Technical Opinion

To: Linda Whalen, Sault Ste. Marie Region Conservation Authority

From: Frank Breen, P.G., Breen GeoScience Management, Inc.

Date: December 26, 2011

RE: Technical Opinion, Pointe Estates Development

Technical Opinion
Evaluation Of The Proposed Pointe Estates Development,
Sault Ste. Marie, Ontario Canada

F. A. Breen, P.G.

I am a professional hydrogeologist and geochemist with expertise in the fate and transport of chemicals in surface and subsurface environments. I am the president of Breen GeoScience Management, Inc. and teach hydrogeology, geochemistry, geology, environmental science, and project management at Lake Superior State University, in Sault Ste. Marie, Michigan. I work throughout the United States and Canada and have conducted numerous projects dealing with the interaction of groundwater and surface water, and the discharge of groundwater to man made canals and water ways, including the Ottawa River in Cleveland, Ohio and the Houston Ship Channel, Houston, Texas. I have experience in the use of numerical models for assessing hydrologic systems, chemical fate and transport, developing remedial strategies at numerous industrial sites, providing litigation support, and in support of environmental and human health risk assessments at the state and federal level. I have over 20 years of technical experience and am a certified professional geologist in the states of Texas, and Indiana and I am recognized as a professional geologist by the National Association of State Board of Geology (ASBOG).

A copy of my curriculum vitae is attached.

I have no stake, either personally or professionally, in the outcome of the issues surrounding the Pointe Estates Development. My purpose for providing this opinion is in response to potential litigation, to assist in minimizing any potential risk to human health or the environment, and to provide technical input regarding the work conducted as part of the permitting of the Pointe Estates Development.

Given the potential for future litigation between the Pointe Estates Development and the Sault Ste. Marie Region Conservation Authority as well as the fact that full discovery of information regarding the proposed development has not been provided by the Pointe Estates technical consultants or counsel, I reserve the right to modify this opinion as additional information becomes available.

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Preface

The following document presents my opinion regarding the technical work conducted in partial fulfillment of the requirements for the permitting the proposed Pointe Estates Development. At the request of the Sault Ste. Marie Region Conservation Authority, I have conducted an objective technical evaluation of the available information and reports. All data, reports, maps, and additional information used in the preparation of this opinion is provided either in paper or electronic form in the attached appendices. The intent of this additional information is to allow for any third party reviewers to have all the necessary information to recreate the analysis presented herein, or to provide a basis for review, questions, or challenges to the conclusions made.

The analysis presented dealt with the issues raised in the Chant Group Appeal to the Mining and Lands Commissioner regarding the June 2010 decision by the Conservation Authority. These issues dealt with the subsurface hydrogeology and surface water hydraulics of the proposed canal in the area of the proposed development. This opinion does not address in any manner the provincial definition of a wetland as it pertains to provincial or regulatory guidance, area, flora, or fauna since this it outside my area of expertise.

Opinions and conclusions made in this document were presented in a direct and specific manner and any strong criticism of past technical work is intentional since it is my opinion, based on the information presented, that the intended litigation brought against the Sault Ste. Marie Region Conservation Authority is baseless and without merit. However, it is important to emphasize that it is not the intention of this document, nor was it my intention in the preparation of this document, to advocate one side of the issue against another. Rather, what should be clearly understood, is the need for a clear understanding and adherence to the spirit, technical intent, and regulatory requirements of the permitting process. This is due to the fact that at present, the available information from the area of the proposed development clearly indicates a potentially significant risk to human health and the environment, and, this risk cannot be addressed without a well defined and implemented site-specific hydrogeologic assessment.

Conceptual figures and illustrations were used in this document in an effort to communicate technical concepts and ideas. These conceptual figures were identified as such and are not based on any site specific analysis or data.

Finally, the cost for the preparation of this document and my participation in meetings has been raised. It is acknowledged that the cost for the preparation of this document was not trivial, primarily due to the requirements of pending litigation. However, it should also be noted that from the period of January 2010 through December 2011, I have provided over 300 hours of work in relation to this issue at no cost to the Conservation Authority or the tax payers of the City of Sault Ste. Marie or the Province of Ontario. Information presented in this report is based on the available data and information, including shortcomings in the data and data gaps, so that regulators and managers can make the best possible decisions for the protection of human health and the environment, and to identify areas where further information is needed. It is my hope that the information presented in this document will be closely evaluated and used in the development of any future hydrogeologic investigations.

1 Introduction

The following technical opinion was prepared by Breen GeoScience Management, Inc. (BGM) at the request of the Sault Ste. Marie Region Conservation Authority (SSMRCA) regarding the Chant Group Appeal to the Mining and Lands Commissioner[1]. Specifically, BGM was requested to conduct a review of the hydrogeology and geochemistry of the proposed development area (Figure 1) in relation to the following:

- shortcomings, if any, in the technical information which formed the basis of the material provided in support of the application;
- comment on the technical information which was submitted, including, but not limited to, modeling, data used, calculations and assessments; and
- comments on the impact or potential impact on water quality and hydrological function of the wetlands, the St. Marys River and the surrounding environment if the development is permitted as proposed.

2 Risk Based Approach

Evaluation of the available information regarding the Pointe Estates Development was conducted using a Risk Based Approach (RBA) which is a common methodology for assessing potential risk to human health and the environment. A description of this methology is provided in Appendix A, Section 5 [5].

In order for a risk to human health or the environment to be presented, three elements are required:

1. a source of chemicals released to the environment (defined as a hazard in [5]),
2. a receptor that may be adversely affected by the hazard, and,
3. a pathway or means by which chemicals released from the source can reach potential receptors.

[1] MLC File No. 004-10

If any of these three elements are not present, there is no risk. For example, if a source of chemicals is present in the environment, but there is no pathway or means for the chemicals to migrate and impact a receptor, then there is no risk.

2.1 Receptors

A receptor is any organism, environment, or ecosystem that can be negatively impacted by chemicals from the source if the receptor is exposed to these chemicals at a concentration which represents a risk. In the case of people, receptor risk typically takes on one of two forms, either acute or carcinogenic. Acute risk means that a person would have an immediate negative effect upon exposure to a particular chemical in the environment, whereas carcinogenic risk occurs as a result of exposure over a longer term duration. In dealing with the potential risk associated with septic systems, the risk to human health is primarily acute. For example, if septic system effluent were to migrate through the groundwater and reach a domestic well, a person could immediately become ill as a result of pathogens in the well water. Exposure to septic system pathogens would not require long term exposure to have a negative effect on human health.

Ecosystems, such as streams and surface waters, can also be susceptible to septic system effluent. In this case, the risk would take the form of excessive nutrient addition which may cause excessive plant growth or eutrophication. Eutrophication would result in a depletion of oxygen from surface waters causing fish kills and stagnation to occur.

2.2 Sources

The primary source of potential constituents of concern (COCs) would be the septic systems. COCs from septic systems include:

1. Pathogens, which would include bacteria such as Escherichia coli (Ecoli) or viruses,
2. Nitrates and phosphates, and
3. to a lesser extent metals and organic compounds.

Of the above mentioned COCs, pathogens, nitrates, and phosphates are of primary concern.

2.3 Pathways

Pathways represent the mechanism by which COCs from the source can reach potential receptors. This is often the most complex aspect of RBA since it involves an understanding of the environmental factors which control chemical migration, such as hydrogeology, as well as the behavior of the chemical in the environment, i.e. does the chemical degrade naturally or adsorb to soils etc.

