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Russell Lake Nutrient Source Desktop Assessment – Final

The following provides a desk top assessment of potential nutrient sources to Russell Lake, under the Standing Offer with Halifax Regional Municipality (HRM).

1.0 Background and Scope

Russell Lake is located within an urban watershed south of Portland Street in HRM. Water quality has been measured in the lake historically. As far back as the early 1970s, high total phosphorus (TP) concentrations have been observed. The lake was considered potentially eutrophic and concerns about lake water quality contributed to the formation of the Dartmouth Lakes Advisory Board (DLAB), which advised the Harbour East Community Council (HECC) until October 2012 (when HHEC was dissolved) about water concerns in the geographic area served by that Council. DLAB currently reports to Regional Council. In 2006, HRM established a threshold value of 15 micrograms/L (0.015 mg/L) for TP. The goal is that TP concentrations would not rise above that level in the Morris - Russell Lake Secondary Planning Strategy (SPS). HRM staff use the annual average TP value of the in-lake station for the purposes of assessing current Russell Lake water quality against this threshold value.

Water quality was perceived to have improved markedly over the years, but still received considerable attention through several studies from a variety of parties. Clayton Developments has been undertaking land developments in the Russell Lake watershed and had conducted water quality monitoring in the area since 2005 through Stantec, in accordance with a Development Agreement with HRM. More recently, a single high TP reading above 20 micrograms/L (0.02 mg/L) was reported in the lake in 2009. High TP results in the lake continued in 2011 through to April 2012. The annual average TP in Russell Lake's "In-Lake" station exceeded 20 micrograms/L for 2011, and was again above the 0.15 micrograms/L value and the meso-eutrophic trigger level of 20 micrograms/L (0.015 mg/L) (Canadian Council of Ministers of the Environment (CCME) total phosphorus trophic status trigger values) in April 2012. The elevated level was not found in the June or August 2012 monitoring results.

HRM has requested a desktop assessment of the most likely causes of total phosphorus results observed in the lake. The following provides a review of background data, identification of key subwatersheds and their potential nutrient contributions, and a summary of relative potential loading from the various sources.

2.0 Overview of Russell Lake

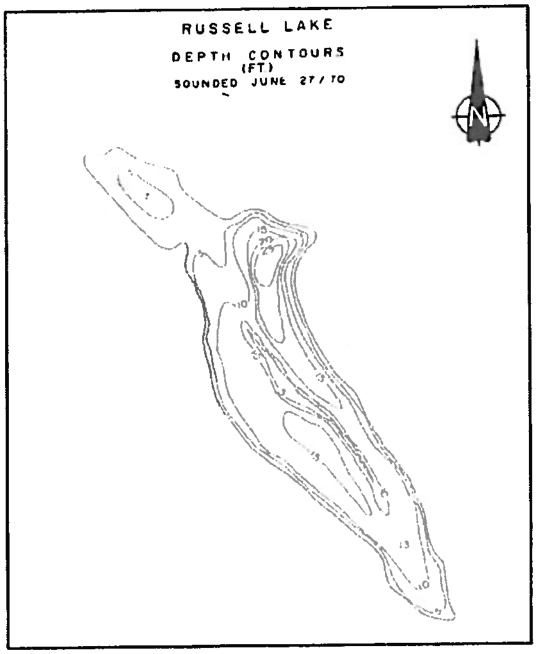
2.1 Lake Physical Characteristics

Russell Lake is a small, relatively shallow lake, currently within a predominately urban area. **Table 1** provides a summary of key physical characteristics.

Table 1 Summary of Lake Physical Characteristics

Characteristic	Data	Source
Watershed Area	334 ha	HRM GIS
Lake Area	34.8 ha	HRM GIS
Volume	1,063,300 m^3	Stantec 2006*
Maximum Depth	7.9 m	OceanChem 1988
Mean Depth	3.1 m	Stantec 2006
Flushing Rate	3-4 times per year	Stantec 2006*
Summer Stratification	Yes	Stantec 2006
Outlet	At north end of lake, flows to Morris Lake – Control structure of concrete and timber	HRM GIS; Griffths Muecke 1994

*OceanChem 1988 identified a higher volume and lower flushing rate.



Bathymetric contours for Russell Lake are provided in **Drawing 1**. It is noted that the deepest portion is near the outlet and the main lake is fairly shallow.

Winds within the area (Shearwater A station Environment Canada Normals) are typically west to northwest (15-20 km/hr.) in October to April, and south to southwest (10-15 km/hr.) in May to September. Both predominant wind directions are aligned with the length of the lake and facilitate wind mixing.

Drawing 1 Bathymetry Contours for Russell Lake (from OceanChem 1988)

A small portion of the north end of the lake (north pond) is somewhat isolated from the main lake by a causeway road construction (trunk sewer) (**Photo 1**). Based on the trunk sewer design drawings (Acres 1988), flow from the north pond area enters the main lake in three 750 mm pipe culverts located below the force main. The rock fill under the causeway may also allow some exchange of water between the pond and lake.

The lake shoreline is moderately steep along the east and west shores limiting rooted aquatic plant growth to the nearshore; but the shallower north pond (**Photo 2**), outlet cove and to some extent, the south tip of the lake allows extensive rooted plant development.

