8.0 EXISTING ENVIRONMENT

8.1 AREA GEOGRAPHY

The proposed Keltic Site and water supply Study Area (the Keltic Study Area) is found in Guysborough County, covering a total surface area of approximately 300 square km (km^2) near Goldboro, Nova Scotia and surrounding areas in the south.

The Keltic Study Area is located within the Southern Upland physiographic region (see Figure 8.1-1).

The topography in this region is somewhat varied. The surface is much like a plateau with long, low ridges running southeast-northwest. The soil is generally thin and acidic. The intervening hollows are swampy flats that have their long axes generally oriented parallel to the strike of bedrock strata. Drainage is poor because of deposits of glacial drift. Peat bogs are common and in some areas there are wide level expanses of heath and meadow.

Chains of lakes, streams, and still-water occur. River channels are shallow because the streams run down tilted erosion plains, across bedrock folds, and layers of resistant strata. The area is mainly forest country.

8.1.1 Population Distribution

The communities present within the Southern Upland in the Keltic Study Area are mostly small hamlets consisting of few homes, a gas station, and a general store which service a greater population that is distributed primarily along the major paved roads, Route 316 mostly.

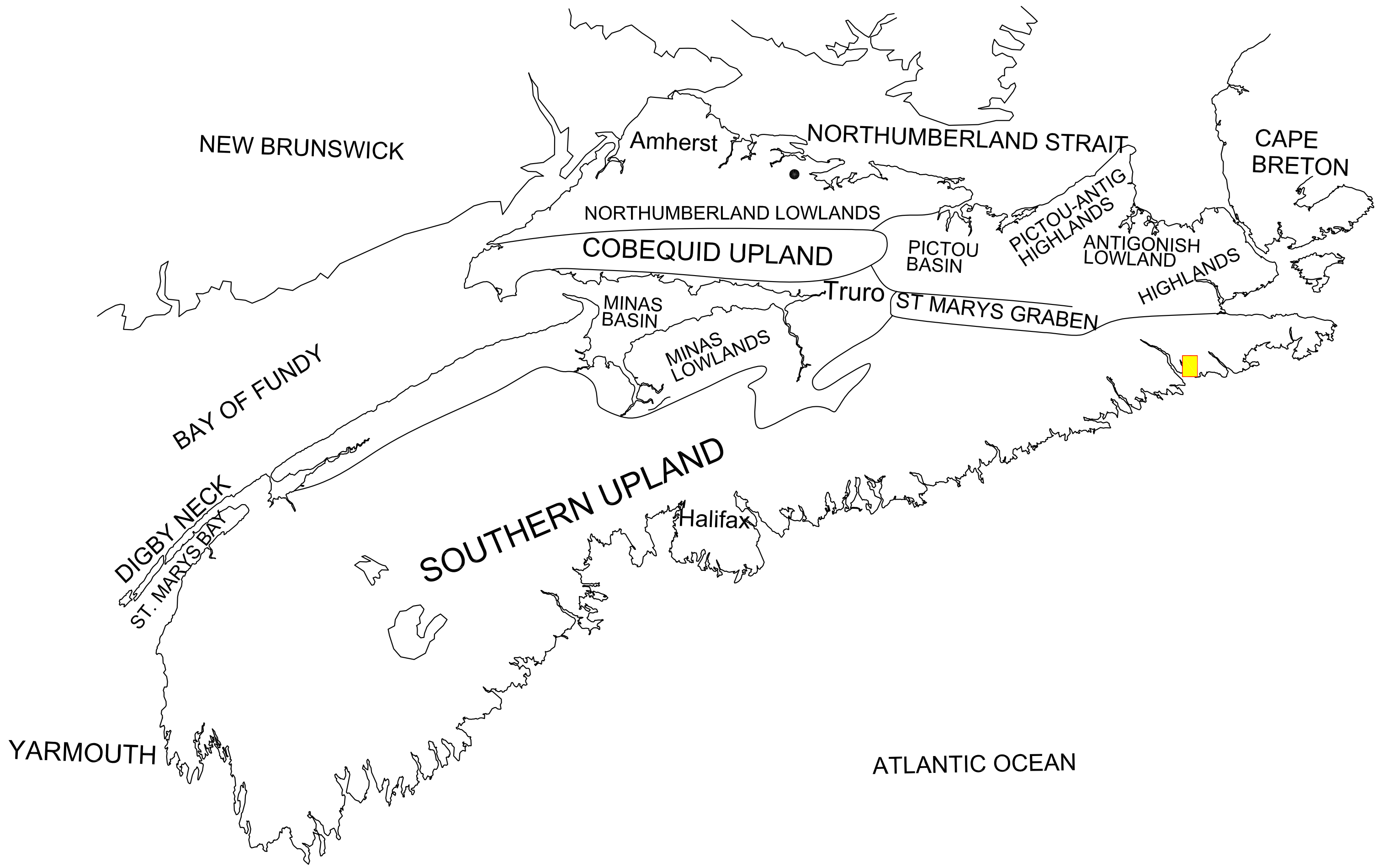
8.2 EXISTING AND PLANNED LAND USE

8.2.1 Proposed Keltic Industrial Site

Prior to the Keltic proposal, the Municipality of Guysborough County was instituting an industrial strategy for the region. Construction of the SOEP gas plant in the Goldboro Industrial Park has spurred expansion of the current industrial site to include land for the proposed Keltic development, which includes a Petrochemical Complex and LNG Importation and Vaporization Facility. The proposed Marginal Wharf is located on Red Head and is a marine facility.

Goldboro and the proposed petrochemical site are covered under the District 7 Planning Strategy and Land Use Bylaws (see Figure 8.2-1). The proposed site was previously zoned M-2 (Industrial Resource) and Residential R-1. The M-2 zoning permitted uses, such as quarry development, that were not deemed suitable for extension to shoreline properties. Zoning has been amended to an M-3 designation that targets the marine aspect of the Keltic development. This designation encompasses an area between 2833 and 3238 ha, of which approximately 300 has been allocated to Keltic. The area includes the shoreline of Red Head to Betty's Cove, including the existing pipeline and Nova Scotia Power Inc. line corridors. The adjoining Sable gas complex has a footprint between 40.5 and 48.6 ha, of which 20.2 ha has been fenced (G. Cleary, pers. comm., 2005).

FIGURE 8.1-1 Nova Scotia's Main Physiographic Regions



Geological Background and Physiography of Nova Scotia, Roland, 1982

Legend:

Project Location

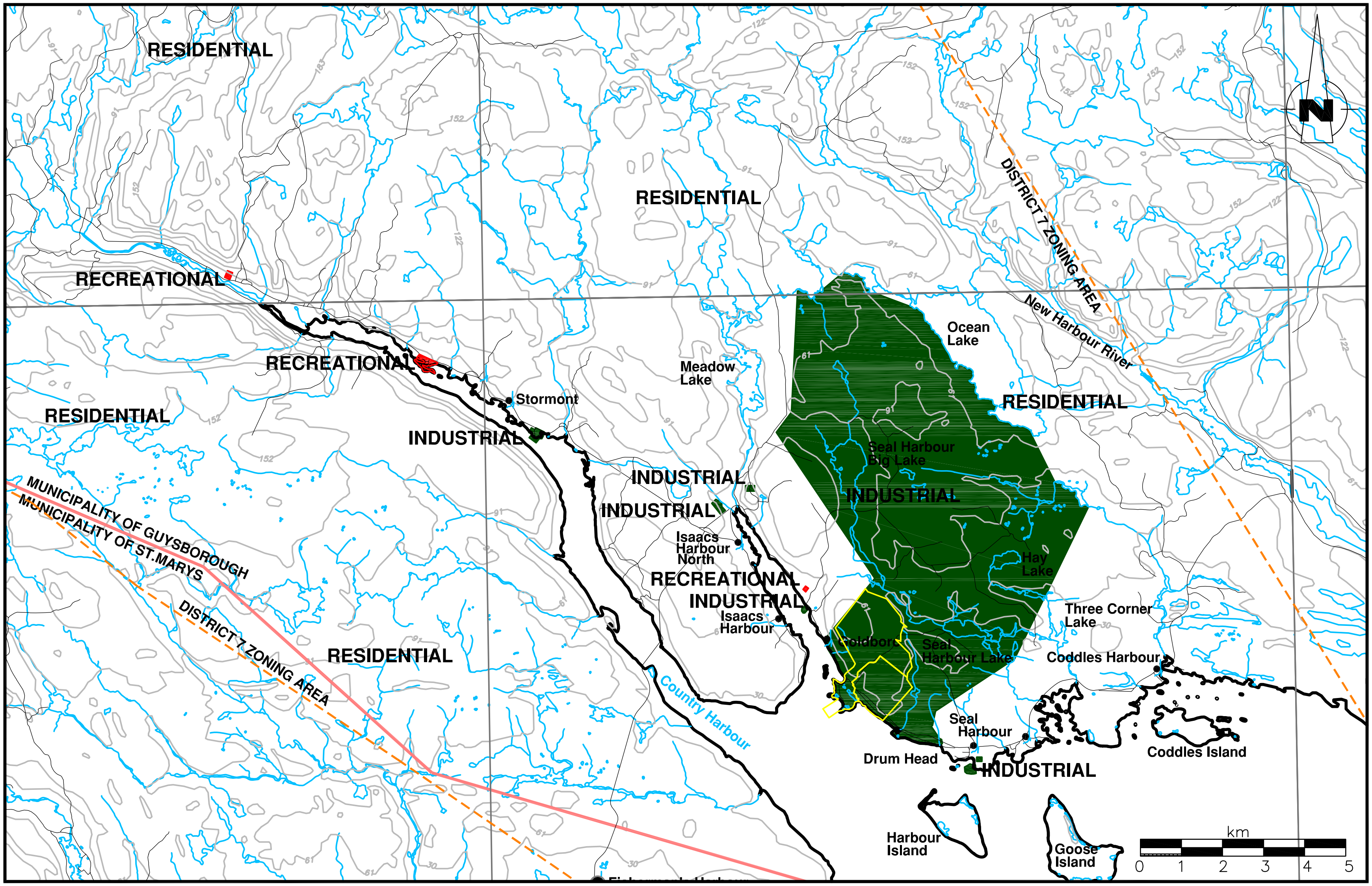
FIGURE No. 8.1-1

KELTIC PETROCHEMICALS INC.

NOVA SCOTIA'S MAIN PHYSIOGRAPHIC REGIONS

JULY 2006

FIGURE 8.2-1 Generalized Future Land Use Map



LEGEND

	Road		Recreational
	River/Streams		Industrial
	Contours		Residential
	Project Location		

FIGURE No. 8.2-1

KELTIC PETROCHEMICALS INC.

GENERALIZED FUTURE LAND USE MAP

JULY 2006

The Municipality of the District of Guysbrough, District 7, Municipal Planning Strategy, Generalized Future Land Use Map, 05/11/23

Changes from the previous zoning designation to M-3 (Industrial Resource) required amendments to the Planning Strategy and land use by-law. The zoning amendments were approved by Municipal Council on October 13, 2005, with final certification received on January 6, 2006. In addition to covering the proposed Keltic site, the amendments encompassed a larger piece of land including a future designation. An appeal was made before the NSUARB in regard to the initial rezoning of the proposed Keltic site. To date, some preliminary hearings have occurred; however, the appeal is not expected to continue because amendments have been approved in both the municipal planning strategy and the land use by-law (D. Torrey, pers. comm., 2006).

8.2.2 Aboriginal Use of Land and Resources

A Mi'kmaq Ecological Knowledge Study was developed by Membertou Geomatics Consultants for Keltic. The purpose of the study was to identify Mi'kmaq land and resource use activities that have been or continue to be pursued by Mi'kmaq in the geographical areas being considered for development. The full report is provided in Appendix 2.

The Mi’kmaq people have occupied various lands located throughout Antigonish and Guysborough counties since contact. The area surrounding Antigonish Harbour and the present town site was an important site for fishing, hunting, gathering of medicinal plants, as well as encampment. One of the most significant historical Mi’kmaq communities appeared to be at St. Mary’s, which for the purpose of this study, is outside of the Keltic Study Area, and located about 30 km southeast of Goldboro. However, it is clearly an important historical area, as there are reported to be Mi’kmaq burial sites here, and the St. Anne’s Chapel was constructed here in the early 19th century. The town of Guysborough was also found to be a significant historical area to the Mi’kmaq, with various archival references to Mi’kmaq petitions and grants during the 19th century. As well, the study also found various references to a burial ground at Isaac’s Harbour and as well at Upper Country Harbour.

Data collected from interviews with Mi'kmaq hunters, fishers, and plant gatherers identified various hunting areas for small game, deer, and areas where these animals have been harvested previously. Medicinal plant gathering sites and areas were also identified. The most significant data appeared to be fishing activities that are pursued on many of the key rivers and waterways which are found throughout the counties. This included many species, such as trout, eels, salmon, tuna, and urchins.

The study found that Mi’kmaq continue to undertake traditional activities throughout the Keltic Study Area. Some of the reported hunting and fishing areas occur within the Keltic Site footprint. However, most of these areas are smaller hunting areas that either encompass large areas of land, or are located throughout areas of the various waterways.

Davis Archaeological Consultants Ltd. identified the South River, Isaac's Harbour and Isaac's Harbour River, Gold Brook, and the Salmon River/Erinville areas as key resource and land use sites using a predictive model. The Mi'kmaq Ecological Knowledge Study and archaeological predictive modelling provided similar results and were performed independently of one another.

8.2.3 Mining

Gold mining has been a major resource extraction activity in Goldboro and the surrounding area. Abandoned mine sites exist around Goldboro and tailings are present in Isaac's Harbour. In recent years, the price of gold has risen to a level high enough to encourage more interest in active gold exploration and mining. Although most activity today is exploratory, there is a move to re-open the Orex site near Goldboro in 2006. The water supply of the proposed Keltic project will intersect this claim area. Acadia Minerals is currently pursuing some exploratory activities near Forest Hill (limited activity), but is focusing most effort towards Goldenville and Sheet Harbour. A processing facility is currently set up in the Country Harbour Cultural Centre near Cross Roads on Highway 316 (B. Mitchell, pers. comm., 2006).

8.3 SOCIO-ECONOMIC CONDITIONS AND RECREATIONAL

8.3.1 The Economy of Nova Scotia

8.3.1.1 Nova Scotia Historical Growth

The data for this review of historical growth were obtained from:

- Statistics Canada's Provincial Gross Domestic Product by Industry 1984 to 2002;
- Labour Force Historical Review 2002;
- "Economic Sector Strategy for Colchester County" by Canmac Economics;
- Greater Halifax Partnership;
- Halifax-Moncton Growth Corridor Asset Mapping -Baseline Research Project, 2003;
- Nova Scotia Department of Finance. Community Counts; and
- Nova Scotia Department of Finance. Overview of the Nova Scotia Economy: 1991 – 2003.

Between 1984 and 2002 Nova Scotia experienced growth in output of 2.2% per year. Growth from 1997 to 2002 almost doubled to 3.6% per year. During the same periods of time employment growth averaged 1.3% and 2.2% respectively. The ratio of output to employment growth suggests that the economy made significant productivity gains in terms of output per job. Over the 1984 to 2002 period, productivity improved by 0.8% per year, and 1.3% per year from 1997 to 2002. Table 8.3-1 provides a breakdown by major economic sector.

8.3.1.2 Nova Scotia Economic Outlook

Economic growth over the next five to 10 years will be dominated by two factors, the province's export, and population growth. Growth in Gross Domestic Product is expected to be in the range of 2.5% per year.

TABLE 8.3-1 Nova Scotia Economic Growth, 1984 – 2002

	Output (%)		Employment (%)		Productivity (%)	
	1984 – 2002	1997 – 2002	1984-2002	1997-2002	1984 – 2002	1997 – 2002
Agriculture	0.5	1.6	0.9	-1.3	-1.1	1.7
Forestry	6.4	21.9	1.2	1.8	-5.2	-2.2
Fishing	0.8	6.8	-1.5	-3.5	1.1	9.1
Mining	7.4	17.6	-1.6	-2.6	6.8	13.7
Utilities	2.6	3.6	1.1	5.0	1.5	-1.3
Construction	0.1	2.5	0.9	3.6	-1.4	-2.4
Manufacturing	2.0	3.7	0.8	4.2	1.1	-0.5
Wholesale Trade	5.6	5.4	3.3	4.9	0.4	0.5
Retail Trade	2.2	4.6	0.8	2.5	0.6	1.9
Transportation and Warehousing	2.8	2.5	1.4	3.9	1.0	-1.4
Finance, Insurance, and Real Estate	3.5	3.0	1.6	0.3	1.9	2.7
Information, Culture and Services	3.7	6.6	2.8	3.8	0.8	2.6
Education Services	0.2	-0.2	1.7	3.1	-1.6	-3.3
Health and Social Services	1.5	2.3	2.2	1.9	-0.8	0.3
Public Administration	0.1	0.8	-1.3	-.8	1.3	5.6

Source: Economic Sector Strategy for Colchester County, Canmac Economics, 2004.

Growth in Nova Scotia's and Canada's main markets will likely remain firm in the next three to five years. Therefore, barring supply side issues or major changes in the Province's competitive position, Nova Scotia's export performance should maintain its historical relationship to economic growth in its main markets.

The rate of population growth will be a key feature of the economy because it will be a major influence on consumer spending and the ability of industry to hire labour. Total growth in consumer spending is expected to:

- ease to about 2.2% per year; and
- change the profile of its market basket of goods and services as the population ages (i.e., as the baby boomers enter pre-retirement years, growth in consumer spending for services will outstrip that for goods).

The aging of the baby boom generation, combined with net out-migration from the younger age cohorts, will result in a reduction of the size of the prime working age cohorts in the labour force age group (i.e., the population aged 15 years and older).

Should total population remain essentially unchanged (through a combination of net out-migration from younger age groups and net in-migration of older age groups, as it has for the last 10 years) the consequences will be a reduction of housing starts and a decline in Provincial housing markets. Further weakness in the construction sector will arise as retiring baby boomers trade their family-size homes for smaller accommodations more appropriate for retirement. Demand will lean toward multiple unit buildings. These factors will likely result in limited growth in residential investment with the resulting negative impact on the residential construction sector.

Non-residential construction investment is expected to fluctuate according to developments in offshore hydrocarbon production, development, and exploration. Intense construction activity could occur over the next five to eight years, assuming EnCana's Deep Panuke project enters construction mode and the second phase of the SOEP continues. These events, plus the potential for the construction of LNG receiving stations and this project's LNG receiving station and petrochemical plant could lead to a reasonable growth in non-residential construction investment over the next five to 10 years.

The mining sector, especially the mineral fuels and services incidental to mining sub sectors, is expected to show strong growth over the next five to 10 years. Approximately 500 mmcfd is expected to flow from SOEP's six fields. In addition, EnCana could be pumping about 400 mmcfd from its Deep Panuke gas field. This would lead to an expansion of the M&NP pipeline to carry the gas to the US.

Shipments of natural gas and manufactured products, combined with the expansion of the Port of Halifax to handle Post-Panamax vessels, will boost real growth in the transportation industry to an average of 2% per year over the next five to 10 years.

8.3.2 Guysborough County Socio-economic Conditions

8.3.2.1 Population

As Table 8.3-2 shows, the population of Guysborough County has been in constant decline for decades. The population declined by 13.8% from 1991 to 1996. The rate of decline slowed during the period 1996 to 2001 to a decline of 1.6% for that five-year period. Based on Statistics Canada estimates for 2004 the five-year population rate of decline has increased again to about 4.2% estimated for the five-year period 2001 to 2005.

TABLE 8.3-2 Guysborough County, Population by Age and Sex

Cohort	1991			1996			2001			2004			
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	% of Total	Male	Female
0-19	3,145	1,605	1,540	2,190	1,135	1,055	2,270	1,180	1,090	1,973	20.7%	1,040	933
20-29	1,735	910	825	350	180	170	865	455	410	936	9.8%	471	465
30-54	4,020	2,020	2,000	2,360	1,235	1,125	3,590	1,785	1,805	3,365	35.4%	1,696	1,669
55-64	1,155	590	565	1,635	820	815	1,245	620	625	1,389	14.6%	694	695
65+	1,540	780	760	3,460	1,740	1,720	1,860	860	1,000	1,848	19.4%	881	967
Total	11,595	5,905	5,690	9,995	5,110	4,885	9,830	4,900	4,930	9,511	100.0%	4,782	4,729

Source: Nova Scotia Department of Finance, Community Counts.

8.3.2.2 Economic Structure

Table 8.3-3 provides an overview of the economic structure of Guysborough County. The numbers in bold reflect the economic sectors in which the proportion of the labour force in that sector in the County is at least two times higher or lower than that in Nova Scotia.

Guysborough County has over three times the percentage of its labour force involved in Agriculture, Forestry, Fishing and Hunting and Mining and Oil and Gas Extraction relative to Nova Scotia. The proportion of the labour force involved in Manufacturing is twice that of the Province.

Relative to the Province it has a low representation of Information and Cultural Industries, Finance, Insurance and Real Estate and Professional, Scientific and Technical Services in its economic structure. These numbers are not surprising given the distance of Guysborough County from Metropolitan Halifax and the physical resource base of the County.

TABLE 8.3-3 Labour Force by Industry, 2001

Industry	Guysborough County		Antigonish County		Nova Scotia	
	#	%	#	%	#	%
All Industries	4,230		9,390		442,425	
Agriculture, Forestry, Fishing & Hunting	675	**16.0%**	960	**10.2%**	22,910	5.2%
Mining and Oil & Gas Extraction	115	**2.7%**	100	1.1%	3,370	0.8%
Utilities	30	0.7%	30	**0.3%**	2,720	0.6%
Construction	355	8.4%	815	8.7%	26,755	6.0%
Manufacturing	820	**19.4%**	665	7.1%	44,195	10.0%
Wholesale & Retail Trade	480	11.3%	1,385	14.7%	71,085	16.1%
Transportation & Warehousing	185	4.4%	330	3.5%	20,065	4.5%
Information & Cultural Industries	35	**0.8%**	120	**1.3%**	10,640	2.4%
Finance, Insurance & Real Estate	65	**1.5%**	305	3.2%	20,615	4.7%
Professional, Scientific & Technical Services	50	**1.2%**	285	3.0%	18,850	4.3%
Management & Administration	105	2.5%	190	**2.0%**	20,715	4.7%
Educational Services	235	5.6%	1,365	**14.5%**	31,660	7.2%
Health Care & Social Assistance	350	8.3%	1,090	11.6%	49,045	11.1%
Accommodation & Food Services	325	7.7%	735	7.8%	31,955	7.2%
Other Services (except public administration)	175	4.1%	650	6.9%	30,015	6.8%
Public Administration	230	5.4%	370	**3.9%**	37,825	8.5%

8.3.2.3 Labour Force Age Group and the Active Labour Force

The key labour force age group, aged 30 years to 54 years, comprises about 35% of the County's population. This is slightly lower than the Provincial rate (Table 8.3-4) of about 38%. The major difference in population structure shows up in the fact that Guysborough County has a substantially lower portion of its population in the age group from the 0 to 29 years than Nova Scotia. The low percentage is symptomatic of the impact that modest economic conditions have had on the ability of families to find work and raise children in the area and on the willingness of new entrants into the labour force age group to remain in the Guysborough County area.

TABLE 8.3-4 Nova Scotia, Population by Age and Sex

Cohort	2004			
	Total	% of Total	Male	Female
0 - 19	218,990	23.4%	111,792	107,198
20 - 29	120,712	12.9%	59,965	60,747
30 - 54	355,597	38.0%	176,278	179,319
55 - 64	109,828	11.7%	54,024	55,804
65+	131,833	14.1%	56,569	75,264
Total	936,960	100.0%	458,628	478,332

Source: Nova Scotia Department of Finance, Community Counts.

Table 8.3-5 describes labour force activity in Guysborough County and shows that the labour force age group from 1991 to 2001 declined by 10.7% compared to a 15.2% decline in the total population of Guysborough County in the same time period. However, the relative strength of the labour force age group is due to the relatively large proportion of the population aged 55 years and older. Those over the age of 55 are not considered prime candidates for work in heavy construction or industry that is relatively technologically intense, such as the proposed LNG receiving station and petrochemical plant.

TABLE 8.3-5 Labour Force Activity - 15 Years and Over, Guysborough County

Year	Pop. 15+	In the Labour Force	In the Labour Force - Employed	In the Labour Force - Unemployed	Not in the Labour Force	Participation Rate	Employment Rate	Unemp. Rate
1991	9,180	5,000	4,085	915	4,180	54.5	44.5	18.3
1996	8,785	4,605	3,575	1,025	4,185	52.4	40.7	22.3
2001	8,200	4,365	3,365	1,000	3,835	53.2	41	22.9

Source: Nova Scotia Department of Finance, Community Counts.

Tables 8.3-5 and 8.3-6 clearly show that the participation rate of the labour force age group is substantially lower than that for the rest of Nova Scotia. Other things being equal, such as education and job skills, the labour force age group in Guysborough County should be able to raise its participation rate and make more labour available to the Project because the participation rate in Guysborough County is at least eight percentage points lower than that for the rest of Nova Scotia. In addition, given the high unemployment rate in Guysborough County labour should, other things being equal, be willing to enter the labour force at the first sign of improvement in economic conditions.

In contrast, in the Province, the population 15 years old and over and those in the labour force have grown consistently since at least 1991 (Table 8.3-6). Even with the growth in the active labour force unemployment rates have dropped since 1996 in Nova Scotia. This suggests relatively robust employment increases in the rest of the Province relative to Guysborough County.