3 Conventional Septic System Design

Conventional septic systems are used to process household waste water through geochemical reactions in the subsurface. These geochemical reactions can be characterized into three oxidation reduction (redox) zones:

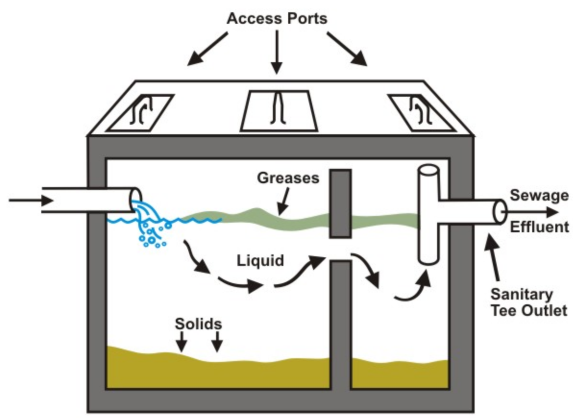
- Septic Tank,
- Tile Field, and,
- Groundwater.

3.1 Septic Tank

The primary role of the septic tank is to collect solids and break down carbon and nitrogen containing organic material. The characteristic geochemical environment with in the septic tank includes:

- Anerobic (oxygen deficient) conditions - low dissolved oxygen and high organic material,
- Organic hydrolysis occurs which breaks down organic carbon to carbon dioxide (CO_2) and organic nitrogen to ammonia (NH_4^+),
- Fermentation of carbon to methane (CH_4), and,
- Transformation of organic sulfur to dissolved hydrogen sulfide (HS^-).

The primary process is the conversion of organic nitrogen complexes to inorganic nitrogen, primarily in the form of ammonia. Solid material will settle to the bottom of the tank while grease and lighter material will form a scum on the surface. Liquid effluent will discharge from the tank to the tile field. This effluent typically contains elevated levels of ammonia, total suspended solids (TSS), total coliforms, and chlorides, with phosphate to a lesser extent.



Septic Tank

Constituent	*Unit*	*Low*	*Typical*	*High*
Total Suspended Solids (TSS)	mg/L	100	220	350
Biochemical Oxidation Demand (BOD5)	mg/L	110	220	400
Total Coliforms	MPN[2]	106	108	109
Nitrogen (total, as N)	mg/L	20	40	85
Ammonia	mg/L	12	25	50
Nitrate	mg/L	0	0	0
Phosphorus (total, as P)	mg/L	4	8	15
Chlorides	mg/L	30	50	100
Metals	mg/L	Low	Low	Unknown
Synthetic Organic Compounds	ug/L	Low	Unknown	Unknown

Constituent Concentrations in Typical Septic Tank Effluent [7]

Constituent	Unit	mg/L
Biological Oxygen Demand (BOD) 5 day	mg/L	300
BOD 5 day (filtered)	mg/L	188
Chemical Oxygen Demand (COD)	mg/L	750
Total Organic Carbon (TOC)	mg/L	200
TOC (filtered)	mg/L	138
Total Solids (TS)	mg/L	781
Total Suspended Solids (SS)	mg/L	250
Total Keljahl Nitrogen (TKN)	mg/L	38
Ammonia (NH_4^+)	mg/L	12
Nitrate (NO_2)	mg/L	0.6
Total Phosphorous (TP)	mg/L	25
Phosphate	mg/L	8.8
Oil & Grease	mg/L	94

Septic Tank Effluent[6]

3.2 Tile Field & Groundwater

Effluent from the septic tank migrates to the tile field and discharges into the aerobic unsaturated zone. Under these condition, oxidation of ammonia occurs resulting in the formation of nitrate that can be roughly two to seven times the drinking water limit[16]. Since nitrate is highly soluble and mobile in groundwater, a distinct groundwater plume of elevated nitrate can extend a significant distance from the septic tile field [17]. Attenuation of nitrate in the groundwater occurs through denitrification provided that sufficient organic carbon is present for complete transformation of nitrate to nitrogen gas. For septic systems near surface waters, nitrate loadings can result in nearshore nitrate levels of ~50 to 100 times greater that adjacent surface water concentrations [9].

In addition to nitrate, the potential for the migration of pathogens also represents a risk [2]. Pathogens, including fecal coliform, Ecoli, and viruses can migrate in groundwater systems and impact domestic wells and shoreline environments [9]. Ecoli levels in the St. Marys River system have also become an increasing problem in recent years. The presence of Ecoli in the St. Marys River will be discussed in a subsequent section of this report.

4 Pathway Analysis

The analysis of potential risk pathways for the migration of COCs to potential receptors is typically the most complex aspect of quantifying human health and environment risk. Often there are multiple potential pathways for chemical migration, and each of these pathways should be addressed.

A diagram illustrating potential sources, pathways, and receptors is presented in Figure 2. An evaluation of potential risk with the proposed Pointe Estates Development indicates three potential sources of chemicals.

- Septic tanks,
- Chemical applications to yards, and
- Chemicals, particularly petroleum, related to the use of water craft.

Of these three sources, septic tanks have been previously identified as the primary source of COCs with water craft and yard chemicals being minor. Therefore, the focus of this risk analysis assumes septic tanks to be the primary sources, although steps should be taken to insure that no COCs are released from other potential sources.

Potential pathways include migration from the septic tanks into the shallow A Sand aquifer and migration and discharge to the proposed canal with subsequent migration of chemicals to the St. Marys River, impacts to sediment, and potential ingestion by fish and lower trophic level organisms. The migration of COCs to the St. Marys River represents a potential risk to bathers and recreational boaters both in the canal as well as along the St. Marys River shoreline downstream of the Alagash. Migration of COCs from the septic systems into the shallow A Sand aquifer and subsequent vertical migration from the A Sand into the lower sandstone bedrock aquifer also represents a potential risk since the bedrock aquifer is heavily utilized for residential water supply.

For the purpose of this evaluation, three primary risk pathways are identified:

- Pathway A - Migration of COCs from the septic systems into the upper aquifer with vertical migration to the sandstone aquifer,

- Pathway B - Migration of COCs from the septic systems in the shallow sand aquifer and discharge to the proposed canal, and,
- Pathway C - Discharge of COCs present in the canal to the St. Marys River system and subsequent migrations along the shoreline.

5 Risk Pathway A - Migration to the Bedrock

The following section interprets the available geologic information as it pertains to the potential migration of COCs vertically from the shallow sand aquifer to the deeper bedrock aquifer. Limitations in this data and information supporting the need for a site specific hydrogeologic study[3] are discussed.

5.1 Well Database

Characterization of the geology and hydrogeology in the area of the Pointe Estates Development was interpreted based on geologic information in the Ontario Ministry of Environment (MOE) online database provided in Appendix B[4]. The MOE database contains geologic, hydrogeologic, well construction, and location information for groundwater wells in Ontario. Information provided in the database was obtained primarily from well drillers dating back numerous decades, and, therefore, some errors as to the location of wells is present. Well location data presented in the database does provide information regarding the error associated with the spatial location of the wells (Figure 3). A number of the wells located within the proposed development, including wells 20, 21, 23, 25, 26, and 29, have location errors in the range of 300 meters to 1 kilometer. Inspection of the aerial photograph does not indicate the presence of residences in the area of these wells, and, therefore, a low degree of confidence in the location of these wells needs to be assumed. Well 19, plotted in the St. Marys River, is obviously incorrectly located in the database.