Photo 1 Causeway (Dec. 2012)

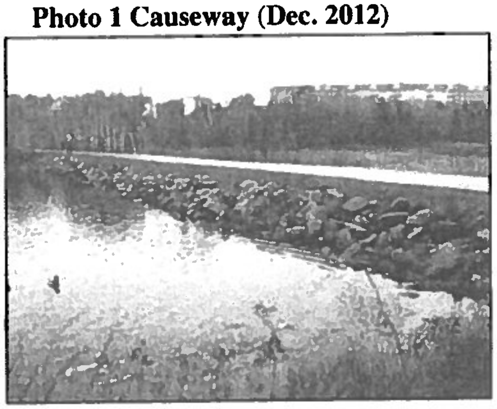
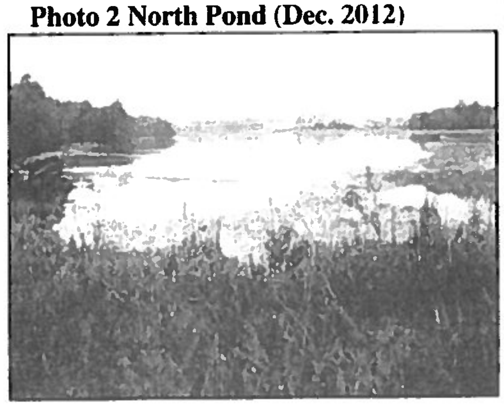


Photo 2 North Pond (Dec. 2012)



The Russell Lake outlet draining to Morris Lake is within a cove at the north east end of the lake. Extensive wetland vegetation occurs at the head of the cove (**Photo 3**) and includes a wetland along the north side receiving stormwater drainage from the north. The outlet structure is concrete with stoplog control and fishway (Clean Nova Scotia 2011) (**Photo 4**).

Photo 3 Lake Outlet Area (Dec. 2012)

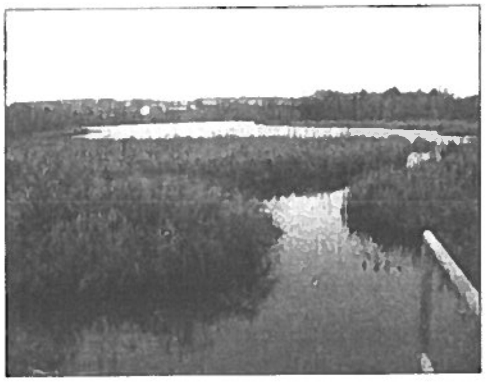


Photo 4 Outlet Structure (Dec. 2012)

2.2 Factors Affecting Nutrient Loading and Trophic Status

The trophic status of a lake is dependent on both the loading of nutrients, and the physical characteristics of the lake and watershed. Generally the key nutrient of concern in lakes is phosphorus. Although concentrations of TP can provide an indication of trophic state (Canadian Council of Ministers of the Environment – CCME Phosphorus: Canadian Guidance Framework 2004; trigger values), the actual trophic state is influenced by site specific phosphorus loading and cycling.

Phosphorus loading occurs from both natural and manmade sources. Natural runoff from native soils and bedrock is modified by watershed vegetation and by manmade (anthropogenic) land use affecting the concentration of TP in runoff. The volume of runoff is a factor of the size of the watershed and intensity of precipitation events. Runoff TP concentration and volume over time combine to make up loading to the lake. Atmospheric inputs directed to the lake include phosphorus derived both naturally and anthropogenically. Once in the lake phosphorous concentrations are affected by lake flushing rates, stratification conditions, settling of sediments, degree of wind mixing, and re-suspension of soluble nutrients associated with lake turnover as well as biological interactions. Suitability of the lake for rooted plants (extent of shallow areas with sediment) or for algae growing within the water column (phytoplankton) also can affect how and when the nutrients are used.

2.3 *Historic and Current TP Data*

Historical reports of algal blooms have been reported throughout the 1970s to 1990s. The following is some of the events noted primarily from a summary in the watershed management plan (Griffths Muecke 1994):

- 1971 hypolimnion anoxic conditions;
- 1974 blue-green algal bloom reported (in Ocean Science report);
- 1975 algal bloom reported (DLAB);
- early 1980s algal bloom reported (DLAB);
- 1994 high levels of algal growth; and
- 1998 algal bloom noted in late summer and abundant macrophyte growth.

