CHAIN LAKES
EMERGENCY WATER SUPPLY
WATERSHED AREA

SOURCE WATER
PROTECTION PLAN

January 2017

EXECUTIVE SUMMARY

This Source Water Protection Plan (SWPP) describes the Chain Lakes watershed area and outlines the management of the source water area, the risk assessment, the management plan and the monitoring program. Delineating the Chain Lakes watershed area boundary lays the foundation for source water protection planning for this area.

This SWPP's risk assessment indicates the Chain Lakes watershed area provides a short-term emergency back-up water supply to the J. D. Kline (Pockwock) water supply system. Further, to maintain water quality for drinking water purposes: future land use must be limited to compatible watershed uses; the inherent risks that are identified in this SWPP must be effectively managed to reduce the impacts to water quality; and a comprehensive source water quality monitoring program (SWQMP) must be sustained.

Baseline monitoring indicates that water quality is mainly impacted by recreational activities, stormwater run-off from public roadways, maintenance to utility pipes and poles, and natural disasters. However, with minimal treatment, Chain Lakes' water quality meets GCDWQ and therefore provides a safe emergency back-up water supply to the Pockwock system. **It is strongly recommended that Halifax Water continue to monitor source water quality parameters to provide data that will guide watershed protection and/or treatment process decision-making; and assess and evaluate the program to ensure water quality needs are being met.**

Halifax Water has set management objectives for implementing this SWPP including: land acquisition; best management practices; public communication, education and awareness programs; fostering stakeholder collaboration and cooperation; regulation and land-use by-law adherence; public roads and highway maintenance collaboration; controlled access and boundary maintenance; enforcement; adherence to pumping station maintenance schedules; chemical use management plans; emergency measures; and source water quality monitoring and evaluation. Monitoring consists of maintaining a presence by way of patrolling, encouraging public reporting of unauthorized or suspicious activities, conducting raw water sampling, and liaising with various governing agencies and stakeholders to ensure a clean and safe drinking water supply.

While water *quality* is the primary focus of this SWPP, under extraordinary circumstances, water *quantity* plays an important secondary role in the decision-making around the protection of the Chain Lakes Emergency water supply. To supplement the Chain Lakes water supply during prolonged periods of flow disruption of the primary systems, water from the Bayer's Lake Business Park could be redirected into the Chain Lakes system. **However, this scenario is not recommended unless a robust water treatment plant is built to mitigate the potential impacts to the water supply that the business park would present. Further, even with a more robust system, the water quantity from the business park area would not be sufficient to boost the Chain Lake water supply to a level that would support the population; therefore, water rationing would be required where the Chain Lake Water supply is relied upon as the sole source.**

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ARD	Acid Rock Drainage
BMP	Best Management Practice
BSLB	Brown Spruce Longhorn Beetle
CCME	Canadian Council of the Ministers of Environment
CN	Canadian National Railway Company
COLT	Chain of Lakes Trail
COLTA	Chain of Lakes Trail Association
DLS	Deep Lake Sampling
ERP	Emergency Response Plan for Halifax Water
GCDWQ	Guidelines for Drinking Water Quality in Canada
GFULM	Generalized Future Land Use Map
HM	Halifax Mainland
HRWC	Halifax Regional Water Commission
HRM	Halifax Regional Municipality
IP	Industrial Park
ISO	International Organization for Standardization
LUB	Land Use By-law
MAC	Maximum Acceptable Concentrations
MPS	Municipal Planning Strategy
MSDS	Materials Safety Data Sheet
NSDNR/DNR	Department of Natural Resources
NSE	Nova Scotia Environment
NSPI	Nova Scotia Power Inc.
NSTIR	Nova Scotia Department of Transportation and Infrastructure Renewal
OHV	Off-Highway Vehicles
PCBs	Polychlorinated biphenyls
PWA	Protected Watershed Area
PWS	Protected Water Supply (Zone)
RMPS	Regional Municipal Planning Strategy
RCMP	Royal Canadian Mounted Police
SWPP	Source Water Protection Plan
SWQMP	Source Water Quality Monitoring Program
TOC	Total Organic Carbon
TSS	Total Suspended Solids
US	Urban Settlement
WHO	World Health Organization
WQGPAL	Water Quality Guidelines for the Protection of Aquatic Health
WUI	Wildland Urban Interface

1 INTRODUCTION

Halifax Water is responsible for monitoring and managing all activities that may impact water quality and quantity on eleven distinct source water supplies. The Chain Lakes water supply is the emergency drinking water supply in the event that the J. Douglas Kline Water Supply Plant is not able to supply water to Halifax customers.

The primary objective of this Source Water Protection Plan (SWPP) for the Chain Lakes watershed area is to comply with Nova Scotia Environment requirements and to meet the needs of its customers. This SWPP describes the watershed area and outlines the current management of the source water area, the risk assessment, the management plan and the monitoring program. While water *quality* is the primary focus of this SWPP, under extraordinary circumstances, water *quantity* plays an important secondary role in the decision-making around the protection of the Chain Lakes Emergency water supply.

2 DESCRIPTION OF THE CHAIN LAKES WATERSHED AREA

This Chapter describes the Chain Lakes watershed area history, land form, location, land cover, built form and landownership; and how the source water supply is managed through provincial, municipal and stakeholder governance structures.

2.1 History of the Chain Lakes Water Supply

The Chain Lakes water supply was selected as the original drinking water supply source for the City of Halifax in 1844. The attraction to this water supply source was its close proximity to the city and naturally high elevation which could provide water via gravity to most of the City.

To increase the holding capacity of the original Chain Lakes water system reservoir, dams were constructed on First Chain Lake and Long Lake in 1845. Long Lake was raised 25 feet (~7.6 metres) above its natural elevation to 206 feet (62.8 metres) above the tide water level. First and Second Chain Lakes were raised to almost the same elevation, 205 feet (62.5 metres). An open canal (flume) was built, connecting Second Chain and Long lakes, allowing water to flow from Long Lake into Second Chain Lake and increasing the supply of potable water. The Chain Lakes water supply system first delivered water to the City of Halifax in 1848.

Map J: Halifax Water Infrastructure (Sewer and Water) on page 41 illustrates the locations of the Bayer's Lake diversion dam; Second Chain Lake and Long Lake flume; and First Chain Lake Dam and spillway as they are today. *Map K: Halifax Water Infrastructure – Long Lake* on page 42 illustrates the Long Lake dam location. Section *2.3.3: Water Supply Infrastructure* beginning on page 23 describes these structures.

The Chain Lakes water system was upgraded several times to meet growing water demands by the City of Halifax. *Map K: Halifax Water Infrastructure – Long Lake* on page 42 illustrates the locations of the lakes which were subsequently added to the Chain Lake water supply network, as described below:

- In 1869, a dam and pipeline from Spruce Hill Lake to Long Lake were constructed;
- In 1942, Big Indian Lake was added to the water supply network via a concrete dam and pipeline; and
- In 1961, Otter Lake was connected to the Big Indian system via an earthen dam with concrete core wall and head works at the Otter Lake outlet.

Conflicts over the years, ranging from landownership and water rights in the early years to water quality concerns and water quantity shortfalls in the latter years, hampered the ability to supply water to the City of Halifax. To help overcome the challenges, the provincial legislature passed the *Halifax Public Service Commission Act* in April 1944. On January 1, 1945 the Public Utilities Commission (later named the Public Service Commission of Halifax) was established. That same year, to further ensure a safe water supply, automated chlorinators were installed at the Chain Lakes pump house located on North West Arm Drive (see location of pump house on *Chain Lakes Dam and Spillway Inset Map* on *Map J: Halifax Water Infrastructure (Sewer and Water)* on page 41). In the 1950s, after a few years of instituting controls over what land use practices were permitted and purchasing land to overcome significant sources of pollution, Halifax became the first major city in Canada to have complete control of the lands around its water supply areas. Although water wastage and pollution issues and customer satisfaction were being adequately dealt with at that point, the utility recognized that a new water supply source was needed to meet the City's growth projection.

In 1971, in partnership with the Province, the City of Halifax identified Pockwock Lake as the future water supply source. The commissioning of the J.D. Kline Water Treatment Plant in 1977 secured a long-term, high-quality water supply for the City of Halifax and repurposed the Chain Lakes water supply as the City's emergency back-up water supply.

Halifax Water has since become the first regulated water and wastewater/ stormwater utility in Canada (2007) which serves the residents of the Halifax Regional Municipality (HRM), pursuant to the *Public Utilities Act*. R.S., c. 380, s. 1.

2.1.1 Chain Lakes Emergency Water Supply

In 1981, the watershed lands around the Chain Lakes were divided into two sub-watershed areas; i.e., Long Lake and Chain Lakes. At that time, Halifax Water retained the Chain Lakes sub-watershed area, which amounted to approximately 217 ha, while the province purchased the Long Lake sub-watershed area, amounting to 2,095 ha (see *Map D: Hydrology and Elevations in Water Supply* on page 20). The Department of Natural Resources (NSDNR) was assigned management of the Long Lake area, which was subsequently designated the Long Lake Provincial Park under the *Provincial Parks Act*[1] in 1984.

To maintain the viability of the Chain Lakes as an emergency back-up water supply, two submersible pumps were installed in 1985 to increase pumping capacity from eleven million gallons per day to approximately 14 million gallons per day. More new pumps were installed in 1992 to increase the capacity to 21 million gallons of water per day in the event that Pockwock is completely disabled.

The Chain Lakes emergency water supply pumping station has proven to be an invaluable emergency back-up water supply system on at least two occasions: i.e., power failures at the J.D. Kline Water Treatment Plant in the early 1980s; and a water main rupture in February 1985, which cut off Pockwock's water supply to the city for two days and required activating the Chain Lakes emergency supply to provide the city with water.

2.2 Land Form

The land formation of the Chain Lakes watershed area is characterized by region-specific activities including geology, rock formation, erosion, topography, faults, climate, fresh water, soils, plants, animals, and cultural environment as defined under the Nova Scotia Museum of Natural History's Theme Region 400 – Atlantic Interior[2], specifically Theme Regions: 413a Quartzite Barrens, sub unit Halifax; and 451a, Granite Uplands, sub unit South Mountain. The

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[1] RSNL1990 CHAPTER P-32 PROVINCIAL PARKS ACT Amended: 1992 c14 s1; 1993 cD-19.1; 1996 c8; 1997 c13 s56; 1997 c29; 2001 c38; 2001 cN-3.1 s2; 2004 cL-3.1 s55.

[2] Davis, Derek S. and Sue Browne, Editors. 1996. *Theme Regions: Natural History of Nova Scotia*, Revised Edition, Volume II. The Nova Scotia Museum, the Department of Education and Culture, Province of Nova Scotia: p. 43.

natural and cultural land formations in the Chain Lakes watershed area influence water quality through naturally occurring elements found in the geology, soils, flora and fauna; and water flow affected by topographical, climatic, and cultural influences that have occurred over time. The following subsections describe how these influences may impact water quality in the Chain Lakes watershed area.

2.2.1 Geology

The Chain Lakes watershed area straddles a significant geological area where the South Mountain Batholith, the largest body of granitoid rocks (course grain rock that is similar to granite) in the Appalachian system[3], extends from the northwest area of Nova Scotia and meets the Meguma strata in the central part of the province. *Map A: Bedrock Geology* on page 17 illustrates the granitoid rock feature and the Meguma strata formations in the context of Nova Scotia and the Chain Lakes watershed area. More details on the rock formations and their relationship to the watershed area are described in the subsections following.

Granitoid Rock

The southern portion of the Chain Lakes watershed area sits on two types of granitoid rock – 12.3% (25.65 ha) biotite monzogranite and 32% (66.23 ha) granodiorite. The age description of these granitic rock formations is Middle – Late Devonian age. These rock formations are considered to have been at one time molten (magma). This rock is igneous, categorized as intrusive and consists of granite, granodiorite, diorite, diabase, and gabbro. It presents itself in a variety of colours, textures, and compositions, most commonly containing large greyish or pink crystals of potash feldspar in a matrix of smaller crystals, dominated by quartz and mica. This rock is commonly used for building stone, aggregate, tin, copper, lead and zinc.

Granitic-type rock is resistant to erosion due to its hard, impermeable and poorly jointed rocks. Where granitoid rocks are prevalent in Nova Scotia, the landscape is characterized by knolls and boulder-strewn surfaces with thin acidic soils and large areas that have exposed bedrock. The drainage pattern typical in granitic-type rock areas is called “deranged” due to the proportion of water that is retained on the irregular surface and how runoff is channeled through a disorganized series of interconnected bogs, shallow lakes and streams, characteristic of the southern section of the Chain Lakes watershed area (see *Map B: Soil and Surficial and Bedrock Geology* on page 18 and *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19).

Meguma Group

The Meguma Group is the parent rock group from the Cambrian to Silurian age, which is divided into the Goldenville Formation (named after a mining area in eastern Nova Scotia where the strata are well exposed) and the Halifax Formation. As illustrated on *Map A: Bedrock Geology* on page 17, the Halifax Formation is the geological base for over half (56%) of the northern

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[3] The Appalachian Region includes all of the Atlantic Provinces, the Gaspe Peninsula and Eastern Townships of Quebec, the Green Mountains in Vermont, the White Mountains of New Hampshire and Maine and the New England Uplands (Source: Davis, Derek S. and Sue Browne, Editors, 1996. *Theme Regions: Natural History of Nova Scotia, Revised Edition, Volume I*. The Nova Scotia Museum, the Department of Education and Culture, Province of Nova Scotia: p. 5).

portion (116ha) of the Chain Lakes watershed area, the boundary of which travels east/west along the northern shoreline of First Chain Lake, arching northward across the Chain of Lakes Trail (COLT) and the 103 Highway. The rock family making up this portion of the Halifax Formation is metamorphic, categorized as sulphide-bearing metasediments consisting of the slate rock type and described as slope-outer shelf slate, siltstone, minor sandstone and iron-manganese nodules. The Halifax Formation contains acid-bearing pyritic slate. As indicated in the research study conducted by Rajaratnam (2009)[4], pre-industrial Chain Lakes was naturally acidic due to the sensitive bedrock geology (where the Halifax Formation meets the South Mountain Batholith granite, exposing acidic rock that is susceptible to acid rock drainage (ARD) when exposed) and organic acid inputs from forested catchments and acid bogs around the watersheds.

2.2.2 Topography

Topography of the southern portion of the Chain Lakes watershed area is defined by the South Mountain Batholith. This batholith intruded as a hot thick liquid during the last stages of the Acadian Orogeny (a major folding event created as the continental plates collided during the Middle-Late Devonian period) and is where most of the granite in Nova Scotia lies. The batholith features are relatively uniform until it meets the Meguma Strata of the Halifax Formation where fairly steep slopes form. Near this contact, xenoliths (rock fragments that are encased in larger rocks as they cooled) can be seen. As the magma cooled, the surrounding Meguma strata was baked, creating a narrow contact aureole where characteristic minerals have developed, giving the surrounding slates a spotted appearance. The topography of the Chain Lakes area and the geology that influences it is illustrated in *Map B: Soil and Surficial and Bedrock Geology* on page 18.

The northern portion of the Chain Lakes watershed area is defined by the Granite Barrens where there may be exposed rock due to the scraping action of glaciers, where sub-parallel faults create linear valleys that are followed by rivers and sometimes filled by lakes. Granite areas also reach the highest elevations (steep slopes). Immediately north of the Chain Lakes watershed area is an area referred to as Geizer Hill which has an elevation of 152 m (see *Map D: Hydrology and Elevations in Water Supply Areas* on page 20). As mentioned in section *2.1: History of the Chain Lakes Water Supply* on page 9, the Chain Lakes were originally chosen as the potable water supply source for Halifax due to its elevation. The highest elevation inside the Chain Lakes watershed area is 144 m, while the lake level is 63 m (see *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19).

2.2.3 Surficial Geology

Surficial geology of the watershed area consists of naturally exposed bedrock resulting from the scouring action of glaciers that are evident from the striations (grooves formed by ice) in the bedrock, distinctive erratics (boulders transported from far away rock sources) and surficial deposits left by passing or melting ice which formed the materials for most soils in Nova Scotia.

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[4] Rajaratnam, Thiyake. 2009. Assessment of Long-Term Changes in Water Quality from Halifax Region Lakes (Nova Scotia Canada) Using Paleolimnological Techniques. Kingston, Ontario. Queens University.

Surficial geology characterizing the Chain Lakes watershed area, as described in the subsections below and illustrated on *Map B: Soil and Surficial and Bedrock Geology* on page 18, is predominantly Bedrock with a small portion of Till Veneer located in the Southwest corner of the watershed area. Despite significant anthropogenic activity from residential and highway development surrounding and within the Chain Lakes watershed area, these areas are mapped by NSDNR as the original material because of the sporadic and shallow nature of the modifications.

Bedrock

Bedrock in this area amounts to 151.3 ha (~73% of the watershed area), is exposed at the surface or beneath shallow soil and may include minor fluvial, lacustrine (water areas) and till deposits.

Till Veneer

Till veneer, which makes up a small area of the Chain Lakes watershed area amounting to 20.86 ha (~10%) is located on approximately 80% of the northern shoreline of Second Chain Lake, extending northwest to the boundary of the watershed area. The type of till veneer in the watershed area is Beaver River Till, consisting of a diamicton (poorly sorted glacial deposits) with sandy matrix and locally derived clasts (rock, sand or mud fragments from pre-existing rock transported by glaciers). These sediments were deposited by ice and derived from subglacial erosion. The thickness of this till is estimated from 0.5–5 m. Some areas include exposed bedrock and thicker till deposits (>5 m) of locally derived till.

Lakes, Streams and Wetlands

The remaining surficial geology area of the Chain Lakes watershed area consists of ~36.99 ha (17.74%) surface water. First and Second Chain Lakes together make up approximately 34.65 ha (16.62%) of the watershed area; Lily Pond covers 1.44 ha (0.69%); and an unnamed pond (vernal pool), located in the ramp area between Highways 102 and 103 covers 0.21 ha (0.1%). Wetland areas included in the surficial geology figures amount to approximately 0.69 ha (0.33%). Streams inside the Chain Lakes watershed area amount to 0.662 km. These areas are described in more detail in the next section *2.2.4: Chain Lakes Hydrology and Environment* and in section *2.3.2: Water Networks* on page 22 and are illustrated on *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19 and on *Map D: Hydrology and Elevations in Water Supply Areas* on page 20.

2.2.4 Chain Lakes Hydrology and Environment

The following subsections briefly describe the freshwater hydrology of the Chain Lakes watershed area.

Hydrology

Hydrology of any area is influenced by the underlying geology and type and depth of surficial overburden. Depth-to-water table of the Chain Lakes watershed area, illustrated on *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19 and *Map D: Hydrology and Elevations in Water Supply Areas* on page 20, shows the characteristic "deranged" drainage pattern of the South Mountain region of Nova Scotia whereby surface water is retained in a disorganized series of streams, lakes, and bogs. Chains of lakes, streams, and stillwaters occur with the low ridges that follow the trends influenced by the elevations and the underlying strata. Many of the streams are slow-flowing and interrupted by shallow, rocky ponds and lakes.

Hydrology of the Chain Lakes watershed area has been altered significantly since the settlement of Halifax. First, it was altered to accommodate the potable water needs of the City of Halifax as described in section *2.1: History* on page 9 and in section *Chain Lakes Dam and Spillway* on page 23. More recently it was altered to prevent runoff impacts from the Bayer's Lake Business Park, as described in section *Bayer's Lake Diversion Dam* on page 23 and illustrated on *Map J: Halifax Water Infrastructure (Sewer and Water)* on page 41 and *Map K: Halifax Water Infrastructure – Long Lake* on page 42.

Bathymetry

Changes in water levels such as those previously described affect the bathymetry and the chemical consistency of the water. The bathymetry of First and Second Chain Lakes at the deepest points are 12.4 m and 12.2 m respectively (see *Appendix 1: Bathymetric Maps of First and Second Chain Lakes on page* 130).

Water Budget

Dillon Consulting[5] assessed the Chain Lakes watershed area and evaluated its water budget based on input (precipitation) calculations and three output (evapotranspiration, runoff and infiltration) parameters. The net quantity of water available is the difference between the total precipitation and evapotranspiration. Due to the small size and order of the Chain Lakes watershed, the shallow nature of bedrock, the vegetation present and the level of urbanization, it was determined that annual precipitation levels highly influence the lake water levels. Therefore, in the event that precipitation levels in our region drop and urbanization of the watershed area continues, the Chain Lakes water system would be greatly impacted, potentially reducing the water budget to very low levels. Under such circumstances, in drought conditions for example, specific measures would need to be undertaken (see section *3.2.1: Drought* on page 67).

Water Quality

Factors known to commonly influence water quality in Nova Scotia surface waters are:

- climate related events (e.g. air temperature, precipitation, and seasonal flows);
- watershed characteristics (e.g. forest cover, amount of wetlands, land use, bedrock geology and soil type); and
- pollution sources (point and non-point).

Groundwater in this Region is stored and transmitted through fractures and joints and along fault and contact zones in the bedrock and like the surface water in this Region, is susceptible to acidification from ARD and to discolouration from contact with naturally occurring minerals

[5] Dillon Consulting Limited, May 2004. *Chain Lake Watershed Assessment Final Report*. Halifax Regional Water Commission.

such as iron and manganese associated with granite and quartzite. Water quality is discussed further in section *5.4: Source Water Quality Monitoring* on page 105.

Precipitation

Runoff rates are influenced by precipitation (described with respect to the Chain Lakes watershed area in more detail in section *2.2.6: Climate* on page 15). During high water discharge times, rock formations, such as exposed pyritic slate, can create water quality problems. When pyritic slates are exposed to water and oxygen, sulfuric acid is produced which can lead to fish kills. Peat moss can also create acidic conditions in lakes. Moreover, increased acidity causes aluminum, cadmium, lead and other potentially toxic metals to leach into waterways.

2.2.5 Soils

The Chain Lakes watershed area soils are predominantly 163.85 ha (78.6%) Gibraltar and 13.99 ha (6.7%) Bridgewater. Gibraltar soils are characterized as course-textured, well-drained, gravelly, sandy loam derived from granite – usually shallow, heavily leached and very acidic. Scattered areas of exposed rock are also found in this area (see Barrens on *Map E: Land Cover* on page 36). Unforested areas of Gibraltar soils tend to form hardpans – a tendency that is characteristic of acid soils – and tend to be impervious. Bridgewater soils are derived from slates.

2.2.6 Climate

Although the Chain Lakes watershed area is considered inland, it is highly influenced by coastal climate conditions, mainly due to its elevation and exposure, such that temperatures are slightly warmer than those of its further inland counterparts (Pockwock Lake, Bennery Lake and Lake Major). Further, in winter, precipitation in the watershed area is more often in the form of rain than snow.

The closest climate research station to the Chain Lake watershed area is the Halifax Citadel Automated Network Station. Historical weather data collected at this station between 1961 and 2010, suggests that overall precipitation has decreased in the Chain Lakes watershed area. Further, as described in section *2.2.4: Water Budget* on page 14, precipitation plays an important role in water production to the Chain Lake water supply. Therefore, the trend toward a decrease in overall precipitation coupled with warmer temperatures and an increase in urbanization of the surrounding areas has the potential to negatively impact the water supply and ultimately the watershed's ability to serve as an emergency back-up water supply.

2.2.7 Flora and Fauna

The main influences on regional vegetation are a unique combination of inland and coastal climate conditions; sandy, acid soils; mixed drainage; extensive disturbance by fire and human activities including former logging, agriculture, and mining practices; and current development.

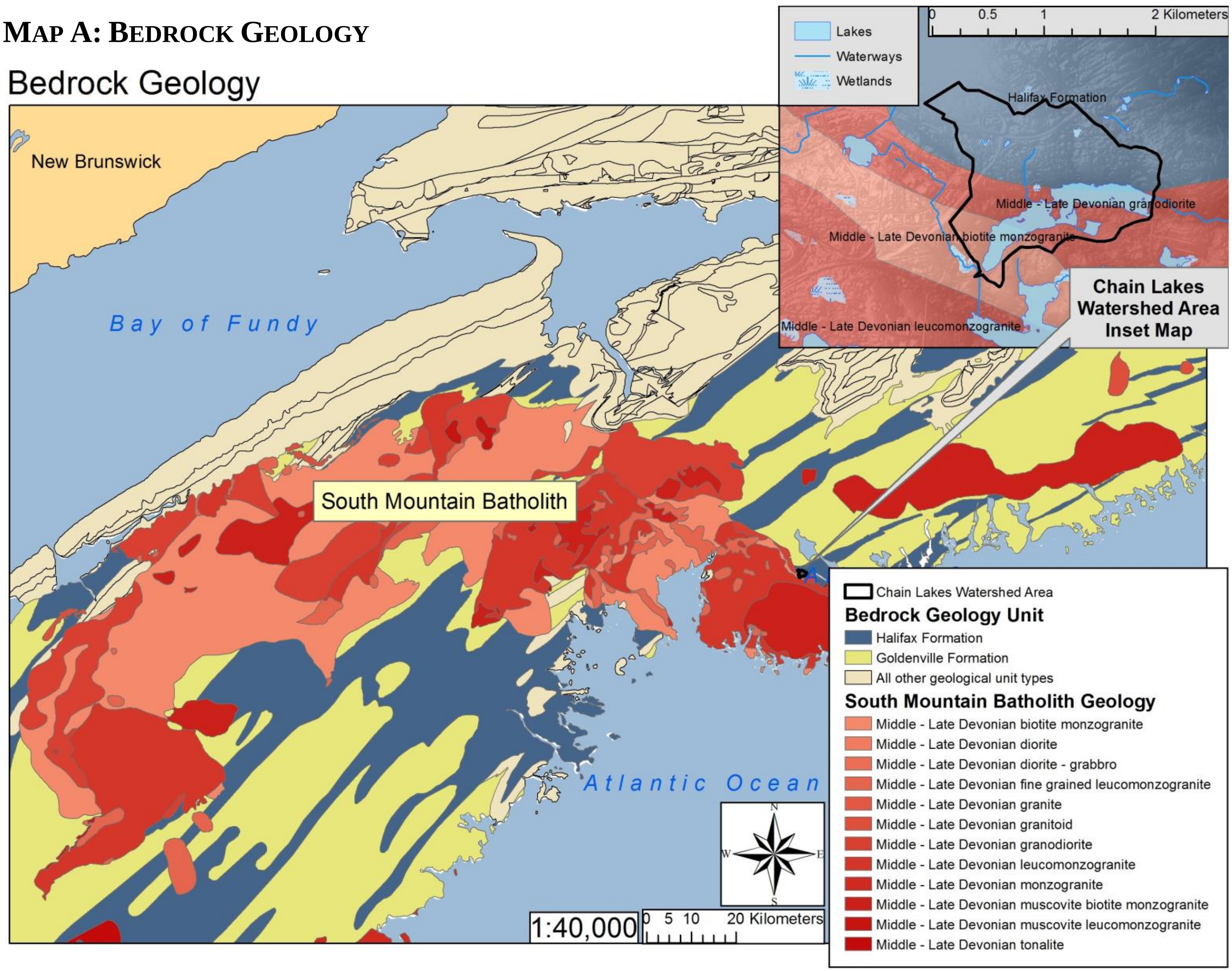
The watershed land base has naturally recovered to a softwood-dominant forest (125.57 ha or 78.84%) with a healthy biodiversity of shade-tolerant and intolerant hardwood stands. The understory vegetation (mainly ericaceous) has rebounded to conditions consistent with the mainly shallow and acidic soil and geological conditions. A wildland fire that occurred in August 2001 was a mild interruption to this rebound.

2.2.8 Cultural Environment

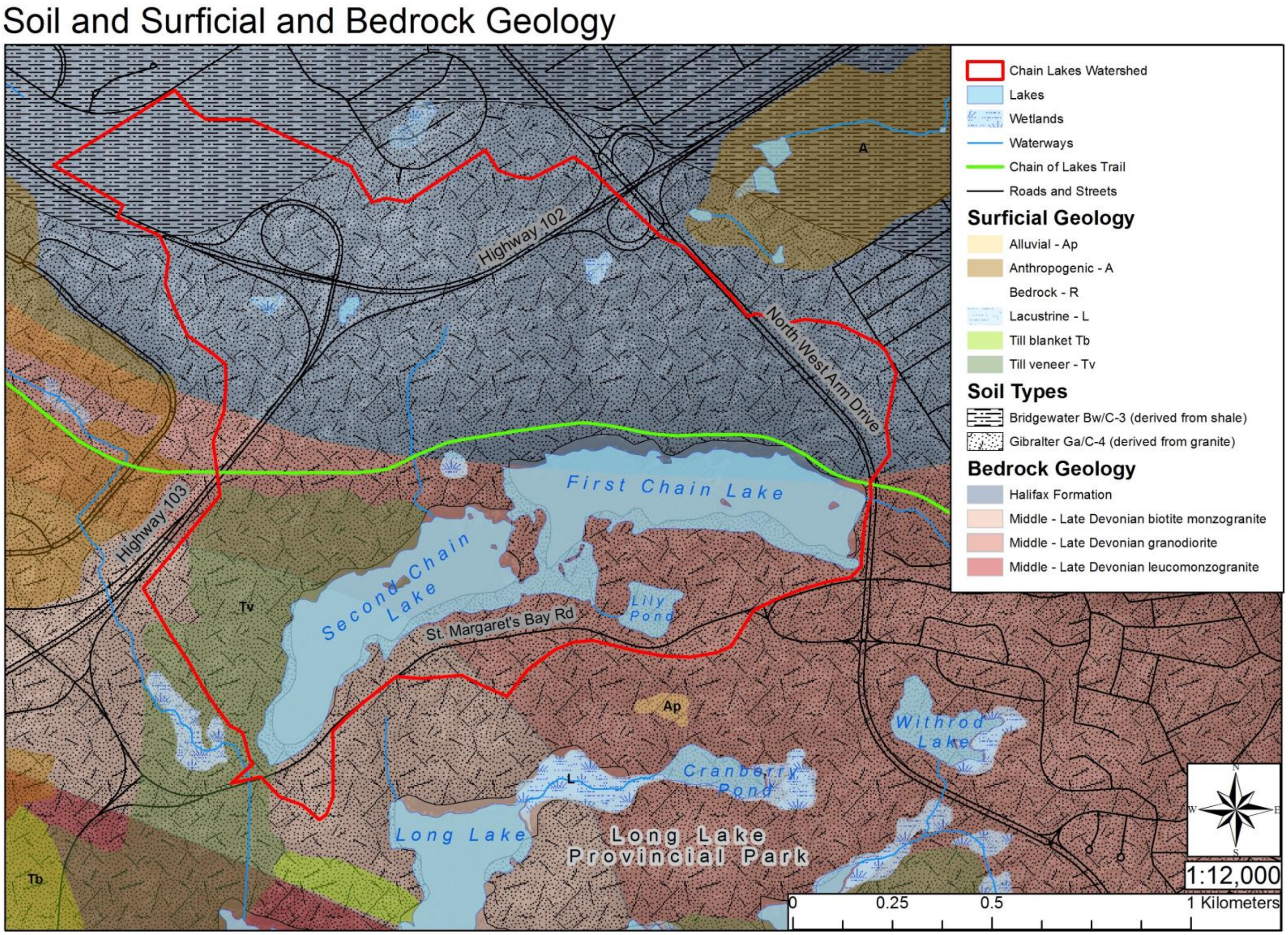
From the early 1700's until the late 1800's the Chain Lakes watershed area was a bustling mecca of industrial and commercial activities including forestry, sawmilling, farming and rock quarrying. Such activities heavily impacted water quality, putting human health at risk. To curb anthropogenic impacts to the water supply, the Halifax Water Company eventually acquired most of the watershed lands. The activities subsequently stopped, allowing the watershed to heal and water quality to improve. In addition to the former industrial and commercial activities, recreational activities including hunting, fishing, hiking, swimming and boating, many of which continue today, have also significantly impacted the landscape of the Chain Lakes watershed area.

The following maps depict the land forms that were described in this section (2.2).

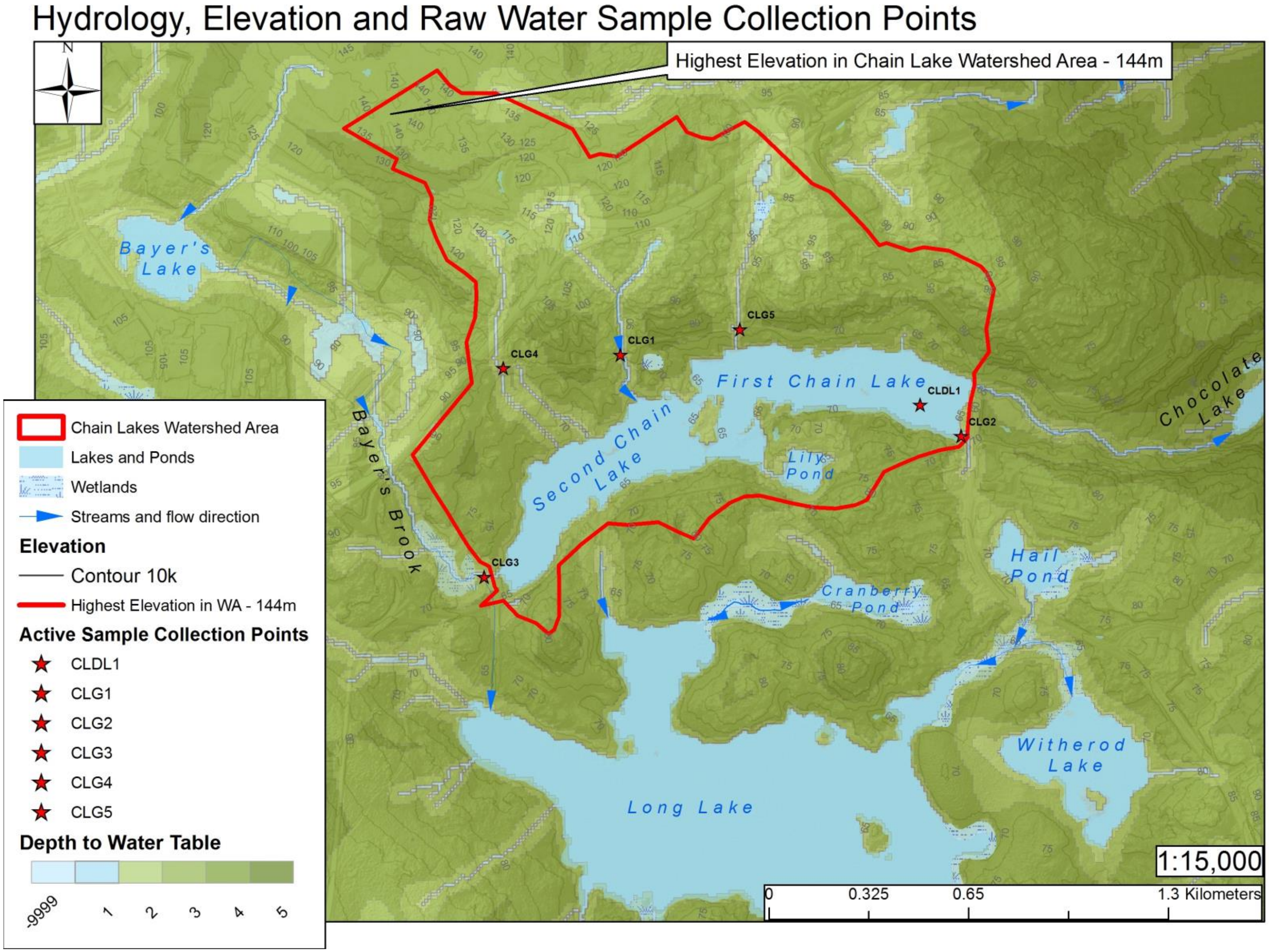
MAP A: BEDROCK GEOLOGY



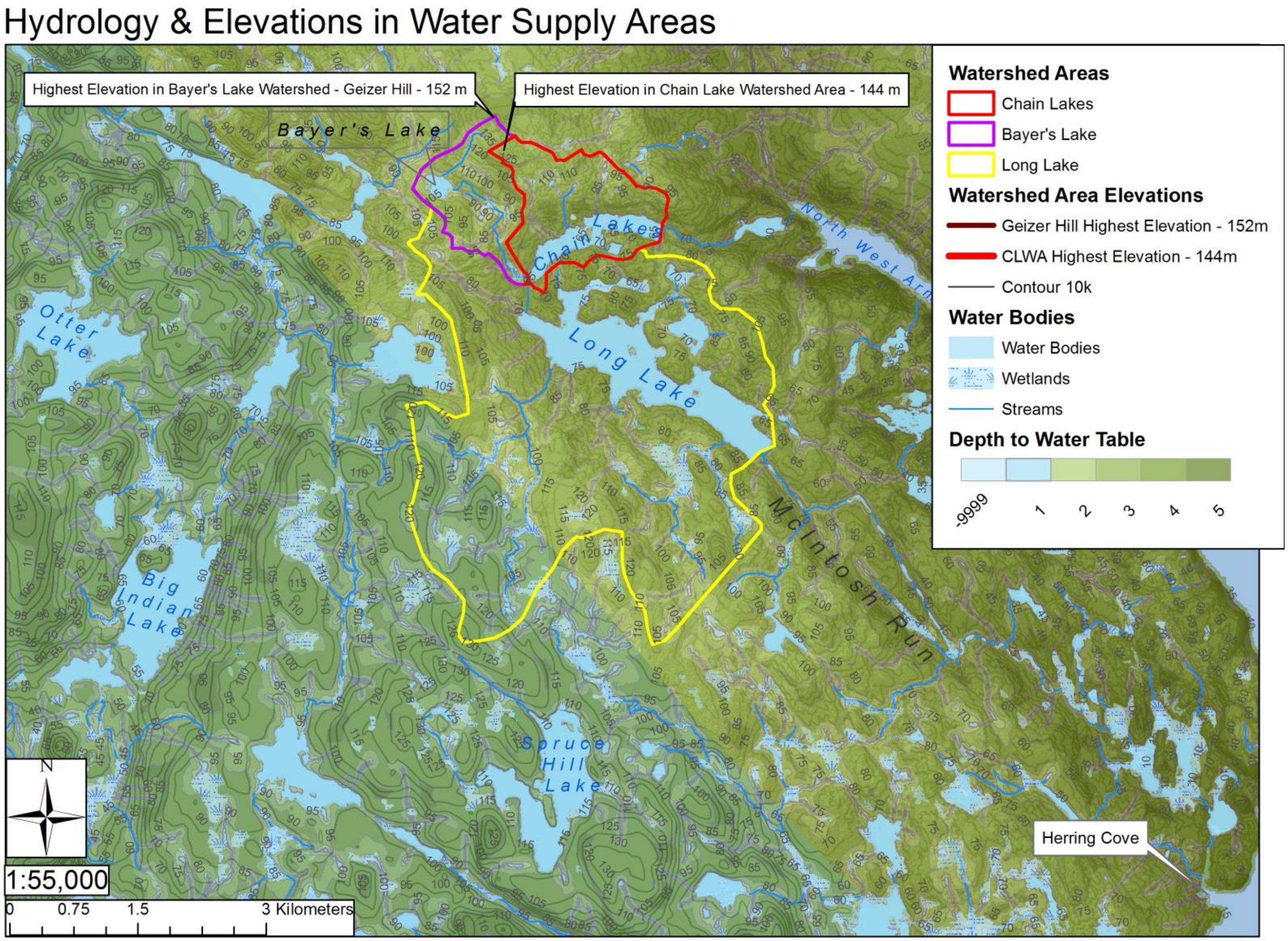
MAP B: SOIL AND SURFICIAL AND BEDROCK GEOLOGY



Map C: Hydrology and Raw Water Sampling Collection Points



MAP D: HYDROLOGY AND ELEVATIONS IN WATER SUPPLY AREAS



2.3 Location, Land Cover, Ownership and Built Form

This section of the SWPP describes the location, land cover, built form and landownership characteristics of the Chain Lakes watershed area. *Map E: Land Cover* on page 36, *Map G: Landownership and By-Law Zones* on page 38, *Map H: Road Infrastructure and Winter Maintenance* on page 39, *Map I: Power Utility Infrastructure* on page 40, *Map J: Halifax Water Infrastructure (Sewer and Water)on page* 41 and *Map K: Halifax Water Infrastructure – Long Lake* on page 42 illustrate the descriptions in this section.

