	m			
Lake Flushing Rate	FR	7.76	times yr^{-1}			
Lake Turnover Time	TT	0.13	yr			
Lake Response Time	RT(1/2)	0.05	yr			

Ledwidge Lake model (headwater lake)						
Input Parameters	**Symbol**	**Value**	**Units**	**Budgets**		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	161.6	ha			
Area Land Use Category 1 (Forest)	Ad1	143.7	ha			**%Total**
Area Land Use Category 2 (Clear Cut & Barren)	Ad2	2.2	ha	Upstream Inflow	0	0
Area Land Use Category 3 (Wetland)	Ad3	15.8	ha	Precipitation	342192.65	18.54
Area Land Use Category 4 (Hay Land)	Ad4	0.0	ha	Surface Run Off	1503020.3	81.46
Area Land Use Category 5 (Residential Lots)	Ad5	0.0	ha	Evaporation	-45164.01	2.45
Area Land Use Category 6	Ad6	0.0	ha	Total Outflow	1800048.9	97.55
Area Land Use Category 7	Ad7	0.0	ha	Total Check		100.00
Area Land Use Category 8	Ad8	0.0	ha			
Area Land Use Category 9	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10	Ad10	0.0	ha			
Lake Surface Area	Ao	25.1	ha			**%Total**
Lake Volume	V	0.46	10^6 m^3	Upstream Inflow	0	0
Hydrology				Atmosphere	6273	34.78
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}	Land Run Off	11762	65.22
Annual Unit Precipitation	Pr	1.36	m yr^{-1}	Development	0	0.00
Annual Unit Lake Evaporation	Ev	0.18	m yr^{-1}	Sedimentation	-9018	50.00
Annual Unit Hydraulic Runoff	Ru	0.93	m yr^{-1}	Total Outflow	9017	50.00
P Loading				Total Check		100.00
Upstream P Input	Pi	0	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0250	gm P m^{-2} yr^{-1}			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}			
Land Use Category 2 P Export Coefficient	E2	0.0625	gm P m^{-2} yr^{-1}			
Land Use Category 3 P Export Coefficient*	E3	0.0031	gm P m^{-2} yr^{-1}	*based on Dillon & Molot (1997)		
Land Use Category 4 P Export Coefficient	E4	0.0081	gm P m^{-2} yr^{-1}			
Land Use Category 5 P Export Coefficient	E5	0.0350	gm P m^{-2} yr^{-1}			
Land Use Category 6 P Export Coefficient	E6	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 7 P Export Coefficient	E7	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 8 P Export Coefficient	E8	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 9 P Export Coefficient	E9	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 10 P Export Coefficient	E10	0.0000	gm P m^{-2} yr^{-1}			
Number of Dwellings	N_d	0	#			
Average number of Persons per Dwelling	N_u	0.00	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	0	yr^{-1}			
Phosphorus Load per Capita per Year	Si	800	gm P cap^{-1} yr^{-1}			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1	0				
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	7.2	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppt_i	342192.6504	m^3 yr^{-1}			
Total Evaporation Hydraulic Loss	Eo	45164.01017	m^3 yr^{-1}			
Total Hydraulic Surface Run Off	Ql	1503020.274	m^3 yr^{-1}			
Total Hydraulic Input	Qt	1845213	m^3 yr^{-1}			
Areal Hydraulic Load	q_s	7.17	m yr^{-1}			
Total Hydraulic Outflow	Qo	1800048.914	m^3 yr^{-1}			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	6273	gm yr^{-1}			
Total Overland Run Off P Input	Je	11762	gm yr^{-1}			
Total Development P Input	Jd	0	gm yr^{-1}			
Total P Input	Jt	18035	gm yr^{-1}			
Lake P Retention Factor	Rp	0.5	n/a			
Lake Phosphorus Retention	Ps	9018	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0050**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	9017	gm yr^{-1}			
Lake Mean Depth	z	1.8	m			
Lake Flushing Rate	FR	3.91	times yr^{-1}			
Lake Turnover Time	TT	0.26	yr			
Lake Response Time	RT(1/2)	0.07	yr			

Trout Lake model (headwater lake)						
Input Parameters	**Symbol**	**Value**	**Units**	**Budgets**		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	879.4	ha			
Area Land Use Category 1 (Forest)	Ad1	689.6	ha			**%Total**
Area Land Use Category 2 (Clear Cut & Barren)	Ad2	127.2	ha	Upstream Inflow	0	0
Area Land Use Category 3 (Wetland)	Ad3	62.4	ha	Precipitation	1029016.9	11.18
Area Land Use Category 4 (Hay Land)	Ad4	0.0	ha	Surface Run Off	8178642.2	88.82
Area Land Use Category 5 (Residential Lots)	Ad5	0.0	ha	Evaporation	-135813.93	1.48
Area Land Use Category 6	Ad6	0.0	ha	Total Outflow	9071845.1	98.52
Area Land Use Category 7	Ad7	0.0	ha	Total Check		100.00
Area Land Use Category 8	Ad8	0.0	ha			
Area Land Use Category 9	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10	Ad10	0.0	ha			
Lake Surface Area	Ao	75.5	ha			**%Total**
Lake Volume	V	1.38	10^6 m^3	Upstream Inflow	0	0
Hydrology				Atmosphere	18863	12.39
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}	Land Run Off	128989	84.72
Annual Unit Precipitation	Pr	1.36	m yr^{-1}	Development	4400	2.89
Annual Unit Lake Evaporation	Ev	0.18	m yr^{-1}	Sedimentation	-56333	37.00
Annual Unit Hydraulic Runoff	Ru	0.93	m yr^{-1}	Total Outflow	95919	63.00
P Loading				Total Check		100.00
Upstream P Input	Pi	0	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0250	gm P m^{-2} yr^{-1}			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}			
Land Use Category 2 P Export Coefficient	E2	0.0625	gm P m^{-2} yr^{-1}			
Land Use Category 3 P Export Coefficient*	E3	0.0031	gm P m^{-2} yr^{-1}	*based on Dillon & Molot (1997)		
Land Use Category 4 P Export Coefficient	E4	0.0081	gm P m^{-2} yr^{-1}			
Land Use Category 5 P Export Coefficient	E5	0.0350	gm P m^{-2} yr^{-1}			
Land Use Category 6 P Export Coefficient	E6	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 7 P Export Coefficient	E7	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 8 P Export Coefficient	E8	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 9 P Export Coefficient	E9	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 10 P Export Coefficient	E10	0.0000	gm P m^{-2} yr^{-1}			
Number of Dwellings	N_d	5	#			
Average number of Persons per Dwelling	N_u	2.20	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}			
Phosphorus Load per Capita per Year	Si	800	gm P cap^{-1} yr^{-1}			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1	0				
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	7.2	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppt_i	1029016.863	m^3 yr^{-1}			
Total Evaporation Hydraulic Loss	Eo	135813.9283	m^3 yr^{-1}			
Total Hydraulic Surface Run Off	Ql	8178642.17	m^3 yr^{-1}			
Total Hydraulic Input	Qt	9207659	m^3 yr^{-1}			
Areal Hydraulic Load	q_s	12.02	m yr^{-1}			
Total Hydraulic Outflow	Qo	9071845.106	m^3 yr^{-1}			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	18863	gm yr^{-1}			
Total Overland Run Off P Input	Je	128989	gm yr^{-1}			
Total Development P Input	Jd	4400	gm yr^{-1}			
Total P Input	Jt	152252	gm yr^{-1}			
Lake P Retention Factor	Rp	0.37	n/a			
Lake Phosphorus Retention	Ps	56333	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0106**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	95919	gm yr^{-1}			
Lake Mean Depth	z	1.8	m			
Lake Flushing Rate	FR	6.57	times yr^{-1}			
Lake Turnover Time	TT	0.15	yr			
Lake Response Time	RT(1/2)	0.06	yr			

Mill Lake model (headwater lake)						
Input Parameters	**Symbol**	**Value**	**Units**	**Budgets**		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	1182.1	ha			
Area Land Use Category 1 (Forest)	Ad1	804.0	ha			**%Total**
Area Land Use Category 2 (Clear Cut & Barren)	Ad2	227.1	ha	Upstream Inflow	0	0
Area Land Use Category 3 (Wetland)	Ad3	62.4	ha	Precipitation	1161153.7	9.55
Area Land Use Category 4 (Hay Land)	Ad4	0.0	ha	Surface Run Off	10993907	90.45
Area Land Use Category 5 (Residential Lots)	Ad5	52.1	ha	Evaporation	-153253.9	1.26
Area Land Use Category 6 (Roads & pavement)	Ad6	36.5	ha	Total Outflow	12001807	98.74
Area Land Use Category 7	Ad7	0.0	ha	Total Check		100.00
Area Land Use Category 8	Ad8	0.0	ha			
Area Land Use Category 9	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10	Ad10	0.0	ha			
Lake Surface Area	Ao	85.1	ha			**%Total**
Lake Volume	V	1.56	10^6 m^3	Upstream Inflow	0	0
Hydrology				Atmosphere	21285	5.44
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}	Land Run Off	345347	88.26
Annual Unit Precipitation	Pr	1.36	m yr^{-1}	Development	24640	6.30
Annual Unit Lake Evaporation	Ev	0.18	m yr^{-1}	Sedimentation	-133032	34.00
Annual Unit Hydraulic Runoff	Ru	0.93	m yr^{-1}	Total Outflow	258240	66.00
P Loading				Total Check		100.00
Upstream P Input	Pi	0	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0250	gm P m^{-2} yr^{-1}			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}			
Land Use Category 2 P Export Coefficient	E2	0.0625	gm P m^{-2} yr^{-1}			
Land Use Category 3 P Export Coefficient*	E3	0.0031	gm P m^{-2} yr^{-1}	*based on Dillon & Molot (1997)		
Land Use Category 4 P Export Coefficient	E4	0.0081	gm P m^{-2} yr^{-1}			
Land Use Category 5 P Export Coefficient	E5	0.0350	gm P m^{-2} yr^{-1}			
Land Use Category 6 P Export Coefficient	E6	0.3500	gm P m^{-2} yr^{-1}			
Land Use Category 7 P Export Coefficient	E7	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 8 P Export Coefficient	E8	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 9 P Export Coefficient	E9	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 10 P Export Coefficient	E10	0.0000	gm P m^{-2} yr^{-1}			
Number of Dwellings	N_d	28	#			
Average number of Persons per Dwelling	N_u	2.20	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}			
Phosphorus Load per Capita per Year	Si	800	gm P cap^{-1} yr^{-1}			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1	0				
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	7.2	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppt_i	1161153.681	m^3 yr^{-1}			
Total Evaporation Hydraulic Loss	Eo	153253.8954	m^3 yr^{-1}			
Total Hydraulic Surface Run Off	Ql	10993907.28	m^3 yr^{-1}			
Total Hydraulic Input	Qt	12155061	m^3 yr^{-1}			
Areal Hydraulic Load	q_s	14.1	m yr^{-1}			
Total Hydraulic Outflow	Qo	12001807.07	m^3 yr^{-1}			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	21285	gm yr^{-1}			
Total Overland Run Off P Input	Je	345347	gm yr^{-1}			
Total Development P Input	Jd	24640	gm yr^{-1}			
Total P Input	Jt	391272	gm yr^{-1}			
Lake P Retention Factor	Rp	0.34	n/a			
Lake Phosphorus Retention	Ps	133032	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0215**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	258240	gm yr^{-1}			
Lake Mean Depth	z	1.8	m			
Lake Flushing Rate	FR	7.69	times yr^{-1}			
Lake Turnover Time	TT	0.13	yr			
Lake Response Time	RT(1/2)	0.05	yr			

Snow Lake model (headwater lake)						
Input Parameters	**Symbol**	**Value**	**Units**	**Budgets**		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	446.7	ha			
Area Land Use Category 1 (Forest)	Ad1	331.5	ha			**%Total**
Area Land Use Category 2 (Clear Cut & Barren)	Ad2	91.0	ha	Upstream Inflow	0	0
Area Land Use Category 3 (Wetland)	Ad3	15.9	ha	Precipitation	1259132.8	23.26
Area Land Use Category 4 (Hay Land)	Ad4	0.0	ha	Surface Run Off	4154503.9	76.74
Area Land Use Category 5 (Residential Lots)	Ad5	8.4	ha	Evaporation	-166185.59	3.07
Area Land Use Category 6	Ad6	0.0	ha	Total Outflow	5247451.2	96.93
Area Land Use Category 7	Ad7	0.0	ha	Total Check		100.00
Area Land Use Category 8	Ad8	0.0	ha			
Area Land Use Category 9	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10	Ad10	0.0	ha			
Lake Surface Area	Ao	92.3	ha			**%Total**
Lake Volume	V	1.69	10^6 m^3	Upstream Inflow	0	0
Hydrology				Atmosphere	23081	20.54
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}	Land Run Off	83141	73.98
Annual Unit Precipitation	Pr	1.36	m yr^{-1}	Development	6160	5.48
Annual Unit Lake Evaporation	Ev	0.18	m yr^{-1}	Sedimentation	-62934	56.00
Annual Unit Hydraulic Runoff	Ru	0.93	m yr^{-1}	Total Outflow	49448	44.00
P Loading				Total Check		100.00
Upstream P Input	Pi	0	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0250	gm P m^{-2} yr^{-1}			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}			
Land Use Category 2 P Export Coefficient	E2	0.0625	gm P m^{-2} yr^{-1}			
Land Use Category 3 P Export Coefficient*	E3	0.0031	gm P m^{-2} yr^{-1}	*based on Dillon & Molot (1997)		
Land Use Category 4 P Export Coefficient	E4	0.0081	gm P m^{-2} yr^{-1}			
Land Use Category 5 P Export Coefficient	E5	0.0350	gm P m^{-2} yr^{-1}			
Land Use Category 6 P Export Coefficient	E6	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 7 P Export Coefficient	E7	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 8 P Export Coefficient	E8	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 9 P Export Coefficient	E9	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 10 P Export Coefficient	E10	0.0000	gm P m^{-2} yr^{-1}			
Number of Dwellings	N_d	7	#			
Average number of Persons per Dwelling	N_u	2.20	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}			
Phosphorus Load per Capita per Year	Si	800	gm P cap^{-1} yr^{-1}			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1	0				
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	7.2	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppt_i	1259132.842	m^3 yr^{-1}			
Total Evaporation Hydraulic Loss	Eo	166185.5929	m^3 yr^{-1}			
Total Hydraulic Surface Run Off	Ql	4154503.904	m^3 yr^{-1}			
Total Hydraulic Input	Qt	5413637	m^3 yr^{-1}			
Areal Hydraulic Load	q_s	5.68	m yr^{-1}			
Total Hydraulic Outflow	Qo	5247451.153	m^3 yr^{-1}			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	23081	gm yr^{-1}			
Total Overland Run Off P Input	Je	83141	gm yr^{-1}			
Total Development P Input	Jd	6160	gm yr^{-1}			
Total P Input	Jt	112382	gm yr^{-1}			
Lake P Retention Factor	Rp	0.56	n/a			
Lake Phosphorus Retention	Ps	62934	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0094**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	49448	gm yr^{-1}			
Lake Mean Depth	z	1.8	m			
Lake Flushing Rate	FR	3.11	times yr^{-1}			
Lake Turnover Time	TT	0.32	yr			
Lake Response Time	RT(1/2)	0.08	yr			

Caribou Lake model (headwater lake)						
Input Parameters	**Symbol**	**Value**	**Units**	**Budgets**		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	265.5	ha			
Area Land Use Category 1 (Forest)	Ad1	235.8	ha			**%Total**
Area Land Use Category 2 (Clear Cut & Barren)	Ad2	24.1	ha	Upstream Inflow	0	0
Area Land Use Category 3 (Wetland)	Ad3	5.5	ha	Precipitation	628988.04	20.31
Area Land Use Category 4 (Hay Land)	Ad4	0.0	ha	Surface Run Off	2468698.1	79.69
Area Land Use Category 5 (Residential Lots)	Ad5	0.0	ha	Evaporation	-83016.46	2.68
Area Land Use Category 6	Ad6	0.0	ha	Total Outflow	3014669.7	97.32
Area Land Use Category 7	Ad7	0.0	ha	Total Check		100.00
Area Land Use Category 8	Ad8	0.0	ha			
Area Land Use Category 9	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10	Ad10	0.0	ha			
Lake Surface Area	Ao	46.1	ha			**%Total**
Lake Volume	V	0.84	10^6 m^3	Upstream Inflow	0	0
Hydrology				Atmosphere	11530	26.80
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}	Land Run Off	31491	73.20
Annual Unit Precipitation	Pr	1.36	m yr^{-1}	Development	0	0.00
Annual Unit Lake Evaporation	Ev	0.18	m yr^{-1}	Sedimentation	-22371	52.00
Annual Unit Hydraulic Runoff	Ru	0.93	m yr^{-1}	Total Outflow	20650	48.00
P Loading				Total Check		100.00
Upstream P Input	Pi	0	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0250	gm P m^{-2} yr^{-1}			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}			
Land Use Category 2 P Export Coefficient	E2	0.0625	gm P m^{-2} yr^{-1}			
Land Use Category 3 P Export Coefficient*	E3	0.0031	gm P m^{-2} yr^{-1}	*based on Dillon & Molot (1997)		
Land Use Category 4 P Export Coefficient	E4	0.0081	gm P m^{-2} yr^{-1}			
Land Use Category 5 P Export Coefficient	E5	0.0350	gm P m^{-2} yr^{-1}			
Land Use Category 6 P Export Coefficient	E6	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 7 P Export Coefficient	E7	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 8 P Export Coefficient	E8	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 9 P Export Coefficient	E9	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 10 P Export Coefficient	E10	0.0000	gm P m^{-2} yr^{-1}			
Number of Dwellings	N_d	0	#			
Average number of Persons per Dwelling	N_u	0.00	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	0	yr^{-1}			
Phosphorus Load per Capita per Year	Si	800	gm P cap^{-1} yr^{-1}			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1	0				
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	7.2	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppt_i	628988.0422	m^3 yr^{-1}			
Total Evaporation Hydraulic Loss	Eo	83016.4596	m^3 yr^{-1}			
Total Hydraulic Surface Run Off	Ql	2468698.126	m^3 yr^{-1}			
Total Hydraulic Input	Qt	3097686	m^3 yr^{-1}			
Areal Hydraulic Load	q_s	6.54	m yr^{-1}			
Total Hydraulic Outflow	Qo	3014669.709	m^3 yr^{-1}			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	11530	gm yr^{-1}			
Total Overland Run Off P Input	Je	31491	gm yr^{-1}			
Total Development P Input	Jd	0	gm yr^{-1}			
Total P Input	Jt	43021	gm yr^{-1}			
Lake P Retention Factor	Rp	0.52	n/a			
Lake Phosphorus Retention	Ps	22371	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0068**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	20650	gm yr^{-1}			
Lake Mean Depth	z	1.8	m			
Lake Flushing Rate	FR	3.59	times yr^{-1}			
Lake Turnover Time	TT	0.28	yr			
Lake Response Time	RT(1/2)	0.08	yr			

Porters Lake Part 1 model						
Input Parameters	**Symbol**	**Value**	**Units**	**Budgets**		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	7478.2	ha			
Area Land Use Category 1 (Forest)	Ad1	5780.1	ha			**%Total**
Area Land Use Category 2 (Clear Cut & Barren)	Ad2	854.0	ha	Upstream Inflow	42047181	35.03
Area Land Use Category 3 (Wetland)	Ad3	466.9	ha	Precipitation	8445719	7.04
Area Land Use Category 4 (Hay Land)	Ad4	0.0	ha	Surface Run Off	69547609	57.94
Area Land Use Category 5 (Residential Lots)	Ad5	355.8	ha	Evaporation	-1114701	0.93
Area Land Use Category 6 (Roads & pavement)	Ad6	21.4	ha	Total Outflow	118925807	99.07
Area Land Use Category 7	Ad7	0.0	ha	Total Check		100.01
Area Land Use Category 8	Ad8	0.0	ha			
Area Land Use Category 9	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10	Ad10	0.0	ha			
Lake Surface Area	Ao	619.3	ha			**%Total**
Lake Volume	V	42.97	$10^6 m^3$	Upstream Inflow	42047181	22.9
Hydrology				Atmosphere	154820	6.78
Upstream Hydraulic Inputs(No Good, Cousins, Ledwidge, Trout)	Qi	42047181	$m^3 yr^{-1}$	Land Run Off	1146452	50.18
Annual Unit Precipitation	Pr	1.36	m yr^{-1}	Development	460240	20.15
Annual Unit Lake Evaporation	Ev	0.18	m yr^{-1}	Sedimentation	-616820	27.00
Annual Unit Hydraulic Runoff	Ru	0.93	m yr^{-1}	Total Outflow	1667700	73.00
P Loading				Total Check		100.01
Upstream P Input(No Good, Cousins, Ledwidge, Trout)	Pi	523008	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0250	gm P $m^{-2} yr^{-1}$			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P $m^{-2} yr^{-1}$	**Model Validation**		
Land Use Category 2 P Export Coefficient	E2	0.0625	gm P $m^{-2} yr^{-1}$			
Land Use Category 3 P Export Coefficient*	E3	0.0031	gm P $m^{-2} yr^{-1}$			
Land Use Category 4 P Export Coefficient	E4	0.0081	gm P $m^{-2} yr^{-1}$	Predicted P (mg L-1)		0.0140
Land Use Category 5 P Export Coefficient	E5	0.0350	gm P $m^{-2} yr^{-1}$	Measured P (mg L-1)		0.0147
Land Use Category 6 P Export Coefficient	E6	0.3500	gm P $m^{-2} yr^{-1}$	% Difference		-4.8
Land Use Category 7 P Export Coefficient	E7	0.0000	gm P $m^{-2} yr^{-1}$			
Land Use Category 8 P Export Coefficient	E8	0.0000	gm P $m^{-2} yr^{-1}$	*based on Dillon & Molot (1997)		
Land Use Category 9 P Export Coefficient	E9	0.0000	gm P $m^{-2} yr^{-1}$			
Land Use Category 10 P Export Coefficient	E10	0.0000	gm P $m^{-2} yr^{-1}$			
Number of Dwellings	N_d	523	#			
Average number of Persons per Dwelling	N_u	2.20	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}			
Phosphorus Load per Capita per Year	Si	800	gm P $cap^{-1} yr^{-1}$			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1					
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	7.2	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppt_i	8445718.523	$m^3 yr^{-1}$			
Total Evaporation Hydraulic Loss	Eo	1114701.081	$m^3 yr^{-1}$			
Total Hydraulic Surface Run Off	Ql	69547608.58	$m^3 yr^{-1}$			
Total Hydraulic Input	Qt	120040508	$m^3 yr^{-1}$			
Areal Hydraulic Load	q_s	19.2	m yr^{-1}			
Total Hydraulic Outflow	Qo	118925806.6	$m^3 yr^{-1}$			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	154820	gm yr^{-1}			
Total Overland Run Off P Input	Je	1146452	gm yr^{-1}			
Total Development P Input	Jd	460240	gm yr^{-1}			
Total P Input	Jt	2284520	gm yr^{-1}			
Lake P Retention Factor	Rp	0.27	n/a			
Lake Phosphorus Retention	Ps	616820	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0140**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	1667700	gm yr^{-1}			
Lake Mean Depth	z	6.9	m			
Lake Flushing Rate	FR	2.77	times yr^{-1}			
Lake Turnover Time	TT	0.36	yr			
Lake Response Time	RT(1/2)	0.16	yr			