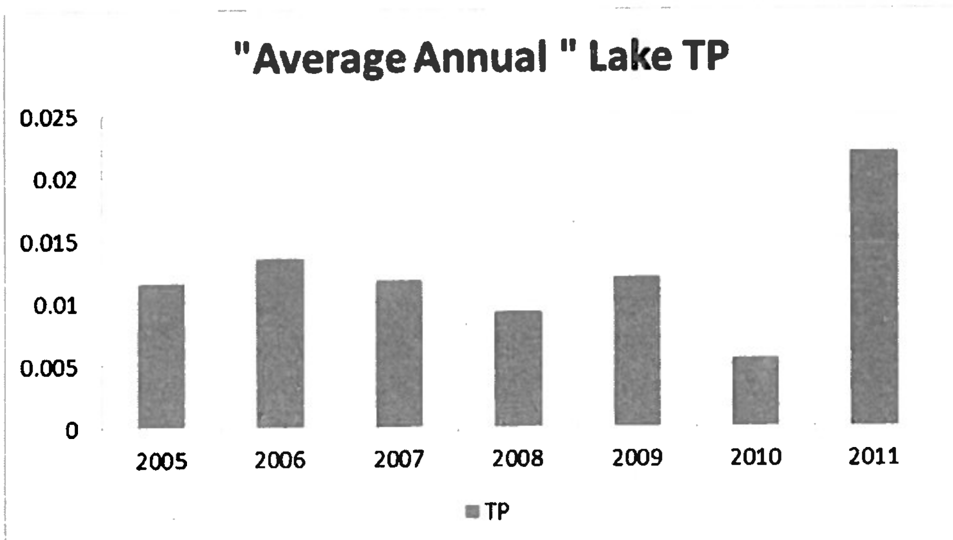
Water quality datasets for the lake TP concentration include one-time spring surveys collected in 1971 (ortho-phosphate only – 0.58 mg/L), 1980, 1991 and 2000 (MAPC 1972, Gordon et al. 1981 and DFO 2007). Since 2005, water quality data has been collected at four sampling stations (in-lake, outlet, south inlet and north inlet – by Stantec on behalf of a developer) typically in April, June, August and November as part of a development agreement. The in-lake dataset (HRM 2012) from 2006 to 2011 has been extracted from the Stantec reports (Stantec 2012). In addition, historical data was collected for the southwest watercourses in 1987 (OceanChem 1988).

In terms of lake TP concentrations, various indicators for trophic state are examined. The CCME trigger values for lake trophic status are based on mean annual TP. Most data sets do not provide a true mean annual value due to the frequency and timing of sampling and the variability of the data set. The Russell Lake dataset provides an estimate of mean TP (based on the seasonal sampling periods) (**Graph 1**). As a check on annual average, TP at spring turnover (mixed water column) has been used as a surrogate for mean annual TP (**Graph 2**).

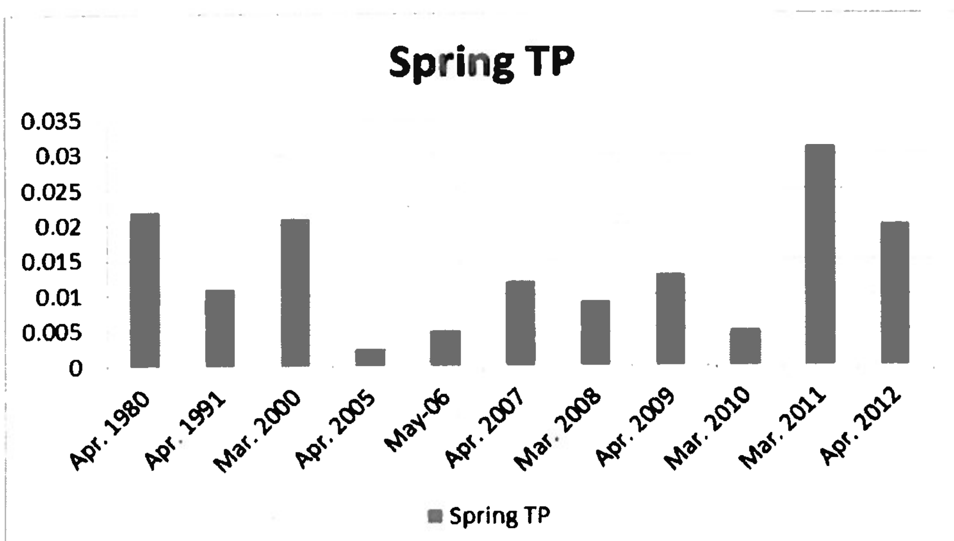
The spring TP and the "average annual" TP generally show similar trends. Neither datasets show consistent increasing or decreasing trends over time. To consider potential rainfall influences, annual precipitation data (Halifax Airport Environment Canada Station) for the years of interest is provided in **Table 2** below. Again, clear indications of trends with annual precipitation are not evident, however datasets are limited.

Table 2 Annual Precipitation in mm (EC Halifax Airport)

1980	1991	2000	2005	2006	2007	2008	2009	2010	2011
1332.6	1310.2	1387.3	1550.5	1358.2	1357.5	1598.9 (no May)	1359 (no June)	1323.8	1723.8



Graph 1. Average Russell Lake dataset annual TP concentration (mg/L)



Graph 2. Spring Russell Lake dataset TP concentration (mg/L)

Phosphorus concentrations within the subwatersheds are discussed in the subsequent section.

3.0 Subwatershed Delineation and Characteristics

Figure 1 depicts the area of the Russell Lake watershed based on the Watershed Management Plan delineation (Griffiths Muecke 1994) and subwatersheds based on topography and available stormwater infrastructure locations provided by Halifax Water. It is noted that detailed information regarding stormwater infrastructure was not available for the majority of recent development around the lake. Although sanitary sewer infrastructure in the watershed is directed to Eastern Passage, sewage pump stations are also shown on the figure for the consideration of potential overflows.

