Heritage Resources Centre
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The Long Point Area:
An Abiotic Perspective

Long Point Environmental Folio
Publication Series

Technical Paper 2

Long Point Environmental Folio Publication Series
Managing Editors: J. Gordon Nelson and Patrick L. Lawrence

A study team at the Heritage Resources Centre is developing an Environmental Folio for the Long Point Biosphere to assist management agencies and local citizens in understanding the human and natural components of the ecosystem. The folio will consist of a series of maps and text that would outline current major management issues and areas of concern. A series of project publications is being prepared to accompany the folio. These reports will consist of supplementary information collected during the study. This project is supported by the Royal Canadian Geographic Society and the Social Sciences and Humanities Research Council of Canada.

THE LONG POINT AREA: AN ABIOTIC PERSPECTIVE

Ron Stenson

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Heritage Resources Centre
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GLOSSARY

Definitions of Abiotic Terms Used in This Report

Aeolian	A term pertaining to the wind; hence wind-borne, wind-blown or wind-deposited materials are often referred to as aeolian.
Aggregate	In civil engineering, the inert material which forms a substantial part of concrete or road metal. It can vary in size from broken stone or gravel to sand.
Bathymetric	Pertaining to the depth of a body of water and its measurement (bathymetry).
Geochronology	The study of age determination in the history of the Earth. It is divided into absolute dating and relative dating.
Glacial	The term is used as a noun to describe a cold phase during an ice age.
Glacier	An extensive body of land ice which exhibits evidence of downslope movement under the influence of gravity and which forms from the recrystalization of névé and firn.
Interglacial	The time period between two glacial stages, during which there is an amelioration of climate, with temperatures in the temperate zone rising to about the level of the present day.
Interstadial	(see Interglacial)
Landscape	An assemblage of plants, soils, and wildlife, other aspects of the Earth's surface.
Moraine	An accumulation of heterogeneous rubble material, including angular blocks of rock, boulders, pebbles and clay, that has been transported and deposited by a glacier or ice sheet.
Periglacial	Non-glacial processes and features of cold climates. The climatic, processes and features created by freeze-thaw action in a zone bordering ice sheets.
Physiography	A term for the combined scientific study of geomorphology, pedology and biogeography.
Spit	A narrow and elongated accumulation of sand or shingle projecting into a large body of water.
Stratigraphy	The branch of geology which deals with the composition, sequence, spatial distribution, classification and correlation of sedimentary rocks.
Till	Unconsolidated, sediments deposited by a glacier.
Topography	The surface features of the Earth's surface.

1. INTRODUCTION

This paper is an initial strategic assessment of the abiotic information available for the Long Point Biosphere and its area of influence. The paper describes, analyzes and synthesizes information on abiotic structure and processes in the Long Point area already available in publications, libraries, government offices and other sources. Only reconnaissance field activity was undertaken for the report. Much of the information is presented in map form and interpretation is often left to the reader. The information provided is analyzed at the basin or region scale. Site specific information is often too geographically confined to be of use to long term or regional scale management.

Information gaps are evident and are a result of a number of circumstances:

1. No information was available for review.
2. Information was available but was incomplete or unreliable.
3. Insufficient time was available for summarizing or interpreting large data sets.

The information provided will hopefully give an overview of the very complex abiotic environments of the region. It should help citizens, planners and managers make decisions based on more knowledge and longer time perspectives than is generally the current practice in Ontario. Some concepts need to be defined to enable the reader to interpret the maps and tables which follow. These concepts in no particular order of importance are:

1. abiotic
2. biodiversity
3. geodiversity
4. sustainability
5. hazards
6. landscape evolution
7. systems

1. The term abiotic, in the context of this report, refers to that part of an ecosystem that is neither alive (biologic) nor a product of human systems (cultural). There are, however, linkages that must be understood. For example, soils are derived from both biologic and geologic sources, and despite the biological importance of soils, they are generally considered within the abiotic regime. Also, human adjustments to hazards such as levees and dikes, or quarries used for the extraction of mineral or aggregate resources are human in origin, but are often considered within the abiotic regime. Frequently this report will refer to a number of specific abiotic features and landforms. For those who may not be familiar with them they are defined in the glossary.

2. Biodiversity is used to refer to the 'variety of life' in a place, to the variety of genes, species, communities or ecosystems and landscapes in a site or region. This can include the benefits of preserving biodiversity including the provision of plant and other biological materials and chemicals for human use and genes for breeding and development of new biotechnologies. Of course the altruistic pursuit of sustaining as large and diverse a natural environment as possible for future generations is also a strong justification for maintaining biodiversity.

3. Although the concept of biodiversity is often not associated with abiotic research, a similar term, geodiversity, can be introduced to refer to the variety of weather, climate, rocks, minerals, landforms, soils, lakes, rivers, and related geologic and hydrologic features and processes. Geodiversity reflects many of the same values as biodiversity. It is important to note that besides the importance of sustaining abiotic systems from a resource or aesthetic standpoint, sustainable biodiversity is dependent on sustainable geodiversity since drainage, soil types, and microclimates are strongly influenced by biotic processes and features.

4. The Brundtland Commission (WCED, 1987) defined sustainability as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This has led to two perspectives which are not incompatible, but which presently still compete for political support:

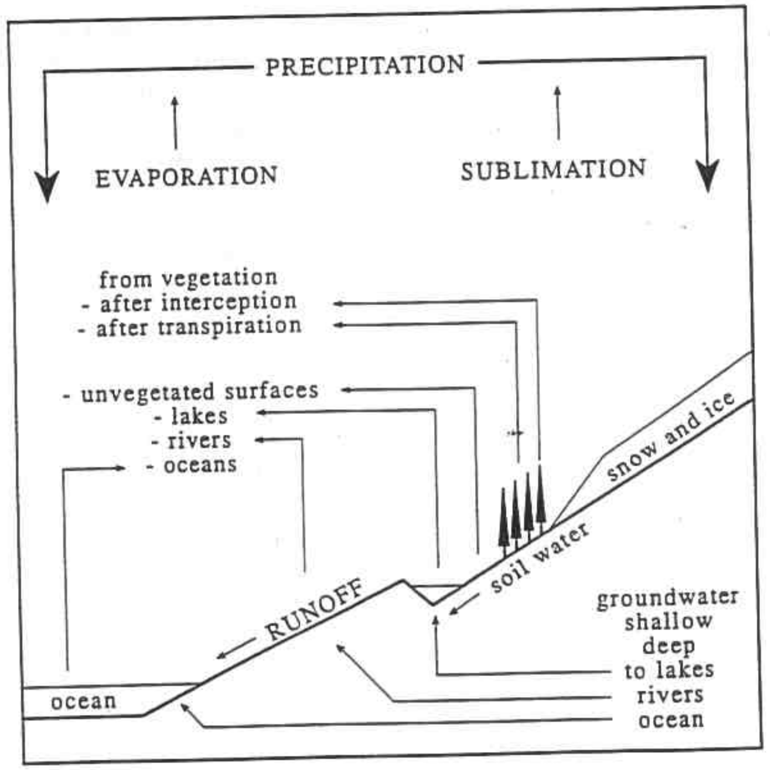
- o Ecologists view sustainability as the preservation of the status and function of ecological systems
- o Economists interpret sustainability as the maintenance and improvement of human living standards

5. Hazards are events or activities that can cause injury, disease, death, economic loss, or environmental deterioration. Examples are floods, droughts, severe storms, and industrial pollution.

6. Landscape evolution is the reconstruction of the landscape in a sequence of stages, each with a specified age. An example is the historical analysis and description of the Long Point area from glacial times to the present.

7. A system is a set of objects together with relationships between the objects and between their attributes. Objects are the physical and or abstract parts or components of a system and attributes are the physical properties of the objects. In the following schematic of the hydrologic system (Figure 1) below the objects include the bedrock, soil, lakes and forests. Their attributes include elevation, slope, permeability, aspect and species distribution. The term ecosystem is generally used to refer to the plants and animals and their relations to soils, water, climate, geology and other elements and processes of an area, In this sense one can refer to the Long Point ecosystem but not without some uncertainty as to the area involved; for example where are the boundaries in the surrounding water to be drawn?

Figure 1. Schematic of a Hydrologic Cycle



2. METHODS

2.1 Study Area

When dealing with natural areas it is always difficult to define the study area precisely. The area of central concern here is that area identified as the Long Point Biosphere Reserve and the surrounding area of cooperation (Figure 2). However, the area is effected naturally, economically and politically by an area at least as large as the Great Lakes basin. Technically of course, the weather systems that affect the study area are part of a continental system which in turn, is part of a global system. This larger perspective is highlighted here for three reasons:

- o to illustrate that the study area is not an independent location, isolated, as it were, from its surroundings.
- o to provide an opportunity to establish its link with global systems.
- o to illustrate that the area exists within systems or places of various scales.

At the scale of the study area each of the identified abiotic variables was assessed with reference to four criteria as defined by IUCN (1980) and described by Nelson et al. (1991) as :

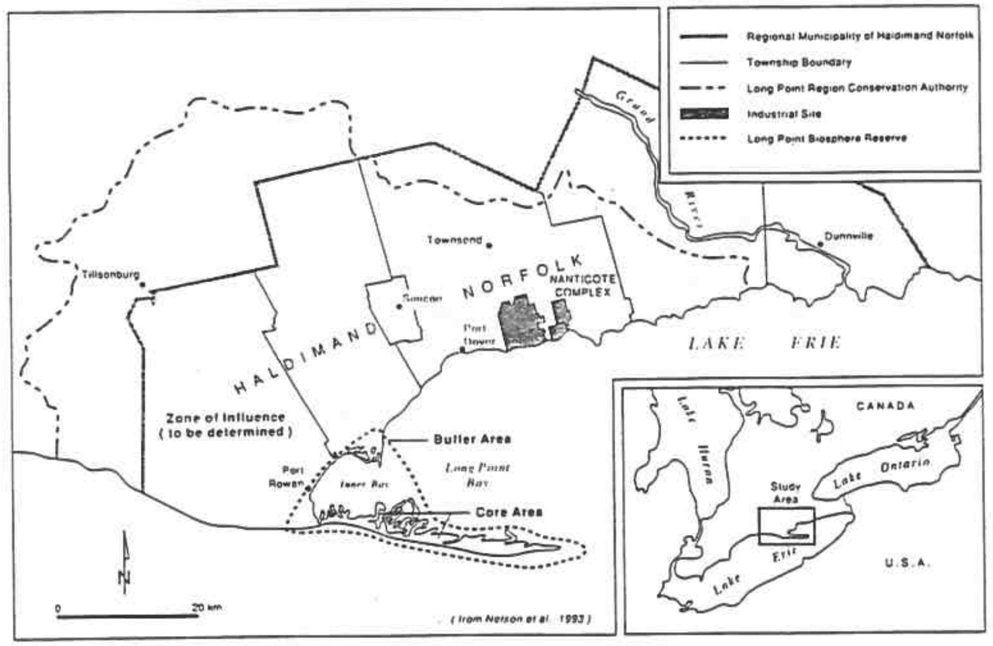
- o Stability: Short term change implies instability. This can be the natural state of a feature. If this is the case then the process affecting the feature must be understood for planning and management.

- o Rarity: Is a measure of the relative occurrence of a feature or process within the immediate coastal zone; Lake Erie; or the Great Lakes basin.

- o Diversity: Is a measure of the variety of associated features or processes within the immediate coastal zone; Lake Erie; or the Great Lakes basin.

- o Representativeness: Is a measure of the completeness of the natural ecosystem and involves the health of features and processes. Representativeness also refers to the degree to which an area is similar to a type of ecosystem or landscape which occurs over a larger area.

Figure 2 Long Point Study Area



(from Nelson et al. 1993)

2.2 Organization

The information is generally organized according to the scale of the system it illustrates. This effectively divides the information into three classes by scale:

- The Great Lakes Basin
- The Lake Erie Sub-basin
- The Haldimand-Norfolk Region and the Long Point Study Area

This approach is taken to emphasis that management of the Long Point area should recognize and take account of the fact that it is part of and affected by larger systems. For each scale, information is introduced from oldest to present day. For instance, the evolution of the spit is likely a more or less continuous process over the last 7500 years. The water levels associated with this process are presented from 12,500 years ago to the present in order to provide an understanding of the dynamic historical context in which Long Point has and is evolving.

2.3 Sources of Information

Information for the folio was taken from a variety of sources. Table 1 lists sources and types of information. This table also indicates information gaps found. The recognition of information gaps is considered an important part of planning and management by the study team.

3. THE LONG POINT ABIOTIC REGIME

3.1 The Great Lakes System

Long Point exists within a series of systems that include the Lake Erie basin and the Great Lakes basin. The Great Lakes Basin was completely glaciated during the Quaternary at least twice (Figure 3). The glacial history of southern Ontario has been described by many authors (e.g. Dreimanis and Karrow, 1972; Lewis, 1969; Karrow and Calkin, 1985; Karrow, 1989). The last complete coverage of the basin ended with the ice leaving the southern Great Lakes about 11,000 years ago. Ice did not completely leave the upper lakes until about 9,000 years ago.