Porters Lake Part 2 model						
Input Parameters	**Symbol**	**Value**	**Units**	**Budgets**		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	364.4	ha			
Area Land Use Category 1 (Forest)	Ad1	131.0	ha			**%Total**
Area Land Use Category 2 (Clear Cut & Barren)	Ad2	20.0	ha	Upstream Inflow	118925807	95.4
Area Land Use Category 3 (Wetland)	Ad3	7.9	ha	Precipitation	2340489.4	1.88
Area Land Use Category 4 (Hay Land)	Ad4	0.0	ha	Surface Run Off	3388990	2.72
Area Land Use Category 5 (Residential Lots)	Ad5	162.7	ha	Evaporation	-308907.53	0.25
Area Land Use Category 6 (Roads & pavement)	Ad6	42.8	ha	Total Outflow	124346378	99.75
Area Land Use Category 7	Ad7	0.0	ha	Total Check		100.00
Area Land Use Category 8	Ad8	0.0	ha			
Area Land Use Category 9	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10	Ad10	0.0	ha			
Lake Surface Area	Ao	171.6	ha			**%Total**
Lake Volume	V	8.60	$10^6 m^3$	Upstream Inflow	118925807	75.5
Hydrology				Atmosphere	42904	1.94
Upstream Hydraulic Inputs(Porters Lk Part 1)	Qi	118925807	$m^3 yr^{-1}$	Land Run Off	228533	10.34
Annual Unit Precipitation	Pr	1.36	m yr^{-1}	Development	270160	12.23
Annual Unit Lake Evaporation	Ev	0.18	m yr^{-1}	Sedimentation	-198837	9.00
Annual Unit Hydraulic Runoff	Ru	0.93	m yr^{-1}	Total Outflow	2010460	91.00
P Loading				Total Check		100.01
Upstream P Input(Porters Lk Part 1)	Pi	1667700	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0250	gm P m^{-2} yr^{-1}			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}			
Land Use Category 2 P Export Coefficient	E2	0.0625	gm P m^{-2} yr^{-1}			
Land Use Category 3 P Export Coefficient*	E3	0.0031	gm P m^{-2} yr^{-1}	*based on Dillon & Molot (1997)		
Land Use Category 4 P Export Coefficient	E4	0.0081	gm P m^{-2} yr^{-1}			
Land Use Category 5 P Export Coefficient	E5	0.0350	gm P m^{-2} yr^{-1}			
Land Use Category 6 P Export Coefficient	E6	0.3500	gm P m^{-2} yr^{-1}			
Land Use Category 7 P Export Coefficient	E7	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 8 P Export Coefficient	E8	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 9 P Export Coefficient	E9	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 10 P Export Coefficient	E10	0.0000	gm P m^{-2} yr^{-1}			
Number of Dwellings	N_d	307	#			
Average number of Persons per Dwelling	N_u	2.20	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}			
Phosphorus Load per Capita per Year	Si	800	gm P cap^{-1} yr^{-1}			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1					
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	7.2	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppt_i	2340489.361	$m^3 yr^{-1}$			
Total Evaporation Hydraulic Loss	Eo	308907.5268	$m^3 yr^{-1}$			
Total Hydraulic Surface Run Off	Ql	3388990.035	$m^3 yr^{-1}$			
Total Hydraulic Input	Qt	124655286	$m^3 yr^{-1}$			
Areal Hydraulic Load	q_s	72.46	m yr^{-1}			
Total Hydraulic Outflow	Qo	124346378.5	$m^3 yr^{-1}$			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	42904	gm yr^{-1}			
Total Overland Run Off P Input	Je	228533	gm yr^{-1}			
Total Development P Input	Jd	270160	gm yr^{-1}			
Total P Input	Jt	2209297	gm yr^{-1}			
Lake P Retention Factor	Rp	0.09	n/a			
Lake Phosphorus Retention	Ps	198837	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0162**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	2010460	gm yr^{-1}			
Lake Mean Depth	z	5	m			
Lake Flushing Rate	FR	14.46	times yr^{-1}			
Lake Turnover Time	TT	0.07	yr			
Lake Response Time	RT(1/2)	0.04	yr			

Porters Lake Part 3 model						
Input Parameters	**Symbol**	**Value**	**Units**	**Budgets**		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	501.3	ha			
Area Land Use Category 1 (Forest)	Ad1	260.8	ha			**%Total**
Area Land Use Category 2 (Clear Cut & Barren)	Ad2	117.5	ha	Upstream Inflow	124346378	94.59
Area Land Use Category 3 (Wetland)	Ad3	43.9	ha	Precipitation	2456238.6	1.87
Area Land Use Category 4 (Hay Land)	Ad4	0.0	ha	Surface Run Off	4662471.4	3.55
Area Land Use Category 5 (Residential Lots)	Ad5	74.7	ha	Evaporation	-324184.59	0.25
Area Land Use Category 6 (Roads & pavement)	Ad6	4.5	ha	Total Outflow	131140904	99.75
Area Land Use Category 7	Ad7	0.0	ha	Total Check		100.01
Area Land Use Category 8	Ad8	0.0	ha			
Area Land Use Category 9	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10	Ad10	0.0	ha			
Lake Surface Area	Ao	180.1	ha			**%Total**
Lake Volume	V	5.27	10^6 m^3	Upstream Inflow	124346378	89.1
Hydrology				Atmosphere	45026	1.99
Upstream Hydraulic Inputs(Porters Lk Part 2)	Qi	124346378	m^3 yr^{-1}	Land Run Off	134667	5.97
Annual Unit Precipitation	Pr	1.36	m yr^{-1}	Development	66880	2.96
Annual Unit Lake Evaporation	Ev	0.18	m yr^{-1}	Sedimentation	-203133	9.00
Annual Unit Hydraulic Runoff	Ru	0.93	m yr^{-1}	Total Outflow	2053900	91.00
P Loading				Total Check		100.02
Upstream P Input(Porters Lk Part 2)	Pi	2010460	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0250	gm P m^{-2} yr^{-1}			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}			
Land Use Category 2 P Export Coefficient	E2	0.0625	gm P m^{-2} yr^{-1}			
Land Use Category 3 P Export Coefficient*	E3	0.0031	gm P m^{-2} yr^{-1}	*based on Dillon & Molot (1997)		
Land Use Category 4 P Export Coefficient	E4	0.0081	gm P m^{-2} yr^{-1}			
Land Use Category 5 P Export Coefficient	E5	0.0350	gm P m^{-2} yr^{-1}			
Land Use Category 6 P Export Coefficient	E6	0.3500	gm P m^{-2} yr^{-1}			
Land Use Category 7 P Export Coefficient	E7	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 8 P Export Coefficient	E8	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 9 P Export Coefficient	E9	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 10 P Export Coefficient	E10	0.0000	gm P m^{-2} yr^{-1}			
Number of Dwellings	N_d	76	#			
Average number of Persons per Dwelling	N_u	2.20	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}			
Phosphorus Load per Capita per Year	Si	800	gm P cap^{-1} yr^{-1}			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1					
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	7.2	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppt_i	2456238.576	m^3 yr^{-1}			
Total Evaporation Hydraulic Loss	Eo	324184.5899	m^3 yr^{-1}			
Total Hydraulic Surface Run Off	Ql	4662471.368	m^3 yr^{-1}			
Total Hydraulic Input	Qt	131465088	m^3 yr^{-1}			
Areal Hydraulic Load	q_s	72.81	m yr^{-1}			
Total Hydraulic Outflow	Qo	131140903.8	m^3 yr^{-1}			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	45026	gm yr^{-1}			
Total Overland Run Off P Input	Je	134667	gm yr^{-1}			
Total Development P Input	Jd	66880	gm yr^{-1}			
Total P Input	Jt	2257033	gm yr^{-1}			
Lake P Retention Factor	Rp	0.09	n/a			
Lake Phosphorus Retention	Ps	203133	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0157**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	2053900	gm yr^{-1}			
Lake Mean Depth	z	2.9	m			
Lake Flushing Rate	FR	24.88	times yr^{-1}			
Lake Turnover Time	TT	0.04	yr			
Lake Response Time	RT(1/2)	0.02	yr			

Porters Lake Part 4 model						
Input Parameters	**Symbol**	**Value**	**Units**	**Budgets**		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	907.3	ha			
Area Land Use Category 1 (Forest)	Ad1	589.8	ha			**%Total**
Area Land Use Category 2 (Clear Cut & Barren)	Ad2	80.9	ha	Upstream Inflow	143142711	91.07
Area Land Use Category 3 (Wetland)	Ad3	99.8	ha	Precipitation	5602675	3.56
Area Land Use Category 4 (Hay Land)	Ad4	0.0	ha	Surface Run Off	8437619.3	5.37
Area Land Use Category 5 (Residential Lots)	Ad5	124.0	ha	Evaporation	-739464.37	0.47
Area Land Use Category 6 (Roads & pavement)	Ad6	12.8	ha	Total Outflow	156443541	99.53
Area Land Use Category 7	Ad7	0.0	ha	Total Check		100.00
Area Land Use Category 8	Ad8	0.0	ha			
Area Land Use Category 9	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10	Ad10	0.0	ha			
Lake Surface Area	Ao	410.8	ha			**%Total**
Lake Volume	V	13.61	$10^6 m^3$	Upstream Inflow	143142711	85.2
Hydrology				Atmosphere	102703	3.78
Upstream Hydraulic Inputs (Porters Lk Part 3, Mill Lk)	Qi	143142711	$m^3 yr^{-1}$	Land Run Off	182587	6.73
Annual Unit Precipitation	Pr	1.36	m yr^{-1}	Development	117040	4.31
Annual Unit Lake Evaporation	Ev	0.18	m yr^{-1}	Sedimentation	-434315	16.00
Annual Unit Hydraulic Runoff	Ru	0.93	m yr^{-1}	Total Outflow	2280155	84.00
P Loading				Total Check		100.02
Upstream P Inputs (Porters Lk Part 3, Mill Lk)	Pi	2312140	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0250	gm P $m^{-2} yr^{-1}$			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P $m^{-2} yr^{-1}$			
Land Use Category 2 P Export Coefficient	E2	0.0625	gm P $m^{-2} yr^{-1}$			
Land Use Category 3 P Export Coefficient*	E3	0.0031	gm P $m^{-2} yr^{-1}$	*based on Dillon & Molot (1997)		
Land Use Category 4 P Export Coefficient	E4	0.0081	gm P $m^{-2} yr^{-1}$			
Land Use Category 5 P Export Coefficient	E5	0.0350	gm P $m^{-2} yr^{-1}$			
Land Use Category 6 P Export Coefficient	E6	0.3500	gm P $m^{-2} yr^{-1}$			
Land Use Category 7 P Export Coefficient	E7	0.0000	gm P $m^{-2} yr^{-1}$			
Land Use Category 8 P Export Coefficient	E8	0.0000	gm P $m^{-2} yr^{-1}$			
Land Use Category 9 P Export Coefficient	E9	0.0000	gm P $m^{-2} yr^{-1}$			
Land Use Category 10 P Export Coefficient	E10	0.0000	gm P $m^{-2} yr^{-1}$			
Number of Dwellings	N_d	133	#			
Average number of Persons per Dwelling	N_u	2.20	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}			
Phosphorus Load per Capita per Year	Si	800	gm P $cap^{-1} yr^{-1}$			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1					
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	7.2	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppti	5602675.025	$m^3 yr^{-1}$			
Total Evaporation Hydraulic Loss	Eo	739464.3676	$m^3 yr^{-1}$			
Total Hydraulic Surface Run Off	Ql	8437619.292	$m^3 yr^{-1}$			
Total Hydraulic Input	Qt	157183005	$m^3 yr^{-1}$			
Areal Hydraulic Load	q_s	38.08	m yr^{-1}			
Total Hydraulic Outflow	Qo	156443540.8	$m^3 yr^{-1}$			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	102703	gm yr^{-1}			
Total Overland Run Off P Input	Je	182587	gm yr^{-1}			
Total Development P Input	Jd	117040	gm yr^{-1}			
Total P Input	Jt	2714470	gm yr^{-1}			
Lake P Retention Factor	Rp	0.16	n/a			
Lake Phosphorus Retention	Ps	434315	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0146**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	2280155	gm yr^{-1}			
Lake Mean Depth	z	3.3	m			
Lake Flushing Rate	FR	11.49	times yr^{-1}			
Lake Turnover Time	TT	0.09	yr			
Lake Response Time	RT(1/2)	0.05	yr			

Porters Lake Part 5 model						
Input Parameters	**Symbol**	**Value**	**Units**	**Budgets**		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	709.7	ha			
Area Land Use Category 1 (Forest)	Ad1	331.4	ha			**%Total**
Area Land Use Category 2 (Clear Cut & Barren)	Ad2	60.9	ha	Upstream Inflow	164705662	92.12
Area Land Use Category 3 (Wetland)	Ad3	84.6	ha	Precipitation	7493389.1	4.19
Area Land Use Category 4 (Hay Land)	Ad4	0.0	ha	Surface Run Off	6600142.7	3.69
Area Land Use Category 5 (Residential Lots)	Ad5	204.4	ha	Evaporation	-989008.68	0.55
Area Land Use Category 6 (Roads & pavement)	Ad6	28.4	ha	Total Outflow	177810185	99.45
Area Land Use Category 7	Ad7	0.0	ha	Total Check		100.00
Area Land Use Category 8	Ad8	0.0	ha			
Area Land Use Category 9	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10	Ad10	0.0	ha			
Lake Surface Area	Ao	549.4	ha			**%Total**
Lake Volume	V	9.36	10^6 m^3	Upstream Inflow	164705662	74.8
Hydrology				Atmosphere	137362	4.37
Upstream Hydraulic Inputs(Porters Lk Part 4, Snow Lk, Caribou Lk)	Qi	164705662	m^3 yr^{-1}	Land Run Off	234473	7.46
Annual Unit Precipitation	Pr	1.36	m yr^{-1}	Development	418880	13.34
Annual Unit Lake Evaporation	Ev	0.18	m yr^{-1}	Sedimentation	-565374	18.00
Annual Unit Hydraulic Runoff	Ru	0.93	m yr^{-1}	Total Outflow	2575594	82.00
P Loading				Total Check		99.97
Upstream P Input (Porters Lk Part 4, Snow Lk, Caribou Lk)	Pi	2350253	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0250	gm P m^{-2} yr^{-1}			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}			
Land Use Category 2 P Export Coefficient	E2	0.0625	gm P m^{-2} yr^{-1}			
Land Use Category 3 P Export Coefficient*	E3	0.0031	gm P m^{-2} yr^{-1}	*based on Dillon & Molot (1997)		
Land Use Category 4 P Export Coefficient	E4	0.0081	gm P m^{-2} yr^{-1}			
Land Use Category 5 P Export Coefficient	E5	0.0350	gm P m^{-2} yr^{-1}			
Land Use Category 6 P Export Coefficient	E6	0.3500	gm P m^{-2} yr^{-1}			
Land Use Category 7 P Export Coefficient	E7	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 8 P Export Coefficient	E8	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 9 P Export Coefficient	E9	0.0000	gm P m^{-2} yr^{-1}			
Land Use Category 10 P Export Coefficient	E10	0.0000	gm P m^{-2} yr^{-1}			
Number of Dwellings	N_d	476	#			
Average number of Persons per Dwelling	N_u	2.20	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}			
Phosphorus Load per Capita per Year	Si	800	gm P cap^{-1} yr^{-1}			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1					
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	7.2	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppti	7493389.118	m^3 yr^{-1}			
Total Evaporation Hydraulic Loss	Eo	989008.6825	m^3 yr^{-1}			
Total Hydraulic Surface Run Off	Ql	6600142.682	m^3 yr^{-1}			
Total Hydraulic Input	Qt	178799194	m^3 yr^{-1}			
Areal Hydraulic Load	q_s	32.36	m yr^{-1}			
Total Hydraulic Outflow	Qo	177810184.8	m^3 yr^{-1}			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	137362	gm yr^{-1}			
Total Overland Run Off P Input	Je	234473	gm yr^{-1}			
Total Development P Input	Jd	418880	gm yr^{-1}			
Total P Input	Jt	3140968	gm yr^{-1}			
Lake P Retention Factor	Rp	0.18	n/a			
Lake Phosphorus Retention	Ps	565374	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0145**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	2575594	gm yr^{-1}			
Lake Mean Depth	z	1.7	m			
Lake Flushing Rate	FR	19	times yr^{-1}			
Lake Turnover Time	TT	0.05	yr			
Lake Response Time	RT(1/2)	0.03	yr			

APPENDIX D

Component Study – Surface Water Use Objectives Questionnaire

Porter's Lake Watershed Study

Water Quality Objectives Questionnaire Results Summary

101015.00 • Final Report • December 2010

ISO 9001
Registered Company

Prepared for:
Halifax Regional Municipality

Prepared by:
CBCL LIMITED
Consulting Engineers

Porter's Lake Water Quality Objectives Questionnaire Response Results

December 2010

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A Water Quality Questionnaire

CHAPTER 1 PORTER'S LAKE WATER QUALITY QUESTIONNAIRE

1.1 Questionnaire Overview

The Porter's Lake Water Quality Questionnaire was part of the Porter's Lake Watershed Study. HRM commissioned this study to develop a solid understanding of the Porter's Lake Watershed as an aid to future planning. The purpose of the questionnaire was to gather community input on future water use and objectives for the Porter's Lake area. The objective was to find out how residents of the area use water bodies now and how they want to be able to use them in the future. The questionnaire is available as Appendix A.

The questionnaire was available online from **August 5 to November 10, 2010**. The survey was publicized through email distribution lists, posters, and an advertisement in the Eastern Gazette. There were **197 responses**. Questionnaire responses are summarized in the sections below.

1.2 Importance of Water Bodies

Respondents were provided with a list of water bodies in the area and asked to indicate the ways in which these water bodies were important to them. Overall, the most responses were provided for Porter's Lake, both north and south of Highway 7 and the ocean. Visual enjoyment, swimming, boating, and habitat were the highest choices for Porter's Lake. Visual enjoyment, leisure on beaches, swimming, and shoreline trails were the most important values for the ocean. Figure 1 shows the important values respondents indicated for each water bodies.

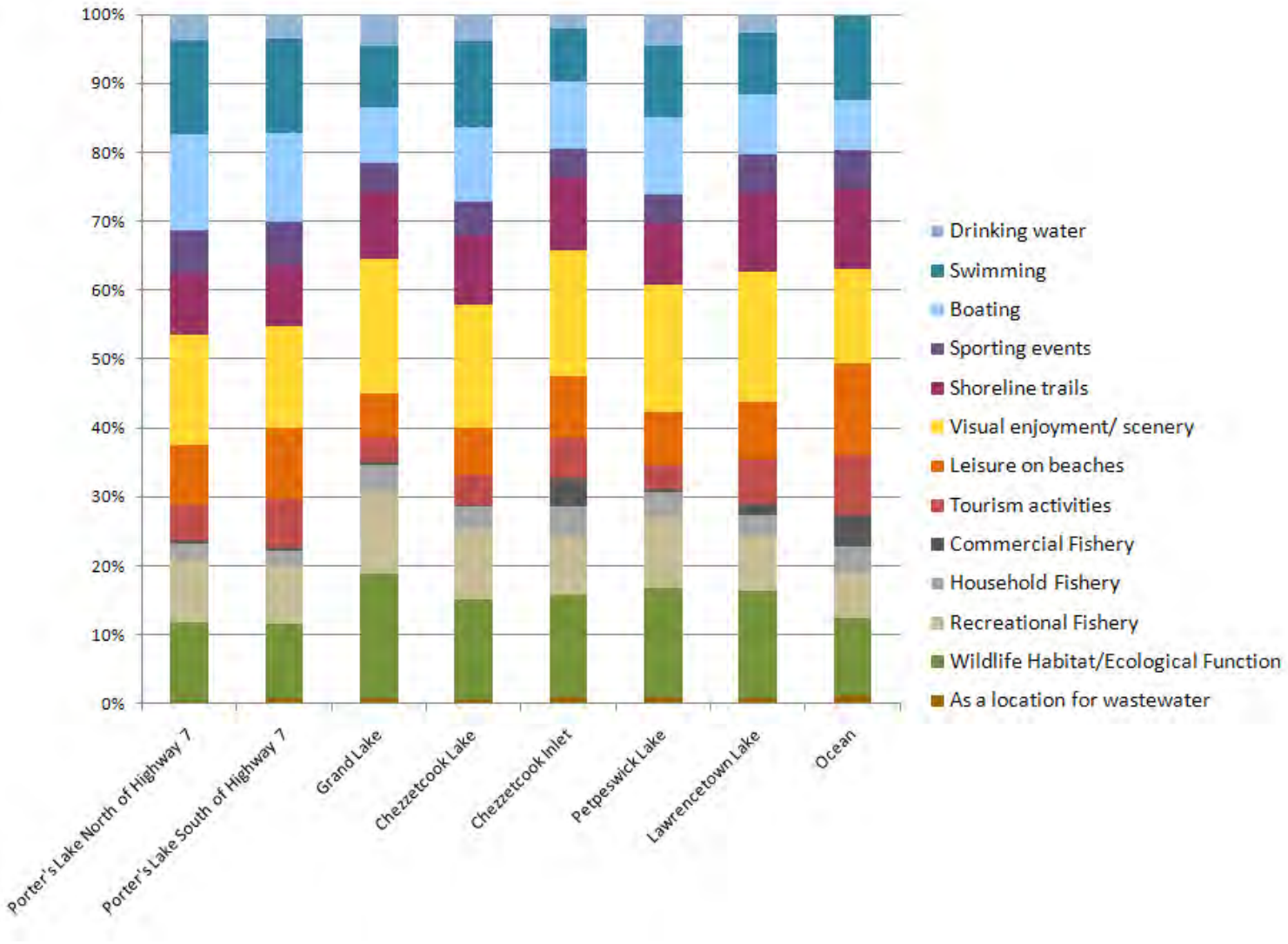


Figure 1: Water Bodies and Importance for Respondents

1.3 Concern about Wwater Bodies

In response to if they were concerned about particular water bodies, respondents indicated "Yes, a great deal" of concern for Porter's Lake, both north and south of Highway 7. The ocean, Chezzetcook Inlet, and Petpeswick Lake were of the next highest concern. In Figure 2 shows the level of concern respondents indicated for each water body.

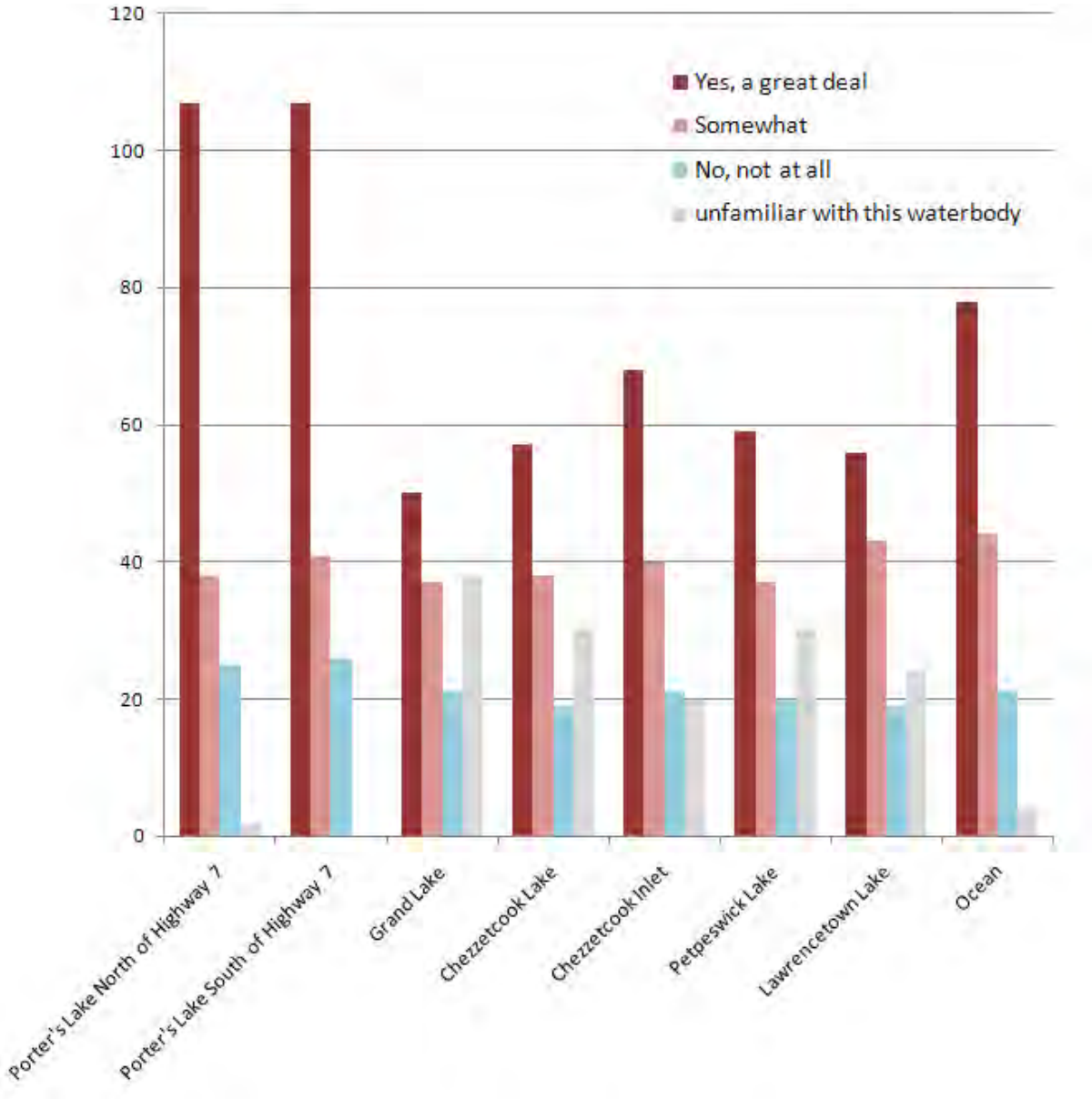


Figure 2: Concern about Water Bodies

1.4 Future Water Quality

The Regional Plan recognizes the difficulties with achieving pristine conditions in every watershed. Respondents were asked what level of water quality they desired for each water body. The questionnaire showed respondents a scale that showed a movement from the LEAST stringent water quality requirements (left) to the MOST stringent water quality requirements (right). Respondents were asked to indicate the level of water quality requirements they would be satisfied with in the future.