2.3.1 Location

The Chain Lakes watershed area is located at longitude 63°39'0.543"W, and latitude 44°38'28.134"N. The elevation of the Chain Lakes watershed area ranges from approximately 144 m to 63 m at lake level (see *Map E: Land Cover* on page 36). The watershed area is bound on the north side by the Halifax Mainland Common – a subdivision bound by Washmill Lake Drive; on the south side by Long Lake Provincial Park; on the west side by Bayer's Lake and Ragged Lake Industrial Parks; and on the east side by North West Arm Drive and residential properties.

The Chain Lakes watershed area, currently amounting to 208.48 ha, was delineated based on a combination of factors including property boundaries, roadways (which define the drainage pattern through culverts and road base development), and natural ridge lines. The size of the original watershed area, amounting to approximately 2312 ha (2095+217), has been significantly reduced since drainage patterns from the Long Lake and Bayer's Lake subwatersheds have been altered to direct water flow away from the Chain Lakes watershed area (see *Map D: Hydrology and Elevations in Water Supply Areas* on page 20).

2.3.2 Natural Land Cover

Natural land cover inside the Chain Lakes watershed area amounts to ~163.87 ha (78.6%) and consists of: 121.46 ha (58.26%) of young-mature forest including 3.67 ha (1.76%) of forested burn area; approximately ~36.99 ha (17.74%) surface water areas (including wetlands); and 1.75 ha (0.84%) barren areas. See illustrations on *Map E: Land* Cover on page 36 and the descriptions of these areas under the corresponding sub-headings below.

Surface water network flow has undergone significant alterations due to a variety of historical uses including mills, quarrying and manipulation of the source water areas to supply potable water to the City of Halifax (see section *2.3.3: Water Supply Infrastructure* on page 23). More recently, surface water flow has been redirected around the development of the 100 series highways that carry travelers and commuters through the watershed. Further details on the Chain Lakes water networks are described under that heading below.

Forestry

Lands owned by Halifax Water within the Chain Lakes watershed area are subject to the *Halifax Regional Water Commission Act*, which restricts the harvesting and removal of wood (see section *2.5.1: Halifax Regional Water Commission Act* on page 26). Also, Halifax Water's Best Management Practices (BMPs) guide forestry (and other) activities on drinking water supply watershed area lands.

Water Networks

Approximately 36.99 ha (17.74%) of the Chain Lakes watershed area consists of surface water area. *Table 1: Chain Lakes Watershed Area Network* below outlines surface water areas within the Chain Lakes watershed. Section *2.2.4: Chain Lakes Hydrology and Environment* on page 13 describes the hydrology of the Chain, Bayer's and Long lakes watersheds, which are illustrated on *Map C: Hydrology and Raw Water Sampling Collection Points on page* 19 and *Map D: Hydrology and Elevations in Water Supply Areas* on page 20.

Bathymetry of First and Second Chain Lakes at their deepest points are 12.4 m and 12.2 m respectively (see Figures 5 & 6 respectively in *Appendix 1: Bathymetric Maps of First and Second Chain Lakes* on page 130).

Table 1: Chain Lakes Watershed Area Network

Surface Water Body	Water Body Area (ha) /Length (km)	Percentage of Watershed (%)	Bathymetry (m) (see *Appendix 1* on page 130)
First Chain Lake	19.18 ha	9.2	12.4
Second Chain Lake	15.47 ha	7.42	12.2
Lily Pond	1.44 ha	0.69	
Vernal pool	0.21 ha	0.1	
Wetlands	0.69 ha	0.33	
Streams and Brooks	662 m*	Negligible	
Totals	**36.99 ha (not included*)**	**17.74**	

2.3.3 Built Form

The watershed area also has undergone significant anthropogenic alterations to over 25% of the watershed area to accommodate transportation corridors (roads and trails), utility lines (power, water, wastewater and stormwater), housing and other built forms. The subsections below describe these built forms and the land area or length of corridor they occupy.

Transportation Corridors

Approximately 45.3 ha (21.73%) of the Chain Lakes watershed area has been converted to various forms of transportation infrastructure and power line corridors (see *Map H: Road Infrastructure and Winter Maintenance* on page 39 and *Map I: Power Utility Infrastructure* on page 40).

The road network supports the existing 14.67 km of paved roadways and pathways including 1.7 km of the Chain of Lakes Trail (see section *2.3.3: Chain of Lakes Trail* on page 22)). Additionally, the road network includes 0.71 km of power line corridor owned by HRM and a 0.48 ha road reserve parcel owned by NSTIR.

Chain of Lakes Trail

The Chain of Lakes Trail (COLT), (formerly the Chester Spur Line railway) travels north of First and Second Chain Lakes, intersecting the Chain Lakes watershed area from east to west for 1.7 km from the North West Arm Drive overpass to the Highway 103 overpass (see *Map H: Road Infrastructure and Winter Maintenance* on page 39). The Halifax Regional Municipality (HRM) purchased the abandoned line from the Canadian National Railway Company (CN) in 2009 in anticipation of building a new active transportation route from Joseph Howe Drive to Bayer's Lake Industrial Park and beyond. With Halifax Water support a new corridor design commenced in July 2010. In May 2011 the Chain of Lakes Trail (COLT) officially opened for non-motorized vehicles (except scooters and wheelchairs). The Chain of Lakes Trail Association (COLTA) was subsequently formed to manage the Chain of Lakes Trail on behalf of HRM.

Halifax Water sees the COLT as a means to educate the general public about source water protection and sustainable watershed management and to promote low-impact and sustainable watershed activities. Further, Halifax Water sits on the COLT Board and considers it a quasi-watershed advisory board, which provides advice on trial-related activities that affect the watershed area along the length of the trail.

Water Supply Infrastructure

The Chain Lakes surface water supply provides the emergency back-up water supply for the regions served by Pockwock Lake, i.e., Halifax, Bedford, Sackville, Timberlea, Fall River, and Waverly (see *Map L: Primary Water Supply Watershed and Distribution Areas* on page 103).

The Chain Lakes Water Supply Pumping Station, (see *Map J: Halifax Water Infrastructure (Sewer and Water)* on page 41) was originally commissioned in 1948. There is no filtering system at the Chain Lakes water treatment facility.

Dam Infrastructures

In 2012 Halifax Water completed a dam safety review of all of its dams and spillways including the Bayer's Lake Diversion Dam and the First Chain Lake Dam. The Plant Operations Group within the Water Services Department at Halifax Water (specifically, staff at the J.D. Kline Water Services Plant) is responsible for the operation and maintenance of these dams. Descriptions of dams and spillways are described under the subheadings below.

Bayer's Lake Diversion Dam

According to record drawings, the Bayer's Lake Business Park diversion dam is 3.3 m high and 83 m long. It was constructed in approximately 1986 and is located at the head of Second Chain Lake. It was constructed to divert Bayer's Brook into Long Lake (see the *Bayer's Lake Dam* inset map on *Map J: Halifax Water Infrastructure (Sewer and Water)* on page 41). The Bayer's Lake Diversion dam is classified as a *low* consequence structure in terms of life, economic and economic losses.

A sampling station (CLG3) is located immediately upstream of the diversion dam (indicated on *Map C: Hydrology and Raw Water Sampling Collection Points on page* 19) to monitor water quality from the Bayer's Lake Business Park as described in section *5.4.2: Bayer's Lake Wastewater System* on page 124).

Chain Lakes Dam and Spillway

The Chain Lakes dam and spillway (see *Chain Lake Dam and Spillway* inset map on *Map J: Halifax Water Infrastructure (Sewer and Water)* on page 41) is situated 64.3 m above sea level. It is located under the North West Arm drive overpass at the outflow from First Chain Lake. This infrastructure was constructed in the mid-19th century to control water levels in First and Second Chain Lakes. The dam and spillway are in need of upgrades according to the Dam Classification

Study conducted in 2012 and detailed in a 2013 report for Halifax Water by Mitchelmore Engineering Company Ltd. (Meco). The Chain Lakes Dam and Spillway is classified as a *high* consequence structure due to the potential for loss of life and economic losses; and a *low* consequence structure in terms of environmental losses.

The Chain Lakes spillway remains open except for emergencies or for temporary use during a scheduled repair of the Pockwock water supply system.

Central Sewer and Wastewater Systems

Prior to the new Chain of Lake Sewer Trunk system, raw sewage was pumped from the pump station located at 118 Chain Lake Drive uphill through the northwest corner of the watershed, under the Hwy 102 and Hwy 103 ramps and eventually into the Halifax Harbour Solutions Wastewater Treatment Plant. The aging 12 inch pre-cast iron forcemain reached its flow capacity and had experienced high rates of failure. To overcome these deficiencies, upgrades were completed in two Phases as described below.

Washmill Court/Lake Extension – Phase I

Washmill Court/Lake Extension – Phase I of the Chain Lakes area sewer line upgrade – was completed in 2011 whereby ~893 m of newly constructed 10 inch (250 mm) polyvinyl chloride PVC SDR 35 gravity flow pipe, was added to the Geizer Hill area. This sanitary sewer pipeline cuts across the northern corner of the watershed area and along the northern watershed boundary connecting to the Harbour Solutions Sewershed at the Mount Royal Estates subdivision (see "*Pre-existing sanitary sewer pipe* and *sewer pipe trunk* illustrations on *Map J: Halifax Water Infrastructure (Sewer and Water)* on page 41).

Chain of Lakes Sewer Trunk – Phase II

Chain of Lakes Sewer Trunk – Phase II of the Chain Lakes area sewer line upgrade – was completed in 2014. The project involved decommissioning ~1213 m of the old 12-inch pre-cast iron Bayer's Lake forcemain and replacing it with a new 42 inch (1050 mm) fused gravity HDPE sewer pipe to accommodate the increased capacity and design flow from the Bayer's Lake Business Park and the Timberlea areas (see *"Decommissioned (2014) Sanitary Sewer Forcemain*" illustration on *Map J: Halifax Water Infrastructure (Sewer and Water)* on page 41). The COLT was deemed the best location to place the new sewer pipe since the grade allows gravity to carry the sewage to the Harbour Solution facility, which reduces pipe pressure and subsequently the environmental risk from potential malfunctioning of mechanical and electrical equipment used to pump sewage through the pipe. Further, the pipe material and fused joint construction allows for a longer life span and fewer point failures.

The new HDPE sanitary sewer pipe transects the Chain Lakes watershed area for 1.7km – from the Hwy 103 overpass to the North West Arm Drive overpass (see also *Map J* on page 41) and is the predominant type of sanitary sewer pipe used under the COLT. There is one joint in the 1050 mm HDPE pipe where it joins a 48 inch (1200 mm) SaniTite® pipe that is located east of the Hwy 103 overpass just inside the watershed area.

Stormwater Management

The Chain Lakes watershed area is particularly vulnerable to stormwater runoff due to the abundance of paved highways, trails and pipelines that crisscross the Chain Lakes watershed area. For more details on how the Chain Lakes watershed area is affected by stormwater, see headings throughout section *3.1: Inherent Risk Factors* beginning on page 43.

Power Line Corridors

Approximately 4.2 km (6.14 ha) or 2.94% of the Chain Lakes watershed area is classified as power line right of way. The locations of the network of power transmission lines within the watershed area are illustrated on *Map E: Land Cover* on page 36.

Urban Development

Approximately 1.23 ha (0.59%) is urban development, specifically housing and business as described in section *2.3.4: Landownership* on page 25 and illustrated on *Map G: Landownership and By-Law Zones* on page 38.

2.3.4 Landownership

The landownership breakdown of the watershed area is outlined in *Table 2* below and illustrated on *Map G: Landownership and By-Law Zones* on page 38.

Table 2: Breakdown of Landownership by Type, Agency/Department and Land Area
(excluding 36.09ha surface water area and including 0.69ha wetland areas and 0.21ha vernal pool)

Agency Type	Agency/Department	Area (ha)	Watershed Area (%)
Utility	Halifax Water	111.51	53.49
	Nova Scotia Power Inc.	0.23	0.11
Province	NSTIR	40.86	19.59
Municipality	HRM	18.82	9.03
Private	Residential	0.70	0.34
	Business	0.32	0.15
Total Land Area		**172.44**	**82.71**

2.4 Water Area Designation

The Chain Lakes watershed area is not designated as a Protected Water Area under the Nova Scotia *Environment Act. 1994-95, c. 1, s. 1*. However, it is referenced as a watershed area and is protected under section 25(1) of the *Halifax Regional Water Commission Act 2007, c. 55, s. 1 (HRWC Act)* described under that heading below.

2.5 Governance

The mechanisms that govern the protection of the Chain Lakes water supply include provincial policies and regulations and municipal land use planning policies and by-laws.

2.5.1 Provincial Policies and Regulations

More specifically, the *Halifax Regional Water Commission Act* and the *Halifax Regional Municipality Charter* regulate activities that pertain to the watershed area; however, the *Special*

Places Protection Act also may restrict activities that may otherwise impact the watershed. The following subsections describe these provincial policies in more detail.

Halifax Regional Water Commission Act

Section 25 of the *Halifax Regional Water Commission Act* amended 2012; c. 60 governs the protection of the Chain Lakes watershed area and is defined as:

25 (1) No person shall place or permit to escape upon any land adjacent to Pockwock, Tomahawk, Chain, Long, Major, LaMont and Topsail Lakes, and all lakes, ponds or other bodies of water tributary thereto, or any lake or tributary of such lake at any time forming part of the water system of the Regional Municipality, or upon any land or water forming part of the watershed of any one of such lakes, any matter or thing of an offensive or deleterious nature or calculated to impair the quality of the water for use for domestic purposes.

(2) No person shall

(a) cut any ice on any lake forming part of the water system of the Commission or fish, bathe, wash in or otherwise impair the quality of the water in any such lake; or

(b) cut any wood or camp on any land of the Commission located on the watershed of any lake forming part of the water system of the Commission or haul any wood, wherever cut, across any such lake without first obtaining the consent in writing of the Commission.

(3) No person shall, upon any land forming part of the watershed of any of the lakes forming part of the water system of the Commission, erect or construct or place or cause or permit to be erected, constructed or placed, any building or structure unless such person has first obtained from the Commission permission to do so. 2007, c. 55, s. 25.

Further, under section 6A of the *Halifax Regional Water Commission Act*, "*Where there is a conflict between this* Act *and the [Halifax Regional Municipality] Charter, this* Act *prevails. 2012, c. 60, s. 4.*"

Halifax Regional Municipality Charter

The *Halifax Regional Municipality Charter 2008, c. 39, s. 1* may provide regulatory protection of a water supply area, including Chain Lakes through the following policies.

<u>Protected water supply area</u>

"198 (1) The Council may, by by-law, designate lands owned by the Municipality as protected water supply areas.

(2) No person shall

(a) place, or permit to escape, any matter or thing of an offensive nature, deleterious nature or likely to impair the quality of water for use for domestic purposes, upon land in a protected water supply area;

(b) fish or bathe in a lake, or other body of water, in a protected water supply area;

(c) camp on land in a protected water supply area; or

(d) cut wood or erect, construct or place a building or structure in a protected water supply area without the permission of the Council.

(3) The Angling Act does not apply to a lake, river or stream forming part of a water supply area of the Municipality or to the land surrounding or adjacent to them.

Special Places Protection Act

The *Special Places Protection Act* R.S., c. 438, s. 1 is relevant to the Chain Lakes watershed area due to an archeological discovery on an HRM parcel of land located in the northwest corner of the Chain Lakes watershed, illustrated on *Map G: Landownership and By-Law Zones* on page 38. The archeological features on this parcel have special protection status through this *Act*.

2.5.2 Municipal Land-Use Planning Policies and By-laws

The Chain Lakes watershed area is municipally governed through the 2014 Regional Plan, Community Plans/Secondary Planning Strategies, and HRM and City of Halifax by-laws. The following subsections outline, through brief descriptions and tables, the municipal governance policies, designations and regulations relative to the Chain Lakes watershed area.

Regional Municipal Planning Strategy (Regional Plan) Policies

The Halifax Regional Municipal Planning Strategy (2014) (2014 Regional Plan) adopted in October 2014 contains land use designations and accompanying policies that guide the land use activity that may occur in a given area. The land use designations relevant to the watershed area are Open Space and Natural Resources (OSNR), Urban Settlement (US) and Business/Industrial Park (IP). The Plan policies that guide the land use activity within the Chain Lakes watershed area are found in: Chapter 2 – Environment, Energy and Climate Change; Chapter 3 – Settlement and Housing; Chapter 8 – Municipal Water Services, Utilities and Solid Waste; and Chapter 9 – Governance and Implementation Policies. The following briefly describe and outline in tables the land use designations, followed by the policies governing them with respect to the Chain Lakes watershed area.

Generalized Land Use Designation Areas

Generalized land-use designation areas of the 2014 Regional Plan policy applicable to the Chain Lakes watershed are outlined in *Table 3: 2014 Regional Plan Generalized Land Use Designation Area Relevant Policies* below.

Table 3: 2014 Regional Plan Generalized Land Use Designation Area Relevant Policies			
Policy	**Definition**	**Details Outline**	**Number**
Land Use Designation			
Open Space and Natural Resource	Strengthens the connection between natural areas, parks and communities to conserve biodiversity, provide opportunities for outdoor recreation, retain HRM's natural and cultural heritage, support the retention of important environmental systems and preserve HRM's quality of life.	This land use designation shall apply to government-owned and private resource sector lands and generally preserve the interconnected system of open space and minimize fragmentation within the Open Space and Natural Resource Designation.	E-1
		HRM shall, through the Subdivision By-law, prohibit residential development on new roads through the Subdivision By-law,	E-2
		Provide for the creation of one additional lot from any area of land that is within the Open Space and Natural Resources Designation provided that the area of land was in existence prior to April 29, 2006;	E-3
Urban Settlement	Areas where HRM approval for serviced areas have been designated under Urban Settlement.	HRM shall work with Halifax Water to coordinate municipal land use planning and development initiatives with the planning and development of municipal water, waste-water and stormwater facilities in areas that have been considered for serviced development over Plan life (subject to Policy S-2).	S-1 and S-2
Business/ Industrial Park	Where HRM has identified lands that may be suitable for industrial uses.	Ensures that secondary planning strategies and land use by-laws allow lands to remain available for intended uses while minimizing conflicts with existing or future incompatible uses in the vicinity	EC-5

The land area and ownership within each land use designation area is outlined in *Table 4: 2014 Landownership in Land Use Designation Areas in Chain Lakes Watershed Area* below.

Table 4: 2014 Landownership in Land Use Designation Areas in Chain Lakes Watershed Area			
2014 Regional Plan Land Use Designations and Land Area (ha)*		**Landownership Areas (ha)**	
Open Space and Natural Resource	~0.65	Halifax Water	~0.65
Urban Settlement (US)	~207.88**	Halifax Water	~110.86
		HRM	~18.82
		NSTIR	~40.86
		Private Resident	~0.7
		Private Business Interest	~0.32
		NSPI	~0.23
Business/Industrial Park (IP)**	~5.96	HRM	~5.64
		Private Business Interest	~0.32

*Note: Landownership areas **do not** include surface water areas (36.09ha) and **do** include wetland (0.69ha) and vernal pool (0.21ha) areas.

- **Note: Urban Settlement Designation includes the ~5.96 ha of the Business / Industrial Park sub-designation.

2014 Regional Plan Policies

Under the following subheadings, brief descriptions and tables outline the respective 2014 Regional Plan policies that are relevant to the Chain Lakes watershed area.

Environment, Energy and Climate Change

The 2014 Regional Plan policies applicable to the Chain Lakes watershed area from Chapter 2: *Environment, Energy and Climate Change* are outlined below in *Table 5: Regional Plan Chapter 2: Environment, Energy and Climate Change Relevant Policies* on page 29.

Urban Settlement and Housing

The Chapter 3 – *Urban Settlement and Housing* policies relevant to the Chain Lakes watershed area (S-1 and S-2) fall under the *Urban Settlement* land use designation as outlined in *Table 3: 2014 Regional Plan Generalized Land Use Designation Area Relevant Policies* above.

Table 5: Regional Plan Chapter 2: Environment, Energy and Climate Change Relevant Policies

Policy	Definition	Policy Details Outline	Policy Number
Greenbelting: Building an Open Space Network			
Natural Networks	Connection between natural areas, parks and communities to conserve biodiversity, provide opportunities for outdoor recreation, and retain HRM's natural and cultural heritage.	Establishes Protected Area Zones applicable to designated wilderness areas, nature reserves, and conservation-related properties owned by government or private conservation organizations.	E--7
		Evaluates the potential for the designation of additional lands for protection under the Wilderness Areas Protection Act.	E-8
		Delineates natural corridors consistent with the Greenbelting and Public Open Space Priorities Plan approach.	E-9
Water Resources			
Potable Water	Protection for non-designated potable water supply areas in HRM the 2014 Regional Plan *recognizes that "[c]onsideration may need to be given to adopting municipal measures that protect water supply watersheds and future water supplies not provincially designated as water supplies.*	Establishes a Protected Water Supply Zone applied to all publicly owned lands which serve as a water supply watershed, including emergency water supply watersheds and well head protection areas.	E-13
		Council shall consider amendments to land use by-laws deemed necessary to: (a) protect the water supply; (b) ensure a consistent regulatory approach within each watershed; or (c) conform with any Statement of Provincial Interest Regarding Drinking Water."	E-14
Wetlands Protection	Wetlands less than 2 ha in area are assessed under the Nova Scotia Wetland Conservation Policy and those more than 2 ha in area require an environmental impact assessment as per the *Environmental Assessment Act*.	Establishes a Wetlands Schedule by-law to be used as a reference to prohibit development within any such wetland except as required to allow for public infrastructure and in conformance with any Provincial guidelines or Statement of Provincial Interest.	E-15
Riparian Buffers	Policy provides a mechanism to retain native vegetation and native soils which enhance runoff storage capacity, infiltration, and preventing activities or land uses which introduce nutrients or contaminants into watercourses.	Requires the retention of a minimum 20 metre wide riparian buffer along all watercourses throughout HRM to protect the … functions of … freshwater resources. Through a secondary planning process, the width of the riparian buffer may be increased.	E-16

Municipal Water Services, Utilities and Solid Waste

Chapter 8 – *Municipal Water Services, Utilities and Solid Waste* of the 2014 Regional Plan explains the role with regard to coordinating common initiatives between HRM and Halifax Water. Generally, these initiatives include ensuring cost effectiveness around financial expenditures, providing services, reducing degradation to the natural environment, managing growth and associated infrastructures and reducing above-grade electrical and telecommunication lines. The Chapter 8 policies relevant to the Chain Lakes watershed are outlined in *Table 6* on page 30.

Table 6: Regional Plan Chapter 8: Municipal Water Services, Utilities and Solid Waste Relevant Policies			
Policy	**Definition**	**Policy Details Outline**	**Number**
Transfer Agreement			
Transfer Agreement	An agreement between Halifax Water and HRM to better serve the public interest with respect to water, stormwater and wastewater services.	HRM shall work with Halifax Water to coordinate municipal land use planning and development initiatives with the planning and development of municipal water, waste-water and stormwater facilities in a manner that is consistent with the objectives of this Plan, the Transfer Agreement and can satisfy policies and regulations of Halifax Water and the Review Board.	S-1
Stormwater Management: A Municipal Role			
Stormwater Management and Erosion Control	HRM can play a role in stormwater management through watershed studies that include appropriate stormwater management strategies and consideration of climate change impacts.	HRM shall consider: adopting a stormwater management and erosion control by-law, subject to approval by the Review Board with area-specific provisions that consider: operational and regulatory measures to reduce quantity and improve quality of stormwater entering public facilities and watercourses; retrofits to mitigate flooding; funding for daylighting watercourses; amending by-laws in accordance with Provincial standards on stormwater quality; and stormwater management rate structures.	SU-7-S-12
Utilities			
Electrical and Telecommuni-cation Lines	Initiatives to provide underground utilities, primarily in urban and commercial centres.	Consider future amendments to the Regional Subdivision By-law to require the underground placement of all electrical and communication lines within street rights-of-way or rear lot servicing.	SU-25
Natural Gas	Encourage distribution infrastructure expansion… providing access to an alternate fuel source for many residents and businesses.	HRM shall work with Heritage Gas and provincial regulators to increase access to a comprehensive natural gas distribution system within the HRM's Urban Service Area.	SU-27

Governance and Implementation

An important component of the 2014 Regional Plan is to ensure community engagement that is inclusive and accessible to all. Chapter 9 – *Governance and Implementation* of the 2014 Regional Plan defines the objectives to achieve this. The relevant component polices regarding *Measuring Success* and *Secondary Planning Strategies* which affect the Chain Lakes watershed area are outlined in *Table 7* below.

Table 7: 2014 Regional Plan: Chapter 9 – Governance and Implementation Relevant Policies			
Policy	**Definition**	**Policy Details Outline**	**Number**
Measuring Success			
Measuring Success	Performance measures assist in evaluating the effectiveness of policies, programs, and investments in achieving the vision and objectives of the Plan.	Performance measures, presented in Appendix A of the 2014 Regional Plan shall assist in evaluating the effectiveness of policies, programs, and investments in achieving the stated vision and objectives of this Plan. Targets will be developed, where appropriate, and Regional Council will be provided with annual reports.	G-4

Secondary Planning Strategies			
Secondary Planning Strategies	…present visions, objectives and policies of a community which may not be consistent with this Plan. HRM will strive to achieve consistency in all its planning documents and programs to ensure that they are consistent with this Plan and that they reflect current community issues and desires for future change	When evaluating amendments to Land Use By-laws or development agreement applications, in the event of conflict between the policies of this Plan and a Secondary Planning Strategy, the more stringent shall prevail.	G-7
		Where minimum setbacks from watercourses have been established under Secondary Planning Strategies and Land Use By-laws differ from the minimum twenty (20) meter setback specified by the 2014 Regional Plan, the more stringent shall prevail.	G-8
		When new secondary planning strategies or amendments to existing secondary planning strategies are brought forward for approval, HRM shall consider whether the proposed objectives and policies are consistent with or further achieve the objectives and policies of the 2014 Regional Plan.	G-9

Community Plan Area

The Chain Lakes watershed area is situated in the Halifax (Community) Plan Area. The "complete package" of zoning regulations (policies and by-laws) for the Halifax Plan Area is comprised of the Municipal Planning Strategy (MPS), Land Use By-law (LUB), Zoning Map, Schedule Map, Height Precinct Map, View Plane Map, McIntosh Run Flood Plain Map, and Building Line Plan.[6] To determine allowable land uses within the Chain Lakes watershed, the "complete package" was reviewed.

Zoning regulations that were determined to be relevant to the Chain Lakes watershed area include particular Halifax MPS policies, LUBs (Zoning By-laws), and Zoning and Schedule Maps and are explained under the following subheadings. The remaining "package" components were determined not to be relevant to the Chain Lakes watershed area.

Halifax Municipal Planning Strategy (MPS) Policies

The Municipal Planning Strategy (MPS) provides the framework to guide decision-making with respect to development of a particular Community Plan area. Governance for the Chain Lakes watershed area is provided through the policies of Halifax MPS and its associated GFLUM (illustrated on *Map F: Community Plan Areas and GFLUMs for 2014 Regional Plan and* Halifax MPS on page 37) and the Halifax Mainland Land Use By-law (LUB) outlined in *Table 9: Landownership Areas in Land Use By-law Zones* on page 34and illustrated on *Map G: Landownership and By-Law Zones* on page 38.

The Halifax MPS policies and objectives under *Part II, Section II: City-wide Objectives and Policies* of the MPS which pertain to the Chain Lakes watershed area and the MPS land use designations are outlined in *Table 8: Community Plan (Halifax MPS) Designation* and Area (ha) and Landownership for the Chain Lakes Watershed* on page 32 and include the following:

[6] Halifax Regional Municipality: Halifax Plan Area. Website source: http://www.halifax.ca/planning/HalifaxPlanArea.php .

Residential Environments

Under this policy the future "*disposition*" of "*Watershed lands*" is considered under the residential objective of the Halifax MPS. However, it is unclear to which "Watershed lands" this policy is referring as there is no reference to the Chain Lakes watershed area in the Halifax MPS.

Environment

Halifax MPS Policy objectives 8.1 and 8.5 pertain to protection of the watershed (generally) by preparing an Environment Strategy Statement which "*upon adoption, shall amend this Plan and accompanying development regulations as appropriate*" (per policy objective 8.1); and create standards for "*maintaining lake systems and their watersheds in a healthy state*" (per policy objective 8.5).

(MPS) Generalized Future Land Use Map (GFLUM)

The Halifax Municipal Planning Strategy: Map 9 Generalized Future Land Use Map (GFLUM) geographically depicts the "*expression of intent of the City of Halifax for a future land use pattern based on the policies"* of *Part II, Section II* of the Halifax MPS as determined by the objectives and policies which correspond to the primary use shown on Map 9. However, "*all other objectives and policies shall apply as appropriate but shall be subordinate to the primary objectives and policies*." The land use designation areas and the landownership within them are outlined below in *Table 8: Community Plan (Halifax MPS) Designation* and Area (ha) and Landownership for the Chain Lakes Watershed* below and illustrated on *Map F: Community Plan Areas and GFLUMs for 2014 Regional Plan and* Halifax MPS on page 37.

Table 8: Community Plan (Halifax MPS) Designation* and Area (ha) and Landownership for the Chain Lakes Watershed

Community Plan (MPS) Land Use Designations and Area (ha)		Landownership and Area (ha)	
Residential	41.53	NSTIR (Road Arteries)	19.98
		Halifax Water	16.15
		HRM (standard parcels (4.4ha) and road artery (0.07ha))	4.47
		Private Residential landowners	0.7
		NSPI	0.23
Industrial	11.97	NSTIR (road arteries)	5.99
		HRM	5.66
		Private Business	0.32
Open Spaces	154.99**	Water areas	36.99
		HRM (road arteries for St. Margaret's Bay Rd and power line corridor (3.68); and COLT (5.07ha))	8.75
		NSTIR (10.65ha road arteries + a 4.32ha standard parcel)	14.97
		Halifax Water land areas (including islands in lakes)	94.28

* Note: This Community Plan Designation is for the Halifax Mainland By-law ID data sourced from the HRM ArcGIS data feature class: SDEADM.LND_gflum accessed March 13, 2014.
** Note: * Note: 36.09ha of surface water lakes, vernal pool (0.21ha) and wetlands (0.69ha) are all included.

Implementation Policies

The Halifax MPS policies relevant to the Chain Lakes watershed area include:

Zoning

3. *"… the City shall adopt the Zoning By-law, Mainland Area and Zoning By-law, … of the City of Halifax substantially as they presently exist to further the objectives and policies of this Plan, except those by-laws shall first be revised according to the directions established by the detailed policies below.*

3.3 *For the residentially designated undeveloped areas of Mainland North, the City shall … establish such development regulations as are necessary to implement the policies of this Plan.*

3.3.1 *Further to Policy 3.3 above, these areas shall be identified on the zoning map and within such areas no development permit shall be issued unless the proposed development has been approved by a resolution of Council, and further, except under an agreement with Council pursuant to [*the MGA*].*

3.3.2 *Further to Policy 3.3.1 above, the purpose for which land within these areas is to be developed shall be primarily residential, and an emphasis shall be placed on a mix of housing types, shall include provision for local commercial uses that are intended to serve the residents of the immediate area, and shall include provision for automobile, transit and pedestrian circulation and an emphasis on conservation of natural environment features including lakes and waterways, mature trees and natural topographic features….*

3.3.3 *The City shall prepare and adopt plans for major public facilities including the location of collector roadways, schools and major community open space in the residentially designated undeveloped areas of the City."*

These policies indicate that, in particular, the northern section of the watershed area shall be developed when the time comes and as approved by Council.

PLAN AMENDMENTS

Under section 7 of the MPS–Implementation Policies, plan amendments are required to "*change, alter, amend, revise or delete any policy of Part II*" of the MPS or "*undertake a proposed zoning amendment or rezoning which would otherwise not conform to the Generalized Future Land Use Map (Map 9) or to the policies of this Plan if warranted by further planning study*."

<u>Land Use By-law for Halifax Mainland</u>

The Municipal Planning Strategy (MPS) for Halifax has two sets of Land Use By-laws (LUBs) associated with it: the Land Use By-law (LUB) for Halifax Mainland (HM) and the LUB for Halifax Peninsula. The LUB governing the Chain Lakes watershed area is the Halifax Mainland LUB (HM LUB) which contains the by-laws permitting land use activities within this LUB Plan area. The regulatory structure is such, as stated in the Halifax MPS, that the "*municipality cannot regulate directly*" from an MPS; rather it must regulate from a Zoning By-law adopted by the municipality to carry out the intent of the Plan

Permissible and actual land use activities and landownership areas within each By-law Zone are outlined in *Table 9: Landownership Areas in Land Use By-law Zones* below and *Table 10: Halifax Mainland LUB By-law Zones Permitted Land-uses in Watershed Area* on page 35, respectively, and illustrated on *Map G: Landownership and By-Law Zones* on page 38.

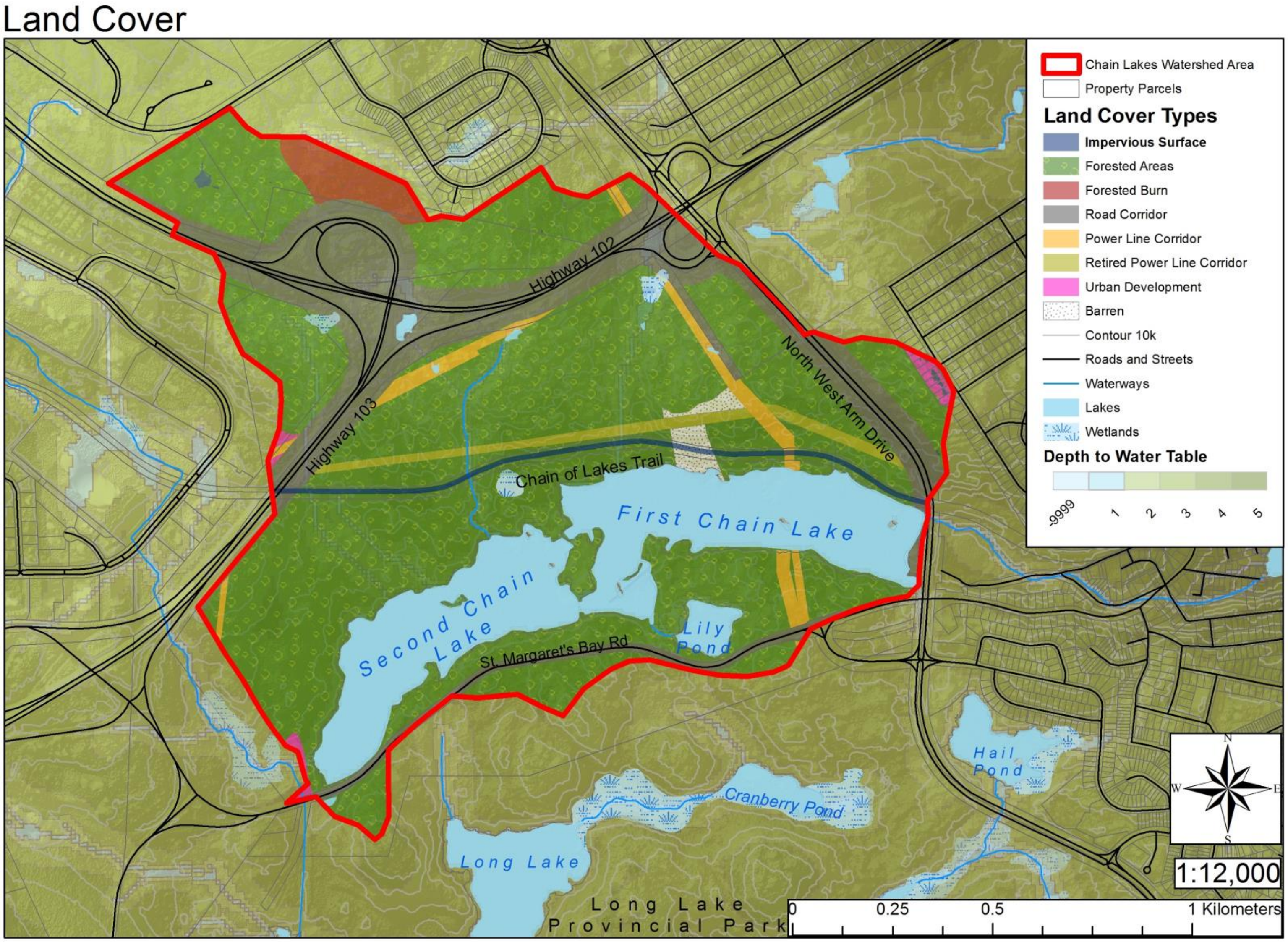
Table 9: Landownership Areas in Land Use By-law Zones

By-law Zone	Landowners	Area (ha)	Total Area (ha)
I-3	HRM	5.64	5.95
	Business	0.32	
Schedule K	Halifax Water.	16.15	17.09
	Nova Scotia Power Inc.	0.23	
	HRM	0.23	
	NSTIR (Road Arteries)	0.57	
PWS (W*)	Halifax Water	92.98	106.1
	HRM	8.76	
	NSTIR	4.32	
	Private	0.022	
R-1	Private	0.68	0.88
	HRM	0.2	
RDD	HRM	0.125	0.126
Total Land Area*		**130.15**	**130.15**

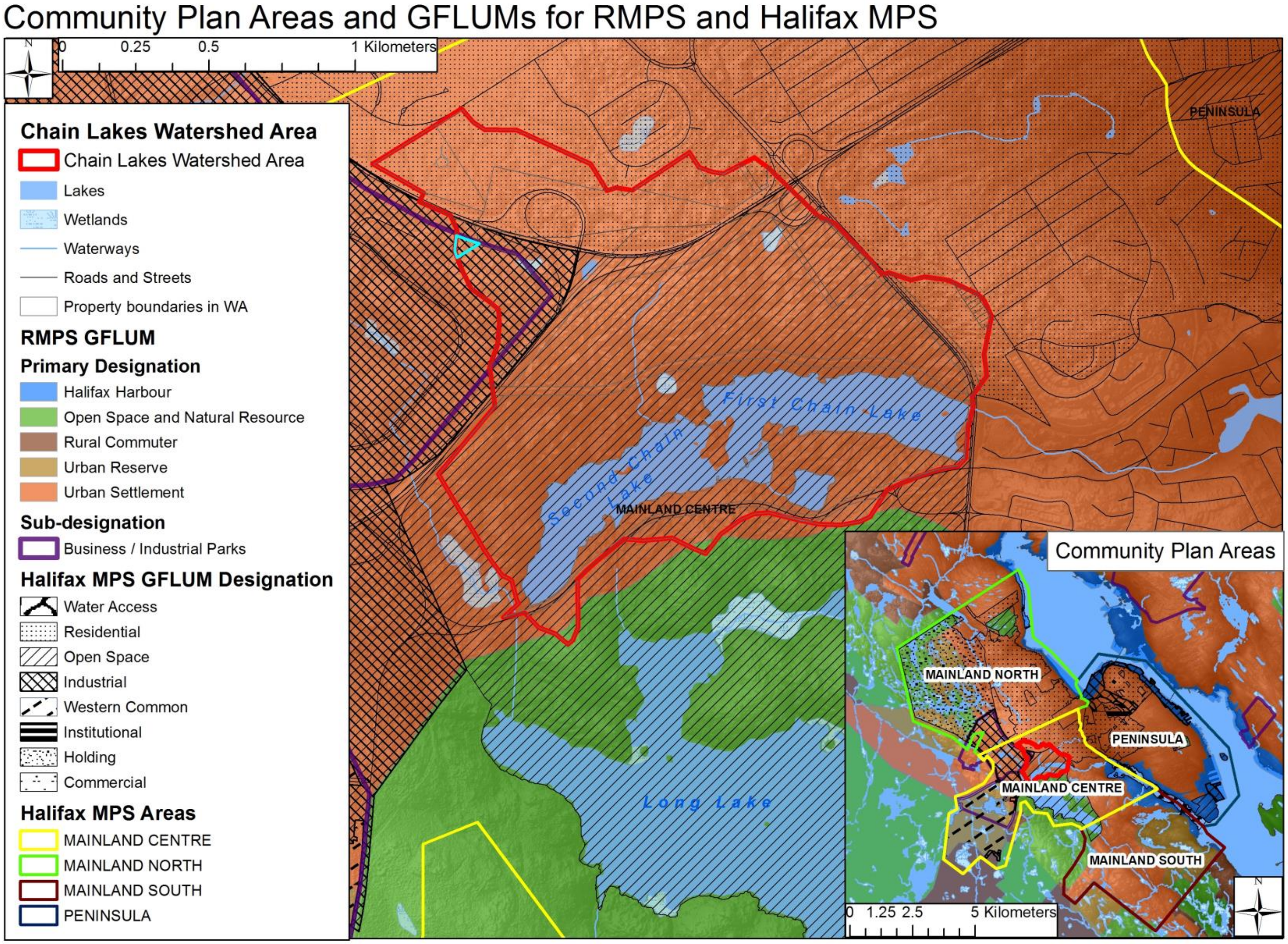
* Note: 36.09 ha of surface water lakes and ~41 ha road parcel amounts are not included (except the COLT, which is included) in the By-law Zone areas. Vernal pool (0.21 ha) and wetlands (0.69 ha) are included.