The five identified subwatersheds are:

1. East lake shore – draining directly to Russell Lake along its east shoreline. This subwatershed is a mix of residential and currently undeveloped land use.
2. North - a large portion of the subwatershed drains to the north end of Russell Lake either to the north ponds or to the associated wetland. Land use is a mix of residential and commercial/industrial.
3. South stream – a largely undeveloped area including portions of Department of National Defence lands, located to the south of Russell Lake which drains to a stream entering the south end of the lake.
4. West lake shore – a largely residential area draining directly to the west shore of Russell Lake.
5. West wetland stream – a mixed residential and undeveloped (including Imperial Oil lands) area which drains to a stream entering the south end of Russell Lake.

Table 3 identifies the land use breakdown within each subwatershed. Land use within the watershed was assessed based on August 2011 Google map coverage and is presented on **Figure 2.**

Table 3 Percent Land use by Subwatershed Area

Land use	Total	East	North	South	West	W.Wetland
Forested	24.9	41.2	2.6	98.7	15.3	47.5
Wetland	4.1	0.8	6.8	0.0	0.0	2.9
Residential	39.8	58.0	38.4	0.0	84.7	28.4
Commercial	31.1	0.0	52.2	1.3	0.0	21.2
Totals	100.0	5.7	48.6	6.9	12.1	26.6

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FIGURE 1
SURFACE WATER

- CDS STORMWATER TREATMENT UNITS (SOURCE: HW)
- PUMP STATION
- WATERCOURSE
- HIGHWAY
- STREET
- STORM SEWER PIPE
- CONTOUR INTERVAL
- POSSIBLE DIVIDE IN NORTH SUBWATERSHED
- Ditch

- RUSSELL LAKE WATERSHED

RUSSELL LAKE SUBWATERSHEDS
- EAST LAKE SHORE SUBWATERSHED
- NORTH SUBWATERSHED
- SOUTH STREAM SUBWATERSHED
- WEST LAKE SHORE SUBWATERSHED
- WEST WETLAND STREAM SUBWATERSHED

0 75 150 300 Meters

MAP DRAWING INFORMATION:
DATA PROVIDED BY HRM/HW

MAP CREATED BY: BOM
MAP CHECKED BY: KLM
MAP PROJECTION: ATS 77 MTM Zone 5

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PROJECT: 12-6723
STATUS: Final
DATE: 10/30/12

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RUSSELL LAKE NUTRIENT SOURCE ASSESSMENT

FIGURE 2

LAND USE

- STORMWATER TREATMENT UNITS (SOURCE: HW)
- PUMP STATION
- WATERCOURSE
- HIGHWAY
- STREET
- STORM SEWER PIPE
- CONTOUR INTERVAL
- POSSIBLE DIVIDE IN NORTH SUBWATERSHED
- Ditch
- RUSSELL LAKE WATERSHED

RUSSELL LAKE SUBWATERSHEDS

- EAST LAKE SHORE SUBWATERSHED
- NORTH SUBWATERSHED
- SOUTH STREAM SUBWATERSHED
- WEST LAKE SHORE SUBWATERSHED
- WEST WETLAND STREAM SUBWATERSHED

LAND USE CATEGORIES

- RESIDENTIAL
- FORESTED
- COMMERCIAL/INDUSTRIAL
- WETLAND

0 75 150 300 Meters

MAP DRAWING INFORMATION
DATA PROVIDED BY HRM/HW

MAP CREATED BY: SCM
MAP CHECKED BY: KLM
MAP PROJECTION: ATS 77 MTM Zone 5

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PROJECT: 12-6773
STATUS: Final
DATE: 10/30/12

The following sections outline key potential point and non-point sources for nutrient loading within the subwatersheds. It is noted that non-point sources are generalized to include subwatershed streams and storm sewer inputs. Bedrock in the watershed is primarily Goldenville Formation (slates, shales) but exposed bedrock is limited due to historical development and to the dominance of tills and fills. The clay derived Lawrencetown tills occur in undeveloped areas and comprise the hills to the east and west of the lake. These tills are generally productive with moderately high phosphorus components and have the potential to erode on steeper slopes.

Potential for Sanitary Sewer Overflows as Nutrient Point Sources
Halifax Water sanitary sewer pump stations within the subwatersheds are identified on **Figure 1**. The sanitary sewage generated in the Russell Lake sewershed is conveyed by five (5) sanitary sewer pumping stations:

- Sprucewood Court (East subwatershed);
- Bruce Street (North subwatershed);
- Russell Lake (West subwatershed);
- Freshwater Trail (West subwatershed); and
- Gaston Road (West wetland subwatershed).

All pump stations are operated by Halifax Water. The following is based on correspondence with Halifax Water operations staff. All of the pump stations identified are equipped with high level alarms that annunciate to a centralized SCADA (supervisory control and data acquisition) system. In the event of a high level alarm emergency crews are dispatched. Nutrient loading to Russell Lake can occur when any one of the pump stations fail leading to an overflow, however the degree of loading depends on the quality and quantity of sewage flowing into the watershed, and effects of attenuation within the watershed environment. Pump stations have three primary causes of overflow:

- Electrical power interruption;
- Mechanical failure; or
- Sanitary flow exceeds pump station capacity.

Halifax Water staff confirmed that in the event of electrical power failure most of the pump stations are equipped with standby generator hook up and emergency crews respond with portable generators to service the pump station. The Freshwater Trail Pumping Station has a dedicated standby generator on site.