As a result of glaciation a sequence of rapidly changing lake levels occurred in all of the lakes. As the ice opened different outlets, direction of lake flow changed, sometimes completely reversing. With the removal of the weight of the continental ice sheets, the compressed ground beneath the glaciers rebounded. This tectonic or isostatic release of ice pressure continues today although at slower rates.

The bedrock geology of the basin is very complex, especially in the southern sections (Figure 4). The geological evolution of the bedrock underlying the Great Lakes region is described by numerous authors (e.g. Hough, 1958; Calkin and Feenstra, 1985; Calkin and Barnett, 1990). The geomorphology of the basin is even more complex and has been described by many authors and most completely by Chapman and Putnam (1984). Basin wide variables such as temperature, moisture, basement rock, depth of glacial till, post glacial processes, and inherited surface material composition all combine to create a complex set of landforms.

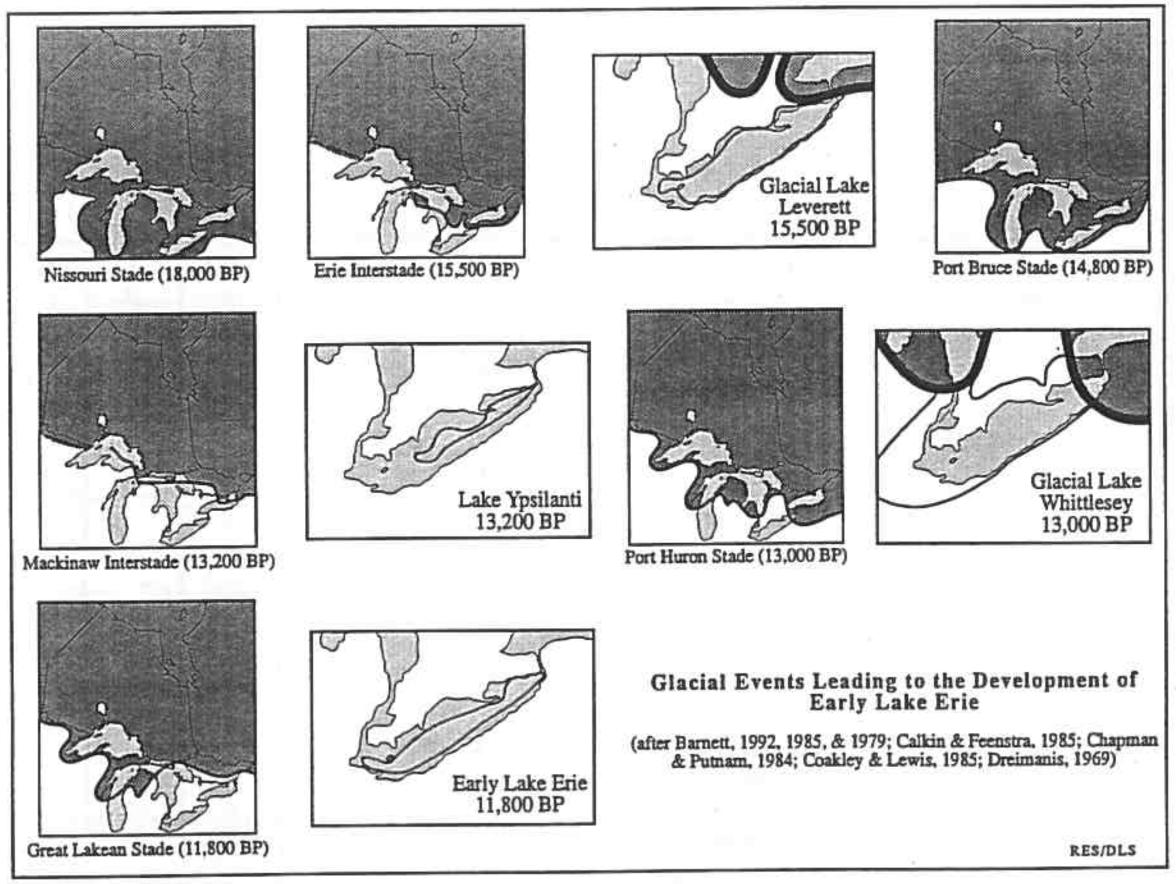
The following sections provide details of some relevance to the geologic development of Long Point and help to define its importance within the Great Lakes system.

Table 1 Information Types and Sources

Component	Subcomponent	Source Agency	LP	U	IG
Topography		OBM	✗	✓	
Bathymetry		CCIW	✗	✓	
Surficial Geology	Stratigraphy	OGS, GSC	✗		
	Structural	OGS, GSC			○
	Aggregate extraction	OGS, GSC	✗	✓	
Bedrock Geology	Stratigraphy	OGS, GSC	✗		○
	Structural	OGS, GSC	✗		○
Soils	Soil chemistry	OSS	✗		
	Soil composition	OSS	✗		
	Soil loss	AgCan			○
Geomorphology	Features	OMNR, CAs	✗		○
	Processes - deposition	OMNR, CAs	✗	✓	
	Processes - erosion	OMNR, CAs	✗	✓	
	Geochronology	OGS, GSC	✗		
Surface Hydrology	Discharge	CAs, CCIW	✗	✓	
	Sediment loads	CAs, CCIW	✗	✓	
	Flood frequency	CAs, CCIW	✗	✓	
	Other variables	CAs, CCIW			
Ground water	Chemistry	OME, EC			○
	Hydrology				○
	Piezometrics	GWI (UW)	✗		
Meteorology		EC	✗		
Climatology		EC	✗		
Human Affects	Dredging		✗	✓	
	Landfilling		✗	✓	
	Control structures		✗	✓	
	Bridges, docks, complexes		✗	✓	

An ✗ in the LP (Long Point) column indicates that information on the component was found in the sources listed. An ✓ in the U (Utilized) column indicates that information of that type has been used in one way or another in planning and management of the coastal zone. An ○ in the IG (Information Gap) column indicates that no information was found, or that the scale of the information was inadequate for coastal zone planning purposes. OBM = Ontario Base Map; CCIW = Canada Centre for Inland Waters Directorate; OGS = Ontario Geological Survey; GSC = Geological Survey of Canada; OSS = Ontario Soil Survey (Ontario Institute of Pedology); AgCan = Agriculture Canada; OMNR = Ontario Ministry of Natural Resources; CAs = Conservation Authorities; OME = Ontario Ministry of the Environment; EC = Environment Canada; GWI (UW) = Ground Water Institute (University of Waterloo).

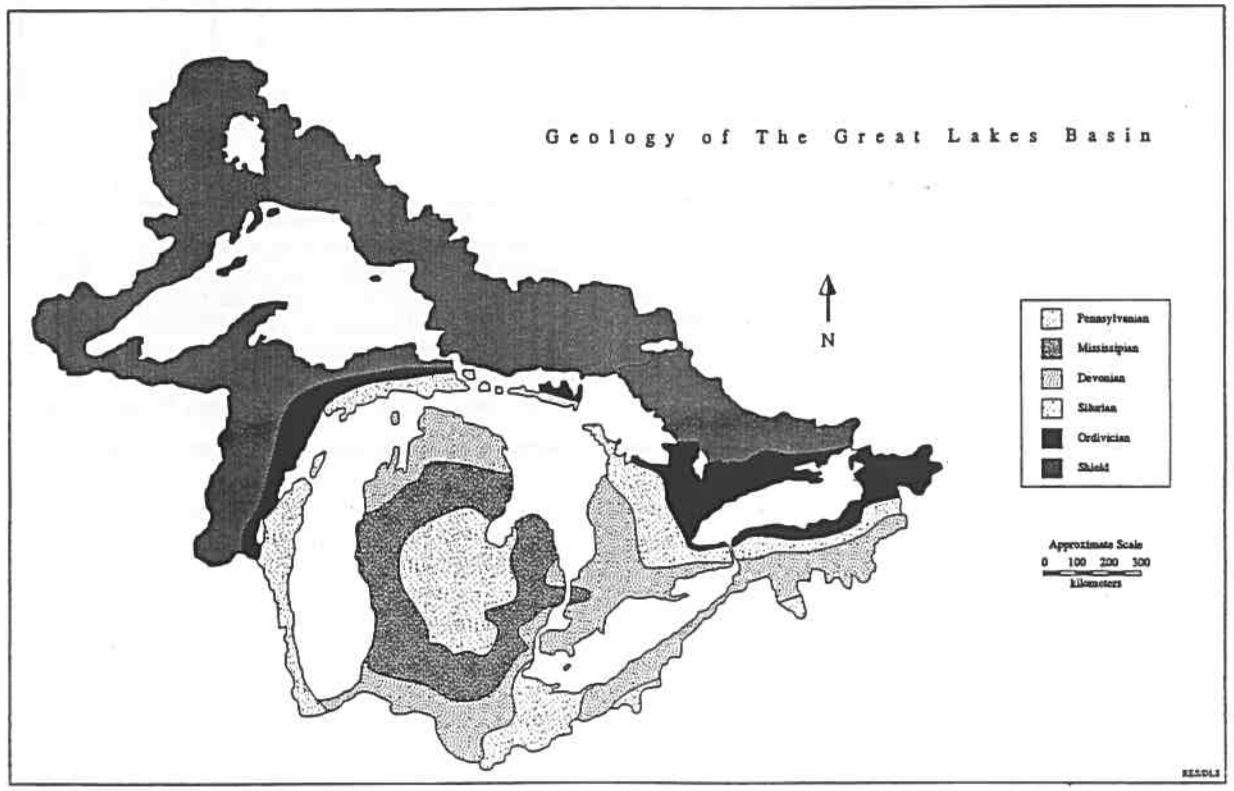
Figure 3



Glacial Events Leading to the Development of Early Lake Erie

(after Barnett, 1992, 1985, & 1979; Calkin & Feenstra, 1985; Chapman & Putnam, 1984; Coakley & Lewis, 1985; Dreimanis, 1969)

Figure 4



Geology of The Great Lakes Basin

3.1.1. Basin Geology

It can be noted that Long Point lies within the Devonian bedrock complex, 400 to 345 Million Years Before Present (BP). More specifically the bedrock is composed of various limestone units from the Lower Devonian Bois Blanc formation, 350 Million Years BP. Within the Lake Erie basin isostatic rebound is occurring at somewhere between zero and about seven centimeters per one hundred years (Clark and Persoage, 1970; Tushingham, 1992). Although these rates are significant geologically, the short term affects are negligible in land and resource use and for planning. This is because many other impacts on the coastal zone act more dramatically and over shorter time periods, for example coastal flooding.

Lake coasts can be divided into distinct types, each with its own planning and management problems. The two basic types are:

- rock coasts
- sediment coasts

In Lake Erie and the Long Point area sedimentary coasts are dominant in contrast to the rock coasts of Georgian Bay and Lake Superior. These coasts in turn, can exhibit a variety of characteristics. Of importance to Lake Erie for example, are:

- high bluffs
- low bluffs
- low graded beaches
- dune complexes
- wetlands of various description

These various abiotic environments require different management approaches reflecting their different sensitivities to change and their different natural values. Processes affecting surface geology are associated with climate which changes with the seasons and through long time scales. Although in some lake basins some geologic features are more common than others (coastal bluffs versus rock coasts in Lake Erie), changing conditions have affected the presence of some features such as wetlands, reducing their extent .

3.1.2 Basin Characteristics

Table 2 lists the general characteristics of the various water bodies within the Great Lakes System. It is shown that Lake Erie is the shallowest of the lakes, has the shortest retention time, the time it takes water entering at the St. Clair River to exit at Niagara, and the second largest total population living along the shores of any of the Great Lakes. Table 3 shows that Lake Erie contains over one third of the wetlands in the Great Lakes system. This reflects a variety of conditions including a favorable climate, variable lake levels, shallow sedimentary nearshore zones and a dynamic cycle of erosion and deposition which delivers nutrients and provides niches for wetland plants. However, Snell (1987) estimates that counties bordering Lake Erie have lost between ~60 and 100% of their wetlands from 1800 to 1982. Most of this has been due to modification of the shoreline by humans.