Table 10: Halifax Mainland LUB By-law Zones Permitted Land-uses in Watershed Area		
Halifax Mainland (9)		***130.15 land**
By-law Zone	**Zone Area* (ha)**	**Permitted Uses in Specified By-law Zone**
I-3 (General Industrial Zone)	5.95	Any industrial/commercial enterprise, except when the operation of same would cause a nuisance or hazard to the public and except: billboards; adult entertainment uses; and amusement centres; and a public park. **REQUIREMENTS** …any development … shall be required to be set back 200ft. from any lake or watercourse and any use permitted … shall be set back a minimum of 30ft from a collector roadway and 10ft. from all other roadways. Sewage disposal and water services may be provided on site or off site in any manner consistent with the regulations of the Province of Nova Scotia, provided that no on-site sewer and water services shall be permitted on land inside the Development Boundary identified on Map II, Appendix "C" of the Halifax-Dartmouth Metropolitan Regional Development Plan.
PWS (Protected Water Supply)	106.1	Municipal water distribution or purification facilities; Conservation uses; and Uses accessory to the foregoing uses. **REQUIREMENTS** Buildings erected, …shall comply with the following requirements: Minimum Front or Flankage Yard:9.1m Minimum Rear or Side Yard: 4.6m **OTHER REQUIREMENTS:** SETBACKS FROM WATER SUPPLY SOURCES (RC-Jun 25/14;E-Oct 18/14) (a) No development permit shall be issued for any development within 30.5 metres of any lake or other watercourse within the PWS (Protected Water Supply) Zone, except for the uses permitted under Section 62(1). (b) Notwithstanding Section 14QA(1), water distribution or purification uses may be built to the lot line where the line corresponds to the shore line.
R-1 (Single Family Dwelling)	0.88	A detached one-family dwelling which may include the office of a professional person located in the dwelling house used by such professional person as his private residence; a home occupation; a public park or playground; a church and church hall; a golf course; a tennis court; a yacht or boat club; a public recreational centre; a day care facility for not more than 8 children in conjunction with a dwelling (CCC-Apr 6/09;E-Oct 8/09); a special care home containing not more than ten persons including resident staff members; and uses accessory to any of the foregoing uses.
RDD (Residential Development District)	0.13	R -1 and R-2 uses as hereinbefore set out; and uses accessory to the foregoing. R-1 AND R-2 USES IN RDD ZONE Buildings erected, altered or used for R-1 and R-2 uses in an RDD zone shall comply with the requirements of the R-1 and R-2 zones respectively. Notwithstanding any other provision of this by-law, Council may, by resolution, approve any specific development application pursuant to Policy 1.5.1 of Part II, Section X (Schedule I) of the Municipal Planning Strategy.
Schedule "K" (Compre-hensive Development District)	17.09	The purpose for which Schedule K land is to be developed shall be primarily residential. An emphasis shall be placed on a mix of housing types; shall include provision for local commercial uses and community facilities that are intended to serve the residents of the immediate area, and shall include provision for automobile, transit, and pedestrian circulation; and an emphasis on conservation of natural environment features including lakes and waterways, mature trees, and natural topographic features. In addition to the above, Council may consider provision for commercial uses in accordance with the policies of the Municipal Planning Strategy.
Total area	**130.15**	
* Note: 36.09 ha of surface water lakes and ~41 ha road parcel amounts are not included (except the COLT which is included) in the By-law Zone areas. ** Note: The acronym PWS is sometimes referenced as "Public" Water Supply and sometimes "Protected" Water Supply, even within the same LUB. For consistency, PWS means "Protected" Water Supply in this document. *** Note: What was formerly zoned Watershed (and may still appear Zoned as such on Map ZM-1 (Centre) associated with the Halifax Mainland LUB, is considered to be Zoned PWS).		

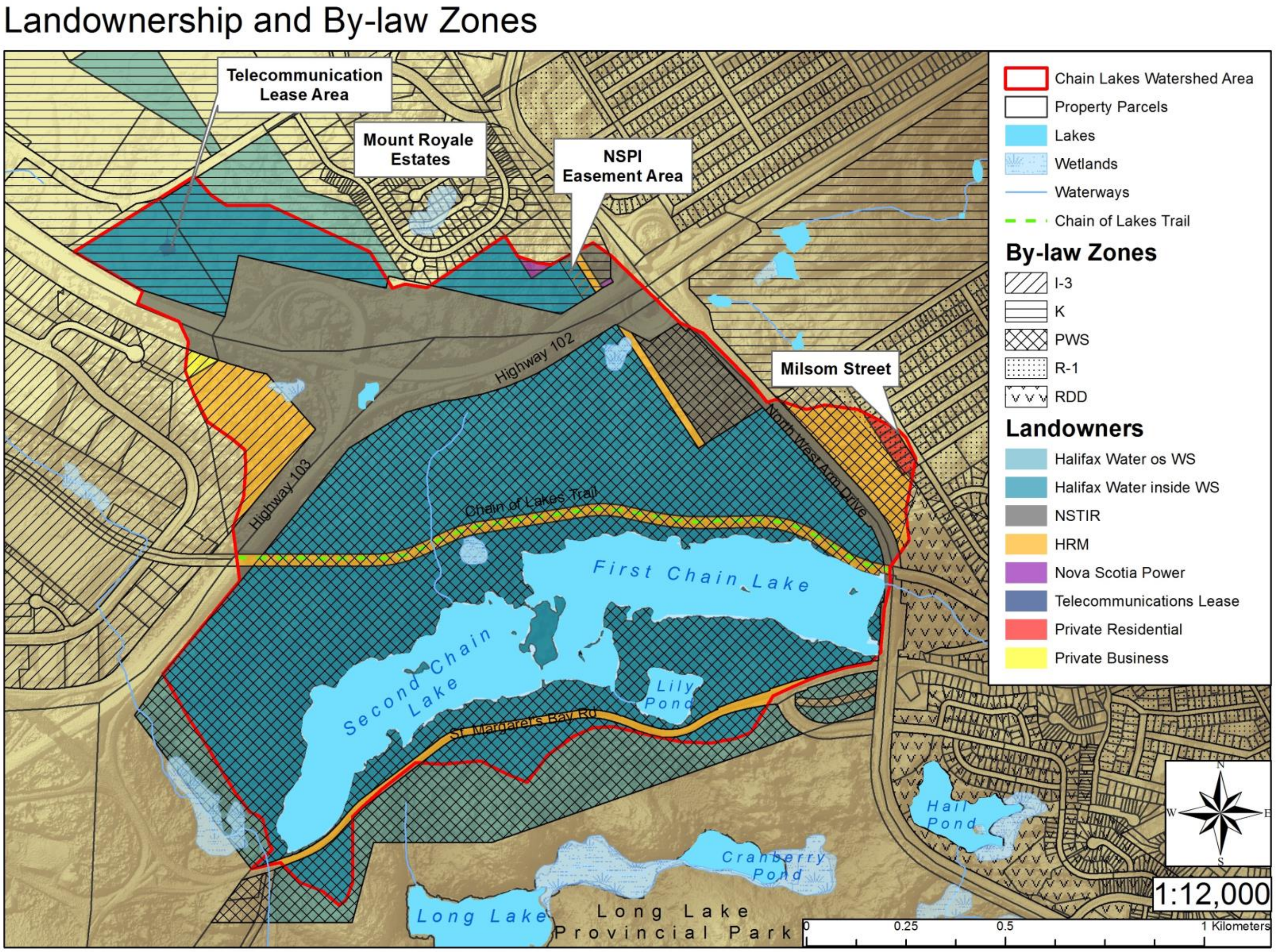
MAP E: LAND COVER



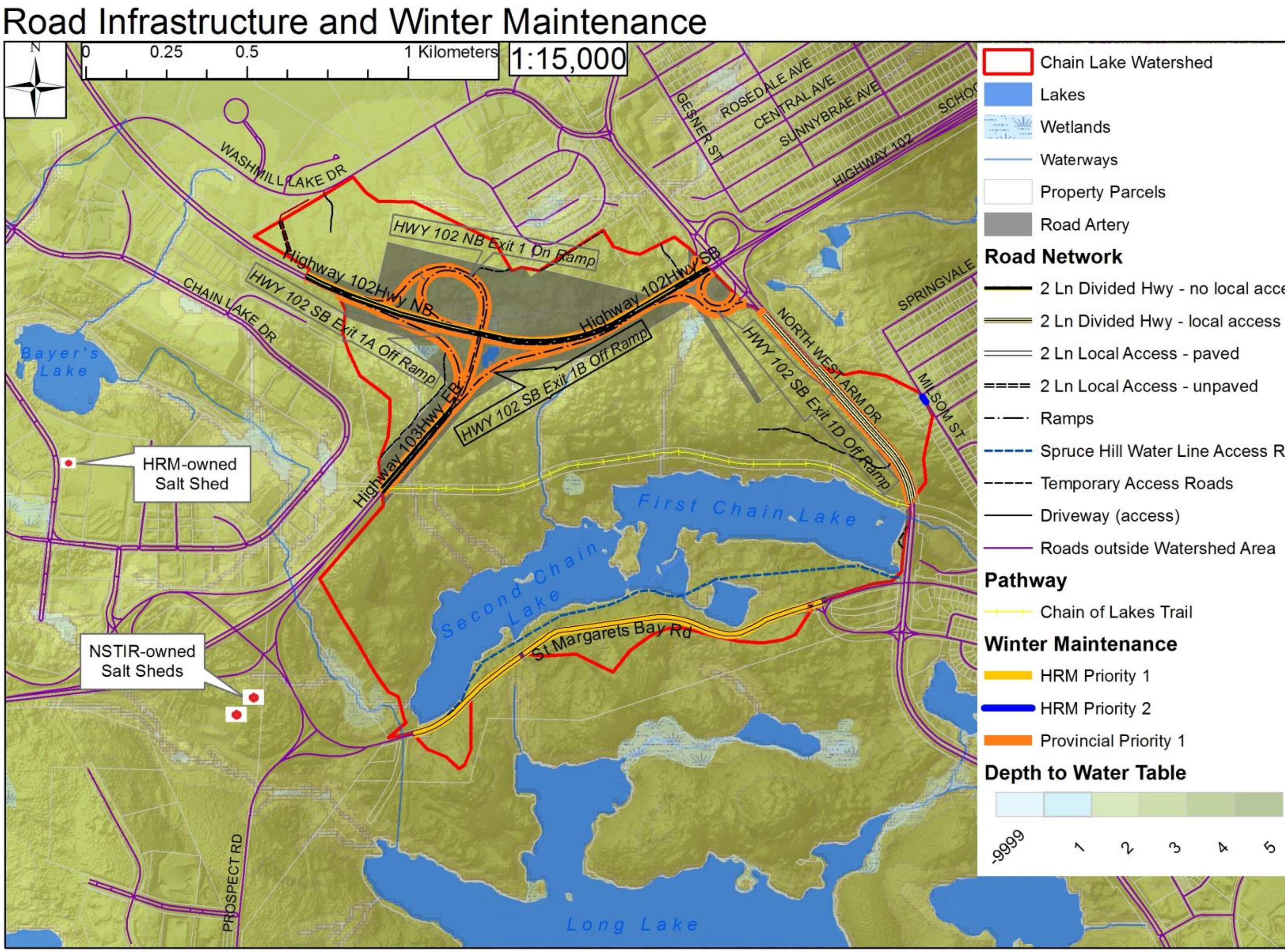
MAP F: COMMUNITY PLAN AREAS AND GFLUMS FOR 2014 REGIONAL PLAN AND HALIFAX MPS



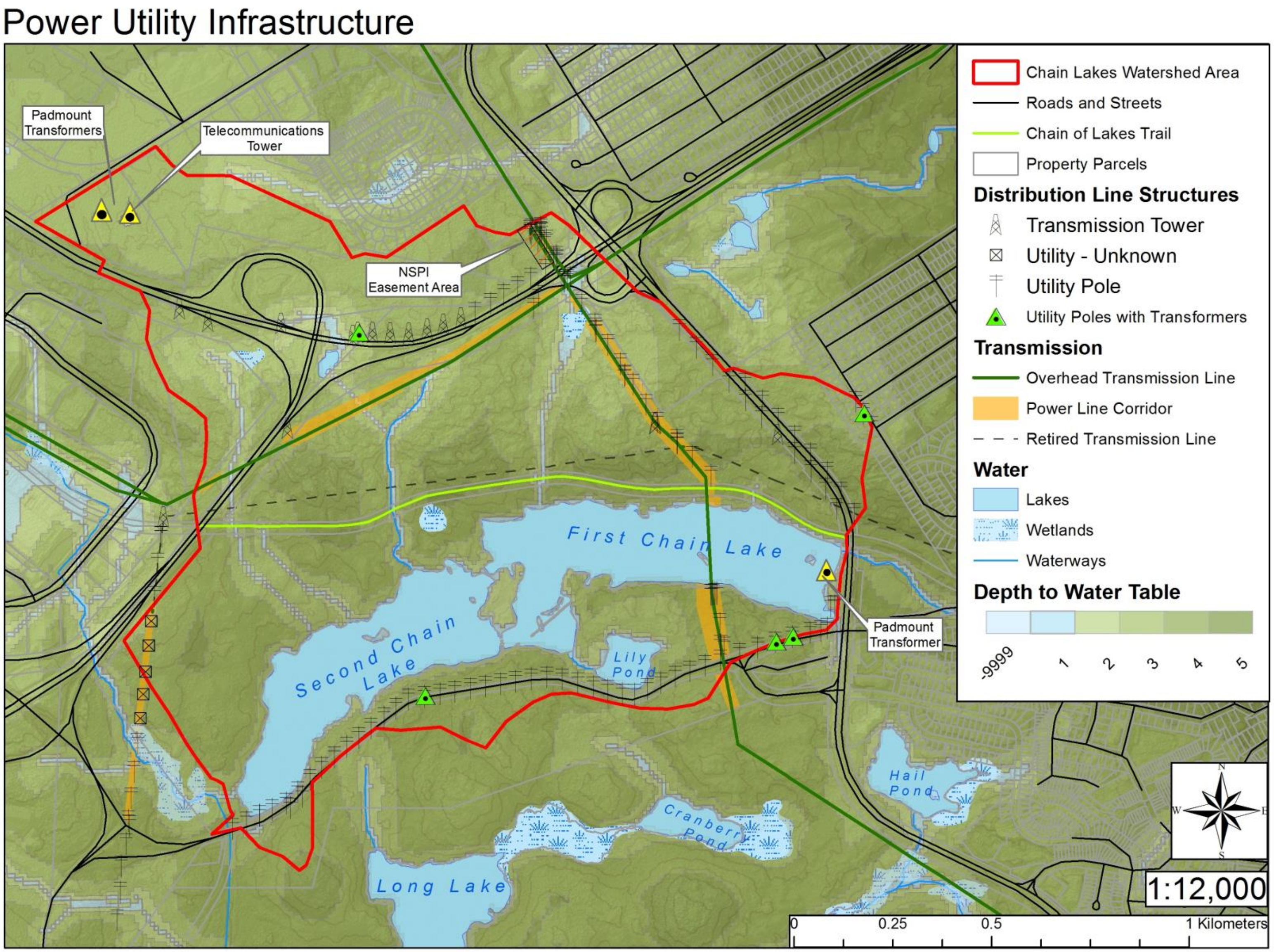
MAP G: LANDOWNERSHIP AND BY-LAW ZONES



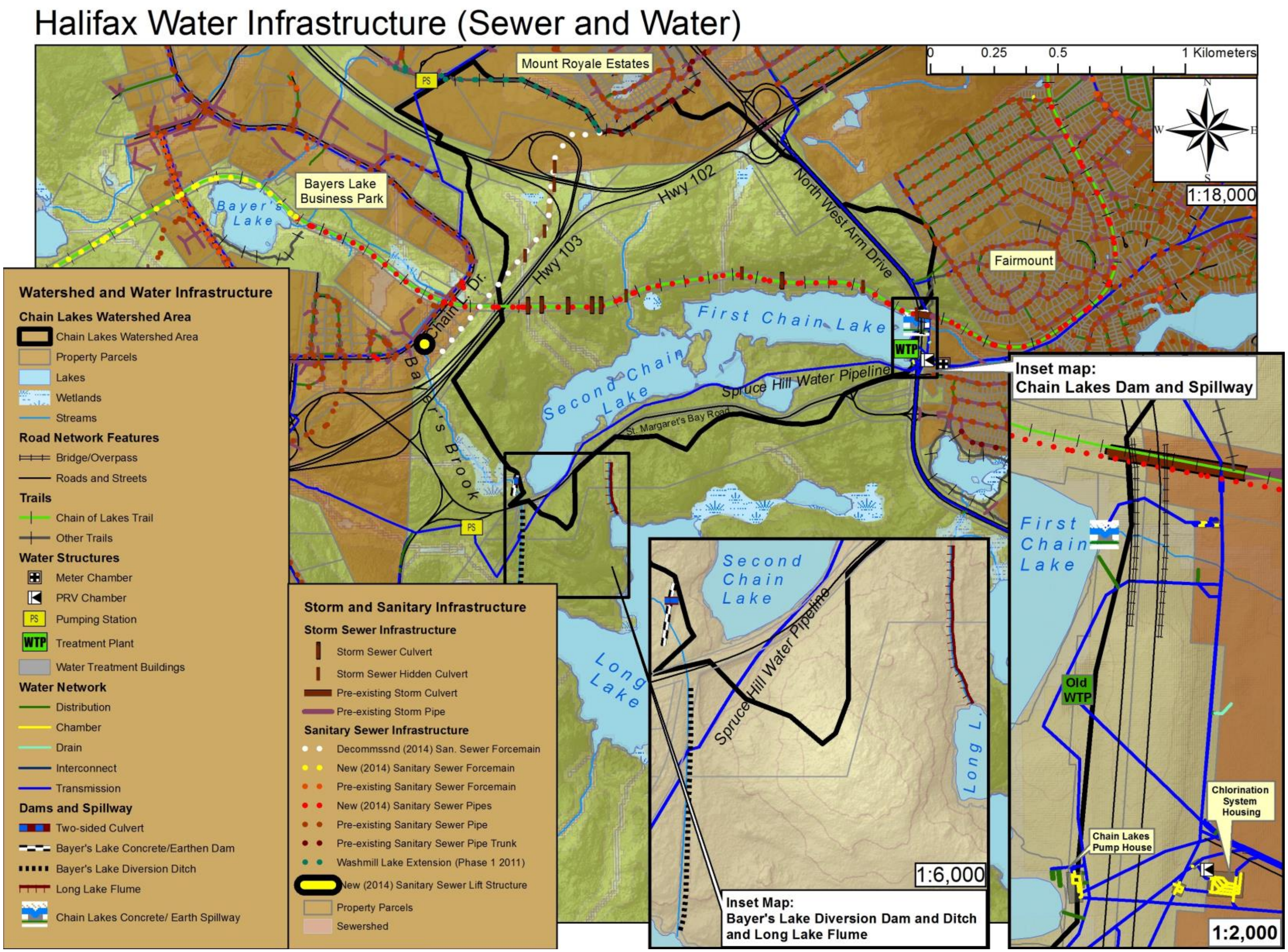
MAP H: ROAD INFRASTRUCTURE AND WINTER MAINTENANCE



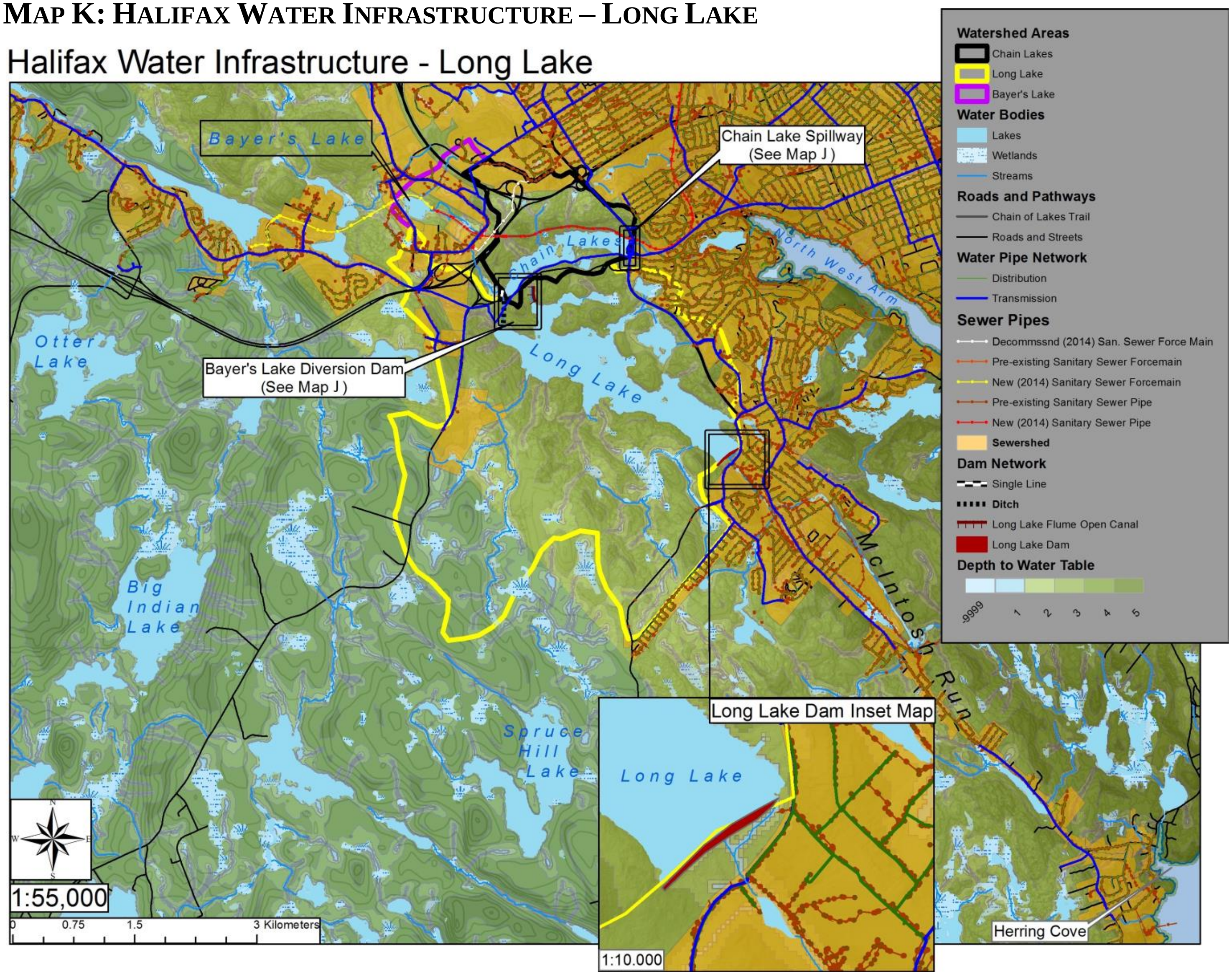
MAP I: POWER UTILITY INFRASTRUCTURE



MAP J: HALIFAX WATER INFRASTRUCTURE (SEWER AND WATER)



MAP K: HALIFAX WATER INFRASTRUCTURE – LONG LAKE



3 RISK IDENTIFICATION AND ASSESSMENT

This chapter identifies and assesses the risk factors that have the potential to impact the Chain Lakes watershed area:

- Section *3.1: Inherent Risk Factors* on page 43 explains the inherent and more predictable human activities associated with environmental, political, historic, social or cultural influences, the potential risk factors associated with them and the necessary measures to protect the water supply.
- Section *3.2: Critical Infrastructure* on page 64 explains the hazards and threats to critical infrastructure that are accidental, natural or intentional or deliberate, which are more difficult to predict. Intentional or deliberate risk factors also tend to be more acute, resulting from highly unusual events such as a terrorist attack.

The risks to the water supply are mainly associated with recreational activities, stormwater run-off from public roadways, maintenance to utility pipes and poles and natural disasters. The following subsections briefly describe the activities within the watershed, and the associated potential contaminants and mitigation measures taken to protect the water supply.

3.1 Inherent Risk Factors

Despite Halifax Water owning the majority of the land in the Chain Lakes watershed area, there are a number of known inherent factors that put the watershed area at risk. The known inherent risk factors include those associated with forestry, recreation, motorized vehicle use and roads; and auxiliary risks associated with buildings (e.g., generators), water supply and pumping station infrastructure and maintenance (e.g., chemicals), wastewater treatment infrastructure (e.g., pipes and the potential for leakage), utility transmission system and distribution line maintenance (e.g., vegetation removal) and commercial and residential activity (e.g., garbage and fuel containment). The known inherent risk factors are described in the following subsections.

3.1.1 Commercial Activities

The Chain Lakes watershed area has very little commercial activity taking place. Further, activities are restricted on the majority –111.51ha (53.49%) – of the watershed lands owned and managed by Halifax Water through company and government policies, procedures and BMPs. Nevertheless, any potential for inherent commercial land use activity and the risks associated with it are described under the relevant headings below.

Forestry

Prior to Halifax Water acquiring the majority of the Chain Lakes watershed lands, the area hosted significant forestry operations. Since acquiring the lands, the forested areas have regenerated to the point where the Chain Lakes watershed area is primarily (125.57 ha or 60.23%) forest cover. On the lands owned by Halifax Water there are no immediate plans to carry out forestry operations or developments.

As described in section *2.5: Governance* on page 25, the Chain Lakes watershed area is subject to a variety of regulations and by-laws inhibiting land use activities. The strongest policies that protect the Chain Lakes watershed area from potentially impacting activities, including those associated with adverse forestry practices, are stated in section 25 of the *Halifax Regional Water Commission Act* (see page *2.5.1: Halifax Regional Water Commission Act* on page 26).

Possible sources of water contamination associated with forest activities include the release of hydrocarbons due to a fuel or oil spill, sedimentation of streams post road construction/maintenance or precipitation event and negative effects from improper forest management activities or disregard for Best Management Practices (BMPs). Improper forestry operations could include inadequate buffer setbacks near watercourses, poor harvest timing or harvesting in sensitive areas, or the incorrect sizing and installation of culverts and bridges.

Should conditions change or harvesting become necessary for the health and sustainability of the watershed area and/or to improve or maintain source water quality, Halifax Water will assess the risks to the water supply and respond accordingly.

Mining Pits and Quarries

Risks associated with mining and pits and quarries inside the Chain Lakes watershed area are very low since there are no mineral rights designations or mineral deposits listed and there are no known mine tailings from past mining practices.

The Chain Lakes watershed area is listed as a municipal water supply area on the Nova Scotia registry of Claims map. Therefore, any mining or quarrying interest should contact Halifax Water to indicate their interest in exploring the area as per the Nova Scotia *Mineral Resources Regulations*[7].

3.1.1 Residential

Residential development within the Chain Lakes watershed area consists of 13 lots amounting to ~0.7 ha. These lots are located on the east side of North West Arm drive along Milsom Street (see *Table 13: Risks Associated with Landownership and Permitted Land-use Activity on page* 54 and *Map G: Landownership and By-Law Zones* on page 38) and have municipal water and wastewater services. The limited size of the watershed area combined with anthropogenic activities such as road construction, blasting and excavation have increased the potential for changes to the surface and groundwater flow, subsequently increasing the risk to the water supply area. To mitigate potential impacts to the water supply, Halifax Water continually monitors development in the watershed area and responds to changes as they occur. Stormwater in this area is redirected away from the watershed area, thus reducing the risk of contaminants associated with these properties.

Backyard Fires

HRM has an "Open Air Burning By-law" (O-109) which restricts backyard burning. Unfortunately, this policy is not always adhered to, which presents an increased risk of

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[7] Province of Nova Scotia *Mineral Resources Regulations* S.N.S. 1990, c. 18O.I.C. 2004-435 (November 4, 2004), N.S. Reg. 222/2004 as amended up to O.I.C. 2013-267 (August 6, 2013, effective August 26, 2013), N.S. Reg. 276/2013: Section 73 (4). Website source: http://www.gov.ns.ca/just/regulations/regs/mrregs.htm.

accidental fire (compared to other Halifax Water watersheds which are located in more remote settings, i.e., Pockwock/Lake Major) in the Chain Lakes watershed area.

Home Heating Fuel

Home heating oil tanks that are exposed to weather, which are not installed or maintained properly, or have shifted at their base from frost action have the potential to leak and cause serious environmental and property damage. Further, oil tank spills or failures pose a risk to the water supply due to the potential persistence and movement of petroleum products in the fractured bedrock aquifer, which is characteristic of the Chain Lakes watershed area (see section *2.2.4: Water Quality* on page 14). Home furnace oil tanks have been observed via street view outside residential buildings in the Chain Lakes watershed area. However, exact numbers and condition of the tanks have not been assessed.

Automobile Fluids

Release of automobile fluids from parked cars in driveways may include antifreeze, oil, and gasoline (petroleum hydrocarbons). If such fluids are released into the soil this could have a serious impact to the water supply, depending on the amount and type of fuel released.

Household Chemicals

The potential use of household chemicals associated with residential activities including persistent mobile chemicals (e.g., fertilizers, private road and driveway de-icing agents, petroleum products, pesticides, solvents, and other chemicals) could present a risk to surface water quality if used repeatedly in large quantities.

Impervious Surfaces

Impervious surfaces as in paved roads and driveways, rooftops and concrete pose an impact on surface water through increased water flow and contaminants that are picked up and carried in stormwater runoff and into the stormwater systems and ditches. Approximately 9.32 ha (4.47%) of the watershed area is covered with impervious surfaces which includes 8.5 ha of contiguous roadway surfaces and 0.82 ha of other surfaces, some of which include hard natural surfaces such as rock (not including the barrens) illustrated on *Map E: Land Cover* on page 36.

3.1.2 Recreation

With effective management, most forms of recreational activity such as walking, hiking, biking, geocaching, and cross-country skiing present low risk, and when conducted responsibly, are largely permissible in the Chain Lakes watershed area. With careful planning, strong partnerships and open lines of communication, opportunities emerge that benefit both the recreational organization and Halifax Water. The most prevalent recreational activities and the potential risks they present to the Chain Lakes watershed are outlined in *Table 11: Impacts to Watershed Area from Recreational Activities* on page 46.

Table 11: Impacts to Watershed Area from Recreational Activities			
Activity	**Negative Impact to water quality**	**Positive Impacts**	**Solutions**
Pet walking	Uncollected pet droppings contaminate waters, especially during stormwater runoff events.	None	Watershed portion of COLT zoned "on-leash" area which limits area of contamination.
			Doggy bag dispensers and garbage cans are located at entrance and exit to watershed.
			Signage (informative/educational).
			Trail wardens patrolling watershed during peak hours.
			Fencing to keep people from venturing off of the maintained trail
Trail use	Many of the trail use activities that negatively impact the watershed are already listed in this table; however, they are reiterated as general trail use impacts. They include pet walking, erosion and sedimentation, tree cutting, fires, garbage, swimmers, geocachers, mountain biking, camping, fishing, boating and a general increase in foot traffic.	A formal approach to creating public access has led to increased reporting, which has helped curb some of the illegal and non-compatible activities within the watershed, especially along the Chain of Lakes Trail.	Signage (informative/educational)
			Fencing to keep people from venturing off of the maintained trail
			Trail wardens patrolling watershed during peak hours.
			Garbage cans.
			Formal partnership agreement with HRM Trails Group has helped create awareness of the importance of the watershed through Halifax Water's participation on the Board of Directors for the Chain of Lakes Trail.
Geo-caching	Similar to trail use impacts; additional impacts include intense search and rescue impacts in the event people become disoriented in their search for geocaches.	Similar to trail use.	Practice Guidelines for Environmental Protection (see *4.3.3: Geocaching* on page 92) and maintain communication between Halifax Water and the geocaching community.
Camping	Garbage and camp fires, which increases wildland fire potential.	None	Signage, patrols and reports from trail users.
			Section 25 of the HRWC Act
Mountain Biking	When activity is not confined to established roads and trails, the tendency is to create new trails, unsafe ramps and water crossings, and conduct unauthorized tree cutting within the watershed area, promoting water quality problems associated with sedimentation and erosion and other issues associated with increased foot traffic, as well as landowner liability issues.	When biking trails are adhered to, the benefits are similar to that of trail use.	Post signs, remove unauthorized mountain bike structures and identify groups who might help be responsible for developing guidelines similar to those established for Geocaching.
Off-highway Vehicles	Petroleum hydrocarbon contamination in the event of a spill or accident, and sedimentation of waterways if vehicles operate in-stream or if riverbanks are damaged. However, there is not a significant problem in this watershed area.	None	Evaluate Off Highway Vehicle (OHV) use through regular patrols. Put into effect section 12F of the *Off-highway Vehicles Act* if problems arise.
Swim-ming	Bacteria contamination, lakeshore soil erosion and litter.	None	Signage (informative/educational).
			Section 25 of the HRWC Act
			Installed fencing along the lake to deter swimmers from entering the lake
Boating	Petroleum hydrocarbons contamination if motors are used. Increased potential for shoreline erosion from wave action and litter.	None	Install security fences and other deterrents (e.g., thorny bushes); put into effect City of Halifax Ordinance 158.

3.1.3 Transportation Corridors

The water supply is highly accessible to motorized, non-motorized and pedestrian traffic, except for lands owned and maintained by Halifax Water where access is restricted by barriers and gates at key access locations. Roads within the watershed area consist of a variety of access road types as illustrated on *Map H: Road Infrastructure and Winter Maintenance* on page 39.

The Chain Lakes watershed area is intersected by Highways 102 and 103, as well as St Margaret's Bay Road and North West Arm Drive. These roads are the main routes leading into and out of metro Halifax and carry high volumes of traffic. The following subsections describe the main risks, the various types and amounts of roadway surfaces the activities that take place on them and the risks they present to the water supply.

Major Highways

Two of the province's four major divided highways traverse the Chain Lakes watershed area:

- 2.65 km of Highway 102 links Halifax to the northern regions of the province; and
- 0.70 km portion of Highway 103 links Halifax to the South Shore.

The point where these highways meet is also situated inside the watershed area (see *Map H: Road Infrastructure and Winter Maintenance* on page 39). Maintenance (summer and winter) of these major highways is the responsibility of NSTIR.

These major highways are core trucking routes and therefore present a high risk to the watershed due to the potential for petroleum and chemical spills resulting from vehicular accidents, and their proximity to the streams that flow into the Chain Lakes. Further, the characteristics of the Gibraltar soil type in this part of the watershed area promote rapid travel of any potential contaminants and soil erosion. The soil type is compounded by the predominantly bedrock (73%) surficial geology in the watershed area which has either exposed bedrock at the surface or beneath shallow soil. Depending on the contaminant, the naturally acidic soil characteristic could heighten the risks associated with a soil contamination event and any subsequent leaching into watercourses, ultimately affecting water quality (see section *2.2.5: Soils* on page 15).

Ramps

There are 3.7 km of ramp road surface within the Chain Lakes watershed area which connect the major roadways described in the previous section. The risks presented by the major highways (see under previous heading) are also presented by the ramps. Maintenance (winter and summer) for these ramps is the responsibility of NSTIR.

Local Access Roads

North West Arm Drive and St. Margaret's Bay Road are locally accessible roadways which traverse 1.26 km and 1.4 km of the Chain Lakes watershed area respectively. Both roadways support high volumes of traffic, presenting considerable risks.

St Margaret's Bay Road runs along the southern edge of the First and Second Chain Lakes. North West Arm Drive skirts the eastern edge of First Chain Lake. Road maintenance (winter and summer) for St. Margaret's Bay Road is the responsibility of HRM. NSTIR is responsible for North West Arm Drive.

Temporary Access Roads

There are eight lengths of unpaved temporary access roads amounting to 3.45 km, illustrated on *Map H: Road Infrastructure and Winter Maintenance* on page 39. Halifax Water and NSPI maintain these roads to access and maintain water and power utility infrastructure. The level of risk to the watershed is low to medium-high depending on the types of activities conducted on these roads. Power line corridor tree and brush removal, and possible transport of chemicals to the water treatment facility in the event of an emergency are considered the highest risk activities that may take place on these roads. For the most part, these roads have controlled access, further reducing the risk:

- Halifax Water maintains three (3) gated access points to the Spruce Hill water main off St. Margaret's Bay Road;
- Halifax Water maintains a gated security fence restricting access to the pump house and First Chain Lake spillway and dam;
- Halifax Water maintains gated access to the discontinued sewer forcemain off of Chain Lakes Drive; and
- Halifax Water maintains an ungated temporary access road from North West Arm Drive running parallel to the COLT. This road provides access for NSPI to access distribution lines within the watershed. Risk is low to moderate as the road is unmaintained and only accessible by four wheel drive.

Road Construction

Due to the high potential for road maintenance and construction on the highly-travelled roadways within the Chain Lakes watershed area, there is a corresponding likelihood for higher risks associated with these activities. Details on the transportation network and road construction contingency plans are found in sections: *2.3.3: Transportation Corridors* on page 22 and *4.3.4: Road Construction* on page 93 respectively.

Chester Spur Line Railway (Chain of Lakes Trail)

Construction of the COLT has helped identify and remove risks associated with past railway activities. Not all rail ties were removed from the trail before HRM acquired the land in 2010. During final construction of the Chain Lake Sewer Trunk in 2014 the remaining abandoned railroad ties, amounting to approximately 150, were removed.

Additional risks were identified during the Chain Lake Sewer Trunk project including rail bed soil contamination through past rail practices, leachate of arsenic from rail ties, and chemical rail tanker transport. Soil tests, prior to the sewer trunk project, confirmed the risk to the watershed was negligible to nonexistent.

Public Transportation Facilities

A 4.32 ha parcel owned by NSTIR which falls under the Protected Water Supply By-law Zone lies within the northeast section of the watershed. There are no apparent activities taking place on this parcel of land at the moment. However, within the updated 2014 Regional Plan, policy (T-6), and within the MPS by-law 14X there is approval to permit public transportation facilities

regardless of the zoning. If this situation were to occur, the risks to the water supply would increase, especially by petroleum hydrocarbons and other associated automotive fluids.

3.1.4 Utilities

The Chain Lakes watershed area supports a myriad of utility and telecommunications infrastructure belonging to Nova Scotia Power, Halifax Water, and communication agencies (radio and television) as described under the corresponding headings below.

Halifax Water

The following briefly describe the risks associated with the Chain Lakes water supply through Halifax Water operations to provide water, as well as fire protection, wastewater and stormwater services, and their potential to impact the Chain Lakes watershed area.

Water Supply Infrastructure

The Chain Lakes water supply infrastructure consists of four buildings including an upgraded water pumping station, circa 1945, a decommissioned pumping station, circa 1848, and a pad-mount power transformer, all located on the lakeside of North West Arm Drive; and two buildings on the east side of North West Arm Drive which contain old and new water pipe infrastructure. These infrastructures are described in more detail under the headings below.

Pumping Station

The Chain Lakes water supply pumping station is located at 834 North West Arm Drive and is not in regular operation. To provide power to the pumping station during a power outage, Halifax Water uses a portable generator which is stored off-site. Risks associated with the generator, which include fuel release and equipment fire, are minimized through Standard Operating Procedure (SOPs) that are implemented while the generator is in operation. To restrict access, a security fence was installed around the pumping station in July of 2004.