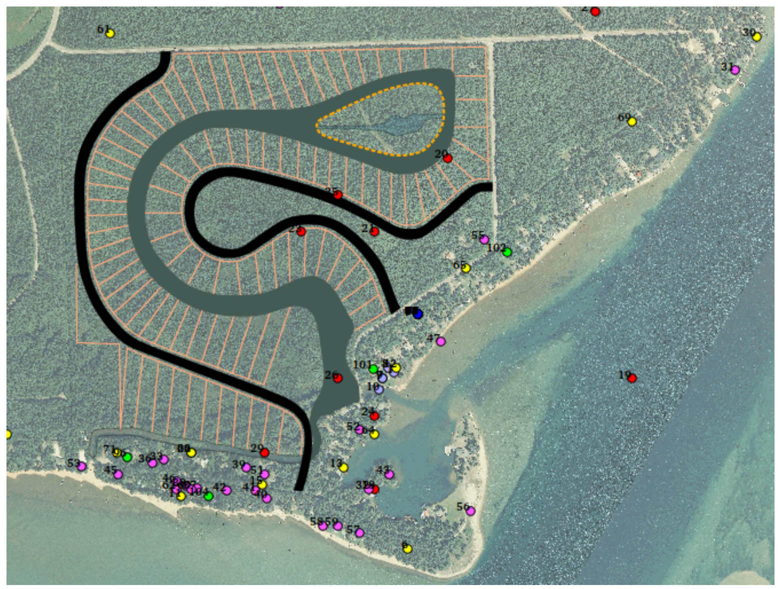
In addition to the error identified in the MOE database, comparison of the ground elevations at each location with the elevation presented in the MOE database (Figure 4) was conducted to identify

[3] Initially requested by the SSMRCA in 2006.

[4] http://www.ene.gov.on.ca/environment/en/resources/collection/data_downloads/index.htm#Well%20Records

any errors associated with calculating the depths of each geologic unit. Ground elevations were obtained for each location using the electronic digital elevation map file[5] and compared with the location information presented in the MOE data. The results of this analysis is presented in Figure 4 and indicates that with the exception of wells 6, 57, 58, and 59, located along the shoreline, vertical errors were less than 1 meter.

In conducting the geologic characterization in this effort, as well as in the previous preliminary hydrogeologic report [10], it is assumed that the well locations are reasonable. The only exception is that well 19 was removed from consideration in this analysis due to it's obvious error. It is strongly recommended that the well locations be accurately identified and the geologic information reevaluated before this information is used in any additional hydrogeologic studies in order to best characterize where additional borings are needed.



MOE Well Location Error

5.2 Area Geology

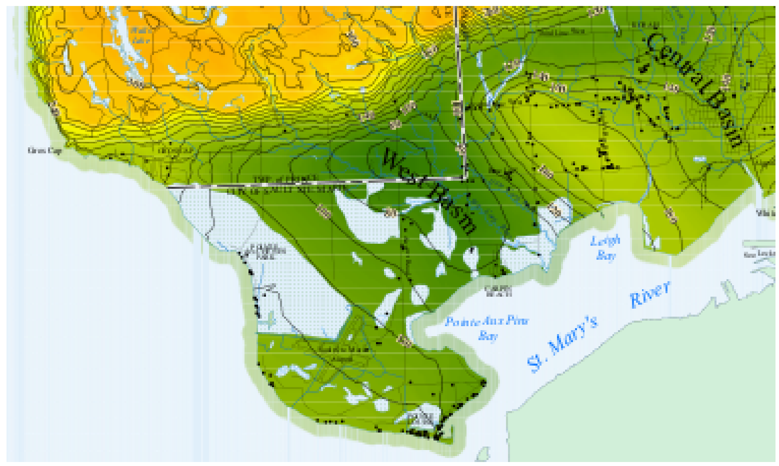
The Sault area consists of two landforms, the Precambrian uplands north of the city, and the lowlands, an area of relatively little topographic relief adjacent to the St. Marys River. Residential and commercial development occurs in the lowlands within the city of Sault Ste. Marie. The geology of the lowlands area consists of three basins identified as the East, Central, and West basins [1][6]. Municipal supply wells for the City of Sault Ste. Marie are present in the East basin (Shannon and

[5]identify file name and appendix location

[6]Appendix C, Figure 4.2

Lorna wells) and the Central basin (Goulais and Steelton wells). No municipal wells are located in the West basin.

The proposed Pointe Estates Development is located on the western extent of the West basin, just southeast of the Sault Ste. Marie airport within the limits of the city of Sault Ste. Marie near Pointe Louise just east of Airport Road. Aside from the airport, land use in the area is primarily residential with most residences located along the shoreline of the St. Marys River.

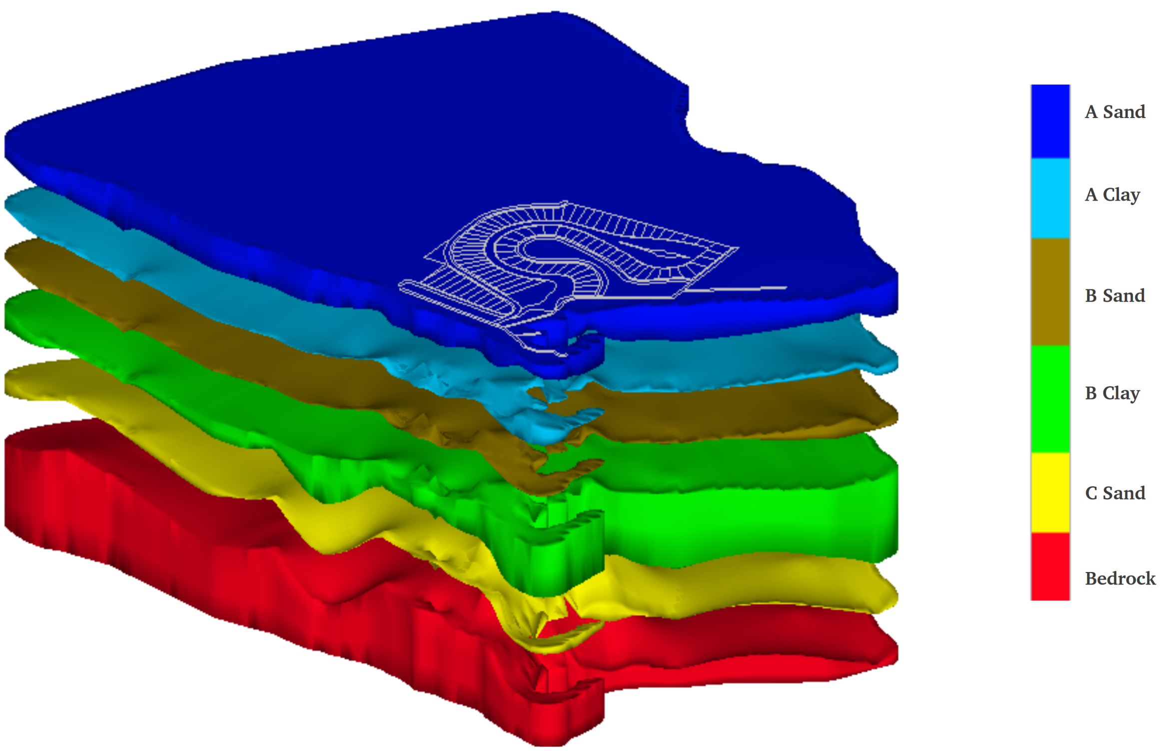


Bedrock Elevation, Burnside Figure 4.2

The geology around the proposed Pointe Estates Development was evaluated by developing a three dimensional geologic model based on the information presented in the MOE database[7] (Table 1). The geology of the Pointe Estates area consists of a sequence of sands, gravels, and clays comprising the glaciolacustrine and lacustrine shallow water deposits[1][8] overlying a sandstone bedrock aquifer which is used as a sole source aquifer for domestic water wells. As previously discussed, the site is located on the western extent of the West Basin where a significant rise in the elevation of the bedrock surface occurs changing from 60 meters msl within the central portion of the West Basin to 140 meters msl in the area of the proposed development. This represents a rise of ~80 meters over a distance of ~5 kilometers. A closer evaluation of the thickness of overburden based on the MOE dataset indicates six geologic units in the Pointe Estates area identified as follows: A Sand, A Clay, B Sand, B Clay, C Sand, and Bedrock. The A Clay, B Sand, and C Sand units are intermittent across the study area and are considered inconsequential. A description of each of these units is presented.