Figure 3 shows the level of water quality respondents would be satisfied with in the future for each water body. The ocean and Chezzetcook Inlet were the water bodies respondents indicated the need for the most stringent water quality requirements. The majority of responses for fresh water bodies indicated a desire for high requirements (level 4). Very few respondents would be satisfied with level one or two water quality requirements. Respondents provided additional comment expressing the desire for highest (level 5) protection for other water bodies in the area including Petpeswick Inlet, Three Fathom Harbour and Conros Lake, and high (level 4) protection for Meisners Lake, Lake Echo, and all water bodies north of Porters Lake.

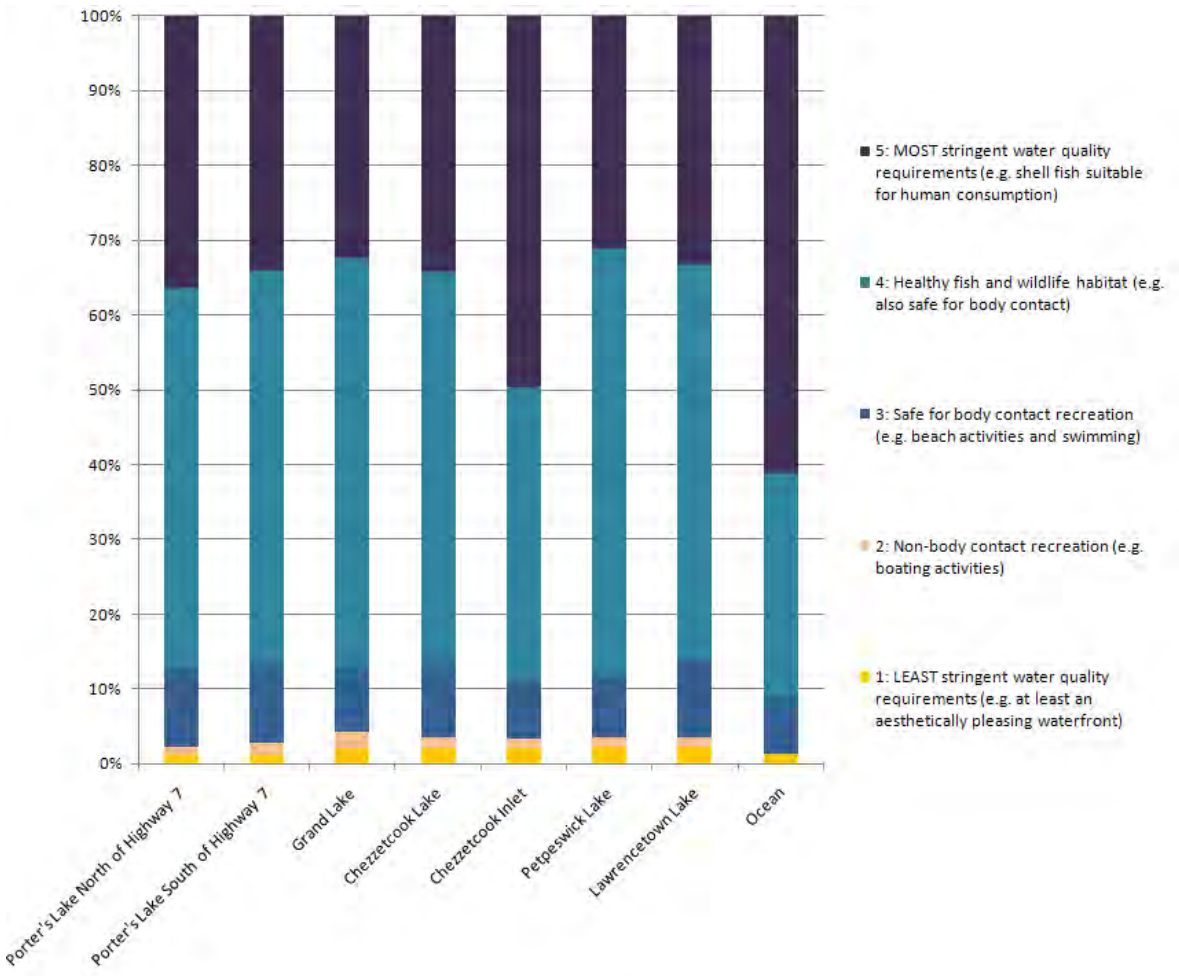


Figure 3: Level of Future Water Quality Respondents Would Be Satisfied With

1.5 Willingness to Pay for Higher Water Quality

Respondents were asked if they would be willing to pay more than the cost of installing a well and septic system for water, sewer, and stormwater services that would achieve better water quality in the area. 33.9% said “yes”, 66.1% said “no” (Figure 4).

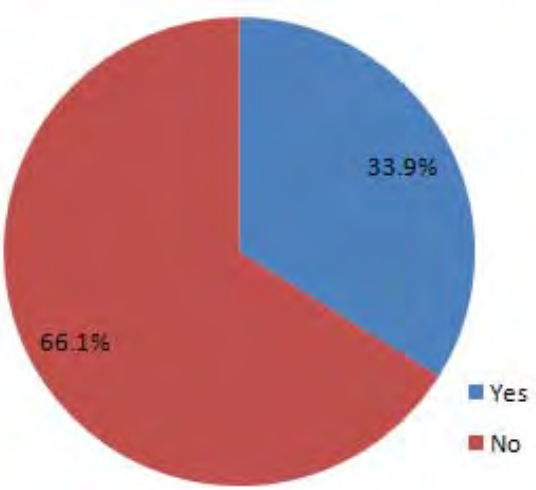


Figure 4: Willingness to Pay for Higher Water Quality

Respondents provided the following additional comments:

- No need or desire for central water or sewer services/ have already paid for own on-site system/ systems that meet standards should not be a water quality problem (26 responses);
- Concern about too much tax paid already/ and receive few services (9 responses);
- Land owners with faulty onsite systems/other pollutant sources should pay to remediate water quality problems, not the larger tax base/area (5 responses);
- Affordability concerns (4 responses);
- Only those directly receiving central and water should pay for it, not the larger tax base/area (1 response);
- Need to better enforce setbacks from water bodies and other environmental protection HRM bylaws and Provincial regulations (5 responses);
- Water from wells is better quality and better for the environment (6 responses);
- Willing if it would provide a cleaner lake/safer environment for future generations (3 responses)
- Would rather pay for central services instead of on-site, but unwilling/unable to pay for both (3 responses);
- Other sources than septic systems need to be considered as potential water pollutants (1 response);
- Concern about changing rural character of the area/no desire for urban type services (1 response);
- Yes, if building new, but not to upgrade (1 response); and
- Need for more details about steps that would be taken to improve water quality (2 responses).

1.6 Potential Sources of Contamination

Respondents were asked to describe any potential past or current sources of contamination in each water body. The most responses were received for Porter's Lake both north and south of Highway 7.

Respondents described the following potential sources of contamination:

1.6.1 Potential Contaminants of Porters Lake North of Highway 7

- **Septic systems in general (domestic and school) and old or failed (20 responses);**
- **Construction/excavation/development too close to the water (20 responses);**
- **Roads / salt / DTIR dept (11 responses);**
- **Chemical fertilizers and pesticides (11 responses);**
- Tree cutting (10 responses);
- Gas and oil leaks - domestic and from boats (9 responses);
- Landfills / informal "dumps" (8 responses);
- Automotive mechanic land use / works yards (7 responses);
- Erosion and sedimentation (4 responses);
- ATV use close to water (4 responses);
- Gas stations (3 responses); and
- Old mines / sawmills / gravel pit (1 response each).

1.6.2 Potential Contaminants of Porters Lake South of Highway 7

- **Septic systems in general, and old or failed (23 responses);**
- **Construction/excavation/development too close to the water (14 responses);**
- **Chemical fertilizers and pesticides (10 responses);**
- **Gas and oil leaks – domestic, from boats, old vehicles (8 responses);**
- Automotive mechanic land use / works yards (6 responses);
- Roads / salt (6 responses);
- Tree cutting (4 responses);
- Commercial uses near lake (e.g. shopping centre businesses, marina) (4 responses);
- Landfills / informal "dumps"/garbage on trails (3 responses);
- Gas stations (2 responses);
- Run-off from exposed shale (1 response);
- Former roof truss property on West Porter's Lake Road (1 response);
- Former saw mill (1 response);
- Leachate from burned garbage/plastics (1 response);
- Gravel pit (1 response);
- Gray water running into lake (1 response); and
- ATV use close to water (1 response).

1.6.3 Potential Contaminants of Grand Lake

- **Septic systems in general and old or failed (8 responses);**
- **Construction/ development too close to water (4 responses);**
- Highway 107 / salt (3 responses);
- Chemical fertilizers or pesticides (3 responses);

- Tree-cutting (1 response);
- Erosion and sedimentation (1 response);
- Old cars/other machinery (1 response);
- Boats (1 response); and
- ATVs (1 response).

1.6.4 Potential Contaminants of Chezzetcook Lake

- **Septic systems (14 responses);**
- **Tree-cutting (4 response);**
- **Construction/development too close to water (4 responses);**
- Roads/salt (3 responses);
- Chemical fertilizers or pesticides (2 responses);
- Old cars/other machinery (1 response); and
- Illegal camping (1 response).

1.6.5 Potential Contaminants of Chezzetcook Inlet

- **Septic systems (16 responses);**
- **Construction/excavation/development too close to the water (5 responses);**
- **Roads / salt (4 responses);**
- Proposed clam plant near Seaforth (3 responses);
- Chemical fertilizers and pesticides (2 responses);
- Tree cutting (2 responses);
- Landfill/ dumping (2 responses);
- Gas and oil leaks from boats (1 response);
- Automotive mechanic land use / works yards (1 response);
- Mineral extraction (1 response);
- Old cars/other machinery (1 response);
- Horses/livestock (1 response);
- Commercial uses near water (1 response); and
- Contaminated water flowing from inland into the inlet (1 response).

1.6.6 Potential Contaminants of Petpeswick Lake

- **Septic systems (10 responses);**
- **Construction/excavation/infill/development too close to the water (5 responses);**
- **Roads / salt (5 responses);**
- Chemical fertilizers and pesticides (3 responses);
- Tree cutting (2 responses);
- Automotive mechanic land use / works yards (2 responses);
- Old cars/other machinery (1 response);
- Erosion and sedimentation (1 response);
- Run-off from exposed shale (1 response); and
- Culvert under rail bridge impedes fish movement (1 response).

1.6.7 Potential Contaminants of Lawrencetown Lake

- **Septic systems (8 responses);**
- **Roads / salt (5 responses);**
- **Construction/excavation/development too close to the water (5 responses);**
- Chemical fertilizers and pesticides (2 responses);
- Tree cutting (2 responses);
- Dumping in ocean/on land (2 responses);
- Automotive mechanic land use / works yards (2 response);
- Potential installation of east link communications tower on Leslie Road (2 response);
- Old cars/other machinery (1 response);
- Contaminated water flowing from inland into the lake (e.g. gaetz brook) (1 response);
- Disturbance of pyritic late in lake echo area (1 response);
- Arsenic from old gold mine activity in the river system (1 response);
- Silt run off from 2008 wildfire (2 response); and
- Farmland (1 response).

1.6.8 Potential Contaminants of the ocean

- **Septic systems generally (9 responses);**
- **Development too close to the water (6 responses);**
- **Dumping garbage in water and on land (4 responses);**
- Gas and oil leaks from boats/dumping of sewage from ships (3 responses);
- Proposed clam plant near Seaforth (2 responses);
- Chemical fertilizers and pesticides (2 responses);
- Septic systems from un-serviced areas in Dartmouth (1 response);
- Works yard (1 response);
- Mineral extraction (1 response);
- Tree cutting (1 responses);
- Old cars/other machinery (1 response); and
- Commercial and industrial uses near water (1 response).

1.6.9 Potential contaminants of other bodies of water

- Three Fathom Harbour – septic system impact on clam fishery;
- Conrod Lake – cottage construction, farm fields;
- Grand Desert – farm fields ;
- Musquodoboit River – general water degradation;
- Lake Echo – general concern;
- Martinique Beach – development too close to water's edge;
- Dollar Lake - tourist attraction; and
- Porters Lake/East & West Brooks – ATV use and habitat disruption along streams.

1.7 Additional Information or Concerns

Sixty-nine respondents provided additional comments at the end of the survey. Many respondents were re-emphasizing areas of concern indicated in responses to earlier questions. Overall there was concern

from residents who feel they take care of their septic systems and abide by by-laws meant to protect water quality and habitat without having to pay increased taxes because of the neglect by others. Respondents expressed concern that existing regulations and by-laws regarding septic systems and development set-backs are not being enforced. Some respondents expressed concern about the quality of water from wells, and expressed interest in city provided services. Other respondents explicitly stated they did not want city provided water and the perceived corresponding increased tax rate.

APPENDIX A

Questionnaire

Porter's Lake Watershed Study

Questionnaire Purpose: To gather community input on future water use and objectives for the Porter's Lake area. We want to know how you use waterbodies in the area now and how you want to be able to use them in the future.

The HRM Regional Municipal Planning Strategy recognizes the importance of using watershed studies as the basis for developing community planning strategies.

This questionnaire is part of the Porter's Lake Watershed Study. HRM has commissioned this study to develop a solid understanding of the Porter's Lake Watershed as an aid to future planning. The study is designed to determine the opportunities for future development that are within the environmental capacity of land and receiving waters. The study will also assess options for servicing the Porter's Lake centre with central water and sewer.

This questionnaire should take approximately 15 minutes to complete. There is a section at the end where you are welcome to provide additional comments.
The survey will be available until September 30, 2010

If you have any questions, please contact:
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OR
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Thank you for your time!

CBCL LIMITED
Consulting Engineers

This survey asks questions about waterbodies within the Porter's Lake Watershed Study Area shown below.



In what ways are these waterbodies in the Porter's Lake area important to you? Please check all that apply.

	Drinking water	Swimming	Boating	Sporting events	Shoreline trails	Visual enjoyment/ scenery	Leisure on beaches	Tourism activities	Commercial Fishery	Household Fishery	Recreational Fishery	Wildlife Habitat/Ecological Function	lo was
Porter's Lake North of Highway 7	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Porter's Lake South of Highway 7	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Grand Lake	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Chezzetcook Lake	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Chezzetcook Inlet	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Petpeswick Lake	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Lawrencetown Lake	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Ocean	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Other (please identify the waterbody and specify its importance to you)

Are you concerned about the water quality of these waterbodies?

	No, not at all	Somewhat	Yes, a great deal	unfamiliar with this waterbody
Porter's Lake North of Highway 7	◯	◯	◯	◯
Porter's Lake South of Highway 7	◯	◯	◯	◯
Grand Lake	◯	◯	◯	◯
Chezzetcook Lake	◯	◯	◯	◯
Chezzetcook Inlet	◯	◯	◯	◯
Petpeswick Lake	◯	◯	◯	◯
Lawrencetown Lake	◯	◯	◯	◯
Ocean	◯	◯	◯	◯

Other waterbodies you are concerned about (please specify waterbody and level of concern - somewhat concerned or concerned a great deal)

The Regional Plan recognizes the difficulties with achieving pristine conditions in every watershed. We want to know the level of water quality the community desires for each waterbody so the community can continue to enjoy and use waterbodies in their area as the population grows.

The scale below moves from the LEAST stringent water quality requirements (left) to the MOST stringent water quality requirements (right).



At what level would you be satisfied with future water quality?

	1: LEAST stringent water quality requirements (e.g. at least an aesthetically pleasing waterfront)	2: Non-body contact recreation (e.g. boating activities)	3: Safe for body contact recreation (e.g. beach activities and swimming)	4: Healthy fish and wildlife habitat (e.g. also safe for body contact)	5: MOST stringent water quality requirements (e.g. shell fish suitable for human consumption)
Porter's Lake North of Highway 7	◯	◯	◯	◯	◯
Porter's Lake South of Highway 7	◯	◯	◯	◯	◯
Grand Lake	◯	◯	◯	◯	◯
Chezzetcook Lake	◯	◯	◯	◯	◯
Chezzetcook Inlet	◯	◯	◯	◯	◯
Petpeswick Lake	◯	◯	◯	◯	◯
Lawrencetown Lake	◯	◯	◯	◯	◯
Ocean	◯	◯	◯	◯	◯

If required, add other waterbodies and indicate desired level of water quality requirements (1-5)

5
6

Would you be willing to pay more than the cost of installing a well and septic system for water, sewer, and stormwater services that would achieve better water quality in the area?

◯ Yes

◯ No

Comment

5
6

Current and former land uses and activities that can contaminate a waterbody include: gas stations, works yards, fuel/salt/chemical storage, sawmills, fertilizer and pesticides from farm fields, mines or aggregate extraction, landfills, failed septic systems, and others.

Please describe any potential sources of contamination in the following waterbodies.

Porter's Lake North of Highway 7	
Porter's Lake South of Highway 7	
Grand Lake	
Chezzetcook Lake	
Chezzetcook Inlet	
Petpeswick Lake	
Lawrencetown Lake	
Ocean	
Other waterbody (specify)	
Other waterbody (specify)	
Other waterbody (specify)	

If you are willing to be contacted for more information about the location of the potential contaminants you have identified, please provide your contact information below.

Name:	
City/Town:	
Email Address:	
Phone Number:	

Please provide any additional information or concerns you have about water quality in the Porter's Lake area. Please be as specific as possible.

Thank you for your time completing this questionnaire and contributing to the Porter's Lake Watershed Study.

APPENDIX E

Component Study – Habitats and Species at Risk

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CHAPTER 1 BIOREGIONS

The habitats that encompass the study area include both that which is found inland and that which is found in the bay (the water environments). Habitat analysis refers to the consideration of the natural setting in which something lives. Generally this means looking at the biota (plants and animals) and how they may relate to surficial geology, hydrology and other environmental systems.

The Natural History of Nova Scotia (Davis and Browne, 1996) is the recognized classification system in describing our natural history and identifies three distinct districts within the study area as described below.

1.1 District 833: Eastern Shore Beaches

Davis and Browne (1996) describe this district, which makes up most of the study area south of Highway 107, as an indented, drowned coastline with headlands, long inlets and drumlin islands. Barrier beaches and spits are formed as coastal sediment is continually being reworked. The inlets provide important migration and overwintering habitat for waterfowl, and are considered to be drowned river estuaries. Large areas of tidal marsh can be found throughout this District.

In spring, the inlet areas are a stopover for several thousand Black Ducks and Canada Geese. The numbers peak again in October, making this an area with larger Black Duck and Canada Geese populations than anywhere else in Nova Scotia.

The inland areas south of Highway 107 are dominated by well-draining Halifax gravelly sandy loams derived from quartzite. The peninsulas and coastal areas in this district feature a variety of soils. On the western shore of Chezzetcook Inlet the dominate soils are well-draining Wolfville soils, which consist of a dark reddish brown loam to sandy clay loam. Areas with less relief, in particular between Porters Lake and Lawrencetown Lake, are covered by imperfectly draining Danesville soil. Other poorly to imperfectly draining soils, such as Aspotogan, Riverport and Peat, can be found in the coastal areas of this district, while pockets of well draining Bridgewater soils can be found around the communities of West Chezzetcook, Middle Porters Lake and West Lawrencetown (MacDougall et al. 1963).

Coastal White Spruce and Balsam Fir forest with maple and birch dominates the district. On old farmlands and drumlins, pure stands of White Spruce are common. Further back from the coast, there are spruce, fir, and pine stands.

1.2 District 413: Quartzite Barrens (Sub-district 413a, Halifax)

This district passes through the study area north of Highway 107 and south of an imagined east-west line along the orientation of Conrod Lake. The bedrock-dominated landscape which gives name to these barrens can best be described as a "ridge-swamp-swale" in seemingly endless repetition (Davis and Browne, 1996). In this district, the mantle of quartzite till ranges in thickness from 1 to 10 meters but averages less than 3 meters. Most of the study area within this district is covered by well-draining Halifax soil. A smaller area between Petpeswick Lake, Chezzetcook Lake and Conrod Lake around Highway 107 is covered by well-draining Bridgwater soil.

While the higher, broader ridges in this District are capped with American Beech, Yellow Birch, maple, the lower side slopes are dominated by spruce. Depressions are inhabited by Black Spruce and larch with patches of White Pine growing in sand. Broad swampy areas with Balsam Firm Black Spruce and Red Maple are common along edges of slow moving streams. Excessive shrub-dominated barrens occur in this District with birch, Red Maple and aspen depending on soil depth and drainage conditions.

1.3 District 453: Granite Ridge

The northern part of the study area falls within the Granite Ridge, a prominent 80-kilometre long ridge rising about 100 m above sea level along the eastern shore. Porters Lake follows a fault line across the ridge into a narrow gorge, while Lawrencetown Lake is a drowned river estuary. The surface of the granite is mostly covered by Gibraltar soils - well-drained, sandy loams derived from granite.

The vegetation common to this district includes Red Spruce, Balsam Fir, birch, Eastern Hemlock and White Spruce on well-drained soils with Black Spruce, and larch in wetter soils. Parts of the district have very thin soils and exposed bedrock where the vegetation has been reduced to a semi-barren state. Shade-intolerant aspen and birch typically colonize burnt areas in this area.

1.4 Cultural Environment

Forest management predominates within the Granite Ridge area. Christmas tree farms have become a new industry in the region. Recent increases in the value of gold has caused interest in mining for this mineral to become reactivated in the Quartzite Barrens, which was the most productive gold mining area in Nova Scotia during the 1800's. Today, Woodlot management occurs in the Quartzite Barrens. The drumlin fields of the Eastern Shore Beaches district have been used for small scale farming since the mid-1700s. Though in decline, fishing continues to be an important economic activity for some communities. Recreational activities such as bird-watching, hiking, camping and swimming are common in the Beach areas.

CHAPTER 2 SPECIES AT RISK

2.1 Introduction

To identify any rare biota located within the study area the following lists were reviewed: the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as well as those listed under the Species at Risk Act (SARA); Nova Scotia Endangered Species Act (NSESA); Nova Scotia Department of Natural Resources General Status of Wild Species List (NSDNR General Status); and the Atlantic Canada Conservation Data Centre (ACCDC) guidance list. Table E5 summarizes the definitions of rarity ranks associated with the referenced lists.

Table E5: Definitions of Rarity Rankings

ACCDC Ranks Definitions (ACCDC 2003)	
S1	Extremely rare throughout its range in the province (typically five or fewer occurrences or very few remaining individuals). May be especially vulnerable to extirpation.
S2	Rare throughout its range in the province (six to 20 occurrences or few remaining individuals). May be vulnerable to extirpation due to rarity or other factors.
S3	Uncommon throughout its range in the province, or found only in a restricted range, even if abundant at some locations (21 to 100 occurrences).
S4	Usually widespread, fairly common throughout its range in the province, and apparently secure with many occurrences, but the species is of long-term concern, e.g., watch list (100+ occurrences).
SU	Unrankable: Possibly in peril throughout its range in the province, but status uncertain: need more information. Used for new species not previously identified.
SX	Extinct/Extirpated: Believed to be extirpated within the province.
S#S#	Numeric range rank: A range between two consecutive numeric ranks. Denotes uncertainty about the exact rarity of the species, e.g., S1S2.
?	In exact or uncertain: For numeric ranks, denotes uncertainty, e.g., SE? denotes uncertainty of exotic status.
NSDNR General Status Rankings Definitions (NSDNR)	
Blue	No longer in Nova Scotia or extinct in wild
Red	Known to be or is thought to be at risk.
Yellow	Sensitive to human activities or natural events.
Green	Not believed to be sensitive, or at risk.