Power Transformer

A pad-mount transformer owned and maintained by NSPI is located inside the Chain Lakes pumping station security fence (see *Map I: Power Utility Infrastructure* on page 40 and *Map J: Halifax Water Infrastructure (Sewer and Water)* on page 41). To reduce risk to the water supply, the transformer sits inside a secondary containment unit designed to catch and hold any oil that may leak or spill. For details on the type of oil this transformer contains and the risks it presents to the water supply see section *3.1.4: Transformers* on page 51.

Wastewater Treatment Infrastructure

The risk to the watershed area from wastewater contamination was significantly reduced through a two-phase sewer line replacement program as described in the subsections below.

Washmill Court/Lake Extension – Phase I (2011)

Phase I, 2011 sanitary sewer line replacement, called the Washmill Court/Lake Extension, created new sewer capacity from Geizer Hill through the Chain Lakes watershed. The new sanitary pipe, a 250 mm diameter polyvinyl chloride (PVC) SDR 35 high flow capacity gravity sewer pipe, now cuts through 686 m of the Geizer Hill area of the watershed. See description in section *2.3.3: Central Sewer and Wastewater Systems* on page 24 and illustration on *Map J: Halifax Water Infrastructure (Sewer and Water)* on page 41. Risk to the watershed area from the new sewer line is low to moderate because its physical location is far-removed from Chain Lake watershed area waterways and is gravity feed, therefore, is not under pressure.

Chain of Lakes Sewer Trunk – Phase II (2014)

In 2014, phase II involved replacing the Bayer's Lake sewer forcemain connection between Chain Lake Drive and Mount Royal Estate (which operated under pressure) with a new state-of-the-art gravity flow sewer system that flows under the COLT (see description in section *2.3.3: Central Sewer and Wastewater Systems* on page 24 and illustration on *Map J: Halifax Water Infrastructure (Sewer and Water)* on page 41) whereby Halifax Water has an easement agreement (2014) with HRM to maintain the line and monitor it for the risks associated with the wastewater system.

Renamed the Chain of Lakes Sewer Trunk, the new sewer line is estimated to last 3 times longer than the original steel pipe due to the type of material it is made of , i.e., HDPE. Though steel is better able to withstand outside pressure (e.g., something falling or puncturing it) fused HDPE is more durable due to its resistance to corrosion and friction from sewage flow contents.

Prior to the new gravity flow system, wastewater breaks were common. However, it was determined through Halifax Water's Source Water Quality Monitoring Program that no raw sewage, resulting from these breaks, entered the water supply (see SWQMP results for CLG4 in section *5.4.2: Bayer's Lake Wastewater System* on page 124).

Risks associated with the old lines were reduced to the water supply; however, the new system presents new risks:

- general maintenance of the new pipeline;
- increased proximity and travel distance for contaminants to reach the source water supply in the event of a break;
- increased wastewater flow capacity from the Bayer's Lake Business Park; and
- redirected flow from the Timberlea wastewater system (see section *2.3.3: Central Sewer and Wastewater Systems* on page 24).

For measures taken to mitigate the risks presented by the sewer lines see section *4.2.10: Wastewater Treatment Plant* on page 87.

Nova Scotia Power Inc.

The following subsections describe potential risks associated with NSPI infrastructure and activities that are conducted in the watershed area.

<u>Transmission Lines</u>

There are two primary transmission routes that cover a total linear distance of 2.78 km in the watershed area (see *Map E: Land Cover* on page 36). Line brushing to remove unwanted vegetation is conducted along transmission line corridors throughout the watershed area as per an Easement Agreement between Halifax Water and NSPI. Maintenance activity on transmission and distribution lines could involve disturbance of the ground, subsequently requiring the use of the Halifax Water BMPs established for industry and commercial activities in the watershed.

Power Poles

NSPI mainly uses poles treated with pentachlorophenol (PCP) and occasionally use poles treated with chromated copper arsenate (CCA). Comparison of the ecotoxicity of each of these treatment types is outlined in *Table 12: Ecotoxicity Levels of Wood Preservatives* on page 51.

PCPs target wood destroying organisms and are a known carcinogen. The ecotoxicity of PCPs is classified in a Dalhousie University paper as “medium”. The important factor to consider regarding its chemical toxicity is the likelihood of exposure. Of further consideration, in the event of a release from the utility pole during the life of its service, is that the toxin is rapidly broken down by indigenous soil organisms.

However, through discussions between Halifax Water and NSPI’s environmental staff, it is understood that standard practices around utility pole installation and watercourse setbacks decrease the risk of exposure to the water supply by this ecotoxin. Installation of treated poles is dependent on the location and proximity to salt, fresh and/or potable water; otherwise, untreated poles are used where water cannot be avoided. Through application of this standard practice, risks associated with chemically-infused power poles are minimized. For details on the management of treated power poles see section *4.3.5: Power Poles* on page 95.

Table 12: Ecotoxicity Levels of Wood Preservatives

Treatment	Tested Organism	Toxicity Level *LD_{50} (medium)
CCA	Rat	50 mg/kg body weight
	Fish (bluegill sunfish)	0.1 mg/L
PCP	Rat	210mg/kg body weight
	Fish (bluegill sunfish)	0.1 mg/L
	Crustacean (Daphnia)	.04 mg/L
*L = lethality	D = dose	50 = % of population

Transformers

Transformers are an electromagnetic device that changes voltage levels. NSPI maintains six of the seven transformers located within the Chain Lakes watershed area (see *Map I: Power Utility Infrastructure* on page 40 for transformer locations):

Pole Top Transformers

Of the four pole top transformers inside the watershed area:

- three are located along St. Margaret’s Bay Road;
- a fourth is on the ramp connecting Hwy 102 to Hwy 103; and

Pad Mount Transformers

There are three pad mount transformers inside the watershed area:

- two are owned and maintained by NSPI;
  - one pad mount transformer is located at the pumping station at 834 North West Arm Drive, 16 m from the shoreline of First Chain Lake, which is secured inside a secondary cement containment pad owned and maintained by Halifax Water;
  - the second is in the Geizer Hill area (475 Washmill Road); and
- a third pad mount transformer is situated next to the NSPI Geizer Hill transformer and is owned and maintained by CTV.

All transformers contain some type of electrical insulating "oil" as a cooling mechanism. The risks posed by insulating oils, as described in the following paragraphs, depend on the type of oil, which is influenced by the age of the transformer, ownership and their location and maintenance schedule.

Until 1983, insulating "oil" contained in pole top transformers typically included Polychlorinated biphenyls (PCBs). New Federal regulation requires power utilities to remove all PCB contaminated equipment (containing >50ppm/L of PCBs) from service by 2025.

Since 1983, NSPI has moved toward using in its transformers a Naphtha-based mineral oil, VOLTESSO 35 or a plant-based mineral oil, Envirotemp® FR3™ – a biodegradable, fire resistant, edible seed oil based dielectric coolant – for use in more environmentally sensitive areas. While NSPI prefers to use the Naphtha-based mineral oil over other insulating oils, because it interferes less with the transformer cooling system, NSPI typically uses the Envirotemp brand name in environmentally sensitive areas, such as drinking water watersheds, when requested. Both NSPI-maintained pad mount transformers in the Chain Lakes watershed area contain VOLTESSO 35.

The MSDS for VOLTESSO 35 suggests there is very little risk to the water supply in the event of a spill. Regardless, in the event of a land spill, the MSDS states that any oil should be recovered by pumping, or with suitable absorbent. In the event of a spill in water, the oil should be confined immediately with booms and removed from the surface by skimming or with suitable absorbants. Advice of a specialist should be acquired before using dispersants. The MSDS also recommends preventing entry into waterways, sewers, basements or confined areas.

The coolant liquid used for the CTV pad mount transformer that is located inside the watershed area contains DowFrost™ HD, a low toxicity coolant that is considered environmentally safe.

If a leak were to occur from any pad mount transformer, the risk of contamination would be minimized by the cement containment in which they sit.

CTV/CHUM Radio Towers and Satellite Dish

Arrangements were made between Halifax Water and CTV/CHUM to accommodate a communication transmission tower and satellite dish on lands owned by Halifax Water within the Chain Lake watershed (475 Washmill Drive) (see location of the tower on *Map G: Landownership and By-Law Zones* on page 38). Construction activities were in accordance with Halifax Water's BMPs to ensure minimal risk to the ecological integrity of the watershed area.

3.1.5 Municipal Land-use Planning and Development Activities

Land-use planning and development activities have an inherent potential to impact the watershed, negatively and positively. Municipal governance regulatory policies and by-laws, when applied and enforced, help mitigate the risks presented by the land use activities or influence or extend the level of risk to the Chain Lakes water supply. Relevant municipal land-use policies and by-laws and ordinances that influence the Chain Lakes watershed are described in section *2.5.2: Municipal Land-Use Planning Policies and By-laws* beginning on page 27.

The following land-use activities are considered primary risks to the Chain Lakes watershed and are outlined in *Table 13: Risks Associated with Landownership and Permitted Land-use Activity* on page 54:

- highway maintenance (e.g., road de-icing agents);
- recreational activity;
- unauthorized garbage dumping;
- utility line maintenance and infrastructures (including power, water, wastewater);
- land development; and
- improper maintenance of heavy equipment.

Table 13: Risks Associated with Landownership and Permitted Land-use Activity					
By-law Zone	**Zone Area (ha) in Watershed Area (% of Plan Area)**	**Permitted Land Uses**	**Landownership (ha) in Watershed Area (% of Plan Area)**		**Level of Risk Associated with Current and Permitted Activity in By-law Zone**
I-3 (General Industrial)	~5.96 (2.86%)	Industrial/ commercial enterprise	HRM	5.64 (2.69%)	Moderate: Although primarily forested land, the risks are associated with a power line and an access road that cross this parcel. Additionally, this parcel may be subject to future industrial development as per the GFLUM (see *Map F: Community Plan Areas and GFLUMs for 2014 Regional Plan and Halifax MPS* on page 37) albeit also subject to HRWC Legislation (see section *2.5.1: Provincial Policies – Halifax Regional Water Commission Act* on page 26) and the Special Places Protection Act (see section *2.5.1: Special Places Protection Act* on page 27) due to archeological features that exist on this parcel.
			Private Business	0.32 (0.15%)	Low: This parcel supports one office building presenting little risk, on a cleared lot allowing stormwater to run off the property at a higher rate. Associated parking is outside the watershed area and therefore presents no risk. There is a propane tank located on the backside of the building which is used as an energy or heating source for the building. It is considered low risk as it is enclosed in a 1.8 m high security fence on a concrete pad with a monitoring alarm system.
Schedule "K" (Comprehensive Development District)	~17.14 (8.22%)	Primarily residential: emphasis on mix of housing types; including provision for local commercial uses and community facilities – Requires Regional Council approval	Halifax Water	16.15 (7.75%)	Low-moderate to High-moderate: This area consists of three parcels located in the northern section of the watershed area and support varied land use activities Low – moderate activity includes the areas that have little activity except for maintenance vehicles to maintain utility lines. High – moderate activity is due to current potential for leakage from the sewage pipe, the transformer that contains VOLTESSO 35 coolant and the high slope and close proximity to hydrological systems that may provide a conduit for fluids to travel to the water supply.
			Nova Scotia Power Inc.	0.23 (0.11%)	Low: This area consists of two parcels which are small in size and currently present negligible risk to the water supply; however, both parcels fall within the sewer shed, presenting a low level of risk if the area is developed and is connected to the sewer pipe that travels through the northern parcel (the portion of which is situated outside the watershed area).

Table 13: Risks Associated with Landownership and Permitted Land-use Activity

By-law Zone	Zone Area (ha) in Watershed Area (% of Plan Area)	Permitted Land Uses	Landownership (ha) in Watershed Area (% of Plan Area)		Level of Risk Associated with Current and Permitted Activity in By-law Zone
			HRM	0.23 (0.11%)	Low to moderate: This parcel is small in size and supports 236 metres of power lines and an unpaved maintenance roadway. The size of the area and the frequency of activity associated with maintaining the power lines present a low-moderate risk to the watershed area. The area allows easy access through roadways in the event of fire or other contamination source that requires quick response.
			NSTIR	0.53 (0.25%)	Low to moderate: This area consists of two parcels which present a low risk due to their small size and moderate-high risk due to their proximity to (in one case) or function (in the other case) because a major road artery parcel and sewer pipe, situated at a high degree of slope and hydrology (see *Map C: Hydrology and Raw Water Sampling Collection Points on page 19*), runs through one of the parcels.
PWS (Protected Water Supply) (RC-Jun 25/14;E-Oct 18/14)	~106.06 (50.87%)	62(1) Municipal water distribution or purification facilities; Conservation uses; and uses accessory to the foregoing uses OTHER REQUIREMENTS: SETBACKS FROM WATER SUPPLY SOURCES No development within 30.5 metres of any lake or other watercourse within the PWS except for the uses permitted under Section 62(1) above. Water distribution or purification uses may be built to the lot line where the line corresponds to the shore line.	Halifax Water	92.98 (44.6%)	Low to Moderate: One parcel (which appears to be four separate parcels) surrounding the Chain Lakes has relatively little activity taking place on them which keeps the risk to the water supply low; the moderate level of risk is due to the utility poles and the transformers that exist on this parcel which are situated next to and north of the Chain Lakes.
			HRM	8.76 (4.2%)	Low to Moderate: Two parcels of land associated with this area; one is the COLT and the other is on the east side of the watershed between North West Arm Drive and the residential properties on Milsom Street. The greatest risks are those presented by the COLT.
			NSTIR	4.32 (2.07%)	Low: Current activity on this uneven-aged forested land parcel is negligible. However, risk will be elevated in the event the land-use bylaw zone is changed because Halifax Water does not own this parcel.

Table 13: Risks Associated with Landownership and Permitted Land-use Activity					
By-law Zone	**Zone Area (ha) in Watershed Area (% of Plan Area)**	**Permitted Land Uses**	**Landownership (ha) in Watershed Area (% of Plan Area)**		**Level of Risk Associated with Current and Permitted Activity in By-law Zone**
R-1 (Single Family Dwelling)	~0.85 (0.41%)	Detached one-family dwelling which may also be used as a professional person in his/her private residence	Private	0.66 (0.31%)	Low: Considering development has already occurred, properties are close to the watershed boundary and away from watercourses, and residential development is bordered by a non-developed section of the watershed owned by HRM and zoned PWS, risk is mitigated by development barriers against stormwater reaching more deeply into the watershed area. Further, stormwater drains down the slopes toward North West Arm Drive where ditching directs water toward First Chain Lake outlet and into Chain Lake Park across from the dammed area of First Chain Lake and outside the watershed area.
			HRM	0.19 (negligible)	Negligible: The level of risk presented by the current activity on these small land portions is negligible considering the small size of the area and that it is undeveloped young and uneven-aged forested areas.
RDD (Residential Development District)	~0.13	R-1 and R-2 uses	HRM	0.13 (negligible)	Negligible: Like the R-1 portion, the level of risk presented by the activity on this parcel is negligible considering the small size of the area and inactivity since the land cover consists of young forest. However, if this area is developed, the risk to the water supply may increase.

Table 13: Risks Associated with Landownership and Permitted Land-use Activity					
By-law Zone	**Zone Area (ha) in Watershed Area (% of Plan Area)**	**Permitted Land Uses**	**Landownership (ha) in Watershed Area (% of Plan Area)**		**Level of Risk Associated with Current and Permitted Activity in By-law Zone**
PWS (Protected Water Supply) (RC-Jun 25/14;E-Oct 18/14)	~8.46	62(1) Municipal water distribution or purification facilities; Conservation uses; and uses accessory to the foregoing uses OTHER REQUIREMENTS: SETBACKS FROM WATER SUPPLY SOURCES No development within 30.5 metres of any lake or other watercourse within the PWS except for the uses permitted under Section 62(1) above. Water distribution or purification uses may be built to the lot line where the line corresponds to the shore line.	Halifax Water	0.24 (negligible)	Moderate: This risk level is moderate due to the proximity of the water pumping station to the water source and the current and potential activities associated with it, including the pad mount transformer which is contained on the site, and the roadways where vehicles frequently park to access the WSP, the utility lines and to collect water samples.
Unzoned (Road arteries)	(~77.2 less 36.99 water areas and islands within them)= ~40.22 land area	Road Artery	NSTIR	36.54 (17.53%)	High – Extreme: Roadways and utility lines present the highest level of risk to the Chain Lakes watershed area due to the use of the land for major highways and thoroughfares, especially considering the hazardous materials some vehicles may carry. Further, these highways must be maintained to ensure road safety which, in the winter, involves primary levels of salt applications. Measurements indicate salt is impacting water quality.
			HRM	3.68 (1.8%)	
Total	**208.48**				

3.1.6 Chemicals

Halifax Water generally does not support the use of chemicals on its private lands and/or inside any of its watershed areas. An exception to this standard is chemical use in the water treatment process, which is strictly monitored and controlled and in the event of an extreme natural biological outbreak or fire for which their impacts on the water supply would outweigh the impact of chemical use.

However, considering 35.58% (~61 ha) of the Chain Lakes watershed area lands are not currently owned by Halifax Water, there is a moderate risk of source water impairment as a result of chemical use by other landowners. Such risk is mainly associated with road maintenance (see section *3.1.3: Transportation Corridors* on page 47) and utility corridor infrastructure such as NSPI transformers (see section *3.1.4: Transformers* on page 51).

The subsections following identify and assess the potential risks associated with chemical use from identifiable point sources inside the Chain Lakes watershed area.

General Use

Chemical and/or biocide pest control use may be permitted through provincial and/or municipal permits and regulations. Although there are provincial permitting processes and regulations (see section *2.5.1: Provincial Policies* on page 25) to control and monitor the use of chemical toxins and biocides or pest control products, the use of any chemical around source water is still considered a risk to the water supply.

Road De-icing

NSTIR and HRM share the responsibility for winter road maintenance on 9.7 km of high priority roadways within the Chain Lakes watershed area. Each agency's winter road maintenance activities are described in see section *3.1.6: Road De-icing Application Practices and Strategies* on page 61. For illustrations of winter road maintenance jurisdictions see *Map H: Road Infrastructure and Winter Maintenance* on page 39.

Chloride testing of water quality samples collected through the Source Water Quality Sampling Program indicates road salt applications have a high-risk impact on the water supply.

Road de-icing agents present a risk to water supply sources when chloride, accumulated from road de-icing agent applications, enters surface waterways through stormwater runoff. Evidence of this risk is apparent through the increased levels of surface water chloride concentrations and conductivity levels measured in the samples collected within the Chain Lakes watershed area.

All levels of government have developed road salt application guidelines due to concerns over the natural environment's sensitivity to de-icing agents. The following subsections provide an overview of the various guidelines to manage the risks to water sources associated with road de-icing agents.

Environment Canada's Code of Practice

Environment Canada completed a five-year study in 2001 which determined that in sufficient concentrations, road salts pose a risk to plants, animals and the aquatic environment. It was subsequently recommended that road salts be added to the Canadian Environmental Protection Agency's List of Toxic Substances[8].

In response to the 5-year study, rather than banning the use of road salts and present increasing hazards to the public on winter roads, the Federal Government designed a system to help municipalities manage their use of road salts to reduce harm to the environment, while maintaining road safety through the *Code of Practice for the Environmental Management of Road Salts* (2004)[9]. Within this Code of Practice, Annex B, sections 7 and 8 identify the risk potential for chloride concentrations to drinking water and groundwater sources respectively. Environment Canada also outlines a Road Salt Management Strategy[10]. However, Environment Canada makes it clear that nothing in the Code should be construed as a recommendation to take action to the detriment of road safety.

Environment Canada also notes public expressions of concern regarding the use of ferrocyanide salts in formulations of road salts, given that, in solution, they can photolyse to yield free cyanide ions, which are highly toxic to aquatic organisms. Sodium ferrocyanides are used as an anti-caking agent in road salts in the Atlantic Provinces. See more on ferrocyanides in section *4.2.6: Public Roads and Highways – Road De-icing* on page 84.

Provincial Policy and Regulations

NSTIR has developed road de-icing application standards, which are found in the department's Highway Maintenance Standards. The Standards state: *"[t]he use of salt in environmentally sensitive areas will be monitored and alternatives to salt will be used where practical*."

The current definition of "environmentally sensitive areas" with respect to the Provincial Highway Maintenance Standards does not classify surface water supply areas, although it does classify areas associated with ground water discharge with medium to high solubility soils.[11] Further, "[s]*and is to be applied to all roads or sections of a road designated as being in environmentally sensitive areas. The use of salt in environmentally sensitive areas will be monitored and alternatives to salt will be used where practical*."[12] However, there are examples of provincial regulations restricting the use of chloride road salt de-icing agents within water supply areas; e.g., section 7(5) of the *Bennery Lake Watershed PWA Regulations*.

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[8] Environment Canada: Acts and Regulations; Canadian Environmental Protection Agency; Toxic Substances List – Schedule I. Date modified 2013-11-06. Website source: http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=0DA2924D-1.

[9] Environment Canada: Pollution and Waste; Code of Practice: The Environmental Management of Road Salts. Website source: http://www.ec.gc.ca/sels-salts/default.asp?lang=En&n=F37B47CE-1.

[10] Environment Canada: Road Salts: Reducing the risks of road salts to the environment while keeping our roads safe. Website source: http://www.ec.gc.ca/media_archive/press/2001/011130-2_b_e.htm.

[11] Referenced from Nova Scotia Transportation and Infrastructure Renewal's Salt Management Plan Manual located in-house.

[12] Nova Scotia Department of Transportation and Infrastructure Renewal Highway Programs: *Highway Maintenance Standards: Effective 1 July 2009*. Chapter 6: Snow and Ice Control, p. 101, 102 and 103(2x). Website source: http://gov.ns.ca/tran/publications/Highway%20Maintenance%20Standards%20Manual.pdf.

Chloride concentrations in the raw water samples collected within the Chain Lake watershed area are among the highest of all Halifax Water's source water areas. As described in section *5.4: Source Water Quality Monitoring – Total Chloride* and outlined in *Table 29: Chain Lakes Chloride Water Quality Monitoring Results* 2007-2016(mg/L)*, both on page 119, chloride levels in the water are at or approaching long term levels considered toxic to aquatic life according to Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (WQGPAH).

Further, upon consultation with NSTIR and HRM winter road maintenance staff, it was confirmed that the anti-caking agent sodium ferrocyanide is added by the Canadian Salt Mine to road salt prior to delivery to the various destinations to ensure the salt is free flowing. Transportation and Infrastructure Renewal's specification for road salt states that it must be treated with an anti-caking conditioner (YPS or equivalent) at a minimum rate of 50 ppm. NSTIR advised that Canadian Salt typically adds 100 ppm. The Material Safety Data Sheet (MSDS) for ferrocyanide received from NSTIR indicates that "the reported probable lethal dose in humans is 0.5-5gm/kg. Ferrocyanide salts are rapidly excreted in urine without metabolic alteration." Additionally, according to a Stantec Report:

> "*In the absence of direct sunlight, ferrocyanide complex is stable and low in toxicity. However, exposure to sunlight results in dissociation and release of free cyanide, which can be hydrated to hydrogen cyanide; both compounds are toxic*."[13]

For more information on the management of this compound with respect to the risks to the water supply see section *4.2.6: Road De-icing* on page 84.

<u>Halifax Regional Municipality Policy Restrictions</u>

HRM has recognized in the 2014 Regional Plan the "crucial" need to protect water resources for

> "*potable water supply, wildlife habitat, recreational enjoyment, and aesthetic value. …HRM's strategy aims to protect this resource through land use control and retention of those features that regulate water flow, mitigate flooding, reduce water pollution and protect ecological functions*."

The 2014 Regional Plan also states as its first objective regarding Municipal Water Services, Utilities and Solid Waste that HRM will "*coordinate municipal initiatives with … (Halifax Water) to:… (c) reduce degradation to the natural environment."*

In response to this need, a water quality monitoring program began in 2006 to identify lake water quality status and trends that included chloride data. Based on the water quality data collected, and to fulfill Environment Canada's Code of Practice (see section *3.1.6: Environment* Canada's Code of Practice on page 58), HRM has created a salt management plan, identified best

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[13] Halifax Regional Municipality. Environment and Sustainability Standing Committee, April 16, 2012, Information Report. Attachment 1: Stantec. November 7, 2011. *Draft Report: Road Salt – Review of Best Management Practices* Prepared for Halifax Regional Municipality Sustainable Management Environment Office. Halifax NS; p. 11. Web-site source: http://www.halifax.ca/boardscom/swrac/documents/RoadSaltImpactsonLakes.pdf.

management practices and applied innovative techniques to winter works operations. Policy SU-8 of the 2014 Regional Plan states

> "*HRM may* consider *regulatory and operational measures to reduce the quantity and improve the quality of stormwater entering public stormwater facilities and watercourses including…reduction in road salts. Any such measures may apply in whole or in part of HRM and may require approval of the Review Board*."

Further, HRM Transportation and Public Works are developing a new Winter Works Management Plan to reflect upgrades in policies and practice. For instance, in October 2011, the HRM Municipal Operations Winter Works Staff initiated and piloted the application of brine (Direct Liquid Brine Application) to HRM roads to achieve enhancements to public safety and a reduction in overall salt usage.

Road De-icing Application Practices and Strategies

A summary of road salt applications and strategies for the province and for HRM are outlined in the subsections below. A map entitled *Winter Maintenance Responsibility in HRM Core* illustrates the agencies responsible for maintaining specific roads under winter conditions and may be viewed online[14].

Halifax Regional Municipality

HRM applies Priority 1 – Main Arterial Highways road de-icing application strategies to 1.4 km of St. Margaret's Bay Road. HRM's Salt Management Strategies[15] and Snow and Ice Service Standards[16] are posted on HRM's website[17].

Salt Shed

HRM maintains a salt shed located at 230 Horseshoe Lake Drive in the Bayer's Lake watershed (see *Map H: Road Infrastructure and Winter Maintenance* on page 39). Any risk posed by this shed is in association with residual chloride. Although the shed is located outside of the Chain Lakes watershed area, it is within the Bayer's Lake watershed (see *Map D: Hydrology and Elevations in Water Supply Areas* on page 20) whereby residual chloride could be washed into Bayer's Brook and diverted into Second Chain Lake if the Bayer's Diversion Dam gate is open (see section *Bayer's Lake Diversion Dam* on page 23 and *Map J: Halifax Water Infrastructure (Sewer and Water)* on page 41). However, since the sheds are located outside of the Chain Lakes watershed area and as long as the Diversion Dam remains closed, the salt sheds are not considered a significant risk to the watershed area.

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[14] Halifax: Winter Maintenance Responsibility in HRM Core. Website source: http://www.halifax.ca/snow/documents/WinterMaintenanceResponsibilitymap.pdf.

[15] Halifax: Snow: Salt Management Strategies. Website source: https://www.halifax.ca/snow/SaltManagementStrategies.php.

[16] Halifax: Municipal Operations: Snow and Ice Service Standards. Website sources: http://www.halifax.ca/municipalops/Winter/SnowServiceStandards.php .

[17] Halifax: Snow: Salt Management Strategies. Website source: https://www.halifax.ca/snow/SaltManagementStrategies.php.

Nova Scotia Transportation and Infrastructure Renewal

The winter maintenance program conducted by NSTIR is outlined in Chapter 6 of the NSTIR's Highway Maintenance Standards[18]. NSTIR maintains the lion's share, applying Level 1A (top priority) application strategies to 8.3 km of 100 Series Highways. The province adjusted its winter maintenance standards to include Direct Liquid Applications (DLA) (brine) in 2013, decreasing the level of chloride applications on provincially maintained roadways since then.

Standards, strategies, regulatory requirements and management plans from the various levels of government are designed to restrict the application of road salt as a de-icing agent, particularly in "environmentally sensitive" areas. However, various levels of chloride salt concentrations are applied within the Chain Lakes watershed area which poses significant risk to water quality. Maintaining open lines of communication between Halifax Water and HRM and NSTIR winter road maintenance staff will help to manage these risks.

NSTIR maintains two salt sheds located at 27 Prospect Road (Beechville Base) which are also within the Bayer's Lake watershed and have been identified as potential sources of chloride contamination (see *Map J: Halifax Water Infrastructure (Sewer and Water)* on page 41). However, since they are located in the Bayer's lake watershed area, outside of the Chain Lakes watershed area, they are not considered to be a significant risk unless the gate is opened at the Bayer's Diversion Dam.

Water Supply Plant

When the Chain Lakes emergency water supply plant (WSP) is activated for use (see section *3.1.4: Water Supply Infrastructure* on page 49), the only chemical used in the water treatment process is chlorine which is delivered via boom truck.

In the event of a power outage, a portable diesel generator is brought on site. Diesel fuel for the generator is delivered to the site as needed.

The risk to the watershed from chemical contamination associated with the water supply plant is low-moderate: the risk is low due to the infrequency with which water treatment chemicals and fuel are delivered to the plant; and in the event of an accident or spill, the risk rises to moderate due to the proximity of the parking area to First Chain Lake (within 10 metres), which is where vehicles access the WSP and the intake. Further, a security fence around the intake and WSP deters public access and provides a physical barrier between vehicles and the lake, which lowers the risk from those potential impacts.

Nova Scotia Power Inc.

Nova Scotia Power Inc. activities present three kinds of potential risks to the Chain Lakes watershed area; they are with respect to chemicals associated with transmission lines and transformers and the risk of fire associated with transmission line maintenance as described under those headings below.

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[18] Nova Scotia Department of Transportation and Infrastructure Renewal Highway Programs: *Highway Maintenance Standards: Effective 1 July 2009*. Chapter 6: Snow and Ice Control. Website source: http://gov.ns.ca/tran/publications/Highway%20Maintenance%20Standards%20Manual.pdf.

Transmission Lines

NSPI has a number of transmission lines that run through the Chain Lakes watershed area (see section *3.1.4: Nova Scotia Power Inc.* on page 50) of which many fall on lands owned by Halifax Water. Through consultation and legal agreement with Halifax Water, NSPI has developed a vegetation management plan which includes prohibiting chemical use within the watershed area. HRM also restricts the use of chemicals to manage vegetation. For NSPI to change their policy, they would need to contact NSE and HRM to apply for an exemption and consult Halifax Water to demonstrate the need to use chemicals inside the watershed area and provide a management plan before proceeding.

Although there is little probable risk of chemical treatment use to maintain transmission line corridors, any vehicular activity along these corridors has the potential for risk presented by petroleum hydrocarbons spills. However, the risk is still low due to the infrequency of vehicular traffic on the corridors and the likelihood that these vehicles will leak petroleum hydrocarbons.

Transformers

NSPI transformers (pole and pad mount) contain coolant oil, which may contain chemicals that could present a risk to the water supply in the event of a leak. The level of risk presented by leaks is dependent on the type of oil the transformers contain. For details on the different types of transformer oil and the risks they present see section *3.1.4: Transformers* on page 51.

Wildland Fire Fighting

In the event of a wildland fire, risk to the water supply from firefighting activities, particularly those using chemical suppressants, has been greatly reduced through collaborative strategies between the water utilities, NSDNR and NSE (see section *4.4.1: Wildland Fire* on page 99). As a last resort, NSDNR has identified Silv-Ex and/or FIRE-TROL Fire Foam 104 as the type of chemical that should be used inside the watershed area in such events.

The benefits to using an approved fire suppressant chemical outweighs the risks to water quality presented by the aftermath of a fire event when fire suppression chemicals are not used (see section *3.2.1: Wildland Fire* on page 67). The material safety data sheets (MSDS) indicate that the application of these fire suppressants pose little risk of environmental impact because they are biodegradable and exhibit little to no biotic toxicity when used according to the manufacturer's recommendations.

Potential Chemical Impacts to Water Supply beyond Halifax Water's Control

Risk of chemical contamination to the Chain Lakes watershed area from sources not controlled by Halifax Water have been greatly reduced through redirection of water flow away from the water supply using dams and/or culvert systems, and through the collaborative relationship Halifax Water has maintained with provincial and municipal agencies regarding land use management to overcome real or potential impacts to the water supply. There are very few active or potential risks whereby Halifax Water has little control other than those presented by roadways (see sections *3.1.3: Transportation Corridors* on page 47 and *3.1.6: Road De-icing* on page 58). Management techniques are described in section *4.3: Contingency (Mitigation, Preparedness and Response)* on page 89.

3.1.7 Illegal Dumping

Opportunities for illegally dumping within the Chain Lakes watershed has been greatly reduced due to the newly created COLT and barrier gates and no parking and illegal reporting signage installed along St. Margaret's Bay Road.

3.2 Critical Infrastructure

Public Safety Canada considers water to be "critical infrastructure" and is defined as such

> *"…processes, systems, facilities, technologies, networks, assets and services essential to the health, safety, security or economic well-being of Canadians and the effective functioning of government…. Disruptions of critical infrastructure could result in catastrophic loss of life and adverse economic effects."*[19]

Because the Chain Lakes water supply is an emergency supply, an isolated disruption of the Chain Lakes water supply should not be considered a critical threat that would result in a serious adverse situation. However, if the primary water supplies for Halifax and Dartmouth (i.e., Pockwock and Lake Major) are interrupted, in addition to the Chain Lakes Emergency supply, then the situation would most certainly be considered a "*disruption[s] of critical infrastructure [that] could result in catastrophic loss of life and adverse economic effects*".

3.2.1 Critical Infrastructure Threats and Hazards

According to Public Safety Canada, the risks to critical infrastructure, which include accidental, natural and intentional hazards (also referred to as threats), are increasingly complex and frequent. Although the list of hazards and threats is never complete, the *Public Safety Canada's Risk Management Guide for Critical Infrastructure Sectors* has created a list of common threats and hazards that could affect critical infrastructure (found in that document's Appendix B: List of Hazards and Threats[20]). There is no single way to assess the risks presented by hazards and threats; the methods and best practices to assess risks continually evolve.

No matter what technique is used to assess the risks, lessons learned and recommendations for improvement need to be captured to keep abreast of the progression of threats to the water supply as they evolve.

The four factors that have been identified as contributing to Canada's vulnerability to a broad spectrum of threats on critical infrastructure, such as a municipal water supply utility are:

1. population, built environment, and wealth, which are increasingly concentrated in a small number of highly vulnerable areas so that such communities are at risk from multiple hazards;

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[19] National Strategy for Critical Infrastructure, Public Safety Canada Her Majesty the Queen in Right of Canada, 2009. ISBN: 978-1-100-11248-0; p. 2. Website sources: http://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/srtg-crtcl-nfrstrctr/srtg-crtcl-nfrstrctr-eng.pdf .

[20] Public Safety Canada: Risk Management Guide for Critical Infrastructure Sectors. Website source: http://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/rsk-mngmnt-gd/rsk-mngmnt-gd-eng.pdf p. 37.

2. climate change, which may increase the frequency and severity of extreme weather events;
3. infrastructure that is aging and is more susceptible to damage; and
4. communities that are increasingly more reliant on advanced technologies and are frequently disrupted during disasters.[21]

The common threats and hazards that have been considered through accidental emergencies, natural events or intentional threats as having the potential to have the greatest impact to the Chain Lakes watershed area source water supply system, are described in the corresponding sections following and outlined in *Table 15: Summary of Existing and Potential Critical Infrastructure Risk Factors Affecting Watershed Area* on page 74.

Accidental Emergencies

Responsibility for emergency measures, including the protection of critical infrastructure (CIP) in Canada is shared among all three levels of government. The federal government provides national leadership and coordinates the overall CIP effort. The federal government lead agencies include the Office of Critical Infrastructure Protection and Emergency Preparedness (OCIPEP) agencies, which include but are not limited to Health Canada, Transport Canada, RCMP, Natural Resources Canada, and the Canadian Security Intelligence Service (CSIS). The lead agency in Nova Scotia is the Nova Scotia Emergency Management Office.

An occurrence of any the accidental emergencies described under the subheadings below is considered to present great risk to the Chain Lakes watershed water supply area in terms of impact.

Accidental Fire

The Chain Lakes watershed area is in a unique position where the natural environment (unoccupied land) interfaces with human development, which is defined as the Wildland –Urban Interface (WUI). Consequently, accidental fire is a moderate-high risk that is exacerbated by various inherent anthropogenic occurrences that are more frequent and varied within the WUI (see section *3.1: Inherent Risk Factors* on page 43).

Aircraft Disaster

The Halifax region's airspace is used by multiple users including domestic and international flights arriving to and departing from the Halifax Stanfield International Airport, Canadian Armed Forces who are training at Canadian Forces Base Shearwater, and helicopter, non-scheduled tourism and non-commercial flights. All things considered, having busy air-space in the vicinity of the Chain Lakes watershed area presents a low-extreme risk.

If an aircraft lands in the watershed area, there is risk for water quality impairment associated with the potential for fire and the chemicals to arrest the fire, fuel leakage, and intrusion of

[21] Government of Canada: Office of Critical Infrastructure Protection and Emergency Preparedness: Threat Analysis: Threats to Canada's Critical Infrastructure. March 12, 2003. Number TA03-001. p. 3. Website source: http:/www.publicsafety.gc.ca/prg/em/ccirc/_fl/ta03-001-eng.pdf .

sediments and debris into waterways. Depending on the severity of an aircraft disaster within the Chain Lake watershed area, the result could be long term damage to the water supply– an extreme risk. However, the likelihood of such an event is very low, hence the low risk potential consideration.

<u>Chemical and Oil spills</u>

There is substantial potential for chemical and oil contamination through accidental spills from various sources including vehicle road traffic and maintenance, and private residential and commercial activities inside the watershed. An oil, fuel, or hydraulic spill likely would be limited to the immediate spill area since there are usually limited quantities of these fluids (unless there was direct discharge to a water body).

<u>Erosion and Sedimentation</u>

In the event of any of the Accidental Emergencies identified in this section, erosion and sedimentation is considered a secondary impact to the water supply due to in-stream activity or shoreline damage associated with the rescue, clean up or after-effects of the emergency. These activities pose a medium-high risk to the watershed.

Natural Events and Disasters

Natural events and disasters include wind and flooding, fire, drought, natural biological outbreaks and infestations and climate change impacts. These events and disasters are unpredictable and can have long-term negative effects on source water quality. They present a risk to water quality mainly due to the impairment associated with the intrusion of sediments and debris into waterways, and the loss of land cover and infiltration areas. The key natural factors to consider as potential risks to the Chain Lake watershed are described below in more detail.

<u>Wind and Flooding</u>

Wind and rainstorm events resulting from tropical storms, surges and hurricanes are a significant threat in Nova Scotia, and put water quality and subsequently public health at risk. Such events cause flooding, which puts drinking water supplies at risk by way of microbial cross contamination and power outages, which threaten to disrupt water pumping stations and blow down of massive forested areas that lead to short and long-term water quality impacts such as soil erosion and sedimentation, increased colour, suspended solids and organic matter levels.

Further, according to Public Safety Canada, floods are the most frequent natural hazard in Canada. They can occur at any time of the year and are most often caused by heavy rainfall, rapid melting of a thick snow pack, ice jams, or more rarely, the failure of a natural or man-made dam, of which there are two within the Chain Lakes watershed area, (see section: *2.3.3: Dam Infrastructures* on page 23).

However, due to the functionality and location of the two dams at either end of the Chain Lakes, the main risk to the water supply is one of contamination rather than flooding. The original holding design-capacity of the Chain Lakes dam-spillway, constructed in the mid-19th century (~1848), incorporated flow from the Bayer’s Lake watershed area.

The Bayer’s Lake diversion dam was subsequently built in 1986 to divert potentially contaminated Bayer’s Lake Business Park water away from the Chain Lakes water supply.

Therefore, if the Bayer's Lake diversion dam fails, flooding would not be a major concern to the immediate watershed, though it could become an issue downstream of the Chain Lakes spillway.

Wildland Fire

Generally, wildland fires in Nova Scotia have become less of a risk due to public awareness and education and a successful Provincial Fire Safety Program. With respect to the Chain Lakes watershed area, wildland fires are mitigated further through adherence to Halifax Water's BMPs. However, forested areas close to the Wildland – Urban Interface (WUI) present a moderate-high risk to the watershed area (see section *3.2.1: Accidental Fire* on page 65). The wildland fire that occurred in the Geizer Hill area of the Chain Lakes watershed area on August 8, 2001 demonstrates this risk.

Wildland fires present a risk because they contaminate water supplies by producing an increase in heterotrophic plate counts (a type of bacteria which feeds on organic compounds of carbon and nitrogen) caused by woody debris, ash or dissolved nutrients in water and increased opportunity for sedimentation through erosion of fire exposed soils.