3.1.3 Basin Hydrology

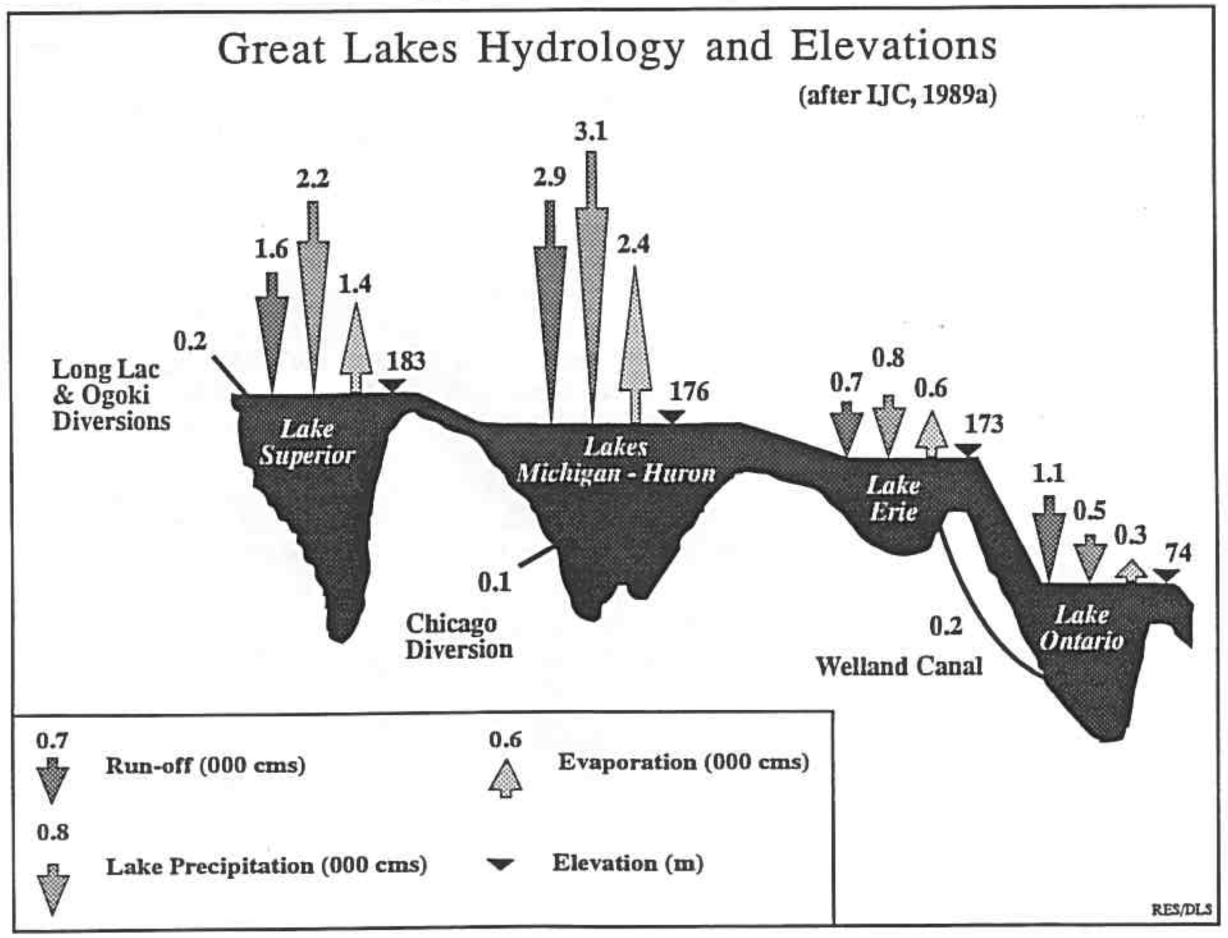
The Great Lakes exhibit a water balance between inputs such as rain, rivers, overland flow and groundwater; and water outputs such as river outlets, evaporation and human use and diversion. Figure 5 shows these values and provides a general cross section of the Great Lakes hydrological system. It can be seen that evaporation plays a major role in Great Lakes hydrology.

Table 2 Great Lakes Physical Parameters

Lake	Superior	Michigan	Huron	Erie	Ontario
Elevation (m asl)	183	176	176	173	74
Length (km)	563	494	332	388	311
Breadth (km)	257	190	245	92	85
Drainage area (km^2)	127 700	118 000	134 100	78 000	64 030
Surface area (km^2)	82 100	57 800	59 600	25 700	18 960
Total basin area (km^2)	209 800	175 800	193 700	103 700	82 990
Lake volume (km^3)	12 100	4 920	3 540	484	1 640
Average depth (m) - AD	145	99	76	21	91
Maximum depth (m) - MD	307	265	223	60	225
AD/MD	0.47	0.27	0.34	0.33	0.4
Shoreline length (km)	4 385	2 633	6 157	1 402	1 146
Retention time (yr)	191	99	22	2.6	6
Outlet	St. Mary's River	Straits of Mackinac	St. Clair River	Niagara River & Welland Canal	St. Lawrence River
Population US (1980)	558 100	13 970 900	1 321 000	11 347 500	2 090 300
Population Canada (1981)	180 440		1 051 119	1 621 106	4 551 875
Total population	738 540	13 970 900	2 372 119	12 968 606	6 642 175

(data from IJC, 1989a)

Figure 5


Great Lakes Hydrology and Elevations

(after IJC, 1989a)

Table 3 Lower Great Lake Wetland Area by Type in km^2

	1 Open	2 Unrestricted Bay	3 Shallow Sloping Beach	4 River Delta	5 Restricted Riverine	6 Lake-Connected Inland	7 Protected	Total
St. Clair River								
Canada	0.89					0.06		0.96
United States								
Total	0.89					0.06		0.96
Lake St. Clair								
Canada	11.28			68.08	0.11		50.84	130.32
United States	0.51			23.67	0.23	1.21	15.40	41.00
Total	11.79			91.75	0.34	1.21	66.22	171.30
Detroit River								
Canada	2.43	0.50			0.40		2.56	5.88
United States	0.51	0.55						1.05
Total	2.93	1.04			0.40		2.56	6.94
Lake Erie								
Canada	2.09	0.57	73.63		9.36	21.13	10.67	117.45
United States	8.11	6.55	1.51		6.35	2.06	73.80	98.39
Total	10.20	7.12	75.15		15.71	23.19	84.47	215.84
Niagara River								
Canada								
United States	0.23	0.05				0.80	0.11	1.18
Total	0.23	0.05				0.80	0.11	1.18
Lake Ontario								
Canada	4.51	25.71	2.16		24.42	18.15	2.39	77.34
United States	1.13	6.96		0.36	3.72	17.81	23.88	53.87
Total	5.64	32.67	2.16	0.36	28.14	35.96	26.27	131.21
St. Lawrence River								
Canada (Ont)	27.96	16.05			7.76	5.39	0.09	57.25
United States	4.16	5.49			6.51	11.44	1.84	29.45
Total	32.13	21.54			14.27	16.84	1.93	86.71
Totals								
Canada	49.17	42.82	75.79	68.08	42.05	44.73	66.55	389.20
United States	14.65	19.52	5.56	24.01	16.81	33.32	115.02	228.89
Total	63.82	62.42	77.31	92.11	58.86	78.05	181.58	614.15

(from Snell, 1987)

3.2 The Lake Erie System

The Lake Erie system contains all of the complexities of the Great Lakes system, but many of the features, processes and concerns exist at different scales. That is not to say that the way the Erie system behaves reflects the Great Lakes system. Many of the variables are different, as seen in Table 2, and sites on each lake should be treated as unique in the sense that they have been and should be managed in terms of their own particular characteristics while cognizant of their place in the Great Lakes system. Changes in Lake Erie can affect other Great Lakes and vice versa.

3.2.1 Lake Erie Bathymetry

Figure 6 illustrates the bathymetry of Lake Erie. It can be seen in long cross section that the west end of the lake is very shallow. The deepest part of the lake is in the east/center, near Long Point. This, combined with the approximately SW-NE orientation of the long axis of the lake, results in wind setup of lake waters during strong, prolonged storms. This setup of water generally occurs from west to east and has been measured at as much as a few meters. When considering the bathymetry of the lake it should be noted that:

- o The western basin of the lake seldom exceeds 10 m in depth.
- o The central basin of the lake reaches a maximum of 30 m but is generally less than 20 m in depth.
- o The eastern basin contains the deepest section (~60 m) which exists just off the tip of Long Point.
- o The deeper sections of the lake act as sinks for cold water, sediments and pollution.

3.2.2 Lake Erie Evolution and Water Levels

Figure 7 illustrates the water levels above sea level (asl) since the Erie interstade – or period of ice retreat (~15, 500 BP). It can be seen that after many fluctuating levels associated with advances and retreats of the position of ice fronts within the basin, the lake basin drained almost completely (Lake Ypsilanti, 13,200 before the present day -- BP). This was followed by a dramatic rise to Glacial Lake Whittlesey (~13,000 BP), another draining and a slow ~11,000 year rise to around 5 meters above the present level (~2,000 BP) (Coakley and Lewis, 1985). The reason for this rise above present levels is likely that a till moraine - the Fort Erie Moraine - existed across the top of the Niagara River, impounding Lake Erie water until the till was removed to the present bedrock sill (Pengelly, 1990).

More recently, as illustrated in Figures 8 and 9, fluctuations in lake levels have continued. On a year to year basis the level of Lake Erie follows a reasonably simple pattern with a rise and fall of about ± 0.5 meters around a mean of ~174 m asl. (Bishop, 1990). It should be remembered that these are average yearly values. Within any given year the water level also fluctuates with the seasons, as illustrated in Figure 7, and on a daily basis with storms and weather crossing the area. When all of these fluctuations are at or near their maximum (for example during a storm in a high water level period during a high year), the potential for aggressive erosion of the lake shore is high.

3.3 Long Point and Environs

The following information on Long Point and the Haldimand-Norfolk region should be viewed at two scales. The regional scale at which it is presented and the basin scale which has been emphasized up to this point. It should also be noted that although the information is reported in sections, all elements of the system affect one another including climate, landforms, vegetation and other elements and processes in the system.