COSEWIC Ranks	
Endangered	A species facing imminent extirpation or extinction
Threatened	A species likely to become endangered if limited factors are not reversed
Special Concern	A species of concern because of characteristics that make it particularly sensitive to human activities or natural events**.**

Additional sources used to determine the regional distribution and habitat preferences for birds were the Atlas of Breeding Birds of the Maritime Provinces (Erskine, 1992) and Eastern Birds (Peterson, 1980). For plants, the additional source used was Roland's Flora of Nova Scotia (Zinck, 1998). The results of this screening are detailed in the following tables and brief overviews.

2.1.1 Species of Concern

In Nova Scotia, plant and animal species are tracked and designated at four levels. SARA and the Endangered Species Act represent legislative designations while the Nova Scotia Department of Natural Resources (NSDNR) and ACCDC provide technical tracking lists.

The purpose of this watershed study was to identify opportunities of development in the study area based on several aspects of the environment and of the surrounding communities. One of the specific tasks of this study was to identify natural corridors and critical habitats for terrestrial and aquatic species of interest and of concern. In the 5km radius of the ACCDC screening no biologically significant sites or managed areas were identified.

2.2 Discussion

2.2.1 Birds

Nine bird species of concern were identified during this study (Table E5.1.1).Six species have been federally and/ or provincially legislated as species of concern under COSEWIC and the Nova Scotia Endangered Species Act.

Table E5.1.1: Bird Species of Concern

Common Name	Scientific Name	COSEWIC	NS Endangered Species Act	NSDNR	ACCDC Rating
Harlequin Duck	*Histrionicus histrionicus*	Species of Concern	Endangered	Yellow	S2N
American Peregrine Falcon	*Falco peregrinus anatum*	Species of Concern	Threatened	Red	S1B
Piping Plover	*Charadrius melodus*	Endangered	Endangered	Red	S1B
Roseate Tern	*Sterna dougallii*	Endangered	Endangered	Red	S1B
Common tern	*Sterna hirundo*			Yellow	S3B
Arctic Tern	*Sterna paradisaea*			Yellow	S3B
Bobolink	*Dolichonyx oryzivorus*			Yellow	S3B
Red Knot rufa	*Bucephala clangula*	Endangered		Yellow	S2B
Rusty Blackbird	*Euphagus carolinus*	Species of Concern		Yellow	S3B

American Peregrine Falcon (*Falco peregrinus anatum*)

The American peregrine falcon was listed as threatened under COSEWIC in 2000. They breed throughout North America and have been known to use traditional nesting cliffs within the Maritimes, however numbers and exact location of the breeding sites are dynamic. Based on ACCDC records the closest sighting of the American peregrine falcon from the study area was less than 10 km away. It is a migratory species, with breeding areas in Nova Scotia restricted to exposed cliffs, most notably around the Bay of Fundy and the Minas Basin in Cumberland, Colchester, Hants, Kings and Victoria counties and in Inverness County. The probability of this species residing in the project site is low.

Habitat Requirements:

- Large cliff faces (61 m tall x 150 m long) with multiple nesting ledges, near water bodies (habitat for prey);
- Abundant prey source (shorebirds, ducks, small-medium sized birds); and
- Minimal human disturbances, such as road construction, blasting, recreational activities.

Terns (*Sterna spp.*)

The Arctic tern (*Sterna paradisaea*), and common tern (*Sterna hirundo*) have been designated Yellow or species of concern by the Nova Scotia Department of Natural Resources. The common tern prefers temperate climates including inland and coastal areas where there are shallow waters for feeding and sandy or gravelly shores for nesting. Unlike the common tern, the Arctic tern prefers cooler coastal areas and prefers to forage further out to sea. Both species of tern were observed less than 10km away from the study area.

Habitat Requirements:

- Colonial nesters on sandy, gravelly or sparsely vegetated shorelines. Will avoid nesting where shrubbery or woody vegetation is present;

- Are more deep water (ocean) feeders diving after schools of fish, but can be found more inshore; and
- Prefer nesting on islands, but will next along secluded beaches.

The roseate tern (*Sterna dougallii*) is listed as endangered under the NS Endangered Species Act and COSEWIC. It is therefore legislated under the Species at Risk Act. The roseate tern has similar habitat preferences to the common and arctic tern but physiologically, the roseate tern has a deeper forked tail and has a more slender appearance. The coastal habitat within the study area is consistent with the breeding site preference of the roseate tern, and the closest record is within 9km of the project area. The likelihood of tern species residing along the coastal areas is high depending on water temperature and availability of food. Potential impacts to this species should be evaluated on a project by project basis.

Habitat Requirements:

- Prefer rocky coast lines or islands, secluded beaches, and salt marsh islands;
- Will nest in vegetation, driftwood or rock crevices which provide moderate cover;
- These divers prefer to forage in shallower waters (< 10m) with sandy bottoms for schools of fish; and
- Very sensitive to human disturbances and often abandon nesting sites.

Piping Plover (*Charadrius melodus*)

The piping plover was legislated under the Species at Risk Act as Endangered in 2001. Fifty to sixty pairs breed along the Atlantic shoreline. Populations have not increased, notwithstanding conservative efforts due to declining nesting habitat quality and predation amongst other disturbances limiting species reproductive success. Piping plover prefer beach breeding areas and will make their nest in soft sand or gravel. This species has been recorded breeding on Conrads Island and the Barrier beaches in the study area would provide suitable habitat for piping plovers. As with the Roseate Tern impacts to this species should be evaluated at the project level.

Habitat Requirements:

- Prefer to nest on coastal beaches containing dunes, pools, and sand pits away from the water. Need beaches greater than a hectare;
- Forage around pools, tidal flats, and beaches for invertebrates; and
- Adults are tolerant to human presence, but nests and young are severely impacted by human activities/disturbances such as ATVs or beach maintenance.

Rusty Blackbird (*Euphagus carolinus*)

The rusty blackbird is a species of special concern under COSEWIC and is therefore legislated under the Species at Risk Act. The Rusty Blackbird is infrequent throughout Nova Scotia, where it typically inhabits wetlands, peat bogs, marshes, swamps and dry pasture edges. Breeding birds are usually seen from late March through mid-April. The Rusty blackbird has been observed approximately 11km from the center of the project site (ACCDC, 2010). The possibility of this species residing in the study area is moderate and impacts to this species should be considered in future development.

Habitat Requirements:

- Often found around wetlands, forested wetlands (coniferous), edges of watercourses or water bodies;
- Degradation or elimination of wetlands will have a significant impact on the population; and
- Prefer to nest in coniferous trees or a dense shrub layer, close to a water source which provides habitat for their prey source (invertebrates, insect larvae, snails).

Harlequin Duck (*Histrionicus histrionicus)*

The harlequin duck is a winter resident which breeds in western and northern North America. Small groups are widely distributed from The Bay of Fundy coast to Cape Breton. It is listed as endangered under the NS Endangered Species Act and a Species of Concern by COSEWIC. The nearest sighting was the 50km from the study area making the likelihood of it being in the study area low.

Habitat Requirements:

- Prefer to reside and nest near turbulent waters such as fast moving streams, or rocky coastlines;
- These diving ducks forage underwater for mollusks, crustaceans, and small fish;
- They require cover for nesting sites which can be located on the ground, small cliff ledge, or in a tree cavity; and
- Sensitive to disturbances such as logging practices, aquaculture, hunting, boating activities, etc. Will only tolerate moderate human presence and will abandon sites if human activity becomes too much.

Red Knot rufa (*Calidris canutus rufa)*

The red knot rufa is a medium sized shore bird that visits the coastal regions of Nova Scotia during migration during the summer and fall. It is written in literature that there are as few as 15000 left in the wild. It is considered to be an endangered species by COSEWIC. This species as declined greatly in a short period of time and risks becoming extinct.

Habitat Requirements:

- When migrating, these birds prefer coastal areas with large sand and mudflats, salt marches, and brackish waters;
- Feed primarily on horseshoe crab eggs and invertebrates; and
- Numbers are impacted due to depletion of their main food source (horseshoe crabs), wetland degradation or elimination, and pollution.

2.2.2 Plants

Eleven plant species of concern were identified as having been seen in the area (20km), or as having habitat preferences similar to what is found in the study area (Table E5.1.2).

Table E5.1.2: Plant Species of Concern

Common Name	Scientific Name	COSEWIC	NS Endangered Species Act	NSDNR	ACCDC Rating
Ghost Antler Lichen	*Pseudevernia cladonia*	Species of Concern			S2
Boreal Felt Lichen (Atlantic)	*Erioderma pedicellatum*	Endangered	Endangered	Red	S1S2
Coast Pepper-Bush	*Clethra alnifolia*	Species of Concern	Vulnerable	Red	S1S2
Eastern White Cedar	*Thuja occidentalis*		Vulnerable	Red	S1S2
Long branched Frostweed	*Helianthemum canadense*		Endangered		S1
Moonwort Grape-Fern	*Botrychium lunaria*			Red	S1
Wiegand's Wild Rye	*Elymus wiegandii*			Red	S1
Seabeach Groundsel	*Senecio pseudoarnica*			Yellow	
Larger Canadian St. John's Wort	*Hypericum majus*			Red	S1
Cut-Leaved Coneflower	*Rudbeckia laciniata*			Yellow	S2
Hairy Lettuce	*Lactuca hirsuta*			Yellow	S2

Ghost Antler Lichen (*Pseudevernia cladonia*)

The Ghost Antler Lichen has been federally legislated as a Species of Concern. The species is a chalky white, finely branched macrolichen occurring on twigs of conifers in cool montane and coastal spruce-fir forests in eastern North America. It is very patchily distributed in New Brunswick and Nova Scotia, probably owing to dispersal limitations. In Nova Scotia and New Brunswick, some population losses are attributable to logging and housing development. The severity of the threats is offset by the abundance of the species over a broad area and potential discovery of large populations on some mountain tops in Quebec. It is possible that this species could occupy the study area as the nearest sighting was at a distance of 23km. Therefore it is recommended that a more detailed screening be conducted on a project by project basis.

Habitat Requirements:

- Prefers areas that are cool, humid, or coastal coniferous forests (balsam fir and red spruce) with high occurrences or fog or cloud cover;
- Occurs frequently in mature or over mature forest;
- Logging operations and land developments have been a key reason for the decline in populations; and
- It does not respond well after major disturbances, and has limited dispersal capabilities for regeneration.

Coast Pepper-Bush *(Clethra alnifolia)*

Coast pepper-bush is both federally and provincially legislated as a vulnerable species of special concern. Its preferred habitat includes the shores of lake headwaters, sandy woods, swamps and thickets. There is one recorded observation of the species within 100km of the project site, approximately 25km away (ACCDC, 2010). The likelihood of this species residing within the project area is moderate.

Habitat Requirements:

- Found in wet woods, thickets, wetlands, and near lakes and streams;
- Is tolerant to brackish waters, but needs moist soils for establishment; and
- Sensitive to natural disturbances such as wind and ice scour.

Larger Canadian St. John's Wort *(Hypericum majus)*

The larger Canadian St. John's wort has been listed by NSDNR as a Red species. It has been sighted in both Halifax County and Victoria County, and was recorded less than 25km away from the study area. Its preferred habitat consists of wet or dry open soil. The likelihood of this species residing within the project boundaries is moderately high due to the presence of wetland complexes scattered throughout the site.

Habitat Requirements:

- Grows along ponds, lakesides (low, wet areas), calcareous soils;
- Associated with riparian habitats (often completely submerged); and
- Threats to populations include the creation of dams, destruction of wetlands, and competition from invasive species.

Boreal Felt Lichen, Atlantic Population (*Erioderma pedicellatum*)

The boreal felt lichen is both federally and provincially legislated as endangered. The lichen prefers to grow on the branches or stems of conifers such as balsam fir, black spruce, or white spruce. On rare occasions, it can also be found on red maple. The lichen has a bluish gray appearance and is usually 2-5cm in diameter. There was one observation of this species within 12 km of the project site and multiple other sightings within 20km of the project site.

Habitat Requirements:

- Found only in mature or over-mature forests, primarily balsam fir or black/white spruce;
- Prefers to grow on slopes with a northern aspect with cool and moist conditions throughout the year;
- Development of new lichen is dependent on the relationship between the spores of adult lichen and a species of liverwort; and
- Very sensitive to acid rain and air pollutants, both of which are possible causes of the drastic decline in numbers. Deforestation is another threat to the survival of this species.

2.2.3 Invertebrates

23 species of invertebrates, nine from the Order Odonata and 12 Lipodoptera and one marine species from the Unionidae family as species of concern were identified as having been seen in the area, or as

having habitat preferences similar to what is found in the study area (Table E5.1.3). One species is described below.

Table E5.1.3: Invertebrate Species of Interest

Common Name	Scientific Name	COSEWIC	NS Endangered Species Act	NSDNR	ACCDC Rating
Monarch	*Danaus plexippus*	Species of Concern		Yellow	S2B

Monarch Butterfly (*Danaus plexippus*)
The monarch butterfly was federally legislated in 1997 and was reconfirmed in 2001 as a species of Special Concern. Although the monarch population is quite abundant over its entire range, it's highly restricted and vulnerable in its winter range. Its preferred habitat consists of open habitats such as fields, meadows, marshes and roadsides. Based on ACCDC records the closest observed sighting of the species was approximately 26km away from the site. The likelihood of this species residing in the project site is moderately low.

Habitat Requirements:

- Found in open fields and meadows that specifically contain milkweed and flowering plants which are a source of food for Monarch larvae and adults; and
- The eradication of milkweed can threaten the status of Monarchs. Milkweeds can be poisonous to livestock.

2.2.4 Fish

Fish species of interest within the study area have been assessed based on desktop surveys, literature review and discussions with representatives from the Department of Fisheries and Oceans and the Provincial Department of Fisheries and Aquaculture, Inland Division.

Three species of concern were identified as being within certain distances of the study area and have been discussed below (Table E5.1.4).

Table E5.1.4: Fish Species of Concern

Common Name	Scientific Name	COSEWIC	NS Endangered Species Act	NSDNR	ACCDC Rating
Atlantic Salmon	*Salmo salar*	Endangered	N/A	Red	S2
Atlantic Salmon (Inner Bay of Fundy)	*Salmo salar*	Endangered	N/A	Red	S2
Striped Bass	*Morone saxatilis*	Threatened	N/A	Red	S1

Atlantic Salmon (*Salmo salar*)

The Atlantic salmon was listed by COSEWIC as an endangered species in 2001. Atlantic salmon are anadromous, spending part of their life feeding and growing during long migrations in the sea, and then return to reproduce in the fresh water stream where they hatch. Atlantic salmon that are ready to spawn begin moving up rivers from spring through fall. They often return to sea immediately before winter or remain in the stream until spring. The young salmon that emerge in April to July migrate down-estuary in the spring. Records of sightings indicate that this species is likely present within close proximity of the study area.

Atlantic Salmon – Inner Bay of Fundy (*Salmo salar*)

Inner Bay of Fundy Atlantic salmon have been listed as endangered under the Species at Risk Act (SARA) since 2003 and are now at risk of becoming extinct. Their rapid decline has been attributed to low marine survival and possibly factors such as tidal barriers and commercial salmon farms. A recovery strategy has been developed and includes identification of their critical habitat. Inner Bay of Fundy Atlantic salmon are not typically found within the vicinity of the study area, but have been sighted within 24 km. Their presence there is still unlikely.

Habitat Requirements:

- Various requirements depending on the stage of development;
- For rearing of eggs and young, a substrate of gravel or cobble with well-oxygenated water with temperatures below 10 °C;
- The egg and alevin/fry stage is highly susceptible to sedimentation in the watercourses (suffocation);
- Poor logging practices (insufficient watercourse buffering) and agriculture (pesticide runoff) heavily impact Atlantic salmon numbers;
- Juveniles tolerate warmer waters (less than 25°C), but still require well-oxygenate and clean water. Prefer water depths of 10 – 61cm and velocities of 30-92 cm/sec. As they develop into the smolt stage, access to the ocean is required; and
- Adults require access to their natal grounds for spawning. Prefer water temperatures below 23°C and dissolved oxygen content above 5 ppm.

Striped Bass (*Morone saxatalis*)

Striped bass populations have been listed by NSDNR as a Red species and are considered threatened under COSEWIC. Shubenacadie River is one of the few rivers in Atlantic Canada with a self-sustained striped bass population. The Stewiacke River, a large tributary to the Shubenacadie is the main spawning habitat for this species. The lead cause in population decline for this species has been attributed to habitat change. The likelihood of this species residing near the study area is low, as the nearest record is 31 km.

Habitat Requirements:

- Inhabit coastal surge, inshore bars and reeds, tidal rips, bays and estuaries;
- Habitat loss or alterations such as dykes, culverts, and causeways greatly affect spawning, rearing, and wintering habitat;
- Highly successful spawning has occurred in waters with:
  - Suitable current (> 30 cm/s to maintain egg suspension);

- Salinity (0.70 – 1.5 ppt, < 5 ppt);
- Water temperatures below 22°C;
- Dissolved oxygen (> 3 mg/l); and

- As the striped bass proceeds through its life stages (egg - larvae - juvenile-adult), It becomes more tolerant to this factors.

Fish Species not of Concern

Other fish species of interest that are not considered to be of concern of being endangered by the federal or provincial regulatory bodies and are known to reside in the project site include: brook trout (*Salvelinus fontinalis*), white perch (*Morone Americana*), rainbow smelt (*Osmerus mordax*), smallmouth bass (*Micropterus dolomieui*), white sucker (*Catostomus commersoni*), and golden shiner (*Notemigonus crysoleucas)* (T. Marshall, personal comm.. December, 2010).

2.2.5 Mammals

Three species of concern were identified as having been seen in the 100km area, although only one species was within 30km of the study area.

Table E5.1.5: Mammal Species of Concern

Common Name	Scientific Name	COSEWIC	NS Endangered Species Act	NSDNR	ACCDC Rating
Moose	*Alces alces*	Endangered	Endangered	Red	S1

Moose (*Alces alces*)

Moose in Nova Scotia are comprised of two genetically different and distinct populations i.e. the mainland population and the Cape Breton population. The mainland population is comprised of less than 1000 individuals. The mainland moose is listed by the *Nova Scotia Endangered Species Act* as Endangered; and hunting of the mainland moose is illegal.

Moose inhabit boreal forests across Canada and northern United States and prefer near-climax vegetation with shrubby growth. Moose feed on aquatic plants in summer and the preferred food in the winter includes certain hardwoods and balsam fir. The closest sighting of moose to the study area was 30km away, most likely away from populated areas.

Habitat Requirements:

- Prefer mature mixed forests (providing cover and food source) with minimal human presence;
- Correlation between deciduous shrub abundance and moose presence; and
- Wetlands and areas with aquatic vegetation are important habitats in the summer periods.

2.2.6 Reptiles

Only one species of reptile were observed near the study area.

Table E5.1.6: Reptile Species of Concern

Common Name	Scientific Name	COSEWIC	NS Endangered Species Act	NSDNR	ACCDC Rating
Wood turtle	*Clemmys insculpta*	Threatened	Vulnerable	Yellow	S3

Wood Turtle (*Clemmys insculpta*)
The wood turtle has been federally legislated as a species of concern and provincially as a vulnerable species. The closest observation of the species recorded under ACCDC to the Project site was less than 9km. The wood turtle typically congregates in small populations of up to 100 individuals near riparian habitat characterized by high depositional sandy banks that are scoured by winter and spring floods. The presence of this species within the study site is moderate and impacts should be evaluated on a project to project basis.

Habitat Requirements:

- Prefer to live in riparian habitats or floor plains;
- Three main necessities to wood turtles habitats are a river or stream, sandy substrate for nesting purposes, and a forested area;
- Prefer clean streams and rivers with a hard substrate, not a clay or mud; and
- Spend a lot of time on land in the summer in wet to moist hardwood or coniferous forests with dense understories.

2.3 Contraints to Development

The upland vegetation, the forest associations and plant communities found in the study area are common throughout the Eastern Shore. While this vegetation is not rare, it is sensitive to disturbance. The forest cover protects the coastal and lake environments from pollution. The primary constraints of the study area for residential development from a habitat perspective would be disturbance to the coastal and lake environments as a result of loss of forest cover on the uplands.

The management of sediment transport from highly erodable thin soils on the forested uplands down onto the surrounding estuarine environments will be critical in protecting the coastal and lake habitats. Slope and aspect mapping are useful tools in identifying where development might occur to minimize erosion. Clear cutting, and other forest management practices in conjunction with how land is cleared and developed should be scrutinized very carefully prior to development. This is particularly critical in areas where pyritic slates are found (see Figure #). Where the bedrock is exposed leaching of heavy metals and aluminum as well as acid runoff can occur damaging downstream environments. Wildlife in aquatic environments is particularly susceptible to acidification. While the eggs of many aquatic organisms are directly affected, reduced productivity can also affect species higher up the food chain. Salmon populations are also particularly sensitive to increased acidification.

Regeneration of forest environments on areas where land is disturbed or burned is difficult once sources of nutrients have been removed. Consideration should also be given to how contaminants from development (i.e. salt runoff from highways and streets) will be managed will help preserve the fragile

coastal and lake environments. Development guidelines and a development ethic should be adopted in ensuring that development in this area can occur alongside the fragile coastal and lake environments that attract people to settle in the area.

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APPENDIX F

Component Study – Evaluation of Alternate Wastewater Servicing Options

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CHAPTER 1 INTRODUCTION

Residents of the community of Porters Lake, through their involvement in a community focus group, have indicated that future growth within the community (outside of the Core Area) should be by means of small developments serviced by individual or cluster water and wastewater services, and not by the installation of central water and wastewater services.

They suggested it should include:

1. Single family homes on individual lots.
2. Cluster systems.
    a. 10 unit developments.
    b. 20 unit developments.

Two scenarios were evaluated for servicing the development concepts using:

- Conventional on-site sewage disposal systems; and
- Packed bed biological filtration systems.

Conventional on-site sewage disposal systems in Nova Scotia refer to contour type systems (C1, C2, and C3), Mounds (M), Area (A) beds, Trench (T) beds, and Peat (P) Treatment systems. The use of the systems is well documented in Nova Scotia and is regulated by Nova Scotia Environment using prescriptive regulations supported by the On-site Sewage Disposal Systems Technical Guidelines, 2009 (Technical Guidelines).

For multi unit developments, however, the use of contour and Mound type systems typically results in a requirement for large land areas, and the use of packed bed biological systems has provided a suitable alternate. The most common type of packed bed biological system includes the re-circulating sand (RSF) and re-circulating textile filter (RTF). The RTF uses the smallest footprint, and was therefore selected as the packed bed biological system to be evaluated.

The purpose of this component of the project is to evaluate the wastewater development concepts in regards to the following:

- System requirements;
- Probable construction costs; and
- Operations and Maintenance issues and costs.

The evaluation was carried out with reference to the Nova Scotia Environment On-site Sewage Disposal Systems Technical Guidelines, 2009 (Technical Guidelines) and the HRM Guide to Open Space Design Development in Halifax Regional Municipality.

The evaluation will include single family homes, condominiums, and rental/condo units for seniors. The requirements for commercial developments, because they are so variable, will be addressed separately.

1.1 On-Site Sewage Disposal Systems

The construction of on-site sewage disposal systems is typically administered by provincial regulations. In Nova Scotia, the regulations are the prescriptive Regulations Respecting On-Site Sewage Disposal Systems under the jurisdiction of Nova Scotia Environment (NSE).

The term "on-site sewage disposal" refers to the disposal of domestic wastewater into a system which includes a septic tank and a soil adsorption system. The septic tank provides a quiescent chamber that allows solids to settle, and the soil adsorption system provides filtration of the septic tank effluent prior to its release into the receiving environment.

On-site sewage disposal systems are typically designed to accommodate peak day uses and have to be located to maintain specific minimum required separation distances as outlined by the regulations.