[7] Appendix B

[8] Burnside Figure 4.3, Appendix C



Three Dimensional Geologic Model

5.2.1 A Sand

The A Sand unit is the dominant sand unit underlying the proposed development. This is the unit where the septic systems will be installed. The sand unit thickness is approximately 35 to 40 feet thick in a north south direction through the proposed development, thickening in an easterly and westerly direction. The thinnest portion of the A Sand is in the southern portion of the development in the vicinity of the Alagash with a thickness of approximately 25 feet (Figure 5).

5.2.2 B Clay

The B Clay unit is a confining unit which separates the upper sand units from the bedrock aquifer. This clay unit is thickest in the northern portion of the proposed development, thinning in a south-westerly direction. The B Clay is an important geologic unit since it's presence will prevent the vertical migration of septic tank effluent from the upper A Sand downward to the bedrock aquifer. Of particular concern is Boring 29 (MOE Well ID 11-01297) which indicates a clay thickness of 3 feet or less than 1 meter (Figure 6). The location error of this boring, however, is high, between 300 meters to 1 kilometer. The kriging analysis indicates that the clay thickness in the southern portion of the development is thin to non-existent. As will be discussed, this is a result of the clay thickness in Boring 29 as well as the rising bedrock surface beneath the clay. The model analysis of the B Clay in the southern portion of the development should therefore be interpreted as possible clay thickness, but, also, clearly indicates a significant datagap that must be addressed in the hydrogeologic study.

5.2.3 Bedrock

The sandstone bedrock unit comprises the primary aquifer beneath the proposed development. Currently over 100 residential wells are installed in this aquifer for the purpose of domestic water supply. The elevation of the bedrock surface is variable across the proposed development and comes to within 50 feet of ground surface in the southern portion of the site (Figure 7). This rise in the bedrock surface is consistent with the regional geology of the Sault Ste. Marie area which indicates the site to be on the western extent of the west basin where a regional rise in the bedrock surface is identified[1][9].

[9] Burnside Figure 4.2, Appendix D

Geologic Unit	Description
A Sand	Uppermost hydrostratigraph unit consisting of fine - medium sands. Geologic unit where septic systems will be installed. Represents the thickest sand unit across the area, generally averaging up to ~50 foot thick across the site.
A Clay	Clay unit underlying the A Sand, discontinuous across the area generally averages a few feet thick to not present across the Pointe Estates area.
B Sand	Sand, similar to A Sand, separated from A Sand where A Clay is present.
B Clay	Clay unit separating upper sands from bedrock unit. Thickest in the northeastern portion of the Pointe Estates Development, thins towards the southwest. Potentially not present in south western portion of the development.
C Sandy Till	Intermittent sand unit overlying sandstone bedrock. Most likely weather bedrock surface. Often characterized as clayey sand or hardpan.
Bedrock	Sandstone bedrock underlying the lowlands area beneath Sault Ste. Marie. Water bearing unit for domestic water wells in the area of the Pointe Estates Development.

Summary of Geologic Units in the Pointe Estates Area

5.3 Previous Geologic Assessment

A preliminary hydrogeologic assessment was conducted in October 2006[10] in response to issues raised by the SSMRCA. As part of this assessment, an interpretation of the geology in the area of the Pointe Estates Development was conducted. Geologic information used in this assessment was obtained from the MOE database. Based on this assessment, a single cross section was developed in a southeasterly direction across the proposed development[10] indicating a depression in the bedrock surface overlain by approximately 55 meters of overburden of which about 30 meters of clay were interpreted above the bedrock surface.

"Beneath the upper sand unit is a relatively thick clay horizon, which acts as an aquitard and hydraulically seperates the surficial water table from the deeper water bearing units beneath the site. This unit ranges in thickness from 1 m to 63 m, and averages 29 m (arithmetic average).

[10] Waters 2006, Figure 1 Site Plan and Cross-Section, Appendix D

Locally, beneath the study site, the clay unit is on the order of 30 m in thickness” [11]

This interpretation was based on MOE well 11-3855. A review of hydrologic report appendix[12] indicated that this well was drilled in 1985 to a depth of 268 feet. Location coordinates for this well, however, were identified as easting 999999, and northing 9999999 indicating that no location coordinates were available for this well. Therefore, the conclusion that the upper sand and the deeper water bearing unit is hydraulically separate by a thick sequence of clay cannot be confirmed. An analysis of the geologic cross section in the same orientation as presented in the Waters report (Figure 6) indicates that the B Clay thickness is significantly less that 10 meters thick and potentially not present in this area.

In the construction of geologic cross sections, it is advantageous to construct more that a single cross section, with at least one cross section in the direction of the greatest geologic variation, and the second in a direction perpendicular to the first. As previously discussed, the regional geology indicates a rise in the bedrock surface in the vicinity of the proposed site with the highest degree of variation occurring in a northeast to southwest direction, perpendicular to the cross section presented by Waters. Therefore, the Waters cross section is misleading and does not present an accurate or clear interpretation of the geology across the proposed development since it is oriented in a direction of the least variation in geology. In fairness to the Waters report it should be noted that the report did state that the clay ranged in thickness from 1 to 63 meters. However, given the high degree of variability in the clay thickness and the implications regarding nature and extent of this clay as it pertains to the protection of human health, a more detailed evaluation of the geology in the area of the proposed development should have been conducted and the variability in the geology more explicitly presented.

5.4 Revised Geologic Cross Sections

Based on the geologic model constructed as part of this evaluation, two cross sections (slice planes) were constructed through the 3D geologic model. Cross section A-A’ was constructed along UTM Easting 5149400 m from west to east, and, cross section B-B’ constructed along UTM Northing 693500 m from south to north (Figures 8 - 9). Consistent with the geologic model previously presented, these cross sections clearly illustrate the rise in the bedrock surface as well as a significant

[11] Waters 2006, Appendix D pg. 2, paragraph 4.
[12] Waters 2006, Appendix D Pg. 225

thinning in the B Clay overlying the sandstone. The greatest change in B clay thickness was observed in the north south cross section (B-B') with the clay thickness ranging across the proposed development from about 60 meters to less than a few meters and potentially not existent in the southern portion of the site.

5.5 Hydrogeology

Groundwater levels across the site, based on records in the MOE database, indicate upward gradients between the lower bedrock and upper A Sand units. This is primarily due to the presence of artesian or discharging well conditions which is consistent with regional groundwater discharge to the St. Marys River. The Waters report indicated that 62% of the wells across the study area showed flowing well conditions upon completion of the well. The distribution of flowing to non-flowing wells is presented in Figure 10. As presented in the Waters report, the majority of wells in the area of the proposed development are flowing indicating upward gradients. Wells 29 and 26, located in the area where the B Clay is thinning, both indicate non-flowing conditions. The combination of a thin sequence of clay and non-flowing wells indicate a potential issue regarding the risk to wells in the bedrock aquifer in this area.

In making a case for upward gradients being protective of the bedrock aquifer, it is important to consider that hydrogeologic conditions can change as a result of pumpage or climate changes. Therefore, unlike geologic controls, hydrogeologic controls can be subject to outside stresses which can alter the direction of groundwater flow. It is also important to consider the potential changes to vertical gradients as a result of the addition of 90+ additional household wells in the area of the proposed development, effectively doubling the number of supply wells in this area. This increase in pumpage could result in a reversal of the upward gradients and increase the potential for downward migration of septic tank effluent particularly during periods of low rainfall and high pumpage such as during the summer months. As previously discussed in 2.1, constituents found in septic tank effluent, in particular Ecoli, represent an acute toxic risk, meaning that long term exposure is not required for illness to occur. A one time event could be sufficient to result in potential toxicity to residents as a result of the migration of septic tank constituents into domestic water wells. Therefore, reliance on groundwater gradients to eliminate the potential vertical migration pathway between the shallow A Sand unit and the underlying bedrock water supply aquifer is not advisable.