Figure 6

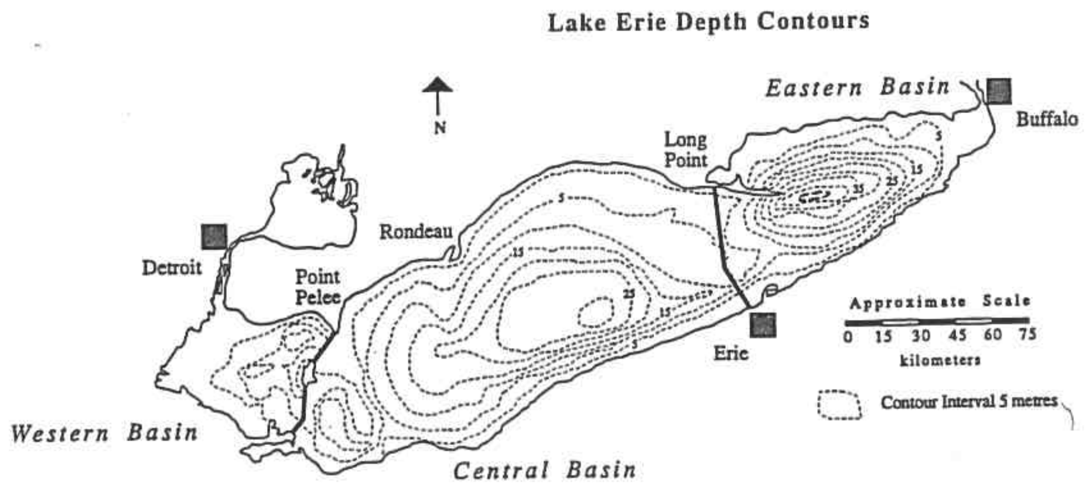


Figure 7

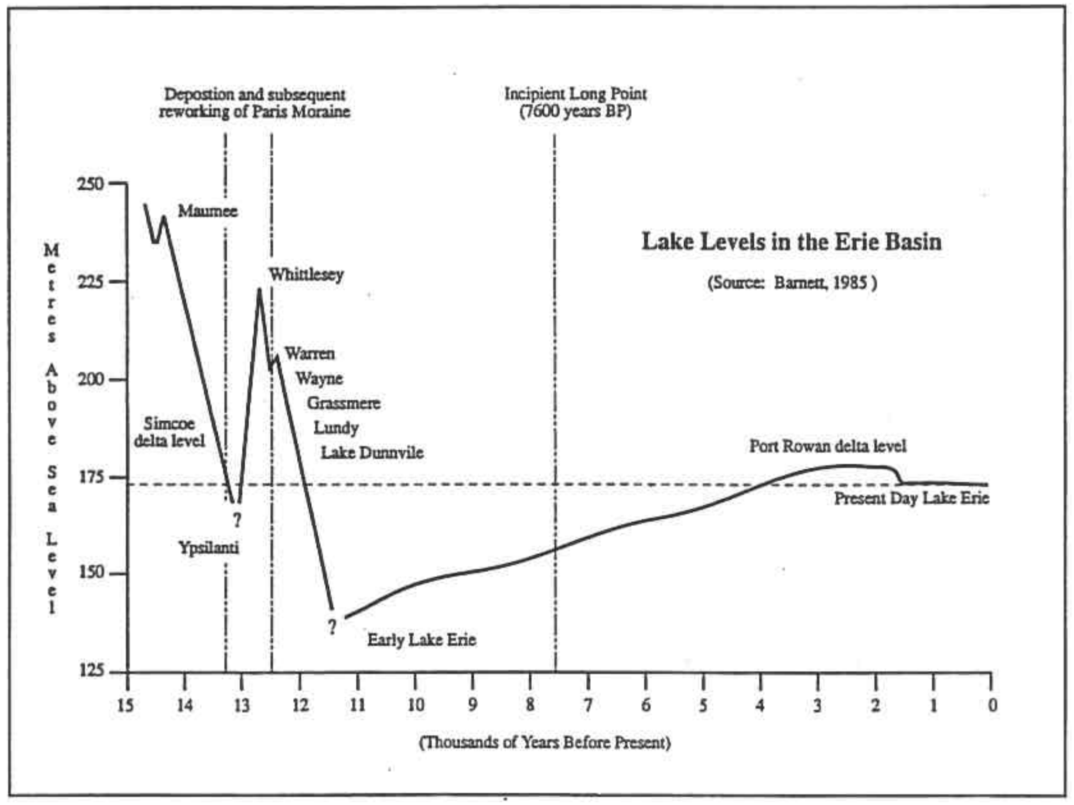


Figure 8 Lake Erie Water Levels 1860-1990

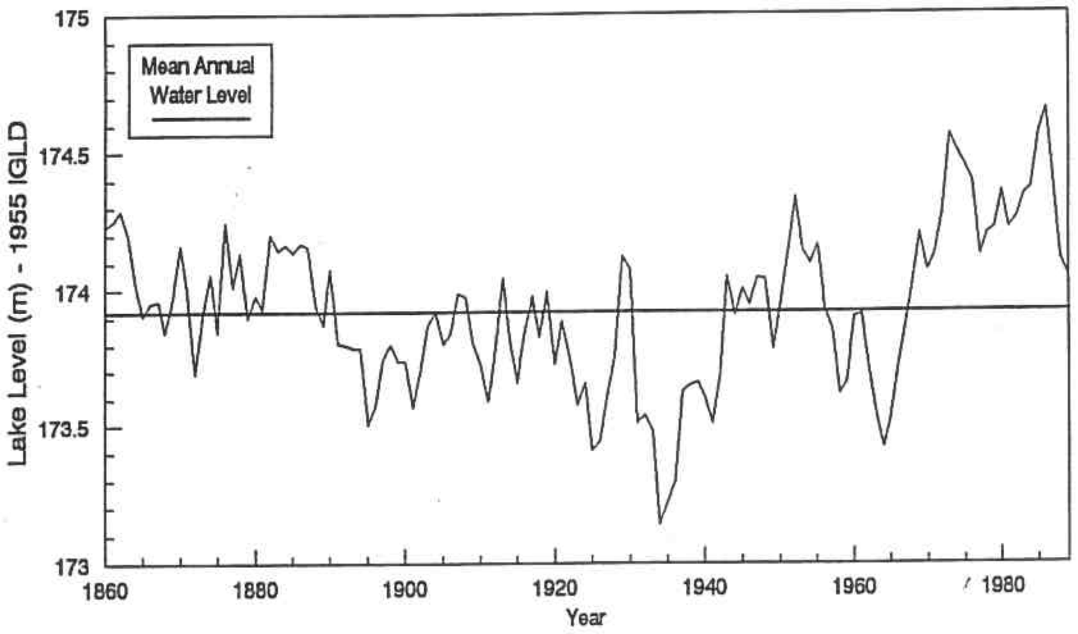
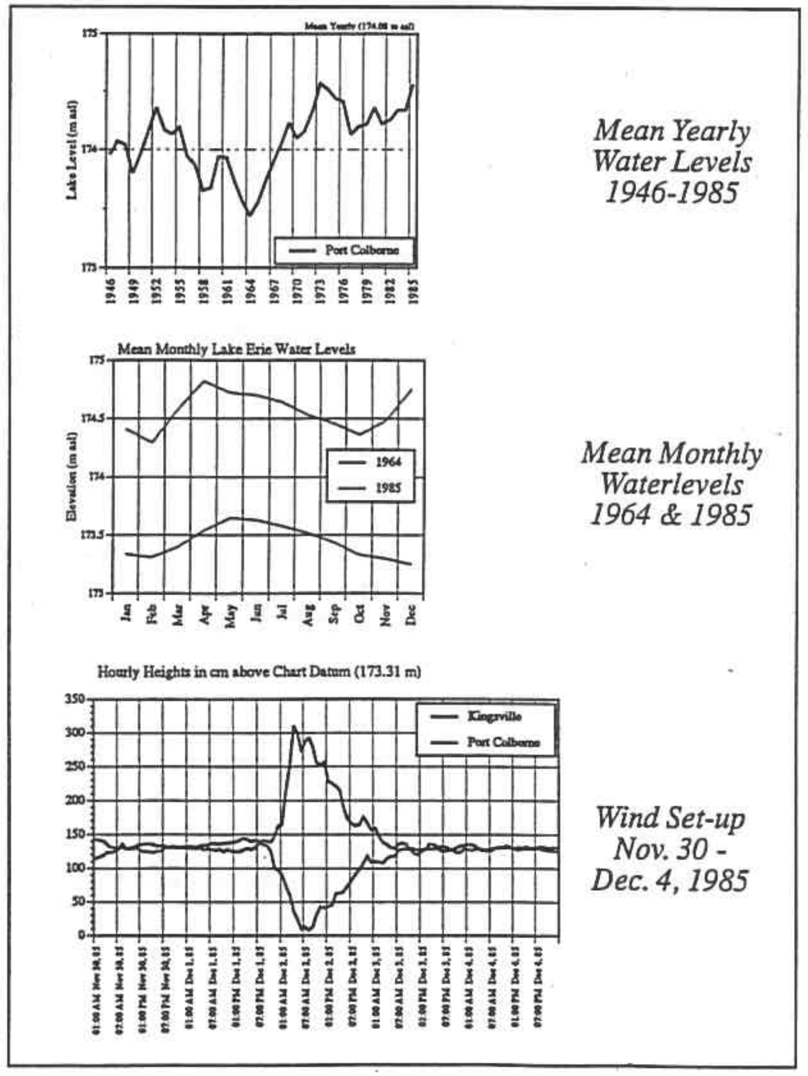


Figure 9 Mean Yearly, Monthly, and Short Term Variations in Water Levels



3.3.1 Regional Physiography

The bedrock geology of the Long Point area consists of sedimentary carboniferous deposits of Silurian and Devonian in age (Figure 10). Soils and offshore subsurface deposits are mainly sand with clay and bedrock deposits to the east (Figure 11). The physiography, or surface land forms, of the region is presented in Figure 12. The region can be divided into three zones with distinct landforms and associated historical processes. Many of the landforms are remnant features that where created under different climatic conditions. Modern processes modify these features. Table 4 lists the zones, features and potential processes. The region has many different landforms which have resulted from many different past and present environments. Glacial features, for example drumlins, represent the oldest, while coastal features, for example dune-marsh complexes, represent the youngest. This variety of landforms and landform assemblages contribute to the diversity of the natural heritage of the area.

The variety and dynamics of these features and processes leads to a high degree of diversity in terms of chemistry, soil structure and texture, erodibility and other factors. These factors influence the way the features and processes can be used an requires a flexible management strategy. The physiography of the land area has been a focus of many studies (including: Barnett, et. al., 1985; Barnett, 1983a, 1984, 1985, 1987; Coakley, 1983a, 1985; Dreimanis, 1987; Sharpe and Barnett, 1985). The physiography of the nearshore zone (i.e.. beaches dunes, etc.) has also received attention (Armstrong, 1990; Coakley, 1983b; Conliffe-Reid, 1991; Fisher, 1989; Law, 1989; Rukavina, 1983a; Saunders, 1990; Stewart, 1986; van Heyningen, 1993; Wood, 1960) and has major implications for environmental management.

The stability of the landforms varies considerably with some landforms remaining relatively unchanged since the last glacial retreat. However, the coastal zone is very dynamic. Cliff recession, or retreat, for most sections or reaches of shore bluff typically exceed 0.5 meters per year (Gelinas and Quigley, 1973). Dune systems located along the sandy shores of Long Point experience less catastrophic change, but change at a slower, and fairly constant rate, although over-washing by high waters during storms can level and change dunes and associated features (Davidson-Arnott, and Fisher, 1992). Low, graded coasts change very little over short periods of time, except that they often flood, causing more sedimentation. Although the Point itself is very large -- the largest sandy spit barrier system on the Great Lakes -- the feature itself is representative of many other spits in the Great Lakes system. The processes that have shaped the point show some similarities to those shaping Rondeau, Pelee, or even the Leslie Street spit in Toronto. The bluffs show some differences from other bluff areas on Lakes Huron, Ontario, Michigan and Erie, but the processes that formed them, including the depositional environments, are essentially the same.

3.3.2 Regional Surface Hydrology

Figure 13 details the stream basins, networks and discharges for the region, including the major lake currents and sediment sinks. The delivery of sediment down the streams has some impact on the sediment regimes of the nearshore zone. Streams that drain the sand plains could potentially deliver significant amounts of sediment to the long shore drift system (Ongley, 1976). However, the fine sediments from streams draining the clay plains often are carried away from the nearshore zone and are deposited in sinks offshore (Davidson-Arnott and Stewart, 1987). The streams are relatively stable landscape features, although their natural tendency is to meander laterally across their valley. Although flooding is more prevalent on the clay plains to the east, extreme discharges associated with channelization and land clearance are absent from the region. Most of the major streams can be seen on air photos as unevenly wooded corridors, that extend from their headwaters to the coast. This is a rare feature in southern Ontario landscapes where the lower reaches of many streams have been cleared for agriculture.

Figure 10 Bedrock Geology of the Long Point Area
(from Heathcote, 1981)

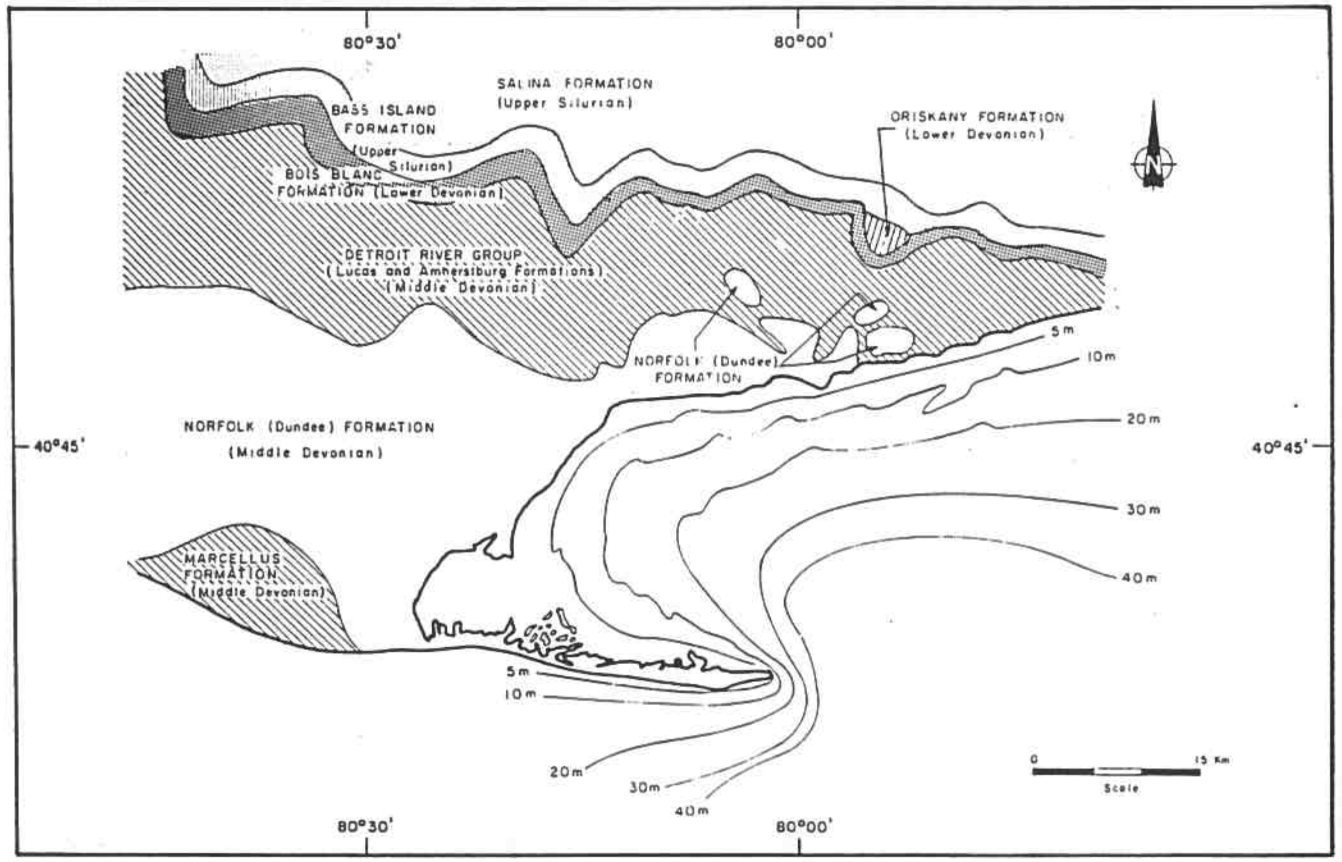
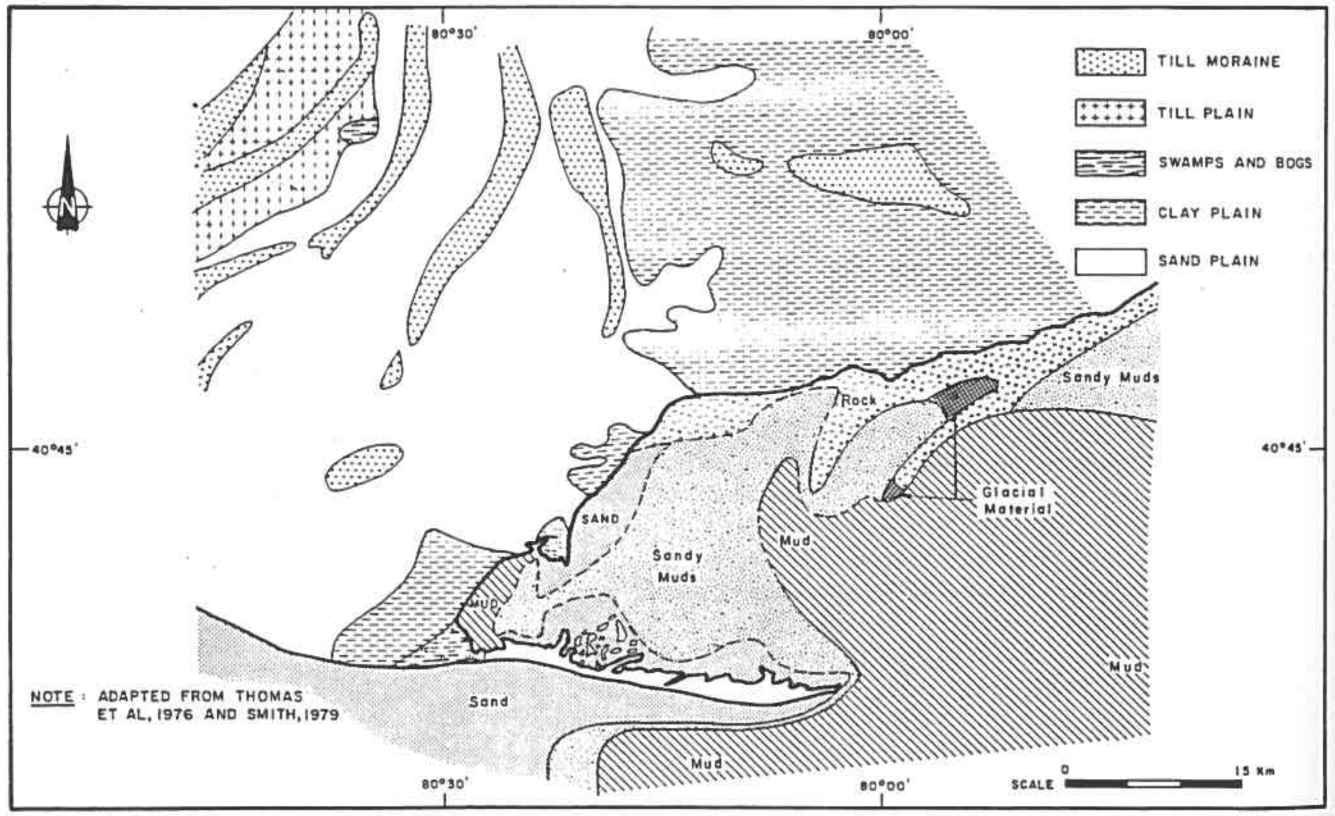