Drought

According to Environment Canada, Atlantic Canada may be more susceptible to drought impacts than areas where drought is more prevalent; where drought occurs less frequently there tends to be a lower adaptive capacity. The risk of drought in the Chain Lakes watershed area is low now, but as the climate continues to change risks associated with drought could rise.

Low flow conditions caused by drought increase concentrations of virtually every parameter known to impair water quality. Of particular concern are the increased concentrations of microorganisms that pose a threat to human health including, but not limited to, cryptosporidium, giardia, listeria, campylobacter, salmonella, and *E. coli*. Under these circumstances a robust water treatment system is vital.

Persistent drought conditions could put pressure on water use, leading to more demand on Halifax Water's water supplies. The report completed by Dillon Consulting in 2004 suggests the Chain Lakes watershed area is precipitation-dependent and has become more so (up to 17%) since the Bayer's Lake diversion dam (see section *Bayer's Lake Diversion Dam* on page 23) was constructed, which currently diverts water away from the watershed. Additionally, in drought conditions, the risk of wildfire is exacerbated by the small size of the watershed area, its place in the WUI and its high forest content (see under previous heading *Wildland Fire)*.

Natural Biological

Natural biological outbreaks can affect the health of the watershed and the water supply, which ultimately put humans, animals, and plants at risk. Natural biological risks that should be considered for the Chain Lakes watershed area and its water supply include insect infestation and water and airborne diseases.

With respect to watershed health and insect and disease outbreak, the Chain Lakes watershed area is considered at a higher risk than the centrally located primary watersheds (Pockwock and Lake Major) because it falls within the WUI, which is easily accessed and therefore subjected to higher volumes of human traffic. Further, Halifax is an international port city where products are distributed to and from all over the world. These situations are ideal for biological outbreaks to be introduced and become established. An unfortunate example of this is the invasive Brown Spruce Longhorn Beetle (BSLB) with which the Canadian Food Inspection Agency has classified Nova Scotia as being totally infested. If not properly managed, these conditions lead to widespread deterioration of the watershed area and result in increased fire risk and degradation of water quality(see section *4.4.1: Natural Biological* on page 100).

Climate Change

The risks posed by climate change to the Chain Lakes watershed area is difficult to assess and determine due to varied and multifaceted considerations; however, identifiable climate change effects, as they relate to the Chain Lakes watershed area, are discussed throughout this SWPP.

Intentional/Deliberate Threats

An intentional or deliberate threat involves an attack or a deliberate act for the purpose of doing damage that involves malicious intentional threats on national security such as chemical, physical, cyber or biological attacks; sabotage, crimes, social unrest, strike or labour disruption; or non-malicious intentional actions such as a border closure or regulation change that can affect critical infrastructure. The different types of possible intentional/deliberate threats and their risks on the Chain Lakes source water supply are described under the next two headings.

Malicious Intent

Halifax was founded by the British Government for its strategic location; initially for trade and later for military purposes. Consequently, the risk of malicious intent to any of our large water supply systems such as chemical, physical, cyber or biological attacks; sabotage, crimes, social unrest, strike or labour disruption is considered high. Therefore, as part of the emergency supply for Pockwock, Chain Lakes would be considered a logical primary target for malicious attack in order to disrupt a major component of Halifax's critical infrastructure.

Non-malicious Intent

Non-malicious intent could negatively affect the Chain Lakes water supply by compromising the ability to protect the watershed area. Considering that the Chain Lakes watershed area is not protected under its own legislation, as is the *Pockwock Lake Watershed Protected Water Area*, there is impetus for non-water utility interests to acquire and/or use watershed lands for other than watershed protection purposes. Therefore, risk of non-malicious intent to the Chain Lakes water supply is directly related to ownership and the regulations and by-laws in place.

3.3 Risk Assessment Summary

Table 14: Summary of Existing and Potential Inherent Risk Factors Affecting Watershed Area on the next page and *Table 15: Summary of Existing and Potential Critical Infrastructure Risk Factors Affecting Watershed Area* on page 74 outline the activities described in this Chapter that have inherent potential to contaminate the Chain Lakes watershed area, the potential contaminants involved, whether they are a point or non-point pollutant source (or both), and the potential impact they have on the watershed area.

Table 14: Summary of Existing and Potential Inherent Risk Factors Affecting Watershed Area				
Activity	**Potential Contaminant**	**Point Source**	**Non-Point Source**	**Potential Impact**
Commercial				
Forestry Operations: including harvesting, silviculture, road maintenance and construction.	Fuel; hydraulic fluid	X		Any oil, fuel or hydraulic spill would likely be limited to the immediate area because there are usually limited quantities of these fluids, unless there was direct discharge to a stream.
	Soil erosion and sedimentation	X		Sedimentation of streams may occur through poor harvesting practices and/or improper road construction and maintenance and watercourse crossings.
	Chemical sprays related to silviculture practices	X		The release of chemicals onto watershed lands for pest and vegetation control related to forestry activities on non-Halifax Water lands. BMPs assist in mitigating impacts from harvest practices, road construction and maintenance. Generally speaking, the risk to watershed lands from chemical use for silviculture purposes is very low as the use of chemicals inside the Chain Lakes watershed area are restricted through legislation and by-laws.
Mining and pits and quarry operations	Petroleum products, soil erosion and sedimentation due to vegetation removal and soil disturbance, and arsenic and other mining operation chemicals that may be discharged into the water supply	X		There is currently no potential impact or risk associate with past mining activity or current mineral rights designation. The Chain Lakes watershed area is listed as a municipal water supply area on the Nova Scotia registry of Claims map.
Residential				
Backyard fires	See Accidental Fire in *Table 15: Summary of Existing and Potential Critical Infrastructure Risk Factors Affecting Watershed Area* on page 74.	X		See Accidental Fire in *Table 15: Summary of Existing and Potential Critical Infrastructure Risk Factors Affecting Watershed Area on page* 74.
Home heating fuel	Home heating oil fuel	X		Spills can occur during tank fueling operations, improper tank maintenance and/or tank failure over time. Release of hydrocarbons into the soil for any length of time could have a serious impact to the water supply.
Automobile fluids released from parked cars in driveways	Antifreeze, oil, and gasoline (petroleum hydrocarbons)	X	X	Automobile fluids could be released into the soil surrounding homes and could have a serious impact to the water supply depending on the amount and type of fuel released.
Household chemicals / fertilizers	Fertilizers, pesticides, soaps	X	X	Household chemicals used in gardens and on lawns or to wash vehicles in the driveway could be a source of contamination.
Impervious Surfaces	Roofs and driveways are contributing factors	X	X	Impervious surfaces promote runoff into the surrounding soil at a higher rate than if these areas were covered with vegetation.

Recreation				
Dog walking	Uncollected dog droppings.		X	Water becomes contaminated with bacteria especially after stormwater events.
COLT traffic	Garbage, bacteria contamination from pet droppings and-off-trail pedestrian activity causing soil erosion and sedimentation.	X	X	Heavy pedestrian activity increases the potential for garbage and bacteria from pet droppings and soil sediments to enter source water.
Geocaching	Off-trail activity causing increased soil erosion, sedimentation and other contaminants associated with general trail use (see COLT/Long Lake above)	X		Off-trail activity associated with geocaching is limited through cooperation with the Atlantic Canada Geocaching Association (http://atlanticgeocaching.com/index.php/component/content/?view=featured)
Camping	Increased heterotrophic plate counts caused by woody debris, ash or dissolved nutrients in water as well as garbage left behind.	X		Camp fires associated with camping increase the risk of wildland fires which elevates the impact of contamination over time; and elevated bacteria and nutrient counts caused by garbage and potential interference with the water treatment process (garbage becoming clogged in pumps).
Mountain biking	Soil erosion and sedimentation.	X		Ad-hoc trail development has led to the unauthorized removal of vegetation and development of watercourse crossings which have the potential to promote increased soil erosion and sedimentation.
Off Highway Vehicles	Petroleum hydrocarbons and other vehicular fluids in the event of accident or spill and soil erosion and sedimentation.	X	X	Petroleum hydrocarbons and other vehicular chemical fluid contamination to water supply plus sedimentation.
Swimming	Bacteria contamination from human and pet body contact.		X	Bacteria released into source waters.
Boating	Even with limited boating access, fuel spills (petroleum hydrocarbons) are a potential contaminant.	X	X	Fuel released into waterways, especially near the water intake could have a serious impact on the water supply and its viability as an emergency drinking water supply source.
Transportation Corridors				
Public roads and highways	Hazardous chemical and dangerous goods spills; chlorides from road de-icing; petroleum hydrocarbons; automotive fluids contained in runoff; and sedimentation due to soil erosion.	X		Contamination of source water: depending on retention time, location and type of contamination, there could be direct contamination of Chain Lakes which could render the source water unusable as an emergency drinking water supply source.
Road Construction	Fuel; hydraulic fluids from machinery.	X		Oil, fuel or hydraulic spill would likely be limited to immediate area because there are usually limited quantities of these fluids, unless there was direct discharge to a tributary stream.
	Soil erosion and sedimentation.	X		Sedimentation of streams may occur through poor road and water crossing construction and maintenance practices.
	Bedrock/Acid (pyritic) slate exposure causing ARD.	X		ARD lowering pH of water and causing fish kills.
Controlled access for utility uses	Petroleum Hydrocarbons.	X		Oil, fuel, or hydraulic spill would likely be limited to immediate area, since there are usually limited quantities of these fluids (unless directly discharged to a waterway).

Utilities				
Chain Lakes water supply pumping station	Diesel fuel and lube oil; vehicle fluids from trucks delivering chemicals or collecting water samples.	X		Oil, fuel, or hydraulic spill would likely be limited to immediate area, since there are usually limited quantities of these fluids (unless directly discharged to a waterway).
	Pad-mount transformer Naphtha-based coolant oil (VOLTESSO 35), for water supply plant transformer.	X		VOLTESSO 35 is not "expected" to be harmful to aquatic organisms.
	Water-treatment chemicals (Chlorine).	X		Chlorine readily dissipates in water and air; therefore, the impact to the watershed is measured according to the spill amount and its proximity and contact time with living organisms.
Halifax Water wastewater treatment infrastructure	Untreated sewage entering waterways from aging pump stations and leaky or broken pipes.	X		Increase in heterotrophic plate and coliform counts.
	Bedrock exposure during construction of new pipe corridor.	X		ARD lowering pH of water supply and causing fish kills.
Power Utility Transformers	Polychlorinated biphenyls (PCBs) may or may not be contained in **pole top** transformers. Those made prior to 1983 likely contain PCBs.	X		Depends on the type of oil, age of the transformer, ownership, and their location and maintenance schedule. PCB-containing transformers could contaminate the watershed (known to be toxic to fish) if they leak. All PCB-containing transformers must be replaced by 2015.
	Naphtha-based transformer mineral oil, (VOLTESSO 35) (contained in two of three **pad mount transformers)**; the other contains DowFrost HD, a low toxicity coolant.	X		VOLTESSO 35 is not considered harmful to aquatic organisms. DowFrost is considered to be a low toxicity coolant suitable for use in the vicinity of drinking water sources.
Utility distribution and infrastructure corridors (construction and maintenance) (NSPI/telecommuni-cations and Halifax Water)	Soil erosion and sedimentation.	X		Sedimentation of waterways, which may be minimized through the use of BMPs including those created by NSPI and Halifax Water.
	Fuel; hydraulic fluid oil.	X		Oil, fuel, or hydraulic spill would likely be limited to immediate area, since there are usually limited quantities of these fluids (unless directly discharged to waterway).
	The activity of cutting the vegetation could ignite a fire in dry weather.	X		Increased heterotrophic plate counts caused by woody debris, ash or dissolved nutrients in water.
	Pentachlorophenol (PCP) or chromate copper arsenate (CCA) is used to treat utility poles to guard against wood destroying organisms, unless within 15 metres of a watercourse. Poles in latter case are not treated with chemicals that may impact waterways.	X		The ecotoxicity of PCPs, a known carcinogen, is classified as medium and is targeted at wood destroying organisms.
Municipal Land Use Planning and Development				

Regional Plan 2014 Regional Plan guiding policy designating permissible land use planning and development activity in HRM, compounded by landownership type. Halifax Regional and City By-laws permitting various land use planning and development activities Halifax MPS & LUB policy and by-laws permitting community land use planning and development activity	Automotive fluids and petroleum hydrocarbons; sedimentation due to soil exposure; bedrock - acid (pyritic) slate – exposure promoting ARD; commercial and residential chemicals/fertilizers; nutrients and bacteria from sewage system failure; and petroleum products from fuel spills.	X	X	Increased sedimentation through stormwater runoff and turbidity; ARD lowering pH of water and causing fish kills; chemical run off from vehicular fluids; eutrophication of water bodies; hydrocarbon contamination from fuel storage and motorized vehicles; fecal bacteria and nutrient contaminants from sewage treatment infrastructure breaks and overflow escaping into water source.
Chemicals				
General Chemical and/or biocide pest control use which may be permitted through provincial and/or municipal permits and regulations	Chemical and/or biocide pest control use products.	X	X	The risk of using any chemical and/or biocide pest control products depends on its properties and reaction with the surrounding environment.
Road de-icing and storage	Chloride, accumulated from road de-icing agents entering surface waterways through stormwater runoff.	X	X	Increased levels of surface water chloride concentrations and conductivity levels measured in collected watershed samples provide evidence of current contamination. A salt shed has been identified in the Bayer's Lake watershed area; however, it is not a source of contamination unless the water from Bayer's Lake is diverted into Second Chain Lake via the Bayer's Lake Diversion Dam.
Water Supply Treatment Plant	Chlorine	X		Chlorine readily dissipates in water and air; therefore, the impact to the watershed is limited to the spill amount, its proximity to and contact time with living organisms.

Chemicals cont.'d

Transmission/utility distribution line maintenance	Pentachlorophenol (PCP) or chromated copper arsenate (CCA) is used to treat utility poles to guard against wood destroying organisms, unless within 15 metres of a watercourse. Poles within that distance are not treated with chemicals that may impact waterways.	X		The ecotoxicity of PCPs, a known carcinogen, is classified as medium and is targeted at wood destroying organisms.
Power Transformers	Polychlorinated biphenyls (PCBs) may or may not be contained in **pole top transformers**. Those made prior to 1983 likely contain PCBs.	X		Depends on the type of oil; age of the transformer; ownership; and their location and maintenance schedule. PCB-containing transformers could contaminate the watershed (known to be toxic to fish) should they leak. All PCB-containing transformers must be replaced by 2015.
	Contamination from **pad mount transformers** depends on: the type of product it contains (i.e., VOLTESSO 35 a low toxicity coolant with low solubility which floats or DowFrost HD, another low toxicity coolant); the ownership; containment; location; and maintenance responsibility (CTV or NSPI or HRWC schedule).	X		VOLTESSO 35 is not considered to be harmful to aquatic organisms; however, depending on geographic conditions (wind and wave action), local experts should be consulted in event of a spill in water. DowFrost HD is industrially inhibited propylene glycol-based, recommended for use in applications where incidental contact with drinking water is possible.
Wildland Fire Retardants	Silv-Ex and/or FIRE-TROL Fire Foam 104 are the types of chemical that could be used inside the watershed area as approved by Halifax Water.	X		The material safety data sheets (MSDS) indicate that the application of these products pose little risk of environmental impact because they are readily biodegradable and exhibit little to no biotic toxicity when used according to the manufacturer's recommendations.
Other potential chemicals	Besides those already mentioned, considering the dammed areas and redirected flow of potentially contaminated water run-off from the Bayer's Lake watershed, there are few potential contaminants to the water supply.	X	X	Few active or potential risks whereby Halifax Water has little control are evident under this category.
Illegal Dumping				
Illegal Dumping	Most prevalent heavy metals and petroleum hydrocarbons.	X		Unlimited range of contaminants, commonly include household appliances, vehicles and electronics which impact water quality through leaching of heavy metals and hydrocarbons into soil and waterways.

Table 15: Summary of Existing and Potential Critical Infrastructure Risk Factors Affecting Watershed Area below outlines the activities described in this Chapter with the potential to contaminate the Chain Lakes watershed area resulting from a threat to national security that impacts the Chain Lakes water supply as a component of the critical infrastructure for the Halifax region.

Table 15: Summary of Existing and Potential Critical Infrastructure Risk Factors Affecting Watershed Area				
Activity	**Potential Contaminant**	**Point Source**	**Non-Point Source**	**Potential Impact to Water Supply**
		Accidental Emergencies		
Accidental Fires	Water run-off from burnt materials that potentially contain hazardous chemicals; nutrient loading caused by organic matter; and soil erosion and sedimentation.	X		Short or long-term impact on water quantity and quality depends on severity of the fire that might lead to a water pumping station shut-down. Such events could lead to increased levels of colour, turbidity, bacteria, suspended solids, organic matter, nutrient loading and possible chemical contamination.
Aircraft disaster	Chemicals associated with burning materials and those used to arrest the associated fire; fuel leakage; and associated intrusion of sediments and debris into waterways.	X		Short and long-term impact on water quantity and quality depending on severity of disaster which could lead to water pumping station shut down. The emphasis is on chemical contamination; however, increased levels of colour, turbidity, bacteria, suspended solids and organic matter should be considered.
Chemicals and oil spills.	Fuel, vehicular fluids, and other chemical spills that threaten water quality, as determined by *Health Canada Canadian Drinking Water Guidelines* and *CCME's* WQGPAH.	X		Short and long-term impact on water quantity and quality depending on severity of spill which could lead to water pumping station shut down. The emphasis is on chemical contamination; however increased levels of colour, turbidity, bacteria, suspended solids and organic matter should be considered.
		Natural Events & Disasters		
Wind and floods resulting from tropical storms, surges and hurricanes	Microbial cross contamination due to flooding and storm surges; disruption of water treatment due to power outages; soil erosion and sedimentation due to tree blow down.	X		Short or long-term impact on water quantity and quality depending on severity of event, which could lead to water pumping station shut-down. Such events could lead to increased levels of colour, turbidity, bacteria, suspended solids and organic matter.
Wildland Fire	Water run-off from burnt materials that potentially contain hazardous chemicals; nutrient loading caused by organic matter; and soil erosion and sedimentation.	X		Short or long-term impact on water quantity and quality depending on severity of fire. Such events could lead to increased levels of colour, turbidity, bacteria, suspended solids, organic matter nutrient loading and possible chemical contamination.
Drought	Promotes growth and concentrations of microorganisms; and increased concentrations of non-microorganism contaminants.	X		Short or long-term impact on water quantity and quality depending on extent of drought and demand on water supplies. Creating the need to ensure robust water treatment system.

Table 15: Summary of Existing and Potential Critical Infrastructure Risk Factors Affecting Watershed Area				
Activity	**Potential Contaminant**	**Point Source**	**Non-Point Source**	**Potential Impact to Water Supply**
Natural Biological (outbreak)	Microbial contamination, water and airborne diseases, nutrient loading, soil erosion and sedimentation due to tree blow down and fire and to a lesser extent chemical contamination.	X		Short or long-term impact on water quantity and quality depending on severity of the outbreak, which could lead to water pumping station shut-down. Such events could lead to increased levels of colour, turbidity, bacteria, suspended solids, organic matter, nutrient loading and possible chemical contamination.
Climate Change	Difficult to assess and determine due to varied and multifaceted considerations.	X		Dependent upon rate and severity of extreme weather events, although impacts would be consistent with those already described throughout Chapter 3.
Intentional / Deliberate Events				
Malicious intent: Terrorism, Vandalism, or Sabotage; crimes, social unrest, strike or labour disruption	Difficult to assess and determine due to varied and multifaceted considerations. Priority consideration of contaminants includes chemical, physical, cyber or biological materials.	X		Catastrophic loss of life, adverse economic effects, and significant harm to public confidence creating partial or total shutdown of water pumping station and long or short-term damage to the water supply.
Non-malicious Intent	Difficult to assess and determine due to varied and multifaceted considerations.	X		Regulation or by-law change initiated by the municipal or provincial government which creates negative impact(s) to the protection of the source water supply due to inability to provide maximum protection to the water supply.

Table 16: Scale of Problem and Priority Rank** of All Activities and Threats to Critical Infrastructure of the Chain Lakes Emergency Supply Watershed* below lists the problem and priority rankings of the inherent and critical infrastructure risk factor activities within the watershed. Priority risk factor management issues identified are predominantly within recreation and transportation corridors.

Table 16: Scale of Problem* and Priority Rank of All Activities and Threats to Critical Infrastructure of the Chain Lakes Emergency Supply Watershed**

Activity	Contamination Issue	Scale of Problem*	Priority Rank**
Commercial			
Forestry Operations	Petroleum hydrocarbons/fluids	5	1
	Soil erosion and sedimentation	5	2
	Acid (pyritic) slate ARD (Low pH)	5	3
	Nutrient loadings	5	4
Mining and Rock Quarry Operations	Metals	5	1
	Soil erosion and sedimentation	5	1
	Acid (pyritic) slate(Low pH)	5	1
Residential			
Home Heating Fuel Tanks	Fuel oil leakage	4	3
Automobile Fluids	Automobile fluid leakage	5	4
Household Chemicals	Spills and improper or excessive use of fertilizers, pesticides, soaps	4	4
Impervious Surfaces	Increased stormwater flow and volume	4	4
Recreation			
Pedestrian and pet traffic including geocaching	Pet droppings	4	3
	Garbage	4	3
	Soil erosion and sedimentation	4	3
Swimming	Bacteria	3	2
Camping (fires)	Increasing heterotrophic plate counts	4	3
OHVs	Petroleum hydrocarbons	5	1
Mountain Biking	Soil erosion and sedimentation	4	2
Transportation Corridors			
Public roads and highways	Hazardous chemicals (fuels, transported/dangerous goods)	2	1
De-icing salt and storage	Chloride and conductivity	1	1
Road construction	Soil erosion and sedimentation	3	1
	Bedrock- Acid (pyritic) slate ARD	2	1
Controlled access for utility use	Petroleum hydrocarbons	4	1
	Water treatment chemicals	5	3

Table 16: Scale of Problem* and Priority Rank** of All Activities and Threats to Critical Infrastructure of the Chain Lakes Emergency Supply Watershed			
Activity	**Contamination Issue**	**Scale of Problem***	**Priority Rank****
Utilities			
Water supply pumping station	Chemicals delivered to pumping station	5	3
Wastewater treatment infrastructure	Leaking / Broken pipes	3	1
Power transformers	PCBs	4	1
	Naphtha-based mineral oil	4	4
Distribution corridors	Soil erosion and sedimentation	5	4
	Accidental fire	5	1
	PCP or CCA wood preservative on poles	5	4
Municipal Land Use Planning and Development			
Policy and regulation set out in Regional Municipal Planning Strategy Halifax Regional and City By-laws Halifax Community MPS and LUB	Petroleum hydrocarbons	4	1
	Soil erosion and sedimentation	4	2
	Household chemicals/fertilizers and pesticides	5	4
	Bedrock – acid (pyritic) slate ARD	1	1
	Stormwater runoff	3	3
	Sewage	3	1
Chemicals			
Pest control chemicals and biocides	Chemicals that impair water quality and/or are toxic to living organism	5	1
Road de-icing salt	Chloride and conductivity	1	1
Water Supply Plant	Chlorine used to treat the water before distribution	5	3
Transmission/utility distribution line	PCP or CCA	5	4
Power transformers	PCBs	4	1
	Transformer coolant (naphtha-based mineral oil)	4	4
Wildland fire retardant	Silv-Ex and/or FIRE-TROL Fire Foam 104	5	3
Illegal Dumping			
Illegal dumping	Heavy metals	3	1
	Petroleum hydrocarbons	4	1
Accidental Emergencies			
Fire	Soil erosion and sedimentation	3	1
	Petroleum hydrocarbons	3	1
	Hazardous chemicals	3	1
	Nutrient loading	3	1
Aircraft disaster	Petroleum hydrocarbons	3	1
	Hazardous chemicals	3	1

Table 16: Scale of Problem* and Priority Rank** of All Activities and Threats to Critical Infrastructure of the Chain Lakes Emergency Supply Watershed			
Activity	**Contamination Issue**	**Scale of Problem***	**Priority Rank****
	Nutrient loading	3	1
	Soil erosion and sedimentation	3	1
Accidents and Spills	Petroleum hydrocarbons	3	1
	Soil erosion and sedimentation	5	2
	Fungicides, insecticides, herbicides	3	1
	Dangerous Goods	3	1
Natural Events and Disasters			
Wind and flood	Microbial cross contamination	4	1
	Soil erosion and sedimentation	3	2
Wildland Fire	Petroleum hydrocarbons	3	1
	Hazardous chemicals	3	1
	Nutrient loading	3	1
	Soil erosion and sedimentation	3	1
Drought	Ideal conditions for microbial and pathogen growth	3	1
	Soil erosion and sedimentation	3	1
	Nutrient loading	3	1
	Increased metal concentrations	3	1
	Increased demand on water supply (secondary objective – water quantity)	3	1
Natural biological	Water and airborne biological outbreak	3	1
	Water quality degradation and ecosystem disruption	3	1
Climate Change	Water quality degradation and ecosystem disruption	4	1
Intentional / Deliberate Events			
Malicious intent	Water quality contamination through biological and/or chemical attack	3	1
	Infrastructure disruption through Cyber and/or physical attack	3	1
Non-malicious intent	Landownership with respect to regulations and/or by-laws with the potential to negatively impact the watershed area.	3	1

*Scale of Problem rank: 1=severe, 3=moderate, 5=minimal
**Priority rank: 1=high, 3=moderate, 5=low

4 MANAGEMENT PLAN

This section describes the management aspect of the Source Water Protection Plan (SWPP) which addresses the risks and issues identified in *Chapter 3: Risk Identification and Assessment* of this document. The primary goal of this management plan is source water protection, implemented through a multi-barrier approach to ensure the source water is clean and safe for consumption and mechanisms are in place to prove it is safe, as directed by the Nova Scotia Department of Environment's Drinking Water Strategy for Nova Scotia. Descriptions of the components of the implementation strategy and the contingency measures in place follow.

4.1 Background

Stakeholder collaboration and cooperation provide the means to evaluate the risks to water quality and help contribute to the development of methods that overcome the obstacles to ensuring clean, safe potable water is provided for Halifax Water clients.

Consistent and sustained communication between those who have a responsibility to ensure clean, safe water is paramount. Meetings between Halifax Water, NSE, and HRM staff help to achieve this goal.

Progress of the Chain Lakes SWPP is reported annually to NSE as part of the 90-day utility report. The report is used to measure the SWPP successes and make adjustments where necessary. A major review is conducted when a significant change is required or a 7-year review is scheduled, whichever comes first.

4.2 Implementation Strategy

To ensure a safe water supply is being delivered to its customers, Halifax Water uses the multi-barrier approach that involves a system of checks and balances. Source water protection is the first in a series of source water quality management steps used in the multiple-barrier approach. Delineating the Chain Lakes watershed area boundary lays the foundation for source water protection planning. Halifax Water has developed programs around set objectives for implementing the SWPP including

- Land acquisition programs;
- Best Management Practices;
- Public communication, education and awareness programs;
- Fostering water supply area protection through stakeholder collaboration and cooperation;
- Regulation and land-use by-law adherence;
- Public Roads and Highway maintenance collaboration;
- Controlled access and boundary maintenance;
- Enforcement;
- Emergency measures; and

- Source Water Quality Monitoring and Evaluation.

Source water protection implementation timelines have been developed by Halifax Water and are included with this SWPP as an addendum with the submitted SWPP. Halifax Water will inform NSE if changes to those timelines are required.

4.2.1 Land Acquisition Program

Landownership of key watershed lands provides the foundation for effective source water protection planning for the Chain Lakes watershed area (see section *2.1: History of the Chain Lakes Water Supply* on page 9). Through successful purchasing of watershed lands, especially those around First and Second Chain Lakes, Halifax Water has reduced the risk of land use activities within the Chain Lakes watershed area.

The SWPP planning process has identified NSTIR and HRM as owners of three (3) large standard parcels within the watershed area. Development of these parcels could pose threats to the watershed area:

- a 5.64 ha parcel owned by HRM amounting to 2.7% of the watershed area is zoned I-3 and is situated adjacent to the Bayer's Lake Business Park; and
- two parcels zoned PWS, amounting to 8.5 ha (4.08%) of the watershed area and consisting of:
    - a parcel owned by HRM amounting to 4.18 ha (2%) of the watershed area located between North West Arm Drive and Milsom Street; and
    - a parcel owned by NSTIR amounting to 4.32 ha (2.07%) of the watershed area located on the west side of North West Arm Drive.

All of these parcels are located in by-law zones that may permit high risk land-use activities. Although two of these parcels are located in the PWS Zone, they are located in areas that could be attractive for a park-and-ride, which is permitted regardless of the zoning, as per by-law 14X.

- Halifax Water's strategy is to continue to purchase watershed lands, within reason, as they become available to provide the highest water quality protection possible. The HRM and NSTIR parcels described above are priority candidates for land acquisition within the Chain Lakes watershed area.

4.2.2 Best Management Practices

Halifax Water manages lands within the Chain Lakes watershed area with respect to provincial regulations and BMPs using water quality as the point of reference. In 2001, Halifax Water developed and implemented separate watershed BMPs to aid in forest management in the Pockwock and Lake Major Protected Watershed Areas, which proved to positively influence the way forestry activities were conducted on watershed lands. In 2009, Halifax Water identified the need to expand and improve the existing BMPs by developing a single working document to reach beyond forest management and watershed boundaries. In 2010, Halifax Water developed BMPs to include aggregate removal, recreation, heavy equipment, and various other activities that may impact water quality in all source water areas managed by Halifax Water.

The latest version of Halifax Water's BMPs was approved and immediately implemented with support from Elmsdale Lumber Company, NSDNR, NSE, the Lake Major Watershed Advisory Board, the Bennery Lake Watershed Management Committee, and the Pockwock Watershed Management Committee. They are also available on Halifax Water's website www.halifax.ca/hrwc/documents/2010ApprovedBMPs.pdf.

Halifax Water's BMPs are not intended to replace existing legislation; they are to enhance watershed protection practices on watershed lands. Staff and contractors practicing on lands owned or managed by Halifax Water are required to be aware of and to follow the BMPs, the legislation and the Standard Operating Procedures (SOPs) before work can begin.

On watershed lands not owned or managed by Halifax Water, the BMPs are meant to be used as an educational tool and guiding document when activities that may pose a risk for watershed contamination are conducted. Halifax Water will continue to monitor and educate landowners about applicable government regulations and BMPs.

Halifax Water will make available and promote its BMPs via public communication and awareness efforts as outlined in the next section.

4.2.3 Public Communication, Education and Awareness

Public communication, education and awareness are key components in Halifax Water's source water protection strategy. Halifax Water's education, communication and awareness program includes

- posting information and regulatory signage;
- conducting and/or supporting educational programming;
- developing source water protection publications (e.g., newsletters, public notifications and reports);
- publishing notifications and information on Halifax Water's website; and
- placing advertisements in periodicals.

The objectives of communicating information about the watershed area are to

- inform and educate users of the location of the watershed area;
- outline the potential impacts of detrimental activities on the water supply;
- report on activities that could negatively impact the watershed area; and.
- promote what measures are required to avoid such occurrences.

Public communication, education and awareness outreach will be continuously developed to encourage cooperation between Halifax Water, customers and stakeholders to ensure that the drinking water quality is safe.

Signs

Signs defining restricted activities and contact information are posted along the defined watershed area boundary, along frequently used trails and at main watershed entry points. Signs are upgraded on an as-needed basis.

Educational Programming

Halifax Water is supportive of the development of watershed protection education programming by non-government organizations such as the Discovery Centre. These agencies deliver water education programs to elementary, junior and senior high school students in accordance with the curriculum. Other educational program development activities involve supporting community groups and associations in their effort to conduct community clean-ups, open houses, surveys, and to develop publications that promote protection of surface and groundwater supplies in the community. Spin-off benefits from supporting such programs come through the leveraging of watershed education and awareness to other groups and agencies that are exposed to the programs that Halifax Water supports and to the general public.

Discovery Centre

The Discovery Centre has solicited Halifax Water for program development support of the Water Gallery exhibit in their new science centre project. The new Water Gallery exhibit will explore the properties of water, demonstrate the importance of sustainable consumption and returning water to nature as it was taken, encourage conservation through instilling a sense of pride in Nova Scotia's water resources and will relate to other areas of the Centre, i.e.; Energy. The new Centre is anticipated to open in early 2017.

Publications

Publishing newsletters and advertising in local newspapers, outdoor magazines and the provincial fishing manual are other tools that Halifax Water uses to promote awareness of the water supply area and to communicate protection techniques to the broader community.

Website

Halifax Water maintains and regularly updates its website www.halifaxwater.ca to provide public notifications and important information on source water protection including contact information for inquiries and to report activities that could negatively impact the watershed area.

4.2.4 Management Committee

Since 2009, the Chain of Lakes Trail Association (COLTA) has been providing advice as a quasi-Chain Lakes watershed management committee with respect to trail-related watershed impacts (see section *2.3.3: Chain of Lakes Trail* on page 22). Halifax Water has representation on the COLTA which holds monthly meetings from September to June each year.

- Initial discussions between Halifax Water and the COLTA have determined that both parties have an interest in protecting the health of the watershed. Further cooperation is required to establish these interests through a ToR. Halifax Water is currently exploring collaborative options.

4.2.5 Regulations and Land-use By Laws

Within the Chain Lakes watershed area, land use activities are subject to provincial, federal, and municipal regulations as outlined in section *2.5: Governance* beginning on page 25.

Halifax Water continually explores opportunities to strengthen or create provincial legislation and local by-laws to enhance the protection of Halifax's (HRM's) drinking water supply areas.

Planning and Development Processes

Through the Regional Municipal Planning Strategy review process (RP+5), Halifax Water presented the following recommendations that were subsequently endorsed in the 2014 Regional Plan:

- conforming with any Statement of Provincial Interest (SPI) Regarding Drinking Water, which is endorsed under Policy E-14 of the 2014 Regional Plan;
- mapping delineated water supply areas, which are illustrated on Map 12 of the 2014 Regional Plan;
- establish a minimum 30.5 m riparian buffer around water supply sources, consistent with provincial water supply protection policy, which is endorsed under Policy E-13 of the 2014 Regional Plan;
- by-laws that consider non-designated municipal water supply areas and wellheads, which is provided for under Policy E-14 of the 2014 Regional Plan, such that these areas are afforded Council's consideration through amendments to land use by-laws;
- opportunity for Halifax Water to review all applications within their regulatory regime, which is provided for under Policy E-14 such that there is a consistent regulatory approach within each watershed;
- afford respective watershed advisory boards opportunity to exercise their function to make recommendations regarding land use activities within their respective watershed areas, which was provided for through policy E-14; i.e., Council shall consider amendments to land use by-laws to protect the water supply, ensure consistent regulatory approaches and conform to any SPI regarding drinking water; and
- wetland protection which has been afforded through Policy E-15 which allows amendments to land use by-laws to conform to any provincial guidelines (e.g., Wetlands of Special Significance such as those in designated protected water areas, or SPIs).

Halifax Water endeavors to further ensure, especially through land use by-law review processes that

- developers are aware of the regulations associated with drinking water supply areas;
- Halifax Water and applicable water supply advisory groups are recognized as authorities to review and provide comment on land use planning and development applications;
- all building permits include an attached copy of the applicable provincial regulations respecting drinking water supply areas;
- all building permits are copied to Halifax Water and reviewed by the applicable water supply advisory group as per municipal policy and by-laws; and
- collaborative opportunities to review applicable SOPs, by-laws and possible developments related to relevant source water areas and maintain emergency contact lists are facilitated between Halifax Water and HRM community development staff.

4.2.6 Public Roads and Highways

Approximately 14.67 km of transportation corridors in the Chain Lakes watershed area are owned and maintained by either HRM, NSTIR or Halifax Water (see *Map G: Landownership and By-Law Zones* on page 38). These corridors support approximately 9.7 km of high traffic volume roadways and ramps. The remaining 3.8 km consists of 1.7 km of the Chain of Lakes Trail and unpaved/paved service roads and streets to homes.

As described in section *3.1.3: Transportation Corridors* beginning on page 47, the road network in the Chain Lakes watershed area presents a high level of risk to the water supply from accidental traffic spills and/or road maintenance activities. Due to its proximity to Second Chain Lake, St. Margaret's Bay Road presents the highest risk of contamination from accidental or maliciously intentional contamination from vehicle and/or chemical entry into the water supply.

- To address the risk of vehicle entry into Second Chain Lake from St. Margaret's Bay Road, in 2015 a 225 m section of guard rail was constructed along that portion of the St. Margaret's Bay Road. The risk has been substantially reduced – from high to moderate – since the guard rail was installed by HRM, in recognition of the risk to the emergency backup water supply, as requested by Halifax Water.

Halifax Water has established a five-part Source Water Quality Monitoring Program to monitor effects on water quality (see section *5.4: Source Water Quality Monitoring Program* on page 105). To help manage the risks presented by road use, Halifax Water collaborates with HRM and NSTIR staff by providing updated contact lists and water quality data regarding the effects on the water supply and by maintaining open lines of communication.

Further, in the event of a roadway emergency with potential to impact the Chain Lakes water supply and/or water pumping station, *Halifax Water's Emergency Response Plan* (ERP) is followed. A copy of the ERP is located at Halifax Water main office, 450 Cowie Hill Road in Halifax.

Road De-icing

Halifax Water conducts monthly total chloride sampling from November to April of each year at locations associated with winter road maintenance activities; i.e., CLG1 and CLG2 (see section *5.4.3: Total Chloride* on page 126).

To develop a better understanding of NSTIR and HRM road salting practices and Halifax Water's source water protection needs, a collaborative meeting was held June 19, 2013. At that meeting, Halifax Water shared with NSTIR and HRM Transportation and Public Works staff its Chain Lakes water quality data, which indicated chloride levels above the recommended long and short term toxicity levels outlined in the CCME Water Quality Guidelines for the Protection of Aquatic Life (WQGPAH). As a result, it was determined that road de-icing agent housekeeping practices (e.g., management of area around salt sheds), optimal salt/sand/brine mixtures, and limitation of route overlap recommendations would be presented to respective departments so solutions to mitigate excessive road salt applications may be applied to Halifax Water drinking water supply areas (see section *3.1.6: Road De-icing Application Practices and Strategies* on page 61), and reported back to Halifax Water.

The Material Safety Data Sheet (MSDS) for sodium ferrocyanide, a required road salt anti-caking agent (see section *2.5.1: Provincial Policy and Regulations* on page 59) states that the potential health effects on humans for handling the product are relatively minor. However, there is concern about the use of ferrocyanide salts in formulations of road salts given that in solution, ferrocyanide can photolyse to yield free cyanide ions, which are highly toxic to aquatic organisms. Not enough is known about ferrocyanide and its impact to the Chain Lakes water supply.

- Halifax Water is working toward gaining a better understanding of ferrocyanide impacts, concentrations and risks it presents to the water supply. If ferrocyanide is found to pose a threat to the water supply, Halifax Water will contact NSTIR and HRM to discuss ways to mitigate or eliminate any threats.

Water Crossings

Within the Chain Lakes watershed area, roadways with water crossings fall under maintenance programs as per ownership. Halifax Water monitors these structures on an informal basis. Where these roads are found to impact the water supply, the applicable owner is contacted by Halifax Water on an as-needed basis.

4.2.7 Controlled Access and Boundary Maintenance

Halifax Water has established methods to control access to the watershed area which includes physical barriers and signage, a land access strategy, stewardship protection, and boundary maintenance. Halifax Water will continue to monitor these areas through company staff and/or private security companies when required, especially during peak seasons (e.g., summer) when human traffic is high.

Physical Barriers and Signage

Halifax Water maintains fences, gates, barriers and signs to limit access to its watershed lands and facilities. Gates are maintained at main entry points to restrict vehicle access to authorized personnel. Halifax Water will continue to monitor these areas and enhance security measures when required. Low impact pedestrian access is permitted as long as it does not interfere with Halifax Water operations and/or endanger staff and infrastructure.

Land Access Strategy

Except for the transportation corridors (including COLT), Halifax Water controls much of the land access in the watershed. For all public and private lands within the watershed, Halifax Water encourages open communication with adjacent landowners and others interested in accessing the land for various purposes.

