Summary Of Volume III "*Long-Term Water And Wastewater Servicing Study, September 2009*" [1]

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VOLUME III: WATER NEEDS ASSESSMENT

1. Introduction

The Municipality of North Shore is located on the Gulf of St. Lawrence, with an average population of 2,230 comprising of 825 private dwellings.
The peak population during the summer can rise to 2,840 people, utilizing 1,051 equivalent dwelling units (EDUs), equating to 2.7 persons/dwelling during peak summer season.

North Shore relies on groundwater for 100% of its potable water requirements, being serviced by private wells and on-site waste treatment. Individual domestic wells tapping into the sandstone bedrock can provide more than adequate yields. However, the long-term sustainability of groundwater supply depends on factors such as, magnitude of groundwater recharge from rain and snow melting and water quality impacts (salt water intrusion, contamination).

2. Hydrologic Setting

2.1. *Topography and drainage*

The topography comprises of rolling hills with slopes between 3-7%. Surface elevation ranges from sea level to the north, to approximately 60 meters on hill peaks in the south.
Most of the North Shore is located within the Brackley Bay – Covehead Bay watersheds, which collectively drain an area of nearly 73 square kilometers.

2.2. *Geology*

2.2.1. Surficial

Surficial mapping is the process of describing the distribution and characteristics of sediment overlying bedrock.
Within the community limits three main types of surficial sediments exist:

- Glacio-fluvial: Produced by rivers from melting glaciers.
- Till: Formed from the erosion of bedrock by glacial ice.
- Re-worked sediments: Deposited by modern rivers and reworked due to the action of waves. [2][3]

2.2.2. Bedrock

The bedrock on the Island consists of red-beds transported by streams and rivers from highlands, in present day New Brunswick and Nova Scotia, deposited under oxidizing conditions in the low-lying area, which is now Prince Edward Island.

2.3. *Bedrock Groundwater System*

2.3.1. Bedrock aquifer properties

PEI red beds are a good example of a fractured porous aquifer (*an aquifer is a body of saturated in which water can move easily [4])*
At depths greater than 35 meters, a decrease in both fracture frequency and fracture width is observed, resulting in the decrease of hydraulic conductivity (*ease of fluid to pass through cracks in soil*) by an order of magnitude for every increment of 60 meters depth.

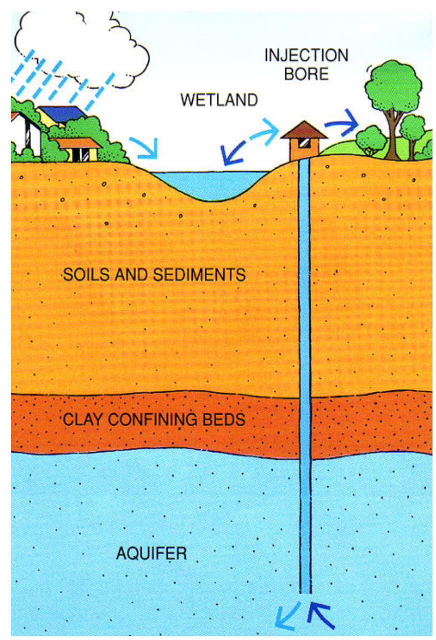

Figure 1: Aquifer diagram [5]

2.3.2. Groundwater levels

On higher ground, depths to groundwater level can be significant ranging from 20 to 30 meters below grade.

Seasonal fluctuations occur, with low water levels occurring during winter months following a fall season with limited recharge. These occurrences are experienced less in lower lying areas.

2.4. *Water Budget and Sustainable Withdrawals*

2.4.1. Background

Winter River drainage basin has been extensively studied, since this area contains three well fields that the City of Charlottetown withdraws water from.

Since the terrain and hydrogeological settings are similar, findings from Winter River basin can be applied to the Brackley Bay – Covehead Bay watershed.

Groundwater recharge was estimated to be between 400mm to 685 mm, from the mean annual precipitation of 1200mm. Numerical modeling by PEIDEEF indicate that groundwater withdrawals should not exceed 50% of the recharge rate, or 200 mm. Which accounts for 17,500 L/min or 63% if applied over the 46 km^2 Community area.

2.4.2. Domestic well use within the Municipality

Approximately, 1,051 wells during peak summer season are used, with a yield between 23 to 230 L/min. Typical well depths range from 25 to 37 meters (80 to 120 feet), with associated steel casing of a typical length 13 meters (40 feet). The mean depth to the static groundwater below grade is 8 meters.