The design of on-site sewage disposal systems must include the assessment of site and soil conditions. Basic considerations in the assessment of a site for suitability to install an on-site sewage disposal system include the following:

- Slopes and surface drainage;
- Depth to bedrock;
- Changes in grade;
- Proximity to watercourses and wetlands;
- Traffic areas;
- Type of natural vegetation;
- Well locations;
- Soils assessment; and
- Depth to groundwater elevation.

The assessment of soil conditions is the most important consideration in the site assessment process, and consists of the use of a test pit to determine the type and depth of permeable soil.

The soil and site conditions, along with the estimated wastewater flows, allows for the selection and design of the appropriate on-site sewage disposal system (s) for the site. Typical system options include the following:

- C1 Contour trench;
- C2 Contour trench;
- C3 Contour trench;
- Mound;

- Area Bed;
- Multiple Trench; and
- Peat Treatment.

The Technical Guidelines indicate that a pump chamber (siphon if grades permit) is required when using a C3, M or any system longer than 30 m when end fed or longer than 45 m if centre fed.

Options for the discharge of septic tank effluent from septic tanks servicing existing single family homes with malfunctioning on-site sewage disposal systems s include the conventional systems as outlined for new homes, plus Sloping Sand Filters (SSF) and more recently, re-circulating textile filter (RTF) systems. A site assessment is required to determine if a conventional system can be utilized, and if not, the SSF or the RTF can be considered for use.

When using a SSF or a RTF, NSE requires a subsurface discharge if possible. If conditions do not allow for such, a "ditch discharge" may be considered. Disinfection may be required subject to the sensitivity of the discharge point. (The local representative of a RFT system has requested that NSE approve a reduced size disposal field for the RFT system, but a decision is still pending).

1.2 Packed Bed Biological Filtration Systems

A packed bed system refers to a biological filtration unit. These systems utilize naturally occurring microorganisms attached to some form of filtration media to biodegrade the contaminants present in the primary effluent during their cellular synthesis. Packed bed systems will vary in size based on allowable loading rates for varying media types as well as the mode of operation and discharge criteria. Currently used packed bed systems include the following:

- Sand Filters (SF);
- Textile Filters (TF); and
- Peat Filters (PF).

Following are brief descriptions of each of the systems.

1.2.1 Intermittent Sand Filter (ISF)

An intermittent sand filter (ISF) utilizes a biologically activated sand bed to treat primary septic tank effluent. The septic tank effluent is pumped to the distribution system that is composed of perforated pipe placed in gravel. The wastewater is spread evenly over the surface of the bed at a rate of approximately 40.7 L/d per square metre of sand bed, and then slowly percolates unsaturated through the sand where it is biologically treated. An effluent collection system beneath the sand directs the filtered effluent to a disinfection unit. The disinfected filter effluent can then be discharged to the ultimate disposal area. ISFs can be installed underground and planted over with lawn or flowers to blend into the existing landscape. Filter effluent is typically around 10 mg/L BOD and TSS and is typically disinfected and direct discharged to a watercourse.

1.2.2 Re-circulating Sand Filter (RSF)

The re-circulating sand filter (RSF) is a wastewater treatment system for producers of small to medium wastewater flows. The RSF design includes the following:

- Septic tanks;
- Re-circulation tank and pumps;
- Multi-cell sand filter bed; and
- Effluent disinfection and discharge.

The re-circulating sand filter uses an unsaturated, biologically activated sand bed to treat septic tank effluent. A high quality effluent is produced and additional treatment may be achieved using dispersal beds or constructed wetlands.

Septic tank effluent is combined with re-circulated sand filter effluent in the recirculation tank and pumped to the sand filter system which is designed to accommodate loading rates ranging from 125–200 L/m^2/d. The effluent is distributed throughout the filter bed and then percolates down through 600 mm of sand media where naturally occurring micro-organisms biodegrade effluent organic particles and physical filtering action occurs reducing the amount of suspended solids. Multi-cell design allows for one cell to be withdrawn from service by loading the other two at a higher rate which is acceptable for a short period of time.

The effluent is collected by a piped underdrain gravity system and conveyed back to the recirculation tank where a splitter valve within the recirculation tank works in conjunction with adjustable timer controls to maintain a constant recirculation rate regardless of flow. This flow splitting device returns a predetermined volume of flow to the sand filter bed and diverts the balance to be disinfected prior to discharge.

1.2.3 Re-circulating Textile Filter (RTF)

The re-circulating Textile Filter (RTF) is similar to the RSF with the exception that textile or synthetic media is used instead of sand. There are several proprietary textiles or synthetic media systems available, each with their inherent advantages and disadvantages.

The use of patented media reduces the quality control risks associated with sand. Synthetic and textile media have been engineered and manufactured to improve biological activity by providing high porosity, large available surface area, improved air flow characteristics and ease of microbial attachment. This allows the filter to be loaded at a higher loading rate than a re-circulating sand filter and therefore require a smaller footprint. Synthetic and textile media, however, are more susceptible to upset caused by misuse and/or the discharge of fats and grease.

1.2.4 Peat Filter

A Peat Filter (PF) system is very similar to an ISF with the exception that a biologically activated peat moss bed is used instead of sand to treat septic tank effluent. Two patented household units are approved for use in Nova Scotia, and therefore the use of peat is also considered to be a conventional system.

The Shaw Peat Modular On-Site Wastewater System consists of a septic tank with effluent filter, distribution box, and completely assembled peat modules. Two types of Shaw Peat Modules are available, the Subsurface Discharge Module and the Off-Site Discharge Model. The Modules are constructed of concrete, weigh approximately 7,500 kg, and therefore a large crane is required to move and place the units. One Module unit is capable to treating up to 350 L/day, and therefore a typical three bedroom home would require the installation of three modules.

The EcoFlo Biofilter consists of a septic tank with effluent filter, and a relatively small fibreglass shell and a filter using specially treated peat moss. Its' design allows it to treat up to 1000 L of wastewater per day. Effluent from the filter can be discharged by infiltration into the soil or discharged off-site. The lifespan of the filtering media is indicated to be 10 years (under normal use), and its' replacement is carried out with the same type of truck used to empty septic tanks.

The loading rate for a peat filter is similar to that of the ISF, and therefore the land area required is similar to that of an ISF. Peat cannot be used a re-circulating mode, and therefore the option of using peat is limited to servicing small wastewater flows.

The RSF and RTF options have smaller footprints than the ISF, and the RTF has the smallest footprint of all. The RTF will be evaluated and compared to the on-site sewage disposal system.

1.3 On-Site Conditions in Study Area

The HRM Report "On-Site and Small Scale Wastewater Management Study" includes an On-site Suitability map that indicates that the soil in the Study Area are considered to be Class 1 (most suitable). The mapping refers primarily to the drainage (permeability) of the soil, however, and does not discuss the depth of permeable soil, which is a key parameter when determining the required lot areas and required types of on-site sewage disposal systems.

As indicated previously, detailed site and soil assessments are required at the specific project sites. Experience in the area has indicated that the depth of permeable soil is very variable, and on this basis, the requirements for conceptual developments, for condominiums and rental /condos for seniors, will be determined based on two depths of permeable soil: i.e. 1.5 m of permeable soil and 450 mm of permeable soil.

CHAPTER 2 SYSTEM DESIGN FLOWS

2.1 Single Family Homes

The design flow requirements as presented in Table 2.3 in the Technical Guidelines are indicated in Table 2.1.

Table 2.1: Design Flows for Single Family Homes

Dwelling Type	Average Daily Flow (Lpd)
3 bedroom home	1,000
3 bedroom home with high use fixtures	1,200
4 bedroom home	1,350
4 bedroom home with high use fixtures	1,500

For purposes of this evaluation, a design flow of 1350 Lpd (4 bedroom home) will be used.

2.2 Clusters

The minimum design flows from multi unit residential dwellings such as cluster systems, apartments or condominiums as presented in Appendix F, Table F2, of the Technical Guidelines are indicated in Table 2.2. In addition, Section 5.13.3 of the Technical Guidelines indicates that a minimum increase of 15 % shall be included in the design flow for a cluster system to cover any unforeseen conditions.

Table 2.2: Multi Unit Residential Flows

Unit Type	Average Daily Flow (Lpd)
For the first 3 bedroom unit or less	1,000
For each additional unit the following flow rates shall be utilized:	
• 1 bedroom unit	500
• 2 bedroom unit	750
• 3 bedroom unit	1,000
• 4 bedroom unit	1,500
• Each addition bedroom	500

For purposes of this evaluation, it will be assumed that all units will be 3 bedrooms each. The design flow will therefore be as follows:

- 10 unit development - 10,000 Lpd +15 % = 11,500 Lpd; and
- 20 unit development - 20,000 Lpd + 15 % = 23,000 Lpd.

CHAPTER 3 SEPTIC TANK CAPACITIES

3.1 General

Minimum required septic tank capacity requirements are outlined in the Technical Guidelines. The requirements are typically based on minimum hydraulic retention times and septic tank pump out frequencies of every 3 to 5 years. Suppliers of proprietary RTF wastewater treatment equipment, however, have requirements that exceed these requirements, based on a combination of requirements for more hydraulic retention times and/or less frequent septic tank pump outs.

Precast septic tanks are constructed in Nova Scotia with specific capacities, and capacities readily available in HRM include the following:

- Variations of 2,725 L to 2,875 L;
- 3800 L;
- Variations in the vicinity of 4500 L;
- 7,300 L;
- 9,100 L;
- 11,400 L;
- 13,600 L; and
- 15,900 L.

Combinations of these standard sizes may be used to achieve the required capacity. As an option, however, septic tanks of a required capacity could be designed by a qualified engineer and constructed in place. In any event, two compartment tanks are recommended for large systems (systems servicing multiple units).

3.2 Conventional On-Site Sewage Disposal Systems

3.2.1 Single Family Homes

The minimum requirements for the capacity of septic tanks for homes as presented in Table 3.1 of the Technical Guidelines are indicated in Table 3.1.

Table 3.1: Minimum Capacity of Septic Tanks for Homes

Number of Bedrooms	Minimum Liquid Capacity (L)
Up to 3	2,800
4	3,300
5	4,500

Discussions with on-site sewage disposal system installers, and with NSE personnel, indicate that 4,500 L septic tanks are typically used for up to a 5 bedroom home, and therefore the use of a 4,500 L septic tank is assumed for purposes of this project.

3.2.2 Custers

The Technical Guidelines indicate that septic tank capacities for larger systems (systems for other than a single family home) are to be determined as follows:

- For average daily flows up to 9,000 Lpd: V = 2 Q; and
- For average daily flows of 9,000 Lpd or more: V = 9,000 +Q.

Where V= tank volume in L, and Q = average daily flow in Lpd.

The required tank volume for the proposed developments is therefore as follows:

- 10 unit development - 11,500 Lpd requires 20,500 L septic tank capacity; and
- 20 unit development - 23,000 Lpd requires 32,000 L septic tank capacity.

3.3 RTF Technologies

3.3.1 Single Family Homes

NSE does not currently allow the use of RTF technologies on new developments, but does allow the technology for the rehabilitation of malfunctioning on-site sewage disposal systems on existing lots. Septic tank requirements for a RTF generally include a 5,700 L tank, which exceeds the Guidelines requirements. In addition, a 2,725 L tank is typically used for a re-circulation tank.

3.3.2 Clusters

The manufacturers of RFT technologies typically require a hydraulic retention Time (HRT) of a minimum of 2.2 days. The required septic tank volume for the proposed developments is therefore as follows:

- 10 unit development - 11,500 Lpd requires 25,300 L septic tank capacity; and
- 20 unit development - 23,000 Lpd requires 50,600 L septic tank capacity.

The re-circulation tank is typically sized to equal the daily flow. The required re-circulation tank volume for the proposed developments is therefore as follows:

- 10 unit development - 11,500 Lpd requires 11,500 L re-circulation tank capacity; and
- 20 unit development - 23,000 Lpd requires 23,000 L re-circulation tank capacity.

CHAPTER 4 PUMP CHAMBERS

4.1 Single Family Homes

The Technical Guidelines indicate that the required capacity of a pumping chamber servicing a single family home is to be no less than the daily flow. Typical capacities for precast pump chambers include the following:

- 325 L;
- 500 L;
- 1130 L;
- 1600 L; and
- 2040 L.

A 1600 L pump chamber will be assumed for a single family home.

4.2 Clusters

Duplex pumps are typically used for large systems, and therefore the pumping chamber capacity is usually reduced to provide a suitable volume for dosing between 2 and 4 times per day. A volume equal to 30 % to 50 % of the daily flow will be assumed. Septic tanks are typically used for pump chambers.

The required pump chamber volume for the proposed developments is therefore as follows:

- 10 unit development - 10,000 Lpd requires 4,750 L pump chamber capacity; and
- 20 unit development - 20,000 Lpd requires 9,100 L pump chamber capacity.

Required design flows, septic tank capacities, and re-circulation tank capacities, as determined previously, is summarized in Tables 4.1 and 4.2.

Table 4.1: Requirements for On-Site Sewage Disposal Systems

	Design Flow (Lpd)	Septic Tank Capacity (L)	Pump Chamber Capacity (L)
New single family	1,350	4,500	1,600*
Existing single family	1,350	4,500	1,600*
10 unit condominium	11,500	20,500	4,750
20 unit condominium	23,000	32,000	9,100
4 unit rental - seniors	3,740	7,500	1,600
10 unit rental - seniors	7,765	15,500	2,040

* Required when using C3 and Mound systems

Table 4.2: Requirements for RTF Systems

	Design Flow (Lpd)	Septic Tank Capacity (L)	Re-circulation Tank Capacity (L)
New single family	N/A	N/A	N/A
Existing single family	1,350	5,700	2,725
10 unit condominium	11,500	25,300	11,500
20 unit condominium	23,000	50,600	23,000
4 unit rental - seniors	3,740	8,230	3,740
10 unit rental - seniors	7,765	17,100	7,765

CHAPTER 5 DISPOSAL OPTIONS

5.1 Single Family Homes

Options for the discharge of septic tank effluent from septic tanks servicing new single family homes include the following conventional systems:

- Contour type systems: C1, C2, C3;
- Mound;
- Area beds;
- Trench Bed; and
- Peat System.

AS discussed previously, the selection of a disposal system requires a site assessment to determine the conditions of the lot and soil. For purposes of this investigation, it is assumed that typical systems used, and their length, to service single family homes is as follows:

- C1 – 25 m;
- C2 – 30 m;
- C3 – 30 m; and
- M – 30 m.

5.1.1 Clusters

Area bed or trench bed systems are not suitable for large developments and therefore contour or mound systems are typically used. The dimensions of the systems are determined using the following:

- Daily flow in Lpd;
- Slope in the location of the system;
- Soil Permeability; and
- Depth of permeable soil.

A detailed investigation of a specific site is required to determine soil conditions. As discussed previously, the determination of system requirements for the concept developments will be based on assumed depths of permeable soil of 1.5 m and 450 mm. The soil type will be assumed to be silty sand with a permeability of $15X10^{-6}$ m/sec, and the slope will be assumed to be 7%. The assumed types of systems will therefore be a C1 (when 1.5 m of permeable soil) and a C2 (when 450 mm of permeable soil).
The type and required lengths of on-site sewage disposal systems are as follows:

- 10 unit development (11,500 Lpd):

- 1.5 m (C1) - 191 m (adjusted to a loading rate of 60 Lpm); and
- 450 mm (C2) - 282 m.

- 20 unit development (23,000 Lpd):
  - 1.5 m (C1) - 382 m (adjusted to a loading rate of 60 Lpm); and
  - 450 mm (C2) - 564 m.

5.2 RTF Technologies

NSE prefers that effluent from RTF systems be discharge into the soil. Surface discharges are possible for large system provided that discharge criteria as established by NSE are met. Where large wetlands are available, the treated effluent may be discharged adjacent to the wetland, and allowed to flow through the rootmat towards the wetland. NSE, however, will not approve discharges to wetlands where the wetland discharges through adjacent properties. The wetland must flow directly to a provincially owned body of water (i.e. discharge to a wetland, owned by the proponent, which is adjacent to a lake would be considered by NSE), so this application has limited potential.

5.2.1 Single Family Homes

For single family homes, a conventional on-site sewage disposal system is required for disposal of the effluent. In some jurisdictions, however, a reduced sized system is allowed, and NSE has been approached by the equipment manufacturer representative to allow such in Nova Scotia. A decision is still pending.

5.2.2 Clusters

Where a surface discharge is not possible or not permitted, drip irrigation is typically considered for disposal of the effluent. Wastewater effluent is allowed to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters. A detailed soil assessment is required and suppliers of proprietary equipment provide detailed instruction on how to perform the assessment and how to determine the required area.
For purposes of this evaluation, the following was assumed:

- A loading rate of 40.7 Lpd per m^2; and
- A loading rate of 20.4 Lpd per m^2.

On this basis, the required area for a drip irrigation system was determined as follows:

- 10 unit development (11,500 Lpd):
  - A loading rate of 40.7 Lpd per m^2 – 282 m^2; and
  - A loading rate of 20.4 Lpd per m^2 – 564 m^2.
- 20 unit development (23,000 Lpd):
  - A loading rate of 40.7 Lpd per m^2 – 564 m^2; and
  - A loading rate of 20.4 Lpd per m^2 – 1128 m^2.

CHAPTER 6 MINIMUM LOT AREAS

6.1 General

Minimum lot size requirements were evaluated with reference to the Technical Guidelines and the HRM Guide to Open Space Design Development in Halifax Regional Municipality.

6.2 Technical Guidelines

6.2.1 Single Family Homes

Minimum lot areas as required in Table 2.4 of the Technical Guidelines are indicated in Table 6.1.

Table 6.1: Minimum Lot Size Requirements for Developments Utilizing On-Site Sewage Disposal Systems (1)

Depth of Permeable Soil (mm)	Minimum Lot Area (m^2)	Minimum Lot Width (m)
0 – 149	9,000	76
150 – 299	6,800	60
200 – 600	4,500	53
Deeper than 600 on a waterfront lot (2)	3,716	45
601 – 899	3,150	37
900 and deeper	2,700	37

(1) For systems with a daily flow greater than 1,500 Lpd, larger lots areas and widths may be required.

(2) A waterfront lot is a lot that contains or is proposed to contain a system in which a portion of the system is or will be located within 60 m of a surface watercourse or marine water body.

Information from the HRM On-site Report indicates that the minimum lot area required in the Study area would typically be 2,700 m^2 to 3,150 m^2, with minimum lot widths of 37 m. It should be noted, however, that NSE may require increased lot areas in multi lot subdivisions.

In addition, NSE specifies minimum horizontal separation distances between the components of the on-site sewage disposal systems and the following, to select a few:

- All lot boundaries;
- Downslope boundaries;
- Drilled wells;
- Dug wells;
- Watercourses;
- Wetlands;
- Downslope ditches;
- Municipal and/or private water distribution systems; and
- Foundation drainage systems.

The application of the required separation distances may result in increased lot size requirements.

6.2.2 Clusters

Lot size requirements for a lot to be serviced by a cluster system are determined as follows:

- For the first 1500 Lpd of design flow, or part thereof, the lot area shall be as indicated in Table 6.1 above;
- For every design flow increase of 1500 Lpd, or part thereof, the lot shall be increased a minimum of one half the lot size requirement in Table 6.1;
- Notwithstanding the above, the lot must have sufficient area and width to accommodate the proposed cluster system, a location for a replacement cluster field, roadways, structures, and water supply; and
- All minimum clearance distances shall be met.

Using assumptions for the depth of permeable soil, the minimum lot size requirements for condominium is as follows:

- 10 unit development (11,500 Lpd):
  - 1.5 m - 12,150 m^2; and
  - 450 mm - 20,250 m^2.
- 20 unit development (23,000 Lpd):
  - 1.5 m - 22,950 m^2; and
  - 450 mm - 38,250 m^2.

6.3 Guide to Open Space Design Development in Halifax Regional Municipality

The Guide to Open Space Design Development in Halifax Regional Municipality indicates minimum lot size requirements as follows:

The Hybrid Open Space Design Development preserves open space by restricting the area for lawns, pavement and buildings to a maximum of 20 % of the lot. All of the open space within these subdivisions, except parkland, is located on large individually owned lots. The maximum density of this form of development is 1 unit per hectare.

The Classic Open Space Design Development preserves culturally and environmentally sensitive areas by clustering smaller lots on a maximum of 40 % of the site and preserving 60 % of the overall development as common open space. The maximum density of this form of development is a unit per 4,000 square meters.

CHAPTER 7 PROBABLE CONSTRUCTION COSTS

As previously indicated, the HRM Report "On-Site and Small Scale Wastewater Management Study" includes an On-site Suitability map that indicates that the soil in the Study Area are considered to be Class 1 (most suitable). Soil conditions, however, are known to vary from site to site, and therefore the probable construction costs for systems will be influenced by soil and site conditions. Probable construction costs for systems servicing individual lots are indicated in Table 7.1.

Table 7.1: Probable Construction Costs for Systems for Single Family Homes

System	Probable Construction Costs ($)
C1	4,000 - 6,000
C2	8,000 - 12,000
C3	12,000 - 15,000
M	17,000 - 22,000
Peat*	20,000 - 25,000
SSF*	12,000 - 20,000
RTF*	20,000 - 25,000

* Engineering fees are not included in the estimate, but the services of a design engineer will be required to design the systems.

Probable construction costs for the servicing options for condominium and rental unit developments were determined for on-site sewage disposal systems (C1 and C2), and for RTF technologies. Costing includes 25 % for engineering fees and contingencies. The probable construction costs are provided in Table 7.2.

Table 7.2: Probable Construction Costs for Large Systems

	On-site (C1)	On-site (C2)	RTF
10 unit Cluster	$47,800	$114,400	$112,400
20 unit Cluster	$91,900	$227,500	$199,700

CHAPTER 8 OPERATIONS AND MAINTENANCE ISSUES

8.1 Single Family Homes

The septic tanks for single family homes should pumped out every 3 to 5 years. Where pumps are used, provision should be made to replace the pump every 10 years.

Septic tank pumping costs are currently in the vicinity of $300. The cost of a pump will range from $500 to $1,000.

Where an RTF is used, NSE currently does not classify the unit, but does require that the system be maintained by a certified person. The certified person would typically perform yearly maintenance on the system, and would address any operational issues on an "as required" basis. A "certified" person would require specialized training for the RTF systems and would typically be a certified operator as approved by NSE. The use of RTF technology at the single family level is new to Nova Scotia, and therefore there is no maintenance history. The cost of annual maintenance, including the cost of a certified person, is therefore assumed to range from $500 to $1,000 per year.

8.2 Multiple Unit Development

Multiple unit developments include the cluster systems.

8.2.1 On-site Sewage Disposal

Septic tanks for large multiple unit developments should be pumped out every 3 years. Typical costs for pumping out septic tanks are as follows:

- 4,500 L - $300;
- 9,100 L - $600; and
- 13,600 L - $900.

In addition, the pump chamber and the area of the disposal field should be inspected every 6 months by a qualified installer to ensure that the system is performing as required. Of note would be the inspection of the pump chamber to check for sign of infiltration, and the inspection of the disposal system to check for evidence of system erosion and /or leakage. This type of inspection can be carried out by a licensed septic tank installer, a QP1, or a QP2. The assumed cost is $500 tom $1,000 per year.

8.2.2 RTF Technologies

Septic tanks for large multiple unit developments should be pumped out every 3 years. Typical costs for pumping out septic tanks are as follows:

- 4,500 L - $300;
- 9,100 L - $600; and
- 13,600 L - $900.

NSE requires that RTF facilities servicing multiple units be classified, and be operated by a certified operator. A Permit to Operate is required from NSE, and the Permit will indicate the monitoring and reporting requirements. It can be assumed, however, that quarterly monitoring for parameters such as BOD, SS and bacteria would be included.

Options for the operations and monitoring of RFT units include the following:

- Municipal operations;
- Private contractor(s):
  - Contract for Individual RTF facilities; and
  - Contract for a group of RTF facilities.

The operation and maintenance costs for RTF units will vary considerably depending on the number of units, and whether public or private operators are utilized.

Experience to date indicates the packed bed biological filtration beds currently in use in HRM are privately operated. Annual maintenance costs generally range from $3,000 per year for a facility with a design flow of 9,100 Lpd to $10,000 per year for a facility with a design flow of 135,000 Lpd, not including the replacement of equipment.