- Halifax Water has developed access strategies for specific groups (e.g., recreational) who wish to access watershed lands. The Geocaching Policy described in Section *4.3.3: Recreation – Geocaching* on page 92 is a good example of a recreation access strategy. These strategies augment the existing regulatory tools and establish terms for accessing watershed lands that help to protect the quality of the drinking water supply.

Stewardship Protection

Halifax Water encourages Chain Lakes watershed area users to report unauthorized activities as per regulatory signage posted throughout the watershed. Part of the purpose for Halifax Water's involvement in the development of the Chain of Lakes Trail was the presumption that public trail use within the watershed area would assist in implementing enforcement of the rules and Halifax Water's BMPs.

Boundary Maintenance

The Chain Lakes watershed area is delineated by man-made boundaries, (e.g. Transportation corridors and property boundaries) and natural contours. In addition to regularly updating the boundary lines, Halifax Water posts signs along the boundaries, as needed, to notify watershed users of the watershed boundary lines.

4.2.8 Enforcement

Changes to the *Environment Act Regulations* in October 2012 granted municipal water utilities the authority to issue blanket Summary Offense Tickets (SOTs) to offenders in provincially designated Protected Water Areas (see section 106 subsection 3 pursuant to subsection 6 of the *Environment Act*). Although this new authority does not apply to the Chain Lakes watershed area because it is not designated as a Protected Water Area, it does provide Halifax Water with the special constable training and the tools to effectively manage the Chain Lakes watershed area in the same manner Protected Water Areas are.

Halifax Water makes every effort to

- enforce applicable regulations pertaining to the Chain Lakes watershed area as per the *Halifax Regional Water Commission Act* (see section *2.5.1: Halifax Regional Water Commission Act* on page 26);
- collaborate with local enforcement authorities including Halifax Police, RCMP and municipal by-law officers to enforce Acts, regulations, and by-laws applicable to the watershed, and collaborate with COLTA to ensure trail activities do not put the water supply at risk.

Halifax Water will continue to educate watershed users through signage, during patrols and public awareness initiatives. If prohibited activities that pose a risk to water quality increase within the watershed area, Halifax Water may seek assistance through increased patrols, and request changes in regulations and an increase in penalties.

4.2.9 Water Supply Pumping Station and Spillway

The Chain Lakes' pumping station and spillway are considered significant aspects of Halifax Water's critical infrastructure (see section *2.3.3: Water Supply Infrastructure* on page 23). The pumping station and Chain Lakes spillway are located inside the watershed area, fully surrounded by a chain link fence and accessible only by authorized personnel. The Bayer's Lake Diversion Dam is publicly accessible; however, controls to the double gating system are protected by a locked small gate house located on top of the dam.

Pad Mount Transformer

The Chain Lake water supply plant pump station has a pad mount transformer which contains VOLTESSO 35 transformer coolant oil (see the risks it presents to the water supply in section *3.1.4:*Transformers *on page 51)*. In addition to NSPI's yearly inspection of the pumping station power transformers, Halifax Water staff routinely conducts visual inspections of the transformer and immediately reports any leaks to NSPI.

Generators

Halifax Water uses a portable generator to provide power to the pumping station during electrical power outages. Fuel and lubricants required to run the generator are delivered daily or as needed. Standard Operating Procedures (SOPs) are implemented while the generator is in operation.

4.2.10 Wastewater Treatment Plant

Although the wastewater treatment plant and lift stations are located outside of the watershed area (see *Map I: Power Utility Infrastructure* on page 40 and *Map J: Halifax Water Infrastructure (Sewer and Water)* on page 41), the Chain Lakes watershed area is at risk of impacts from the wastewater infrastructure that passes through the watershed area. To manage and mitigate the risks associated with this infrastructure, a new main line was constructed in 2014 (see *3.1.4: Wastewater Treatment Infrastructure* on page 49) such that a smaller pump station is now required to service a few buildings within the low-lying area of the business park. The sewage is pumped to a connection point outside of the watershed where it joins the gravity flow pipe and flows through the watershed to the Halifax Harbour Solutions WWTF. Monitoring of the diversion tributary for risk of sewage overflow and business park sources of contaminants will continue.

- To manage the risk of sewage contamination, the water from the Bayer's Lake sub-watershed area (CLG3) and three other sites (CLG1,CLG4,CLG5) are monitored monthly at sampling locations illustrated on *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19 and described in section *5.4.2: Bayer's Lake Wastewater System* on page 124.

4.2.11 Stormwater Runoff

As described in section *Stormwater Management* on page 25 the main source of contaminated runoff is associated with winter maintenance chloride residuals. Halifax Water is working with NSTIR and HRM to reduce the use of road de-icing agents in the watershed (see section *4.2.6: Road De-icing* on page 84). Other sources of stormwater contaminants have been mitigated through systems that divert stormwater runoff away from the watershed area (e.g. Milsom Street runoff in the Fairmont area).

The Bayer's Lake Diversion Dam is considered as much a part of the stormwater system as it is part of the water supply system. The dam accomplishes a dual role where contaminated stormwater runoff may be directed from the Bayer's Lake Business Park, away from the Chain Lake watershed area and into Long Lake (the default position) or directed into Second Chain Lake to increase water quantity in the event of an extraordinary emergency (e.g., in a drought situation as described in section *4.4.1: Drought* on page 99). A sampling station (CLG3) is located immediately upstream of the Bayer's Lake diversion dam to monitor water quality from

Bayer's Lake Business Park (see location of sample site illustrated on *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19 and sampling description in section *5.4.2: Bayer's Lake Wastewater System* on page 124).

The key method of ensuring effective protection management of potential risks due to stormwater runoff is consistent communication between the agencies responsible for the land use activities taking place in the watershed area.

4.2.12 Chemical, Biocide and Pest Control Use

Generally, the use of chemicals is not permitted on lands owned or managed by Halifax Water. An exception to this standard is the use of chemicals in the water treatment process, which is strictly monitored and controlled, and/or in the event of an extreme natural biological outbreak or fire for which such impacts would outweigh the use of chemicals, pending review and approval (e.g. FIRE-TROL fire suppressant). The use of chemicals inside the Chain Lakes watershed area is subject to the *Halifax Regional Water Commission Act* (see section *2.5.1: Halifax Regional Water Commission Act* on page 26).

- Halifax Water will continue working with applicable agencies including NSPI, NSTIR, NSE, NSDNR and HRM to reduce or eliminate the use of all chemical control products inside the watershed area.
- Halifax Water has developed and implemented a source water quality monitoring program which regularly assesses for chemical impacts, as described in the subsections below and in section *3.1.6: Chemicals* on page 58, at several locations within the watershed (see *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19), using the methodology described in section *5.4: Source Water Quality Monitoring Program* on page 105.

Road De-icing Agents

Section *4.2.6: Road De-icing* on page 84 describes the management of road de-icing agents.

Treatment Plant Use

When the Chain Lakes emergency water supply plant (WSP) is activated for use (see section *3.1.4: Water Supply Infrastructure* on page 49), the only chemical used in the water treatment process is chlorine which is delivered via boom truck.

Wildland Fire

In the event of wildland fire in the watershed, water as a fire suppressant is first priority; however, if the benefits to using chemical fire suppressants (see section *3.1.6: Wildland Fire Fighting* on page 63) outweigh the risks to water quality, then chemical fire suppressants may be used.

- Halifax Water has communicated by letter to NSDNR that their agency will be responsible for conducting a follow-up water quality assessment if a chemical suppressant is required inside the watershed. In the event of a fire emergency, the ERP will be followed, and target-based water quality sampling will be conducted accordingly (see section *5.4.4: Targeted-Based Sampling* on page 127). Emergency Plan copies are found at the main office located at 450 Cowie Hill Road in Halifax.

4.2.13 Source Water Quality Monitoring

As described in Chapter *1: Introduction* of this SWPP on page 8, the primary objective of the plan is to comply with NSE requirements and to provide the highest water quality possible to our customers. Halifax Water formalized its Source Water Quality Monitoring Program in 2009 to better understand existing baseline conditions in the Chain Lakes watershed area and to meet the primary objective (see section *5.4.1: Baseline Sampling* on page 105). In 2011, Halifax Water reached its two-year goal of setting water quality trend baselines for all source water sample sites, i.e., CLG1 through CLG5 (see *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19). The decision to change the monitoring program sampling protocol in the fall of 2011 from a baseline to a risk-based monitoring program (see section *5.4.2: Risk-Based Sampling* on page 124) was supported by the consistent data gathered during the two year baseline collection program. Unlike many of the other watershed monitoring programs, all the sample points that were used to collect the baseline data remain active due to the level of risk from anthropogenic activities that influence this watershed area. For more details on the Source Water Quality Monitoring Program please refer to *Chapter 5: Monitoring and Evaluation* beginning on page 104.

4.3 **Contingency (Mitigation, Preparedness and Response)**

The following describes the contingency plans that Halifax Water has in place to mitigate, prepare and respond to events associated with the inherent land-use activities described in section 4.2, which may put the water supply at risk.

4.3.1 Commercial Activity

Although there is no commercial activity in the Chain Lakes watershed area, there is the potential for such activities, including forestry, and mines and pits and quarries. The risks these activities present are described in section *3.1.1: Commercial Activities* on page 43 of this document. Further, the large land parcels owned by HRM and NSTIR, as illustrated on *Map G: Landownership and By-Law Zones* on page 38, have the highest potential for commercial development. However, in the event such activity takes place within the watershed area, accidental contamination must be reported immediately to appropriate agencies (i.e., Halifax Water, HRM, NSE, RCMP, and/or the local fire department).

In addition to reporting requirements, Halifax Water has developed policies and procedures, including BMPs which are to be followed on lands owned and managed by Halifax Water. For all other watershed lands, these BMPs are voluntary and intended for educational purposes.

Halifax Water is prepared for spill containment and cleanup through the guidance of contingency plans for such incidents as per the ERP, copies of which are found at 450 Cowie Hill Road in Halifax, and using Halifax Water's BMPs. Additionally, Halifax Water will continue to evaluate any threat to the raw water supply through the Source Water Quality Monitoring Program as described in *5.4: Source Water Quality Monitoring Program* beginning on page 105.

Forest Management

In the event forest interventions are required for the health and sustainability of the watershed area and/or to improve or maintain source water quality, Halifax Water will assess the risks to the water supply and respond accordingly. As described above, all applicable by-laws, provincial regulations and Halifax Water policy, procedures and BMPs will be followed.

Mining and Pits and Quarries

Mining and pits and quarries are not an issue inside the Chain Lakes watershed area because there are no mineral rights designation or mineral deposits listed and no known mine tailings from past mining practices. The Chain Lakes watershed area is listed as a municipal water supply area on the Nova Scotia registry of Claims map; therefore, any mining or quarrying interest should contact Halifax Water to indicate their interest in exploring the area so Halifax Water may respond accordingly.

4.3.2 Residential

New residential development occurring inside the Chain Lakes watershed area is unlikely since there are essentially no new lots available for new development. However, in the event land is subdivided for residential development, which is possible on some land parcels, especially those currently owned by HRM (see *Map G: Landownership and By-Law Zones* on page 38), the new mapping and potable water policy in the 2014 Regional Plan and the applicable Plan Area By-laws (see section *2.5.2: Municipal Land-Use Planning Policies and By-laws* beginning on page 27) will guide consultations between Halifax Water and HRM toward mitigation measures that protect the Chain Lakes watershed area.

Activities on existing residential properties need special consideration in terms of contingencies as described in the following subsections.

Garbage and illegal dumping

In addition to provisions made under Section 25 of the *Halifax Regional Water Commission Act* that are enforceable by Halifax Water (see *2.5.1: Halifax Regional Water Commission Act* on page 26), the HRM *Dangerous and Unsightly Premises Administrative Order* (Number AO30) provides authority to Halifax By-law Services to deal with property-related public safety and quality of life issues including enforcing exterior property legislation on private property such as dangerous or unsightly premises. Further, in 2011, the provincial government enacted the *Dangerous and Unsightly Premises Amendment (2011) Act*[22] to strengthen municipal restrictions on dangerous and unsightly premises. Halifax Water will explore avenues to enforce garbage and any illegal dumping issues using these and other enforcement tools where necessary.

[22] Government of Nova Scotia: An Act to Strengthen Municipal Restrictions on Dangerous and Unsightly Premises. Created May 17, 2011: Website source: http://nslegislature.ca/legc/bills/61st_3rd/3rd_read/b041.htm .

On-Site Septic Systems

On-site septic systems are not an issue in the Chain Lakes watershed area because residences are connected to the municipal wastewater system.

Furnace Oil Spill

In addition to the provisions made under Section 25 of the *Halifax Regional Water Commission Act* that are enforceable by Halifax Water (see *2.5.1: Halifax Regional Water Commission Act* on page 26), NSE is responsible for enforcing the *Environmental Emergency Regulations* N.S. Reg. 16/2013 which states:

> *3 (1) These regulations apply to a release of a substance or impending release of a substance into the environment, including all of the following:*
>
> > *(a) an environmental emergency;*
> >
> > *(b) a reportable release;*
> >
> > *(c) an unauthorized release;*
> >
> > *(d) a release of a substance or impending release of a substance into the environment on lands owned or claimed by Her Majesty in the right of Canada.*

If the owner(s) does not comply, NSE or the Minister responsible could impose penalties or perform the clean-up for which the owner must reimburse the Minister or NSE. Residents with concerns or regarding an oil spill emergency should contact their respective municipal office/first responders at 911 or Halifax Water (902-490-4820) to report an incident triggering Halifax Water to activate its Emergency Response Plan.

In the event of an emergency, the ERP outlines steps to be followed. Copies of the ERP manual can be found at the Halifax Water's main office located at 450 Cowie Hill Road in Halifax.

Accidental Fire within Residential Areas

Residents are encouraged to review the Nova Scotia Department of Natural Resources: "*How to protect your home and property from Wildfire"*[23]. Further, the province and HRM have developed by-laws and regulations concerning open fire burning (see section *3.1.1: Backyard Fires* on page 44). Residents can contact first responders at 911 or Halifax Water (902-490-4820) to report a fire and may trigger Halifax Water to activate its Emergency Response Plan.

4.3.3 Recreation

Low-impact recreation such as hiking, biking, walking, and cross-country skiing are permissible within the Chain Lakes watershed area. Halifax Water closely monitors these activities and educates users about which activities may present risks to the water supply. Although the most prevalent recreational activity is trail use, persistent swimming in the lake presents a higher risk.

[23] Nova Scotia Department of Natural Resources: "*How to Protect your Home and Property from Wildfire*". Website source: http://www.gov.ns.ca/natr/forestprotection/wildfire/firecentre/pdf/Wildfirebrochure2.pdf.

To deter unwanted activities inside the watershed area, chain-link fencing was installed around the pumping station in 2004. In June 2011, 220 m of chain-link fence was added from the existing pumping station fence along the dam to the spillway under the North West Arm Drive overpass to address public safety concerns around the dam and to deter persistent swimmers. In 2015 the chain-link fence was again extended from the spillway, 1.5 km along the COLT, to further deter persistent swimmers from accessing the lake further up the trail. Gates are used along main access points to mark Halifax Water's property and to control vehicle access. Halifax Water posts signage throughout the watershed to notify users of restricted activities.

Further, Halifax Water closely monitors recreational activities through its own regular patrols and contracts private security personnel during high-traffic periods.

HRM has approached Halifax Water with a proposal to develop new trails that would transect the watershed area further. Considering such a proposal would expose new areas of the watershed to the general public and could compromise source water protection efforts, a land access strategy would be required to address the concerns presented by a new trail.

Chain of Lakes Trail

Halifax Water collaborates with COLTA (see section *4.2.4: Management Committee* on page 82) to educate trail users along the watershed section of the COLT. Education and awareness information located on watershed signage, Halifax Water's website, and publications in local newspapers have helped reduce unauthorized activities within the watershed.

Signage is posted along the COLT alerting users that they are within an emergency water supply area and that certain activities are prohibited including, swimming, garbage dumping, camping, tree cutting, Off Highway Vehicle (OHV) use and camping.

As described in the previous section, security fencing has been installed along the trail to deter trial users from moving off the existing trail and accessing the watershed area.

Geocaching

Halifax Water developed Guidelines for Geocaching (see *Appendix 4: Halifax Water Guidelines for Geocaching* on page 134) in cooperation with the Association of Nova Scotia Geocaching (formally the Atlantic Canada Geocaching Association). These guidelines facilitate safe and low-impact use of Halifax Water watershed lands by geocachers, while ensuring the protection of Halifax Water's managed resources.

Mountain Biking

Mountain biking within the Chain Lakes watershed area is not a significant problem, however, to discourage mountain biking from becoming established (although mountain bikes are permitted on the COLT), Halifax Water has posted signs and removed the few existing mountain biking structures found on watershed lands.

Off-Highway Vehicles

Off-highway vehicle (OHV) use inside the Chain Lakes watershed area is negligible. If the extent of OHV use increases, Halifax Water will put into effect section 12F of the *Off-highway Vehicles Act* R.S., c. 323, s. 1:

12F

> *(1) At the request of the water works operator for a drinking-water supply area, the Minister of Environment and Labour may, for the protection of water quality in the supply area, make an order, consistent with any applicable source-water protection plan, controlling, prohibiting or regulating off-highway vehicle use in the supply area.*
>
> *(2) No person shall operate an off-highway vehicle in a drinking-water supply area contrary to an order made pursuant to subsection (1). 2005, c. 56, s. 7.*

4.3.4 Transportation

The major highways that are prevalent throughout the Chain Lakes watershed area present a high risk to the source water supply because there are no immediate mitigation measures to limit contamination from entering the watercourse through vehicular accidents or stormwater runoff. Halifax Water's water quality monitoring program measures road effects on watercourses as described in section *5.4.2: Risk-Based Sampling* on page 124.

Road Construction

There are no watershed area-related regulations restricting the timeframe of road construction activity and the amount of exposed roadway sub-base or right-of-way clearing for the Chain Lakes watershed area as there is for the designated PWAs (i.e., Pockwock and Bennery Lakes, and Lake Major). However, there is Federal, provincial and municipal regulations regarding road construction as described in the following paragraphs. Regardless of the existing regulations regarding road construction, any impact due to such construction is considered high risk and Halifax Water should be informed of potential road construction activity to provide opportunity to advise the contractor accordingly.

NSTIR requires that its construction contractors' supervisory staff attend an erosion and sediment control (ESC) course to ensure the protection of the construction site and adjacent properties and water bodies. Further, the province has a Standards Specification: Highway Construction and Maintenance Manual, updated annually in February and a Management Guide for Construction and Demolition Debris including road construction debris, which was developed by the Regional Waste Reduction Coordinators of Nova Scotia. These documents provide other resources for mitigating the impacts of road construction.

Transportation Routes

In the event of an emergency as a result of a spill or accident that may affect the water supply, Halifax Water's ERP will be followed. A copy of the ERP is at 450 Cowie Hill Road, Halifax.

Controlled Access and Boundary Maintenance

The Chain Lakes pumping station facility located on North West Arm Drive is contained within a locked and fenced facility accessible only by approved Halifax Water personnel. The pumping station is fully surrounded by security fencing to prevent vandalism and swimmers near the intake. To reinforce the physical boundaries, Halifax Water employees patrol the area to assess activities; private security personnel are contracted to perform patrols during peak activity; and police enforcement is used when required. Halifax Water also maintains gates to restrict vehicle access to the watershed.

Halifax Water will continue to monitor these areas and will enhance security measures as needed. Halifax Water encourages local users to report unauthorized activities using the information provided on signs posted throughout the watershed area.

In the event of any emergency, the ERP is followed, copies of which are found at the main office located at 450 Cowie Hill Road in Halifax.

4.3.5 Utilities

Utility activity in the Chain Lakes watershed area and the risks associated with these activities are significant and are described in section *3.1.4: Utilities* on page 49. According to the BMPs required on Halifax Water's lands, to help mitigate such activities, contractors operating in the watershed generally must

- complete a yearly review of the fire regulations before start up;
- daily monitor the provincial fire index;
- follow operating restrictions;
- maintain fire equipment on site; and
- check equipment daily for potential malfunction and rectify any issues.

Utilities conducting activities that present a risk inside the watershed area mitigate specified activities as described in the subsections below.

Halifax Water Operations

Halifax Water operations inside the Chain Lakes watershed area is usually limited to water quality monitoring and activating the pumping station when required, and upgrades and/or maintenance to water and wastewater system infrastructure. All plant operators and contractors working on behalf of Halifax Water are made aware of surrounding risks and are educated on the response plans and procedures outlined in Halifax Water's ERP, copies of which are found at Halifax Water's main office located at 450 Cowie Hill Road in Halifax.

Nova Scotia Power Operations

There is significant activity conducted by NSPI to maintain infrastructure such as transformers, and distribution and transmission poles and lines that present risks to the Chain Lakes watershed area. Contingency plans to manage the risks are described in section *3.1.4: Nova Scotia Power Inc.* on page 50 and are outlined below.

Transformers

As described in section *3.1.4: Transformers* on page 51 there are 8 transformers in the Chain Lakes watershed area, seven of which (5 pole top and 2 pad mount) are maintained by NSPI while the remainder is a pad mount transformer maintained by a telecommunications company.

NSPI is federally required to replace all transformers containing PCB's by 2025. If any of the five (5) pole-top transformers contain PCBs and have been compromised such that there is a release of oil to the environment, spill response is immediate. All line trucks are equipped with a spill kit and all power line technicians, generally the first on site, are trained in spill response. All releases are reported immediately to area Transmission & Distribution Supervisors and the Territory Environmental Coordinator.

Any transformer that is considered to potentially contain PCBs is field-tested for PCBs to determine if the oil is greater or less than 50mg/kg. Any oil that tests positive is treated as PCB in the immediate clean up and an oil sample is sent for analysis by an accredited laboratory to confirm PCB concentration. Spills that trigger reporting under the Nova Scotia Emergency Spill Regulations or NSE Contaminated Sites Regulations are reported accordingly and cleanup is carried out to meet the applicable guideline. The Environmental Coordinator, in consultation with the Environmental Operations Manager will oversee all clean up and remediation at the site, following all applicable Acts and Regulations.

The pad mount transformers maintained by NSPI and the telecommunications companies do not pose as high a risk as the pole top transformers (see section *3.1.4: Transformers* on page 51 for more details and associated risks). In any event, when there is a spill of transformer coolant oil or diesel fuel to power the generator used in the event of a power failure, Halifax Water's ERP outlines the steps that are to be followed. Copies of the manual can be found at Halifax Water's main office located at 450 Cowie Hill Road in Halifax.

In 2014, NSPI activated the first phase of their province-wide PCB removal program to test 2,250 pole top transformers. NSPI expects to change out approximately 100 of them in accordance with federal and provincial guidelines. It is not known whether any of the five (5) pole-top transformers within the Chain Lakes watershed area contain PCBs; therefore, the risk presented by these transformers is unknown. As well, in an attempt to minimize oil releases, transformers are inspected through the feeder inspection program, which in 2014 was an annual program. Units are then prioritized according to their condition and scheduled for repair or replacement based on this priority.

- Halifax Water will discuss with NSPI replacing the pole and pad mount transformers that do not contain the highest environmental standard of transformer insulating oil with that of the highest order of environmental protection.

<u>Power Poles</u>

All power poles within the Chain Lakes watershed are treated to prevent decay. The treatment, which may present some risk to the watershed area, is described in section *3.1.4: Power Poles* on page 51. NSPI adheres to the Industrial Treated Wood users Guidance Document[24] as prepared by the Wood Preservation Strategic Options Process' Guideline Development Working Group, in 2004. Internal NSPI policy regarding pole treatment and installation dictates that all treated poles are set a minimum distance from the high water mark of any fresh water resource; a minimum of 15 m for PCP treated poles and a minimum of 5 m for CCA treated poles. Untreated cedar poles are used within 15 m of a drinking water well. When a pole is replaced, the old pole is completely removed from the ground and properly disposed of.

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[24] Government of Canada Publications: *Industrial Treated Wood users Guidance Document*. Website source: http://publications.gc.ca/site/eng/455006/publication.html

Transmission Lines

When planning vegetation management projects on distribution lines, the NSPI forestry group consults GIS mapping to determine where any designated or municipal watershed interacts with infrastructure. Any distribution line area that crosses through a watershed area is not treated with any herbicide or pesticide.

Halifax Water works with NSPI linesmen and provides them with its BMPs to ensure protection of the watershed area when maintenance activities are conducted.

Maintenance is carried out at a given site as required; i.e., when there is damage to overhead equipment and when maintenance is required based on feeder inspections and vegetation growth levels. Distribution lines running through the Chain Lake watershed area that are *not* road side are accessed "via off-road track machinery."

Chemical Use

If a chemical enters a watercourse inside the watershed and threatens the source water supply, the ERP is used to respond, minimize and clean-up the impact to source water. A copy of the ERP is at 450 Cowie Hill Road, Halifax.

4.3.6 Public Awareness

Halifax Water will continue to post signage, conduct patrols, and distribute information regarding restricted activities in the Chain Lakes watershed area.

4.4 Emergency Response Management for Critical Infrastructure

Water is listed as one of the ten critical infrastructure sectors in the *National Strategy and Action Plan for Critical Infrastructure* [25] and in Public Safety Canada's *Risk Management Guide for Critical Infrastructure Sectors – Appendix B*: *List of Hazards and Threats*[26]. A key principle of the National Strategy is

> "*Critical infrastructure roles and activities should be carried out in a responsible manner at all levels of society in Canada…"* whereby the responsibilities are shared by *" federal, provincial and territorial governments, local authorities and critical infrastructure owners and operators – who bear the primary responsibility for protecting their assets and services. Individual Canadians also have a responsibility to be prepared for a disruption and to ensure that they and their families are ready to cope for at least the first 72 hours of an emergency*."

Considering Halifax Water is critical infrastructure, the National Security's principles and statements should be adhered to such that Halifax Water should be prepared for a 72 hour

[25] Public Safety Canada: National Strategy for Critical Infrastructure. Website source: http://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/srtg-crtcl-nfrstrctr/srtg-crtcl-nfrstrctr-eng.pdf.

[26] Public Safety Canada: Risk Management Guide for Critical Infrastructure Sectors; p. 37. Website source: http://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/rsk-mngmnt-gd/rsk-mngmnt-gd-eng.pdf .

National Security critical infrastructure disruption scenario that could result in "*catastrophic loss of life, adverse economic effects, and significant harm to public confidence*."

4.4.1 Critical Infrastructure Management of Security Threats and Hazards Management

Halifax Water's ERP attempts to identify and categorize all emergencies that could affect its operations including stormwater, wastewater and drinking water services. To help sort and identify potential emergency scenarios, this SWPP's Emergency Response management subsection on management is divided into four sections: accidental, natural event, intentional threats and hazards and backup emergencies.

Emergencies caused by natural disasters, accidents or spills, and malicious intent pose serious threat to water quality because they are often unpredictable and difficult to prepare for. Further, considering, as previously stated, "*disasters most often occur locally, the first response to a disruption is almost always by the owners and operators, the municipality, or the province or territory*." Also, the smaller the party affected, the fewer resources may be available to effectively and quickly deal with the emergency.

Security against malicious intent is taken very seriously at Halifax Water. However, also as previously stated, *"[i]mproving the resilience of Canada's critical infrastructure will always be a work in progress. It will never be possible to protect against every threat or hazard and mitigate against every consequence.*"[27]

For specific types of emergencies, the following subsections describe Halifax Water's response and contingency plans according to whether it is an accidental, natural or malicious type of emergency.

Accidental Emergency Response

The following emergencies are considered to be the greatest threat to water quality in the Chain Lakes watershed area.

Accidental Fire

Due to the Wildland-Urban Interface (WUI), a characteristic of the Chain Lakes watershed area, there is substantial potential for accidental fire from various sources including residences, recreational pursuits, highway mishaps, distribution line maintenance activity and other anthropogenic activities (see section *3.2.1: Accidental* Fire on page 65). In the event of a fire, emergencies are addressed through 911 services and Halifax Water Emergency preparedness documents and its BMPs. While Halifax Water's Emergency Response protocols must be followed in water supply areas, wildland fire reporting and response protocols follow provincial Forest Fire Protection Regulations.

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[27] Her Majesty the Queen in Right of Canada. Public Safety Canada: Action Plan for Critical Infrastructure (2014 – 2017). 2014. Website source: http://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/pln-crtcl-nfrstrctr-2014-17/pln-crtcl-nfrstrctr-2014-17-eng.pdf

Aircraft Disaster

NavCanada is the agency responsible for safe and efficient traffic flow in Canadian airspace. Transport Canada is responsible for licensing pilots and other aviation specialists as well as registering and inspecting aircraft. The Transportation Safety Board of Canada is responsible for advancing transportation safety in Canada.

Through meetings with HIAA Security staff and by regularly reviewing its emergency-response plans Halifax Water continues to assess the possibility of an event occurring. More details on the risks of aircraft disasters are found in section *3.2.1: Aircraft Disaster* on page 65.

- Halifax Water has offered to supply the HIAA with GIS shape files of the watershed areas to use as a reference layer, especially in case of a catastrophic event, to add to their mapping system. The HIAA recognizes the importance of the water supply areas, but places greatest priority on insuring flight safety. Halifax Water will also approach CFB/Shearwater with the same offer.

In an aircraft emergency, Halifax Water will cooperate with the appropriate agency(ies), and follow the outlined procedures documented in the *Emergency Response Plan for Halifax Water* located at 450 Cowie Hill Road, Halifax.

Chemical or Oil Spill

In the event of a chemical spill inside the Chain Lakes watershed area, emergencies are addressed through 911 services. Emergency response protocols include Halifax Water's ERP and Halifax Water's BMPs, Nova Scotia Environment's *Environmental Emergency Regulations*, the Nova Scotia Emergency Management Office and those in cooperation with Transport Canada, the agency responsible for an accident or spill occurring on roadways.

Natural Event Response

Natural events and disasters that could occur within the Chain Lakes watershed include wind and flooding, fire, drought, natural biological outbreaks and infestations and climate change impacts. Management considerations for such events are described in the subsections below.

Wind and Flood

Wind and flood

- put drinking water supplies at risk through microbial cross-contamination;
- cause power outages that threaten to disrupt water pumping stations; and
- cause forest blow down that lead to short and long-term water quality impacts such as soil erosion and sedimentation, increased colour, suspended solids and organic matter levels.

Halifax Water will manage the risks presented by these events by following the ERP and continuously improving response procedures and readiness in preparation for such events. Communication with other first responders will help to ensure Halifax Water is connected to the appropriate agencies to ensure timely response in such events.

Wildland Fire

In 2012, a *Provincial Forest Fire Watershed Protection Policy (FFWPP)* was created as an internal government document regarding how to respond to and fight fires within municipal water supplies. The protocol includes applying water first, only using the "Primary" drinking water supply source as a water source to fight fire as a last resort and using only those chemicals described in section *3.1.6: Wildland Fire Fighting* on page 63. NSDNR staff is aware of these protocols. Another tool available is the *Renewable Resources Municipal Source Water Protection Wildfire Management Manual IV6*, which is available on the provincial government's intranet site. There is also an updated GIS layer available showing watershed boundaries, to help NSDNR staff define fire suppression limits.

During forest management planning, Halifax Water and NSDNR target high-risk forest stands prone to natural disasters such as insect, disease, wind damage and fire, and follow the Fire Policy developed by NSDNR on the advice of NSE. Forest fire reporting protocol and procedures fall under the provincial *Forest Fire Protection Regulations* made under subsection 23(2) and Section 40 of the *Forests Act*. Also, 911 Emergency Response information signs are strategically placed throughout the watershed.

As per Halifax Water's BMPs, contractors working in forested areas hired by Halifax Water must

- complete a yearly review of the fire regulations before start-up when operating inside the watershed during fire season;
- conduct daily monitoring of the provincial fire index;
- follow appropriate operating restrictions;
- maintain fire equipment on-site; and
- check equipment daily.

Halifax Water will evaluate any threat to the raw water supply through the Target-Based Sampling Program outlined in *5.4.4: Targeted-Based Sampling* on page 127.

Drought

As indicated in section *3.3: Drought* on page 68, according to Environment Canada, Atlantic Canada may be more susceptible to drought impacts than are areas where drought is more prevalent because it occurs less frequently in Atlantic Canada, resulting in a lower adaptive capacity. Drought also makes forests more susceptible to fire and puts more pressure on water use and more demand on the water supply.

While water *quality* is the primary function of this SWPP, water *quantity* is shown to play a secondary role for the Chain Lakes Emergency water supply, particularly under extraordinary drought conditions, which leads to water rationing as identified in Chapter *1: Introduction* on page 8. Under such conditions, the water from Bayer's Lake Brook could be redirected into the Chain Lakes system via the Bayer's Lake diversion dam.

Considering that Bayer's Lake Brook receives the stormwater runoff from the Bayer's Lake Business Park, its suitability as a drinking water supply source to the Chain Lakes system is questionable because the water quality may put the public's health at risk. Therefore, it is recommended that the Chain Lakes water supply should only be used for water quantity purposes and not as a drinking water supply source. Through the Source Water Quality Monitoring Program as described in section *5.4.2: Bayer's Lake Wastewater System on page 124*, Halifax Water monitors for changes in water quality above the Bayer's Lake diversion dam (see sample site on *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19).

The *Emergency Response Plan for Halifax Water* (ERP) outlines the procedures in a drought or water rationing situation that includes banning of non-essential water use (e.g. lawn watering, car washing etc.) and the procedures to implement in the event of wildfire that may or may not be caused by drought conditions. A copy of the ERP is at 450 Cowie Hill Road, Halifax.

<u>Climate Change</u>

Regarding the impacts associated with climate change events (e.g., precipitation and temperature fluctuations), Halifax Water will continue to collaborate with other agencies to keep abreast of new challenges and techniques that limit the impacts on water infrastructure and impact the ability to adapt to climate change.

<u>Natural Biological</u>

Halifax Water generally manages the threats and hazards associated with natural biological risks within the Chain Lakes watershed area through the *Implementation Strategy* objectives described in section *4.2: Implementation Strategy* beginning on page 79. As described in section *3.2.1: Natural Events and Disasters* beginning on page 66, the Chain Lakes watershed area is particularly vulnerable due to the risks presented by its proximity to the urban core (WUI) and by its public accessibility (COLT and major highways). Further, the watershed area has been identified by HRM as having elevated archeological potential (see 2014 Regional Plan: Map 9) and historical significance (see section *2.1: History of the Chain Lakes Water Supply* beginning on page on page 9. Therefore, to effectively manage the natural biological threats and hazards to the Chain Lakes watershed area, public consultation should be considered. For instance, insect infestation (e.g., BSLB) may be managed through planned forest activities, which may need to be implemented in consultation with the public and applicable by-laws and regulations.

Natural events and disasters are hard to predict; however, in order to respond effectively, Halifax Water prepares its staff and its facilities through company policy and management plans, and Emergency Response and Preparedness Plans. In the event of a natural event occurrence that requires an emergency response, Halifax Water's Emergency Response protocols must be followed (see section *4.4: Emergency Response Management for Critical Infrastructure* on page 96 for more detailed information).

Intentional Threat Response

In this document an intentional threat is considered to be one that involves an attack or a deliberate act for the purpose of doing damage. Protecting against an intentional or deliberate attack on the water supplies in the event of war or sabotage is perhaps more difficult than protecting against more predictable events such as social unrest and labour disputes.

Maintaining open lines of communication and fostering new opportunities for cooperation with the various agencies that affect or would be affected by the inability to use the Chain Lakes water supply as an emergency supply will help to continuously decrease the risk level of malicious intent and non-malicious intent attacks.The next two subsections describe these two forms of intentional threats; and how Halifax Water may manage them.

Malicious Intent

Halifax Water has completed an industry-developed risk assessment for its facilities. The security measures procedures were designed based on this assessment to reduce the probability, increase the likelihood of detection and lessen the impact of a malicious event. In the event of an emergency resulting from malicious intent, Halifax Water will follow the ERP to continue operations during an emergency. A copy of the ERP is located at 450 Cowie Hill Road in Halifax.

Halifax Water posts signs, maintains fences and gates, installs security cameras at main operating locations, performs patrols, conducts routine intense water sampling to ensure the safety of HRM's drinking water and encourages watershed users to report any suspicious activities within the watersheds. Contact information can be found on signage throughout the watershed as well as listed on Halifax Water's website, www.halifaxwater.ca.

Non-malicious intent

An example of non-malicious intent that could occur in the Chain Lakes watershed area is in the event that the municipality develops watershed area lands in a manner that is not consistent with source water protection efforts, which may pose a negative impact to the protection of the source water supply or a change in provincial legislation that reduces protection mechanisms (as described in section *3.2.1: Non-malicious Intent* on page 68). The most important tool to manage for non-malicious intent is open communications and "*cooperation with Canada's international partners, all levels of government, security intelligence and law enforcement agencies, industry stakeholders and civil society*"[28].

Emergency Back-up Water Supply

The Chain Lakes water supply is the emergency back-up water supply for the Pockwock water supply. In case of an emergency (e.g., contamination, security, disaster), affecting the functionality of the Pockwock Water Supply Plant whereby senior management would decide to shut it down, the Chain Lakes emergency water supply could supply the system for 72 to 96 hours with limited use.

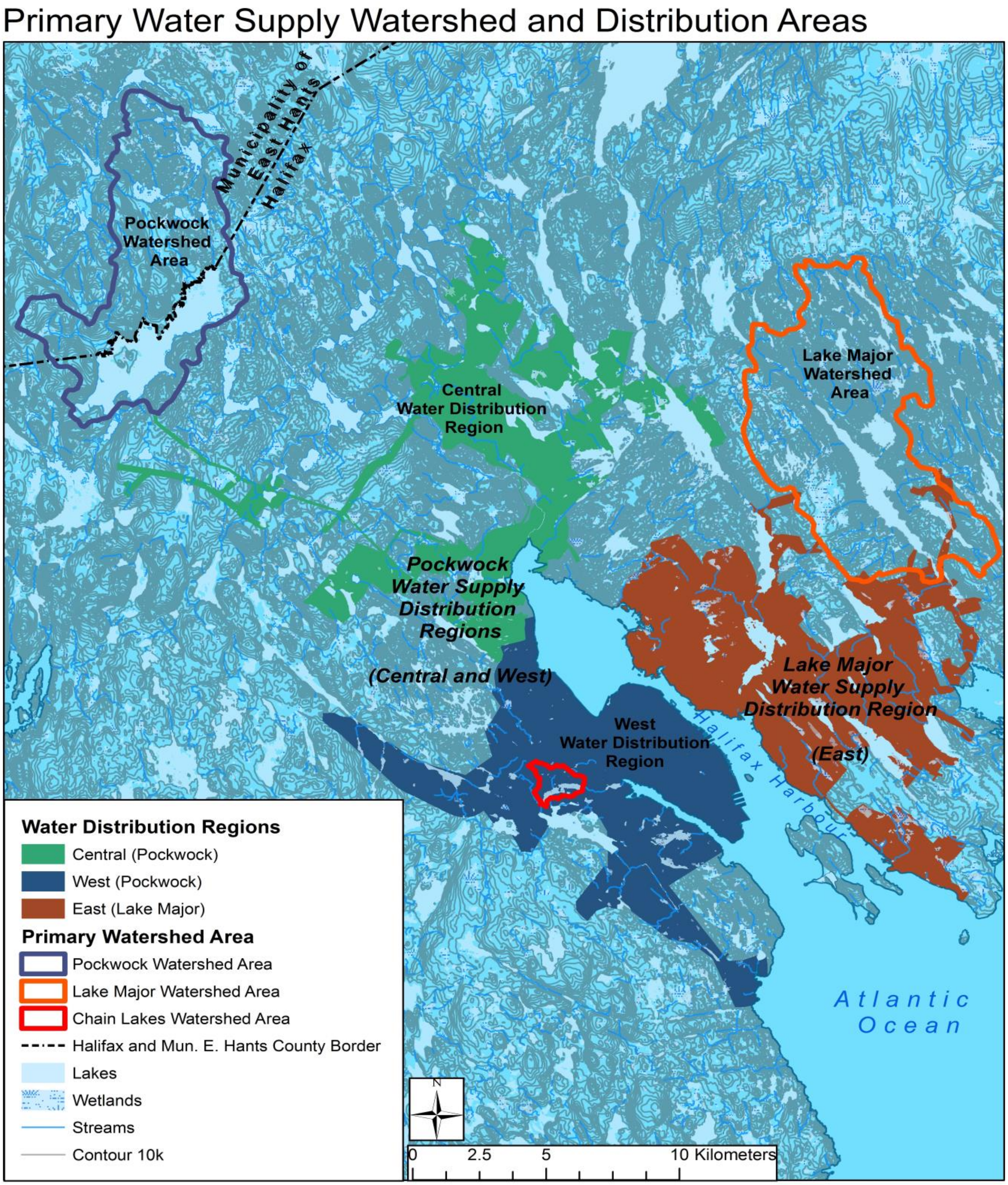
An approximate area range of customers whose water supply would be backed up by the Chain Lakes Water Supply in an emergency situation is illustrated in *Appendix 2: Customer Service Area in Chain Lakes Water Supply Emergency Scenario* on page 132. When required, a portable chlorination unit will be used to provide disinfection during emergency use of the water supply. The chlorine residual will be monitored hourly during operation, and a boil order will be issued by Nova Scotia Environment.