Groundwater withdrawals must support a peak population of 2,840 or an equivalent 1,051 EDUs. Assuming each EDU requires between 650 to 1,000 Liters/Day, this equates to a daily withdrawal rate ranging from 0.7 to 1.0 Million Liters/Day. Representing 3 % (40 Million Liters/Day) of the sustainable yield of the bedrock aquifer.

Half of the peak population (1,420 persons) is located within the approximate area of 2 km^2 in the Stanhope Peninsula.

Using the 200 mm/year sustainable withdrawal figure, the recharge area required for individual domestic wells is as little as 365 m^3/year

2.5. *Water Quality and Contamination Issues*

2.5.1. General

Groundwater quality in North Shore is generally good. However, elevated dissolved iron issues exist in wells located in the vicinity of the Stanhope golf course. Saltwater intrusion has been reported in the Stanhope Peninsula and on MacMillan Point.

Water quality problems with residential wells are dealt with on case-by-case basis. Involving re-drilling or deepening a well, repairing or replacing a leaking septic tank and/or by providing bacteria treatment.

These approaches are considered to be less reliable methods of ensuring safe drinking water, than would be the case with a professionally managed, and monitored central well supply.

Table 1: Summary of Resident Survey-2009

Subarea/Zone	Survey Details						
	Well Contaminations	Saltwater or high Chloride	Total Coliform	E-coli	Faecal Coliform	Nitate	Other
Stanhope Peninsula/ Coastal Zone1	31	2	20	1	1	0	7
Balance Of Coastal Zone/Coastal Zone2	8	0	4	1	0	2	1
Outside Winter River Watershed/Agricultural Zone1	5	1	2	1	0	1	0
Inside Winter River Watershed/Agricultural Zone2	0	0	0	0	0	0	0
Total	44	3	26	1	3	3	8

2.5.2. Surface water

Routine water sampling at the Brackley and Covehead Bays has been conducted annually since 2000 as part of the PEIDEEF annual estuaries water quality survey. Water quality has been very poor in mid-summer as a result of nutrient input (from agricultural activities). Also, Nitrate levels in Covehead Bay have been higher than Brackley Bay; on possible account of the larger contributing drainage area and that there has been more agricultural land-use activity.

In 2002 the PEI Agricultural Crop Rotation Act was introduced, stating that land larger than 1 hectare (2.5 acres) with slopes of 9% or more should either not be planted with regular crop or if planted, require an approved management plan. Also, where agricultural land is close to riverbanks that are highly susceptible to erosion, leading to higher nitrate levels into surrounding surface water, which directly or indirectly recharge groundwater supply.

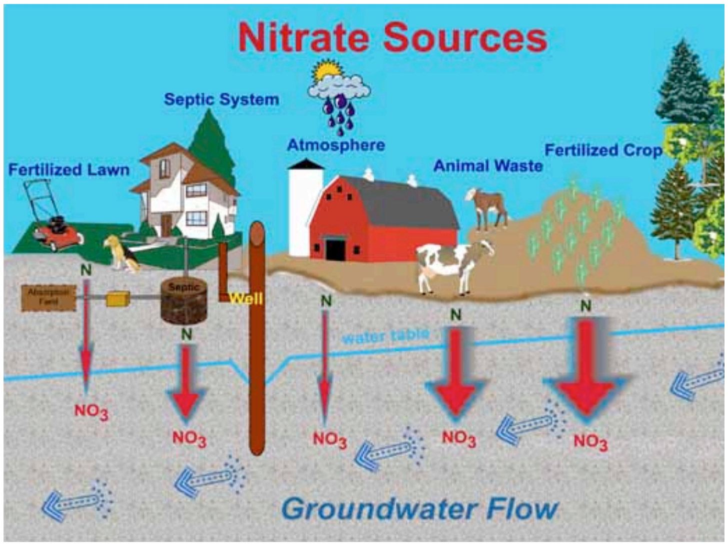

Figure 2: Nitrate sources [6]

2.5.3. Saltwater Intrusion

The geographical location of the Stanhope Peninsula being surrounded by salt water on three sides, being visualized as an "Ocean Island", imposes saltwater intrusion as anticipated.

As the number of dwelling units increase, the need for fresh water relatively increases, requiring more wells tapping into the body of fresh water underground that is surrounding by a saltwater interface around the coastline area of the Peninsula. This will decrease the amount of fresh water if the demand is higher than the recharge rate, occurring from rain and snow melting precipitation into the ground. Leading to the saltwater interface to rise and causing wells to yield salty water

A central shallow well field system in the middle of the peninsular is a very feasible solution in the future for the Stanhope Peninsula area (Coastal zone 1), even if the density of development increased by a factor of two, it would still yield freshwater.