TABLE 8.3-6 Labour Force Activity - 15 Years and Over, Nova Scotia

Year	Pop. 15+	In the Labour Force	In the Labour Force – Employed	In the Labour Force – Unemployed	Not in the Labour Force	Participation Rate	Employment Rate	Unemployment Rate
1991	706,675	447,525	390,785	56,735	259,155	63.3	55.3	12.7
1996	719,970	438,970	380,790	58,185	281,000	61	52.9	13.3
2001	732,365	451,375	402,295	49,080	280,990	61.6	54.9	10.9

Source: Nova Scotia Department of Finance, Community Counts.

8.3.2.4 Potential New Labour Supply

Table 8.3-7 shows that the education attainment levels of the labour force age group in Guysborough County are substantially lower than those for the rest of Nova Scotia (i.e., almost 53% of people aged 15 years and older have less then high school education). Although the County is roughly comparable to the rest of Nova Scotia in terms of the attainment of post secondary certificates or diplomas it has much lower attainment levels with respect to those having some post secondary education or a university degree. However, the data show that the labour force age group in Guysborough County has about the same propensity to hold a high school graduation certificate as the highest level of education attained as the rest of the Province.

TABLE 8.3-7 Educational Attainment, Population 15+ (%), 2001, Guysborough County

	Less than High School	High school Graduation Certificate	Some Post-Secondary Education	Post-Secondary Certificate or Diploma	University Degree - Bachelors or Higher
Guysborough County	52.7%	8.7%	5.5%	5.5%	4.8%
Antigonish County	27.6%	8.0%	9.9%	9.9%	20.5%
Nova Scotia	31.7%	9.8%	9.4%	9.4%	15.3%

Source: Nova Scotia Department of Finance, Community Counts.

8.3.2.5 Income

Table 8.3-8 shows household income in Guysborough County is substantially lower than in Nova Scotia. The average household income stands at about 79% of that in the rest of Nova Scotia. The median household income stands at about 77% of that in the rest of Nova Scotia. The fact that the average and median household incomes are roughly the same percentage of the Nova Scotia household incomes suggests that the income distribution in Guysborough County is similar to that of the rest of Nova Scotia.

Notwithstanding the lower household income, according to Statistics Canada definitions, the incidence of low income among households is roughly the same in Guysborough County as in the rest of Nova Scotia. This suggests that living costs in the County are substantially lower than in the rest of Nova Scotia. What is significant is the change in the incidence of low income households from 1996 to 2001. These data suggest that the run-up to and commissioning of the Sable gas project, and expansions at Stora, enabled the households in Guysborough County to substantially improve their material well-being.

TABLE 8.3-8 Household Income for Guysborough County, Antigonish County, and Nova Scotia

	Household Income, 2001		Incidence of Low Income in Households (%)		
	Average Household Income	Median Household Income	1991	1996	2001
Guysborough County	$38,106	$30,441	14.6	23.5	16.1
Antigonish County	$50,007	$43,127	12.4	16	12.7
Nova Scotia	$48,457	$39,908	15.0	16.0	16.6

Source: Nova Scotia Department of Finance, Community Counts.

8.3.2.6 Socioeconomic Planning in Guysborough County

The Guysborough County Regional Development Authority is the lead economic planning agency in Guysborough County. The "Strategic Planning Report, 2003-2007" describes the principal strategic directions to improve economic conditions in the County. The strategic directions are:

- promoting of the importance of rural living;
- adding value to natural resources in forestry, fisheries, aquaculture, tourism, heritage and cultural, mineral resources and petroleum industries; and
- enhancing and maintaining infrastructure.

8.3.3 Antigonish County Socioeconomic Conditions

8.3.3.1 Population

Table 8.3-9 shows that the population of Antigonish County grew 11.1% to 19,540 from 1991 to 1996. Population held constant from 1996 to 2001. Based on Statistics Canada estimates for 2004 the five-year population growth rate now stands at about 1.6%.

8.3.3.2 Economic Structure

Table 8.3-3 provides an overview of the economic structure of Antigonish County. It has over twice the percentage of its labour force involved in Agriculture, Forestry, Fishing and Hunting and Educational Services than Nova Scotia as a whole.

Relative to the Province it has a low representation of Utilities, Information and Cultural Industries, Management and Administration and Public Administration in its economic structure.

TABLE 8.3-9 Antigonish County, Population by Age and Sex

	1991			1996			2001			2004			
Cohort	Tot.	M	F	Tot.	M	F	Tot.	M	F	Tot.	% of Tot.	M	F
0 - 19	4,995	3,390	3,260	5,275	2,435	2,840	5,695	2,855	2,840	5,317	26.7%	2,669	2,648
20 - 29	2,685	1,380	1,305	1,580	360	1,220	2,410	1,190	1,220	2,573	12.9%	1,328	1,245
30 - 54	6,210	3,130	3,080	6,110	2,530	3,580	7,050	3,470	3,580	6,987	35.1%	3,487	3,500
55 - 64	1,355	650	705	2,255	1,350	905	1,870	965	905	2,332	11.7%	1,200	1,132
65+	2,335	970	1,365	4,320	2,785	1,535	2,560	1,025	1,535	2,690	13.5%	1,118	1,572
Total	17,580	9,520	9,715	19,540	9,460	10,080	19,585	9,505	10,080	19,899	100.0%	9,802	10,097

Source: Nova Scotia Department of finance, Community Counts

With the exception of the relatively low representation of Information and Cultural Industries these numbers are not surprising given the strong university presence in Antigonish County and the role of the Town of Antigonish as a service and retail centre for the North Shore area.

8.3.3.3 Labour Force Age Group/Active Labour Force

The key labour force age group, aged 30 years to 54 years, comprises about 35% of the County's population. This is slightly lower than the Provincial rate (Table 8.3-4) of about 38%. The major difference in population structure shows up in the fact that Antigonish County has a higher portion of its population in the age group from the 0 to 29 years than Nova Scotia. The higher percentage is due mainly to the existence of St. Francis Xavier University in the Town of Antigonish. The University, in addition to attracting younger persons to the community also employs people who at their stage of the lifecycle tend to have young families.

The demographic data indicate that Antigonish County, relative to Guysborough County, is an easier place for families to find work and raise children. Antigonish County is also easier for families and younger persons to settle in from other areas of northern and eastern Nova Scotia.

Table 8.3-10 describes labour force activity for Antigonish County. It shows that the labour force age group (i.e., the population aged 15 and over) from 1991 to 2001 grew by 8.2% compared to an 11.4% increase in the total population of the County in the same time period. The fact that the labour force age group grew less in percentage terms than the overall population is due mainly to aging of the baby-boom generation.

TABLE 8.3-10 Labour Force Activity - 15 Years and Over, Antigonish County

Year	Pop. 15+	In the Labour Force	In the Labour Force – Employed	In the Labour Force – Unemployed	Not in the Labour Force	Participation Rate	Employment Rate	Unemployment Rate
1991	14,200	8,925	7,685	1,240	5,270	62.9	54.1	13.9
1996	14,960	9,335	8,165	1,170	5,625	62.4	54.6	12.5
2001	15,370	9,575	8,345	1,235	5,795	62.3	54.3	12.9

Source: Nova Scotia Department of Finance, Community Counts.

8.3.3.4 Potential New Labour Supply

As Table 8.3-7 shows, education attainment levels of the labour force age group in Antigonish County are substantially higher than those for the rest of Nova Scotia. The lower propensity of the labour force age group in Antigonish County to have less than high school or a high school graduation certificate is merely a reflection of the higher rates of those having some, or having completed, post secondary education.

8.3.3.5 Income

As Table 8.3-8 shows household incomes in Antigonish County are substantially higher than in Nova Scotia. The average household income stands at about 108% of that in the rest of Nova Scotia. The median household income stands at about 103% of that in the rest of Nova Scotia. The fact that the average household incomes in Antigonish County are 15% higher than the median household income compared to 21% higher for Nova Scotia as a whole suggests that in addition to having higher averages and median values, household incomes in Antigonish County are more closely grouped around the mid-points of the distribution. That is, there appears to be a more equitable distribution of household incomes in Antigonish County than in Nova Scotia as a whole.

According to Statistics Canada definitions, the incidence of low income households is lower in Antigonish County than in Nova Scotia as a whole. The incidence of low income households is not so low to suggest that living costs in the County are substantially lower than in the rest of Nova Scotia. What is significant is the change in the incidence of low income in households from 1991 to 1996 and 1996 to 2001. These data suggest that the early 1990s saw a weakening in income levels and hence rising incidence of low income in households. The rise in the incidence of low income in households from 1991 to 1996 was greater in Antigonish County than in Nova Scotia as a whole. However, the run-up and commissioning of the Sable gas project, combined with the generally improving conditions in the Canadian economy in the late 1990s, enabled the households in Antigonish County to substantially improve their material well-being.

8.3.3.6 Socio-economic Planning in Antigonish County

The Antigonish Regional Development Authority is the lead economic and community development agency in Antigonish County. Its economic development objectives are described in the 2000-2005 strategic plan. The plan sees Antigonish Town and County becoming:

- a Regional Centre that is a friendly, caring and safe place to live;
- an area that is rich in culture, recreation, sports, natural beauty and renewable resources; and
- a place where:
  - development and growth enhance the quality of life for all parts of the community;
  - economic growth matches or exceeds the national average;
  - there is a rural-urban balance with self reliance, year-round work and local input to the management of community change;

  - o educational and health institutions provide amenities and services that are customer driven and the envy of smaller communities across Canada; and
  - o a diversified economy builds upon local institutions and increasingly focuses on sustainable, value-added and knowledge based activities in the global marketplace.

Gaps between present conditions and the vision will be filled by following these action planning themes:

- advocacy and improving financing resources;
- advocacy for improved financing, operation and maintenance of supportive infrastructure for the transporting of people, goods and information;
- enhancing the entrepreneurial climate;
- ensuring human resources are maintained at adequate and competitive levels;
- ensuring the image and identity of Antigonish are effectively disseminated; and
- being responsive to community opportunities and endeavours and reinforcing the work by other interests in community economic development.

<u>Socio-economic Planning Related Implications of the Project for the Antigonish County Area</u>

The inclusion of direct and indirect jobs and spending due to the Project will contribute to the following aspects of the County's economic strategy:

- to develop and enhance the quality of life for all parts of the community;
- to strive for economic growth that matches or exceeds the national average;
- to strive for a rural-urban balance with self reliance, year-round work and local input to the management of community change;
- to have educational and health institutions that provide amenities and services that are customer driven and the envy of smaller communities across Canada; and
- to create a diversified economy that builds upon local institutions and increasingly focuses on sustainable, value-added and knowledge based activities in the global marketplace.

The proposed LNG receiving station and petrochemical plant will provide the County with opportunities to make progress on each of the strategic directions summarized above because it will:

- offer opportunities for people and businesses in all parts of the County;
- bring a growing and high value added industry to the area;
- provide year-round opportunities for people and businesses in rural and urban areas;

- expand the tax base and raise household incomes that will help support improved education and health institutions and related amenities and services;
- diversify the economic base of the County;
- provide sustainable economic activity, via the petrochemical plant, as it imports raw material from around the world as inputs to its manufacturing processes; and
- participate in, and further expose the County to, the global marketplace.

8.3.3.7 Tourism

The Guysborough County Heritage Association works to promote tourism, heritage, and culture in the region. The Association is currently developing a marketing strategy which includes a website, brochures, and signage, to increase the profile of the region and highlight its heritage resources. These promotional materials are expected to be ready for summer of 2006 (K. Avery, pers. comm., 2006).

The Guysborough County Heritage Association has several active members and community groups in Guysborough County. These include the Goldboro/Isaac's Harbour Development Association, the United Empire Loyalists' Association of Canada, Port Bickerton and Area Planning Committee, Lincolnville Community Development Society and the Tor Bay Acadian Society. These groups seek to preserve particular aspects of the region's heritage through promotion and/or interpretive services.

Most cultural and heritage activity appears to be associated with coastal communities. Interior communities (such as Erinville) do not currently have any active membership promoting local cultural or heritage resources (K. Avery, pers. comm., 2006). Cultural and heritage resources include the Goldboro Interpretive Centre, Port Bickerton Lighthouse Interpretive Centre, and Country Harbour Cultural Centre. Community halls exist in Goshen, Port Bickerton, and Erinville (firehall).

Specific heritage projects include the exhumation and relocation of a former black settlement cemetery on Redhead, which was within one kilometre of the proposed Keltic site. The Lincolnville Community Development Society was instrumental in this project, and the gravesites have now been moved to another cemetery on Gold Brook Road (L. Hayne, pers. comm., 2006). Another project is the United Empire Loyalists' Municipal Park, which is a small seaside park (approximately 1 ha) in Country Harbour. First opened in 1983 and neglected for years, the park has recently seen a rebirth with a reopening scheduled for 2006. This park can be accessed via a 2.2 km walking trail leased from the NSDNR off of Highway 316, just north of the intersection with Highway 211. There is a memorial cairn and planned interpretive signs that will describe the cultural and natural history of the area (D. Hayne, pers. comm., 2006).

Guysborough County's natural heritage is also protected in numerous provincial parks and natural areas. In the Goldboro area, Salsman Provincial Park is located off Highway 316, eight km north of Isaac's Harbour, on a peninsula on the east side of Country Harbour. The park is open during the summer months (June to September) and has campground facilities. The Fraser Mills fish hatchery is located on Route 7, west of Erinville. This hatchery raises approximately 500 000 fish annually, including four different salmonid species. The facility also includes an interpretive centre.

Antigonish is the major cultural centre in the County of Antigonish. The Heritage Association of Antigonish operates the Antigonish Historical Museum as the main vehicle to promote and preserve the region's cultural and historical heritage.

8.3.4 Recreational Opportunities and Aesthetics

The proposed location of the Keltic Site offers a variety of non-formal recreational opportunities such as hiking, boating, fishing, camping, scuba diving, etc. However, in terms of formal recreation the area has limited parks and campgrounds, such as the picnic area at the Goldboro community centre.

8.3.5 Property Values

The average value per dwelling for Guysborough and Antigonish County were available through the Statistics Canada website. The average value of a dwelling in Guysborough County was $59,216 in 2001 (Statistics Canada 2001). In Antigonish County the average value of a dwelling was $94,281 in 2001. The average value for Nova Scotia as a whole was $101,515 for the same time period.

8.4 ATMOSPHERIC CONDITIONS

Nova Scotia has a "temperate continental" climate (Rudloff, 1981) marked by relatively large daily and day-to-day ranges of temperature, especially during the spring and fall, and moderate rainfall. This area lies in the "prevailing westerlies" that are characteristic of mid-latitudes in the northern hemisphere. Within this general circulation are embedded air masses originating at higher or lower latitudes that interact to produce storm systems. Nova Scotia experiences a relatively large number of storm systems that contribute to a roughly twice-weekly shift between fair and cloudy and stormy weather.

The continental climate is modified by Nova Scotia's surrounding waters (EC, 2005a). The Atlantic and Bay of Fundy waters are relatively cold (8-12°C) which helps to keep the air temperature over southwestern Nova Scotia on the cool side in spring and summer. In January, when water temperatures are between 0 and 4°C, they moderate the winter temperatures. Farther offshore to the east, southeast, and south are the comparatively warm 16°C waters of the Gulf Stream that are credited with prolonging warm weather well into October.

Ice conditions in the Gulf of St. Lawrence retard the arrival of spring. Cool summer seas also help stabilize overriding air masses, thus suppressing local storm development. In addition, the merging of contrasting ocean currents (i.e., warm Gulf Stream and the cold Labrador Current) produces a great deal of sea fog that often moves far inland.

8.4.1 Review of Baseline Climatological Data

The following data are taken from EC, 2005b.

8.4.1.1 Temperatures

Winter temperatures are moderate along the coast. Yarmouth's average January temperature of -2.7°C is the highest of any mainland station in the Maritimes. Inland, January means are between -4°C and -6°C. The most significant aspect of winter is the marked day-to-day variation caused by the alternation of Arctic and maritime air.

Summers are relatively cool in Nova Scotia. Afternoon summer temperatures reach 25°C in the interior, but along the coast are frequently 4°C to 6°C cooler. At night the ocean remains a cooling source, keeping minimum temperatures along the coast about 2°C to 3°C below those inland. Halifax's July mean of 17.4°C and Yarmouth's 16.3°C compare closely with Vancouver's 17.3°C but are somewhat cooler than Toronto's 20.6°C.

8.4.1.2 Winds

Winds blow predominantly from the south or southwest in the summer with an average speed of about 10 to 15 km/h. In the coldest months, the predominant direction is from the west and northwest with an average speed of 22 km/h.

The wind at any given location is often quite different from the wind conditions which prevail even a short distance away. The variation that occurs in both wind direction and speed results from the characteristics of natural and man-made obstructions, topography, and surface cover. Along the coast, an onshore sea breeze circulation often sets up, particularly during a warm, sunny afternoon in the spring or early summer.

Wind statistics taken between 1988 and 1999 from Beaver Island at the mouth of Country Harbour showed average monthly nearshore wind speeds between 19 and 31 km/hr. Extreme average hourly wind speeds ranged between 65 and 98 km/hour. Westerly winds predominated, with stronger winds from the northwest (November to January) than the southeast (Meteorological Service of Canada, 2000).

8.4.1.3 Precipitation

Nova Scotia is wettest over the highlands of Cape Breton Island, where over 1600 mm of precipitation fall in an average year. The southern coast experiences almost as much, with totals of 1500 mm. By contrast, the north shore along the Northumberland Strait has less than 1000 mm a year.

Precipitation is slightly greater in the late fall and early winter because of the more frequent and intense storm activity. In most years there is a good supply of rain during the growing period. However, drought is not unknown in Nova Scotia.

On average, only about 15% of Nova Scotia's total annual precipitation originates as snow. Snowfall is relatively light near the warm Atlantic shore and near the entrance to the Bay of Fundy, where less than 150 centimetres (cm) may fall in one winter. Here, copious rain and freezing rain make up for the scanty snowfalls. Inland, the yearly snowfall increases to 250 cm. As a rule, elevated areas receive the greatest snowfall and have the longest snow cover season.

The snow-cover season, that is, the period when there is at least 2.5 cm of snow on the ground, varies considerably. Usually its duration extends from about 110 days a year along the southern coast to 140 days inland and in areas adjacent to the frozen seas. In coastal areas the snow-cover may come and go.

8.4.1.4 Fog

Each year there is an average of 101 days with fog at Shearwater, although on most days fog persists for less than 12 hours. The period from mid-spring to early summer is the foggiest time. Bands of thick, cool fog lie off the coast, produced where the chilled air above the Labrador Current mixes with warm, moisture-laden air moving onshore from the Gulf Stream. With onshore winds these banks of fog move far inland. Sea fog often affects the headlands by day, moving inland and up the bays and inlets at night. At other times of the year fog is much more transient and local in nature.

Because of the extensive fogs, as well as mists, low cloud, and smog, sunshine amounts throughout the province are usually less than half the total possible. Sunshine totals range from 1700 to 1969 hours a year. July is the sunniest month inland, and August is the sunniest along the coast. Sunless days (days with less than 5 minutes of bright sunshine) amount to between 75 and 90 a year, with a marked seasonal high from November to February. Sunny days, on which less than 70% of the sky is covered with cloud in the early afternoon, amount to between 130 to 160, with a peak from July through October.

8.4.1.5 Severe Weather

Storms frequently pass close to the Atlantic coast of Nova Scotia and cross the southern part of Newfoundland, producing highly changeable and generally stormy weather. This region has more storms over the year than any other region of Canada. With a variety of weather conditions from hurricane-force winds to heavy precipitation, they can pass rapidly through or stall and batter the region for several days. Other conditions associated with these storms include freezing spray, reduced visibility in snow, rain, or fog, and numbing wind chills, especially in the storm's wake.

In late summer and fall the remnants of a hurricane or tropical storm are felt at least once a year in Nova Scotia. For example, on August 15-16, 1971, Hurricane Beth brought 296 mm of rain to Halifax, enough to wash away several bridges, damage buildings, and flood farmland.

Nova Scotia is not known for frequent thunderstorms that occur on about 10 days of the year, about half the number that occurs in northern and central New Brunswick. Tornadoes have been recorded but are rare. Reports of waterspouts over near-shore waters are received yearly.

Other severe weather phenomena include ice storms and blizzards. Each year one or two 25 cm snowfalls occur in Nova Scotia. When combined with strong winds, they can cause property damage and loss of life.

8.4.1.6 Normals and Extremes

The climate of the Keltic Site is best characterized by long-term meteorological data collected by EC at Stillwater-Sherbrooke (Table 8.4-1) and at Halifax-Shearwater station (Table 8.4-2). Stillwater-Sherbrooke is located approximately 25 km west of the Keltic Site. The Halifax-Shearwater station is located approximately 160 km southwest of the Keltic Site and is included for its wind speed and direction data and other parameters that are not available from Stillwater-Sherbrooke. These distances from the site support their spatial representativeness since they place them in the same general synoptic flow regime as well as most mesoscale systems. The Stillwater-Sherbrooke and Halifax-Shearwater stations are also located in a similar geographic setting as the Keltic Site. These stations are the closest to the Keltic Site and provide the commonly observed meteorological parameters.

Normal monthly precipitation is fairly uniform throughout the year at both stations with the larger amounts generally occurring in the fall and early winter months (90-148 mm per month) and the least amounts in the summer (97-112 mm per month). The annual average rainfall amount at Stillwater-Sherbrooke is 1,517 mm per year while at Halifax-Shearwater, it is 1,421 mm per year. Record 24-hour rainfall amounts of 142.6 mm and 184.9 mm have been recorded at Stillwater-Sherbrooke and Halifax-Shearwater, respectively. The average annual snowfall amounts at Stillwater-Sherbrooke and Halifax-Shearwater are 172.1 cm and 176.4 cm per year, respectively. Specific precipitation data for the Goldboro Region itself is explored in more detail in Section 8.6.5 and Table 8.6-16, where some 20 months of monthly precipitation is documented for Sherbrooke, Deming, Collegeville, Goldboro and Salmon River, during the period from October 2001 through May 2003. Further details are also shown in Appendix 3 and Figure 8.6-2 (Section 8.6), which indicates the location of study rain gages and EC Climate Stations.

The range of temperatures at the site is rather large from winter to summer. Summers are relatively cool, for example, the warmest average daily maximum temperature recorded at either station from June to August was 24 ^{o}C. The record high temperature at Stillwater-Sherbrooke is 35^{o}C in the month of June and is 33.3^{o}C at Halifax-Shearwater occurring in July and September. The average daily maximum temperature at Stillwater-Sherbrooke for July and at Halifax-Shearwater for August is 24^{o}C and 22.4^{o}C, respectively. Winters are cold with average daily minimum temperatures in January at Stillwater-Sherbrooke and Halifax-Shearwater of -11.0^{o}C and -9.2^{o}C, respectively. The lowest recorded temperature at Stillwater-Sherbrooke is -39^{o}C and at Halifax-Shearwater, it is -26.5^{o}C.

Winds at Halifax-Shearwater are fairly light with the highest speeds occurring in the winter with an average of 17.8 km/h for those months. A peak gust of 150 km/h was recorded in December 1956. The lightest winds occur in summer with a monthly average wind speed of 11.1 km/h in August. The mean wind speed for the year is 15.1 km/h. The prevailing wind direction at Halifax-Shearwater is from the south or southwest from May through September and from the west or northwest from October through April. There are no wind data available from Stillwater-Sherbrooke.