[28] Her Majesty the Queen in Right of Canada. Public Safety Canada: Action Plan for Critical Infrastructure (2014 – 2017). 2014. p. 4. Web-accessed August 21, 2014 at: http://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/pln-crtcl-nfrstrctr-2014-17/pln-crtcl-nfrstrctr-2014-17-eng.pdf

In the event that the Chain Lakes emergency back-up water supply is not available, other back-up supply options such as Lake Major may be considered (see section *3.2: Critical Infrastructure* on page 64). However, if the primary water supply sources (i.e., Pockwock and Lake Major) are interrupted, in addition to the Chain Lakes Emergency supply, then the situation would most certainly be considered a "*disruption of critical infrastructure [that] could result in catastrophic loss of life and adverse economic effects*"[29]. The measure of risk to the Chain Lakes watershed area is based on its "critical infrastructure" status in the latter scenario.

[29] Public Safety Canada. National Strategy for Critical Infrastructure, ISBN: 978-1-100-11248-0; p. 2. Web-accessed August 5, 2014 at: http://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/srtg-crtcl-nfrstrctr/srtg-crtcl-nfrstrctr-eng.pdf .

MAP L: PRIMARY WATER SUPPLY WATERSHED AND DISTRIBUTION AREAS



5 MONITORING AND EVALUATION

Halifax Water is responsible for monitoring, reporting and enforcing activities that may impair water quality within the Chain Lakes watershed area. Monitoring consists of maintaining a presence by way of patrolling, encouraging public reporting of unauthorized or suspicious activities, conducting raw water sampling, and liaising with various governing agencies and stakeholders to ensure a clean and safe drinking water supply.

5.1 Reporting

Monitoring the watershed involves reciprocal reporting processes. Halifax Water provides annual reports to governing agencies and to the public via publications including those found on Halifax Water's website. Halifax Water also relies on and encourages the public to act as a "watch dog" and report activities that could adversely affect source water quality.

5.1.1 Annual Reports

In March of each year, Halifax Water prepares and provides a Source Water Protection Report (SWPR) to fulfill obligations to NSE for the annual 90-day utility report. The report includes, but not limited to the status of current risks, identification of new risks, results of the previous year's monitoring program, activities within the watershed and recommended changes to the SWPP for continuous improvement.

5.1.2 Public Reporting

Halifax Water maintains signage throughout the Chain Lakes watershed area for public information purposes. Information includes restricted activities, applicable legislation and contact information. Contact information includes, but is not limited to, applicable civic addresses if available, the NSDNR hotline, emergency spill contact numbers (e.g., 911) and Halifax Water's 24hr emergency hotline (902) 490-4820.

5.2 Meetings

Consistent and sustained communication between those who have a responsibility to ensure clean, safe water is paramount. Meetings between stakeholders that impact the watershed area provide a means to evaluate risks to water quality and contribute to the development of methods to overcome obstacles that ensure clean, safe, potable water is being provided to Halifax Water clients. Stakeholders that help to attain this goal include Halifax Water, COLTA and other agencies including NSPI, NSDNR, HRM and NSTIR.

5.2.1 Scheduled Meetings

Halifax Water and HRM maintain a close working relationship regarding possible development or scheduled events that could pose a threat to water quality. As part of the development application review process, HRM Community Planning staff forward proposed development applications to Halifax Water for comment, including applications that may have an impact on the Chain Lakes watershed area. Each party has agreed to work together to minimize or eliminate the impact of any concerning issues through a series of scheduled meetings.

5.2.2 Management Committee Meetings

Although no official Watershed Management Committee exists for the Chain Lakes watershed area, Halifax Water is represented on the COLTA. Currently, COLTA acts as an unofficial quasi-Chain Lakes Watershed Advisory Board. As per section *4.2.4: Management Committee* on page 82, Halifax Water and COLTA are in discussions to form an official Advisory Board.

5.3 Patrolling

Halifax Water continues to conduct regular patrols throughout the Chain Lakes watershed area by foot, OHVs, boat and marked vehicles to identify and respond to activities of concern. Additionally, upon request by Halifax Water, Halifax Regional Police provide valuable support by conducting routine bike patrols and responding to complaints of trespassing or other activities that may threaten water quality. Those who are stopped during enforcement patrols are informed of the protected status of the watershed area. As identified in section *5.1.2: Public Reporting* on page 104. Halifax Water encourages watershed users to report any unauthorized or suspicious activities using the contact information located on the posted watershed signs.

5.4 Source Water Quality Monitoring Program

In September 2009, Halifax Water updated its raw water sampling program to include a proactive five-part Source Water Quality Monitoring Program (SWQMP) to measure the health of the watershed with respect to baseline, risks, activities, targets and operations. The initial sample sites were, CLG1 and CLG2. Prior to establishing these sample sites in 2009, source water monitoring consisted of collecting raw water samples at the water treatment facility and/or in response to emergencies to fulfill regulatory obligations. In 2011, data gaps were identified in the Chain Lakes SWQMP. To close those gaps, new sample sites were added – CLG3 in 2012 and CLG4 and CLG5 in 2013.

Water Quality samples are collected pending weather and safety conditions and analyzed to help determine the effectiveness of the Source Water Protection Program. The sampling parameters are measured and assessed, where possible, according to the CCME WQGPAH. Halifax Water considers these to be the highest standards available to assess the health of its watersheds. In cases where aquatic life parameters do not exist, Halifax Water uses GCDWQ.

Sampling procedures are included in the current *Water Quality Sampling and Permit Compliance Manual* which can be found by contacting the Water Quality Manager. The manual is revised on an as-needed basis. The Chain Lakes watershed area source water sampling locations and dominant tributaries are illustrated on *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19 and listed in *Appendix 3: Chain Lakes water Sampling Locations, Frequency and Parameters* on page 133.

5.4.1 Baseline Sampling

Baseline sampling is used to set water quality parameter baselines within the watershed area. Each baseline parameter is measured monthly, except for the metals scan which is measured twice per year. Subsequent water quality parameter data results are compared with the baseline data to determine if an investigation is required and whether parameter changes are associated with land use activities.

As previously mentioned, to better understand Chain Lakes raw water quality, baseline sampling was expanded in the fall of 2009 to include more remote areas of the watershed area; (i.e., sample sites CLG1 and CLG2). Subsequently, new sites were added to better understand water quality across the watershed – CLG3 in 2012 and CLG4 and CLG5 in 2013

Furthermore, over a 24 month period, sample site CLG4 was impacted by three sewer forcemain breaks (January 2013, April 2013, and July 2014) and during a sewer forcemain replacement project (June to December 2014). It should also be noted, during the months of August and September 2014 during the sewer replacement project, blasting activities may have allowed ground water to temporarily infiltrate CLG4 which may have impacted water quality (see *Table 17* to *Table 32* between pages 107 and 123). In December of 2015, after the project was completed for approximately one year, water quality at CLG4 stabilized; it remains at conditions similar to that of other Chain Lakes sampling points.

In this section, the general baseline SWQMP is divided into four sections: field tested (in-situ) and lab tested (both tested monthly); metals scan (tested twice a year); and deep lake sampling (typically collected three times per year). The first set of parameters, i.e., dissolved oxygen, pH, temperature, and specific conductivity, are measured in the field (in-situ) using the YSI Sonde, while the turbidity is measured in the field using a portable turbidity meter. The second set of parameters consists of total suspended solids (TSS), *E. coli*, Nitrate / Nitrite, Total Phosphorus (TP), and Total Organic Carbon, which are tested by a third party accredited laboratory. Both sets of parameters are collected in the same location and at the same approximate time. The difference is that the second set is taken to an independent lab for analysis. The following subsections describe the parameters and purpose for the four types of monitoring program methodologies, outlined in *Appendix 3: Chain Lakes water Sampling Locations, Frequency and Parameters* on page 133.

Field Tested

The following describes the significance of sampling for each set of in-situ-tested parameters (as listed in the previous paragraph):

Dissolved Oxygen

Dissolved Oxygen (DO) is essential to the metabolism of aerobic aquatic organisms. Concentrations of DO are indicative of a stream or lake system's overall health. Minimum levels are required to support fish and other aquatic life. Dissolved Oxygen also plays a key role in the chemical form and solubility of many inorganic nutrients (i.e., measuring shifts between aerobic and anaerobic aquatic conditions that influence the biological availability of nutrients and metals). Therefore, long-term changes in DO conditions can drastically alter the productivity and function of an entire lake or stream.

Of the six (6) Chain Lakes watershed sample sites (see *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19), during two sewer forcemain break related events, CLG4 briefly experienced concentrations outside of the CCME WQGPAL range for DO. Minimum allowable DO concentrations are 5.5 mg/L for warm water and 6.5 mg/L for cold water.

The first break occurred April 13, 2013 where samples collected at site CLG4 recorded levels below the minimum standard, for a 2-day period after the initial break; i.e., 3.59 mg/L on April

16, 2013 and 2.59 mg/L on April 18, 2013. The second break occurred on July 9, 2014 as a result of the Bayer's Lake sewer replacement project. DO samples collected after the second break recorded a measurement of 2.50 mg/L. Dissolved Oxygen levels at CLG4 fell temporarily (Aug-Sept 2014) below CCME WQGPAL (see *Table 17: Chain Lakes DO Water Quality Monitoring Results* 2007 – 2016mg/l*) below) due to infiltration of ground water, presumed to be the result of the sewer replacement project activities. Section *5.4.2: Bayer's Lake Wastewater System* on page 124 describes the situation around the breaks and section *3.1.4:* Wastewater Treatment Infrastructure *on page 49* describes the sewer replacement project activities undertaken to replace the aging infrastructure. *Table 17: Chain Lakes DO Water Quality Monitoring Results* 2007 – 2016mg/l)* below outlines DO concentrations monitored since 2007.

Table 17: Chain Lakes DO Water Quality Monitoring Results* 2007 – 2016mg/l)

Year / Sample Site Name	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CLG1	-	-	12.48	11.08	9.83	12.19	10.95	11.44	12.29	12.69
CLG2 (intake)	-	-	11.36	9.87	8.91	10.97	10.28	9.99	11.73	10.91
CLG3	-	-	-	-	-	10.62	10.15	10.04	9.66	10.02
CLG4	-	-	-	-	-	-	9.84/ 3.09**	12.06/ 2.50**/ 6.19***	12.92	13.31
CLG5	-	-	-	-	-	-	13.26	11.15	12.17	12.12
DLS	-	-	-	8.85	-	9.89	-	8.37	8.42	9.96
HRM	9.98	10.57	11.33	11.40	10.43	-	-	-	-	-

* All results are Baseline Conditions unless otherwise indicated
** Sewer forcemain break events averages
***Assumed Temporary Ground Water Infiltration (Aug-Sept 2014) during sewer replacement activities

pH

Within an aquatic environment, pH is an indicator of acidity or alkalinity. A reading between 0 and 7 is considered acidic and contains more hydrogen. A reading between 7 and 14 is considered basic or alkaline and contains more hydroxyl groups. Acidification from land use activities, soil conditions and precipitation can negatively impact aquatic biota, contribute to the mobilization of toxic metals and affect drinking water aesthetics. Halifax Water's Source Water Quality Monitoring Program (SWQMP) is intended to establish baseline conditions and track changes in pH to determine which, if any, watershed activities are affecting pH levels.

The Chain Lakes water system has been the topic of many water quality research studies. A water quality assessment of Chain Lakes (Rajaratnam, 2009) suggests First and Second Chain Lakes were early-mesotrophic/oligotrophic during the pre-industrial Halifax period. Since that time, these Lakes have experienced oligotrophication through lake-acidification. The theory proposed by Rajaratnam (2009) is that during pre-industrial Halifax, lake pH was already trending towards acidity due to natural conditions.

The surficial geology of the area is shallow-exposed sulphide-bearing bedrock with poor buffering capacity (see more details on the geology of the area in sections *2.2.1: Geology* on page 11 and *2.2.3: Surficial Geology* on page 12). As rainwater falls on the bedrock the acid in the rain reacts, creating a mild sulphuric acid which lowers the pH of the water

The industrialization of North America from the mid-west to the east resulted in industrial gases being released into the atmosphere that fell in the form of acid rain, which particularly affected the Eastern Atlantic Region. Further, activities such as forestry, farming, and quarrying were common within the Chain Lakes watershed prior to the City of Halifax obtaining ownership. These activities together with the acidic nature of the watershed geology are believed to have expedited the acidification of the Chain Lakes system.

The CCME WQGPAL for pH indicates levels should fall within the range of 6.5 to 9.0. Unfortunately, no data that was examined, including pre-SWQMP (2009) data, fell within this range. See *Table 18* on page 109 for pH levels observed since 2007.

The Halifax Formation bedrock which underlies the water area at sample site CLG1 (see *Map A: Bedrock Geology* on page 17), known as Geizer Hill, is acidic in nature. *Table 18* on page 109 shows that each year the pH at this location is the lowest. A wildland fire in August 2001 burned a large part of the watershed in the Geizer Hill area. The fire was intense enough to completely burn the humus layer off and exposed the soil and bedrock. Subsequently, vegetation has been slow to recover. Additionally, construction of Hwy 102, which transects the northern part of the watershed, further exposed large bedrock areas to acid rain and increased the potential for pH levels to plummet.

Sample site CLG3 is used to monitor the water flowing from the Bayer's Lake Business Park. Despite being developed on a geological formation with acid-bearing characteristics, as *Table 18* on page 109 shows, the Bayer's Lake Business Park consistently has the highest pH reading of all the Chain Lakes monitoring sites. This demonstrates how the *Sulphide Bearing Material Disposal Regulations*, NS Reg. 57/95 made under section 66 of the *Environment Act* reduces the impact of exposed acid-bearing slates on water quality. Tactics used to cover up acid-bearing slates within the Bayer's Lake Business Park include commercial development, parking lots and landscaping activities.

With respect to pH, the overall impact to CLG4's source water quality was minimal during the three sewer forcemain breaks. In all three cases the breaks were identified and repaired immediately such that pH levels returned to baseline conditions comparable to that of the other watershed sample sites (see *Table 18*).

During temporary infiltration of groundwater from sewer forcemain replacement activities (Aug-Sept 2014), pH levels at CLG4 were closer to but did not meet minimum CCME WQGPAL. Since work on the new gravity Chain Lakes Sewer Trunk was completed in 2014, pH baseline conditions by the end of 2015 returned to levels similar to other Chain Lakes sample points (see *Table 18* below).

Table 18: Chain Lakes pH Water Quality Monitoring Results* 2007 - 2016										
Sample Site Name / Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CLG1	-	-	4.02	3.76	4.04	3.84	3.94	3.94	4.05	3.95
CLG2 (intake)	-	-	4.76	5.18	4.86	4.59	4.68	5.02	4.88	5.59
CLG3	-	-	-	-	-	5.69	5.24	5.82	5.96	6.40
CLG4	-	-	-	-	-	-	5.24/ 6.20**	4.99/ 6.68**/ 6.61***	4.88	4.53
CLG5	-	-	-	-	-	-	4.70	4.26	4.39	4.37
DLS	-	-	-	4.59	-	4.52	-	4.81	4.46	5.18
HRM	4.73	4.79	5.10	5.34	5.12	-	-	-	-	-

* All results are Baseline Conditions unless otherwise indicated
**Sewer forcemain break events averages.
***Assumed Temporary Ground Water Infiltration (Aug-Sept 2014) during sewer replacement activities

Temperature

Temperature affects many biological (e.g., biotic growth and decay, uptake of toxins, organism behaviour) and chemical (e.g., solubility, rate of reaction) processes. Monitoring the source water temperature allows Halifax Water to establish normal baseline conditions, adds context to some of the water quality parameters and tracks changes resulting from anthropogenic activities.

Water temperature characteristics measured in the SWQMP were consistent across the Chain Lakes watershed area, regardless of land use impacts. Water temperatures ranged from 0.04 degrees Celsius on the coldest day of the year to 24.71 degrees Celsius on the warmest day of the year. Temperature will continue to be monitored for future research or reference.

Specific Conductivity

CCME WQGPAL for specific conductivity has yet to be specified. However, the impact that human activities have on specific conductivity levels may be formulated through measurement.

Specific conductivity measures water’s ability to conduct electricity and is highly dependent on the concentration of dissolved solids such as salt. Monitoring specific conductivity is useful for detecting the effects of road de-icing and other pollution inputs such as wastewater breaks.

The Chain Lakes watershed area is bound on all four sides by major roadways; the north and west boundaries are bordered by 100 series highways, and by connector routes along the east and south boundaries. The watershed area is also a thoroughfare for the COLT under which lies the Chain of Lakes Sewer Trunk. When compared to other watersheds, the specific conductivity measured in the Chain Lakes watershed area is considered high. Typical specific conductivity for Halifax Water source water supplies that are not under the influence of anthropogenic activities is ~30μs/cm^2. *Table 19* on page 110 outlines specific conductivity recorded in the Chain Lakes watershed area since 2007.

Halifax Water, HRM public works and NSTIR met in May 2013 to discuss winter road maintenance practices and to share water quality information. HRM and NSTIR acknowledged the water quality data collected by Halifax Water and the need to improve the water quality based on that data. HRM suggested that operator awareness and road de-icing best management practices would help to reduce the impact of cold weather road practices on water quality. NSTIR and HRM indicated they would share the information with operations staff and search for possible solutions that would not compromise traffic safety. Follow-up letters have been received confirming NSTIR and HRM have spoken with operations and are working on solutions. Halifax Water will continue to monitor specific conductivity.

Specific conductivity at CLG4 was moderately impacted by three sewer forcemain breaks, particularly the April 2013 break (see *Table 19*). In each case the breaks were identified and repaired immediately such that specific conductivity levels returned to baseline conditions similar to that of the other watershed sample sites.

As well, specific conductivity levels at CLG4 temporarily increased (Aug-Sept 2014) due to presumed ground water infiltration during Bayer's Lake sewer forcemain replacement activities. The levels returned to normal once activities were complete (see *Table 19* below).

Table 19: Chain Lakes Specific Conductivity Water Quality Monitoring Results* 2007 – 2016

Year / Sample Site Name	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CLG1	-	-	382	887	566	743	670	670	493	575
CLG2 (intake)	-	-	482	412	336	310	384	326	352	353
CLG3	-	-	-	-	-	910	913	945	793	885
CLG4	-	-	-	-	-	-	674/ 1678**	647/ 813**/ 878***	287	346
CLG5	-	-	-	-	-	-	249	505	418	440
DLS	-	-	-	450	-	329	-	364	432	345
HRM	330	540	575	440	303	-	-	-	-	-

* All results are Baseline Conditions unless otherwise indicated
** Sewer forcemain break events averages
***Assumed Temporary Ground Water Infiltration (Aug-Sept 2014) during sewer replacement activities

Turbidity

Turbidity is a visual property of water and a measurement of light scattered and absorbed due to the presence of suspended material (e.g., organic or inorganic particles originating from the erosion of soil or re-suspension of bottom sediments). Through turbidity monitoring, Halifax Water will be able to set a baseline to determine whether land use activities in the watershed are linked to turbidity changes, and whether changes in land management should be considered.

The freshwater CCME WQGPAL standard for turbidity is 8 nephelometric turbidity units (NTU)'s above background conditions. Health Canada's Drinking Water Standards for visual aesthetics (after treatment) is 0.1 NTU. See *Table 20*: **Chain Lakes Turbidity Water Quality Monitoring Results* 2007 – 2016 (NTU)** on page 111 outlining average turbidity of the Chain Lakes SWQMP.

In general, CCME WQGPAL for turbidity remains consistently below the 8 NTU standard. The only exception(s) were

- the Bayer's Lake sewer forcemain breaks (CLG4):
    - April 2013 break turbidity levels reached 12.4 NTU;
    - July 2014 break turbidity levels reached 14.2 NTU;
- the 2014 Bayer's Lake sewer replacement project, despite erosion control measures and work stoppage during heavy rainfall in September 2014, turbidity levels reached 9.18 NTU and >10 NTU for CLG1 and CLG4 respectively; and
- a heavy rainfall event in the Bayer's Lake Industrial Park where turbidity levels reached 13.1 NTU at sample point CLG3 in November of 2014.

In all instances, turbidity levels returned to CCME WQGPAL standards within two to three days after the break was repaired or after the event stopped.

The data levels of the turbidity water samples collected at CLG3 are, on average, higher than all the other Chain Lakes watershed sample points because it originates from the Bayer's Lake Industrial Park, which is considered a highly impacted watershed. Therefore, it is *not* recommended to divert water from the Bayer's Lake Industrial Park into the Chain Lakes system unless deemed absolutely necessary. When Bayer's Brook water must be diverted into the Chain Lakes system to supplement the drinking water supply, a boil order advisory should be issued and the Bayer's Lake Industrial Park put on notice to minimize industrial contamination.

Turbidity levels at CLG4 during temporary (Aug-Sept 2014) infiltration by ground water, presumed to be the result of the Bayer's Lake sewer forcemain replacement activities, were consistently higher than the baseline conditions of other similar watershed sample sites, though turbidity levels did not exceed CCME WQGPAL (see *Table 20* below).

Table 20: Chain Lakes Turbidity Water Quality Monitoring Results* 2007 – 2016 (NTU)

Sample Site Name \ Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CLG1	-	-	0.73	0.32	2.00	1.76	0.91	1.60	0.65	0.29
CLG2 (intake)	-	-	0.48	0.52	0.53	0.40	0.33	0.39	0.48	0.59
CLG3	-	-	-	-	-	2.13	2.52	3.86	3.84	2.45
CLG4	-	-	-	-	-	-	2.92/ 12.4**	0.75/ 14.9**/ 6.11***	0.54	0.32
CLG5	-	-	-	-	-	-	1.16	0.62	0.87	0.51
DLS	-	-	-	0.12	-	0.30	-	0.48	0.16	0.59
HRM	0.1	0.17	0.37	0.27	0.4	-	-	-	-	

* All results are Baseline Conditions unless otherwise indicated
** Sewer forcemain break events averages
***Assumed Temporary Ground Water Infiltration (Aug-Sept 2014) during sewer replacement activities

Lab Tested

Lab tested parameters described in the following subsections are used to set water quality baselines to compare with water quality samples tested during changes in watershed activities.

These parameters include Total Suspended Solids (TSS), *E. coli*, Nitrate/Nitrite, Total Phosphorus (TP), and Total Organic Carbon. The samples are collected at the same sample points as the in-situ parameters (see section *5.4.1: Field Tested* on page 106), are contained in appropriate bottles and delivered to an independent laboratory for analysis. Results help direct investigations of changes in water quality, which may be associated with land use activities.

Total Suspended Solids (TSS)

Total Suspended Solids (TSS) are solids found in water that can be trapped in a filter. Increased suspended solids change a stream's ecological integrity by filling in interstitial spaces between rocks, altering the stream bottom and affecting light penetration in the water column. These effects have a cascading effect (i.e., there is a decrease in dissolved oxygen, causing stress on aquatic biota and an increase in TSS-associated substances). Changes in TSS can be indicative of erosion and run-off. For example, land-use activities such as forestry, agriculture or community development can increase the amount of sediment released into a stream or lake. CCME WQGPAL for TSS is based on clear flow or high flow conditions as described below.

Clear flow Conditions

A maximum increase of 25 mg/L from background levels for any short-term exposure (i.e., a 24 hour period) and/or a maximum average increase of 5 mg/L from background levels for longer term exposures (i.e., inputs lasting between 24 hours and 30 days); and/or

High flow Conditions

A maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L. TSS background levels should not increase more than 10% when the background level is ≥ 250 mg/L.

Background conditions indicate that TSS levels for the Chain Lakes system fall within CCME WQGPAL for clear and high flow conditions, except for samples collected at CLG4 during the three sewer forcemain breaks and the Bayer's Lake sewer replacement project. Where the highest TSS level observed at CLG4 as a result of the breaks was 16 mg/L (July 2014) and the highest TSS level observed during the sewer replacement project was 47 mg/L (Aug. 2014), which exceeds the Clear Flow Condition of the CCME WQGPAL. Ground water infiltration, through oxidation of metals in combination with residual sewage (organic matter), is suspected to have influenced the higher TSS levels *see Table 21*: Chain Lakes TSS Water Quality Monitoring Results* 2007 – 2016 (mg/L) *on page* 113*).* Since the new sewer project was completed, CLG4 TSS levels returned to baseline conditions similar to other Chain Lake watershed sample points.

No increase in TSS was observed at the point of entry to Second Chain Lake (where CLG4 empties) through the sewer breaks or construction activities period because contaminated water was captured in a small wetland area 200 m upstream. See *Table 21* on page 113 for TSS levels since construction.

Table 21: Chain Lakes TSS Water Quality Monitoring Results* 2007 – 2016 (mg/L)										
Year / Sample Site Name	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CLG1	-	-	ND	ND	2.23	2.34	1.57	1.73	1.2	ND
CLG2 (intake)	-	-	ND	1.04	0.82	0.84	0.97	0.56	ND	ND
CLG3	-	-	-	-	-	1.49	3.96	3.94	4.19	1.72
CLG4	-	-	-	-	-	-	7.91/ 10**	2.10/ 16**/ 29***	12.4	ND
CLG5	-	-	-	-	-	-	1.5	1.64	2.34	7.25
DLS	-	-	-	ND	-	ND	-	ND	ND	ND
HRM	ND	ND	ND	ND	ND	-	-	-	-	-

* All results are Baseline Conditions unless otherwise indicated
** Sewer forcemain break events averages.
***Assumed Temporary Ground Water Infiltration (Aug-Sept 2014) during sewer replacement activities

E. coli

E. coli is an indicator of how much fecal contamination is entering a water system through human or animal waste. However, research suggests *E. coli* may not be the best indicator as it mutates over time, making it difficult to identify where the contamination originated. CCME WQGPAL for *E. coli* is not specified. Until an alternative cost-effective and qualitative scientific method is identified, Halifax Water will continue to gather *E. coli* samples and report results.

Data suggests that the Bayer's Lake sewer system, which runs through the watershed, needs close monitoring to effectively manage the source and ensure the delivery of safe drinking water. Detailed water quality monitoring results observed since 2007 show the effect (or lack thereof) on the Chain Lakes watershed area, pre- and post- sewer line breaks/overflows, are found in *Table 22* below illustrate *E. coli* levels measured during the three sewer forcemain breaks that occurred on January 16, 2013, April 16, 2013, and July 9, 2014. Emergency response and follow-up water quality monitoring assessments were conducted for each break or overflow and immediately repaired (<1day). The monitoring conducted indicates that there was no impact to the water supply sources.

Table 22: Chain Lakes *E. coli* Water Quality Monitoring Results* 2007-2016 (CFU/100 ml)										
Year / Sample Site Name	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CLG1	-	-	8.33	1.00	1.32	4.63	1.25	2.94	3.5	ND
CLG2 (intake)	-	-	1.67	2.54	1.68	1.29	1.64	2.06	3.95	11
CLG3	-	-	-	-	-	3.10	2.67	33.94	129	36
CLG4	-	-	-	-	-	-	2.3*	4.50*	2.4	ND
CLG5	-	-	-	-	-	-	5.5	5.75	4.43	ND
DLS	-	-	-	ND	-	ND	-	ND	7	ND
HRM	ND	ND	ND	ND	ND	-	-	-	-	-

*sewer forcemain not included; see *Table 23, Table 24* and *Table 25* following for sewer forcemain *E.coli* levels.

Table 23: Bayer's Lake Sewer Forcemain E. coli Water Quality Monitoring Results Jan. – Mar., 2013 (CFU/100 ml)					
Date / Sample Site Name	Jan 16 Day 1 after break	Jan 29 Day 14 after Jan break	Feb1 Day 17 after Jan break	Feb 21 Day 37 after Jan break	Mar 21 Day 65 after Jan break
CLG4 200m	2600	6	38	1	1
Bayer 2 250m	1700	DRY	18	DRY	DRY
Bayer 3 350m	1	DRY	1	DRY	DRY
Bayer 4 500m	ND	DRY	2	DRY	DRY
Bayer 5 500m	ND	DRY	ND	DRY	DRY
Bayer 6 Spillway	ND	DRY	ND	DRY	DRY

Table 24: Bayer's Lake Sewer Forcemain E. coli Water Quality Monitoring Results Apr. – Jul 2013 (CFU/100 ml)									
Date / Sample Site Name	Apr 16 Day of break	Apr 17 Day 1 after break	Apr 26 Day 10 after break2	May 2 Day 16 after break	May 14 Day 28 after break	May 31 Day 44 after break	June 3 Day 48 after break	June 18 Day 63 after break	July 31 To Dec 9
CLG4 200m	5400	1000	2000	40	100	3	ND	1	ND
Bayer 2 250m	1100	220	100	60	100	DRY	ND	DRY	DRY
Bayer 3 350m	ND	ND	3	2	300	DRY	ND	DRY	DRY
Bayer 4 500m	ND	ND	ND	ND	4	DRY	12	DRY	DRY
Bayer 5 500m	ND	ND	ND	2	9	DRY	3	DRY	DRY
Bayer 6 Spillway	ND	ND	ND	ND	2	DRY	2	DRY	DRY

Table 25: Bayer's Lake Sewer Forcemain E. coli Water Quality Monitoring Results July 2014 (CFU/100 ml)								
Date / Sample Site Name	July 9 Day of break	July 10 Day 1 after break	July 11 Day 2 after break2	July 14 Day 5 after break	July 15 Day 6 after break	July 16 Day 7 after break	July 17 Day 8 after break	July 18 Day 9 after break
CLG4 200m	2500	290	DRY	3	DRY	5	1	ND
Bayer 2 250m	DRY	ND	1	ND	DRY	5	ND	ND
Bayer 3 350m	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Bayer 4 500m	DRY	ND	ND	ND	ND	ND	ND	ND
Bayer 5 500m	DRY	ND	ND	ND	ND	ND	ND	ND
Bayer 6 Spillway	DRY	DRY	ND	1	DRY	ND	ND	ND

No increase in *E. coli* was observed at the point of entry to Second Chain Lake because the sewage was mainly captured by a small wetland area 200 m upstream, which lies between sample points Bayer's 2 and Bayer's 3 (see *Table 23*, *Table 24* and *Table 25* above).

Total Phosphorus and Nitrate-Nitrogen

Total phosphorus and nitrate-nitrogen concentrations are used to monitor nutrient loading in a freshwater system. Excess nutrient loading is harmful to an aquatic ecosystem and promotes an increase in trophic status, which can result in algal and plant growth. These conditions are a concern for drinking water quality due to the difficulty in removing nitrate-nitrogen through the water treatment process, and loss of aquatic habitat biodiversity. Excessive growth places oxygen demands on aquatic systems during organic breakdown of material, and can promote the secretion of algal toxins.

Total Phosphorus (TP)

Phosphorus is not considered to be toxic by itself. However, phosphorus is the key limiting nutrient that determines the trophic status of aquatic ecosystems. The CCME WQGPAL TP trigger range is 20 µg/L.

Recorded ranges for TP that indicate trophic status levels are

- ultra-oligotrophic <4
- oligotrophic 4-10
- mesotrophic 10-20
- meso-eutrophic 20-35
- eutrophic 35-100
- hyper-eutrophic >100

The water quality levels observed in the Chain Lakes watershed area system are well within the TP 20 µg/L trigger range as outlined in *Table 26* below, except for CLG4 in 2013 and 2014, the latter being associated with the sewer main breaks.

Table 26: Chain Lakes Total Phosphorus Water Quality Monitoring Results 2007 – 2016 (µg/L)

Sample Site Name / Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CLG1	-	-	ND	3.8	12.4	4.8	3.3	5.4	4	3.5
CLG2 (intake)	-	-	ND	8.8	9.3	5.1	ND	3.1	2.3	ND
CLG3	-	-	-	-	-	5.2	ND	6	13.3	ND
CLG4	-	-	-	-	-	-	22.1*/ 680**	9.5/ 180**/ 23***	3.6	3.5
CLG5	-	-	-	-	-	-	ND	3.3	5.9	5
DLS	-	-	-	ND	-	ND	-	3.5	ND	ND
HRM	2	7	12	9	4	-	-	-	-	-

* All results are Baseline Conditions unless otherwise indicated
** Sewer forcemain break events averages
***Assumed Temporary Ground Water Infiltration (Aug-Sept 2014) during sewer replacement activities

Increased TP levels were observed at CLG4 during the forcemain breaks in 2013 and 2014, see *Table 26* above. TP levels have returned to levels comparable to other Chain Lakes sample sites. Halifax Water will continue to monitor CLG4.

The highest levels of TP are experienced at CLG3 which is consistent with the types of anthropogenic activities within the Bayer's Lake Business Park. At this point it is strongly recommended that the diversion dam remain closed off from Second Chain Lake to minimize any water quality concerns associated with the Bayer's Lake Business Park.

The Rajaratnam report (2009), referred to throughout this document, suggests the Chain Lakes system was already sensitive to acidification prior to the industrialization of the City of Halifax. However, since industrialization and the impacts from acid rain, the system has experienced lower pH and phosphorus levels, and increased aluminum levels. Phosphorus inputs are limited within the Chain Lake watershed due to its small size, limited vegetation, shallow soils and past anthropogenic history. Increased aluminum content is suspected from acid rain washing aluminum deposits from the exposed bedrock. It is suggested that the high concentration of aluminum and low phosphorus levels form a phosphorus-compound that settles out through natural coagulation, resulting in lake(s) that are clear and nutrient poor. Chain Lakes' status is therefore considered to be approaching ultra-oligotrophic. The result is a treatable water supply which supports limited life forms.

Nitrate-Nitrogen

Nitrogen is the second limiting nutrient in influencing trophic status of freshwater systems. Nitrogen occurs in freshwater in numerous forms; the major form of inorganic nitrogen is likely found in the nitrate form.

GCDWQ standards for nitrate concentrations are 10 mg/L which is a higher standard than CCME's WQGPAL, at 13 mg/L; therefore, Halifax Water uses the GCDWQ for nitrogen as the minimum acceptable baseline standard (10 mg/L). All nitrate/nitrite samples collected since 2007 from the Chain Lakes water quality sampling locations are well below the detection limit (see *Table 27* below).

Studies suggest there is a link between nitrate and nitrite and health issues such as Blue Baby Syndrome as well as possible links to cancer if consumed. Nitrate is difficult and expensive to remove from untreated water; therefore, it is best to avoid increases in nitrogen levels in the water supply. Halifax Water will continue to monitor phosphorus and nitrate-nitrogen concentrations. If water quality becomes impacted, water quality background information will assist Halifax Water in developing effective solutions. *Table 27* below displays nitrate levels in the Chain Lakes system.

Table 27: Chain Lakes Nitrate Water Quality Monitoring Results* 2007-2016 (mg/L)										
Sample Site Name \ Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CLG1	-		ND	0.089	0.150	0.083	0.076	0.074	ND	0.057
CLG2 (intake)	-	-	ND	ND	0.040	0.046	0.053	0.068	ND	ND
CLG3	-	-	-	-	-	0.268	0.249	0.404	0.148	0.22
CLG4	-	-	-	-	-	-	0.411/ ND**	0.332/ ND**/ 0.17***	0.17	0.24
CLG5	-	-	-	-	-	-	ND	0.043	ND	ND
DLS	-	-	-	ND	-	ND	-	ND	ND	ND
HRM	ND	ND	ND	ND	ND	-	-	-	-	-

* All results are Baseline Conditions unless otherwise indicated
** Sewer forcemain break events averages
***Assumed Temporary Ground Water Infiltration (Aug-Sept 2014) during sewer replacement activities

Total Organic Carbon (TOC)

Total organic carbon concentration is indicative of organic matter loading into source water supplies. Elevated organic matter concentrations can result in taste and odour issues and lead to the formation of disinfection by-products. Dissolved organics can also play a role in the transport and availability of metals (i.e., methyl mercury). There is no maximum allowable concentration (MAC) for TOC for either the WQGPAL or GCDWQ because there is no known health concern directly related to elevated TOC concentrations. Detection limits are at 0.5 mg/L.

Chain Lakes TOC concentrations are low compared to other surface source water areas; i.e., Pockwock ~15 mg/L and Lake Major ~7 mg/L. Rajaratnam's (2009) report suggests that the lower TOC concentrations in the Chain Lakes system are due to the relative small size of the watershed area (~208.5 ha), natural state of the watershed, and past anthropogenic activities which has removed much of the organic overburden through forest, farming and quarrying operations. *Table 28*: Chain Lakes TOC Water Quality Monitoring Results 2007-2016(mg/L) below displays TOC concentrations since 2007.

Table 28: Chain Lakes TOC Water Quality Monitoring Results 2007-2016(mg/L)										
Sample Site Name \ Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CLG1	-	-	2.63	1.38	3.78	2.69	1.99	2.15	1.72	1.38
CLG2 (intake)	-	-	0.68	0.87	1.10	0.69	0.64	0.52	0.50	0.64
CLG3	-	-	-	-	-	2.35	2.19	2.16	3.37	1.98
CLG4	-	-	-	-	-	-	6.30*/ 46**	1.60*/ 67**/ 5.70***	1.85	1.31
CLG5	-	-	-	-	-	-	2.3	1.78	2.27	1.93
DLS	-	-	-	ND	-	ND	-	ND	ND	1.14
HRM	ND	ND	0.50	0.83	0.80	-	-	-	-	-

* All results are Baseline Conditions unless otherwise indicated
** Sewer forcemain break events averages.
***Assumed Temporary Ground Water Infiltration (Aug-Sept 2014) during sewer replacement activities

Sample point CLG4 showed the highest TOC levels (67 mg/L) for a short period (less than a month) due to a sewer forcemain break. TOC levels have since returned to baseline conditions similar to that of the other watershed sample sites (see *Table 28* above).

Rajaratnam's (2009) report also suggests it would only take a fire or development of some kind to increase TOC concentrations. Due to its relative small size the impact(s) would be immediate and last indefinitely. The Chain Lake water treatment facility does not have the capabilities of removing organic carbon; therefore, it is important that TOC concentrations remain at a low level. Further, the water treatment process involves chlorination only. In the event of an organic carbon increase, unacceptable levels of disinfection by-products such as trihalomethanes (THM) could result and be released into the main distribution system as Chlorine is added to the water as it leaves the plant. THM is considered a health risk and has demonstrated carcinogenic activity in laboratory animals.

Halifax Water will continue to measure TOC to properly assess the health of the water supply. If CCME WQGPAL or GCDWQ change, Halifax Water will have adequate water quality information available to aid in water quality management decision-making.

Total Chloride

Chlorides are measured across the watershed to better understand natural conditions and monitor for anthropogenic activities. CCME WQGPAL chloride levels considered toxic to aquatic life are; short term concentration is 640 mg/L and long term concentration is 120 mg/L. *Table 29* on page 119 displays the Chain Lakes watershed area water quality sample chloride levels.

The chloride levels in the Chain Lakes watershed area are the highest among all of Halifax Water's source water areas – Pockwock and Lake Major ~4 mg/L. As demonstrated in *Table 29* on page 119, chloride levels are above or approaching the CCME WQGPAL long term levels (120 mg/L) considered toxic to aquatic life.

Halifax Water has met with NSTIR and HRM public works staff to share water quality information and discuss measures to lower chloride levels. Both public works agencies have met with their respective operations staff and have since confirmed via formal letter to Halifax Water that they are using best management practices and alternative cold weather road maintenance programs to help reduce road de-icing agents and/or activities that impact the watershed. For instance, NSTIR and HRM acknowledge that there is high probability that salt truck operators from each agency are doubling up on road de-icing applications, to cross over roads that are not their responsibility. HRM and NSTIR staffs have indicated they will no longer apply road de-icing agents to roads that are not under their jurisdiction, to help reduce chloride concentrations in runoff to the watershed. Halifax Water will continue to monitor chloride levels and meet with HRM and NSTIR to assess cold weather practices and changes to water quality as necessary.