In the event of mechanical failure the high level alarm would be tripped and emergency crews dispatched. Should the mechanical failure lead to a potential overflow, Halifax Water will engage the services of vacuum trucks to void the wet-wells of sewage and prevent overflow.

In the Russell Lake watershed only the Gaston Road pump station has been identified as being under capacity. During wet weather flows the pump station has a history of high level alarms. Thirteen (13) overflows were recorded during the period from April 2011 to October 2012. It was noted by Halifax Water staff that this station is monitored closely by operations and Halifax Water staff respond with vacuum trucks to limit discharge to the environment. The use of vacuum trucks has been implemented at least as early as 2002. Halifax Water has confirmed that these overflows were diverted from the environment.

Due to monitoring and emergency response efforts by Halifax Water staff it is anticipated that current nutrient loading from sanitary sewer overflows within the Russell Lake watershed is negligible.

3.1 East Lake Shore Subwatershed

The northern portion of this watershed is largely developed (Portland Estates) and the residential area is subject to urban runoff. The storm sewer infrastructure detail was not available for this area, however it is generally expected that storm flows follow topography. The development has been in place for over 20 years, consists of single family residences and a couple of apartment buildings. Although the slope to the lake is steep, there is a buffer strip of 30 m– 60 m of natural vegetation (forest) between the residences and the lake.

No specific water chemistry data is available for drainage from this area.

3.2 North Subwatershed

The North subwatershed includes several individual storm sewer inputs to the lake. One of these (east end of Norm Newman Drive) reflects a historical subwatershed divide (noted as a dashed line on **Figure 1** and approximately 24% of the area of the total north subwatershed). This portion of the watershed drains to either the north pond or its associated wetland area. The area on the north shore of Russell Lake (south of Norm Newman Drive) is both a Nova Scotia Department of Natural Resources (NSDNR) identified wetland surrounding the north pond and a low-lying wetland/forest complex to the east of the identified wetland. The east (dashed) sub area appears to have runoff / storm-flow directed towards the east end of the outlet cove (**Figure 1**).

Surface runoff from this subwatershed (either within storm sewers or direct) primarily reflects residential or commercial / industrial runoff. This area has generally been developed for over 40-50 years and includes the Woodlawn, Penhorn and Portland Street areas. Newer development (10- 25 years) includes industrial / commercial development along Baker Street, Norm Newman Drive and Eisener Boulevard. These developments include numerous car lots, large parking areas, gas stations and at least one car wash. It is assumed that the car wash components are directed to sanitary systems (however this should be confirmed).

Water chemistry data was collected from one of the stormwater outlets (entering at the northern most point of the north pond) (Stantec - North Inlet site). This water chemistry is expected to generally reflect storm water quality from the north watershed. Although concentrations of TP are generally below 0.05 mg/L, occasional peaks have been noted above 0.15 (August 2006, spring 2008; Stantec). A historical (MAPC 1972) concentration of ortho-phosphate in this drainage was 0.085 mg/L.

3.3 South Stream Subwatershed

This small subwatershed receives drainage to a small stream located at the south end of Russell Lake. The area is predominately forested, although historical clearing has occurred for the 12 Wing Shearwater runway infrastructure and as a result of blow-down. The south end of the subwatershed is delineated by a water pipeline road to Imperial Oil. Storm water is currently overland runoff.

No specific water chemistry data is available for this subwatershed.

3.4 West Lake Shore Subwatershed

The Russell Lake West development area is located on the southwest slope of Russell Lake. The majority of this subwatershed was developed in the 2006 to 2010 period with single family houses and some multi-family units. Thirty to 60 m buffer strips are present between the streets and adjacent to Russell Lake. Storm water infrastructure was not available from Halifax Water for this development and therefore it is assumed that the topography provides direction on storm water flow.

Some information was available from Halifax Water regarding the stormwater management in the subwatershed. Three stormwater treatment units have been constructed. There are two on Freshwater Trail and one on Coldstream Run. These units capture stormwater and treat it through the removal of sediment, buoyant debris and oil and grease.

No specific water chemistry is available for this subwatershed.

3.5 West Wetland Stream Subwatershed

Various potential legacy point sources of nutrients have been identified in historical datasets for the watershed. The sources of particular interest include:

- Runoff from a pump station (Gaston Road) into the west wetland.
- A historic pig farm in the west wetland subwatershed.
- Historic infilling of the Imperial Oil lands into the west wetland subwatershed.

Gaston Road Pump Station - A study was completed for this sewershed in 2005 (CBCL 2005). This sanitary sewer system is part of the Old Ferry Road System which goes to the Dartmouth Cove pump station outside of the Russell Lake watershed. The Gaston Road Pump Station study area served approximately 230 residences (many of which are mobile homes) and two apartment buildings. Parts of this system are over 80 years old and are subject to both inflow and infiltration resulting in flows exceeding the system capacity and therefore the pump station historically overflowed. CBCL recommended remedial measures to address this situation. Discussions with Halifax Water indicated that the remedial measures have not been fully implemented to date, but that the Halifax Water responses to overflows through pumping currently alleviates this issue. Remedial measures did include pump replacements approximately two years ago; however Halifax Water staff confirms that high level alarms continue to be experienced during wet weather events.