TABLE 8.4-1 Stillwater-Sherbrooke Climate Normals (1971-2000) and Extremes (1967-2001) (EC, 2005b)

Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Average (°C)	-6	-5.7	-1.2	4	9.2	14.4	18.3	18.4	14.3	8.8	3.8	-2.2
Daily Maximum (°C)	-0.9	-0.5	3.6	8.4	14.6	20.3	24	23.9	19.8	13.9	7.8	2.2
Daily Minimum (°C)	-11	-10.8	-6	-0.5	3.8	8.5	12.7	12.9	8.7	3.7	-0.3	-6.5
Extreme Maximum (°C)	17.5	14.5	25.5	23.3	32	35	34	32.5	32.2	26.7	18.5	15.5
Date (yyyy/dd)	1995/16	1981/23	1998/31	1973/18	1992/22	1976/24	1999/18	1991/14	1969/01	1968/02	1983/05	1998/01
Extreme Minimum (°C)	-31	-39	-29	-12.5	-6.1	-2.2	3.5	1.7	-3	-7	-15.5	-32.5
Date (yyyy/dd)	1993/31	1985/07	1985/07	1986/05	1972/14	1969/01	1993/18	1968/20	2000/30	1993/11	1989/25	1989/29
Precipitation												
Rainfall (mm)	94.5	72.9	97.9	102.1	126.1	112.5	97.1	109.9	122.9	141.5	149	118.9
Snowfall (cm)	42.6	41.8	29.2	14.2	0.5	0	0	0	0	0	9.1	34.7
Precipitation (mm)	137	114.7	127.1	116.2	126.6	112.5	97.1	109.9	122.9	141.5	158.1	153.6
Extreme Daily Precipitation (mm)	96	71.2	80	85	105.9	78.7	75	134.8	142.6	81.3	89.6	114.3
Date (yyyy/dd)	1990/26	1988/16	1972/23	1982/28	1972/16	1970/27	1983/22	1990/01	1996/14	1967/10	1983/16	1975/10
Days with												
Maximum Temperature > 0 °C	14	14.3	24.5	29.5	31	30	31	31	30	31	28.8	20.9
Measurable Rainfall	6.2	5.4	7.2	9.4	11	9.9	8.5	8	9	10.9	11.4	8.4
Measurable Snowfall	7.3	6.7	4.3	2.3	0.15	0	0	0	0	0.08	2.2	5.7
Measurable Precipitation	11.6	10.5	10.2	10.9	11	9.9	8.5	8	9	10.9	12.4	12.4

TABLE 8.4-2 Halifax Shearwater Climate Normals (1971-2000) and Extremes (1944-201) (EC, 2005b)

Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average (°C)	-4.7	-4.5	-0.8	4.2	9.2	14.2	17.8	18.2	14.7	9.1	4.2	-1.6	6.7
Daily Maximum (°C)	-0.2	-0.2	3.2	8.1	13.6	18.7	22.1	22.4	18.9	13.1	7.8	2.6	10.9
Daily Minimum (°C)	-9.2	-8.8	-4.8	0.2	4.7	9.6	13.5	14	10.4	5.1	0.5	-5.7	2.5
Extreme Maximum (°C)	14.3	16.2	21.8	27.8	32	33	33.3	32.4	33.3	27.8	22.2	15.6	
Date (yyyy/dd)	1995/16	1994/20	1998/31	1945/11	1977/23+	1983/23	1963/26	1995/01	1945/08	1946/06	1956/01	1957/10	
Extreme Minimum (°C)	-26.5	-25.7	-22.2	-12.2	-3.3	2	6.7	5.6	-0.5	-5.6	-11.4	-23.5	
Date (yyyy/dd)	1994/26	1993/07	1948/06	1946/01	1945/03	1982/12	1946/04	1965/31	1980/29	1974/22	1978/27	1989/29	
Precipitation													
Rainfall (mm)	95.5	69.3	97.2	97.9	110.8	107.8	107.4	96.9	100.1	124.9	129	117.6	1254.3
Snowfall (cm)	43	40.3	30.9	15.6	2.3	0	0	0	0	1.6	9	33.6	176.4
Precipitation (mm)	134.7	107.4	127.3	114.3	113.5	107.8	107.4	96.9	100.1	126.6	137.1	148.3	1421.4
Extreme Daily Precipitation (mm)	78.2	87.9	70.4	96.9	91.4	80	131.6	184.9	90.8	78.2	70	111.3	
Date (yyyy/dd)	1958/16	1958/08	1972/23	1982/28	1947/01	1944/21	1954/20	1971/15	1996/02	1967/10	1991/11	1946/21	
Wind Speed													
Speed (km/h)	18.1	17.7	17.8	16.9	14	12.8	11.3	11.1	12.8	14.8	16.5	17.7	15.1
Most Frequent Direction	W	NW	NW	N	S	S	S	SW	SW	W	NW	W	W
Maximum Hourly Speed	83	97	78	85	72	77	87	60	97	80	89	89	
Date (yyyy/dd)	1990/30	1963/20	1986/07	1962/13	1961/20	1964/12	1975/28	1956/08	1954/11+	1962/07	1958/29	1956/30+	
Maximum Gust Speed	127	146	148	122	106	111	114	93	126	132	121	150	
Date (yyyy/dd)	1960/03	1976/02	1976/17	1962/13	1961/03	1964/12	1975/28	1986/09	1958/29	1963/29	1963/08	1956/30	
Direction of Maximum Gust	S	S	SW	NE	W	NW	S	SW	N	S	NE	SW	SW

Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Days with													
Maximum Temperature > 0 °C	15.9	14	24.2	29.7	31	30	31	31	30	31	28.7	22.1	318.5
Measurable Rainfall	9.2	7	10	12.7	14.5	13.1	12.2	10.8	11.8	12.6	13.3	11.5	138.6
Measurable Snowfall	11.3	9.7	8.1	4.5	0.5	0	0	0	0	0.3	2.7	8.8	45.9
Measurable Precipitation	16.7	13.4	14.7	14.5	14.7	13.1	12.2	10.8	11.8	12.6	14.7	16.5	165.7
Other													
Sunshine Hours	111.7	127.5	143.1	155.4	195.9	221	227.8	229.6	181.9	157.2	113.3	100	1964.6
Daytime Relative Humidity (%)	76.3	73.4	72.7	69.3	69.8	69.5	71.2	69.5	66.8	67.7	72.3	76.6	71.2

8.4.2 Description of Existing Ambient Air Quality

The specific air contaminants that are of most interest relative to the impact of the Keltic facility operations consist of the following:

- sulphur dioxide (SO_2), formed when fuel containing sulphur, such as coal and oil, is burned, and when gasoline is extracted from oil, or metals are extracted from ore;
- NO_x, generated when fuel is burned at high temperatures as in a combustion process;
- CO, formed from the incomplete combustion of carbon-containing fuel;
- total suspended particulates (TSP), PM with aerodynamic diameter less than a nominal 10 micrometers (PM_{10}) and less than 2.5 micrometers ($PM_{2.5}$), terms for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets; and
- Volatile Organic Compounds (VOCs).

According to a 2003 emissions inventory reported by EC, the only other significant source of air contaminants emissions within 25 km of the Keltic Site is the SOEP gas plant and metering station that is adjacent to the Keltic Site. As a result of the lack of industry in the Project area, the only available background air quality data consist of short-term monitoring data collected by ExxonMobil at their Goldboro Gas Plant as that facility is the primary contributor to ambient concentrations of most air contaminants in the area. Background ozone concentrations are primarily the result of long range transport of ozone and its precursors (i.e., NO_x and VOC) from upwind regions, primarily from the south and west.

Continuous monitoring for nitrogen dioxide (NO_2) and SO_2 near the Goldboro plant was conducted in Seal Harbour from June 10, 2004, through August 10, 2004. There are no other longer term background air quality data available that are representative of this area. The highest monitored 24-hour NO_2 concentration during this 2 month period was approximately 2.0 parts per billion (ppb) and the highest SO_2 value was 4.0 ppb. Monitoring for TSP and $PM_{2.5}$ at Seal Harbour was conducted for three 24-hour periods in each of July, August, and September of 2004. The highest monitored 24-hour TSP concentration during this 3 month period was 19.8 micrograms per m^3 ($\mu g/m^3$) and the highest $PM_{2.5}$ value was 4.0 $\mu g/m^3$.

8.5 AMBIENT NOISE AND LIGHT LEVELS

8.5.1 Noise

The general locale of the proposed facility is semi-rural in nature. However, its actual location is in an industrial park which is currently the site of the SOEI Gas Plant (Figure 1.1-1).

In September 2004, noise monitoring was conducted in the vicinity the SOEI gas plant at four locations (northeast, southeast, southwest, and northwest corners) within the property bounds. The monitoring was conducted over a period of 24 hours (Sept.15-16, 2004), with measurements being taken once per minute in decibals (dBA). Given the limited noise sources in the area, this sample can be considered representative of typical noise levels in the area of the Project. The results are reported as Leq. Leq is the level of a constant sound which, in a given situation and time period, has the same sound energy as does a time-varying sound. Technically, equivalent sound level is the level of the time-weighted, mean square, A-weighted sound pressure. Typical noise guidelines are usually related to time of day, since noise impacts are generally perceived as being of the nuisance variety in terms of human activity, which also varies by time of day. The results of this monitoring are summarized in Table 8.5-1 below.

TABLE 8.5-1 Hourly Leq Range (dBA) SOE Gas Plant, Sept. 15-16, 2004

Time Period	Leq Range	Guideline Value*
14:00-18:00	45.5-63.7	65
18:00-23:00	38.6-54.8	60
23:00-07:00	38.5-52.7	55
07:00-14:00	39.1-61.4	65

The 'Guideline Values' are the criteria established by the Nova Scotia Department of the Environment in 1991, and are intended to reflect the effect that noise has on man. The Guideline states that "Noise legislation should be designed primarily to protect public health and within reasonable economic restraints provide a quiet and restful environment in which to live, work and play."

The context for noise assessment may be assisted by an understanding of typical noise levels for a variety of scenarios/activities. These are exemplified in Table 8.5-2 below.

TABLE 8.5-2 Typical Noise Values (dBA)

Sound Level (dBA)	Descriptor
0-25	Threshold for Normal Hearing
10	Normal Breathing
40 (generally lower limit of ambient sound)	Quiet Office, Quiet Residential Street
50	Rainfall
50-60	Typical Office
60-95	Typical Household Appliances
80-120	Typical Construction Equipment
110	Jet Takeoff

8.5.2 Lighting

8.5.2.1 Socio-economic

The Project site has virtually no artificial lighting sources. The surrounding community has artificial lighting sources consistent with those found in sparsely populated rural communities. Existing ambient light levels were not monitored; however, as with noise levels, they would be typical of a semi-rural environment, with some slight impacts from the flare stack at the SOEI Gas Plant.

8.5.2.2 Migratory Birds

There are several generalities with regard to migratory bird mortality and lighted structures, including lights on high towers to ground level window lights. Most birds migrate at night and for unknown reasons are attracted to light, especially red light. Birds of all taxa, including waterfowl, are susceptible to mortality from collision with lighted objects.

8.6 SURFACE WATER

The Keltic Project will touch on three watersheds and their sub-watersheds. The Project components and sub-watershed identities based on Nova Scotia Department of the Environment (1980) designation are given in the project-watershed matrix in Table 8.6-1. The watershed locations are shown in Figure 8.6-1.

8.6.1 Water Uses and Users

Figure 8.6-1 shows the locations of water bodies on and near the Keltic plant site. Table 8.6-2 presents a summary of basic known and assumed water uses for these water bodies.

In addition to the natural water bodies listed in Table 8.6-2, within the marginal wharf area, the second pond south of the lane way to the existing home on the peninsula is a dug pond used for cattle.

TABLE 8.6-1 Project-watershed Matrix

Watershed	Sub-Watershed		Project Component			NTS Map Sheet
	NSEL Designation	Major Watercourse or Water Body	Plant Site	Water Supply	Off Site	
coastal	1EP-SD1	none	x			11F/4
	1EQ-SD31	Gold Brook	x	x[1]		11F/4
	1EQ-SD32	none	x			11F/4
Isaac's Harbour River	1EP-1A	Meadow Lake		x		11F/4
	1EP-1B	tributary to Meadow Lake		x		11F/4
	1EP-1C	tributary to Isaac's Harbour River		x		11F/5
	1EP-1D	Garry River		x		11F/5
	1EP-1E	Costley Lake, Isaac's Harbour River		x		11F/4,5
New Hbr. River	1EQ-4H	Ocean Lake		x[1]	x	11F/4
	1EQ-4J	New Harbour River			x	11F/4

Note: 1 – potential back up/contingency water supply only.

8.6.2 Water Quality Methods

As part of the aquatic-biology surveys completed in the Keltic Study Area during 2001, 2004, and 2005, evaluation of selected water-quality parameters was undertaken. In 2001, surveys were confined to Gold Brook Lake, Seal Harbour Lake, and Meadow Lake, along with the major tributaries to these lakes. In the spring and summer of 2004, water-quality surveys were expanded to include Ocean Lake and New Harbour River. In 2005, key aquatic features were again surveyed.

FIGURE 8.6-1 Keltic Study Area Watersheds

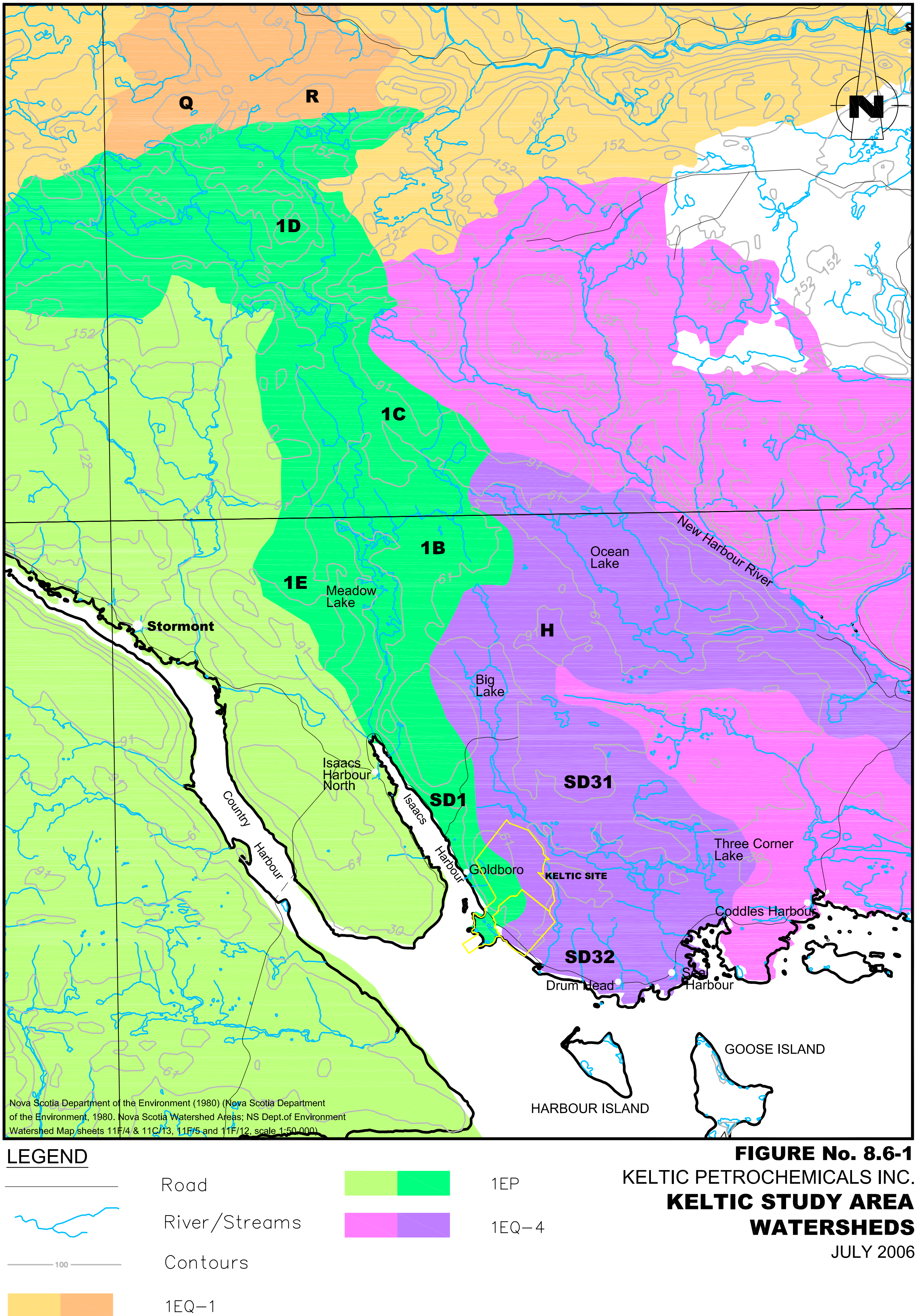


FIGURE No. 8.6-1

KELTIC PETROCHEMICALS INC.

KELTIC STUDY AREA WATERSHEDS

JULY 2006

TABLE 8.6-2 Known, Assumed, and Possible Water Uses in the Keltic Study Area

Water Body	Past Uses						Current Uses					
	Commercial Fishing	Recreational Fishing	Other Recreation	Mining	Drinking Supply	Industrial (Other)	Commercial Fishing	Recreational Fishing	Other Recreation	Mining	Drinking Supply	Industrial (Other)
Ocean Lake		x	x					x	x			
Meadow Lake		x				x		x				
Gold Brook lake		x	x	x		x		x	x			x
New Harbour River		x	x					x	x			
Seal Harbour Lake		x		x		x		x				
Isaac's Harbour River		x		x		x		x				
Gold Brook		x		x		x		x				
Dung Cove		x		x				x				
Red Head Ponds												
Crusher Brook				x		x						
Betty's Cove Brook		x						x				
Unnamed tributary to Dung Cove				x		x						

Note: Industrial (other) implies use for logging or as energy to run small mills.

Basic water-quality parameters measured during these surveys included temperature, dissolved oxygen (DO), pH, conductivity, and salinity where applicable. All parameters were determined with the use of a Yellow Springs Instrument 650 Multi Parameter Display System. This metre was calibrated daily with the use of standard and accepted methods. Additionally, samples were collected for lab analysis for general chemistry, dissolved metals, and some for mercury, using the following protocol:

- General chemistry samples collected in 200 millilitre (ml) polyethylene bottles with no preservatives.
- Dissolved metals samples field filtered to 0.45 micrometre (µm) using millipore Luer-Lok filters attached to a new (sterile) 60 ml syringe for each water sample. Raw water was used to rinse the syringe twice before attaching the filter. Filtered samples were placed into 50 ml polyethylene bottles, to which nitric acid was added for sample preservation.
- Mercury samples were collected by syringe and then transferred into 100 ml amber glass bottles with Teflon-lined cap; potassium dichromate in nitric acid was added as a preservative before sample collection. Each bottle was filled to zero head space but not allowed to overflow so as to not lose preservative.

Samples were stored in coolers with ice pack immediately until delivery to Maxxam Analytics Inc. in Bedford, Nova Scotia. Maximum sample storage time was seven days. Samples were analyzed using the lab protocol summarized in Table 8.7-3 located in Section 8.7.2.

8.6.3 Water Quality in Study Area Lakes, Rivers and Ponds – Offsite

A summary of basic field water-quality parameters measured during the biological surveys in the Keltic Study Area is presented in Table 8.6-3 and Table 8.6-4. A summary of the lab analytical results for water samples collected from these is presented in Table 8.6-5. The local watersheds and water sample collection locations are shown in Figure 8.6-2.

8.6.3.1 Meadow Lake

Meadow Lake is the largest body of water in the Isaac's Harbour River - Meadow Lake watershed. This lake is relatively shallow, with a maximum depth of about 2 m. Dissolved oxygen levels were within normal ranges during all surveys. Conductivity is low because of the nature of the geology associated with this watershed. Humic substances concentrations are elevated, as are total organic carbon, colour, and aluminum, which may be present as an organic chelate. Aluminum values exceeded the CCME guideline in all samples.

Copper and lead were found present above CCME guideline values in only one water sample collected in March 2002. This result may represent an anomalous event or a sampling error. Iron and manganese are both present in varying concentrations, sometime exceeding both, the CCME aquatic habitat and drinking water guidelines.

TABLE 8.6-3 Surface Water Quality - Offsite

Aquatic System	Location	Survey	Temperature (°C)	Conductivity	Dissolved Oxygen (mg/L)	pH
Meadow Lake	Northeast Inlet 0603321 E 5011240 N	Spring, 2004	13.8	26.3	11.03	4.2
Meadow Lake	Northwest Inlet 0603301 E 5011301 N	Spring, 2004	11.7	35.3	12.25	3.4
Meadow Lake	East Branch Tributary Inlet 0604555 E 5010807 N	Spring, 2004	14.3	33.8	9.68	4.14
Meadow Lake	Western Shore 0604228 E 5009951 N	Spring, 2004	15.6	-	9.95	4.19
Meadow Lake	Centre of South Bay 0604284 E 5009138 N	Spring, 2004	16.9	33.1	9.53	4.24
Meadow Lake	Outlet 0604284 E 5008371 N	Spring, 2004	18.9	32.8	8.57	4.96
Gold Brook Lake	Centre of Lake 0606799 E 5007492 N	Spring, 2004	15.6	35.2	9.9	4.79
Gold Brook Lake	Western Inlet 0606330 E 5007538 N	Spring, 2004	18.6	37.4	7.93	4.61
		Spring, 2005	11.04	34.0	9.32	4.70
Gold Brook Lake	Northern Inlet 0606926 E 5007853 N	Spring, 2004	17.8	35.0	9.70	4.38
		Spring, 2005	16.45	28.0	9.76	5.18
Gold Brook Lake	Eastern Inlet 0607371 E 5007447 N	Spring, 5.182005	16.29	28.0	9.37	5.32
Gold Brook Lake	Eastern Shore 0607150 E 5006562 N	Spring, 2004	18.8	33.9	8.88	4.62
Gold Brook Lake	Outlet 0607042 E 5006358 N	Spring, 2005	17.5	28.0	9.08	5

Aquatic System	Location	Survey	Temperature (°C)	Conductivity	Dissolved Oxygen (mg/L)	pH
Gold Brook Lake	Northern Shore 0606932 E 5008080 N	Spring, 2005	16.83	28.0	9.53	5.06
Ocean Lake	Northern Inlet 0608363 E 5011123 N	Spring, 2004	15.4	32.0	11.15	3.78
		Spring, 2005	15.08	25.0	10.17	5.17
Ocean Lake	Outlet 0609964 E 5011237 N	Spring, 2004	13.2	24.9	13.2	3.89
		Spring, 2005	19.13	26.0	10.14	5.24
Ocean Lake	Western Shore 0609391 E 5010069 N	Spring, 2005	16.83	25.0	10.22	5.43
Ocean Lake	Western Inlet 0609814 E 5009289 N	Spring, 2004	14.7	26.7	12.62	3.77
		Spring, 2005	19.76	26.0	11.02	5.02
Ocean Lake	Eastern Shore 0611900 E 5009529 N	Spring, 2005	16.92	25.0	10.3	5.51
Ocean Lake	Southern Inlet 0611667 E 5008045 N	Spring, 2004	16.8	30.0	11.55	4.04
		Spring, 2005	14.02	35.0	9.80	4.74
Ocean Lake	Centre of Lake 0610095 E 5009338 N	Spring, 2004	13.4	25.5	12.34	3.89
			13.6	23.7	11.15	3.95
Ocean Lake	Centre of Southeast Cove 0611207 E 5008045 N	Spring, 2004	16.7	27.0	10.83	4.22
		Spring, 2005	16.78	24.0	9.95	5.51
New Harbour River	0611636 E 5011299 N	Spring, 2004	13.7	-	9.76	5.01
New Harbour River	0610894 E 5011717 N	Summer 2004	20.2	60.0	9.08	4.8

TABLE 8.6-4 Water-Chemistry Profile of Ocean Lake, Spring 2005

Depth (m)	Temperature (ºC)	Conductivity (µS/cm)	DO (mg/L)	pH
1	15.08	25.0	10.18	5.42
2	15.22	25.0	10.13	5.43
3	15.14	25.0	10.12	5.39
4	15.12	25.0	10.13	5.41
5	14.98	25.0	10.13	5.38
6	14.73	25.0	10.14	5.36
7	14.54	25.0	10.14	5.34
8	11.12	25.0	10.97	5.45
9	10.28	25.0	11.02	5.43
10	10.08	25.0	11.02	5.42
11	9.81	25.0	10.89	5.40
12	9.65	25.0	10.86	5.38
13	9.55	25.0	10.82	5.39
14	9.53	25.0	10.81	5.38
15	8.48	25.0	10.80	5.37
16	9.46	25.0	10.78	5.36

* microsiemens (µS)