Finally, as an additional note, there is an assumption through this section that all the residential wells are drilled into the sandstone bedrock. Anecdotal information indicates that some of the older residents may have non-recorded sand point wells that may be directly impacted by septic dispersal in to the upper A sand layer.

6 Risk Pathway B - Migration to the Proposed Canal

The following risk pathway deals with the potential migration of COCs from the septic systems into the shallow A Sand aquifer and migration of these COCs towards the proposed canal. This section also deals with specific comments to the Preliminary Hydrogeological Impact Assessment[10].

6.1 Groundwater Flow to the Proposed Canal

In a presentation to the SSMRCA Board of Directors, the consultant for the Pointe Estates Development[13] stated that water in the shallow A Sand aquifer will migrate under gravity conditions to the proposed canal and Alagash, specifically,

"Groundwater Pathways

- *The flow of groundwater in the upper (unconfined) aquifer is driven by gravity.*
- *Groundwater generally flows downhill to the south (towards the St. Marys River).*
- *In the study area groundwater levels are controlled by (and effectively equal to) the water level in the river.*
- *At the existing Alagash, groundwater on either side of the waterway flows towards the Alagash"*

These statements appear to indicate that groundwater from the lots will migrate in a southerly direction towards the St. Marys River while shallow groundwater from the existing lots along the Alagash will flow towards the Alagash. Also the statement *"In the study area groundwater*

[13] SSMRCA Hearing Board, April 20, 2010

levels are controlled by (and effectively equal to) the water level in the river.", is misleading. If the groundwater levels in the study area were the same as the river, groundwater flow would not occur since there would be no hydraulic gradients causing groundwater to flow and discharge to the river. Groundwater flow model simulations were also presented to demonstrate groundwater flow towards the Alagash and the proposed canal, however, sufficient documentation of this model was not provided in the presentation, and, therefore, a review could not be conducted.

Statements regarding the migration of groundwater in the shallow aquifer appear contradictory. One the one hand, shallow groundwater from the proposed lots will migrate south or remain stagnant and not be influenced by the proposed canal, while shallow groundwater from lots along the Alagash will be controlled by the Alagash. Assimilative Capacity Model analysis conducted by Coldwater[14] further assumes that shallow groundwater from each of the lots will discharge to the proposed canal.

A reasonable assessment as to the direction of groundwater flow in the shallow system would be towards the proposed canal since the water level in the canal would be expected to be lower than in the shallow aquifer. This conclusion is based on straightforward and well documented hydrogeologic principles. The rate of groundwater flow and the magnitude of the groundwater discharge to the canal, however, cannot be accurately calculated since a hydrogeologic study has not been performed.

In evaluating this risk pathway, it is reasonable to assume that septic tank effluent will discharge to the shallow A Sand aquifer and migrate towards the proposed canal where it will potentially discharge into the canal. The potential impact to the water quality in the canal is based on a number of factors, including:

- the initial concentration of COCs discharging from the septic tanks,
- the volume of septic tank effluent discharged from the septic tile field,
- the nature of the COCs originating from the septic tanks,
- the rate of migration of groundwater potentially impacted by the septic tanks towards the canal,

[14] Presentation to the SSMRCA Board of Directors, April 19,2010, slide 24

- rainfall and weather conditions,
- the nature and extent of the shallow A Sand aquifer,
- the nature and extent of the underlying B Clay,
- the downgradient distance between the septic tank and the proposed canal, and
- the water level in the proposed canal.

Although groundwater in the A Sand will most likely migrate towards the canal, it is not certain that this groundwater will contain septic tank COCs at concentrations that could represent a risk to water quality in the canal. Engineering designs of the septic tank systems or the attenuation capacity of the A Sand could greatly limit or eliminate the discharge of COCs. However, conclusions regarding the migration of COCs, or lack thereof, cannot be made without the benefit of a well designed and complete hydrogeologic study.

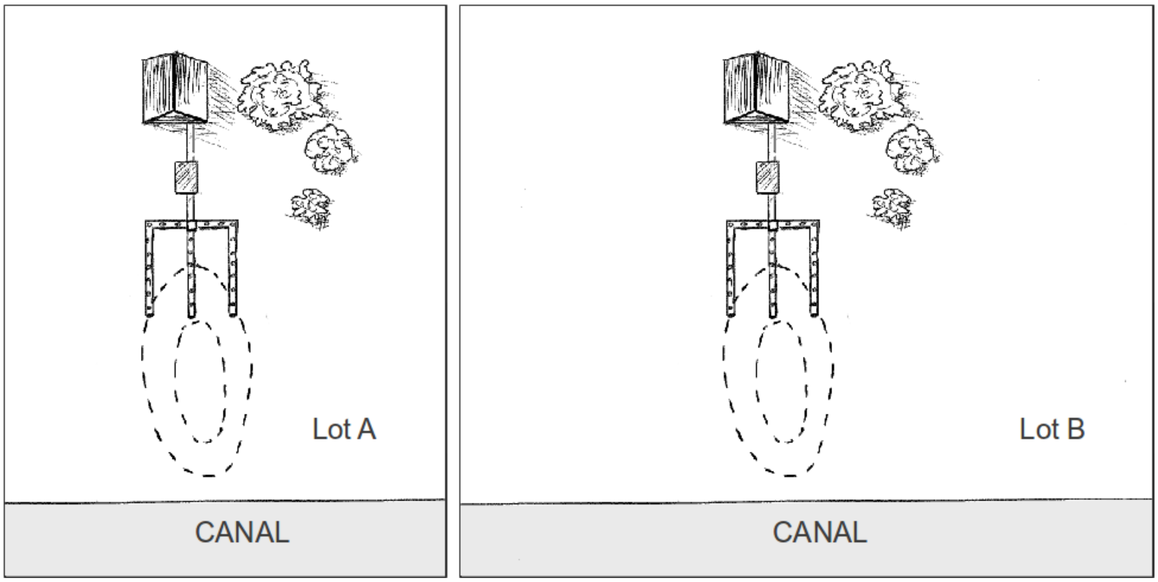
6.2 Discussion of the Proposed Subdivision Lot Sizes

One conclusion of particular concern was made regarding the impact of lot sizes[10] as taken from provincial guidance[15][8]. Excerpts regarding this analysis include:[16]

- *"The assessment considers the nitrogen loading from a single on-site sewage system to the water table aquifer beneath each property, based on a simple-dilution mixing model. The source concentration of nitrate-nitrogen is set at 40 mg/L (as N), and the daily discharge volume for a single family residential unit is set at 1000 L/day/lot (Procedure D-5-4)."*
- "T*he effluent from the on-site system, once entering into the subsurface, is then considered to mix with fresh rainwater infiltration over the entire property area, thereby achieving a dilution of the concentration of nitrate-nitrogen prior to any off-site discharges from the lot."*

These statements and the resulting calculation regarding lot sizes are completely erroneous, technically incorrect, and misleading. The simple idea that an arbitrary factor such as lot size will dilute the concentration of nitrate-nitrogen from the septic system is simply wrong.

[15] Provincial Guidance D-5-4, Appendix E
[16] Section 3.0 Groundwater Impact Assessment, pg. 5 [10]



Conceptual Diagram of Lot Sizes Related to Plume Concentration

Consider the following conceptual illustration depicting two lots, Lot A and Lot B.

Both lots are adjacent to the proposed canal and both are identical, except for the lot sizes. Lot A has a lot size approximately half the size of Lot B. In both these cases, the distance from the septic tank tile field to the canal is the same and the chemical plumes from both septic systems are also equal. Since both plumes are migrating towards the canal, the discharge concentrations from each system is the same, regardless of the lot size. Infiltrating water onto the lots will not mix more with the plume on Lot B than on Lot A since lot size is arbitrary and has nothing to do with the hydrologic processes of mixing of infiltrating rainwater with each plume.