The filter fabric used in the RTF can be cleaned and is considered to have a life cycle of more than 30 years. An allowance, however, should be made to replace pumps on a 10 year cycle, at an assumed cost of $500 per year.

Economies of scale may be possible if an operator is responsible for a number of facilities located in the area. For a large number of facilities in an area, however, the option of using public sector operators will most likely be more cost effective.

CHAPTER 9 COMMERCIAL DEVELOPMENTS

Commercial developments can include uses small wastewater generators such as small retail stores without public washroom to large wastewater generators such as restaurants and department stores with public washrooms.

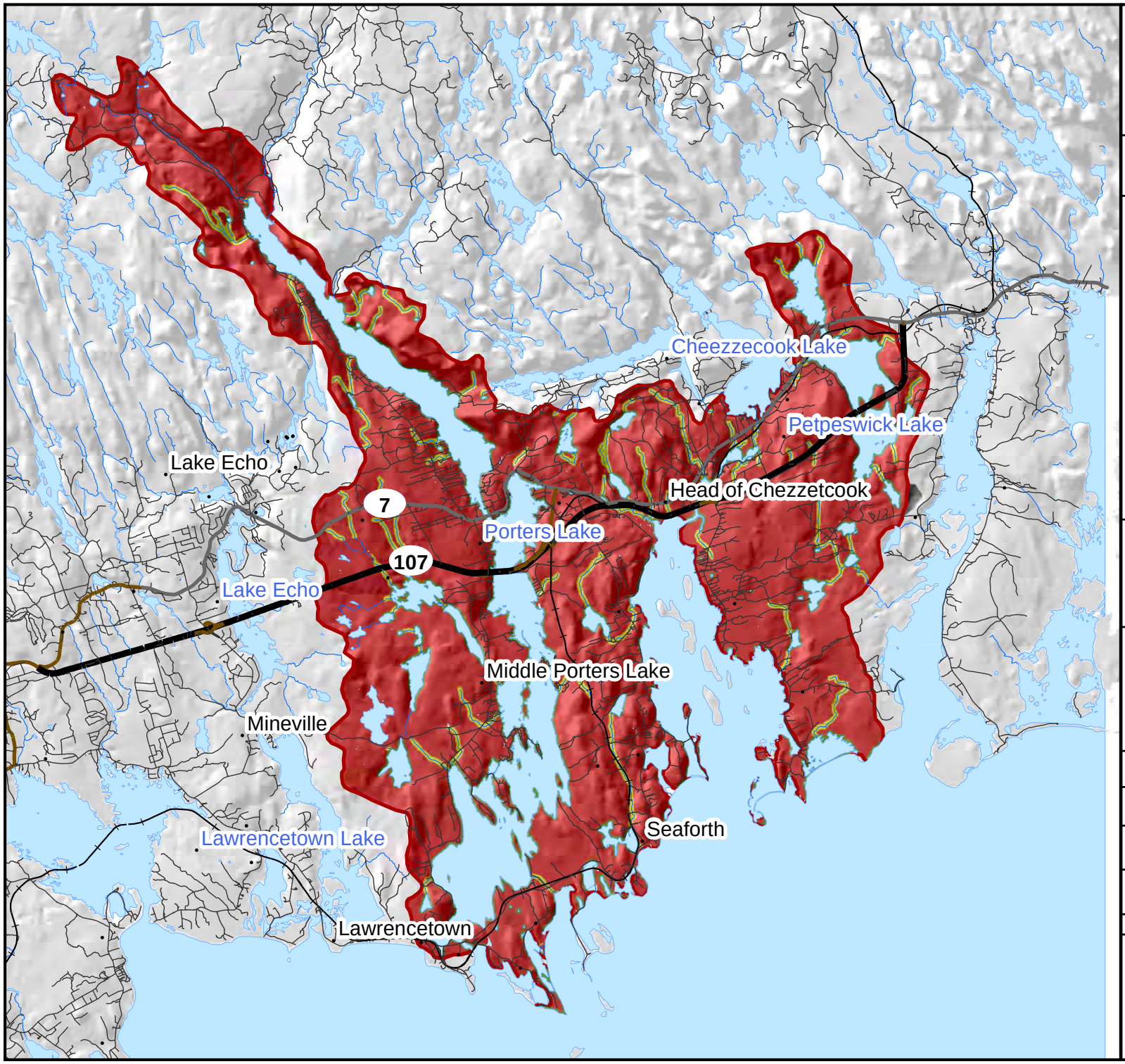
Design flows will vary with the proposed uses, and the required capacity of wastewater systems for commercial uses will vary from system equal to those used to service single family homes to those equal to service 20 unit condominium projects. Space requirements for commercial projects will have to consider the requirements for the delivery and shipping of supplies, and for customer parking, in addition to the typical space requirements associated with a residential development.

The location of the septic tanks and disposal area, in relation to the location of the building, will determine the dimensions of the conveyance systems. Depending on grades at the site, the locations of the septic tanks and disposal area will vary. The use of multiple buildings may require a wastewater collection system. In cases where the collection system is greater than 200 m, NSE requires that infiltration be taken into account when determining the wastewater loadings.

The cost of a wastewater to service a commercial building cannot be determined without knowing the details of the systems. It can be determined, however, based on design flows that the costs could be in the vicinity of $10,000 for a very small commercial development to as much as $200,000 for a development of 20,000 Lpd.

APPENDIX G

Component Maps – Land Desirability



HALIFAX
REGIONAL MUNICIPALITY

Lake Echo Watershed/Servicing Study

Study Area

View

- Ocean Front/ Lake Front
- Ocean/Water View/River Front
- No Water Views
- Rivers
- Streets
- Trunk Highway
- Divided Highway
- Arterial
- Collector
- Railroad

CBCL LIMITED
Consulting Engineers

Views

Drawn: VF	**Date: May 2012**
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Appendix G

Notes:

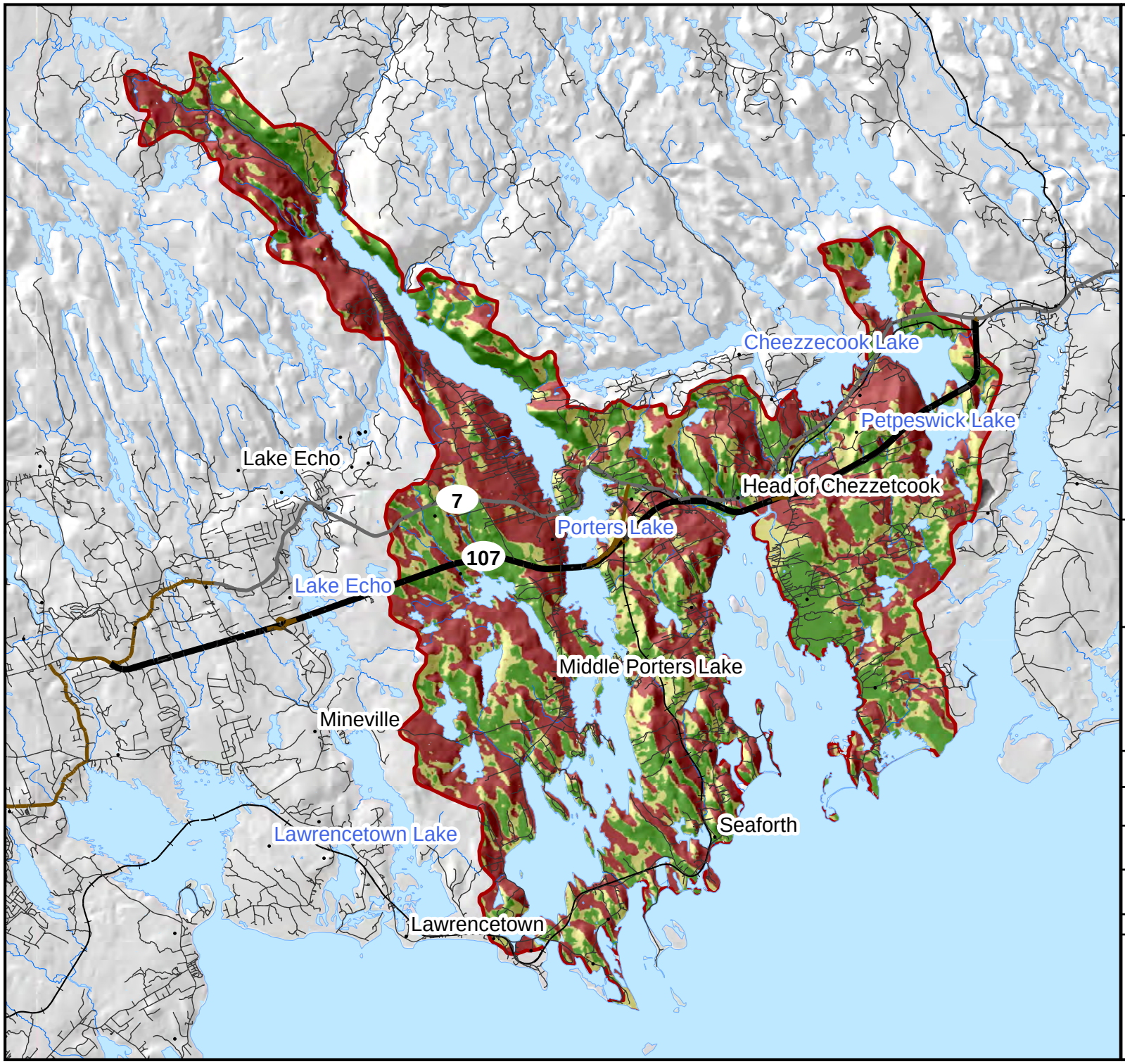
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Linear Unit: Meter

N W E S

0 1,000 2,000 4,000 Meters

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HALIFAX
REGIONAL MUNICIPALITY

Porters Lake Watershed/Servicing Study

Study Area

Aspect

- South, South West
- Southeast, West
- None

Rivers
Streets
Trunk Highway
Divided Highway
Arterial
Collector
Railroad

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Aspect

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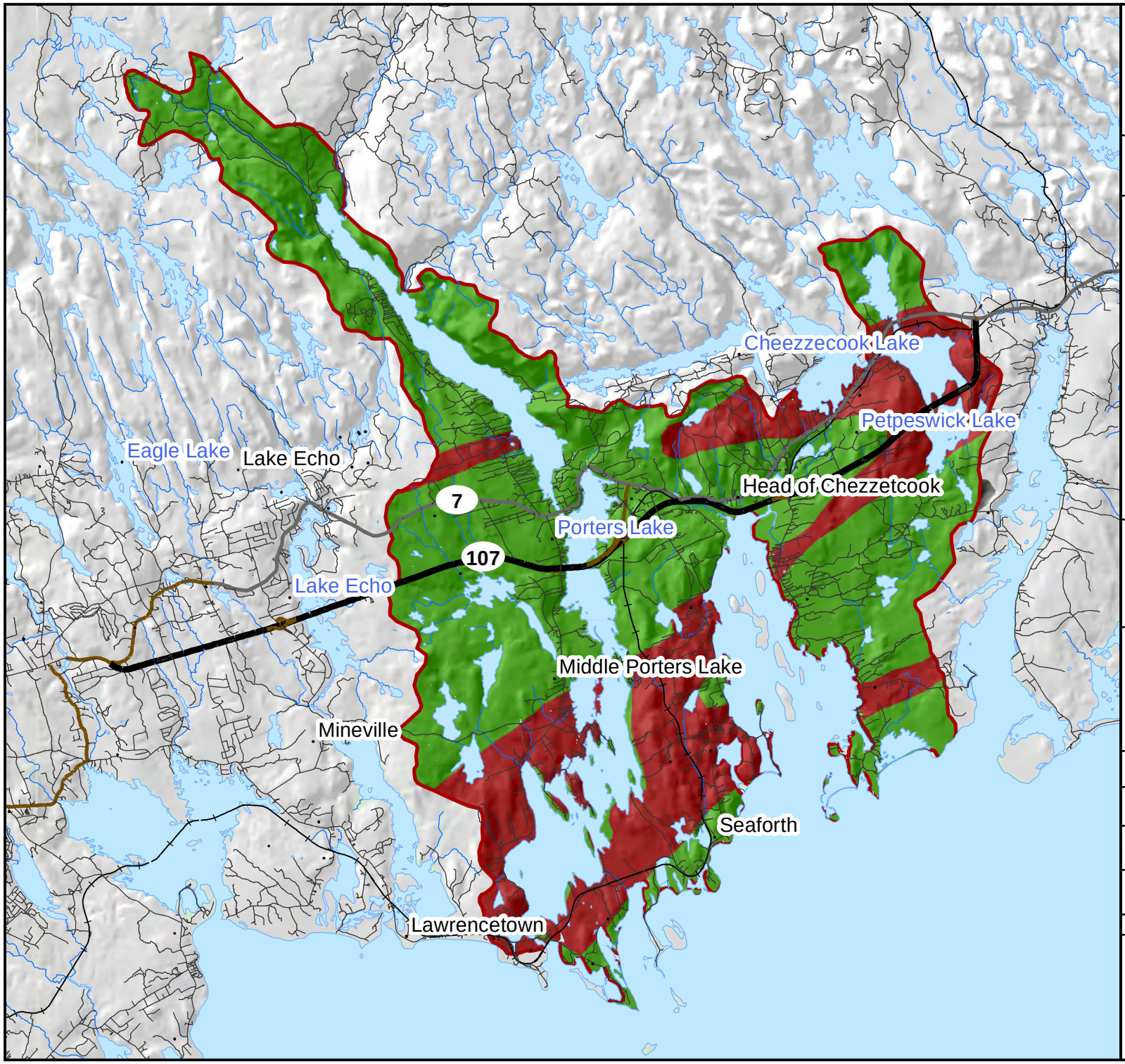
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N W E S

0 1,000 2,000 4,000 Meters

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HALIFAX
REGIONAL MUNICIPALITY

Porters Lake Watershed/Servicing Study

Study Area

Pyretic Slate Bedrock

- Absent
- Present
- Rivers
- Streets
- Trunk Highway
- Divided Highway
- Arterial
- Collector
- Railroad

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Pyretic Slate Bedrock Potential

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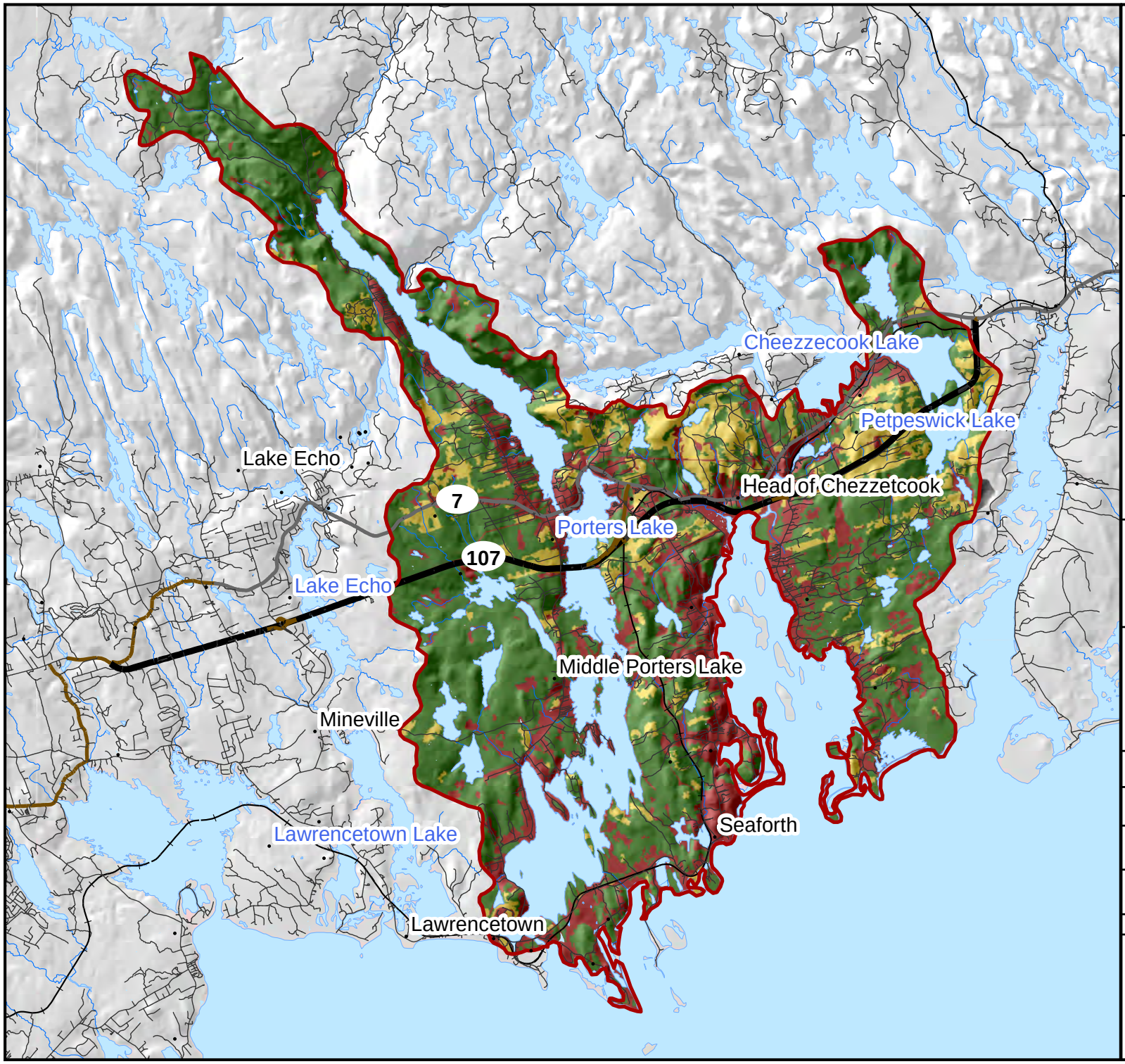
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N W E S

0 1,000 2,000 4,000 Meters

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HALIFAX
REGIONAL MUNICIPALITY

Porters Lake Watershed/Servicing Study

- Study Area

Vegetation

- Mature
- Immature
- Other
- Rivers
- Streets
- Trunk Highway
- Divided Highway
- Arterial
- Collector
- Railroad

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Vegetation

Drawn: VF	**Date: May 2012**
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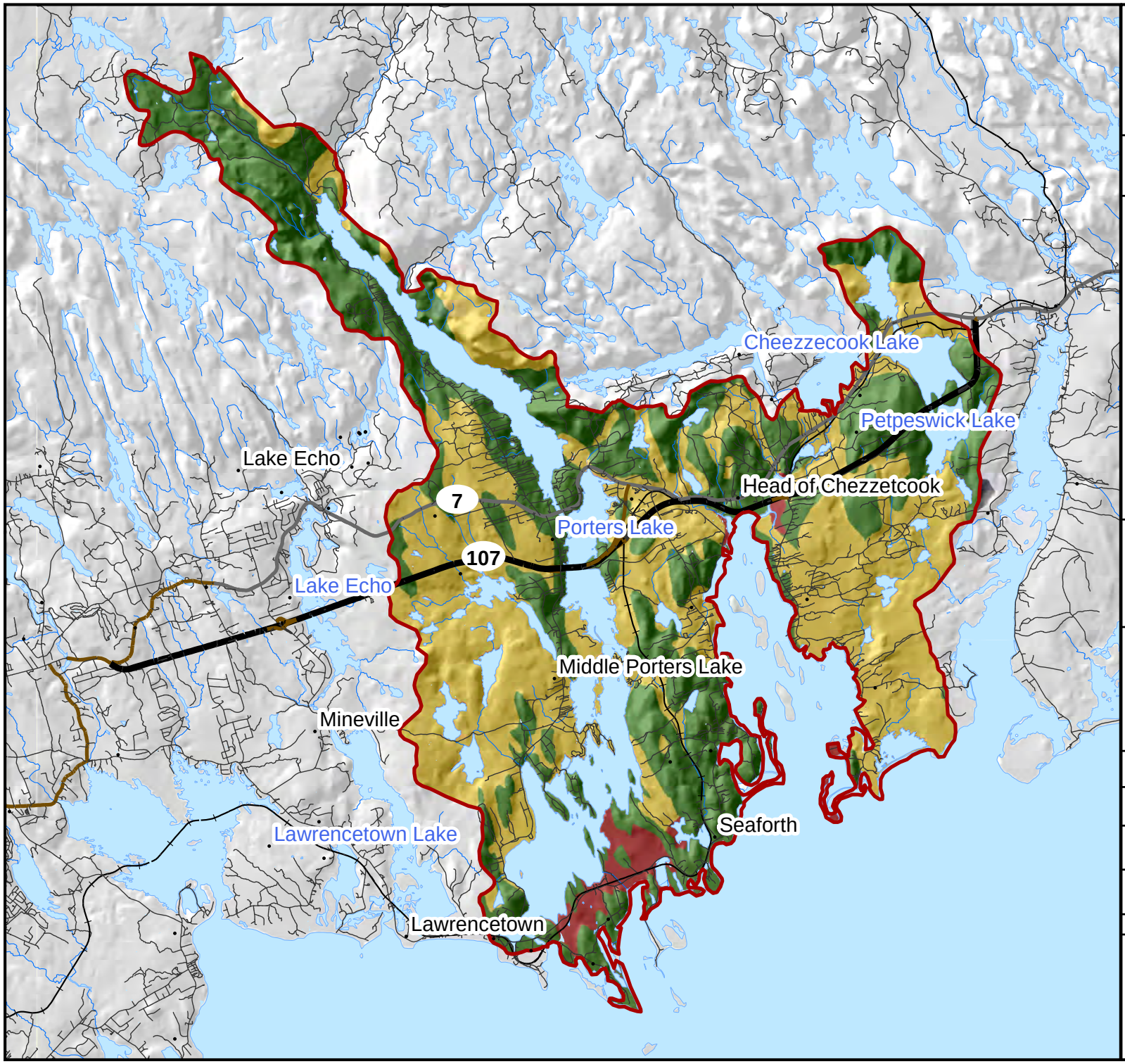
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N W E S

0 1,000 2,000 4,000 Meters

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HALIFAX
REGIONAL MUNICIPALITY

Porters Lake Watershed/Servicing Study

Study Area

Soil Type

- Dry
- Imperfectly Drained
- Wet and Wet Organic

Rivers
Streets
Trunk Highway
Divided Highway
Arterial
Collector
Railroad

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Soil Type

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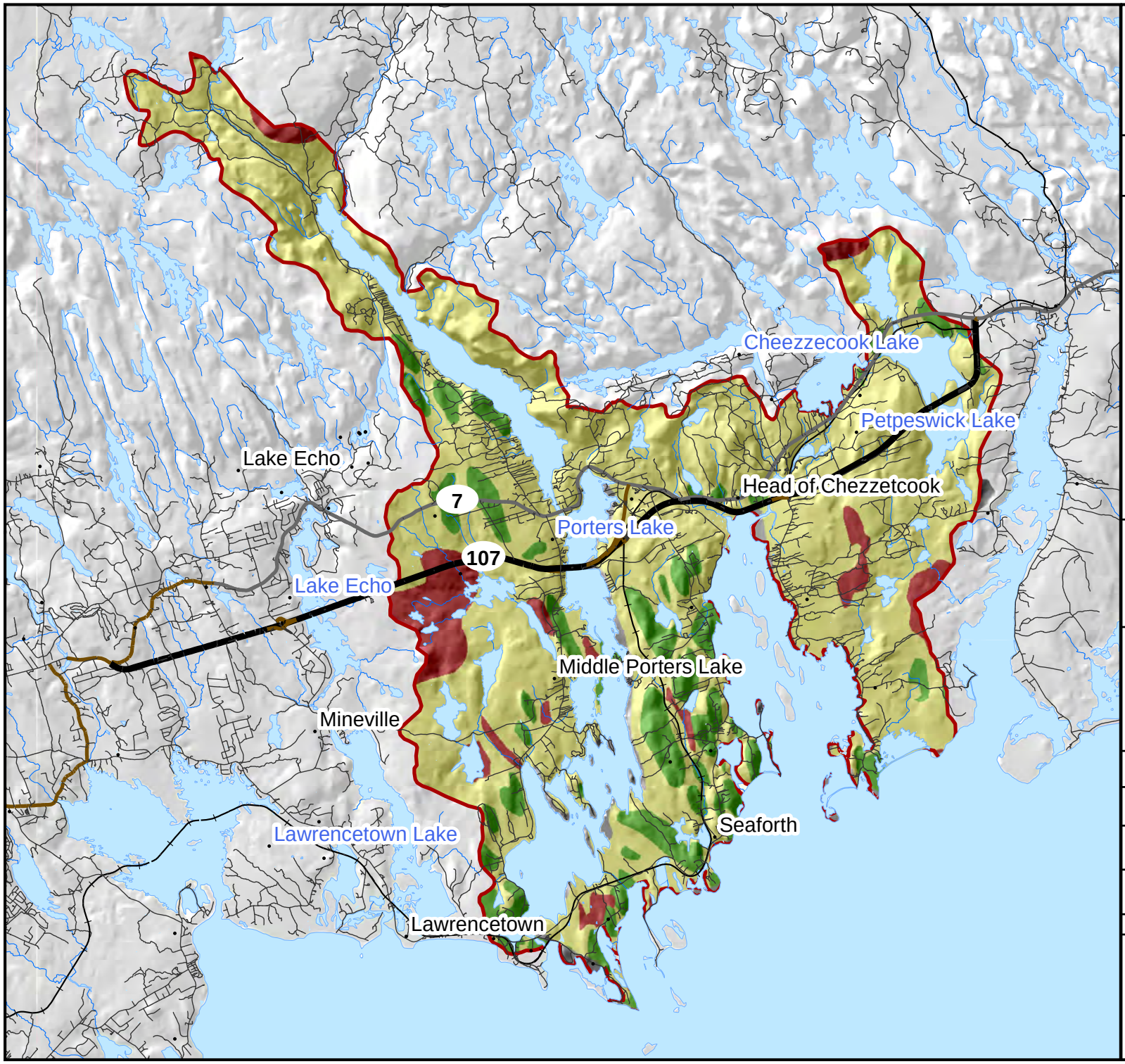
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N W E S