TABLE 8.6-5 Lab Analysis Results for Off Site Water Samples

TABLE 8.6-5 Lab Analysis Results for Off Site Water Samples

Description	Units	CCME Guidelines Values (2003)				Gold Brook at Station GB1					Gold Brook at station GB2					Gold Brook at GB3		Issacs Harbour River at ML1					Ocean Lake	New Hbr. River	Detection Limit
		Drinking Water		Aquatic Life		30-Sep-01	09-Nov-01	11-Mar-02	28-Jun-02	19-Oct-02	30-Sep-01	09-Nov-01	11-Mar-02	28-Jun-02	19-Oct-02	30-Sep-01	09-Nov-01	30-Sep-01	09-Nov-01	11-Mar-02	28-Jun-02	19-Oct-02	31-May-04	31-May-04	
Sample ID/paramete		MAC/IMAC	AO	Fresh	Marine	058B01-GB1-1	058B01-GB1-2	058B01-GB1-3	058B01-GB1-2806	058B01-GB1-191002	058B01-GB2-1	058B01-GB2-2	058B01-GB2-3	058B01-GB2-2806	058B01-GB2-191002	058B01-GB3-1	058B01-GB3-2	058B01-ML1	058B01-ML1-2	058B01-ML1-3	058B01-ML1-2806	058B01-ML1-191002	058D01-OL1	058D01-NHR1	
Humic Substances Sub	mg/L					38	56		35		24	27		28		24	30	51	30		23				1
Tannin & Lignin	mg/L					3.8	8.3				1.8	2.5				2.2	3.4	3.7	3						0.1
Sodium (Na)	mg/L	200				4.1	4.9	3.5	4.4	3.9	3.2	3.6	3.8	3.2	3.5	3.9	5	3.3	3.7	3.2	3.2	3.3	3.3	3.3	0.1
Potassium (K)	mg/L					0.5	0.5	0.3	ND	0.4	0.3	0.4	0.4	ND	0.3	0.7	0.7	0.6	0.4	0.4	0.3	0.3	0.3	0.2	0.1
Calcium (Ca)	mg/L					2.4	1.2	0.5	0.6	1	0.6	0.7	0.7	0.9	0.8	1.2	1.7	0.7	0.7	0.7	0.8	1.1	0.5	0.5	0.1
Magnesium (Mg)	mg/L					0.8	0.9	0.4	0.4	0.6	0.4	0.6	0.5	0.4	0.5	0.6	0.8	0.7	0.6	0.4	0.3	0.5	0.4	0.4	0.1
Alkalinity (as CaCO3)	mg/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
Sulphate (SO4)	mg/L	500				21	ND	10	18	14	12	2	10	10	9	14	3	19	2	6	7	8	ND	2	2
Chloride (Cl)	mg/L	250				5.6	6.4	6	5	6	4.8	4.9	6	4	6	5.8	7.7	4.7	5.4	5	4	6	4	5	1
Reactive Silica (SiO2)	mg/L					4.6	6.1	2.5	3.4	3.6	1.3	2	2.4	1.4	2.5	2	4.8	2.7	3.3	2.4	0.8	2.5	0.9	ND	0.5
Orthophosphate (P)	mg/L					0.02	ND	ND	0.02	0.03	0.01	0.02	ND	0.01	0.01	0.03	ND	0.02	ND	ND	0.01	ND	ND	ND	0.01
Phosphorus (P)	mg/L					0.1	ND	ND	ND	0.1	ND	ND	0.1	0.1	0.1	ND	ND	ND	ND	ND	0.1	ND	ND	ND	0.2
Nitrate + Nitrite	mg/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05
Nitrate (N)	mg/L	45				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05
Nitrite (N)	mg/L	3.2		0.06		ND	ND	ND	0.01	ND	ND	ND	ND	ND	0.02	ND	ND	ND	ND	ND	ND	0.01	ND	ND	0.01
Nitrogen (Ammonia Nitrogen)	mg/L			1.37 – 2.20		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05
Total Organic Carbon (C)	mg/L					12.5	21.5	7.9	11	19.7	6.5	7.4	8.6	5.8	12.6	8.1	9.4	15.6	8.2	5.2	5.3	11.8	2.2	2.1	0.5
Colour	TCU		15			71	140	39	120	140	34	58	41	66	100	47	100	68	49	25	54	82	17	16	5
pH	pH		6.5 – 8.5	6.5-9.0	7.0-8.7	5.2	4.5	4.4	4.9	4.5	5.4	5	4.5	5.1	4.9	5.6	5.6	4.7	5.1	4.7	5.1	4.8	6.6	5.4	N/A
Turbidity	NTU	1	5			0.5	0.6	ND	0.4	0.3	0.8	0.7	ND	0.7	0.6	1.1	0.9	0.6	2.1	ND	1.2	0.5	1.2	0.2	0.1
CoNDuctivity	uS/cm					34	50	42	33	44	26	31	43	27	33	32	42	33	36	33	26	32	25	26	1
Calculated TDS	mg/L		500			42	23	26	36	33	26	15	27	23	26	32	25	34	17	21	20	25	15	15	1
Hardness (CaCO3)	mg/L					9.3	6.7	2.9	3.1	5	3.1	4.2	3.8	3.9	4.1	5.5	7.5	4.6	4.2	3.4	3.2	4.8	2.9	2.9	N/A
Bicarb. Alkalinity (calc. as CaCO3)	mg/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	ND	ND	ND	ND	ND	ND	ND	1
Carb. Alkalinity (calc. as CaCO3)	mg/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Cation Sum	me/L					0.39	0.4	0.26	0.28	0.31	0.22	0.26	0.29	0.23	0.26	0.3	0.39	0.27	0.27	0.24	0.22	0.27	0.21	0.21	N/A
Anion Sum	me/L					0.69	0.25	0.48	0.62	0.56	0.49	0.2	0.48	0.42	0.46	0.57	0.32	0.61	0.22	0.37	0.36	0.44	0.26	0.29	N/A
Ion Balance (% Difference)	%					28.4	23.3	29.6	37.2	28.4	38.4	13.1	25.3	29	28.3	30.9	9.66	38	10.2	21.1	23.8	24.4	9.57	14.4	N/A
Langelier INDex (@ 20C)	N/A					-5.54	-7.24	-6.72	-6.22	-6.62	-5.72	-6.81	-6.62	-6.02	-6.22	-5.44	-5.68	-6.42	-6.71	-6.41	-6.01	-6.28	-4.51	-5.71	N/A
Langelier INDex (@ 4C)	N/A					-5.14	-6.84	-6.32	-5.82	-6.22	-5.32	-6.41	-6.22	-5.62	-5.82	-5.04	-5.28	-6.02	-6.31	-6.01	-5.61	-5.88	-4.11	-5.31	N/A
Saturation pH (@ 20C)	N/A					10.7	11.7	11.1	11.1	11.1	11.1	11.8	11.1	11.1	11.1	11	11.3	11.1	11.8	11.1	11.1	11.1	11.1	11.1	N/A
Saturation pH (@ 4C)	N/A					10.3	11.3	10.7	10.7	10.7	10.7	11.4	10.7	10.7	10.7	10.6	10.9	10.7	11.4	10.7	10.7	10.7	10.7	10.7	N/A
Aluminum (Al)	ug/L			5 – 100		270	470	150	270	410	200	210	200	210	350	170	210	400	210	160	180	290	130	100	10
Antimony (Sb)	ug/L	6				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Arsenic (As)	ug/L	25		5	12.5	ND	ND	ND	ND	ND	11	5	3	38	12	270	150	2	ND	2	2	2	ND	ND	2
Barium (Ba)	ug/L	1000				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
Beryllium (Be)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Bismuth (Bi)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Boron (B)	ug/L	5000				5	5	ND	ND	6	ND	ND	ND	ND	5	ND	5	ND	ND	ND	ND	ND	ND	ND	5
Cadmium (Cd)	ug/L	5		0.017	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3
Chromium (Cr)	ug/L	50		1	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Cobalt (Co)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Copper (Cu)	ug/L	1000		2 – 4		ND	ND	ND	ND	ND	ND	ND	10	ND	ND	ND	ND	ND	ND	140	ND	ND	ND	ND	2
Iron (Fe)	ug/L		300	300		320	550	150	350	520	180	210	210	270	340	460	400	420	260	150	230	310	160	70	50
Lead (Pb)	ug/L	10		1 – 7		0.5	1	ND	0.7	0.9	ND	ND	0.7	0.7	0.6	ND	ND	ND	ND	1.1	ND	ND	ND	ND	0.5
Manganese (Mn)	ug/L		50			13	15	11	7	11	18	18	25	17	19	33	27	51	30	53	29	26	24	15	2
Molybdenum (Mo)	ug/L			73		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Nickel (Ni)	ug/L			25 – 150		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Selenium (Se)	ug/L	10		1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Silver (Ag)	ug/L			0.1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5
Strontium (Sr)	ug/L					10	13	5	6	9	6	7	7	6	7	8	11	8	8	5	5	7	5	6	5
Thallium (Tl)	ug/L			0.8		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1
Tin (Sn)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	40	ND	ND	ND	ND	2
Titanium (Ti)	ug/L					3	6	ND	3	4	2	3	2	2	2	2	3	3	3	2	2	2	2	ND	2
Uranium (U)	ug/L	100				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1
Vanadium (V)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Zinc (Zn)	ug/L		5000	30		10	6	3	6	11	4	5	43	12	22	5	6	6	7	16	4	13	ND	ND	5

ND = Not detected

CCME – assumes lowest values (i.e. haxavalent chromium vs. trivalent, etc)

Values that exceed one CCME guideline value or another (guideline may or may not be applicable to water use) are shaded.

CCME MAC = maximum allowable concentration, IMAC = interim MAC, AO = aesthetic objective

FIGURE 8.6-2 Location of the Study Rain Gauges and Environment Canada Climate Stations

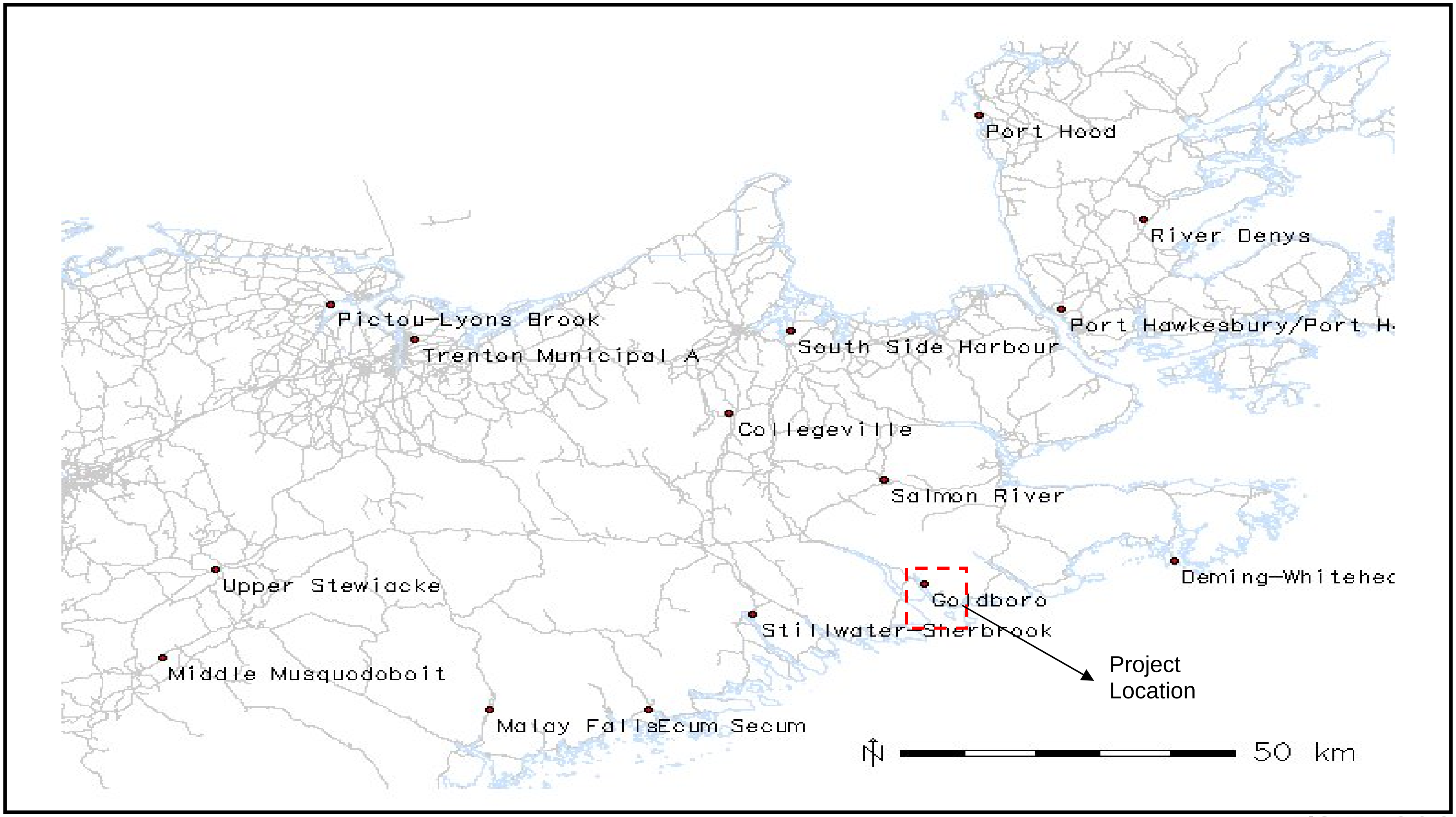


FIGURE 8.6-2
KELTIC PETROCHEMICALS INC.
LOCATION OF THE STUDY OF RAIN GAUGES AND ENVIRONMENT CANADA CLIMATE STATIONS
JULY 2006
Source: ewC (2005)

The most noteworthy results from the water-quality survey in this lake are the low field-measured pH values, which ranged from 3.4 to 4.96 during the 2004 surveys. The lab-measured pH values were slightly higher, ranging between 4.7 and 5.1, but it is normal for pH values in the lab to differ from those taken in the field. The field-measured values are considered to be more representative of lake conditions.

The low pH levels are likely the result of the combination of acidic precipitation and the low alkalinity of study-area waters due to the underlying bedrock geology. The significance of this situation in Meadow Lake is that Atlantic salmon cannot spawn successfully in waters with such low pH levels. Reproduction begins to fail at a pH of 5.4 and reproduction is impossible at a pH of 4.6 or below. The low pH levels in Meadow Lake is the likely explanation for the near absence of Atlantic salmon in the survey catches (see section 8.11).

Other noteworthy water quality results from this lake were the highly negative Langelier Index Values. Water from this lake should be considered to be very corrosive. This, in combination with high colour and elevated values of iron and manganese, are of particular concern as relates to the use of this lake as a water supply. However, these are not at all unusual when compared to other surface municipal and/or industrial water supplies in Nova Scotia, and corrective treatment is possible.

8.6.3.2 Gold Brook Lake

Dissolved oxygen levels during surveys of Goldbrook Lake were all within ranges considered normal. Like other study-area lakes, conductivity is low, as were field-measured levels of pH which ranged from 4.38 to 5.32.

Observations made on humic substances, aluminum and iron reported for Meadow Lake also apply to waters from the Gold Brook Lake and stream system. In particular, the increasing concentration of dissolved arsenic, iron, and sulphate in water samples progressively downstream in the system is noteworthy and likely as a result of past mining activity/tailings disposal into the system.

8.6.3.3 Ocean Lake

Concentrations of dissolved oxygen in Ocean Lake were all within normal ranges during both the 2004 and 2005 field investigations. Conductivity was low, reflecting the geology of the Keltic Study Area. The field-measured pH values were also low, ranging from 3.78 to 4.22 in 2004 and from 5.02 to 5.51 in 2005. The reason for the lower levels in 2004 is not known. A water-chemistry profile throughout the 16 m depth of Ocean Lake was determined during the spring of 2005 (Table 8.6-4). Water temperature dropped from 15.08ºC at the surface to 9.46ºC at 16 m, and there was a concurrent slight rise in dissolved oxygen from 10.18 to 10.78 mg/L. Conductivity and pH were relatively constant at all depths.

The values for colour and aluminum for Ocean Lake were elevated as appears to be the case for surface waters throughout the area.

8.6.3.4 New Harbour River

Dissolved oxygen concentrations in New Harbour River were within normal range during the surveys of 2004; conductivity was low; Levels of pH were also low (4.8 and 5.1 for field measurements, 5.4 for the lab analyses), although not at levels low enough to impair Atlantic salmon reproduction. Again, colour and aluminum were elevated.

8.6.4 Water Quality in Study Area Lakes, Rivers and Ponds – On-Site

A summary of water-quality results collected during the on-site biology surveys is presented in Table 8.6-6. A summary of the lab analytical results for water samples collected from these is presented in Table 8.6-7.

TABLE 8.6-6 Water-Chemistry in Red Head Ponds

Location	Survey	Temperature (°C)	Conductivity (µS/cm)	DO (mg/L)	pH	Salinity (ppt)
Pond 1	Spring, 2005 0606793 E 5002155 N	19.69	85.0	9.44	6.35	0.04
Pond 2	Spring, 2005 0606799 E 5002068 N	19.32	27.0	8.65	6.14	0.01
Pond 3	Spring, 2005 0606618 E 5001904 N	22.41	2326.0	9.05	7.50	1.20
Pond 4	Spring, 2005 0606814 E 5001577 N	16.59	38880.0	10.03	8.46	24.83
Pond 5	Spring, 2005 0606952 E 5001553 N	18.75	25120.0	9.34	7.43	15.32
Pond 6	Spring, 2005 0606932 E 5001957 N	14.93	75.0.	8.36	6.49	0.03

8.6.4.1 Red Head Ponds

Ponds 1, 2, and 6 are fresh-water, Pond 3 is slightly brackish, and Ponds 4 and 5 are saline. Pond 6 is the only one which has input from a freshwater stream.

All parameters in all ponds are within ranges considered normal although pH levels were higher than in other Keltic Study Area waters and were generally close to neutral. All ponds support at least one species of fish.

Crusher Brook, Betty's Cove Brook and Other Surface Samples

All parameters in Crusher Brook and Betty's Cove Brook are within normal ranges for the area with low values for pH and elevated levels of colour and aluminum. One notable exception to this is pH at Crusher Brook. It flows near old mine workings and appears to have been impacted by either mine dump material or subsurface mineralization. The water sample from Crusher Brook is the only surface water sample to demonstrate presence of any measurable alkalinity and thus, its pH is neutral.

Both Crusher Brook and Betty's Cove Brook originate at wet forested areas inside the proposed Keltic boundaries. Although the other "surface water" samples summarized in Table 8.6-7 are not "true" spring or stream samples, they are representative of these wet area sources – with general chemistries similar to that from the two streams.

8.6.5 Water Supply

The Keltic Facility will require approximately 1,200 m^3/hr of water to operate the proposed plants. Figure 8.6-3 shows the watersheds studied and the locations of the stream and rainfall gauging stations installed to define those watersheds in terms of their potential as potential sources of water. The key characteristics of the systems reviewed are shown in Table 8.6-8.

TABLE 8.6-8 Key Characteristics for Systems Reviewed

Watershed	Catchment Area (ha)	Total Estimated Water Available from Precipitation*	
		m^3/year	m^3/hr
Isaac's Harbour River at ML1	7,746.25	106,820,787	12,194
Gold Brook at GB1	125.75	1,734,092	198
Gold Brook at GB2	899.69	12,406,725	1,416
Gold Brook at GB3	1,608.00	22,174,320	2,531
Ocean Lake	1,636.00	22,560,440	2,575

* based on mean total 2002 annual precipitation of 1,379 mm for Collegeville, Deming and Sherbrooke climate stations

8.6.5.1 Description of the Watersheds Studied

Two watersheds were initially identified as potential water supply sources for the Keltic Project. One is the Gold Brook sub-watershed in which the proposed Keltic Site is located. The other is the Isaac's Harbour River watershed which is proposed to serve as the water supply for the Keltic Facility. The following sections describe the general physical characteristics and the surface water hydrology of these two watersheds.

TABLE 8.6-7 Lab Analysis Results for On-Site Water Samples Collected in April 2005

Description	Units	CCME Guidelines Values (2003)				Surface Water Samples					Stream Samples		Detection Limit
		Drinking Water		Aquatic Life		Snow Melt	Flowing Ditch	Stream-Snow Melt	Snow Melt	Flowing Ditch	Bettys Brook	Crusher Brook	
Sample ID/parameter		MAC/IMAC	AO	Fresh	Marine	102F01-4-1	102F01-4-2	102F01-4-3	102F01-4-4	102F01-4-5	102F01-4-5C	102F01-4-7C	
Sodium (Na)	mg/L	200				4.4	24	11	4.9	17	4.8	5.7	0.1
Potassium (K)	mg/L					0.5	0.8	0.7	0.4	0.4	0.4	0.5	0.1
Calcium (Ca)	mg/L					0.3	3.1	1.7	1.3	4.2	1.3	2.3	0.1
Magnesium (Mg)	mg/L					0.4	0.7	0.7	0.5	0.9	0.4	0.6	0.1
Alkalinity (as CaCO3)	mg/L					ND	ND	ND	ND	ND	ND	8.6	5
Sulphate (SO4)	mg/L	500				ND	ND	ND	ND	ND	15	ND	2
Chloride (Cl)	mg/L	250				6.6	38	18	7.3	29	6.3	7.8	1
Reactive Silica (SiO2)	mg/L					2.4	2.2	2.6	3.2	2	4.4	5.5	0.5
Orthophosphate (P)	mg/L					ND	ND	ND	ND	ND	ND	ND	0.01
Phosphorus (P)	mg/L					ND	ND	ND	ND	ND	ND	ND	0.2
Nitrate + Nitrite	mg/L					0.05	0.06	0.14	0.06	0.06	ND	0.06	0.05
Nitrate (N)	mg/L	45				0.05	0.06	0.14	0.06	0.06	ND	0.06	0.05
Nitrite (N)	mg/L	3.2		0.06		ND	ND	ND	ND	ND	ND	ND	0.01
Nitrogen (Ammonia Nitrogen)	mg/L			1.37 – 2.20		0.07	0.06	ND	ND	ND	ND	0.05	0.05
Total Organic Carbon (C)	mg/L					11	8.6	11	12	12	6.2	6.4	0.5
Colour	TCU		15			68	57	80	72	72	39	34	5
pH	pH		6.5 – 8.5	6.5-9.0	7.0-8.7	4.7	5.24	4.71	4.91	5.82	5.77	7.15	N/A
Turbidity	NTU	1	5			0.3	0.6	1.2	1.3	0.3	0.4	1.6	0.1
CoNDuctivity	uS/cm					41	140	76	42	120	36	57	1
Calculated TDS	mg/L		500			15.2	69.4	35.3	18.4	54.6	32.3	28	1
Hardness (CaCO3)	mg/L					2.4	11	7.3	5.6	14	5	8	N/A
Bicarb. Alkalinity (calc. as CaCO3)	mg/L					ND	ND	ND	ND	ND	ND	9	1
Carb. Alkalinity (calc. as CaCO3)	mg/L					ND	ND	ND	ND	ND	ND	ND	1
Cation Sum	me/L					0.289	1.28	0.65	0.363	1.05	0.324	0.433	N/A
Anion Sum	me/L					0.188	1.08	0.52	0.211	0.819	0.48	0.395	N/A
Ion Balance (% Difference)	%					21	8.41	11.1	26.4	12.2	19.5	4.53	N/A
Langelier INDex (@ 20C)	N/A					NC	NC	NC	NC	NC	NC	-2.87	N/A
Langelier INDex (@ 4C)	N/A					NC	NC	NC	NC	NC	NC	-3.12	N/A
Saturation pH (@ 20C)	N/A					NC	NC	NC	NC	NC	NC	10	N/A
Saturation pH (@ 4C)	N/A					NC	NC	NC	NC	NC	NC	10.3	N/A
Aluminum (Al)	ug/L			5 – 100		210	200	180	370	240	150	150	10
Antimony (Sb)	ug/L	6				ND	ND	ND	ND	ND	ND	ND	2
Arsenic (As)	ug/L	25		5.0	12.5	ND	ND	3	ND	8.8	ND	ND	2
Barium (Ba)	ug/L	1000				ND	10	ND	5.1	5.7	ND	ND	5
Beryllium (Be)	ug/L					ND	ND	ND	ND	ND	ND	ND	2
Bismuth (Bi)	ug/L					ND	ND	ND	ND	ND	ND	ND	2
Boron (B)	ug/L	5000				ND	ND	ND	ND	ND	ND	ND	5
Cadmium (Cd)	ug/L	5		0.017	0.12	ND	ND	ND	ND	ND	ND	ND	0.3
Chromium (Cr)	ug/L	50		1.0	1.5	ND	ND	ND	ND	ND	ND	ND	2
Cobalt (Co)	ug/L					ND	ND	ND	ND	2.6	ND	ND	1
Copper (Cu)	ug/L	1000		2 – 4		ND	ND	ND	ND	ND	ND	ND	2
Iron (Fe)	ug/L		300	300		300	150	190	370	420	100	230	50
Lead (Pb)	ug/L	10		1 – 7		ND	0.6	0.6	0.6	ND	ND	0.7	0.5
Manganese (Mn)	ug/L		50			9.8	38	52	6.3	520	8.7	16	2
Molybdenum (Mo)	ug/L			73		ND	ND	ND	ND	ND	ND	ND	2
Nickel (Ni)	ug/L			25 – 150		ND	ND	ND	ND	ND	ND	ND	2
Selenium (Se)	ug/L	10		1.0		ND	ND	ND	ND	ND	ND	ND	2
Silver (Ag)	ug/L			0.1		ND	ND	ND	ND	ND	ND	ND	0.5
Strontium (Sr)	ug/L					ND	17	12	5.2	29	8.1	14	5
Thallium (Tl)	ug/L			0.8		ND	ND	ND	ND	ND	ND	ND	0.1
Tin (Sn)	ug/L					ND	ND	ND	ND	ND	ND	ND	2
Titanium (Ti)	ug/L					2.6	2.4	ND	4.3	2	ND	ND	2
Uranium (U)	ug/L	100				ND	ND	ND	ND	ND	ND	ND	0.1
Vanadium (V)	ug/L					ND	ND	ND	ND	ND	ND	ND	2
Zinc (Zn)	ug/L		5000	30		ND	5.4	8.1	34	6.8	5.9	7.6	5

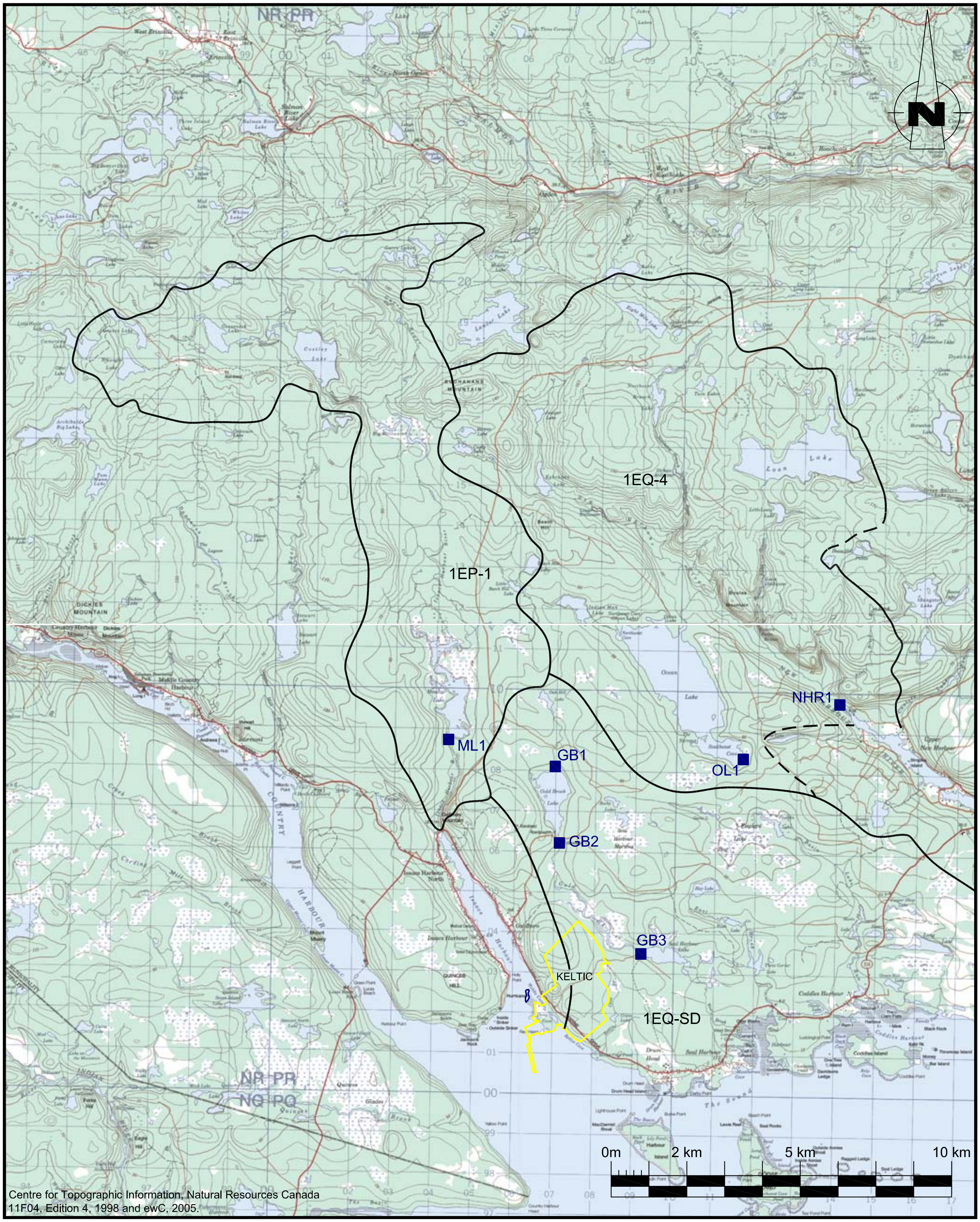
ND = Not detected

CCME – assumes lowest values (i.e. haxavalent chromium vs. trivalent, etc)

Values that exceed one CCME guideline value or another (guideline may or may not be applicable to water use) are shaded.