Figure 11 Surficial and Aquatic Subsurface deposits in the Long Point Area
(from Heathcote, 1981)



NOTE: ADAPTED FROM THOMAS ET AL, 1976 AND SMITH, 1979

Table 4 Physiographic zones and potential associated processes

Zone	Features	Potential Associated Modern Processes
Norfolk Sand Plain	Dune complexes	° Aeolian sand movement ° Slope failure ° Rapid downward water drainage ° Rapid laterial groundwater transport
	Till moraines	° Slope failure ° Tension cracking ° Water storage
	Abandoned shorelines	° Aeolian sand movement ° Slope failure
	Coastal bluffs	° Slope failure due to - undercutting (sapping) by waves - liquifaction (from groundwater) - failure along plains of weakness - spalling along tension cracks - sand piping by groundwater - biological weakening - plant roots, animals burrowing ° Longshore sediment transport ° Flooding and associated deposition
	Insized river systems	° Slope failure along banks ° Valley widening through meandering ° Sediment transport and deposition along reaches ° Winnowing of clay, silt and fine sands
	River mouth barrier systems	° Deposition of sediments from both longshore and river systems ° Development of wetlands ° Seiche cycles and associated energy transfers - absorbtion of river flood pulses - protection of riverine environment from rapid fluctuations in lake level
	Interior wetlands	° Groundwater recharge ° Energy sinks - dissipation of energy from incoming rivers
Haldimand Clay Plain	Drumlins	° Moderate drainage ° Slope failure
	Coastal bluffs	° See coastal bluffs above
	Shallow river systems	° Slope failure along banks ° Valley widening through meandering ° Sediment transport and deposition along reaches
	River mouth barrier systems	° See River mouth barrier systems above
	Interior wetlands	° See Interior wetlands above
Long Point Spit	Dune complexes	° See Dune complexes above
	Wetlands	° Groundwater recharge ° Shore protection - dissipation of energy from incoming rivers and waves
	Longshore transport	° Continuous erosion and deposition of sediment along spit. - if net deposition the spit will comtinue to grow in length and width

Figure 12

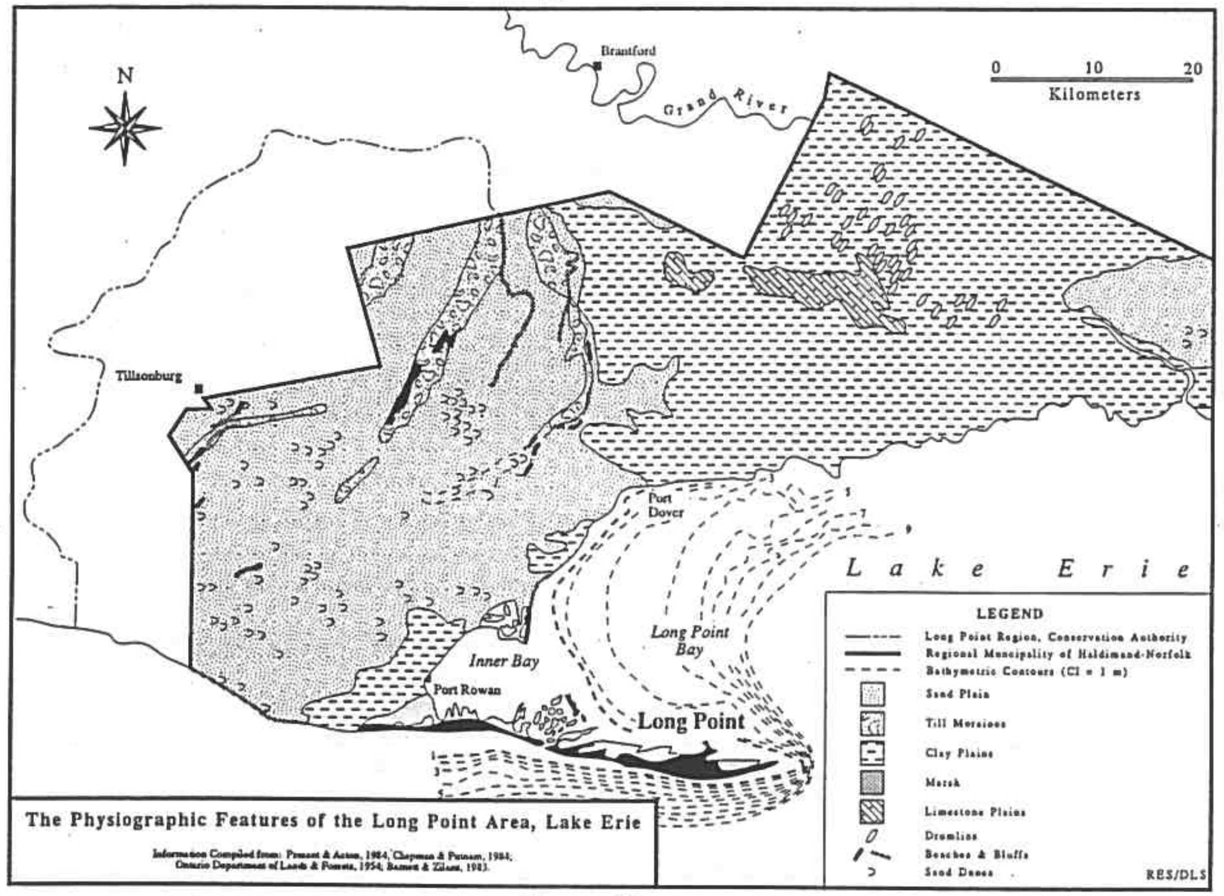
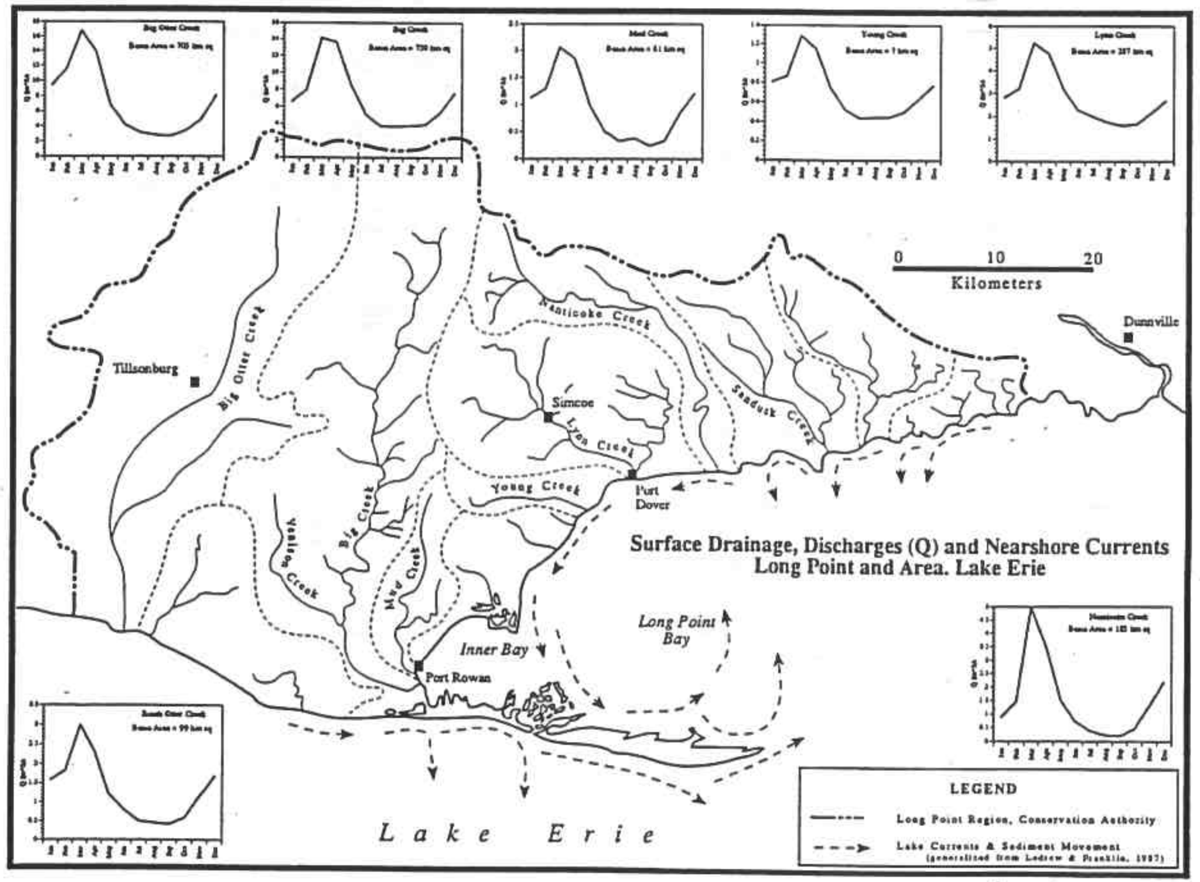


Figure 13



3.3.3 Regional Climate

Weather systems often affect the whole Great Lakes basin, just as the concentration of water within the basin affects weather systems. The impact of these weather systems varies from lake to lake depending on the surface area and depth of the lake and the direction of its long axis. Dry weather systems crossing the Great Lakes can evaporate large amounts of water from the lakes, while storm systems often deliver large amounts of water to the basins.

The climate of the Long Point area has changed dramatically over the last 10,000 years (Barnett, 1985; Karrow, 1985). After the retreat of the glaciers the area was subject to a periglacial, or near the ice-sheet, climate in which cold temperatures, high winds and low moisture regimes prevailed. The present day climate of the Long Point region is influenced by maritime tropical air masses. The conflicting influence of continental polar air masses creates frequent frontal disturbances.

The modern climate of the region is summarized in Table 5 and Figure 14 (AES, 1982). They show the temperature and precipitation normals, and the average wind magnitude and direction for the Long Point area. Although the data for Long Point proper is incomplete (presumably reflecting the difficulty in reaching the station at the end of the spit during the winter). The station record does show that no significant mean temperature differences appear to exist, in relation to inland stations, although lower mean precipitation is measured at the spit.