Historic Pig Farm - A pig farm was historically located on Gaston Road with associated manure ponds that may have drained to the west wetland. This farm was closed in 1977 and now is a developed area with no evidence of the ponds within Russell West. Concentrations of TP measured in May 1987 (OceanChem 1988) were over 1.8 mg/L, however decreased to below 0.2 mg/L in the winter.

Historic Infill/Landfill – Historical landfilling has occurred in the headwaters of this subwatershed. Infill is noted on airphotos along the Morris Lake Road (Imperial Oil water pipeline), between the Shearwater runway extension to the east and the Imperial Oil ponds to the west. This is identified as an Esso fill site in a 1988 review of the subwatershed (OceanChem group). Although elevated concentrations of TP (as high as ~0.6 mg/L) were noted in May 1987 in the small feeder stream (draining to the south west stream), generally concentrations decreased below 0.2 mg/L in the winter.

In addition to historic point sources associated with the pig farm and pump station overflows, general storm runoff within this subwatershed occurs from the Gaston Road trailer park area (developed over 50-60 years ago), a small portion of the Russell Lake West and the Mount Hope Avenue commercial area (both developed in the past 10 years to on-going), limited drainage from the Circumferential Highway (built over 40 years ago) and general runoff from the largely forested area to the east of this development. The majority of the developed areas drain towards a small wetland (NSDNR identified). This wetland was identified as a potential sink and continual source for legacy point source TP loading (Stantec 2006). Peat samples taken in 2006 in the cattail wetland downgradient of the Circumferential had 8 times higher TP than control samples (**Photo 5** shows the cattail area downgradient of the pump station).

Photo 5 Cattail Area Downgradient of Pump Station (Dec. 2012)

It is noted that although still present immediately downstream of the highway, the extent of this wetland downstream appears to have been reduced in recent years due to adjacent land use encroachment.

The Imperial Oil water treatment ponds also border the edge of this watershed. Although treated water is directed to the harbor there is potential for minor surface runoff from this area to enter this Russell Lake subwatershed. Significant TP sources are not expected from this runoff.

This subwatershed is well characterized in terms of TP contribution to Russell Lake as input to the lake is through the small stream that enters Russell Lake at its south-west end. A water quality monitoring station has been established at the outlet to this watercourse as part of the Russell Lake West Monitoring Program (Stantec 2005-2012). Historic data has also been sporadically collected at this sampling station. Although concentrations of TP are often below 0.05 mg/L, peaks have been noted approaching 0.1 mg/L. A historical (MAPC 1972) concentration of ortho-phosphate in this drainage was high at 4.7 mg/L.

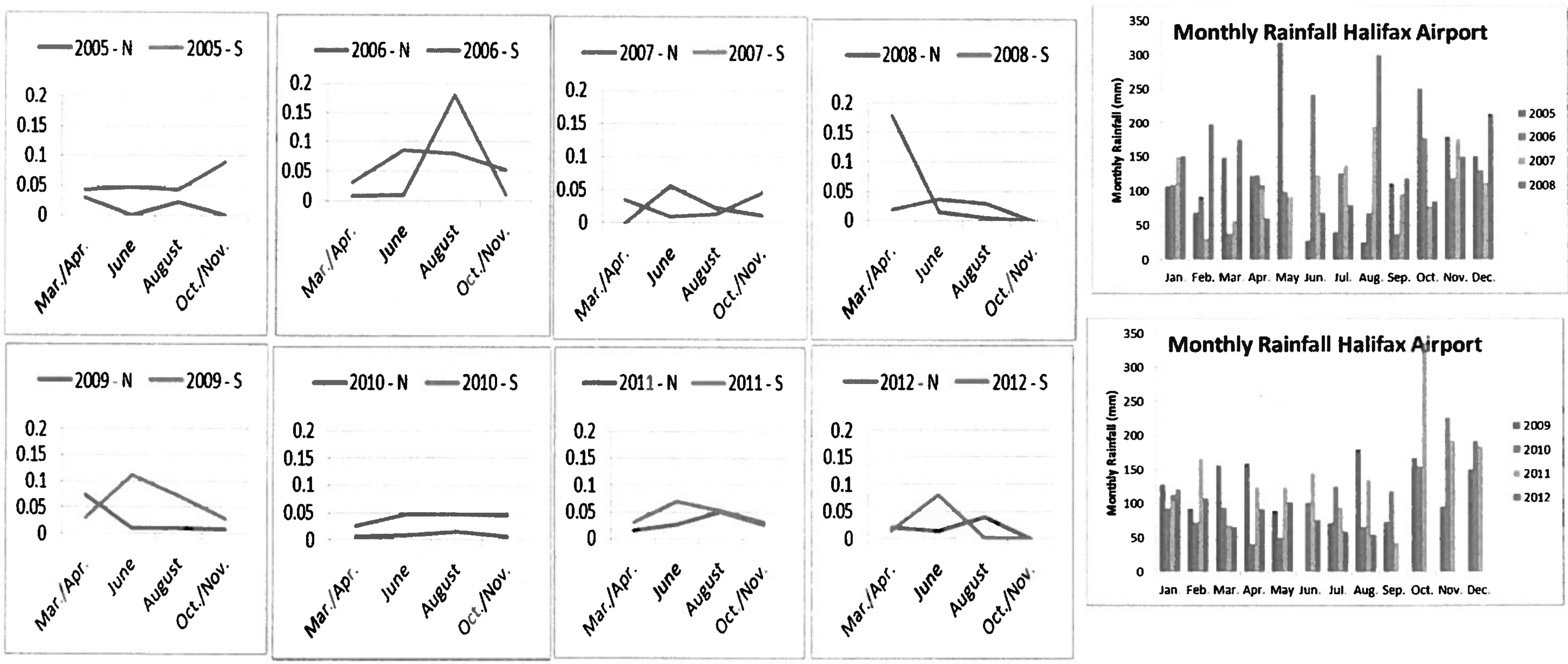
3.6 Comparison of North and South Drainage Water Chemistry Data