Chloride levels at CLG4 did increase (440 mg/L) during the sewer forcemain breaks; however have since returned to baseline conditions similar to those of the other watershed sample sites (see *Table 29* on page 119).

Table 29: Chain Lakes Chloride Water Quality Monitoring Results* 2007-2016(mg/L)										
Year / Sample Site Name	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CLG1	-	-	104	218	145	191	212	137	118	128
CLG2 (intake)	-	-	130	97	81	72	95	65	87	94
CLG3	-	-	-	-	-	288	295	197	172	250
CLG4	-	-	-	-	-	-	166/ 440**	136/ NA**/ NA***	82	94
CLG5	-	-	-	-	-	-	65	129	110	117
DLS	-	-	-	125	-	85	-	97	110	93
HRM	87	147	147	114	79	-	-	-	-	-

* All results are Baseline Conditions unless otherwise indicated
** Sewer forcemain break events averages.
***Assumed Temporary Ground Water Infiltration (Aug-Sept 2014) during sewer replacement activities

Metals Scan

Metals occur naturally within soils and bedrock and can present a negative impact to drinking water quality. Therefore, it is important to determine which metals are detectable within the Chain Lakes water supply source and whether they are within the recommended GCDWQ and CCME WQGPAL, and/or are present as a result of watershed area activities.

Water chemistry of surface waterways is highly influenced by the kind of soil and rock through or over which the water flows. The main physical, chemical and biological parameters that influence water composition are temperature, pH, redox potential, adsorption and desorption processes from inorganic or organic suspended matter or bottom sediments, cation exchange, dilution, evaporation, and presence of organisms. These conditions are the product of natural background conditions and/or anthropogenic activities that cause heavy metals to accumulate to critical levels in the food web and damage to organisms on a higher trophic level.

Generally, water quality sample results reflect the natural soil and rock formation-types that are typical in the area. Within the Chain Lakes watershed area, however, results were affected by the Bayer's Lake sewer pump house and forcemain breaks (see section *5.4.2: Risk-Based Sampling – Bayer's Lake Wastewater System* on page 124 for details).

Metal samples are collected twice a year; once during low-flow conditions (typically in July) and once during high-flow conditions (typically in September) at each of Halifax Water's six sample point locations.

The following are the most prevalent metal concentrations found in the Chain Lakes water supply.

<u>Aluminum (Al)</u>

Aluminum is the most abundant element on earth, making up about 8% of the earth's crust and is found naturally in foods such as spinach, potatoes and tea. It is widely used throughout the world in manufacturing processes, agriculture industries and as a coagulant in the treatment of drinking water to reduce the organic matter, colour, turbidity and microorganisms contained in raw water.

Aluminum concentrations in natural waters "*can vary significantly depending on various physicochemical and mineralogical factors*". Also, "*acid environments caused by … acid rain [accumulated in the soil*[i]*] can cause an increase in the dissolved aluminium content of the surrounding waters (ATSDR, 1992; WHO, 1997)*." PH influences the solubility of aluminum such that "[*i]n pure water, aluminium has a minimum solubility in the pH range 5.5–6.0;* and *concentrations of total dissolved aluminium increase at higher and lower pH values (CCME, 1988; ISO, 1994)*." The main sources of aluminum in the environment are from fertilizers, sewage sludge, mining and smelting.

The CCME WQGPAL recommends maximum aluminum concentration levels at: 5 µg/L where pH is <6.5 and 100 µg/L where pH is >6.5. Studies associating the link of human health effects due to the consumption of high levels of aluminum found in drinking water (<2000 µg/L) are inconclusive, therefore, presently there is no recommended Maximum Acceptable Concentration (MAC) for Aluminum. *Table 30*: Chain Lakes Aluminum Water Quality Monitoring Results* 2007 – 2016 (µg/L) below outlines aluminum levels recorded since 2007.

Table 30: Chain Lakes Aluminum Water Quality Monitoring Results* 2007 – 2016 (µg/L)

Year / Sample Site Name	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CLG1	-	-	-	1490	714	865	621	1045	875	920
CLG2 (intake)	-	-	-	331	254	269	325	200	255	103
CLG3	-	-	-	-	-	919	436	66	136	81
CLG4	-	-	-	-	-	-	465	300** /38***	200	410
CLG5	-	-	-	-	-	-	-	465	420	415
DLS	-	-	-	340	-	406	-	185	200	130
HRM	510	697	564	481	198	-	-	-	-	-

* All results are Baseline Conditions unless otherwise indicated
** Sewer forcemain break events averages
***Assumed Temporary Ground Water Infiltration (Aug-Sept 2014) during sewer replacement activities

With reference to *Table 18: Chain Lakes pH Water Quality Monitoring Results* 2007 - 2016* on page 109, showing Chain Lakes' source water pH levels are <5, aluminum levels should not exceed 5 µg/L for the CCME WQGPAL. However, as *Table 30: Chain Lakes Aluminum Water Quality Monitoring Results* 2007 – 2016 (µg/L)* on page 120 shows, First Chain Lake aluminum hovers around the 250-300 µg/L, which is 1.5 to 2 times higher than those of its closest source water supply counterparts; i.e., Bennery's (126.7 µg/L), Pockwock's (139.7 µg/L) and Lake Major's (226.4 µg/L). Further, Rajaratnam (2009) observes that First and Second Chain lakes are undergoing oligotrophication through acidification. Moreover, high aluminum concentrations released through acid rain and acidic soil runoff bond with low phosphorus levels (see under heading *Total Phosphorus and Nitrate-Nitrogen* earlier in this section on page 115) to settle out at the bottom of the lake. Rajaratnam (2009) believes these lakes were mildly acidic due to their natural surroundings during pre-industrial Halifax. Industrialization has expedited the process, which has further impacted water quality.

Zinc (Zn)

Zinc (Zn) is fourth in the world among annually consumed metals behind Iron (Fe), Aluminum (Al), and Copper (Cu). Zinc is extensively used in automobile manufacturing and agriculture industries. The main sources of zinc in the environment are fertilizers, sewage sludge, and mining and smelting. Other sources include vehicle exhausts and tire wear and corrosion of galvanized steel.

Zinc is essential for both plants and animals. Zinc toxicity in humans is very rare. High intake of this metal may affect cholesterol levels. As shown in *Table 31: Chain Lakes Zinc Water Quality Monitoring Results* 2007 – 2016 (µg/L)* on page 122, zinc levels recorded from samples collected in the Chain Lakes watershed area are well within GCDWQ maximum concentration (5000 µg/L).

CCME WQGPAL's recommended maximum zinc concentration depends on the hardness of the water sampled. Recommended zinc concentrations are not to exceed 30 µg/L at any one time or 7.5 µg/L on a 30-day average when water hardness is less than or equal to 90 mg/L. *Table 31* on page 122 outlines the Chain Lakes watershed area raw water supply source average zinc levels, for each year since Halifax Water began recording the data since 2007.

The average raw water hardness of First Chain Lake is 20 mg/L and exceeds CCME WQGPAL, which recommends 30-day 7.5 µg/L. First Chain Lake zinc concentrations hover around 15- 20 µg/L which is 3 to 4 times higher than its larger source water counterparts Bennery (<5 µg/L), Pockwock (<5 µg/L) and Lake Major (<5 µg/L). On average, most of the Chain Lakes' tributaries reflect the same zinc concentrations (see *Table 31* on page 122) as First Chain Lake, indicating zinc sources are evenly distributed across the watershed.

However, three of the seven Chain Lake watershed sample points had at least one sample exceeding the one-time 30 µg/L threshold. Between 2009 and 2013, tributary sample points CLG1 and CLG4 each experienced single events measuring slightly over the threshold; i.e., 30.6 µg/L (Sept. 2012) and 37.4 µg/L (July 2013) respectively. Considering both tributaries flow through Halifax Formation sulphide-bearing bedrock in the northern section of the watershed and there is little to no development within the watershed, it is believed these increased zinc levels are the result of tributary acidification. Acid rain reacts with the highly soluble zinc as it runs over and through the bedrock and shallow soils, causing higher than normal background conditions.

A second significantly higher zinc concentration level (85 mg/L) was observed in July 2014, which may be attributed to the Bayer's Lake sewer forcemain break since the sample was collected the day of the break.

Although the water in the tributary leading to sample point CLG3 is most likely affected by acidification as well, this tributary crosses over two totally different bedrock types; i.e., late Devonian biotite monzogranite and middle late Devonian granodiorite (see Map A: Bedrock Geology on page 17). These formations have less acidic characteristics. However, elements are more concentrated where geological formations meet which could explain why Zinc concentrations are 3 to 4 times higher in this area compared to the areas covering the Halifax Formation as previously described.

In addition to being impacted by the differing bedrock types, the tributary at sample site CLG3 is also highly impacted by anthropogenic activities associated with the Bayer's Lake Business Park. Such activities would include development and exposure of sulphide-bearing soils and rock, manufacturing, sewage overflow from the Bayer's Lake wastewater pump station and exhaust from high levels of traffic. The Bayer's Lake pumping station was reduced to a single pump as part of the Bayer's Lake sewer replacement project in 2014. This has greatly reduced the risk to the Bayer's Lake Brook, however, a concentration of 150 μg/L was observed in July 2015 due to a clogged pipe at the Bayer's Lake diversion dam that caused the water to back up. The water was slowly released and zinc concentrations returned to normal background conditions within one week.

Although dilution could reduce the impacts associated with the Bayer's Lake Business Park, water flow from the Park should not be allowed to be diverted into the Chain Lakes watershed area unless deemed absolutely necessary. If water diversion into Chain Lakes is permitted, a boil order advisory should be issued and the Bayer's Lake Business Park put on notice to minimize industrial contamination, as indicated in other water quality sections.

Table 31: Chain Lakes Zinc Water Quality Monitoring Results* 2007 – 2016 (μg/L)

Sample Site Name \ Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CLG1	-	-	-	18.9	14.35	22.35	15.50	21.50	20.50	20
CLG2 (intake)	-	-	-	15.4	14.55	15.50	18.15	13.50	19	11
CLG3	-	-	-	-	-	56.20	58.25	19.10	78	14.1
CLG4	-	-	-	-	-	-	28.2	85**/ ND***	23	25
CLG5	-	-	-	-	-	-	-	16	17.50	15.5
DLS	-	-	-	19	-	15.45	-	17	14.50	14.25
HRM	22.00	24.33	23.67	14.5	10.5	-	-	-	-	-

* All results are Baseline Conditions unless otherwise indicated
** Sewer forcemain break events averages
***Assumed Temporary Ground Water Infiltration (Aug-Sept 2014) during sewer replacement activities

Nickel (Ni)

Nickel (Ni) is ranked 23rd in abundance within the earth's crust with an average of 80 ppm. The average concentration of Ni in a freshwater medium is 0.5 μ/L and in a soil medium (world) is 20ppm. Nickel is a metal mainly used for electroplating, alloy production, battery components and as a catalyst for hydrogenation of fats and methanation. Nickel is most largely applied in stainless steel production and is therefore found in a broad range of products including automobiles, batteries, coins, jewellery, surgical implants, kitchen appliances, sinks and utensils. The main source of Ni in the environment is from mining and smelting, sewage sludge and from fuel oil and coal combustion.

Nickel is an essential nutrient for both plants and animals. However, Ni is approaching toxicity levels towards plants in concentrations >50 ppm; therefore, concentrations must be restricted when applied to agricultural lands. Nickel is insoluble in water, but in lakes, dosages can be harmful to aquatic fish and plants. Long term exposure to low levels may result in reduced skeletal calcification and asphyxiation in fish. The human body can regulate Ni levels homeostatically, although large acute doses can be harmful or even fatal. The most common long-term effect for humans is contact dermatitis.

There is no MAC for Ni in drinking water according to GCDWQ; though the WHO recommends a drinking water MAC of 70 µg/L. Twenty (20) µg/L should be achievable by conventional water treatment processes (e.g., coagulation). *Table 32: Chain Lakes Nickel Water Quality Monitoring Results 2007 - 2016* below displays the Ni levels recorded in the Chain Lakes watershed area raw water supply source since 2007.

The suggested maximum Ni concentration for the protection of aquatic life is dependent on the hardness of the water sampled. The average raw water hardness of First Chain Lake is 20 mg/L; therefore, according to the CCME WQGPAL, when water hardness is 0 to ≤ 60 mg/L, the GCDWQ is 25 µg/L. Observed nickel concentrations in the Chain Lakes watershed area meet WHO recommended human health guidelines (70 µg/L) for all watercourses. However, sample point CLG3 experienced Ni levels that exceed the CCME WQGPAL. High nickel concentrations in this area are presumed to be due to bedrock formations exacerbated by anthropogenic activities in the Bayer's Lake Business Park, similarly due to conditions described under the Aluminum and Zinc headings in this subsection.

Table 32: Chain Lakes Nickel Water Quality Monitoring Results 2007 - 2016

Year / Sample Site Name	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CLG1	-	-	-	7.2	7.1	11.4	10.0	12.0	10.5	9.05
CLG2 (intake)	-	-	-	3.1	3.0	3.4	4.1	3.1	4	3.1
CLG3	-	-	-	-	-	35.3	50.5	13.25	12	5.55
CLG4	-	-	-	-	-	-	6.4	60**/ 6.7***	5.7	6.8
CLG5	-	-	-	-	-	-	-	4.4	4.5	3.2
DLS	-	-	-	3.3	-	3.8	-	3.6	3.7	3.7
HRM	4	4.3	4	4	3	-	-	-	-	-

* All results are Baseline Conditions unless otherwise indicated
** Sewer forcemain break events averages
***Assumed Temporary Ground Water Infiltration (Aug-Sept 2014) during sewer replacement activities

Overall, Ni concentrations in the Chain Lakes watershed area have been recorded at twice the recommended CCME WQGPAL concentration levels and are approaching the WHO human exposure recommendation limit. Such concentration level readings indicate that if water were diverted to the Chain Lakes water supply system, via opening of the Bayer's Lake Diversion Dam, it could have a negative impact on the aquatic life present in the system. Although ambient dilution could reduce that impact, diverting water from the Bayer's Lake Business Park into the Chain Lake system is nevertheless not recommended unless deemed absolutely necessary. In such an event, a boil order advisory should be issued and the Bayer's Lake Business Park put on notice to minimize industrial contamination, as stated in other water quality sub-sections.

Overall, the increase in metal concentrations in the Chain Lakes watershed area is apparently largely due to runoff from the Bayer's Lake Business Park.

Deep Lake Sampling

The Bathymetry of First and Second Chain Lakes at their deepest points are 12.4 m and 12.2 m respectively (see *Appendix 1: Bathymetric Maps of First and Second Chain Lakes* on page 130).

Weather permitting, Deep Lake Sampling (DLS) is carried out in First Chain Lake (see sample site location indicated on *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19) quarterly. Deep-lake sampling is collected to better understand baseline conditions of the water supply characterize the water supply source and monitor for any changes in baseline water-quality conditions. The method used to conduct deep lake sampling involves collecting several discrete water samples at various depths using a single volume-weighted sampling unit.

Deep lake water quality information collected to date is outlined in *Table 17 –Table 32* beginning on page 107. Based on the information gathered, First and Second Chain lakes display strong oligotrophic to ultra-oligotrophic characteristics through acidification. Although these lakes are capable of supporting aquatic life, there are a number of factors (already described in this section) which may be limiting the system's potential to host aquatic life. Halifax Water will continue to conduct deep lake sampling in First Chain Lake to monitor for changes in water quality.

5.4.2 Risk-Based Sampling

Risk-based sampling is scheduled and linked to probable risk(s). Results of the sampling may lead to changes in management, protection efforts, regulations and/or restriction of certain activities.

Petroleum Hydrocarbons

Petroleum-hydrocarbon sampling is monitored at five locations (CLG1-CLG5) for potential hydrocarbon spills. Sources of contamination include vehicular traffic along Hwy 102, North West Arm Drive, Hwy 103, St. Margaret's Bay Road and Bayer's Lake Business Park, and other sources such oil-based heating systems and manufacturing facilities associated with the Bayer's Lake Business Park. Petroleum hydrocarbon samples are taken twice a year, in March and September during high water-flow periods at all sample site locations. To date, collected sample results show no indication of petroleum hydrocarbon contamination. Halifax Water will continue to monitor these locations as a precautionary measure and to raise the alert should concerns arise.

Bayer's Lake Wastewater System

The Bayer's Lake Wastewater system was upgraded in 2014.The upgrade consisted of replacing the old forcemain with a gravity flow system, and the Bayer's Lake pump station was reduced to a lift station to continue servicing a small number of businesses below the gravity flow line (see section *Central Sewer and Wastewater Systems* on page 24). Prior to the upgrade completion, three (3) forcemain breaks were experienced in a 19 month period (January 16, 2013, April 16, 2013 and July 9, 2014) (see section *5.4.1: Baseline Sampling* beginning on page 105 and monitoring results in *Table 17 – Table 32).* As outlined in these tables, emergency response and follow-up water quality monitoring was completed as a result of these breaks. The results of the monitoring indicated that the impact to water quality inside the watershed area was confined to the immediate area and did not reach the Chain Lakes water supply.

Water quality baseline sampling sites CLG1, CLG4 and CLG5 along the length of the new pipeline are monitored for the unlikely event of a leak or break in the new pipeline (see *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19).

Bayer's Lake Diversion Tributary

Sample point CLG3 will continue to monitor the Bayer's Lake diversion tributary for risk of sewage overflow from the refitted Bayer's Lake lift station and business park sources of contaminants. For more details on the risks that are being monitored by this program, see section *3.1.4: Wastewater Treatment Infrastructure* on page 49.

5.4.3 Activity-Based Sampling

Activity-based sampling is scheduled based on known events including forestry, road de-icing, construction activities and other known activities. Activity-based sampling helps determine cause-and-effect relationships and short- and long-term effects of impacts on the watershed area that help determine how best to manage land-use activities and the frequency with which physical patrols and water quality monitoring are conducted. The parameters tested for are determined by the activity and the impact it may present to the water supply source, as described in the subheadings below.

The most recent implementation of an activity-based sampling initiative was in association with the sewer forcemain replacement program, the results of which are described in section *5.4.3: Bayer's Lake Sewer Forcemain Replacement Program* on page 126.

E. coli

Activity-based *E. coli* sampling is a result of activities such as removing beaver dams, or wastewater replacement programs within the watershed. When there is a clear and direct pathway to the lake during an activity, *E. coli* sampling will be performed daily and continue for one week after the event is over.

Total Phosphorus and Nitrate-Nitrogen

Phosphorus and nitrate-nitrogen samples are collected during scheduled forestry, or other development activities. Samples will be conducted weekly during the activity and continue for one week after the activity has been completed.

Total Suspended Sediments (TSS)

Total suspended sediments are typically elevated in stream systems during and immediately following forestry activities, road construction and maintenance, and any other activity that disturbs stream crossing or nearby land. Increased suspended sediments change a stream environment by clogging interstitial spaces between rocks, altering the stream bottom and affecting light penetration in the water column. Each of these effects has a cascading effect (e.g., decreased dissolved oxygen, stressed aquatic biota, and increased TSS). Sampling will be conducted daily during activities where there is a clear and direct pathway to the lake.

Petroleum Hydrocarbons

Activity based petroleum sampling is in response to events or spills occurring within the watershed area. In response to such an event, sampling will be conducted daily and continue for one week after operations have been completed. Samples will be collected from watercourses within 200 m of the event site, as well as from affected dominant feeder streams downstream from the spill where they flow into Chain Lakes.

Activities that recently required an activity-based sampling regime were the Bayer's Lake sewer forcemain replacement program and road de-icing (Total Chloride), described in more detail under the relevant headings following.

Bayer's Lake Sewer Forcemain Replacement Program

The Bayer's Lake sewer forcemain replacement project was completed along the Chain of Lakes Trail in the summer of 2014. The project was considered a scheduled activity for which activity-based samples were collected during the project's operation where the project fell within 200 m of a clear and direct path to the lake or tributary (see section *5.4.2: Bayer's Lake Wastewater System* on page 124). The following parameters were collected daily and continued for one week after operation activities were completed and until baseline conditions were achieved:

- Temp
- pH
- Colour
- Conductivity
- E.coli
- Total Phosphorus and Nitrate-Nitrogen
- Total Suspended Solids
- Petroleum Hydrocarbons

Throughout the construction phase, when water quality parameters exceeded baseline conditions, work was stopped immediately, corrective measures were implemented to identify the source and restore the affected area to baseline conditions as early as possible, and NSE was notified, as required. For example, under normal conditions, clear flow conditions for CLG4 TSS levels were calculated to be 2.10 mg/L (see section *5.4.1: Clear flow Conditions* on page 112). Permit requirements were such that TSS was not to exceed 25 mg/L. During the project, the average clear flow condition was ~6 mg/L not including the July 9 forcemain break. However an unanticipated heavy rain fall event in August 2014 was observed where TSS high flow conditions, measuring 47 mg/L, was captured (see section *5.4.1: Clear flow Conditions* on page 112). In response, extra hay and silt fences were installed to reduce the impact of future high flow conditions. After the sewer line installation was completed, TSS levels have since returned to baseline conditions similar to other areas (see *Table 21: Chain Lakes TSS Water Quality Monitoring Results* 2007 – 2016 (mg/L)* on page 113).

Total Chloride

Road de-icing is not restricted within the Chain Lakes watershed area (see section *3.1.6: Road De-icing* on page 58), as a result Activity-based samples are collected monthly at each site along major roadways within the watershed; i.e., Hwy 102, Hwy 103, North West Arm Drive and the

Bayer's Lake Business Park during cold-weather operations to monitor chloride levels (see *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19).

As per section *4.2.12: Road De-icing Agents* on page 88, NSTIR and HRM have acknowledged operational inefficiencies that may be contributing to the increase in Total Chloride levels in the Chain Lakes watershed area. They have met with their respective staff and formally responded via posted letter to Halifax Water to acknowledge that these agencies would improve cold weather road practices and reduce or find alternatives to road de-icing. This should reduce chloride levels within the Chain Lakes watershed area while ensuring that public safety is not at risk from icy road conditions. See *Table 29: Chain Lakes Chloride Water Quality Monitoring Results* 2007-2016(mg/L)* on page 119 which shows that chloride concentrations levels are above or approaching levels considered toxic to aquatic life over the long term (see more details in section *5.4.1: Total Chloride* on page 118).

5.4.4 Targeted-Based Sampling

Target-based sampling is done as a response to incidents or unplanned events such as a fuel or environmental spill, significant weather events, vandalism or malicious intent. Such sampling protects customers by providing a warning system that monitors events with the potential to shut down the pumping station.

Target-based sampling will be conducted at watercourses within at least 200 m of the scene and in all dominant feeder streams downstream of the event at minimum 500 m intervals daily until it reaches First and/or Second Chain Lake, then daily at minimum 500 m intervals along the lake(s) to track its progress. Sampling intensity could be increased and or reduced depending on whether detection limits persist and the contaminant progresses along the travel path. The pumping station will be shut down, if in operation, when an event occurs and high-levels of a contaminant persist within 500 m of the pumping station. Sampling will continue until it has been determined there is no longer a threat to water quality and the plant can be restarted.

The following parameters are considered to present the highest probable threat to water quality in the event of an accident or unplanned event within the Chain Lakes watershed area and are monitored as described under the following headings.

Petroleum Hydrocarbons

Petroleum-hydrocarbon sampling is conducted in response to incidents or unplanned events along Hwy102, Hwy 103, North West Arm Drive, the Bayer's Lake Business Park, forestry activities, OHVs, boating inside the watershed and construction within the watershed.

E. coli

E. coli sampling is conducted in response to incidents or unplanned events such as the failure of the Bayer's Lake wastewater system (see section *5.4.1: E. coli* on page 113 for further details of past breaks and overflows). For the three breaks that occurred over a 19 month period (see *Table 23* on page 114 – *Table 25* on page 114) *E. coli* levels usually returned to baseline conditions (see *Table 22* on page 113) within 2 weeks of repairs. In all cases, the entry points to the water supply (Second Chain Lake) were monitored with no impact to the water supply observed.

Total Phosphorus and Nitrate-Nitrogen

Total phosphorus and nitrate-nitrogen sampling is conducted in response to unplanned events such as chemical spills, accidents, and wastewater system.

Turbidity

Turbidity samples are collected in response to unplanned events such as a storm, fire, and wastewater failure.

Chemical Spill or Release

Chemical sampling will be conducted in response to incidents or unplanned events along Hwy102, Hwy 103, North West Arm Drive, and the Bayer's Lake Business Park.

5.4.5 Operational/Compliance Raw Water Sampling

Operational raw water sampling is routinely performed as per operating permits and is the responsibility of the Water Quality Supervisors and Managers. Raw water compliance monitoring is also conducted at the intake and reported back to NSE. Water quality data gathered for both operational and raw water sampling programs may be used as supplemental water quality data for either program if necessary.

5.4.6 Source Water Quality Monitoring Program Summary

The SWQMP indicates, under normal (baseline) conditions, that the Chain Lakes water supply may not always meet the CCME WQGPAL (see section *5.4.1: Metals Scan* on page 119); however, with minimal treatment it meets GCDWQ and thereby provides an acceptable short-term (72 hr) emergency back-up water supply to the Pockwock system. It is strongly recommended that Halifax Water continue to monitor CLG1 through CLG5 and CLDL to provide data that will guide watershed and/or pumping station decision-making; and continually assess and evaluate the program to ensure water quality needs are being met.

6 ACKNOWLEDGEMENTS

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APPENDIX 1: BATHYMETRIC MAPS OF FIRST AND SECOND CHAIN LAKES

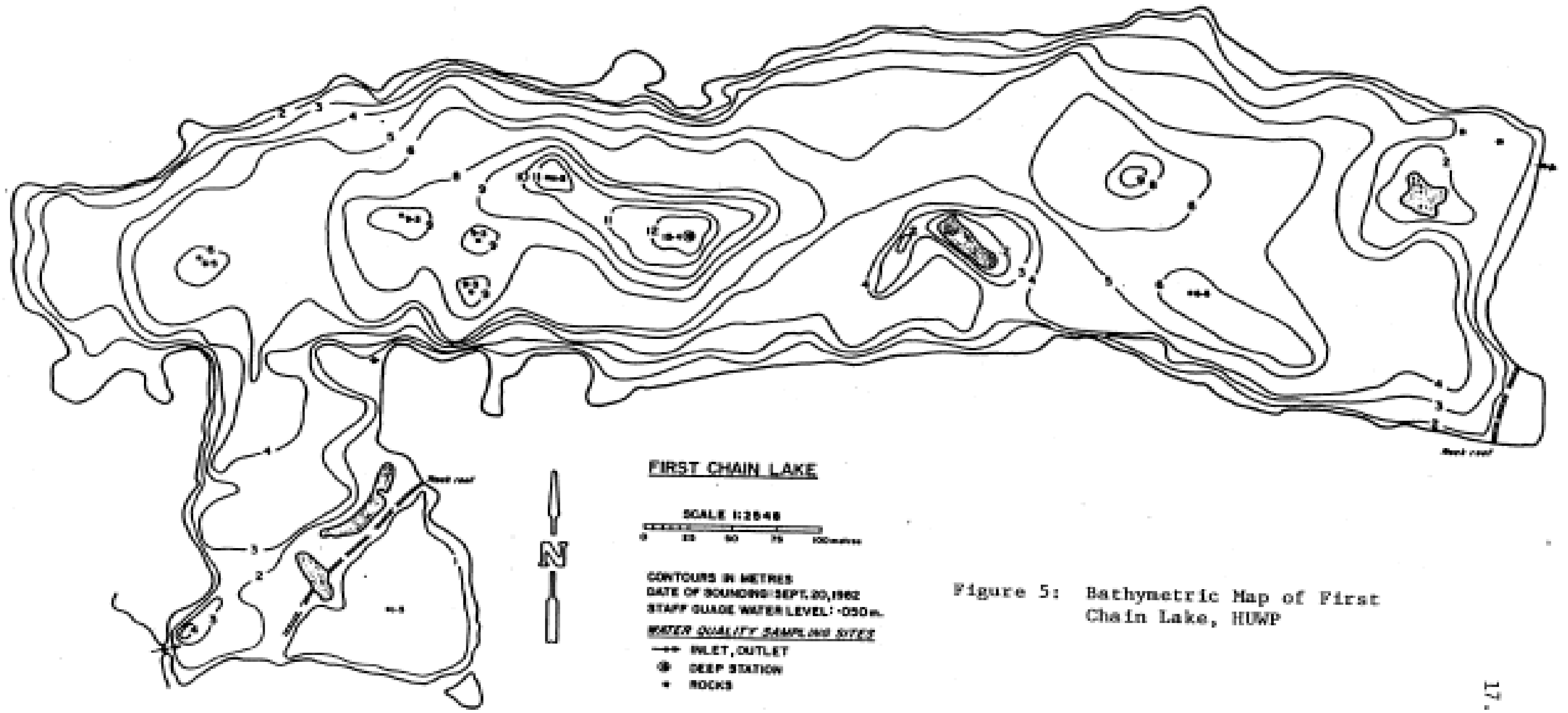


Figure 5: Bathymetric Map of First Chain Lake, HUWP

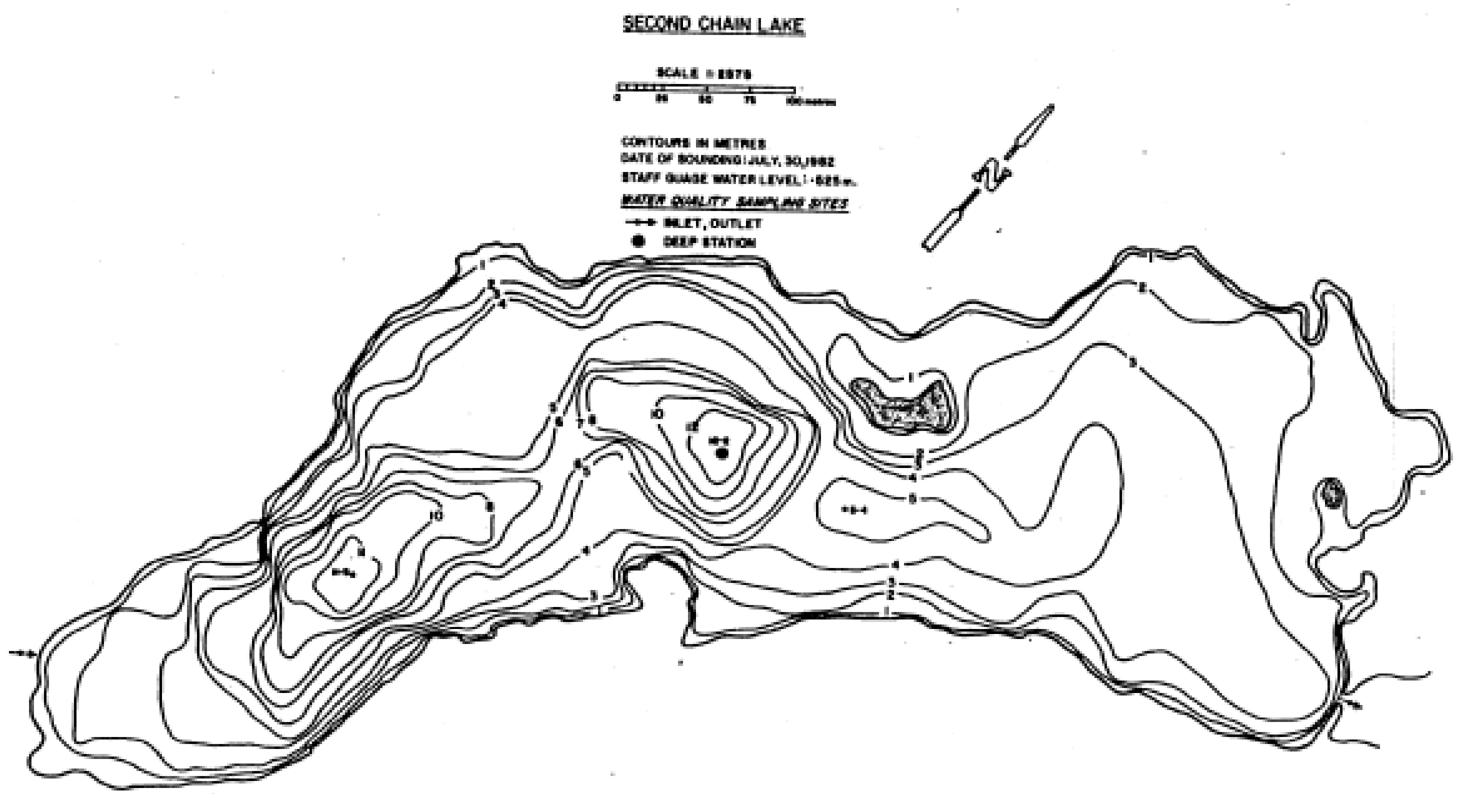
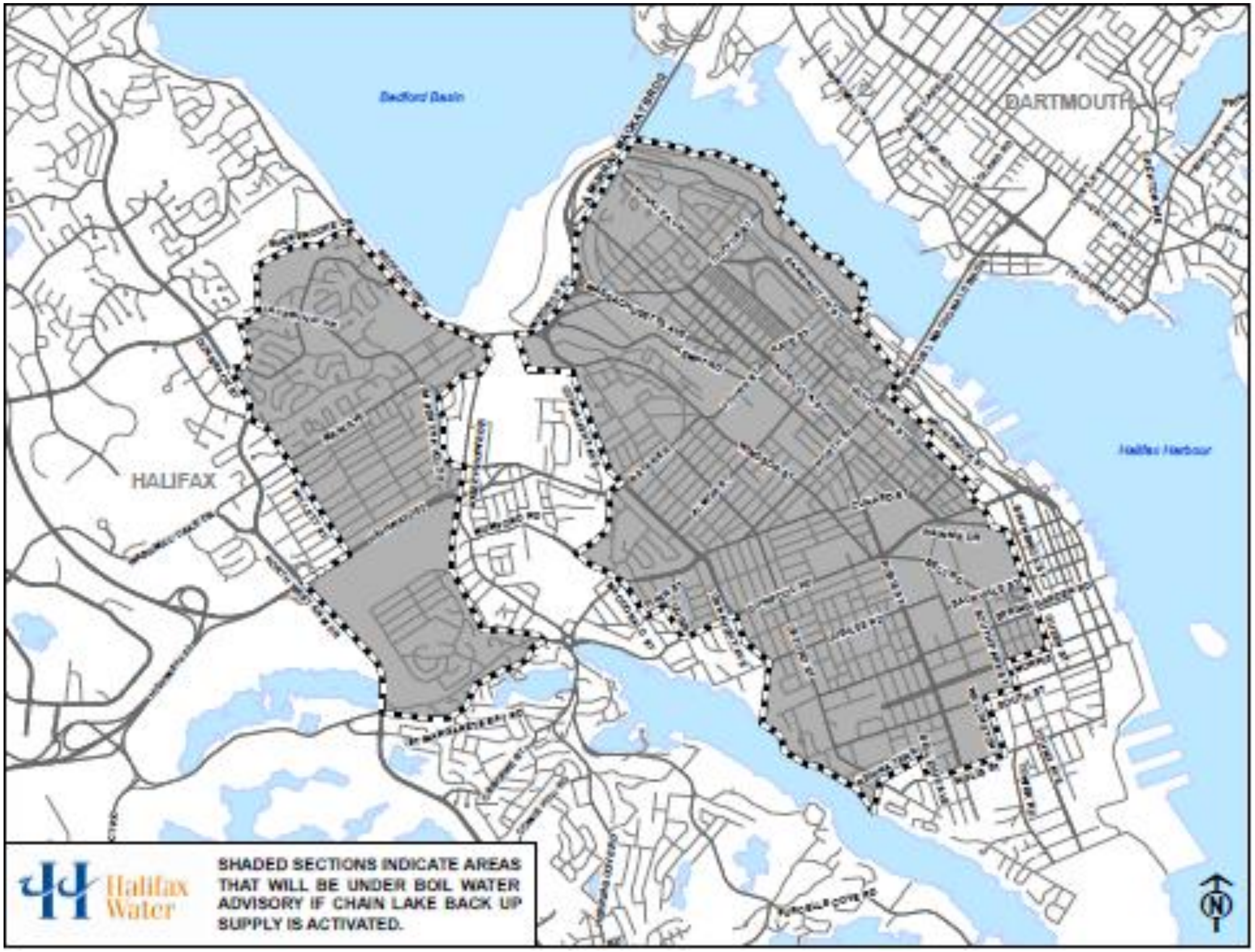


Figure 6: Bathymetric Map of Second Chain Lake, HUWP

19.

APPENDIX 2: CUSTOMER SERVICE AREA IN CHAIN LAKES WATER SUPPLY EMERGENCY SCENARIO



APPENDIX 3: CHAIN LAKES WATER SAMPLING LOCATIONS, FREQUENCY AND PARAMETERS

Sample Site Name	Description	Sampling Frequency	Parameters Monitored

CLG-1	Geizer Hill Brook inlet into Chain Lake	Monthly: unless there are operational or safety constraints	**Field Test** (In Situ Parameters):
			• Using YSI Sonde:
			  ○ DO, pH, Temperature, Conductivity
			• Using Turbidimeter:
			  ○ Turbidity
			Lab Tests (by third party, currently Maxxam):
			• Total Suspended Sediments (TSS)
			• *E. coli*
			• Total Phosphorus
			• Nitrate-Nitrogen
			• Total Organic Carbon
			• Metals Scan performed July and September
			• Chlorides testing November to April
			• Petroleum Hydrocarbons testing March and September

CLG-2	Pumping station inlet		
CLG-3	St Margaret's Bay Rd.		
CLG-4	Bayer's Lake diversion		
CLG-5	Bayer's Lake diversion		

CLDL1	Single deep lake station in Chain Lake (see approximate location in *Appendix 1: Bathymetric Maps of First and Second Chain Lakes* on page 130) where samples are collected at each thermal layer during stratification. Otherwise, samples will be collected at surface and bottom.	Seasonally; i.e., three times per year	**Field Test** (In Situ Parameters):
			• Using YSI Sonde:
			  ○ DO, pH, Temp, Conductivity
			• Using Turbidimeter:
			  ○ Turbidity
			• Secchi Disc Method:
			  ○ Total Suspended Sediments
			Lab Tests (by third party, currently Maxxam):
			• Chlorophyll-a
			• *E. coli*
			• Total Phosphorus
			• Nitrate-Nitrogen
			• Metals Scan

See *Map C: Hydrology and Raw Water Sampling Collection Points* on page 19 for illustration of sample sites.

APPENDIX 4: HALIFAX WATER GUIDELINES FOR GEOCACHING

Halifax Water Guidelines for Geocaching

Halifax Water manages approximately 14,000 hectares of watershed land in and around Halifax Regional Municipality. This land is managed using a multiple barrier approach that is comprised of a series of checks and balances designed to protect the high quality of existing water resources in the Halifax area. Halifax Water is experiencing more frequent geocaching activities on its watershed lands.

Halifax Water may allow low impact recreational use of watershed lands when conducted in compliance with Halifax Water policy and guidelines. The following guidelines have been developed in cooperation with the Atlantic Canada Geocaching Association. The goal of these guidelines is to facilitate safe and low-impact use of Halifax Water watershed lands by geocachers, while ensuring the protection of the quality of Halifax Water managed resources.

Geocaching Guidelines:

1) **Halifax Water watershed lands may contain geographic or other features that pose a risk to the health and safety of recreational users. Users of Halifax Water watershed lands must do so at their own risk.**

2) **Caches may only be placed in approved locations authorized by Halifax Water as prescribed:**
   a. Map and description must be submitted to Halifax Water for review and approval before site is established;
   b. Halifax Water Geocache seal must be clearly marked on cache container or the cache will be removed by Halifax Water staff;
   c. Cache must be registered with *Geocaching.com* website (www.geocaching.com) or cache will be removed; and
   d. Cache owner must maintain site.

3) **Caches must be easily accessible from established roads and maintained trails. Preference will be given to significant cultural and heritage sites.**

4) **Caches must only be placed where natural resources such as soil, vegetation, and/or water quality will not be compromised. Similarly, contents of caches must not present an environmental hazard.**