0 1,000 2,000 4,000 Meters

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HALIFAX
REGIONAL MUNICIPALITY

Porters Lake Watershed/Servicing Study

Study Area

Soil Condition

- Thick Till
- Thin Till
- Disturbed Soil and Bedrock Condition

Rivers
Streets
Trunk Highway
Divided Highway
Arterial
Collector
Railroad

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Soil Condition

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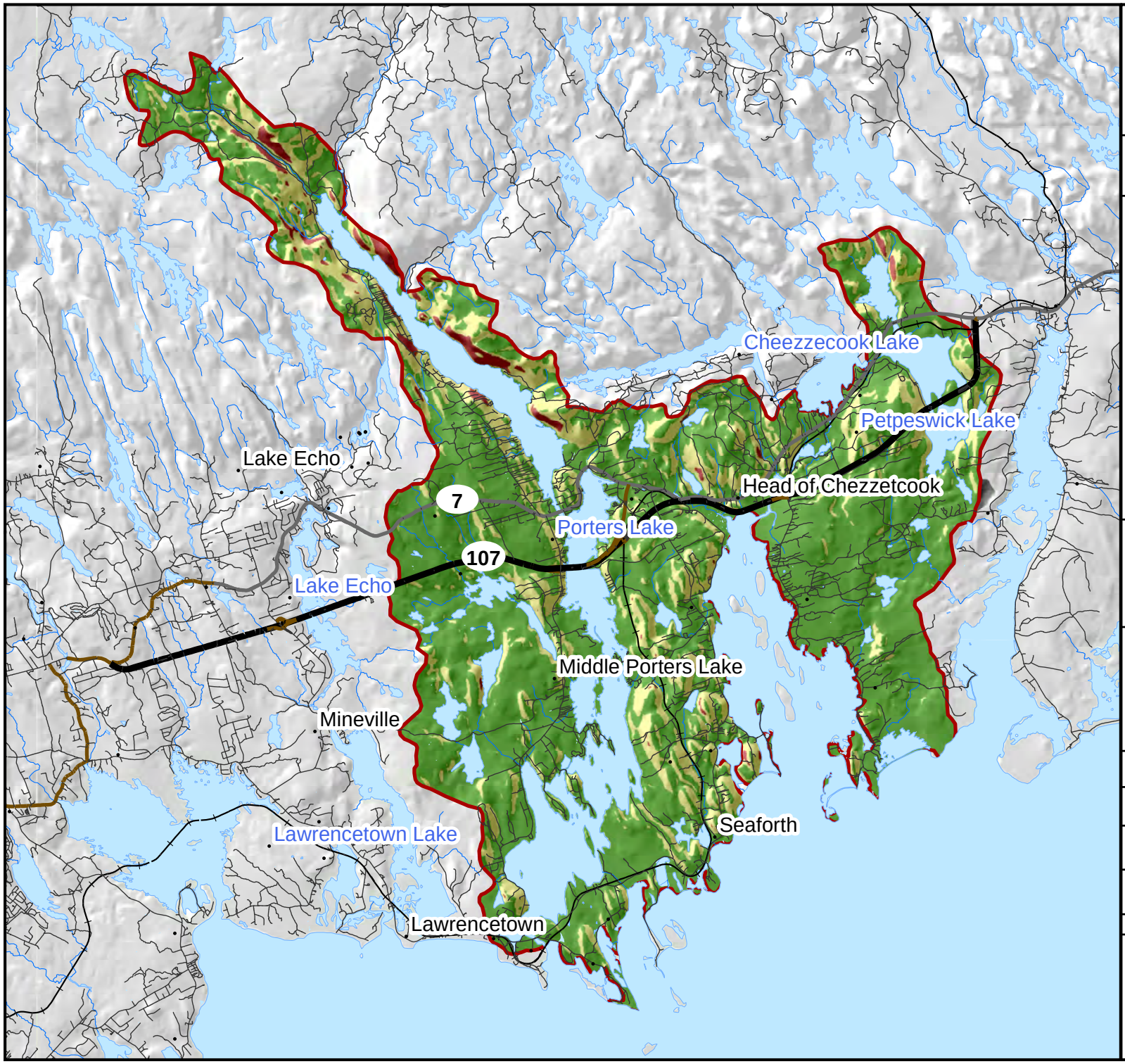
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N W E S

0 1,000 2,000 4,000 Meters

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HALIFAX
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Porters Lake Watershed/Servicing Study

- Study Area

Slope

- 0- 8 %
- 8 - 20 %
- > 20%
- Rivers
- Streets
- Trunk Highway
- Divided Highway
- Arterial
- Collector
- Railroad

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Slope

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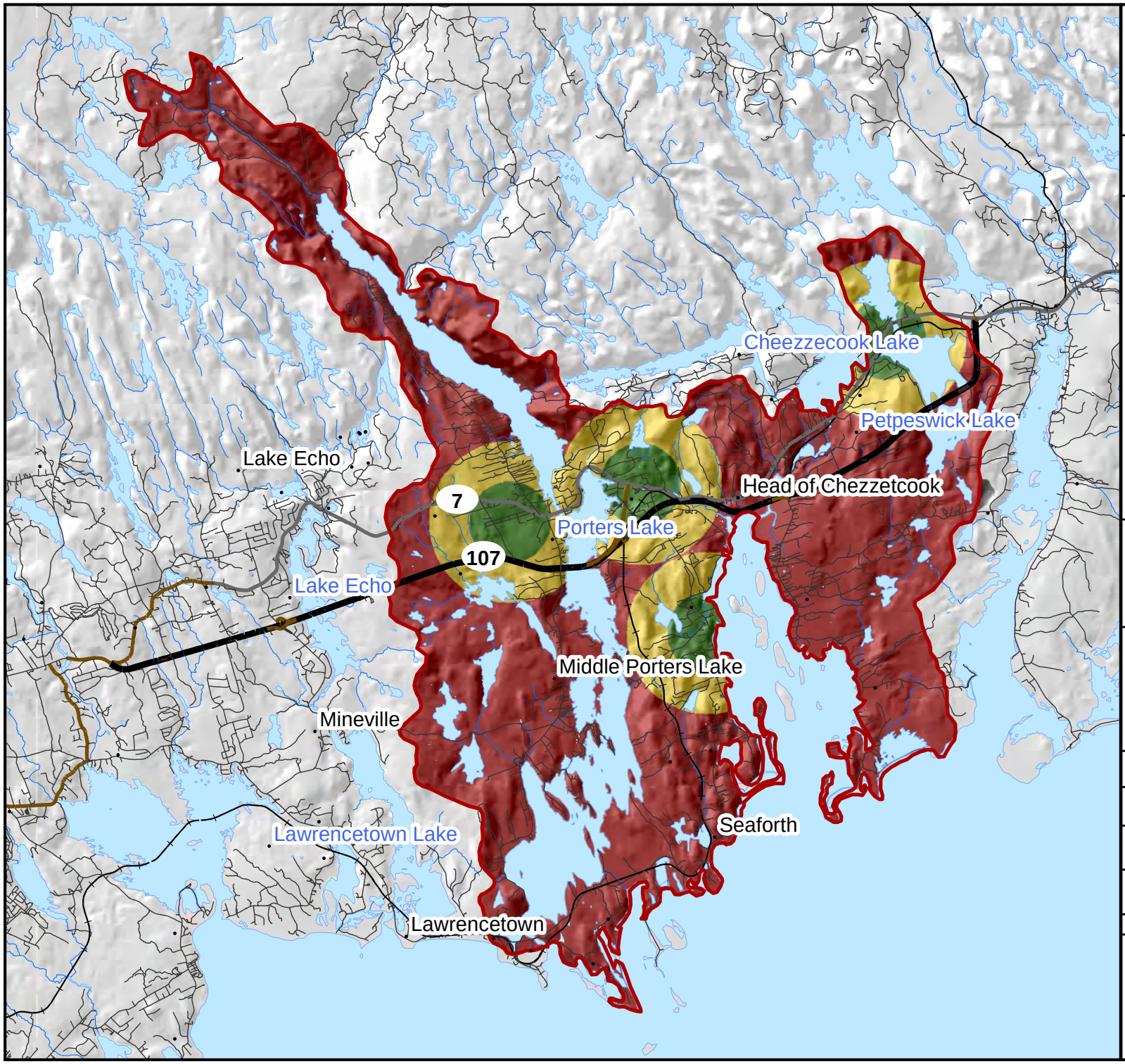
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N W E S

0 1,000 2,000 4,000 Meters

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HALIFAX
REGIONAL MUNICIPALITY

Porters Lake Watershed/Servicing Study

Study Area

School Access

- within 1 Km
- 1 - 2 Km
- > 2 Km

Rivers
Streets
Trunk Highway
Divided Highway
Arterial
Collector
Railroad

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School Access

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Appendix G

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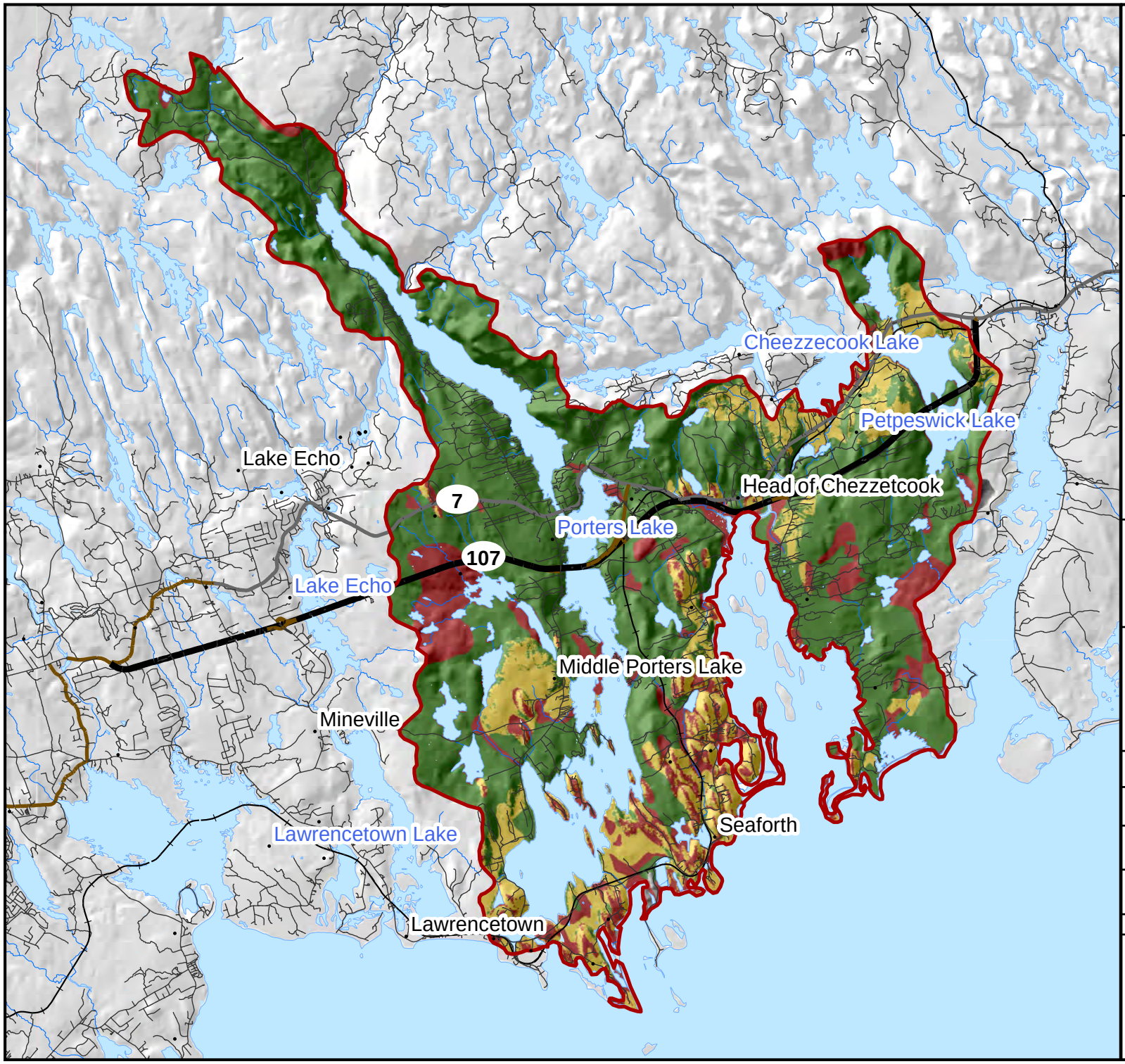
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N W E S

0 1,000 2,000 4,000 Meters

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HALIFAX
REGIONAL MUNICIPALITY

Porters Lake Watershed/Servicing Study

Study Area

Onsite Treatment Capability

- Most Suitable
- Mean
- Least Suitable
- Streets
- Trunk Highway
- Divided Highway
- Arterial
- Collector
- Railroad
- Rivers

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Onsite Treatment Capability

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Appendix G

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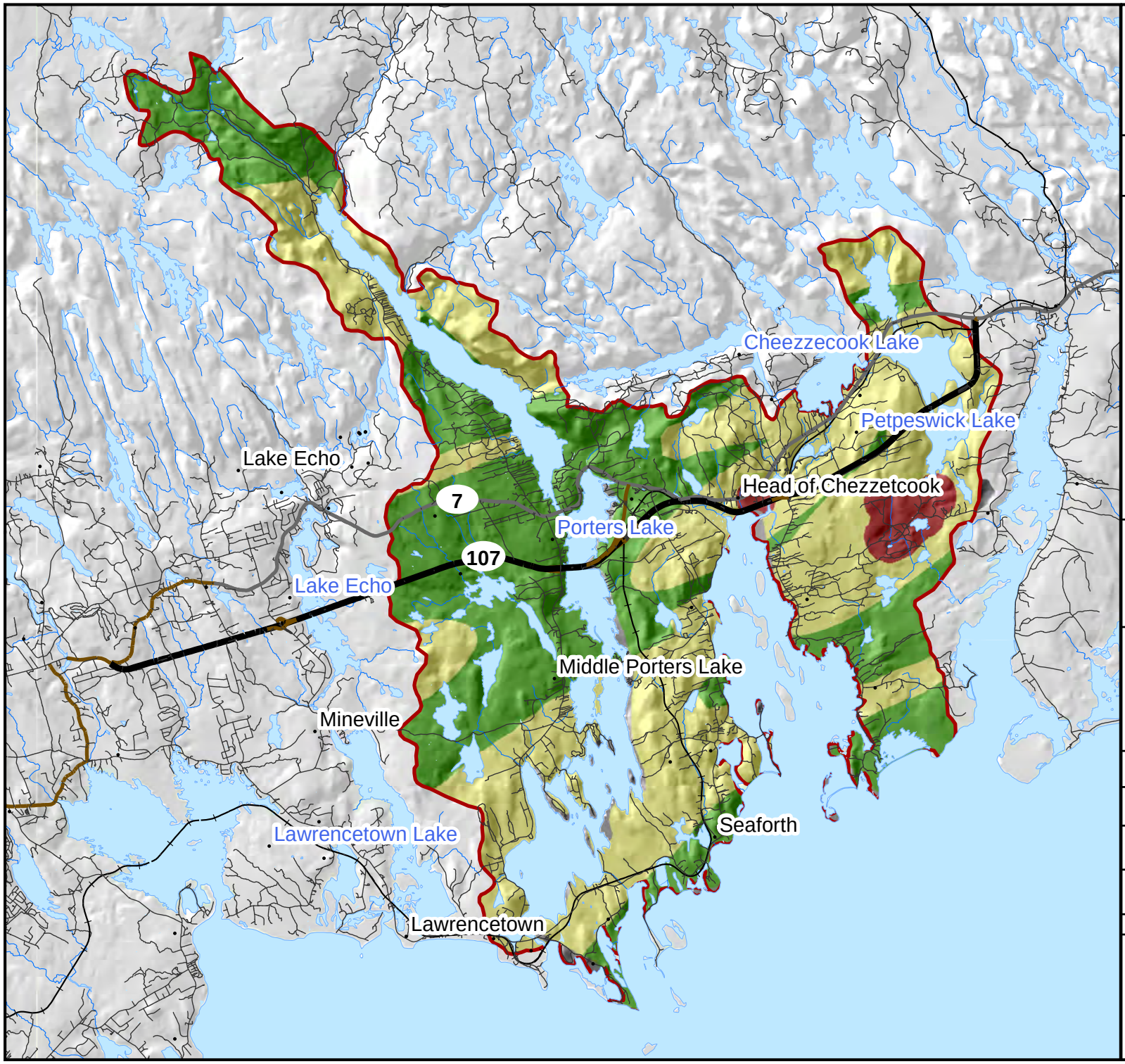
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N W E S

0 1,000 2,000 4,000 Meters

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HALIFAX
REGIONAL MUNICIPALITY

Porters Lake Watershed/Servicing Study

- Study Area

Groundwater

- Class B
- Class C and D
- Class E
- Rivers
- Streets
- Trunk Highway
- Divided Highway
- Arterial
- Collector
- Railroad

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Groundwater Potential

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Appendix G

Notes:

Map Parameters

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N W E S

0 1,000 2,000 4,000 Meters

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APPENDIX H

Component Study – Sanitary Survey

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A Survey Questionnaire
B Notice to Homeowners

Chapter 1 Introduction

The Porters Lake Sanitary Survey was conducted in developed areas throughout Porters Lake, East Chezzetcook, West Chezzetcook, and Gaetz Brook.

1.1 Survey Procedure

The Sanitary Survey was conducted by means of a door to door survey conducted by CBCL personnel. A copy of the survey questionnaire used is attached as Appendix A.

A notice regarding the watershed studies and the investigation of a range of environmental issues within the watershed(s) or sub-watersheds (study areas) affected by the Regional Plan for the Porters Lake area was prepared by CBCL, approved by HRM, and delivered by CBCL personnel to properties identified for the survey. Copies of the notice are attached as Appendix B.

In general, the Sanitary Survey was conducted in two parts. Personnel visited the properties and requested homeowner participation for the following:

Part 1:
Participation in the completion of a sanitary survey questionnaire;

Part 2:
A maximum of 40 property owners could participate in a more detailed investigation which included the collection of an untreated well water sample for analyses for bacteriological quality, general chemistry, and metals; and dye testing of the on-site sewage disposal system.

The notice indicated approximate times during which the survey would be conducted, and requested residents to contact CBCL if they would like to participate.

The sanitary survey was completed between September 26, 2011 and October 21, 2011. In general, the survey consisted of the following:

- Completion of the questionnaire;
- Preparation of a sketch of the property;
- Where applicable, water quality sampling and dye testing was performed;
- General discussions with respondents as required;
- Monitoring of properties where dye testing was performed.

Copies of the analyses of water quality results were delivered to the respective properties and, where required, discussions were held with the homeowners in regards to the water quality.

1.2 Sanitary Survey Results

A total of 282 properties were visited during the Sanitary Survey. The survey areas are provided in Figure H.2.1.

Survey questionnaires were completed on 85 properties out of the 282 properties, for a participation rate of 30.1 %.

Six (6) homeowners participated in the water sampling and dye testing protocol, for a participation rate of 2.1 %.

1.2.1 Porters Lake Area Results

The Porters Lake area surveyed included the Porters Lake Station Road area, Millside Drive, Karen Crescent, and Crowell Road in West Porters Lake. A total of 97 properties were visited.

Survey questionnaires were completed on 30 properties out of the 97 properties, for a participation rate of 30.9 %. Four (4) homeowners participated in the water sampling and dye testing protocol, for a participation rate of 4.1 %.

The occupant at two properties (2.1 %) were home during the site visits, but indicated that they did not want to participate in the survey.

Most of the homes in the area appear to be permanent homes.

1.2.2 East Chezzetcook Area Results

The area of East Chezzetcook included in the survey consisted of two sections along East Chezzetcook Road. A total of 67 properties were visited.

Survey questionnaires were completed on 20 properties out of the 67 properties, for a participation rate of 30 %. None of the homeowners were willing to participate in the water sampling and dye testing protocol.

The occupants at 2 properties (3 %) were home during the site visits, but indicated that they did not want to participate in the survey.

Based on field observations, the majority of homes in the area appear to be permanent homes.

1.2.3 West Chezzetcook Area Results

The West Chezzetcook area surveyed consisted of Highway No. 207, Shore Road, and Petain Station Road. A total of 60 properties were visited.

Survey questionnaires were completed on 17 properties out of the 60 properties, for a participation rate of 28.3 %. Two (2) homeowners participated in the water sampling and dye testing protocol, for a participation rate of 3.3 %.

The occupant at two properties (3.3 %) were home during the site visits, but indicated that they did not want to participate in the survey.

Most of the homes in the area appear to be permanent homes.

1.2.4 Gaetz Brook Area Results

The Gaetz Brook area surveyed consisted of Pleasant Drive, Highway No. 7, and the Brook Point Road area. A total of 58 properties were visited.

Survey questionnaires were completed on 18 properties out of the 58 properties, for a participation rate of 31.0 %. None of the homeowners were willing to participate in the water sampling and dye testing protocol.

The occupants at 4 properties (7 %) were home during the site visits, but indicated that they did not want to participate in the survey.

Eighteen (18) homes in the area appeared to be seasonal homes, with over 65% of the properties in the Brook Point area being seasonal.

Chapter 2 Lot Sizes

Minimum lot sizes prior to the 1970's were typically up to 1394 m^2 to 1860 m^2 , with lot widths of 23 m to 30 m respectively.

Current lot size requirements as indicated in the Nova Scotia Environment On-site Sewage Disposal Systems Technical Guidelines, 2009 (Technical Guidelines) are as indicated in Table 2.1.

Table 2.1 Minimum Lot Size Requirements for Developments Utilizing On-Site Sewage Disposal Systems (1)

Depth of permeable soil (mm)	Minimum Lot Area (m^2)	Minimum Lot Width (m)
0 – 149	9,000	76
150 – 299	6,800	60
200 – 600	4,500	53
Deeper than 600 on a waterfront lot (2)	3,716	45
601 – 899	3,150	37
900 and deeper	2,700	37

(1) For systems with a daily flow greater than 1,500 Lpd, larger lots areas and widths may be required.
(2) A waterfront lot is a lot that contains or is proposed to contain a system in which a portion of the system is or will be located within 60 m of a surface watercourse or marine water body.

Lot sizes in the survey area were determined using data in the Nova Scotia Property Online Database and are summarized in Table 2.2.