The influence of lot sizes relates to the density of septic systems in a subdivision and the collective migration of effluent plumes. If a subdivision utilizes smaller lot sizes, more septic systems are present per given area, and the likelihood of intersecting a plume with elevated COCs is more likely. This will increase the potential risk to downgradient receptors. If, on the other hand, lot sizes are larger, the overall density of septic systems will be lower and the potential impacts are reduced. A good description of this process is presented in Appendix A[17].

In relation to the proposed Pointe Estates Subdivision, the *“width”* of each lot along the canal will have an impact on the total mass of COCs present in the proposed canal not the lot size. Obviously,

[17] Section 2.4.8, pg. 25, Figures 8,9, & 10[5]

the more lots present along the canal, the more potential mass of COCs in the canal and the greater the resulting COC concentrations. Density of lots in this case, however, is a function of the number of lots per linear distance along the canal, not the total area of each lot, i.e., the wider the lots, the less lots along the canal, the less potential impact. The resulting concentration of COCs in the canal will also be influence by mixing in the canal, rainfall, etc. These processes were not addressed in the hydrologic study.

Finally, it needs to be emphasized that there is a possibility that COCs from the septic systems will not impact the proposed canal due to the attenuation potential of the A Sand aquifer and potential design considerations for the septic systems. The important consideration here is not the lot size or width, but the linear distance from the septic system tile field to the canal in the direction of groundwater flow. The longer the distance, the longer the residence time of any potential COC in the groundwater, the greater the potential for attenuation. Hydraulic properties along with the geochemical conditions in the A Sand aquifer are important factors to consider in assessing the potential attenuation of COCs. As stated numerous times, characterization of these processes can only be conducted if a hydrogeologic study is performed.

6.3 Unsaturated Zone Thickness

The thickness of the unsaturated zone beneath the septic tank tile field plays an important role in both the attenuation of potential COCs as well as the overall hydraulic performance of the septic system [12, 15, 14, 13, 11]. Currently, the vertical permeability of the unsaturated soils and the distance from ground surface to the water table is unknown. These factors will have a significant impact on the performance of the septic systems and should be addressed. Site specific information to address these factors would be obtained through a proper hydrogeologic investigation.

6.4 Preliminary Hydrogeologic Assessment - Additional Comments

Development of subdivisions which require individual septic tank systems requires permitting in accordance with the Ontario Ministry of Environment Guidelines[8](Appendix E). Based on information in this guideline, the hydrogeologic assessment conducted by Waters[10] does not represent a valid hydrogeologic investigation, since it is preliminary and incomplete, i.e., *Where a report is found to be incomplete, draft or preliminary, or makes unsubstantiated claims, the MOEE will advise the proponent by letter with regard to the report's deficiencies. MOEE may not undertake a full review until such time that a complete report (i.e., on which satisfies the requirement of this Guideline) has been submitted.*[18]

Also, the report does not contain the site specific hydrogeologic data or analysis required for permitting. The SSMRCA requested that a hydrogeologic investigation be conducted at the proposed development in accordance with D-5-4, but to date, this work has not been performed.

Special consideration also needs to be made for developments along shorelines or developments which could potentially impact surface waters, i.e.,

In some cases, it may be necessary to demonstrate isolation from sensitive surface water environments. Wherever there is a potential for surface water impact, the proponent should contact the MOEE Regional Surface Water Staff.[19]

Shoreline development proposals will be reviewed on a case-by-case basis.[20]

The Pointe Estates Development Group has not met the permitting requirements and has not clearly demonstrated through a valid hydrogeologic study, that surface waters or domestic drinking water supplies will not be impacted. This section is intended to strongly emphasize that neither the appropriate level of technical evaluation or regulatory requirements have been met by the developers. Therefore, the Pointe Estates Development Groups assertion that all of the required technical information has been submitted is not valid. Additional studies are required, and any potential legal action brought by the Pointe Estates Developers claiming sufficient technical evaluations have been done, is baseless. Since the Waters report does not meet the permitting requirements, a valid hydrogeologic study, conducted by a reputable hydrogeologic firm will need to be done as previously requested by the SSMRCA.

7 Risk Pathway C - Discharge to the St. Marys River System

In order to address potential impacts to the proposed canal, a hydrologic analysis was conducted[3]. The primary purpose of this analysis was to demonstrate that water from the St. Marys River

[18] *D-5-4, Section 5.2*
[19] *D-5-4, Section 5.5*
[20] *D-5-4, Section 6.0 Implementation*

will dilute canal water and prevent degradation of the water quality. The primary mechanism for dilution in the canal was waves from the river as a result of seiches and commercial shipping traffic through the Sault Locks. Comments conducted by BGM regarding the application of the hydraulic modeling[4] is presented in Appendix F. Additional comments regarding the application of this model and potential impacts of the proposed management options for the canal are discussed in this section.

7.1 Commercial Shipping and Ship Wake Effects

The passage of ships in the St. Marys River through the Sault Locks generates waves which could potentially result in the exchange of water between the river and the proposed canal. The result of this exchange would be to keep the lower portion of the proposed canal well-flushed and maintain good water quality. Widening of the mouth of the Alagash was proposed to increase this degree of exchange.

7.1.1 Water Exchange

Wave action between the proposed canal and the St. Marys River causes the displacement of water in the canal as a wave from the river moves into the canal. This process will cause mounding on the far side of the canal followed by the discharge of water from the canal into the river. This back and forth movement of water into and out of the mouth of the canal will result in the displacement of water, but will not result in the effective mixing or dilution of canal water.

At the contact of canal and river water, a slight mixing zone will occur which will result in the dilution of canal water, however, these exchange processes will only occur at the mouth of the proposed canal and will not be adequate to insure the water quality throughout the entire canal.

In addition to the exchange processes, it is important to consider the net flow of water between the canal and the river. The total flow of water into the canal will not be from the river, but rather from the canal into the river. This net discharge of water from the canal into the river is the result of the discharge of groundwater from the proposed lots, direct precipitation into the canal, and the impact of regional groundwater flow towards the St. Marys River. The resulting canal water will then migrate along the shoreline in a downstream direction after discharging from the mouth of the

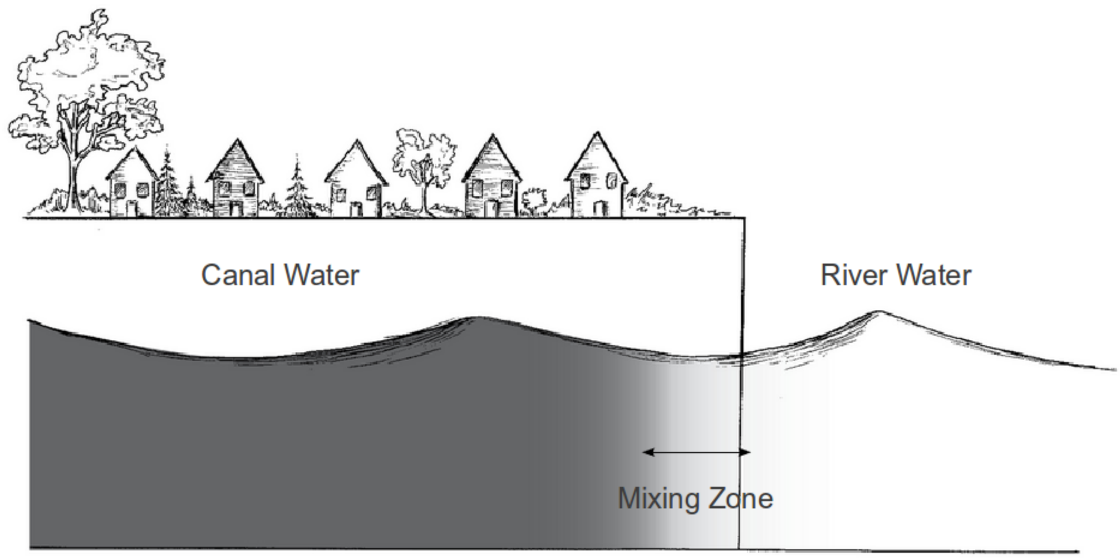


Illustration showing the displacement of canal water and river water and the formation of a mixing zone.