Table 5 Climate Data for Stations in the vicinity of Long Point, Ontario

Location	Mean Annual Temp °C	Highest Recorded Temp °C	Lowest Recorded Temp °C	Mean Annual Prec (mm)	Mean Annual Snow (cm)	Mean Annual Frost Free Days
Delhi	7.9	40.6	-31.1	803.1	133.1	148
Simcoe	7.8	40.0	-37.8	748.0	141.5	149
St. William's	8.1	34.4	-28.9	831.6	142.2	160
Clear Creek	8.1	33.9	-26.1	745.5	121.2	162
Long Point						165

The wind roses in Figure 15 show that the predominant wind direction throughout the year is roughly from the west or west-south-west, which happens to be the direction of longest fetch for the lake side of the Point, as indicated by the two lines on the charts. The second set of lines (pointing east) indicate the direction of longest fetch affecting the inner bay. The highest magnitude winds occur during the winter. However, the spring, fall and summer winds are most responsible for severe wave damage. This is a result of the ice that builds up along the shore during the winter, which provides natural protection for the soft sediment shoreline.

The last indicator of climate provided here is a rough water budget based on data for the meteorological station at Simcoe. The graph (Figure 16) shows the mean monthly precipitation (P), the potential evaporation using the Thornthwaite model (PE) and the actual evaporation (AE). It is evident that the AE always equals PE. In other words, there is always sufficient rainfall to account for the potential evaporation from the ground, streams and water bodies, and transpiration from plants.

Figure 14 Seasonal Temperature and Precipitation variations in the Long Point Area

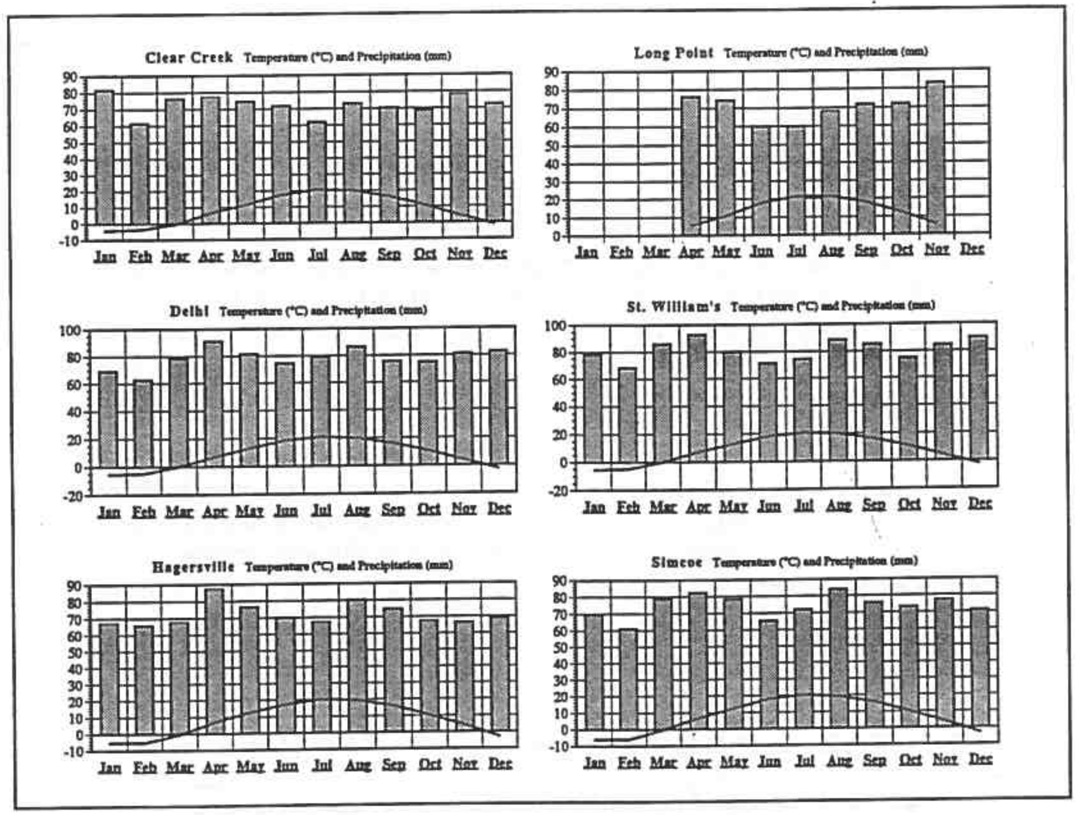
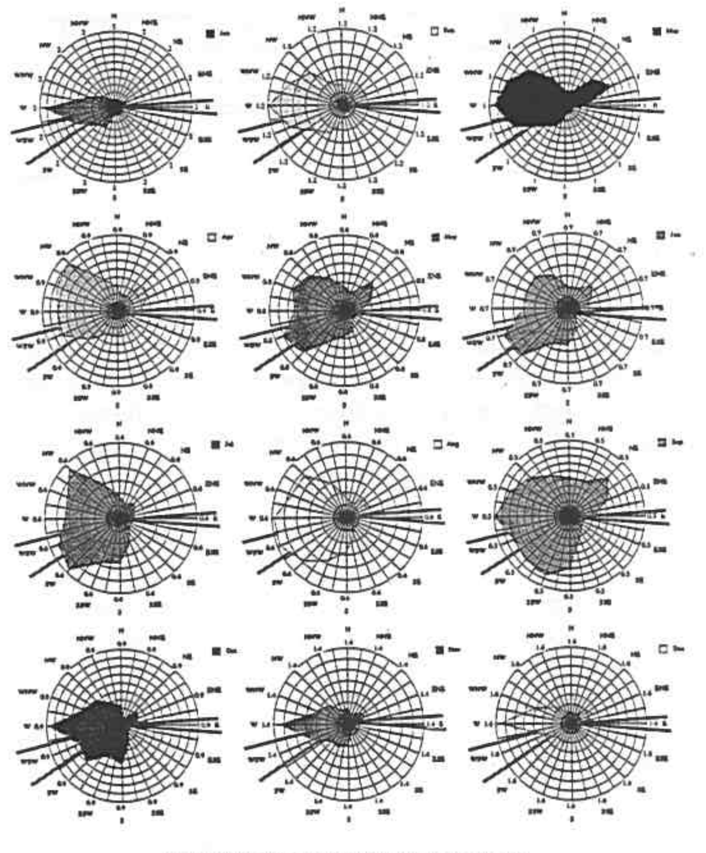
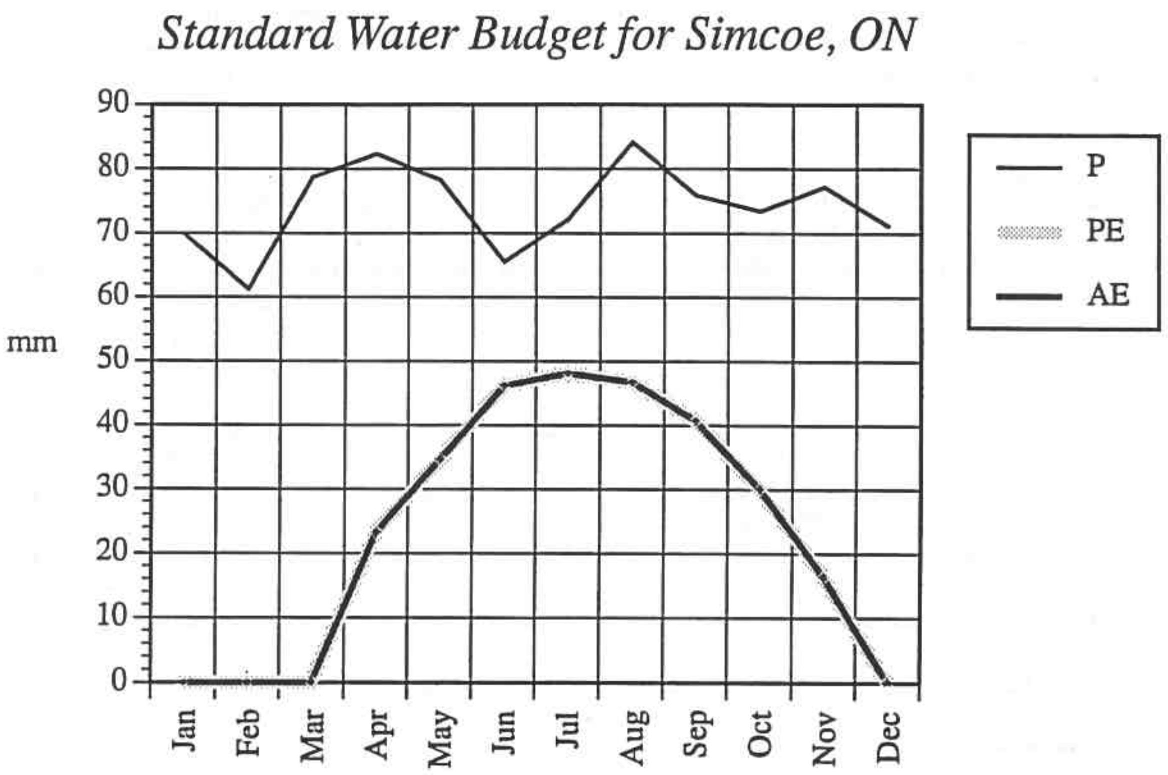


Figure 15 Monthly MeanWind Roses, Long Point, Ontario



Lines indicate direction of maximum fetch - the longest distance over open water the wind can build waves

Figure 16



This has two implications. The first is that there is usually some excess water running off into steams and lakes, ensuring the associated erosional and depositional processes. The second implication is that theoretically no irrigation should normally be required, although some years can be drier than others and lead to some need for irrigation in the drier year. However large amounts of irrigation can be witnessed throughout the study area during the summer. Personal communication with local residents suggests that the reason for this is that the permeability of the sandy soils (their ability to let water pass to lower layers) robs the surface layers of the water. Since many of the crops grown locally, including tobacco and peanuts, have shallow root systems, irrigation is necessary to ensure that sufficient water is available at the right time for crops. The climate of the Long Point coast is representative of coastal areas within humid, mid-latitude zones. Land and sea breezes moderate temperatures, and large cyclonic weather systems dictate daily conditions.

3.3.4 Economic Geology

The major potential extraction industries are oil and natural gas, clay and sand mining (Figure 17). In the 19th and early 20th centuries, the availability of dense clay supported a reduced economy which produced tiles and pipe as well and some pottery. The shift in building materials over the last 30 years has resulted in this industry being all but lost in the region. Oil and gas extraction have come into some conflict with fisheries because of location of the wells and pipes in the outer bay. Very few wells have actually been operated, but potential has been reported in some sources (LPCA, 1972). The stability of the extraction based economies of the region is affected primarily by the regional economy and changing technologies. None of the resources being extracted are unique to the region and as such local markets largely must support the industries. The rate of economic growth of the region has been generally declining over the last 15 or 20 years (Wilcox, 1993), and the extraction industries have followed suit.

3.3.5 Long Point Sedimentology

Studies of the sedimentology of the Point and the bluffs to the west which provide the bulk of the point's sediment are numerous (e.g. Calkin and Geier, 1983; Dick, 1980; Gelinas, 1974; Quigley et al., 1977; Quigley and Tutt, 1968; Barnett, 1983b, 1985, 1987). The bluff studies have focused on two aspects. The first, and earliest, was the scientific study of the tills composing the bluffs in an attempt to help define regional and provincial glacial chronologies or histories. The second and more recent studies have been concerned with the stability of the bluffs, the character of the sediments and their relation to sediment supply to the Long Point area. An example of the types and relative locations of sediments composing the bluffs east of Turkey Point is provided in Figure 18. The bluff studies conducted primarily to the west of Long Point describe various till units at the base, covered with clay, then silt and clay and very often sand (Zeman, 1983a; 1983b, 1986). The importance of the sediment sequence, with tills and clay at the base, is two fold.

- o The relatively impermeable clays perch water at the base of the silts and sands. This creates a bedding plane with low resistance to movement. This results in progressive slumps of the upper beds.
- o The relatively high density of the clays and tills resists wave erosion for long periods of time. This allows the bluffs to maintain moderate to steep slopes.