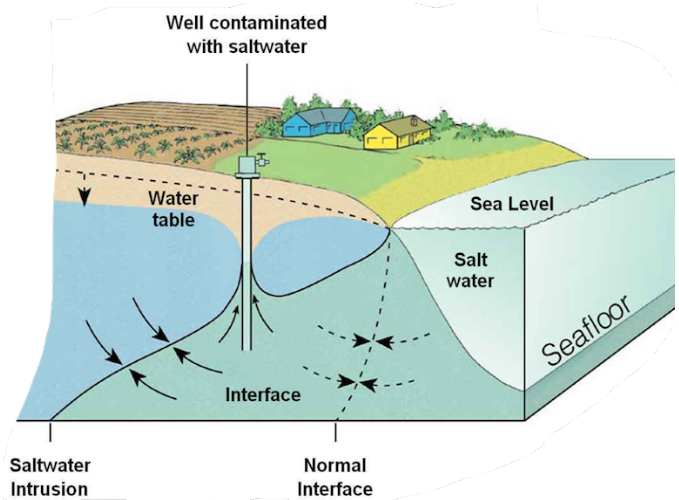

Figure 3: Saltwater intrusion diagram [7]

2.5.4. Nitrates

Nitrates occur naturally in the environment and are essential nutrients for plants to grow. However, excess can contaminate groundwater and affect surface water quality. Key sources of nitrates are fertilizers, manure storage and septic systems.

In recent decades PEI has experienced a steady increase levels in nitrates in groundwater and surface waters. This lead to the creation of the Commission on Nitrates in Groundwater, in July 2007. The Commission report included these recommendations that *were considered to be absolutely essential*:

- Improving Public Education on Protecting Water Quality
- Reducing Nutrient Loading from Sewage Treatment Systems
- Supporting Watershed-based Water Management Planning
- Mandatory Three-year Crop Rotation
- Matching Nutrients With Crop Needs to Reduce Nitrogen Leaching
- Identifying High Nitrate Areas (and taking corrective action)

2.5.5. Bacteriological Contaminants

Poorly maintained septic systems in proximity to inadequately constructed wells are the typical causes for bacteriological problems.

Disposal fields become a potential source of groundwater and surface water contamination, more likely to threaten downgrade water wells rather than closer well on the property.

Septic disposal fields constructed perpendicular to groundwater flow direction dramatically decreases the risk of contamination, rather than being located up gradient from wells and parallel to the flow.

2.5.6. Other Issues

- Local well drillers indicated wells drilled in the Stanhope lane area; yield hard water with elevated iron concentrations.
- City of Charlottetown personnel indicate elevated barium (1mg/L Health Canada Drinking Water Guideline) from wells in "Winter River Basin". Attributed to naturally occurring minerals in the rock.
- Most homes and business are heated with oil. Increasing the potential for fuel oil releases impacting groundwater sources.
- Road salt application affects wells that have shorter than normal protective steel casings, making them more vulnerable to near-surface contamination.

3. Development Of a Groundwater Availability/Vulnerability Map

3.1. *Approach*

It was resolved that a map should be developed to distinguish parts of the community where groundwater supplies would be likely viable, and those areas where challenges might be expected.

The factors where induced to generate such a map, with each factor having a maximum of 100 points and minimum of 0 points. These points were assigned to each area and were translated into a map. These factors are:

- Distribution of wells and sewage systems (30% weight factor)
- Nitrate concentrations in groundwater (30% weight factor)
- Bedrock type (5% weight factor)
- Soil type (5% weight factor)
- Elevation from sea level (15% weight factor)
- Surface Slope (15% weight factor)

3.2. *Findings*

The six factors were combined and weighted to produce a Groundwater Availability/Vulnerability Index Map. This map distinguishes areas that would most likely provide groundwater of good quality and quantity (Shaded green in figure 4), from areas considered to be at high risk for groundwater issues and less groundwater supply (shaded red in figure 4)

4. Groundwater Assessment By Subarea

4.1. *Coastal Zone 1 – The Stanhope Peninsula*

In the longer-term, a central water supply is to be considered for the peninsula at its eastern edge and south of the PEI National Park, due to increase of population, saltwater intrusion and contamination due to lot sizes and proximity.

However, some obstacles facing a central well supply might occur for this location, since local well drillers indicate many cases of very high dissolved iron concentrations and elevated nitrate concentrations.