CCME MAC = maximum allowable concentration, IMAC = interim MAC, AO = aesthetic objective

FIGURE 8.6-3 Watersheds Studied



LEGEND

Project Location

GB1 Hydrometric Station Locations

FIGURE No. 8.6-3

KELTIC PETROCHEMICALS INC.

WATERHSEDS STUDIED

JULY 2006

8.6.5.2 Gold Brook System Watershed

Gold Brook sub watershed 1EQ-SD31 encompasses a surface area of approximately 3160 ha that includes Gold Brook Lake and its tributaries, Gold Brook, Seal Harbour Lake, and Hay Lake as its main water courses and water bodies. The proposed Keltic Site is located on the western edge at approximately the centre of this sub watershed. This sub watershed is essentially "linear" with first and second order streams in its upper reaches, but it is bifurcated in its lower reaches, such that below Seal Harbour Lake and Three Corner Lake, it discharges into the ocean at two locations. Seal Harbour Lake drains into the ocean via West Brook, whereas Three Corner Lake drains into the ocean via East Brook. Due to the environmental concerns at Seal Harbour Lake from past mining legacies, the only part of this sub-watershed which might be considered for use as possible water supply is that above the bottom of Gold Brook Lake (there are past mining environmental concerns there too). This section of the watershed above the Gold Brook- Gold Brook Road crossing (former Boston Richardson and more recently, Orex mine) encompasses a surface area of approximately 900 ha.

8.6.5.3 Isaac's Harbour River Watershed

The Isaac's Harbour River watershed is directly bordered to the southeast by the Gold Brook Lake sub watershed, to the east by the New Harbour watershed 1EQ-4 and to the north by Salmon River watershed 1EQ-1. It is shown by Nova Scotia Department of the Environment (1980) to have a total surface area of 7,724 ha extending down Isaac's Harbour River to Route 316. However, watershed delineations and calculations using geographic information system (GIS) show it to have a surface area of approximately 7746 ha extending down to the bottom of Meadow Lake at Isaac's Harbour River (excluding any lands which may contribute to the river between Meadow Lake and the ocean).

The watershed is dendritic in the upper reaches, including several second and third order streams, and contains more than a dozen lakes, wetlands, and tributaries. It is linear by comparison within its lower reach, and has a single point discharge to the ocean via Meadow Lake and the Isaac's Harbour River. Meadow Lake, which encompasses an area of roughly 104 ha and is located near the bottom of the watershed, is the largest lake present in the watershed. The second and third largest lakes are Costly Lake and Gooseneck Lake with areas of roughly 95 ha and 32 ha, respectively.

The M&NP crosses the lower eastern and western parts of the watershed. One major power line crosses the northwest part of the watershed, through the Forest Hill mine area.

8.6.5.4 Stream-Flow Data

The nearest two established hydrological stations on the Eastern Shore are on Little Sackville River in Middle Sackville, and on St. Mary's River at Stillwater. Due to different watershed size, precipitation, geology, and topography, data from neither of these two stations could be applied to the Isaac's Harbour River watershed. Therefore, rain gauges were installed in Goldboro and at Salmon River Lake and four hydrometric stations (GB1, GB2, GB3, and ML1) were installed at the locations shown in Figure 8.6-3. Data was collected for a period of 20 months from October 1, 2001 to May 23, 2003. A description of the data, corrections applied to it, station calibration and other details of the hydrologic assessment of the Isaac's Harbour River watershed and the Gold Brook sub-watershed are given in Appendix 3.

The stream-flow data collected from the study-area hydrometric stations is presented in Tables 8.6-9 to 8.6-14. The Isaac's Harbour River had a median annual (2002) total flow of 10,286 m^3/hr, (mean annual flow of 13,895 m^3/hr). However, given that the plant demand is 1,200 m^3/hr and minimum flows for several months are close to or below this requirement (see Table 8.6-12 - Minimum Flows for June to September 2002) the need for storage in order to fulfill this prerequisite is confirmed.

TABLE 8.6-9 Total 2002 Outflow (m^3) for ML1, GB1 and, GB2

ML1	GB1	GB2
118,752,483	3,712,699	23,098,767

TABLE 8.6-10 Statistics of 2002 Flow (in m^3/hour) for ML1, GB1, and GB2

Station	Mean	Mode	Minimum	25th Percentile	Median	75th Percentile	Maximum
ML1	13,895	11,033	156	3,262	10,286	20,176	79,755
GB1	424	196	37	187	279	490	10,445
GB2	2,637	1,139	216	1,177	2,136	3,258	10,850

TABLE 8.6-11 Monthly Summary Statistics of Flow Values for ML1, October 2001 to May 2003 (m^3/hr)

Month	Mean	Mode	Minimum	Median	Maximum
October 2001	2,038	295	233	1,285	12,075
November 2001	4,274	917	698	3,508	13,961
December 2001	11,445	10,189	1,597	10,078	34,043
January 2002	14,117	16,291	2,475	12,907	45,360
February 2002	16,550	3,679	2,651	18,455	54,126
March 2002	32,783	18,123	9,167	34,171	79,755
April 2002	27,282	20,736	8,401	23,348	64,959
May 2002	13,473	11,406	3,174	12,152	30,812
June 2002	1,353	552	156	1,027	4,582
July 2002	3,905	2,533	1,225	2,683	12,899
August 2002	5,297	1,027	705	1,601	34,357
September 2002	3,560	3,537	323	2,840	13,272
October 2002	11,588	5,575	2,461	9,540	36,783
November 2002	26,021	11,033	6,724	19,430	61,414
December 2002	16,572	7,868	5,443	15,511	37,529
January 2003	6,699	6,129	2,320	4,817	25,401
February 2003	20,274	5,575	4,817	17,004	56,562
March 2003	15,708	12,899	3,632	12,152	78,394
April 2003	20,746	5,575	3,352	10,846	65,705
May 2003	11,186	12,152	1,357	12,339	27,640

TABLE 8.6-12 Monthly Statistics of Flows for GB1October 2001 to May 2003 (m^3/hr)

Month	Mean	Mode	Minimum	Median	Maximum
October 2001	278	235	132	235	1,195
November 2001	383	302	246	315	913
December 2001	452	235	215	368	1,531
January 2002	528	235	215	441	2,238
February 2002	836	279	246	490	10,445
March 2002	638	279	37	382	5,887
April 2002	607	659	179	474	4,710
May 2002	362	215	187	302	790
June 2002	253	162	126	215	701
July 2002	261	196	106	225	618
August 2002	173	126	50	119	1,164
September 2002	179	50	43	126	723
October 2002	330	154	119	225	2,192
November 2002	640	279	162	382	4,867
December 2002	320	196	154	235	1,019
January 2003	239	179	95	162	1,226
February 2003	578	279	132	327	3,637
March 2003	560	196	89	246	6,839
April 2003	149	79	46	119	1,047
May 2003	111	65	22	106	279

TABLE 8.6-13 Monthly Statistics of Flows for GB2 October 2001 to May 2003 (m^3/hr)

Month	Mean	Mode	Minimum	Median	Maximum
October 2001	704	283	260	604	1,745
November 2001	1,009	566	530	943	1,769
December 2001	1,752	2,164	656	1,672	4,113
January 2002	2,168	2,000	740	1,895	5,427
February 2002	2,345	994	784	2,404	6,610
March 2002	5,161	6,873	1,488	5,033	10,324
April 2002	4,119	2,667	1,139	3,456	10,225
May 2002	2,119	1,625	617	1,895	4,770
June 2002	948	1,065	441	960	2,601
July 2002	2,167	2,277	861	2,164	3,488
August 2002	1,642	579	316	994	6,150
September 2002	1,261	316	216	1,083	3,423

Month	Mean	Mode	Minimum	Median	Maximum
October 2002	2,625	2,000	1,139	2,306	5,657
November 2002	4,609	1,973	1,555	3,390	10,850
December 2002	2,464	1,158	1,065	2,404	4,836
January 2003	1,128	1,236	484	994	3,225
February 2003	3,251	960	799	2,601	9,272
March 2003	2,004	894	670	1,745	11,507
April 2003	4,981	2,930	1,870	3,439	11,934
May 2003	3,283	3,488	815	3,521	5,789

TABLE 8.6-14 Monthly Statistics of Flows for GB3 October 2001 to March 2002 (m^3/hr)

Month	Mean	Mode	Minimum	Median	Maximum
October 2001	1,190	849	481	1,068	3,375
November 2001	1,331	810	771	1,192	2,735
December 2001	2,061	2,185	810	2,033	4,620
January 2002	2,589	2,970	870	2,690	5,385
February 2002	3,785	1,324	1,117	3,875	16,206
March 2002*	5,147	4,053	2,345	4,753	9,339

*indicates a month for which the full month of data is not available.

8.6.5.5 Stream-Flow Amounts Greater than Total Precipitation Catchment

Total monthly precipitation for the period October 2001 to May 2003 for the nearest three EC climate stations located at Collegeville, Deming, and Sherbrooke, and the two study rainfall gauges at Goldboro and Salmon River Lake, are presented in Table 8.6-15.

TABLE 8.6-15 Total Monthly Precipitation (in mm) October 2001 to May 2003

Date	Deming	Sherbrooke	Goldboro	Collegeville	Salmon River
Oct-01	99	53	36	69	-
Nov-01	124	84	89	80	99
Dec-01	118	90	122	64	101
Jan-02	131	102	174	106	94
Feb-02	158	146	148	75	108
Mar-02	179	87	247	78	60
Apr-02	191	62	230	52	-
May-02	100	89	117	55	-
Jun-02	100	71	104	92	14
Jul-02	129	103	-	81	25
Aug-02	104	61	-	44	34
Sep-02	119	123	-	107	5

Date	Deming	Sherbrooke	Goldboro	Collegeville	Salmon River
Oct-02	178	155	67*	127	77*
Nov-02	235	254*	305	150	-
Dec-02	98	101*	93	98	-
Jan-03	144	128	83	40	-
Feb-03	131	206	135	52	40*
Mar-03	88	92	110	131	142
Apr-03	206	127	197	104	102
May-03	96	98	105	79	65

* indicates a month for which the full month of data is not available.

Total annual flow for 2002 (full water year for which stream data is available) for the Isaac's Harbour River was 118,752,483 ± 3,000,000 m^3. An estimate of the total water available to the watershed for 2002, based on a 77,462,500 m^2 watershed and a total annual precipitation of 1,379 mm (mean for Collegeville, Deming and Sherbrooke for January to December 2002) is 106,820,787 m^3. This suggests that about 11 percent more water was present as stream discharge at the Isaac's Harbour River at ML1 than was available as total precipitation falling within the watershed for the year 2002.

It is clear from the relationship above that there are significant groundwater contributions to the Isaac's Harbour River at ML1 from other places: likely the Salmon River watershed which is located at higher elevations, is underlain by more porous and permeable sandstone, and with which bedrock faults present within the Isaac's Harbour River watershed are likely in hydraulic contact. Also, the large variation that exists in monthly and annual precipitation from station-to-station (see Table 8.6-15) suggests that using simple means from the nearest climate stations would not produce reliable data for the Keltic water supply. So a detailed study (GIS modeling) of the precipitation at the watershed and detailed hydrologic analysis were done (see Appendix 3) to better understand the water balance in the area and total quantity of water moving through the watershed system.

Climate data for all EC climate stations within 100 km of Goldboro was used to determine monthly, seasonal, and annual precipitation distribution over the Isaac's Harbour River watershed for both the October 2001 to May 2003 period of detailed record and the monthly and annual means for the period 1982 to 2002. Figure 8.6-6 shows the locations of the study rain gauges and EC climate stations. Table 8.6-16 shows the corrected monthly precipitation values over the Isaac's Harbour River watershed for the period October 2001 to May 2003, along with measured total monthly stream flow, the quantities of flow which were ascribed as base flow, as quick flow, and the ratios of total flow (TF/P), base flow (BF/P) and quick flow (QF/P) to precipitation. This data suggests values for mean total flow to precipitation, base flow to precipitation and quick flow runoff to precipitation coefficients for the Isaac's Harbour River watershed system at ML1 of 1.03, 0.55, and 0.48, respectively.

For the climate stations included in the precipitation modeling, precipitation records were found to be most complete for the period 1982 to 2002. Table 8.6-17 shows mean monthly and total annual precipitation values obtained for the period 1982 to 2002 over the Isaac's Harbour River watershed and based on these and the ratios obtained above, calculated monthly and annual total stream flow, base flow and quick flow for the Isaac's Harbour River at ML1.

Water balance calculations made as part of the detailed hydrologic analysis suggest that sub-flow groundwater imports (SubI) and/or contributions from changes in groundwater storage to the Isaac's Harbour River watershed at ML1 may have been approximately 41,193,000 m^3 for the year 2002, or on average, 23,110,800 m^3 per year (about 2,638 m^3/hr), or about 27 percent of total annual stream flow, for the period 1982 to 2002.

8.6.5.6 Drought and Flood Frequency Forecasting

Drought frequency analysis was performed on total summer (June, July, plus August) precipitation values for the three nearest EC stations (Collegeville, Deming-Whitehead, and Stillwater-Sherbrooke. The results are summarized in Table 8.6-18.

Storm frequency analysis for 100, 200, and 500 year storms was done for 24, 48, and 72 hour precipitation events for the EC climate stations at Collegeville, Deming-Whitehead, and Stillwater-Sherbrooke). The results are summarized in Tables 8.6-19, 8.6-20, and 8.6-21. The typical precipitation event to hydrograph peak delays (i.e., storm response times) for the Isaac's Harbour River and Gold Brook systems are shown in Table 8.6-22.

8.6.5.7 Reservoir Water Balances

The 95% annual stream flow exceedance frequency at Isaac's Harbour River for the 2002 calendar year represents a withdrawal rate of 720 m^3/hr. With a dam, the flow characteristics of the River may be modified such that the 95% annual stream flow exceedance frequency with a dam in place could be roughly equal to the 90% annual (2002) stream flow exceedance frequency, which would represent a withdrawal rate of 1,260 m^3/hr as defined from the current Keltic study data.

TABLE 8.6-16 Monthly Summary for Isaac's Harbour River at ML1 October 2001 to May 2003

Month	Precip. (m^3)	Total Flow (m^3)	Base Flow (m^3)	Quick Flow (m^3)	TF/P	BF/P	QF/P
Oct-01	5,634,481	1,516,085	828,433	687,652	0.27	0.15	0.12
Nov-01	7,281,637	5,331,479	2,710,218	2,621,261	0.73	0.37	0.36
Dec-01	8,526,869	6,435,641	3,719,646	2,715,995	0.75	0.44	0.32
Jan-02	9,840,439	10,328,155	5,676,480	4,651,675	1.05	0.58	0.47
Feb-02	9,702,234	14,690,627	7,510,770	7,179,857	1.51	0.77	0.74
Mar-02	14,883,402	27,481,652	15,072,012	12,409,640	1.85	1.01	0.83
Apr-02	13,841,780	20,103,119	10,829,556	9,273,563	1.45	0.78	0.67
May-02	7,801,808	8,820,617	5,788,062	3,032,555	1.13	0.74	0.39
Jun-02	7,806,563	1,479,522	1,044,922	434,600	0.19	0.13	0.06
Jul-02	3,573,861	2,400,045	1,340,118	1,059,927	0.67	0.37	0.30
Aug-02	3,432,845	3,940,844	1,099,726	2,841,118	1.15	0.32	0.83
Sep-02	9,615,633	3,079,701	1,451,062	1,628,638	0.32	0.15	0.17

Oct-02	11,753,728	8,869,048	3,444,291	5,424,757	0.75	0.29	0.46
Nov-02	20,847,237	21,375,682	8,680,356	12,695,326	1.03	0.42	0.61
Dec-02	7,301,132	8,924,936	6,104,988	2,819,948	1.22	0.84	0.39
Jan-03	6,967,033	4,984,243	4,150,660	833,583	0.72	0.60	0.12
Feb-03	6,241,024	14,037,745	8,460,078	5,577,667	2.25	1.36	0.89
Mar-03	9,898,641	15,885,776	6,621,264	9,264,512	1.60	0.67	0.94
Apr-03	11,069,070	10,701,359	4,062,265	6,639,094	0.97	0.37	0.60
May-03	6,436,220	6,008,197	4,329,774	1,678,423	0.93	0.67	0.26

TABLE 8.6-17 Monthly Average Values for Precipitation (GIS-Modeled Values) and Calculated Flow for the Years 1982 to 2002 for the Isaac's Harbour River Watershed At ML1

Month	Precipitation (m^3)	Total Flow (m^3)	Base Flow (m^3)	Quick Flow (m^3)
January	9,736,045	8,869,995	5,692,556	3,177,439
February	8,076,487	14,553,131	8,090,463	6462668
March	9,359,327	16,378,389	8,192,806	8,185,584
April	9,033,673	11,170,939	5,400,371	5,770,567
May	8,612,891	8,970,270	6,120,498	2,849,773
June	8,328,281	1,578,400	1,114,755	463,645
July	7,418,206	4,981,735	2,781,661	2,200,073
August	7,950,241	9,126,733	2,546,892	6,579,841
September	9,667,652	3,096,361	1,458,912	1,637,449
October	10,867,227	6,490,466	2,670,353	3,820,113
November	12,009,330	11,402,344	4,863,087	6,539,257
December	10,371,420	10,065,137	6,437,667	3,627,469
Total annual	111,430,780	106,683,900	55,370,021	51,313,878

TABLE 8.6-18 Summer (June, July, and August) Drought Estimates (in mm)

Station Name	50-year	100-year	200-year	500-year
Collegeville	110-115	85-95	65-77	25-55
Deming-Whitehead	100	70-75	37-50	0-15
Stillwater-Sherbrooke	120	85-92	53-70	15-28

TABLE 8.6-19 100-year Storm Events (in mm)

Station Name	24-hour event	48-hour event	72-hour event
Collegeville	150-204	176-240	180-250
Deming-Whitehead	135	170	185-188
Stillwater-Sherbrooke	145-150	185-192	208-213

TABLE 8.6-20 200-year storm events (in mm)

Station Name	24-hour event	48-hour event	72-hour event
Collegeville	164-212	186-258	196-270
Deming-Whitehead	138-142	179-185	194-202
Stillwater-Sherbrooke	155-162	200-210	222-230

TABLE 8.6-21 500-year Storm Events (in mm)

Station Name	24-hour event	48-hour event	72-hour event
Collegeville	184-220	204-280	210-300
Deming-Whitehead	144-153	191-204	208-220
Stillwater-Sherbrooke	171-179	220-230	242-251

TABLE 8.6-22 Typical Event-to-Peak Delay (time in hours) between Precipitation Events and Stream-flow Peak on Hydrographs

Station Name	Fall	Winter	Spring	Summer
ML1	24 - 36	48	24 - 48	36
GB1	6 – 18	24 - 48	6 – 12	6
GB2	48	48 – 72	24 - 36	36 - 48
GB3	18 - 42	24 - 48	24	-

Based on the historic low (June 1982-2002) monthly stream flow, allocation values above, and applying an appropriate safety factor, approximately 10 percent of monthly flow might be regarded as a “safe” monthly withdrawal rate from the system – the volume of water which could be placed into storage and/or removed from stream-flow to meet the proposed Keltic Facility demand. With proper flood-gate management practices, such withdrawals from the Meadow Lake watershed would likely leave more than sufficient amounts of water for fisheries maintenance flow requirements.

Monthly figures showing net supply deficit (need for stored water) and surplus (water which can be placed into storage) and approximate flows remaining (subject to flood-gate controls) after storage, are summarized in 38.6-24. Based on an average proposed water demand of 1,200 m^3/hr. Table 8.6-23 suggests that without storage there would be net water supply deficits during the months of January, June, July, September, and October totalling 1,904,705 m^3. This would be the volume of water needed to be stored annually during periods of high flow, or the volume of the reservoir needed to be created by placing a dam across Isaac's Harbour River at Meadow Lake.

Meadow Lake has at present a surface area of 98.6 ha to 104 ha, depending on the information source used. GIS-generated simulations suggest that raising the lake's water level by 1m would yield about 1.42 million m^3 of water storage and a new lake surface area of approximately 185 ha. Raising the lake's water level by 2 m would yield about 4.00 million m^3 of water storage and a new lake surface area of approximately 244 ha. A 2 m water level rise would likely be required to safely meet plant water demands plus downstream flows during extensive periods of dry weather.

TABLE 8.6-23 Results of Withdrawing 1,200 m^3/hr. from Isaac's Harbour River at Meadow Lake Based on 1982-2002 Data

Period	Column 1 Total Flow (m^3)	Column 2 Proposed Withdrawal Allocation (m^3)	Column 3 Plant Demand (m^3)	Column 4 Net Surplus or Deficit (m^3) (col. 2 Minus col. 3)	Remaining Stream-Flow (m^3) (col. 1 Minus col. 2)
January	8,869,995	887,000	892,800	-5,801	7,982,996
February	14,553,131	1,455,313	806,400	648,913	13,097,818
March	16,378,389	1,637,839	892,800	745,039	14,740,550
April	11,170,939	1,117,094	864,000	253,094	10,053,845
May	8,970,270	897,027	892,800	4,227	8,073,243
June	1,578,400	157,840	864,000	-706,160	1,420,560
July	4,981,735	498,174	892,800	-394,627	4,483,562
August	9,126,733	912,673	892,800	19,873	8,214,060
September	3,096,361	309,636	864,000	-554,364	2,786,725
October	6,490,466	649,047	892,800	-243,753	5,841,419
November	11,402,344	1,140,234	864,000	276,234	10,262,110
December	10,065,137	1,006,514	892,800	113,714	9,058,623
Annual	106,683,900	10,668,390	10,512,000	156,390	96,015,510

8.7 GROUNDWATER

Groundwater has a dynamic relationship with surface water, and provides a potable water supply to all of the unserviced residences adjacent to the proposed Keltic Site. Obtaining a proper understanding of groundwater also requires having a clear understanding of the soil and bedrock through which it flows. Soil and bedrock is discussed in Section 8.13 of this report.

A description of the hydrogeology within the proposed Keltic Site was documented by conducting:

- a review of all available published maps and reports;
- reconnaissance-level and detailed geologic assessments of the hydrogeologic Study Areas;
- monitoring well installations, slug hydraulic testing and groundwater sampling at the proposed Keltic Site to help characterize the hydrogeology of the site and to provide baseline groundwater quality data;
- a reconnaissance-level survey of all homes and wells present within 1 km of the proposed Keltic Site; and
- a door-to-door well survey with water sampling within 1 km of the proposed Keltic Site boundaries to further assess the hydrogeology of the area and to provide baseline information.

Reconnaissance-level geologic assessments of the greater Keltic Site were done by a geoscientist during the periods May 31 to June 6, 2004 and June 24-25, 2004. Due to the industrial nature of the site, more detailed field mapping of parts of the Keltic Site, monitoring well installations, hydraulic testing at those wells and groundwater sampling were carried out during the period from April 4 to May 3, 2005.