Table 2.2 Lot Sizes

Location	Properties Visited	Area (m^2)				
		< 1,500	1,500 – 2,700	2,700 – 4,500	4,500 – 9,000	>9,000
Porters Lake Area						
P.L. Station Road Area	42	11	6	11	13	1
Millside Drive	18	4	8	5	1	0
Karen Crescent	12	0	10	1	1	0
Crowell Road	25	8	16	1	0	0
East Chezzetcook Area						
E. Chezzetcook Road *N*	42	5	2	20	11	4
E. Chezzetcook Road *S*	25	0	13	8	3	1
West Chezzetcook Area						
Highway 207	33	7	6	8	9	3
Shore Road	15	3	5	3	0	3
Petain Station Road	12	2	1	3	4	2
Gaetz Brook Area						
Pleasant Drive	25	6	15	4	0	0
Brook Point Road	19	4	12	2	1	0
Highway 7	14	4	7	3	0	0

A review of the data indicates lot sizes vary over the different survey areas, but the majority of the properties visited were less than 2,700 m^2. Of the 282 properties visited during the survey, 155 (55 %) properties have lot sizes of less 2,700 m^2, and 54 (19 %) properties have lot sizes of less than 1,500 m^2.

In the Porters Lake area, the Station Road area consists of a wide variety of lot sizes, while on Crowell Road twenty four of the twenty five homes visited consist of lot areas less than 2,700 m^2. The East Chezzetcook area consists of generally larger lots, while West Chezzetcook consists of a wide variety of lot sizes. The Gaetz Brook area consists of smaller lot sizes with 48 (83 %) of the 58 properties visited being less than 2,700 m^2 in area.

Chapter 3 Wastewater Systems

3.1 Porters Lake Area

Of the 30 properties surveyed in the Porters Lake area, the construction type of on-site sewage disposal systems is summarized as follows:

- 25 systems (84 %) are area bed systems;
- 2 systems (7 %) are contour type systems;
- 1 system (3%) is a chamber systems;
- 1 system (3 %) is a cesspool; and
- 1 property (3 %) has an outhouse.

Twenty three of the respondents (77 %) indicated that they pump out their septic tanks at a frequency of more than once in five years.

3.2 East Chezzetcook Area

Of the 20 properties surveyed in the East Chezzetcook area, the construction type of on-site sewage disposal systems is summarized as follows:

- 12 systems (60 %) are area bed systems;
- 6 systems (30 %) are contour type systems; and
- 2 properties (10 %) have an outhouse.

All respondents (100 %) indicated that they pump out their septic tanks at a frequency of more than once in five years.

3.3 West Chezzetcook Area

Of the 17 properties surveyed in the West Chezzetcook area, the construction type of on-site sewage disposal systems is summarized as follows:

- 14 systems (82 %) are area bed systems;
- 1 systems (6 %) is a contour type systems;
- 1 system (6 %) is a holding tanks with overflow systems; and
- 1 system (6 %) is a chamber system;

Fifteen of the respondents (88 %) indicated that they pump out their septic tanks at a frequency of more than once in five years.

3.4 Gaetz Brook Area

Of the 18 properties surveyed in the Gaetz Brook area, the construction type of on-site sewage disposal systems is summarized as follows:

- 9 systems (50 %) are area bed systems;
- 4 system (21 %) are contour type systems;
- 2 properties (11 %) have an outhouse.
- 1 system (6 %) is a peat filter;
- 1 system (6 %) is a chamber system;
- 1 property (6 %) has a holding tanks with overflow;

Fourteen of the respondents (78 %) indicated that they pump out their septic tanks at a frequency of more than once in five years.

Chapter 4 Water Supply Systems

4.1 Water Supply Sources

4.1.1 Porters Lake Area

Out of the 30 sanitary surveys conducted, the following was found:

- 20 dug well supplies;
- 9 drilled well supplies; and
- 1 property did not have a piped water supply.

Water supplies along the Porters Lake Station Road area were mainly dug wells, while the Millside Drive and Karen Crescent areas consisted mainly of drilled wells. Supplies along Crowell Road in West Porters Lake were split evenly between dug and drilled wells.

4.1.2 East Chezzetcook Area

Out of the 20 sanitary surveys conducted, the following was found

- 10 drilled well supplies;
- 8 dug well supplies; and
- 2 properties did not have a piped water supply.

Both the north and south sections of the East Chezzetcook Road that were surveyed consisted of an even number of drilled and dug well. The two properties containing no water supply are older seasonal homes.

4.1.3 West Chezzetcook Area

Out of the 17 sanitary surveys conducted, the following was found:

- 14 dug well supplies; and
- 3 drilled well supplies.

Supplies throughout the West Chezzetcook area were mainly dug wells. Drilled wells appeared to be located on properties with newer homes.

4.1.4 Gaetz Brook Area

Out of the 18 sanitary surveys conducted, the following was found:

- 9 drilled well supplies;
- 4 lake water supplies;
- 3 dug well supplies; and
- 2 properties did not have a piped water supply.

Supplies along Pleasant Drive on Petpeswick Lake were mainly drilled wells. The Brook Point road area and the area surveyed along Highway 207 consisted of a variety of drilled wells, dug wells, and lake water supplies.

4.2 Water Quality

4.2.1 Dug Wells

Samples of untreated water were collected from 6 dug wells to determine representative water quality. The total number of dug wells is considerably higher than the total number of drilled wells. During the survey the majority of properties whose owners participated in the dye test and water sampling were properties with dug wells and older on-site sewage disposal systems.

Health based parameters were exceeded as follows:

- All six wells had Coliform Bacteria above the respective Maximum Acceptable Concentration (MAC);
- One well had turbidity above the CDWQ guideline standards; and
- One well had a lead concentration above the CDWQ guideline standards.

Aesthetic based parameters were exceeded as follows;

- Three wells had elevated iron and/or manganese concentrations;
- Two wells had elevated aluminium concentrations;
- One well had elevated pH;
- One well had an elevated Total Dissolved Solids concentration; and
- One well had an elevated Hardness.

4.2.2 Drilled Wells

Samples were not collected from drilled wells. The majority of homes containing drilled wells were newer homes, and therefore the opportunities to sample drilled wells were minimal.

4.3 Water Treatment

Water treatment equipment in use in each area is summarized in Table 4.1.

4.1 Water Treatment

Location	Properties Surveyed	Homes With Treatment	Water Treatment Equipment				
			Sediment Filter	Ultraviolet Disinfection	Water Softener	Reverse Osmosis	Chlorine Disinfection
Porters Lake	30	11	8	4	8	1	0
East Chezzetcook	20	5	3	3	0	2	0
West Chezzetcook	17	9	3	3	5	0	1
Gaetz Brook	18	9	2	3	6	2	0

* Some homes have multiple treatment units

During the survey home owners were asked if they drink their water. In the Porters Lake area, six of the thirty respondents indicated that they do not drink the water. In the East Chezzetcook area, two of the twenty respondents indicated that they do not drink the water. In the West Chezzetcook area, five of seventeen respondents indicated that they do not drink the water. In the Gaetz Brook area only three of eighteen respondents indicated that they do not drink the water.

Discussions with homeowners indicate reverse osmosis units appear to have been installed due to concerns of arsenic, however was not confirmed through sampling.

Chapter 5 Wastewater System Overview

5.1 Porters Lake Area

5.1.1 Porters Lake Station Road Area

The Porters Lake Station road area consisted of Doyle Drive, Meadowview Drive, Roblea Drive, and Arthur Road, all located off Porter Lake Station Road. The area is located on the Northeast of Porters Lake and contains a variety lot sizes. With forty percent of the visited properties having a lot area of less than 2,700 m^2, and the homes generally built between 1970 and 1990, this area was identified as a suspect area.

Three dye tests were carried out in the area, all three on systems identified as being suspect. The three tests, however, were negative. It appears that good soils in the area may limit the negative impact of smaller and possibly inadequate on-site sewage disposal systems. Only one homeowner in the area indicated concerns with the adequacy of on-site sewage disposal systems in the area.

5.1.2 Millside Drive

Similar to the Porters Lake Station Road area, homes on Millside Drive are located on smaller lots with two thirds of the lots in the area being less than 2,700 m^2. With the exception of a few homes at one end of Millside Drive, the distance from homes to the water is further than in the Porters Lake Station Road area. The ages of the homes in the area are older, therefore there is still a concern of malfunctioning sewage disposal systems. Dye tests were not carried out in the area.

One homeowner in the area indicated concerns with the adequacy of on-site sewage disposal systems in the area with relation to the age of all the older homes.

5.1.3 Karen Crescent

Karen Crescent is located on the northwest of Porters Lake and consists of homes built in two different phases. The first phase of homes was built in the mid 1970s, and the second phase was built in the mid 1980s. The sizes of ten of the twelve lots in the survey area were between 1,500 and 2,700 m^2, and all were water front lots. Although the lots in the area are small, through observation and acknowledging the age of the homes, this did not appear to be an area with many suspect systems.

The level of participation in the area was disappointing with only one survey being conducted, and no dye tests being completed. The one homeowner surveyed has lived in the area since 1975 and had no concerns with the adequacy of on-site sewage disposal systems in the area.

5.1.4 Crowell Road

Crowell Road is located in West Porters Lake and the area surveyed consisted of very small lots. Eight of the twenty five lot sizes were less than 1,500 m^2, and sixteen of the twenty five were between 1,500 and 2,700 m^2. The age of the homes in the area ranges from twenty to thirty years old. With the lots being very small in the area, the most likely problem appears to be undersized on-site sewage disposal systems.

One dye test was carried out in the area, on a system identified as being suspect, but the test was negative. Homeowners in the area did not indicate concerns with the adequacy of on-site sewage disposal systems in the area.

5.2 East Chezzetcook Area

5.2.1 East Chezzetcook Road (North Section)

The north section of the East Chezzetcook Road surveyed consisted of lot sizes generally larger than those in Porters Lake. Only seven of the forty two properties visited had lot areas less than 2,700 m^2. The homes in the area were also located further from the water indicating the impact of any malfunctioning on-site sewage disposal systems would be minimized. Although the area generally appears to consist of adequate systems, there are five lots with sizes of less than 1,500 m^2 which appear to have suspect systems.

Dye tests were not carried out in the area, and homeowners in the area did not indicated concerns with the adequacy of on-site sewage disposal systems in the area.

5.2.2 East Chezzetcook Road (South Section)

Homes in the south section of the East Chezzetcook Road survey were generally located closer to the water than homes in the north section. Thirteen of the twenty five properties visited had lot sizes between 1,500 and 2.700 m^2, however, none of the properties were less than 1,500 m^2. The area consisted of several seasonal homes along the water with suspect on-site sewage disposal systems, but in the general the area was not much of a concern.

Dye tests were not carried out in the area, and homeowners in the area did not indicate concerns with the adequacy of on-site sewage disposal systems in the area.

5.3 West Chezzetcook Area

5.3.1 Highway No. 207

The Highway No. 207 area consisted of generally older homes with a large variety of lot sizes. The age of the homes in the area increases the number of potential inadequate on-site sewage disposal systems. Concerns expressed by homeowners included the following:

1. Concerns of the adequacy of on-site sewage disposal systems on Shore Road.
2. Multiple contaminants getting into the creek along Petain Station Road.
3. The age of all the older homes in West Chezzetcook

Of the nine surveys completed in the area, five homes contained suspect or inadequate on-site sewage disposal systems. An additional ten properties were identified as suspect by observation only, with no survey being completed. One dye test was carried out in the area, with the test result being negative. Although there appears to be to a considerable number of inadequate systems in the area, the majority of the homes are located greater than 75 metres from the water.

5.3.2 Shore Road

The Shore Road area consists of a cluster of older homes located close the water just off Highway No. 207. Eight of the fifteen lot sizes in the survey area were less than 2,700 m^2. Only four surveys were completed in the area, all of which contained suspect or inadequate on-site sewage disposal systems. With the shore road area being identified as a problem area by several homes owners, the level of participation was disappointing. Dye tests were not carried out in the area.

Homeowners in the Shore Road area did not indicate concerns with the adequacy of on-site sewage disposal systems. Homeowners in other areas, however, identified the Shore Road area a concern.

5.3.3 Petain Station Road

The Petain Station Road area consists of homes with various ages located on a variety of lot sizes. Malfunctioning on-site sewage disposal systems did not appear to be a problem in this area, however

homeowners in the area were concerned of specific potential contaminants getting in the creek along Petain Station Road. One homeowner indicated that clam diggers in the area occasionally discharge clam waste directly in the creek. Contaminants from the upper farming fields and malfunctioning on-site systems were also a concern of the homeowners.

One dye test was carried out in the area on a systems identified as being suspect, but the test was negative.

5.4 Gaetz Brook Area

5.4.1 Pleasant Drive

Pleasant Drive is located on Petpeswick Lake in Gaetz Brook. The area consists on newer homes built generally between the late 1970s and early 2000s. The lot sizes are small with twenty one of the twenty five properties lots having lot sizes of less than 2,700 m^2. Only one of the nine completed surveys consisted of a suspect system. There does not appear to be many problems in the area, however with the small lots sizes there is likely more inadequate systems than the survey results indicate. Dye tests were not completed in the area.

Two homeowners in the area indicated concerns with the adequacy of on-site sewage disposal systems in the area. They indicated that there is septic smell in the ditches during the spring.

5.4.2 Brook Point Road

Brook Point Road is located off Highway No. 207 in Gaetz Brook and surrounds the area where Chezzetcook Lake enters the Chezzetcook River. The area generally consists of seasonal homes, with thirteen of the nineteen homes visited being seasonal. Most homes are older in age and are located on small lots. Sixteen of the nineteen properties have lot sizes of less than 2,700 m^2. Of the seven surveys completed, five properties included suspect or inadequate on-site sewage disposal systems. This area is of concern as all the homes are located on small properties are situated close to the water.

Dye tests were not carried out in the area, however, two homeowners in the area indicated concerns with the adequacy of on-site sewage disposal systems in the area.

5.4.3 Highway No. 7

The area surveyed along Highway No. 7 was located on Chezzetcook Lake near Brook Point Road. The area consisted of small lots, with eleven of the fourteen lot sizes being less than 2,700 m^2. The first eight homes surveyed were newer homes, but as the survey moved east, the majority of the homes were seasonal. Only three surveys were completed, and all three properties contained adequate on-site sewage disposal systems.

Dye tests were not carried out in the area, and homeowners in the area did not indicate concerns with the adequacy of on-site sewage disposal systems in the area.

Chapter 6 Water Supply Overview

6.1 Water Supplies

6.1.1 Porters Lake Area

The survey indicated that water supplies in the Porters Lake Station Road area were mainly from dug wells. The Millside Drive and Karen Crescent were the only two surveyed areas where water supplies were mainly drilled wells. The survey indicated that water supplies on Crowell Road were a mix of dug and drilled wells. Two home owners in the Porters Lake area, both in the Station Road area indicated water shortage problems during dry summer.

6.1.2 East Chezzetcook Area

The survey indicated that the water supplies along East Chezzetcook Road in the East Chezzetcook area were a mix of dug and drilled wells. Homeowners in the area did not indicate water shortage issues.

6.1.3 West Chezzetcook Area

The survey indicated that water supplies in the West Chezzetcook area were mainly from dug wells. Homeowners in the area did not indicate water shortage issues.

6.1.4 Gaetz Brook Area

The survey indicated that water supplies in the Gaetz Brook area were mainly from drilled wells. Three of the eighteen homes surveyed use lake water as their only water supply. Homeowners in the area did not indicate water shortage issues.

6.2 Water Quality

6.2.1 Dug Wells

All six wells had coliform bacteria above the respective Maximum Acceptable Concentration (MAC), but none had *E. Coli* above the respective Maximum Acceptable Concentration (MAC). Other quality issues included elevated iron and/or manganese concentrations, elevated color, and an elevated lead concentration.

Water treatment generally includes sediment filters, disinfection, or Reverse Osmosis.

Two respondents indicated that yield was a concern.

6.2.2 Drilled Wells

Samples were not collected from drilled wells.

Chapter 7 Sanitary Survey Summary

7.1 Wastewater Component

Table 7.1 summarizes the wastewater component of the sanitary survey.

Table 7.1 Summary of Wastewater Component of the Sanitary Survey

Area	Number of Homes Visited	Number of Survey s Completed	Number of Dye Tests Completed	Did Not Want to Participate	Number of Suspect or Inadequate Systems
Porters Lake Area	97	30 (31%)	4 (4%)	2 (2%)	11 (37%)
East Chezzetcook Area	67	20 (30%)	0 (0%)	0 (0%)	6 (30%)
West Chezzetcook Area	60	17 (28%)	2 (3%)	2 (3%)	11 (65%)
Gaetz Brook Area	58	18 (31%)	0 (0%)	4 (7%)	6 (33%)
Total	282	85 (30%)	6 (2%)	8 (3%)	34 (40%)

The findings indicate a participation rate of 28% to 31% by geographical area, for a total participation rate of 30 %. Participation in the dye testing program, however, was very low, ranging from no participation in East Chezzetcook and Gaetz Brook to 4 % in the Porters Lake area.

There are no obvious reasons for the low participation rates.

7.2 Water Component

Table 7.2 summarizes the water component of the sanitary survey.

Table 7.2 Summary of Water Component of the Sanitary Survey

Area	Number Homes Surveyed	Number of Dug Wells	Number of Drilled Wells	Number of Lake Water Users	No Water Supply	Number of Water Samples Collected
Porters Lake Area	30	20	9	0	1	4
East Chezzetcook Area	20	8	10	0	2	0
West Chezzetcook Area	17	14	3	0	0	0
Gaetz Brook Area	18	3	9	4	2	2
Total	85	45	31	4	5	6

In general, dug wells are more prevalent in the older sections.

Annex A
Survey Questionnaire

PORTERS LAKE AND LAKE ECHO AREA SANITARY SURVEY QUESTIONNAIRE

Conducted By: _____CBCL Limited

Date: _____

1. Occupant's Name _____
   Civic Address: _____
   Permanent property _____; Seasonal property _____

2. Type of sewage disposal system?
   ( ) Area Bed
   ( ) Trench Bed
   ( ) Contour system, type _____
   ( ) Mound
   ( ) Sloping Sand Filter
   ( ) Privy
   ( ) Other _____
   ( ) Chambers
   ( ) Holding Tank
   ( ) Straight discharge to _____
   ( ) Cesspool
   ( ) Peat Filter
   ( ) Unknown _____
   Combinations of the above? _____
   Pumping used: Sewage_____; Septic Tank Effluent_____

3. Year On-Site System Constructed?_____

4. System Status: Adequate_____; Suspect_____; Inadequate_____

5. Is there any internal separation in your disposal system, i.e., separate bathroom/kitchen discharge? Yes____; No____
   If yes? Black water to _____; Grey water to _____

6. Do you experience problems with your on-site sewage disposal system?
   Yes___; No_____
   If yes, indicate the problem:
   ( ) odour
   ( ) backup
   ( ) ponding water,
   ( ) sewage leaks, to where? _____
   Other _____

7. How often do you pump out your septic tank? Every _____ years?

8. Are there problems/concerns with on-site sewage disposal systems in any geographic area of Tantallon? Yes_____; No _____
   If yes, where? _____

9. Are there problems/concerns with other potential contaminants in any geographic area of Tantallon? Yes_____; No_____
   If yes, what type and where?_____

10. What is your source of water?
    ( ) Dug well; ( ) Drilled well; Year Well Constructed _____
    ( ) Lake; ( ) Cistern;
    Do you drink the water? Yes ____; No _____

11. Is treatment performed on the water? Yes ____ ; No_____
If yes, outline what type: _____

12. Have you ever submitted samples of your water supply for bacteriological or chemical analysis? Yes_____; No ____

If yes, could you briefly summarize the results: _____

_____

13. Water sample collected? Yes _____; No _____.
Parameters of concern_____

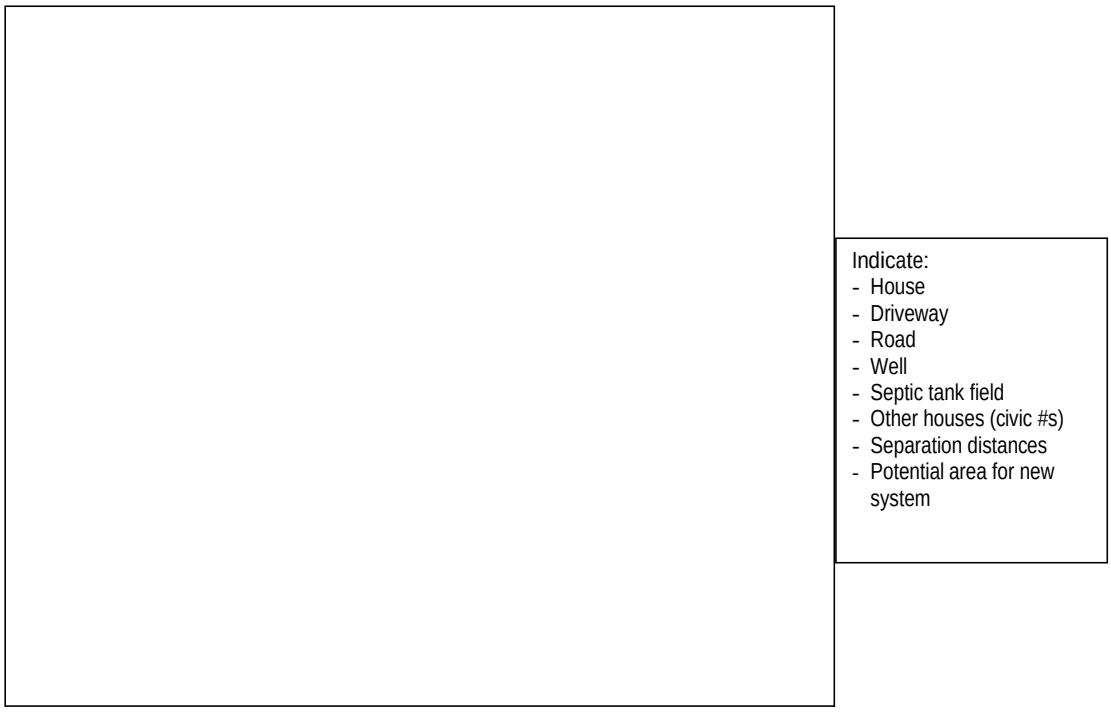
14. Dye test performed? Yes_____; No _____ ; If yes, Positive _____; Negative _____

15. Distance from house to water? _____

16. Landscaping complete to water's edge? Yes _____; No _____

17. Other comments _____

Sketch of Lot



Annex B
Notice to Homeowners

CBCL LIMITED
Consulting Engineers

NOTICE TO RESIDENTS OF PORTERS LAKE AND LAKE ECHO

HRM is completing watershed studies to investigate a range of environmental issues within watersheds (study areas) affected by the Regional Municipal Planning Strategy for Porters Lake and Lake Echo. As part of this process, CBCL Limited was engaged to conduct a receiving water sampling program within the area. Water samples were collected in surface waters between June and November 2010, coincident with seasonal changes in weather and precipitation conditions.

In order to assess the overall health of the water bodies throughout the watersheds, we are undertaking a confidential sanitary survey of properties located within the area during the period of September 26, 2011 to October 14, 2011.

Sanitary Survey Process

The Sanitary Survey will be conducted in two parts by technical personnel with CBCL Limited. Personnel will visit the properties and request homeowner participation for the following:

Part 1:

Participation in the completion of a sanitary survey questionnaire;

Part 2:

A maximum of 40 property owners will be asked to voluntarily participate in a more detailed investigation as follows:

1. Collection of an untreated well water sample for analyses for bacteriological quality, general chemistry, and metals; and
2. Dye testing of the on-site sewage disposal system. The properties dye tested will be monitored every 2 to 3 days for 2 weeks after the introduction of the dye.

Your participation in the survey will be greatly appreciated. For participants in Part 2, the water quality results and dye test findings will be provided to the homeowners, and CBCL personnel will be available to discuss the findings. All costs for sampling will be taken care of as part of the Watershed Study Project.

Sanitary Survey Findings

The information collected by the Sanitary Survey will be kept confidential by CBCL. A summary of the findings, without specific names or addresses, will be presented as part of the report to HRM, and will be used to determine the future definition and direction of the project.

Dates

The Sanitary Survey will be conducted over a period of three weeks, September 26, 2011 to October 14, 2011.

Please contact Dustin Carr at 220-5552 if you would like to participate.