The possible site for a central well field to service the Stanhope Peninsula is identified as Area A in Figure 4

In the shorter term, current water supply problems could be resolved by:

- Drilling new wells
- Connecting unaffected wells
- Water treatment
- Trucking of water for onsite storage

Using the drinking water guideline for nitrate (10 mg/L) as an indicator for when a Central Wastewater/Sewer System would be necessary, a linear "best fit" model was developed based on a rate of 4 EDUs per year (360 EDUs in 90 years). This indicated that a Central Wastewater system is needed in about 23 years, when 55% build-out is reached.

It is very likely that a Central System would be needed prior to that, due to increased bacteriological issues, saltwater intrusion and coastal erosion.

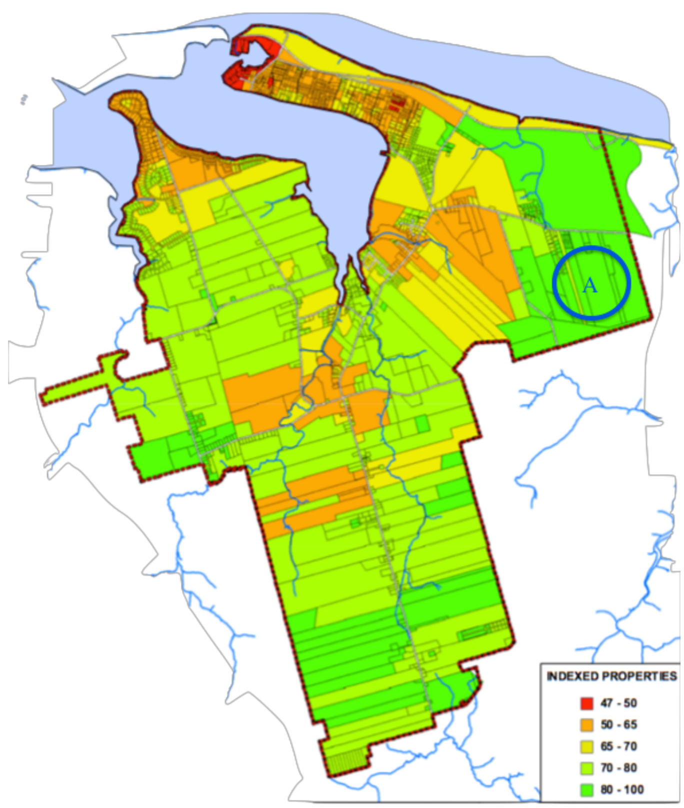

Figure 4: Groundwater availability/Vulnerability Index map

4.2. *Coastal Zone 2- The balance of the outlined Coastal Zone*
In the longer run, the existing central water supply will need to be maintained for MacMillan point, with some lots being added to the current system as development increases. With an expected 150 homes to be serviced, by this central system.

4.3. *Agricultural Zone 1 – Outside the Winter River Watershed*
Central water supplies are not likely required, even in the longer term. However, due to potentially high nitrate concentrations, it may be advisable to drill test wells to confirm water quality before developing new lots.

4.4. *Agricultural Zone 2 - Within the Winter River Watershed*
Central water supplies are not likely required, even in the longer term and might not be feasible for regulatory reasons.

5. Summary

Table 2: Summary of Potable Water Assessment

Subarea	Relative Level of Need	Discussion
Coastal Zone 1 - Stanhope Peninsula	Medium to High	In the longer-term, a central water supply may be warranted for the peninsula, due to high risk for water quality and quantity issues
Coasta Zone 2- South and East of Brackley And Covehead Bays	Low to Medium	In the longer run, the existing central water supply will need to be maintained for MacMillan point, with some lots being added to the current system as development increases
Agricultural Zone 1 - Outside the Winter River Watershed	Low	Central water supplies are not likely required, even in the longer term. However, due to potentially high nitrate concentrations, it may be advisable to drill test wells to confirm water quality before developing new lots.
Agricultural Zone 2 - Within the Winter River Watershed	Low	Central water supplies are not likely required, even in the longer term and might not be feasible for regulatory reasons

References

[1]: *Long-Term Water & Wastewater Servicing Study, Volume: 1. By Engineering Technologies Canada Ltd. September 2009*

[2]:http://www.nr.gov.nl.ca/nr/mines/geoscience/publications/surficial_geology_mapping.pdf

[3]:http://csdms.colorado.edu/wiki/Movie:Coastal_Sediment_

[4]:http://imnh.isu.edu/digitalatlas/hydr/concepts/gwater/aquifer.htm

[5]: https://www.aila.org.au/

[6]: http://www.co.portage.wi.us/

[7]:http://www.geo.hunter.cuny.edu/tbw/ncc/Notes/chapter12.humans.env/tapping_goundwater.htm