8.7.1 General Hydrogeology

The physical and general chemical hydrogeology of the various hydrostratigraphic units underlying and within 1 km of the Keltic Site in Goldboro are presented below. Reference is made to the NSEL well log database during this review to give insight on typical well depth and yield for each of the hydrostratigraphic units described.

8.7.1.1 Meguma Group (Halifax and Goldenville Formations)

Due to their lithologic composition and degree of metamorphism, the Goldenville Formation, Halifax Formation, and granitic plutons of the Meguma Group contain no primary permeability and so well production from these bedrock units is nearly entirely dependent on fracture flow.

Wells drilled into Meguma Group bedrock may be expected to yield anywhere from less than 1 L/min to as much as 400 L/min, depending on location and fracture frequency, aperture size and interconnectedness. However, well yields in the order of 4 to 18 L/min are more the norm.

A search of the NSEL well log database returned the data presented in Table 8.7-1 below:

TABLE 8.7-1 Average Well Data, (NSEL Well Log Database, Goldenville and Halifax Formations)

Community	No. of Wells	Average Depth (m)	Average Yield (L/min)	Extreme yields (L/min)	
				Low	High
Country Harbour	31	63	21	1.1	68
Isaac's Harbour	10	57	16.5	2.3	55
Goldboro	8	73	10.5	2.3	23
Drum Head	4	55	3	2.3	4.5

The data returned for the community of Country Harbour included the hamlets of Country Harbour, Middle Country Harbour, Country Harbour Mines, and Cross Roads Country Harbour.

Within the Goldenville and Halifax Formations, calcium bicarbonate type waters appear to be most common, but calcium sulphate, calcium chloride and sodium chloride waters are also common. Waters from the Goldenville and Halifax Formations are typically only slightly hard to moderately hard with low to moderate concentrations of total dissolved solids, neutral to slightly acidic pH and low alkalinity. Iron and manganese concentrations often exceed their respective guidelines, arsenic concentrations can at places be elevated, and elevated values for uranium have also been reported.

The granites generally produce calcium bicarbonate type waters mostly, although sodium chloride type waters can be found. The granites generally yield waters that are very soft to only slightly hard, with low pH, low alkalinity and low total dissolved solids. Iron, manganese, and uranium concentrations often exceed their respective guidelines, as can radon.

8.7.1.2 Groundwater Flow Direction

Local and intermediary groundwater flow direction may be controlled by a number of factors, including piezometric or water table hydraulic gradient, hydraulic conductivity, and fracture orientation where there is fracture flow through bedrock or fractured soils. Some often attempt to predict (while assuming a fair degree of accuracy) local groundwater flow direction on the belief that the water table in unconfined aquifers is a subdued replica of the local topography, but that may not always be the case (Haitjema and Mitchell-Bruker, 2005) and so defining groundwater flow direction solely based on surface topography may not be accurate. However, groundwater is expected to follow general relief on a regional or macro-scale.

Notwithstanding the generalities noted above, subsurface assessments were possible on the proposed plant site and immediate surrounding areas, and the local groundwater flow direction details are understood in that part of the Keltic Study Area. That information is presented in Section 8.7.3 of this report.

8.7.2 Local Well Survey

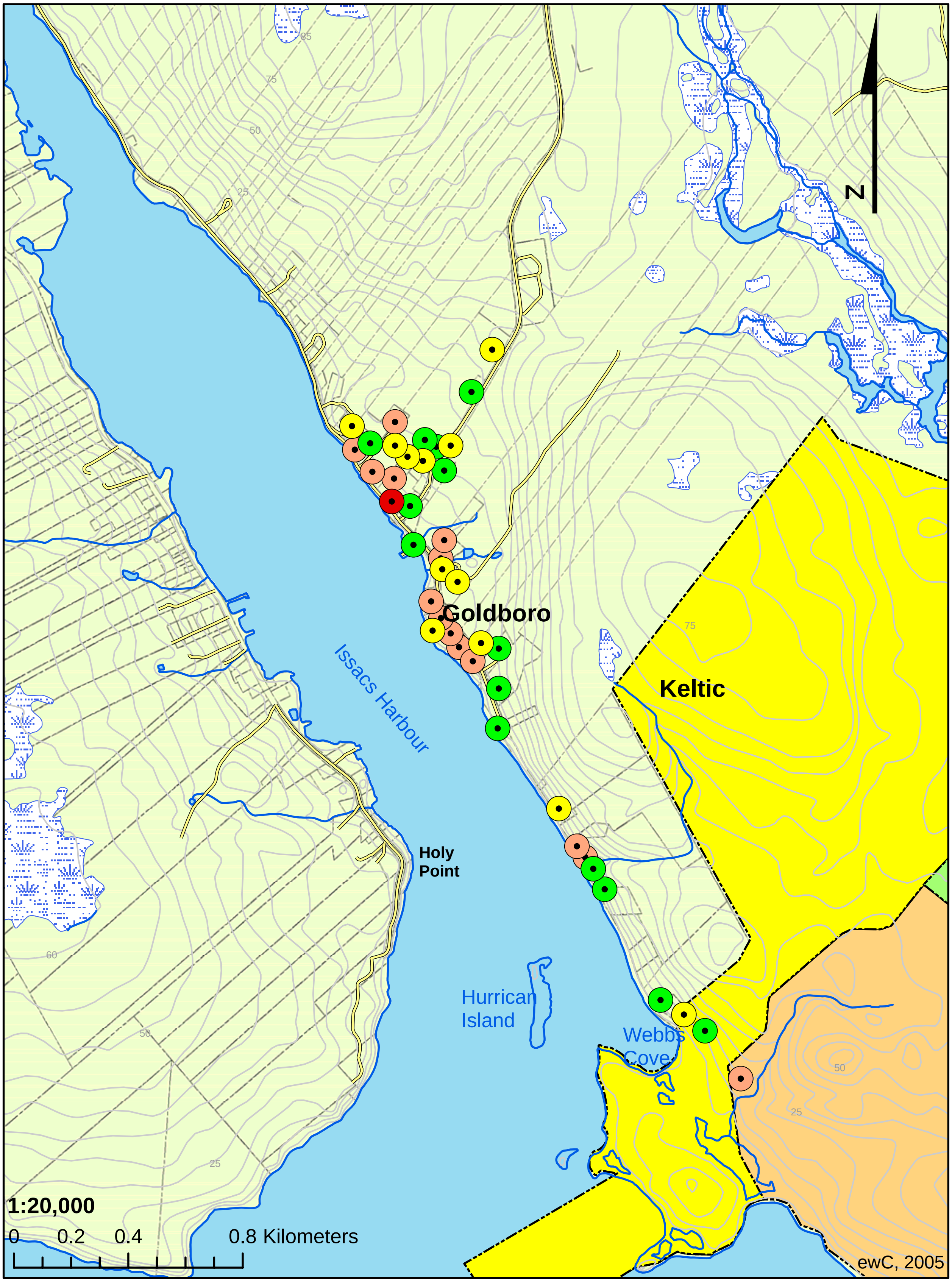
A door-to-door survey of the water supply wells located within 1 km of the proposed Keltic Site boundaries was carried out. Up to 40 wells were identified in the community of Goldboro (see Figure 8.7-1), most of which are dug wells. There are only about eight drilled wells in the community.

Fourteen of the approximately 40 wells identified in the survey area were sampled for general chemistry, total metals, and coliform analysis. One homeowner refused to allow their well to be sampled. Twelve others whose homes appeared to be occupied (outside lights were on, outside plantings maintained) could not be contacted during the three-day survey or during subsequent visits to the site. Thirteen other homes and/or businesses appeared to be abandoned and/or used only seasonally. A newly drilled well located off-site was also sampled to serve as a groundwater quality benchmark.

Well owners agreed to participate in the sampling program on condition that identities would not be revealed. Thus the Table does not give sample locations. Well owners have been advised where results showed possible health concerns. Lab certificates of analysis are enclosed in Appendix 5. The following protocol was used to sample the water supply wells:

- Samples collected for general chemistry and total metals were taken directly from most commonly used faucet if no treatment was present or from the boiler valve on pressure tank upstream of any treatment, after purging the well and plumbing system for a minimum five minutes.
- Samples were collected in 200 ml polyethylene bottles directly from source for both general chemistry and total metals, without preservatives added.

FIGURE 8.7-1 Dug and Drilled Domestic Wells Within 1 km Site Boundaries



Legend

- Homes Occupied, Owner not Contacted
- Home Refused to be Sampled
- Home Samples
- Seasonal Home

FIGURE No. 8.7-1
KELTIC PETROCHEMICALS INC.

DUG AND DRILLED DOMESTIC WELLS WITHIN 1km SITE BOUNDARIES

July 2006

- Samples collected for coliform analysis were taken directly from most often used faucet (aerators removed) into sterile (sealed) 100 ml bottles after purging wells and plumbing system for a minimum of five minutes. Sodium thiosulfate (to neutralize chlorine) was used as sample preservative.
- All samples were stored on ice in coolers immediately after collection until return to field office daily, then (except for coliform analysis) refrigerated until returned to coolers with ice packs for delivery to the lab. The maximum sample storage time was seven days.
- Samples collected for coliform analysis were delivered to the lab daily.
- All samples collected for general chemistry, total metals and some of the coliform analysis were analyzed at Maxxam Analytics inc. in Bedford, Nova Scotia, except for coliform samples 102F01-5-1 through 102F01-5-11, 102F01-5-13 and 102F01-5-15, which were analyzed daily at St. Martha's Hospital in Antigonish, Nova Scotia.
- Analytical results for the survey and benchmark well samples are summarized in Table 8.7-2.
- The lab analytical protocol used for general chemistry and metals is shown in Table 8.7-3. Samples collected for coliform were analyzed using the Colilert (Presence/absence) method.

The dug wells generally produce water classed as soft, sodium-chloride type waters with low total dissolved solids, low alkalinity and low pH. The relative proportions of sodium and chloride appear to increase with increased total dissolved solids concentration, suggesting a possible road salt (less likely) and/or sea spray (more likely) influence on these wells. The values for pH and aluminum are generally outside of acceptable guideline limits. Nearly all of the dug wells showed positive for total coliform. This is likely a function of well construction in many cases: most wells are old, some consisting of nothing more than a cover placed over surface springs, others had holes and water pooling near them, and nearly all had poor fitting covers and vents with no screens. Many wells showed signs of containing insects.

The drilled wells sampled inside the survey area generally produce soft to only slightly hard, calcium-bicarbonate type waters with that are, low total dissolved solids, low alkalinity and neutral to just below neutral pH. Aluminum, iron, and manganese concentrations were found to be outside of acceptable guideline limits. Only one well indicated the presence of coliform. The chemistry for water from drilled wells inside the survey area was in general very similar that or the off-site benchmark well.

8.7.3 Hydrogeology at the Proposed Keltic Site

The hydrogeology of the proposed Keltic Site was evaluated via the construction of 14 monitoring wells, installed as piezometre pairs at seven locations. Six piezometre pairs are located inside the proposed Keltic Site boundaries, and one was installed outside the boundaries between the site and Isaac's Harbour. The monitoring well locations are shown in Figure 8.7-2.

TABLE 8.7-2 Analytical Results for Water Samples Collected from Water Supply Wells Located within 1 km of the Proposed Petrochemical Plant Site Boundaries

TABLE 8.7-2 Analytical Results for Water Samples Collected from Water Supply Wells Located within 1 km of the Proposed Petrochemical Plant Site Boundaries

Description	Units	CCME Guidelines Values (2003)				Water Supply Well Samples Located in Survey Area														Off Site	Detect Limit
		Drinking Water		Aquatic Life		Dug Well	Dug Well								Drilled Well		Dug Well		Drilled Well		
Location / Parameter		MAC/IMAC	AO	Fresh	Marine	102F01-5-1*	102F01-5-2*	102F01-5-3*	102F01-5-4*	102F01-5-5*	102F01-5-6*	102F01-5-7*	102F01-5-8*	102F01-5-9*	102F01-5-10*	102F01-5-11*	102F01-5-13*	102F01-5-15*	102F01-6-1*	102F01-4-9*	
Sodium (Na)	mg/L	200				7.5	7.9	6.4	6.6	68	8.6	11	28	37	14	21	6.4	9.4	9.5	10	0.1
Potassium (K)	mg/L					0.5	0.7	0.7	0.6	1.6	0.7	2.1	2.7	1.6	1.4	0.6	0.3	0.4	0.8	1.6	0.1
Calcium (Ca)	mg/L					2.8	6.1	4.7	3.8	10	1.9	8.5	9.5	4.4	29	23	1.3	2.9	18	38	0.1
Magnesium (Mg)	mg/L					1	1	0.9	1	1.4	0.9	1.9	1.1	1.2	2	1.2	0.8	1.5	1.1	4.2	0.1
Alkalinity (as CaCO3)	mg/L					ND	13	6.7	11	10	ND	9.8	9.6	6	81	74	ND	ND	45	120	5
Sulphate (SO4)	mg/L	500				2.5	4.6	4.7	3.4	13	4.7	8.7	7.6	5.4	9.9	12	2.5	3.8	3.6	5.7	2
Chloride (Cl)	mg/L	250				11	13	10	8.9	100	14	22	43	56	9.6	13	9.5	17	10	12	1
Reactive Silica (SiO2)	mg/L					3.5	3.8	3.6	6.2	5.8	3.5	4.9	3.5	5.5	12	8	4.2	3.3	7.5	9.7	0.5
Orthophosphate (P)	mg/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
Phosphorus (P)	mg/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2
Nitrate + Nitrite	mg/L					ND	0.17	0.16	ND	0.16	ND	0.7	2.3	0.14	ND	ND	ND	0.57	ND	0.06	0.05
Nitrate (N)	mg/L	10				ND	0.17	0.16	ND	0.16	ND	0.7	2.3	0.14	ND	ND	ND	0.57	ND	0.06	0.05
Nitrite (N)	mg/L	3.2		0.06		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
Nitrogen (Ammonia Nitrogen)	mg/L			1.37 – 2.20		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05
Total Organic Carbon (C)	mg/L					2.5	1.3	2.7	ND	ND	0.5	1.6	1.1	4.6	ND	ND	1.3	0.6	ND	0.6	0.5
Colour	TCU		15			9.6	ND	10	ND	ND	ND	ND	ND	29	ND	ND	5.2	ND	ND	ND	5
pH	pH		6.5 – 8.5	6.5-9.0	7.0-8.7	6.84	7.83	7.47	7.11	6.61	6.15	6.06	6.06	5.61	6.75	7.2	6.09	6.72	6.63	6.72	N/A
Turbidity	NTU	1	5			0.3	0.4	0.2	ND	0.2	ND	ND	1.2	2.7	0.3	1.7	0.3	ND	12	ND	0.1
CoNDuctivity	uS/cm					59	81	63	59	390	66	120	200	210	190	200	47	78	130	250	1
Calculated TDS	mg/L		500			29.1	44.9	35.8	37	209	34.5	67.5	112	116	127	123	25.2	40.5	78.8	154	1
Hardness (CaCO3)	mg/L					11	19	15	14	31	8.7	29	28	16	81	62	6.8	13	49	110	N/A
Bicarb. Alkalinity (calc. as CaCO3)	mg/L					ND	12.7	7	10.8	10.1	ND	10	10	6	80.5	73.4	ND	ND	45	118	1
Carb. Alkalinity (calc. as CaCO3)	mg/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Cation Sum	me/L					0.558	0.743	0.607	0.573	3.64	0.568	1.11	1.84	1.98	2.28	2.16	0.427	0.689	1.46	2.75	N/A
Anion Sum	me/L					0.372	0.715	0.526	0.539	3.36	0.495	1.03	1.74	1.83	2.09	2.08	0.321	0.586	1.26	2.83	N/A
Ion Balance (% Difference)	%					20	1.93	7.15	3.08	3.9	6.9	3.41	2.71	3.83	4.4	1.68	14.2	8.1	7.21	1.49	N/A
Langelier Index (@ 20C)	N/A					NC	-1.59	-2.33	-2.57	-2.77	NC	-3.34	-3.32	-4.32	-1.23	-0.931	NC	NC	-1.8	-0.994	N/A
Langelier Index (@ 4C)	N/A					NC	-1.84	-2.58	-2.82	-3.02	NC	-3.6	-3.58	-4.57	-1.48	-1.18	NC	NC	-2.05	-1.24	N/A
Saturation pH (@ 20C)	N/A					NC	9.42	9.8	9.68	9.38	NC	9.4	9.38	9.93	7.98	8.13	NC	NC	8.43	7.71	N/A
Saturation pH (@ 4C)	N/A					NC	9.67	10.1	9.93	9.63	NC	9.66	9.64	10.2	8.23	8.38	NC	NC	8.68	7.96	N/A
Aluminum (Al)	ug/L			5 – 100		180	68	81	11	ND	310	120	140	450	ND	110	71	120	ND	ND	10
Antimony (Sb)	ug/L	6				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Arsenic (As)	ug/L	25		5.0	12.5	ND	ND	13	ND	ND	ND	ND	ND	2.7	2	ND	ND	ND	ND	ND	2
Barium (Ba)	ug/L	1000				6.1	6.8	7	ND	25	7.3	6.9	76	30	ND	5.1	ND	9.3	ND	ND	5
Beryllium (Be)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Bismuth (Bi)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Boron (B)	ug/L	5000				6.6	7.4	5.9	ND	7.8	6.4	12	11	8.6	38	51	5.2	6.8	11	17	5
Cadmium (Cd)	ug/L	5		0.017	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3
Chromium (Cr)	ug/L	50		1.0	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Cobalt (Co)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	2	ND	ND	ND	ND	ND	5.8	1
Copper (Cu)	ug/L	1000		2 – 4		59	14	9.7	82	99	5.6	85	150	110	4.9	ND	230	18	13	11	2
Iron (Fe)	ug/L		300	300		ND	ND	ND	ND	ND	ND	ND	ND	760	ND	ND	64	ND	1100	ND	50
Lead (Pb)	ug/L	10		1 – 7		0.7	1.5	ND	0.5	0.5	1.8	2.8	ND	4	2.8	ND	0.8	ND	ND	ND	0.5
Manganese (Mn)	ug/L		50			12	5.8	2.1	ND	170	15	7.8	54	120	43	130	7.3	15	50	1100	2
Molybdenum (Mo)	ug/L			73		ND	ND	ND	ND	ND	ND	ND	ND	ND	4.2	ND	ND	ND	ND	ND	2
Nickel (Ni)	ug/L			25 – 150		ND	ND	2.4	ND	ND	ND	ND	ND	2.4	ND	ND	ND	ND	ND	4.2	2
Selenium (Se)	ug/L	10		1.0		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Silver (Ag)	ug/L			0.1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5
Strontium (Sr)	ug/L					18	34	32	21	51	16	55	35	38	180	180	11	22	75	120	5
Thallium (Tl)	ug/L			0.8		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1
Tin (Sn)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Titanium (Ti)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	3.7	ND	ND	ND	ND	ND	ND	2
Uranium (U)	ug/L	20				ND	ND	ND	ND	ND	ND	ND	ND	ND	1.8	0.4	ND	ND	0.1	ND	0.1
Vanadium (V)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Zinc (Zn)	ug/L		5000	30		14	8	18	7	56	5.1	16	22	150	22	ND	6.8	ND	22	26	5
Total coliform	P/A	A				P	P	P	P	P	A	P	P	P	A	A	P	P	P		
E.coli.	P/A	A				A	A	A	A	A	A	A	A	A	A	A	A	A	A		

ND = Not detected

NC = Non-calculable

CCME – assumes lowest values (i.e. haxavalent chromium vs. trivalent, etc). MAC = maximum allowable concentration. IMAC = interim MAC. AO = aesthetic objective.

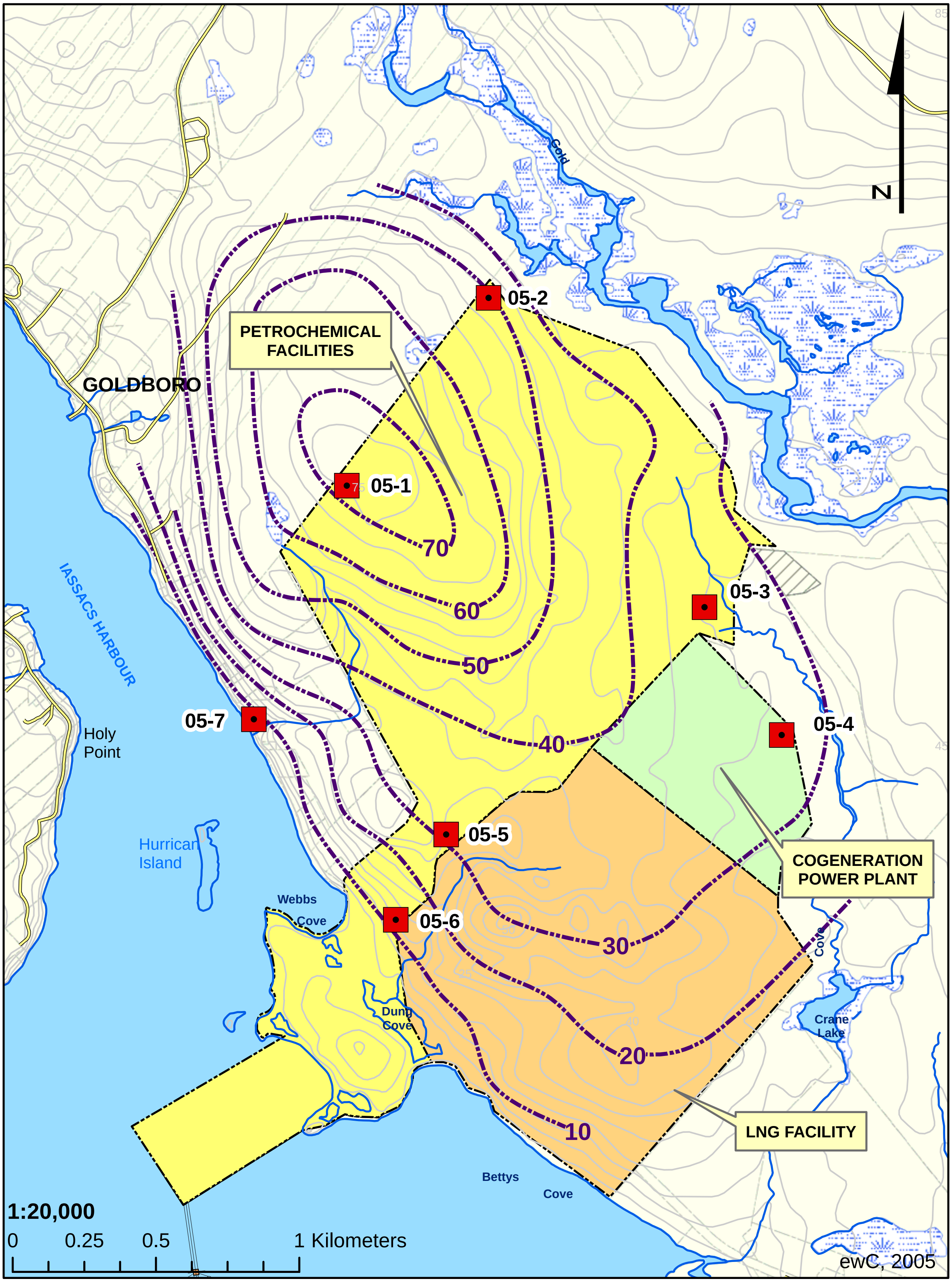
Values that exceed one CCME guideline value or another (guideline may or may not be applicable to water use) are shaded.

TABLE 8.7-3 Lab Analytical Protocol Used For Groundwater Sample Analysis

Analysis	Maxxam Laboratory Method	Method Reference
Alkalinity	2015-1-2	Based on EPA310.2
Chloride	2045-1-2	Based on SM4500-Cl-
Colour	2156-1-1	Based on EPA110.2
Conductance – water	1013-1-2	Based on SM2510B
TEH in Water (Atlantic Partnership in Risk-based Corrective Action (RBCA) implementation (PIRI))	9025-1-5	Based on Atl. PIRI
Mercury (Total)	3425-1-2	C V A A
Metals in water ICP-OES	3120-2-1	Based on EPA200.7
Elements by ICPMS - dissolved (FIAS)	3013-1-1	Based on EPA6020A
Nitrogen Ammonia - water	2105-1-2	Based on USEPA 350.1
Nitrogen - Nitrate + Nitrite	2115-1-2	Based on EPA 353.1
Nitrogen – Nitrite	2125-1-1	Based on USEPA 354.1
Nitrogen - Nitrate (as N)	SOP 2130-1-1	Based on ASTMD3867
pH	1007-1-1/1011-1-2	Based on USEPA150.1
Phosphorus – ortho	2165-1-1	Based on USEPA 365.1
VPH in Water (PIRI)	9120-1-5	Based on Atlantic PIRI
Reactive Silica	2185-1-1	Based on USEPA 366.0
Sulphate	4065-1-2	Based on USEPA 375.4
Organic Carbon – Total	2020-1-3	Based on SM 5310C
Mod Total Petroleum Hydrocarbons (T1) Calc. for Water	--	Based on Atlantic PIRI
Turbidity	1040-2-4	based on USEPA 180.1
VOCs in Water	9615-1-3	Based on USEPA624

The predominance of secondary permeability within the bedrock of the Goldenville Formation, and the large number of shear zones known and thought to be present at the site (especially those in the southwest part of the site) in conjunction with the large number of possibly extensive abandoned underground workings, can be expected to have a significant influence on groundwater flow pathways and on overall groundwater flow velocity within and beyond the site. Therefore, the monitoring wells were located where they might best explain these underground phenomena and provide broad coverage and even distribution in areas where process infrastructure and thus, possible material spills might occur at some time in the future. The intent of the monitoring well program was to help characterize the site through definition of its baseline physical and chemical hydrogeology. As such, the hope is that these wells will not be disturbed during construction, so they may continue to serve as long-term groundwater monitoring stations.