Graph 3 provides a time series of TP concentrations within both the north and south monitoring stations. The concentrations within the south drainage are typically (but not consistently) higher than concentrations in the north drainage. Concentrations in the south drainage also typically (but not consistently) peak during the early summer period. It is noted that storm water concentrations are typically higher than lake concentrations.

3.7 Subwatershed Summary

Table 4 provides a summary of the subwatersheds, potential point sources for nutrient loading, and key aspects of non-point runoff. Land use appears to have the primary influence on nutrient loading in this largely developed watershed.

Graph 3 Comparison of North and South Monitoring Station TP Concentrations – mg/L (from Stantec monitoring 2005-2012) and Monthly Rainfall Data (Halifax Airport Environment Canada Station)



* S - South, N – North

Table 4 Summary of Subwatersheds

	East Lake Shore Subwatershed	North Subwatershed	South Stream Subwatershed	West Lake Shore Subwatershed	West Wetland Stream Subwatershed
Historical (and proposed) Development	1980s&90s Portland Estates; reported infill of wetland 1986 construction of trunk sewer, pump station; lake lowering	1950-60s Woodlawn subdivision 1970s Penhorn Mall 1969-70 Circumferential Hwy 1960-70s Ellenvale subdivision 1990s Baker Dr. car lots 1990s Superstore, Kent on Eisener	1970s Imperial Oil waterline, DND clearing Proposed Block G school Proposed Mt Hope Extension	2005-current Russell Lake West	1950-60s Gaston Road trailer court 1970s Imperial Oil sites 2007 wetland encroachment 2006-current Mt Hope Ave Development proposed Block F, G (School),H, I developments Proposed Mt Hope Extension
Potential Point Sources	No	No	No	No	Legacy Gaston Road pump station overflows and pig farm to Wetland. Legacy infill site drains to stream.
Potential Factors in Soil Erosion	Lawrencetown clay till and soils; steep slopes; not active development currently	Limited native soils due to development; slopes generally flat to moderate; generally not active development currently	Hantsport soils; slopes moderate to steep; generally not active development currently	Lawrencetown clay till and soils; steep slopes; active development currently limited	Lawrencetown clay till and soils; moderate slopes; active development ongoing
Potential contributors to TP loading in storm flow*	Lawn fertilizer	Car lots (assumed washes go to sanitary; however this should be confirmed), lawn fertilizer	Limited	Lawn fertilizer; storm water treatment infrastructure (expected to improve runoff water quality)	Lawn fertilizer; legacy from historic point sources
Overall potential for general runoff elevated in TP	Moderate	High	Low currently	Moderate	Moderate to High
Relative Stormwater flow contribution	Low	High	Low	Low	Low-Moderate

*Storm sewer discharges must meet Halifax Water Schedule of Rules and Regulations for water, wastewater and stormwater services specifying a phosphorus limit of 10 mg/L

Approximately 50% of the area within the watershed flows from the urbanized north sub-watershed. The majority of the north subwatershed drains either to the small north pond area or to the adjacent wetland complex. This drainage is closest to the outlet to Morris Lake at the north end of the lake.

Approximately 25% of the overall watershed area is from the developed west wetland subwatershed. Although historic point sources for nutrient loading in this watershed appear to be currently alleviated, there is still potential for legacy loads (reduced from historical highs) to the stream and thus to Russell Lake. Minor contributions by area are from the west, east and south watersheds.

4.0 Comparison of Relative TP Loading by Subwatershed

A summary of the modeled relative phosphorus loading from each subwatershed is provided in **Table 5**. As part of an assessment of potential effects of a proposed development, a phosphorus modeling exercise was undertaken in 2006 (Stantec 2006). The model examined the 2006 condition using available water quality data to calibrate phosphorus loading within various subwatersheds.

To assess subsequent TP loading associated with existing the existing landuse condition, the Nova Scotia Lake Phosphorus model (Brylinsky 2004) was used with approximated Stantec loading coefficients and compared with the earlier model results. An additional run was made with higher coefficients identified in literature values (Brylinsky 2004).

The total phosphorus loading was also estimated using the method outlined in the HRM Stormwater Management Guidelines based on potential relative TP loading associated with comparable land uses. A volume of runoff was estimated using the normal annual rainfall amount multiplied by an estimated runoff coefficient and the area of each land use. The volume was then used to get a TP loading in kilograms based on estimates of mean pollutant concentrations for specific land uses.