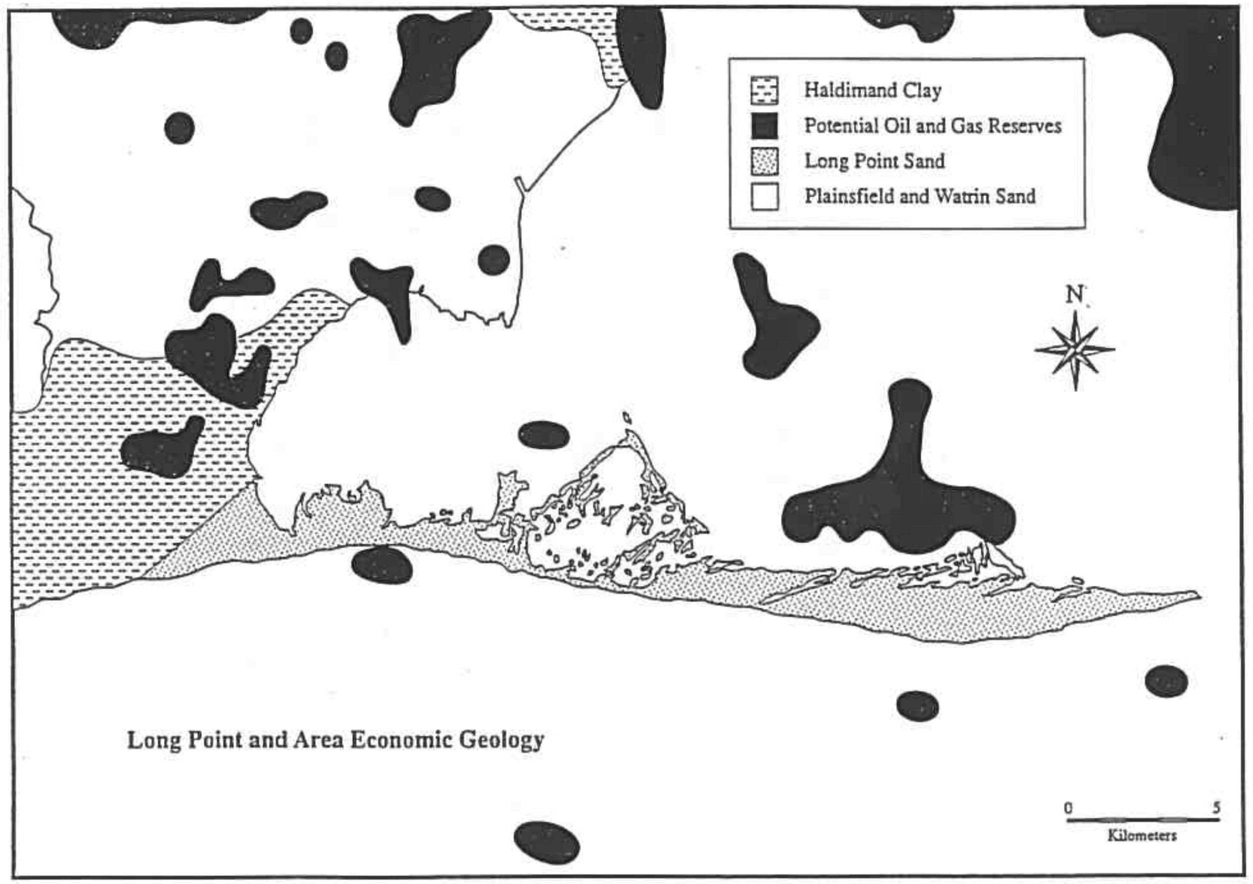
(summarized from Dreimanis and Reavely, 1953; Quigley et al., 1977)

Much of the sediment core work on the spit was summarized by Coakley (1983b) in his attempt to describe the likely evolution of the point (Figure 19). Generally bedrock is found between 80 and 120 meters below the modern surface. Above this is a plastering of glacial till, then glacial clay and then post glacial mud. This mud is likely glacially deposited or reworked glacial deposits, both in situ and delivered from eroding bluffs. Above this are transitional silts which were deposited in shallow lacustrine environments and then overlain by a layer of sorted sand. The sand is sorted suggesting deposition in a fairly consistent moderate energy environment such as long shore drift or by wind.

3.3.6 Long Point Evolution

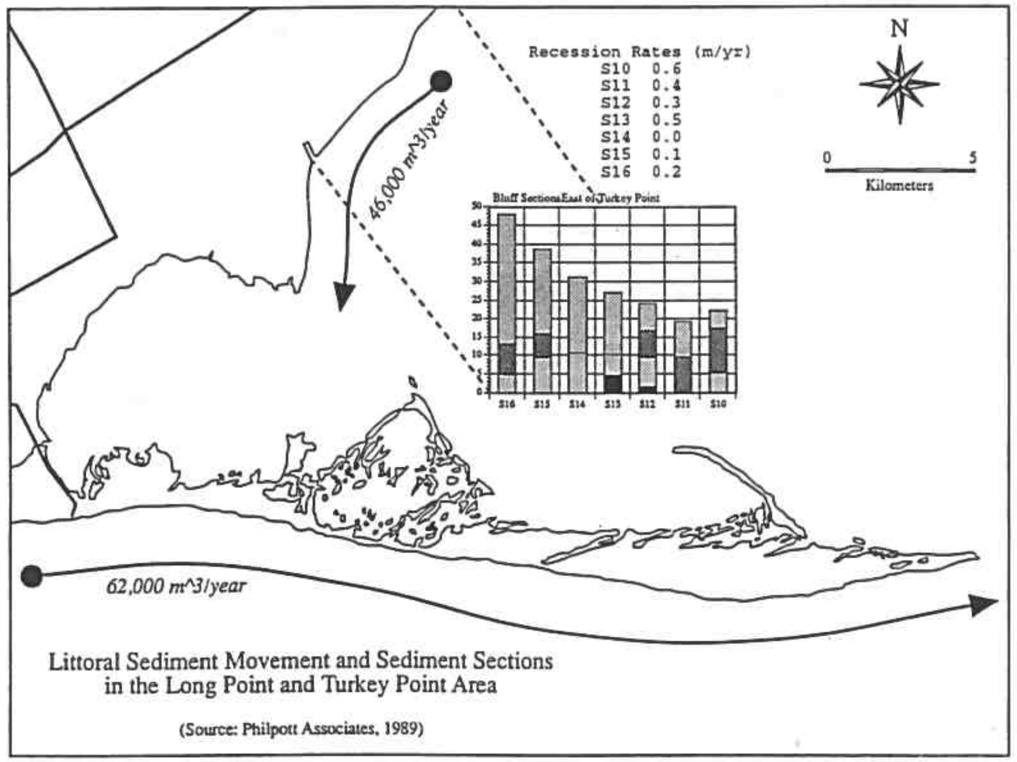
The Point began as Lake Erie levels rose to a level at which deposits of the Paris moraine began to be reworked (7600 BP) (Coakley, 1983a) (Figure 20). This same process was followed at progressively later dates, reflecting early rates of isostatic rebound farther west, for the Rondeau Peninsula and then Point Pelee. Sediments from the long shore drift from the east and west were deposited in the shallow water environment and began to form the Point (Coakley, 1983a). This has proceeded ever since. It should be noted that the Point has at numerous times, been an island.

Figure 17



Long Point and Area Economic Geology

Figure 18



Littoral Sediment Movement and Sediment Sections in the Long Point and Turkey Point Area

(Source: Philpott Associates, 1989)

Figure 19

Core Sections in Long Point Spit

(Source: Coakley, 1983)

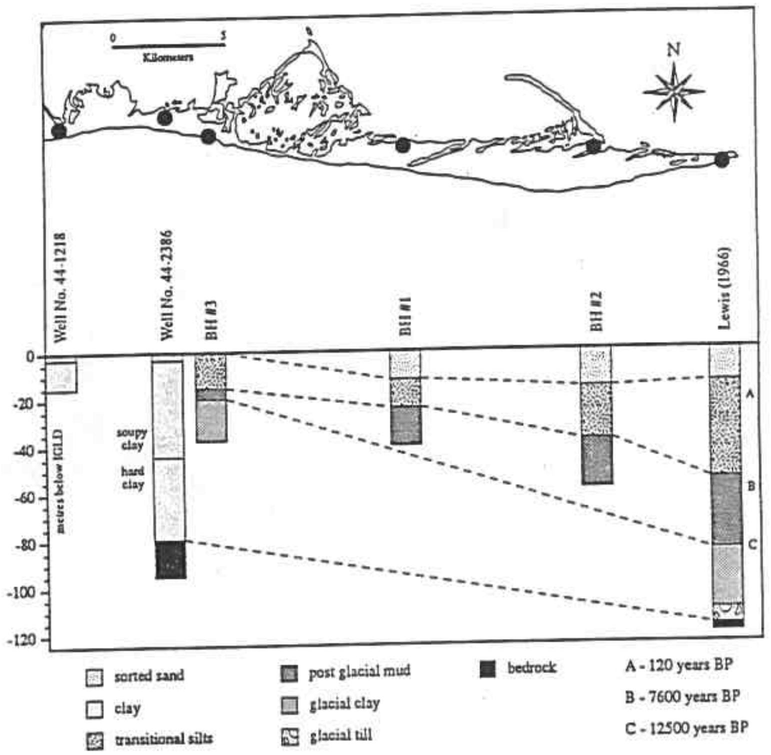
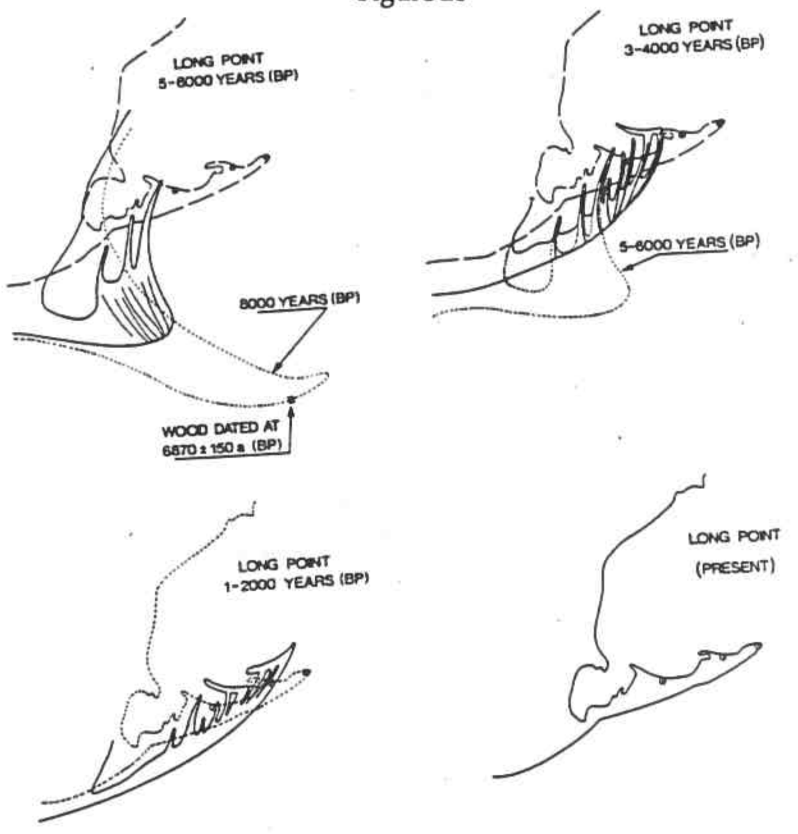


Figure 20



(from Coakley, 1983)

It is the nature of many sand spits to be eroded or broken from the mainland during times of high water or during storms (Davidson-Arnott, 1988). These breaks often close again with deposition over time. It is likely that Long Point was more often an island than a peninsula for most of its history. The present causeway or road linking the Point to the mainland was built in the 1920s and is maintained for the sake of the residents living in the community of Long Point and visitors to the Point (Barrett, 1977) Laidler (1944) describes historical reports of the separation of the spit from the mainland many times since it was first discovered (e.g. in 1813 the gap was "quite wide"; in 1834 - 390 yards; and in 1865 - 1/2 mile).

3.3.7 Shoreline Sediment Transport and Nearshore Currents

Sediment supply to the nearshore zone has been calculated from various sources such as bluffs (Boyd, 1981: Zeman and Thompson, 1982), streams (Ongley, 1976), and offshore glacial deposits (Kemp et al., 1977; Rukavina and St.Jaques, 1971, Rukavina, 1983) Alongshore transport rates for north-central Lake Erie and Long Point have been estimated by several studies (Bishop and Dick, 1980; Conliffe-Reid, 1991; Liard, 1973; Rukavina and Zeman, 1987, Thomas and Haras, 1978). Philpott Associates (1989) has estimated 62,000 m^3 per year of sediment moving alongshore east of Long Point as derived from sediment sources and wave energy modelling. LeDrew and Franklin (1987) used satellite imagery analysis to identify major currents at the distal end of the Long Point spit (see Figure 13). Limited monitoring of currents in the Inner Bay has taken place (Berst and McCrimmon, 1966), but the dynamics are not clearly understood.

The important things to remember about these sediment transport amounts and regional currents are:

- They are only expressed as general lines of direction.
- The actual current system is very complex with many local changes in direction and velocity induced by bottom topography, temperature gradients and surface pressures.
- Currents both erode and deposit sediment depending on their constantly changing character.
- Off shore, as opposed to long shore, currents deliver sediments to sediment sinks away from shallow waters. This will reduce the estimated sediment loads of long shore currents that are based on bluff recession rates.

3.3.8 Shore Protection

Shore protection is covered elsewhere in the Long Point Environmental Folio Publication series; however its impact on the "natural" abiotic system should be discussed here. The percentage of the shore that is protected has steadily increased over the last twenty years during a period of rapid shoreline residential development (Philpott, 1989). This includes all types of shore protection (i.e.. seawalls, revetments, breakwalls and other structures) constructed by individuals and agencies. Furthermore the number of marinas and recreational facilities along the shoreline has increased substantially in the same period. Apart from the obvious impact on fisheries and water fowl habitats, the potential effects on the abiotic system could have major consequences. Although it is still too early to determine the exact magnitude of the effects of changing the abiotic environment of the shoreline a few points to consider in pondering potential scenarios are:

- The shoreline has a dual character in the Long Point area. It is either a coastal bluff susceptible to erosion, or it is low and susceptible to flooding.
- When bluffs are protected at the base they can not longer provide sediment to maintain the dynamic system which includes Turkey Point and Long Point.