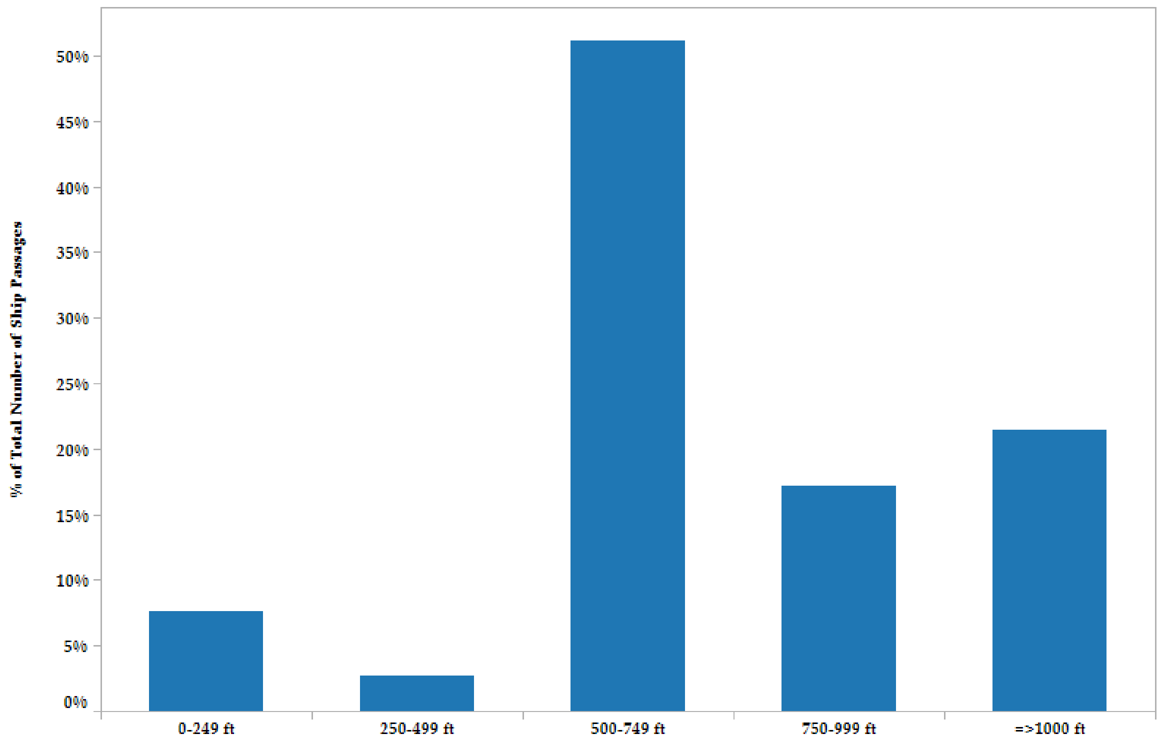
proposed canal. Wave action from seiches and ship traffic will cause the discharged canal water to migrate along the shoreline and not flow or mix with water in the deeper portion St. Marys River. This migration of canal water represents a direct risk to bathers and residents along the shoreline should the canal water contain elevated levels of septic tank COCs.

7.1.2 Shipping Traffic

As discussed in the hydraulic report, critical to the hydrologic modeling and canal / river water exchange, is the passage of ships in the St. Marys River. The assumption in the modeling effort was that, on average, 6000 large commercial vessels will pass by Pointe Louise, many of which are 1,000 foot or greater. In order to evaluate this assumption, ship passage records for the Sault Locks were obtained [21] and dimensions and dates of passage for each ship were compiled into a database for the shipping year 2010 (Table 2).

Over the 2010 shipping year, there was a total of 4,216 passages which was less than 75% of the 6000 passages assumed in the hydraulic model. Also, since the Sault Locks are closed during a

[21] Appendix G - http://www.boatnerd.com



Summary of Ship Passages According to Vessel Length

portion of the winter months, there were no passages between January, 16 and March 20, 2010. Therefore a continuous exchange of water as a result of ship passage throughout the year cannot be assumed.

Comparison of ship passages with the dimensions of each ship indicates that only approximately 22% of the vessels passing through the Sault Locks were 1000 ft or greater, with the majority (~50%) being between 500-749 feet.

Therefore, based on the available data from 2010, the primary assumptions of the size and frequency of freighter passages is less than the assumptions in the model indicating that the hydraulic model overestimated the influence of shipping on the exchange of water between the proposed canal and the St. Marys River.

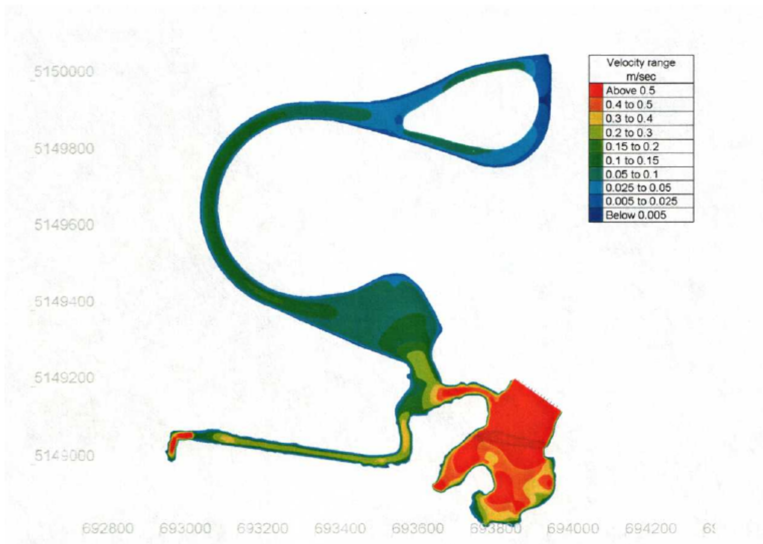


Figure 35 Velocity fluctuations caused by ship passage using ADCIRC model

Hydraulic Model Simulation of the Inlet Bay

7.2 Flushing of the Proposed Canal

One potential remedial option for maintaining the water quality in the proposed canal is to flush water through the canal by pumping water from the St. Marys River at a rate of 1500 gpm to the upstream portion of the canal. The resulting flushing action will displace the existing water in the canal subsequently discharging the impacted canal water into the inlet bay formed by Pointe Louise. Water present in the inlet bay will then migrate along the shoreline in a downstream direction towards Marks Bay and will represent a risk to bathers and residents along the shore.

7.2.1 The Potential for Dilution of Canal Water

The basic idea behind this proposed flushing is that water discharged from the canal will mix and dilute with water in the St. Marys River. However, while mixing of waters in this manner does not occur under normal flow conditions, the additional factor regarding the inlet bay needs to be considered. In the hydraulic modeling[3], it was concluded that wave action will be significant in the inlet bay.

Based on the results of the hydraulic model, water from the St. Marys River will flow into the inlet bay more than in the proposed canal. It is reasonable, therefore, to assume that the water from the proposed canal will migrate into the inlet bay. As previously discussed, water from the river will tend to displace canal water, and mixing will be limited. In addition, the amount of water in the proposed canal is greater than the amount of water in the inlet bay significantly limiting potential dilution, even if mixing were to occur, for example:

> Assuming that the depth of the inlet bay and the proposed canal are the same, the amount of potential dilution can be estimated based on the area of the proposed canal and the inlet bay and assuming complete mixing (which is unlikely). Estimated areas are as follows:

- Area of Canal including the Canal Island = 173,560 m^2
- Area of Inlet Bay = 63,564 m^2
- Area of Canal Island = 47,552 m^2

> Therefore:

- Net area of canal = 173,560 - 47,552 = 126,009 m^2

> The ratio of the area of the canal to the area of the inlet bay:

$$Ratio = \frac{126{,}009 m^2}{63{,}564 m^2} \approx 2.0$$

Therefore, since the amount of water in the proposed canal is approximately twice the amount of water in the inlet bay, the potential for impacts to the water quality in the inlet bay is significant. In addition, once the water in the inlet bay is impacted, it will tend to migrate downstream along the shoreline. This will result in an increase risk to the residents along both the shoreline and inlet bay and should be avoided.