This phosphorus loading analysis (Stantec and NS Model) supports the predominance of the north sub watershed to the lake loading with moderate influence of the west wetland subwatershed and minor influences of lands to the east and west. The use of higher loading coefficients does change the assessment of total loading but the relative contribution of the subwatersheds does not change significantly. As the Stantec coefficients were found to provide a good estimate of actual lake phosphorus concentrations, it is assumed that they were appropriate for this watershed. It is noted that influence of active development and increased soil erosion inputs of phosphorus could be significant at the time of erosion within any watershed. However the biological availability of soil inputs is likely less than inputs associated with sewage or land use components such as lawn fertilization.

Table 5 Modeled Annual Phosphorus Loading (kg/y) to Russell Lake

Scenario	TP Coefficients ($mg/m^2/y$)	Runoff TP Input (kg/year)	East Sub-watershed	North Sub-watershed	South Sub-watershed	West Sub-watershed	West Wetland Sub-watershed
2005-2006 Baseline (Stantec 2006)	Urban 30 Residential 25 Forest/ Wetland 10 West Wetland watershed averaged 45 or with separate TP source at 25 kg/y	87	4%	45.2%	1.7%	4.7%	35.4%
Estimate of post Russell Lake West Development (Stantec 2006)	Urban 30 Residential 25 Forest/ Wetland 10 West Wetland watershed with separate TP source at 25 kg/y	96	3.7%	41.6%	1.5%	10.8%	34.9%
NS Model (2011 landuse)	Urban 30 Residential 25 Forest/ Wetland 10 West Wetland watershed 45	94	3.4%	40.4%	2.2%	8.7%	38%
NS Model (2011 landuse)	Urban 50 (potential for higher load investigated) Residential 25 Forest 10 Wetland 30 (legacy inputs moderated)	87	3.4%	58.5%	2.3%	8.7%	19.7%
NS Model (2011 landuse)	Higher Coefficients Investigated Urban 80 Residential 50 Forest 20 Wetland 40	153	4%	58%	2.7%	10.2%	20.7%
HRM Stormwater Management Guidelines	Using average annual rainfall and rational method runoff coefficients	348	4.9%	57.8%	2.3%	13.8%	21.2%

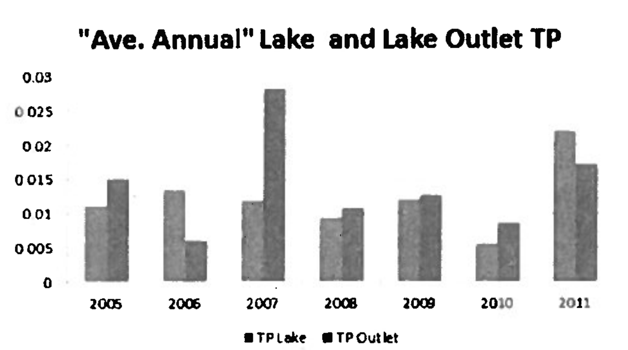
The loading estimates based on the Stormwater Management Guidelines provided fairly conservative TP loadings. This analysis is rather conservative and used for design of stormwater infrastructure. Secondly, the rational method is typically not used for watersheds of the magnitude of the Russell Lake watershed and subwatersheds. The other methods for TP estimation are better used to understand what is actually occurring in the watershed.

5.0 Other Considerations and Recommendations for Follow-up

Additional considerations in the TP flux within the lake which may be important in lake trophic status have not been fully investigated. These include:

- Phosphorus stored in lake sediments (reflecting historic loading) may be an on-going source of phosphorus independent of current watershed loading. This internal loading may contribute to elevated lake phosphorus levels. Interaction of lake sediment phosphorus with lake water column phosphorus effects may depend on the form of phosphorus (bioavailable), extent of anoxic conditions and of lake turnover conditions, biological conditions, as well as potentially wind mixing in shallow areas. Further investigation is recommended of the degree of re-suspension of TP stored in lake sediments (either historic or ongoing) and the amount and bioavailability particularly at biologically important times.
- Further investigation is suggested to determine the potential for the relatively higher loading associated with the north watershed to incompletely mix within the main lake and "bypass" directly to the outlet. An initial determination (reported in Griffths Muecke 1994) was that bypass was not significant. This assessment should be revisited based on current data. **Graph 4** provides a comparison of lake versus outlet data on an "annual average" basis. Generally the lake TP is slightly less than the outlet TP (with the exception of 2006).

Graph 4 Lake and Outlet TP (mg/L)



- It is likely that the large wetland complex in the north pond area contributes to sequestration of nutrients and reduction/moderation of the loading of nutrients to the main lake. Further investigations of the pathways of flow to the lake in this area are suggested.
- Information on the manipulation of the outlet control would be helpful to the overall understanding of the system.

6.0 Summary

Based on the results of the review, no distinct point sources were identified as likely sources of nutrient loading to the lake. General storm water urban and residential runoff feeds phosphorus loading to the lake, with the highest contribution coming from the large north subwatershed.

If you need further information, please contact the undersigned.

Yours truly,

DILLON CONSULTING LIMITED

Orignal Signed

Karen L. March, M.Sc.
Project Manager

KLM:srb
Attachments
Our File: 12-6723-1000

Attachment 1
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