- Sediment starved beaches will increase the threat of flooding during inevitable high water levels and reduce the potential of the area to sustain its tourist economy.
- Sediment deprived wetlands will eventually become less topologically diverse and unable to sustain many varieties of subaqueous plants and animals.
- When flood protection structures are put into place, it is most often at the sacrifice of natural flood protection features such as wetlands or dune systems.
- Instead of absorbing the impacts of natural fluctuations in water levels, the artificial structures transfer the impacts to neighboring shorelines. This upsets the balance that exists along the coast and reduces the ability of the coast to react elastically to severe events.

4. SIGNIFICANCE AND CONSTRAINTS

Abiotic information has been assessed in order to identify significant processes and features and constraints for management and planning. The criteria of: stability, rarity, diversity and representativeness were used to evaluate the information.

4.1 Significant Abiotic Processes in the Long Point Area

Figure 21 provides a schematic view of the major active inputs to and impacts on the abiotic environment of the Long Point area. Coastal currents, air currents, groundwater and rivers transport materials (including chemicals and nutrients) are essential to the natural system. Much of the shoreline from east of Turkey Point to the Village of Long Point has been affected by human impacts of one sort or another including shore protection works , marinas, and dredging for water access. The modification of shoreline properties and the removal of natural environments to provide access has placed stress on natural processes.

When a function or structure of a abiotic system is stressed it affects the other components as both materials and energy transfers can be altered. In very dynamic environments this may lead to the development of flooding and erosion hazards or other unwanted changes, although ultimately the natural resiliency of the landscape will adjust, sometimes to the detriment of landowners. However in low energy environments - such as Long Point Inner Bay - even minor disruptions could lead to extensive or unwanted changes in the coastal or near-shore environments.

4.2 Abiotic Constraints in the Long Point Area

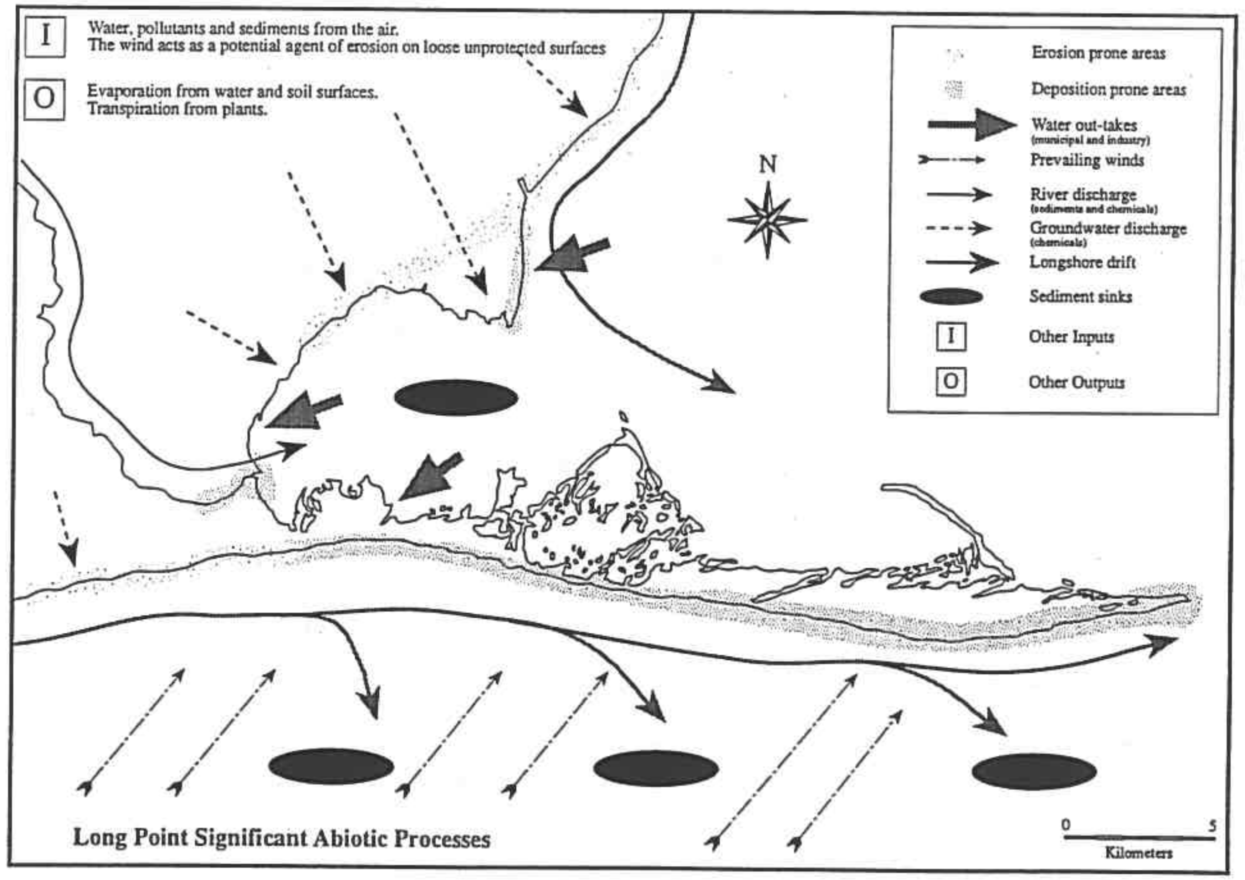
As Figure 22 shows, the areas that humans find most desirable and worthy of use and development, are in direct conflict with erosion prone areas, riverine inputs to the Inner Bay, groundwater and surface (sheet) flow to the Inner Bay, and long shore currents. The Inner Bay, and to a lesser extent the outer bay, is the site of a much conflict between natural abiotic processes and human activities such as boating, oil and gas extraction, dredging and fishing.

The key constraints have been identified as:

- Inland constraints on land use due to soil loss to streams from development and agricultural activities, inputs of agro- chemicals to groundwater and surface flow, and depletion of groundwater resources for irrigation and drinking.

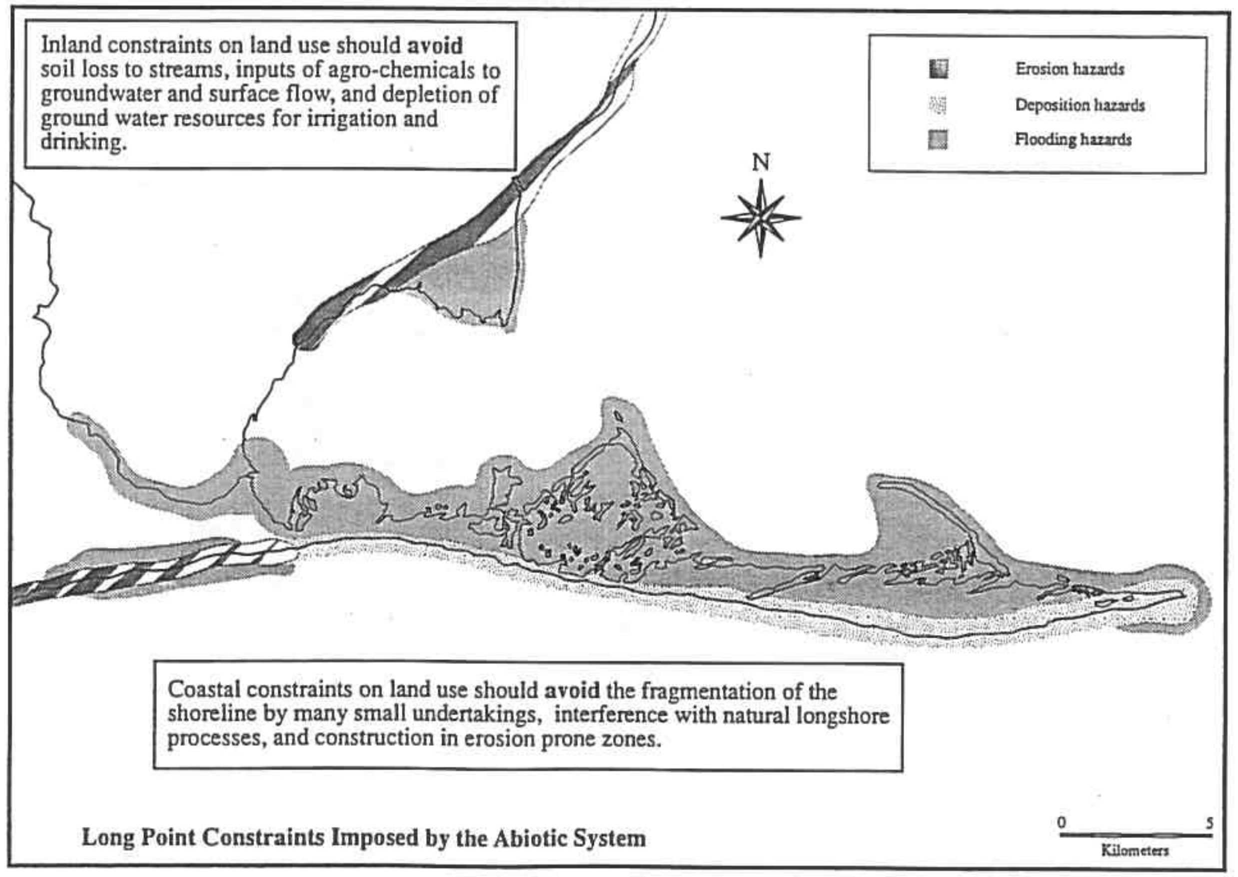
- Shoreline constraints on land use due to fragmentation of natural areas by cumulative impacts from development, interference with natural longshore sediment transport from shore protection, and continued development in long-term flooding and erosion hazard zones.

Figure 21



Long Point Significant Abiotic Processes

Figure 22



Inland constraints on land use should **avoid** soil loss to streams, inputs of agro-chemicals to groundwater and surface flow, and depletion of ground water resources for irrigation and drinking.

Coastal constraints on land use should **avoid** the fragmentation of the shoreline by many small undertakings, interference with natural longshore processes, and construction in erosion prone zones.

Long Point Constraints Imposed by the Abiotic System

5. SUMMARY

This report has provided a review and assessment of information concerning abiotic features and processes in the Long Point area. In addition to the material presented and the development of a set of abiotic feature and process maps in the report, information gaps and identification of important abiotic concepts for management and planning have been outlined.

5.1 Information Gaps

A large amount of information is available on the abiotic environments of the Great Lakes, Lake Erie and the Long Point area. As stated in the introduction, the information gaps identified are a result of three circumstances: 1. No information was available for review; 2. Information was available but was incomplete or unreliable; and 3. Insufficient time was available for summarizing or interpreting large data sets. The most obvious information gaps are:

- groundwater chemistry
- groundwater hydrology
- surficial geology - structural character
- soil loss values
- bedrock stratigraphy and structural character

In the case of the bedrock information the information gap is a result of scale and a lack of available time to extrapolate data from large data sets. Data is available at a regional scale but apart from some areas with gas and oil potential, little is reported on the structural character of the rock at the local scale. This is not a glaring omission as much of the rock basement surface is covered by more than 100 metres of overlying glacial and post glacial sediments in most areas of southwestern Ontario and the Long Point area. The impact of the bedrock structure on the surface topography is buffered by the overlying till blanket. The lack of information on surficial geology (geomorphology) and soil loss results from insufficient data for review. The obvious importance of understanding the groundwater regime (not just the depth to the water table) makes this information gap very important. Groundwater acts as a pathway for movement of many pollutants including road salts, agrochemicals, waste effluents and acid drainage. Groundwater supplies also are being drawn on strongly for irrigation and other uses.

5.2 Abiotic Concepts for Management

Probably the most important concepts that should be considered when including abiotic components in environmental planning are:

Evolution - The coastal landscape is a dynamic environment with characteristics which protect and provide opportunity for biotic environment. Furthermore, built in thresholds and the ability to respond elastically or flexibly to events lessen the impact of many "hazards" on the landscape.

Geodiversity - Variations in the landscape, that are often "graded" or changed during construction or dredging, contribute to both the aesthetic value of the coast and its ability to host a variety of floral and faunal species. Biodiversity cannot be maintained without geodiversity.

5.3 Conclusions

An evaluation of abiotic information has revealed significant abiotic features and processes and constraints which should be considered in the development, application and enforcement of management and planning initiatives. An understanding of abiotic resources is essential to understanding biological diversity, ecosystem health, economic opportunities, and human activities in the context of managing for sustainable development of the Long Point area.

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This listing includes references related to understanding the Long Point abiotic system. Not all of the references are cited in the text, in as much as one of the aims of this project was to assess available information.

Acronyms used in this bibliography include:

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OMNR	Ontario Ministry of Natural Resources
IAGLR	International Association for Great Lakes Research
NRCC	National Research Council Canada
NWRI	National Water Research Institute
CCIW	Canada Centre for Inland Waters
USGS	United States Geological Survey
EMR	Energy, Mines and Resources

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