FIGURE 8.7-2 Monitoring Well Locations and Piezometric Contours



Legend

Monitoring Well Locations

Piezometric Contours

FIGURE No. 8.7-2
KELTIC PETROCHEMICALS INC.
MONITORING WELL LOCATIONS AND PIEZOMETRIC CONTOURS
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8.7.3.1 Monitoring Well Design, Construction and Development

The monitoring wells were installed employing the services of Lantec Drilling from Dieppe, New Brunswick. The boreholes were advanced using augers and split spoon samplers where possible, advancing into bedrock with HQ-size diamond equipment. Due to the great depth to bedrock, monitoring well MW05-2b was screened in soil just above bedrock. All other monitoring wells were screened in bedrock. Details are provided in Table 8.7-4.

8.7.3.2 Hydraulic Conductivity (Slug) Testing

Hydraulic conductivity (slug) testing was carried out on each monitoring well after allowing at least 24 hours for water levels to recover following well development and groundwater sampling. The exception to this was MW05-1a and MW05-1b where due to the long distance in from the road and the need to carry well development and testing equipment in on foot, hydraulic testing was done prior to, and on the same day as, well development and sampling.

The slug testing was done using a 1 L aluminum slug on a rope, an electronic data logger, and electronic water level tape. At least two drawdown and recovery tests were carried out on each monitoring well. Presence or absence of response in the neighbouring well-pair was noted during each test. The field data was interpreted using the Hvorslev Method. The results are summarized in Table 8.7-5 and the analysis details are presented in Appendix 6.

8.7.3.3 Groundwater Sampling

Groundwater samples were collected from the monitoring wells for analysis for general chemistry, dissolved metals, mercury, total petroleum hydrocarbons, and VOC. The water samples were collected directly from the end of the Waterra tubing installed at each well. Table 8.7-6 summarizes the protocol used for sample collection.

All groundwater sample collection was done in fair weather conditions. The generator used to power the Hydrolift pump was kept at least 10 m downwind of the monitoring wells during sample collection.

The sampling QA/QC program included the following:

- sample and analyze all water sources used to drill during monitoring well construction;
- collect one full suite of duplicate samples at MW05-6a;
- carry a field blank to all sampling locations;
- do an air-transfer blank at MW05-7a while maintaining a 5 cm gap between lab-prepared distilled water bottle and sample collection bottles (handled as per Table 8.7-6), for VOC analysis;
- sample (directly from the grease tube) and analyze the lubricant used on drilling equipment;

TABLE 8.7-4 Monitoring Well Construction and Development Details

Well I.D.	Depth (m)		Elevation (m)		Well Development	
	To Bedrock	Well Total	Ground Surface	Top of Piezometre	Volume Removed (L)	Number of Casing Volumes
MW05-1a	2.29	17.68	74.73	75.28	1000	31.5
MW05-1b		8.54	74.66	75.18	828	62.5
MW05-2a	17.45	24.31	56.47	56.91	1449	32.0
MW05-2b		11.59	56.46	56.96	1536	79.0
MW05-3a	2.44	17.38	37.44	38.16	1207	38.7
MW05-3b		8.23	37.49	38.21	1173	92.9
MW05-4a	5.49	19.21	35.19	35.66	1035	29.7
MW05-4b		10.08	35.17	35.72	844	51.5
MW05-5a	0	17.68	34.86	35.41	1035	32.6
MW05-5b		8.54	33.30	33.82	862	65.0
MW05-6a	5.49	20.73	16.83	17.43	780 (dry 1x)	20.6
MW05-6b		7.01	16.79	17.25	186 (dry 2x)	18.3
MW05-7a	4.57	20.73	9.37	10.03	138 (dry 2x)	3.6
MW05-7b		11.59	9.24	9.78	855 (dry 2x)	44.0
Well construction		3 m of 50 mm schedule 40 threaded PVC 0.020 slot screen (pointed cap) at the bottom by schedule 40 threaded PVC casing to surface				
Annular packing material		No. 2 silica sand to about 1m above the top of screen, followed by 1m of bentonite chips, then more sand to surface				
Water used for drilling		Snow-melt from pools at root-ball of fallen trees, ditches, steams.				
Well protection		100 x 100 mm x 1.24 m lockable steel protectors with brass locks.				
Sampling apparatus		Dedicated 13 mm diameter high-density polyethylene Waterra® tubing with Delrin® foot valves.				
Well development		Soloinst Hydrolift® pump powered by 1 Kilowatt generator (kept a minimum 10 m downwind) to actuate the Waterra tubing. MW05-7a may have been underdeveloped as only 3.6 casing volumes were recoverable.				

TABLE 8.7-5 Hydraulic Conductivity Results at Monitoring Wells (All Values in cm/sec)

Location	Test 1		Test 2		Test 3		Mean	Standard Deviation
	Falling	Rising	Falling	Rising	Falling	Rising		
MW05-1a	2.98×10^{-3}	2.63×10^{-3}	4.47×10^{-3}	3.73×10^{-3}	3.44×10^{-3}	3.73×10^{-3}	3.50×10^{-3}	6.44×10^{-4}
MW05-1b	3.31×10^{-3}	4.06×10^{-3}	3.73×10^{-3}	4.06×10^{-3}	3.89×10^{-3}	4.26×10^{-3}	3.89×10^{-3}	3.34×10^{-4}
MW05-2a	8.60×10^{-4}	9.94×10^{-4}	8.60×10^{-4}	8.94×10^{-4}	--	--	9.02×10^{-4}	6.33×10^{-5}
MW05-2b	7.45×10^{-4}	1.28×10^{-3}	7.45×10^{-4}	8.28×10^{-4}	--	--	8.99×10^{-4}	2.55×10^{-4}
MW05-3a	3.58×10^{-3}	5.26×10^{-3}	4.97×10^{-3}	5.96×10^{-3}	4.26×10^{-3}	5.96×10^{-3}	5.00×10^{-3}	9.48×10^{-4}
MW05-3b	8.94×10^{-3}	6.88×10^{-3}	9.94×10^{-3}	8.94×10^{-3}	2.63×10^{-2}	5.96×10^{-3}	1.12×10^{-2}	7.56×10^{-3}
MW05-4a	5.73×10^{-3}	4.86×10^{-3}	5.59×10^{-3}	6.12×10^{-3}	6.58×10^{-3}	6.39×10^{-3}	5.88×10^{-3}	6.24×10^{-4}
MW05-4b	1.02×10^{-2}	1.24×10^{-2}	1.12×10^{-2}	--	--	--	1.13×10^{-2}	1.13×10^{-3}
MW05-5a	4.97×10^{-4}	4.97×10^{-4}	3.99×10^{-4}	5.26×10^{-4}	--	--	4.80×10^{-4}	5.54×10^{-5}
MW05-5b	5.96×10^{-4}	1.28×10^{-3}	6.77×10^{-4}	--	--	--	8.50×10^{-4}	3.72×10^{-4}
MW05-6a	3.44×10^{-4}	4.06×10^{-4}	--	--	--	--	3.75×10^{-4}	4.42×10^{-5}
MW05-6b	3.89×10^{-5}	2.37×10^{-5}	--	--	--	--	3.13×10^{-5}	1.08×10^{-5}
MW05-7a	8.94×10^{-4}	2.03×10^{-3}	--	--	--	--	1.46×10^{-3}	8.05×10^{-4}
MW05-7b	5.81×10^{-4}	3.58×10^{-4}	--	--	--	--	4.69×10^{-4}	1.58×10^{-4}

TABLE 8.7-6 Summary of protocol used for Sample Collection

Sample	Bottle Type	Sample Filtered	Preservative Added	Additional Comments
General Chemistry	200 ml polyethylene	No	No	None
Dissolved Metals	50 ml polyethylene	Yes Millipore Luer-Lok filters to 0.45 µm with sterile syringe (new) for each sample	Nitric acid	None
Mercury	100 ml amber glass with Teflon lined cap	No	Potassium dichromate in nitric acid	Preservative added prior to sample collection. Bottle filled to zero headspace without overflow.
Total Petroleum Hydrocarbon	2 – 250 ml clear glass with Teflon lined cap	No	No	None
	3 – 40 ml amber glass with Teflon lined septum caps	No	Copper sulphate	Preservative added prior to sample collection. Bottle filled to zero headspace without overflow
VOC	3 – 40 ml clear glass with Teflon lined caps	No	Sodium bi-sulphate	Collected directly from open end of Waterra tubing. Preservative added prior to collection. Bottle filled to zero headspace without overflow.

- all samples were stored in coolers with ice pack immediately after collection until return to the field office daily, where they were kept refrigerated until return to coolers with ice pack for delivery to Maxxam Analytics inc. in Bedford, Nova Scotia. Maximum sample storage time was seven days; and
- samples were analyzed using the lab protocol summarized in Table 8.7-3.

8.7.3.4 Physical Site Hydrogeology

With the exception of MW05-1a and MW05-1b, static groundwater depths were measured at the monitoring wells on two occasions during the field program – once just before commencing well development and a second time at the start of the hydraulic testing. The measurement dates and calculated groundwater elevations are summarized in Table 8.7-7 below.

Measurements were taken only once at MW05-1a and MW05-1b because well development and hydraulic testing there were done the same day. Measurements were taken at MW05-6a on two separate occasions. However, it was found that bentonite had fallen into the monitoring well during construction and water was used to wash it out. Due to a slow water level recovery time, an accurate measurement was not possible before commencing well development. It was not possible to measure groundwater levels at all wells on the same day due to field schedules and long distances between stations.

TABLE 8.7-7 Groundwater Elevations at Monitoring Wells (elevations reference mean sea level)

Location	Measurement Event 1			Measurement Event 2		
	Date	Elevation (m)	h* (m)	Date	Elevation (m)	h* (m)
MW05-1a	16/04/05	73.27	+0.05	na	na	na
MW05-1b		73.21			na	
MW05-2a	10/04/05	54.19	-1.2	14/04/05	54.36	-0.81
MW05-2b		55.39			55.17	
MW05-3a	11/04/05	37.01	+0.07	14/04/05	36.90	+0.08
MW05-3b		36.94			36.82	
MW05-4a	13/04/05	34.97	-0.05	14/04/05	35.00	0
MW05-4b		35.02			35.00	
MW05-5a	17/04/05	33.88	+0.95	18/04/05	33.85	+0.95
MW05-5b		32.93			32.90	
MW05-6a	18/04/05	na	na	19/04/05	14.54	+0.53
MW05-6b		14.47		19/04/05	14.01	
MW05-7a	21/04/05	6.17	+0.05	03/05/05	6.65	+0.09
MW05-7b		6.12		03/05/05	6.56	

Note: * (+) and (-) values designate groundwater recharge and discharge conditions, respectively.

Groundwater level fluctuations were found to range from about 3 cm at most wells, to 48 cm at MW05-7a. Water level fluctuations in the order of 2 m to 3 m might be expected seasonally, with the greatest fluctuations occurring at station MW05-7 based on currently available information.

Based on h values (difference in water elevation between shallow and deep well pair) in Table 8.7-7, most areas of the proposed Keltic Site would be considered to be groundwater recharge zones (groundwater recharge conditions are considered present when piezometric levels for shallow horizons are higher than for deeper horizons). Hydraulic communication was found to exist between many of the monitoring well pairs during hydraulic testing (suggesting both vertical and lateral bedrock fracturing), and so the relative differences in magnitude for .h values from one monitoring well station to the other are likely as much a function of the communication that exists between well pairs, as it is to the relative degree of recharge or discharge at any location.

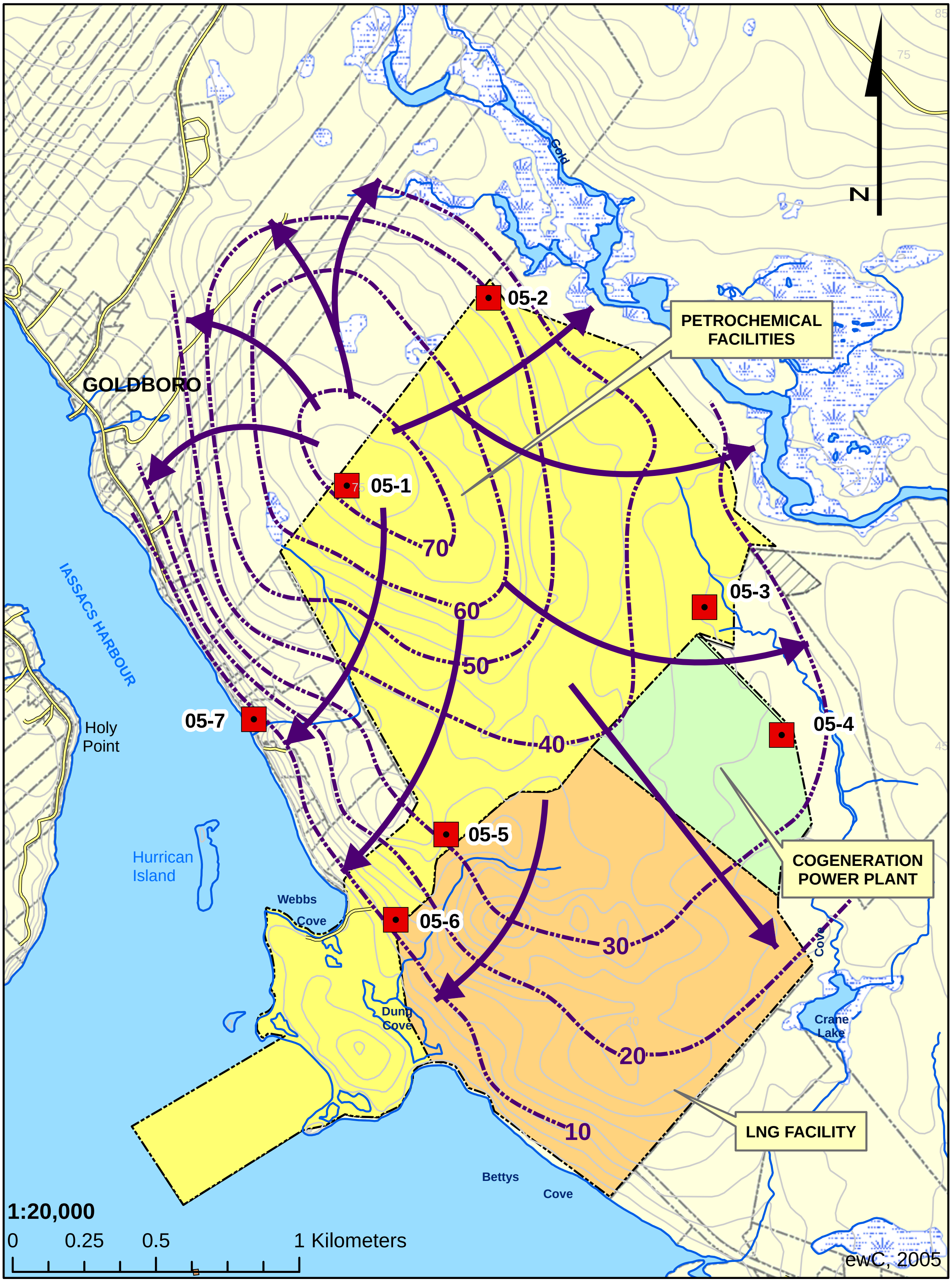
Figure 8.7-3 is a piezometric contour map of the site drawn using the second set of groundwater level measurements for the “a” (deeper) well series. The piezometric contours for the “b” (shallow) well series would be similar. From this, groundwater would be expected to flow radially (dark blue curved arrows) from around the northwest boundary of the site toward Gold Brook and Betty’s Cove Brook to the east, southeast and south, the hamlet of Goldboro to the north and northwest, and the ocean to the west and southwest. However, also shown in Figure 8.7-10 are possible groundwater flow paths of potential least resistance (straight, light blue lines) as might be indicated from the current knowledge of faults, shear zones and abandoned underground workings on the proposed Keltic Site. These are expected to have a significant influence on the actual routes groundwater would flow underground – some components of flow could parallel the shore of Isaac's Harbour, while others are deflected east and west just above the proposed marginal wharf area. However, some faults are also known in other places to not allow groundwater to migrate along or across them. Additional monitoring wells are needed to help better characterize this situation.

The results of the hydraulic (slug) conductivity testing are summarized in Table 8.7-5. The overall average value obtained for hydraulic conductivity at the proposed Keltic Site is $3.30x10^{-3} \pm 3.83x10^{-3}$ cm/sec, with the lowest of $3.13x10^{-5}$ cm/sec being at MW05-6b, and the highest value of $1.13x10^{-2}$ cm/sec at MW05-4b. The norms for fractured and unfractured metamorphic rock are in the order of $7x10^{-7}$ to $5x10^{-2}$ cm/sec, and $< 1x10^{-12}$ to $1x10^{-8}$ cm/sec, respectively (Freeze and Cherry, 1979). The hydraulic conductivity values obtained at the Keltic Study Area are within the upper end of the generally recognized spectrum for fractured metamorphic bedrock.

There was a response at the shallow monitoring wells when testing the deeper ones, and vice-versa at nearly all of the monitoring well pairs. These usually rapid water fluctuation responses ranged from 1 cm at the monitoring well pairs where the hydraulic conductivity values were generally lower, to 8 cm at other well pairs – a significant water level change considering the relatively small (maximum 49 cm) displacement actually created by dropping a 1 L slug into the well being tested.

The distribution of values throughout the proposed Keltic Site suggests that hydraulic conductivity in the vicinity of MW05-3 and MW05-4 are highest. This is consistent with the understanding that the lineaments defined by Betty's Cove Brook may represent bedrock faults which no one has yet been able to otherwise map.

FIGURE 8.7-3 Piezometric Contour Map Showing Probable Gravitational Flow Direction



Legend

Monitoring Well Locations

Piezometric Contours

Probable Gravitational Flow Direction

FIGURE No. 8.7-3

KELTIC PETROCHEMICALS INC.

PIEZOMETRIC CONTOUR MAP SHOWING PROBABLE GRAVITATIONAL FLOW DIRECTION

July 2006

The hydraulic conductivity values obtained at the deep and shallow piezometres at each monitoring well pair are for the most part quite similar. The hydraulic conductivity values obtained for the shallower wells are general slightly higher than those for the neighbouring deeper well. This is likely a function of the greater degree of bedrock weathering expected at the shallower depths. The reverse appears to be the case at MW05-6 and MW05-7 where hydraulic conductivity for the deeper bedrock horizon was found to be greater than in the shallower horizons. The overall hydraulic conductivity at these wells was lower than in other places. This reverse relationship may suggest a greater relative degree of bedrock fracturing at depths below the wells at those locations.

Table 8.7-2 lists average values (shallow and deep wells for two monitoring well locations) for hydraulic conductivity, and estimated average groundwater flow velocities between various monitoring stations using hydraulic gradients from Figure 8.7-2. Based on this information and assuming that plant facilities are located up to about ¾ of the distance from the centre of the site (roughly 200 m from the site boundaries), notwithstanding the effects that faults and/or underground workings may have on groundwater flows locally, one could conceivably expect groundwater (and dissolved spills) to take in the order of 3.8 to 9.5 years to migrate off site in a northeasterly direction toward Gold Brook and Betty's Cove Brook, 8 years to migrate in a west to southwesterly direction toward the ocean, and about 20 years to migrate in a southeasterly direction to Betty's Cove Brook.

TABLE 8.7-8 Groundwater Flow Velocity Estimates at the Proposed Keltic Site

From – To		Average K (cm/sec)	Average Groundwater Flow Velocity (m/yr)
MW05-1	MW05-2	$2.30x10^{-3}$	21.0
MW05-1	MW05-7	$2.33x10^{-3}$	51.7
MW05-1	MW05-3	$5.90x10^{-3}$	53.0
MW05-3	MW05-4	$8.35x10^{-3}$	9.5
MW05-1	MW05-4	$6.14x10^{-3}$	43.6
MW05-1	MW05-5	$2.18x10^{-3}$	22.6
MW05-5	MW05-6	$4.34x10^{-4}$	6.0
MW05-1	MW05-6	$1.95x10^{-3}$	24.6
MW05-5	MW05-7	$8.15x10^{-4}$	9.1

With few exceptions, the glacial till appears to be relatively thin throughout the proposed Keltic Site and as such, the low permeability till is expected to influence only very local groundwater flows at the site. The more intermediary to regional groundwater flows present within bedrock should be considered as the more significant flow components at this site.

8.7.3.5 Chemical Hydrogeology

The analytical results for the samples of surface water used to drill and for the groundwater samples collected from the monitoring wells installed during the 2005 field season are summarized in Table 8.7-9 for general chemistry and metals, and Table 8.7-10 for organic compounds.

The Piper diagram in Figure 8.7-4 shows the relative distribution of major ions in water and gives a comparison of the groundwater samples collected from the monitoring wells to other groundwaters collected from dug and drilled water supply wells located within 1 km of the proposed Keltic Site, and surface water samples taken from local streams (Gold Brook, Isaac's Harbour River) and on- or near-site surface water used for drilling (from local ditches, snow melt and Betty's Cove Brook and Crusher Brook, which both originate within the Keltic Site boundaries).

The major ion chemistry is similar for most of the monitoring well samples as well as for all of the drilled water supply wells sampled, being mostly calcium bicarbonate type waters. There are generally no significant differences in major ion concentration among the deeper and shallower monitoring wells. Two notable exceptions, however, are at the north edge of the Keltic Site at MW05-1a, MW05-1b, MW05-2a and MW05-2b, where samples from the deeper wells contained sodium bicarbonate type waters and samples from the shallow wells contain sodium chloride type waters. The sample from MW05-6b is a sodium-bicarbonate type water, and that from MW05-7b is borderline between calcium-bicarbonate and sodium-chloride type water. These are likely showing a certain degree of surface water influence (recharging waters with lower residence times). The dug water supply wells in Goldboro are similar to these, but exhibit a greater range in relative amount of chloride versus bicarbonate.

The surface waters are distinct from groundwater in that they are predominantly sodium sulphate type waters from Gold Brook and Isaac's Harbour River (waters from off the Keltic Site), and sodium chloride type waters used for drilling (waters originating at the Keltic Site). The Gold Brook and Isaac's Harbour River waters also contain a slightly higher proportion of magnesium than the other surface waters (those used for drilling), whereas the relative proportion of magnesium is roughly the same for all water supply wells and monitoring well waters.

The monitoring wells generally produce soft to only slightly hard waters with low total dissolved solids, low alkalinity, and generally near neutral pH. The Langelier Index calculations for waters from the monitoring wells are all slightly negative – these are all under saturated with respect to calcium carbonate. A few monitoring wells have elevated aluminum concentrations, several have iron and manganese concentrations that exceed guideline values, and arsenic concentrations were elevated at MW05-5a, MW05-5b, MW05-6a and MW05-6b, all of which are located within or near highly mineralized areas.

As relates to the organic parameters in Table 8.7-10, all concentrations are generally below the lab's detection levels, except chloroform, which is above the fresh water aquatic guideline value at MW05-1a, MW05-1b, MW05-2b, and present (but below the guideline value) at MW05-7a, as well as in the air transfer blank. This suggests either analytical problems (unlikely based on the lab's QA/QC data), or airborne contributions during sampling (sampling at these locations was done near/under conifers).