Conceptual Model of Canal Water Migration Along the Shoreline of the St. Marys River from the Inlet Bay

7.2.2 Ecoli Levels in the St. Marys River

While an analysis of Ecoli levels in the St. Marys River is beyond the scope of this opinion, Ecoli information was compiled. Sampling locations are presented in Figure11 and the compile data is provided in Table 3 as well as Appendix H.

The basis for the inclusion of St. Marys River Ecoli data is to emphasis the following:

- that water discharged to the St. Marys River does not dilute to below risk levels,
- to identify that water quality in the St. Marys River is being impacted, and
- that not all of these impacts are the result of possible sources downstream of the Sault Locks, that impacts upstream of the Locks are present.

While the vast majority of sampling points are present below the Locks due to the identification of potential sources, sampling points above the Locks, such as the outfall at MOE_1 have historically indicated elevated levels of Ecoli contamination. Therefore, it should not be assumed that discharge from the proposed canal into the St. Marys River will result in dilution of canal water with no potential impact to the St. Marys River system. The assumption of dilution in the St. Marys River does not represent a valid approach to maintaining water quality. Also, since the discharge of water from the canal represents a point source discharge, regulatory permitting maybe required.

8 Conclusions

Based on a review of the available information and the opinion provided herein, the following conclusions are made.

- *The legal proceedings against the SSMRCA are baseless.*

The appeal made by the Pointe Estates Development Group regarding the SSMRCA decision (Decision) of June 6, 2010 claiming, in part, that,

> *"SSMRCA made the Decision without proper or any regard to the scientific evidence submitted and filed by the Applicants in support of it's Application"* and
> *"SSMRCA based the Decision upon facts unsubstantiated in evidence"*

is baseless and without merit. As presented in this opinion, the technical information provided to the SSMRCA by the Pointe Estates Developers is at best preliminary, incomplete, and to some extent misleading and inaccurate. The hydrogeologic assessment conducted and submitted to the SSMRCA is inconsistent with applicable provincial guidance and does not present a complete evaluation of the available MOE well data. Furthermore, this assessment incorrectly applies portions of the MOE guidance, fails to make a clear determination of the risk to residential wells and nearby surface waters, and contains no site-specific data or information with which to accurately quantify the potential risk to human health or the environment. In short, it contains no valid *"scientific"* evidence as claimed in the appeal.

The hydraulic model evaluating the influence of seiches and ship traffic on water quality in the proposed canal also cannot be considered to be a valid scientific evaluation of the potential risk to human health or the environment. The application of this model was not conducted in a manner consistent with accepted modeling practices, or accepted practices identified by the consultant on previous modeling projects[4], and the physical process of wave action causing dilution in the canal is technically incorrect. Furthermore, the proposal to conduct flushing of the canal could pose a risk to residents along the shoreline as well as the overall water quality in the St. Marys River.

- *The hydraulic modeling conducted by the Pointe Estates Development Group does not meet the permitting requirements and cannot be considered valid scientific evidence for the development application.*

Provincial guidance regarding the scientific requirements for permitting subdivision developments requires that a valid hydrogeologic study be performed. There are no requirements or guidance indicating that hydraulic studies, surface water models, or the assessment of impacts of shipping or seiches needs to be conducted as part of the permitting process. Nor can the hydraulic model analysis be accepted in place of a valid hydrogeologic study in the permitting process. Therefore, submission by the Pointe Estates Development Group of the hydraulic analysis cannot be considered by the SSMRCA as valid scientific evidence or as meeting the minimum permitting requirements.

- *A reputable hydrogeologic firm needs to be retained by the Pointe Estates Development Group in order to carry out a valid, technically defensible hydrogeologic study.*

As has been reiterated multiple times thoughout this opinion, a valid hydrogeologic assessment needs to be conducted as originally requested by the SSMRCA. The hydrogeologic assessment should clearly identify and address all potential impacts to residential wells or surface waters in the area. It is also important that a reputable hydrogeologic firm be retained to conduct this work to insure that all technical work is conducted in accordance with the required permitting process.

References

[1] R.J. Burnside & Associates. Sault ste. marie area groundwater management and protection study: Volume 1 - main report. Technical report, 2003.

[2] Roger C. Bales, Shimin Li, Kimberly M. Maguire, Moyasar T. Yahya, Charles P. Gerba, and Ronald W. Harvey. Virus and bacteria transport in a sandy aquifer, cape cod, ma. *Ground Water*, 33(4):653–661, 1995.

[3] PhD. P.Eng. Davies, M. Pointe estates hydrologic and hydraulic analysis. technical report. Technical report, Coldwater Consulting, Ltd., December 2008.

[4] P.Geo F. Breen, MSc. Technical opinion, hydrologic evaluation of the proposed pointe estates development, sault ste. marie, ontario, canada. Technical report, Breen GeoScience Management, Inc., October 2010.

[5] Kenneth Froese PhD, Kevin Frankowski MASc, Cathy Ryan PhD, and Angus Chu PhD. Onsite wastewater treatment systems in subdivisions. September 2009.

[6] R.C. Knox L.W. Canter. *Septic Tank Effects on Ground Water Quality*. Lewis Publishers, Inc., Chelsea, Michigan USA, 1988.

[7] Metcalf and Eddy. *Wastewater Engineering: Treatment, Disposal and Reuse*. McGraw Hill, Inc. New York, NY, USA, New York, N.Y. USA, 1991.

[8] MOEE. Procedure d-5-4: Technical guideline for individual on-site sewage systems: Water quality impact risk assessment. Technical report, Ontario Ministry of the Environment, 1996.

[9] William G. Reay. Septic tank impacts on ground water quality and nearshore sediment nutrient flux. *Ground Water*, 42(7):1079–1089, 2004.

[10] MSc. P.Eng Richards, P.A. Preliminary hydrogeological impact assessment, the pointe estates sault ste. marie, ontario. Technical report, Waters Environmental Geosciences Ltd., PO Box 69, Lively, Ontario P3Y 1M2, October 2006.

[11] W. D. Robertson. Irreversible phosphorus sorption in septic system plumes? *Ground Water*, 46(1):51–60, 2008.

[12] W. D. Robertson, J. A. Cherry, and E. A. Sudicky. Ground-water contamination from two small septic systems on sand aquifers. *Ground Water*, 29(1):82–92, 1991.

[13] W.D. Robertson. Enhanced attenuation of septic system phosphate in noncalcareous sediments. *Ground Water*, 41(1):48–56, 2003.

[14] W.D. Robertson and J. Harman. Phosphate plume persistence at two decommissioned septic system sites. *Ground Water*, 37(2):228–236, 1999.

[15] W.D. Robertson, S.L. Schiff, and C.J. Ptacek. Review of phosphate mobility and persistence in 10 septic system plumes. *Ground Water*, 36(6):1000–1010, 1998.

[16] Sheryl R. Wilhelm, Sherry L. Schiff, and John A. Cherry. Biogeochemical evolution of domestic waste water in septic systems: 1. conceptual model. *Ground Water*, 32(6):905–916, 1994.

[17] Sheryl R. Wilhelm, Sherry L. Schiff, and William D. Robertson. Biogeochemical evolution of domestic waste water in septic systems: 2. application of conceptual model in sandy aquifers. *Ground Water*, 34(5):853–864, 1996.