TABLE 8.7-9 General Chemistry and Metals Analysis Results for Surface Water Used to Drill and for Groundwater Samples Collected from the Monitoring Wells Installed During the 2005 Field Season

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TABLE 8.7-9 General Chemistry and Metals Analysis Results for Surface Water used to Drill and for Groundwater Samples Collected from the Monitoring Wells Installed during the 2005 Field Season

Description	Units	CCME Guidelines Values (2003)				Surface Water Samples – Water Used for Drilling Monitoring Wells							On Site Monitoring Wells Installed Spring 2005															QA/QC	Detection Limit
		Drinking Water		Aquatic Life		Snow Melt	Flowing Ditch	Stream-Snow Melt	Snow Melt	Flowing Ditch	Stream	Stream	MW-1a	MW-1b	MW-2a	MW-2b	MW-3a	MW-3b	MW-4a	MW-4b	MW-4b	MW-5a	MW-5b	MW-6a	MW-6b	MW-7a	MW-7b	Field Dup at MW-6a	
Sample Location/Parameter		MAC/IMAC	AO	Fresh	Marine	102F01-4-1	102F01-4-2	102F01-4-3	102F01-4-4	102F01-4-5	102F01-4-5C	102F01-4-7C	102F01-4-1A	102F01-4-1B	102F01-4-2A	102F01-4-2B	102F01-4-3A	102F01-4-3B	102F01-4-4A	102F01-4-4B	102F01-4-4B Dup	102F01-4-5A	102F01-4-5B	102F01-4-6A	102F01-4-6B	102F01-4-7A	102F01-4-7B	102F01-4-8A	
Sodium (Na)	mg/L	200				4.4	24	11	4.9	17	4.8	5.7	11	5.3	11	6	9.6	7.3	8.2	7.2	7.2	10	14	10	51	8.1	10	10	0.1
Potassium (K)	mg/L					0.5	0.8	0.7	0.4	0.4	0.4	0.5	1	0.7	2.9	0.6	1.8	1.4	2	1.9	1.9	2.2	2.6	2.2	2.2	4.5	1.4	1.4	0.1
Calcium (Ca)	mg/L					0.3	3.1	1.7	1.3	4.2	1.3	2.3	3.5	1.6	6.4	1	18	16	14	14	15	29	27	25	4.6	20	11	11	0.1
Magnesium (Mg)	mg/L					0.4	0.7	0.7	0.5	0.9	0.4	0.6	0.8	0.6	2.3	0.7	1	0.8	1	1	1.2	2.5	2.4	2.8	0.8	1.9	1.5	1.4	0.1
Alkalinity (as CaCO3)	mg/L					ND	ND	ND	ND	ND	ND	8.6	22	ND	27	ND	47	35	42	35	39	87	96	87	89	42	25	27	5
Sulphate (SO4)	mg/L	500				ND	ND	ND	ND	ND	15	<5	4.6	3	ND	3.6	3.2	2.9	3.1	2.7	2.8	4.3	9.2	7.1	7.8	11	5.4	5.5	2
Chloride (Cl)	mg/L	250				6.6	38	18	7.3	29	6.3	7.8	10	8.3	7.6	7.2	10	9.8	6.5	6.6	6.6	10	12	6.5	5	8.4	15	15	1
Reactive Silica (SiO2)	mg/L					2.4	2.2	2.6	3.2	2	4.4	5.5	4.4	7.8	18	5.5	8.1	7.6	9.5	8.9	8.8	6.4	7	7.7	8.1	3.8	5.5	5.6	0.5
Orthophosphate (P)	mg/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
Phosphorus (P)	mg/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1	ND	ND	ND	0.2
Nitrate + Nitrite	mg/L					0.05	0.06	0.14	0.06	0.06	ND	0.06	ND	ND	ND	0.07	0.07	0.06	0.13	0.1		ND	ND	0.07	0.19	0.08	ND	ND	0.05
Nitrate (N)	mg/L	10				0.05	0.06	0.14	0.06	0.06	ND	0.06	ND	ND	ND	0.07	0.07	0.06	0.13	0.1	TBA	ND	ND	0.07	0.18	0.08	ND	ND	0.05
Nitrite (N)	mg/L	3.2		0.06		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01	ND	ND	ND	0.01
Nitrogen (Ammonia Nitrogen)	mg/L			1.37 – 2.20		0.07	0.06	ND	ND	ND	ND	0.05	ND	ND	ND	ND	ND	ND	ND	0.05	ND	0.14	0.06	ND	ND	0.1	ND	ND	0.05
Total Organic Carbon (C)	mg/L					11	8.6	11	12	12	6.2	6.4	ND	ND	ND	ND	ND	0.8	ND	ND		2.5	6.1	ND	11	ND	ND	ND	0.5
Colour	TCU		15			68	57	80	72	72	39	34	ND	ND	18	ND	ND	ND	ND	ND	ND	21	26	ND	ND	15	8.9	12	5
pH	pH		6.5 – 8.5	6.5-9.0	7.0-8.7	4.7	5.24	4.71	4.91	5.82	5.77	7.15	7.18	6.46	6.86	6.31	6.66	6.8	7	6.95	6.95	6.75	7.03	6.86	7.37	8.38	7.08	6.68	N/A
Turbidity	NTU	1	5			0.3	0.6	1.2	1.3	0.3	0.4	1.6	22	80	98	770	120	1.4	8.3	110	120	15	49	350	240	2200	38	54	0.1
CoNDuctivity	uS/cm					41	140	76	42	120	36	57	69	41	110	44	150	130	130	120	120	190	190	180	190	130	110	110	1
Calculated TDS	mg/L		500			15.2	69.4	35.3	18.4	54.6	32.3	28	48.3	27.7	70.2	25.7	81.5	67.3	70.4	63.5	67.3	123	133	114	135	83.8	65.7	66.7	1
Hardness (CaCO3)	mg/L					2.4	11	7.3	5.6	14	5	8	12	6.6	25	5.4	49	43	40	38	43	82	77	74	15	57	33	33	N/A
Bicarb. Alkalinity (calc. as CaCO3)	mg/L					ND	ND	ND	ND	ND	ND	9	21.9	ND	27.4	ND	47.1	35.1	41.8	34.7	38.8	86.9	96.2	86.5	89.2	41.2	25.1	27.4	1
Carb. Alkalinity (calc. as CaCO3)	mg/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Cation Sum	me/L					0.289	1.28	0.65	0.363	1.05	0.324	0.433	0.736	0.389	1.25	0.407	1.46	1.23	1.21	1.13	1.23	2.3	2.24	1.97	2.6	1.63	1.14	1.13	N/A
Anion Sum	me/L					0.188	1.08	0.52	0.211	0.819	0.48	0.395	0.815	0.296	0.763	0.282	1.31	1.04	1.09	0.945	1.02	2.12	2.45	2.07	2.11	1.31	1.04	1.09	N/A
Ion Balance (% Difference)	%					21	8.41	11.1	26.4	12.2	19.5	4.53	5.08	13.5	24.1	18.1	5.52	8.07	5.04	9.04	9.2	4.14	4.54	2.38	10.4	10.8	4.48	2.03	N/A
Langelier Index (@ 20C)	N/A					NC	NC	NC	NC	NC	NC	-2.87	-2.24	NC	-2.22	NC	-1.74	-1.77	-1.55	-1.69	-1.6	-1.22	-0.919	-1.15	-1.38	-0.042	-1.81	-2.17	N/A
Langelier Index (@ 4C)	N/A					NC	NC	NC	NC	NC	NC	-3.12	-2.49	NC	-2.47	NC	-2	-2.03	-1.8	-1.94	-1.85	-1.47	-1.17	-1.4	-1.63	-0.294	-2.06	-2.43	N/A
Saturation pH (@ 20C)	N/A					NC	NC	NC	NC	NC	NC	10	9.42	NC	9.08	NC	8.4	8.57	8.55	8.64	8.55	7.97	7.95	8.01	8.75	8.42	8.89	8.85	N/A
Saturation pH (@ 4C)	N/A					NC	NC	NC	NC	NC	NC	10.3	9.67	NC	9.33	NC	8.66	8.83	8.8	8.89	8.8	8.22	8.2	8.26	9	8.67	9.14	9.11	N/A
Total Mercury (Hg)	ug/L	1		0.1							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND	ND	ND	ND	ND	
Aluminum (Al)	ug/L			5 – 100		210	200	180	370	240	150	150	120	200	79	46	53	ND	31	28	27	67	120	38	400	470	51	54	10
Antimony (Sb)	ug/L	6				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.2	ND	ND	ND	ND	ND	ND	2
Arsenic (As)	ug/L	25		5.0	12.5	ND	ND	3	ND	8.8	ND	ND	ND	ND	2	ND	12	3.2	ND	ND	ND	600	280	100	53	2.9	ND	ND	2
Barium (Ba)	ug/L	1000				ND	10	ND	5.1	5.7	ND	ND	6.4	6.1	6.2	5.4	6.4	ND	6.5	ND	5.1	7.9	9.6	7.1	5.5	7.7	6.9	6.5	5
Beryllium (Be)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Bismuth (Bi)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Boron (B)	ug/L	5000				ND	ND	ND	ND	ND	ND	ND	ND	ND	6.3	5.8	5.4	ND	5.1	ND	ND	13	11	5.9	13	5.9	8.4	5.9	5
Cadmium (Cd)	ug/L	5		0.017	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5	ND	ND	ND	0.3
Chromium (Cr)	ug/L	50		1.0	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Cobalt (Co)	ug/L					ND	ND	ND	ND	2.6	ND	ND	ND	1.5	ND	3.1	ND	ND	ND	ND	ND	6.4	1.5	1.2	ND	ND	6.4	6.3	1
Copper (Cu)	ug/L	1000		2 – 4		ND	ND	ND	ND	ND	ND	ND	ND	2.1	ND	13	ND	ND	ND	ND	ND	ND	2.1	3.7	3.2	2.9	ND	2.1	2
Iron (Fe)	ug/L		300	300		300	150	190	370	420	100	230	ND	150	4200	560	470	130	ND	ND	ND	3400	430	ND	230	460	120	120	50
Lead (Pb)	ug/L	10		1 – 7		ND	0.6	0.6	0.6	ND	ND	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.3	4.1	ND	0.6	0.6	ND	ND	0.5
Manganese (Mn)	ug/L		50			9.8	38	52	6.3	520	8.7	16	100	110	360	140	120	35	47	55	55	980	640	140	33	170	450	450	2
Molybdenum (Mo)	ug/L			73		ND	ND	ND	ND	ND	ND	ND	21	6.7	2.2	36	15	6.3	28	28	27	10	6.5	20	190	39	6.5	5.9	2
Nickel (Ni)	ug/L			25 – 150		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.5	ND	ND	2.2	2.2	2.3	ND	ND	2.9	ND	ND	3	3.1	2
Selenium (Se)	ug/L	10		1.0		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Silver (Ag)	ug/L			0.1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5
Strontium (Sr)	ug/L					ND	17	12	5.2	29	8.1	14	21	8.4	39	15	93	85	70	63	64	200	150	100	25	57	50	49	5
Thallium (Tl)	ug/L			0.8		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1
Tin (Sn)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Titanium (Ti)	ug/L					2.6	2.4	ND	4.3	2	ND	ND	ND	ND	2.4	ND	ND	ND	ND	ND	ND	ND	4.8	ND	9.1	12	ND	ND	2
Uranium (U)	ug/L	20				ND	ND	ND	ND	ND	ND	ND	0.1	ND	ND	ND	0.5	0.2	0.2	0.1	0.1	0.7	0.6	0.7	1.1	0.4	ND	ND	0.1
Vanadium (V)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Zinc (Zn)	ug/L		5000	30		ND	5.4	8.1	34	6.8	5.9	7.6	7.1	ND	7.5	7.8	5.7	ND	ND	ND	ND	7.2	20	8	ND	ND	7.5	12	5
Total coliform	P/A	A																											
E.coli.	P/A	A																											

ND = Not detected

CCME – assumes lowest values (i.e. haxavalent chromium vs. trivalent, etc)

Values that exceed one CCME guideline value or another (guideline may or may not be applicable to water use) are shaded.

CCME: MAC = maximum allowable concentration, IMAC = interim MAC, A) = aesthetic objective.

TABLE 8.7-10 Organic Chemistry Analysis Results for Groundwater Samples Collected from the Monitoring Wells Installed During the 2005 Field Season

TABLE 8.7-10 Organic Chemistry Analysis Results for Groundwater Samples Collected from the Monitoring Wells Installed during the 2005 Field Season

Description	Units	CCME Guideline Values				Monitoring Well Groundwater Samples														Field Quality Assurance/Quality Control			Detection Limit
		Drinking Water		Aquatic Life		MW-1a	MW-1b	MW-2a	MW-2b	MW-3a	MW-3b	MW-4a	MW-4b	MW-5a	MW-5b	MW-6a	MW-6b	MW-7a	MW-7b	air transfer	field dup MW-6a	Field Blank	
Sample/Parameter		MAC/IMAC	AO	Fresh	Marine	102F01-4-1A	102F01-4-1B	102F01-4-2A	102F01-4-2B	102F01-4-3A	102F01-4-3B	102F01-4-4A	102F01-4-4B	102F01-4-5A	102F01-4-5B	102F01-4-6A	102F01-4-6B	102F01-4-7A	102F01-4-7B	102F01-4-7C	102F01-4-8A		
EXTRACTABLE HYDROCARBONS (PIRI)																							
>C10-C21 Hydrocarbons	mg/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.06	ND	ND	ND	ND	0.06	ND	0.05
>C21-<C32 Hydrocarbons	mg/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1
Modified TPH (Tier1)	mg/L	1.1				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1
Volatile Hydrocarbons																							
Benzene	mg/L	0.005	0.32	0.11		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.001
Toluene	mg/L		0.024	0.002	0.215	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.001
Ethylbenzene	mg/L		0.0024	0.09	0.025	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.001
Xylene (Total)	mg/L		0.3			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.002
C6 - C10 (less BTEX)	mg/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
Surrogate Recovery (%)																							
Isobutylbenzene - Extractable	%					97	99	100	97	95	94	97	100	97	96	98	96	96	99	95	100	94	
n-Dotriacontane - Extractable	%					93	94	89	85	82	91	90	95	86	86	90	86	86	92	96	96	92	
Isobutylbenzene - Volatile	%					101	101	96	93	96	96	95	96	100	100	100	99	96	102	104	105	108	
CHLOROBENZENES																							
1,2-Dichlorobenzene	ug/L	200	3	0.7	42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5
1,3-Dichlorobenzene	ug/L			150		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
1,4-Dichlorobenzene	ug/L	5	1	26		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Chlorobenzene	ug/L	80	30	1.3	25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
VOLATILES																							
1,1,1-Trichloroethane	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
1,1,2,2-Tetrachloroethane	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
1,1,2-Trichloroethane	ug/L	50		21		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
1,1-Dichloroethane	ug/L	14				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
1,1-Dichloroethylene	ug/L	14				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
1,2-Dibromoethane (EDB)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
1,2-Dichloroethane	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
1,2-Dichloropropane	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Benzene	ug/L	0.005	0.32	0.11		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Bromodichloromethane	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Bromoform	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Bromomethane	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8
Carbon Tetrachloride	ug/L	5		13.3		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Chloroethane	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8
Chloroform	ug/L			1.8		2.7	2.7	ND	1.9	ND	ND	ND	ND	ND	ND	ND	ND	1.1	ND	2.3	ND	ND	1
Chloromethane	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8
cis-1,2-Dichloroethylene	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
cis-1,3-Dichloropropene	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Dibromochloromethane	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Dichloromethane(Methylene Chloride)	ug/L	50		98.1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3
Ethylbenzene	ug/L		0.0024	0.09	0.025	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
o-Xylene	ug/L		0.3			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
p+m-Xylene	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Styrene	ug/L			72		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Tetrachloroethylene	ug/L	30		111		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Toluene	ug/L		0.024	0.002	0.215	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
trans-1,2-Dichloroethylene	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
trans-1,3-Dichloropropene	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Trichloroethylene	ug/L	50		21		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Trichlorofluoromethane (FREON 11)	ug/L					ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8
Vinyl Chloride	ug/L	2				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Surrogate Recovery (%)																							
4-Bromofluorobenzene	%					100	98	97	95	97	94	97	96	99	98	99	97	101	100	99	100	101	
D4-1,2-Dichloroethane	%					102	104	100	99	99	98	99	97	105	104	106	108	105	106	106	104	105	
D8-Toluene	%					107	99	95	93	93	93	93	97	102	101	99	99	100	100	101	101	102	

ND = Not detected

CCME: MAC = maximum allowable concentration, IMAC = interim MAC, AO = aesthetic objective.

Values that exceed one CCME guideline value or another (guideline may or may not be applicable to water use) are shaded.

FIGURE 8.7-4 Piper Diagram for the Water Samples in this Study

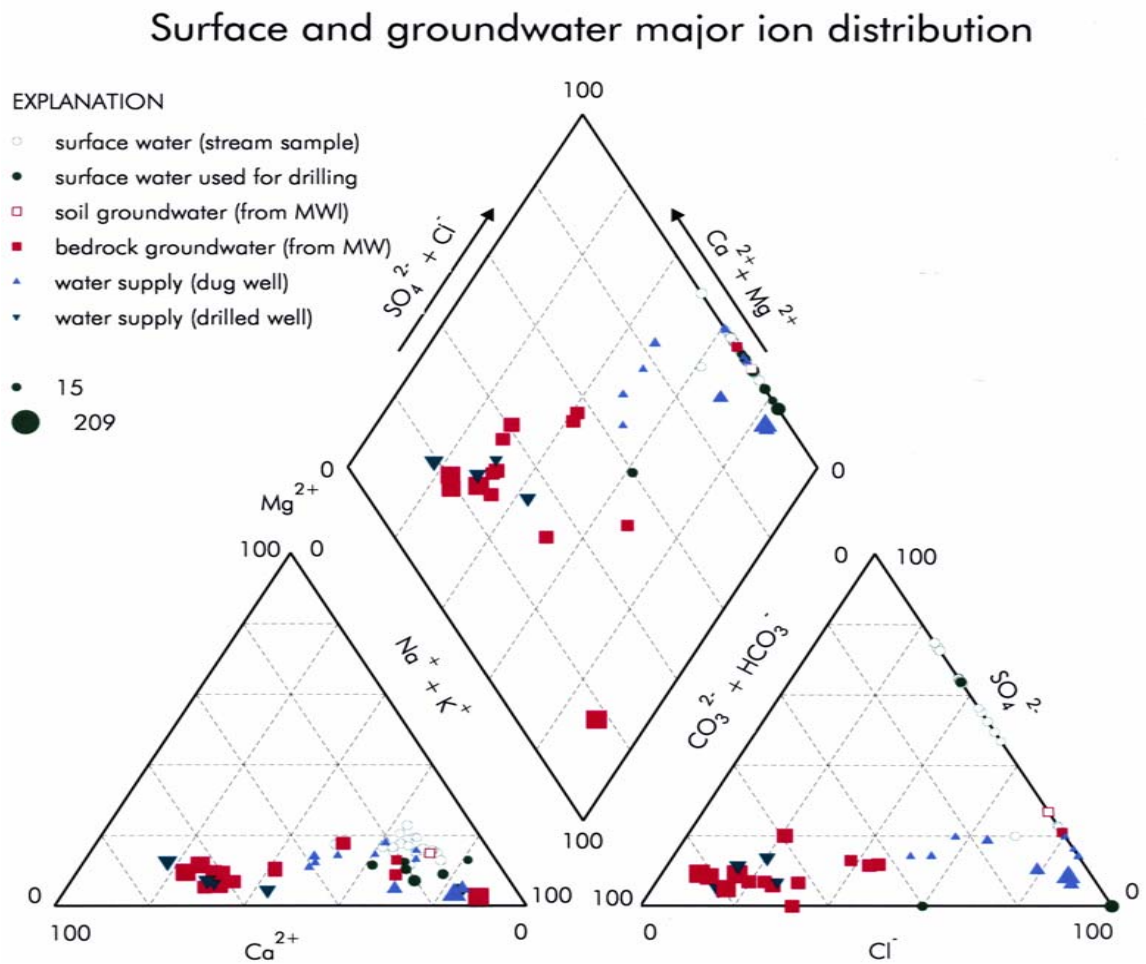


FIGURE 8.7-4
KELTIC PETROCHEMICALS INC.
PIPER DIAGRAM FOR THE WATER SAMPLES IN THIS STUDY
JULY 2006
ewC, 2005

8.8 FLORA, FAUNA, AND TERRESTRIAL HABITAT

8.8.1 Methods

The objectives of the terrestrial studies were:

- to carry out an environmental evaluation of the terminal area, and the main Keltic Site (Figure 8.8-1); and
- to evaluate the terrestrial impacts of impoundment in the upper reaches (upstream of the Fox Island vicinity) of New Harbour River and in three lake basins; i.e., Meadow, Goldbrook and Ocean Lakes as possible sources for cooling water.

The main Keltic Site, the three lake basins and New Harbour River are referred to collectively as the "Keltic Study Area." Individually, they are referred to as "study sites."

Vegetation, wildlife, and wildlife habitat were examined in all the relevant areas, with special attention being paid to the possible presence of rare or otherwise unique species, populations, and assemblages.

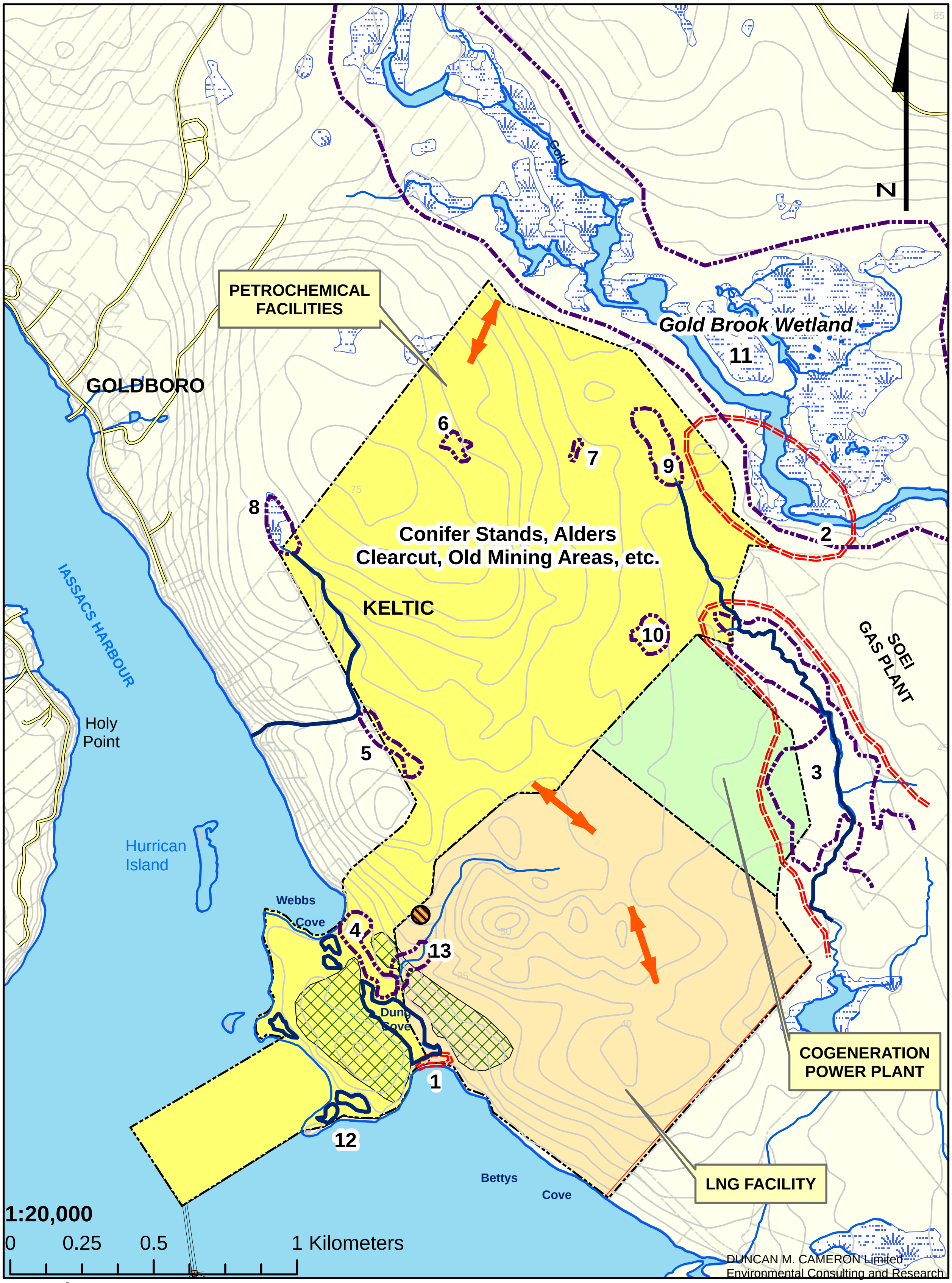
Late in the process, Meadow Lake was selected as the sole proposed source of water for the Keltic Project. Data had been collected from New Harbour River and the two remaining lakes, and are presented herein in tabular form (See Appendices 7 and 8) with discussion at a minimum. Conversely, Meadow Lake is addressed in more detail.

Field studies on both vascular plants and wildlife were carried out in June, August, and early September, 2004, mostly in the lake basins, New Harbour River, and the Keltic Site area. Visits were made in October and November, respectively, to assess the fall migration of waterfowl and marine birds. A winter study directed primarily toward mammalian activity, especially white-tailed deer, took place in February 2005. Field studies in June, July, and August, and early September, 2005, were carried out to complete the full season evaluations of vascular plants and wildlife in all relevant areas, and to complete the evaluation of the Keltic Site proper. Common and scientific names of vascular plants and vertebrate wildlife species observed and noted are presented in Appendices 7 and 8.

Several environmental experts were consulted during the study, including:

- Mark Pulsifer, Regional Biologist, NSDNR, Antigonish;
- Randy Lauff, Dr. Barry Taylor, and Dr. Norman Seymour, St. Francis Xavier University, Antigonish;
- Dr. Graham Forbes, University of New Brunswick;
- Andrew Boyne, Canadian Wildlife Service (CWS), Dartmouth;

FIGURE 8.8-1 Keltic Plant Site and Terminal



Legend

- Sensitive Areas-Birds
- Wetland Areas
- roads_polyline
- Deer Wintering Areas
- Ponds/Streams
- Sample Transects
- Rare Plant Lcoation

Note: See Text for Numbered Map Site Designations

FIGURE No. 8.8-1
KELTIC PETROCHEMICALS INC.
KELTIC PLANT SITE AND TERMINAL
July 2006

- Dr. Hugh Broders, St. Mary's University;
- Dr. Alan Hanson, CWS, Sackville, New Brunswick;
- Andrew Hebda, Alex Wilson, and John Gilhen, Nova Scotia Museum of Natural History (NSMNH), Halifax;
- Richard Hatch and Fulton Lavender, knowledgeable birders and naturalists in general, Halifax;
- Richard Morash, NSDNR Resources, Truro; and
- Frank Manthorne, Joey Manthorne, and Brian Fanning, knowledgeable and observant local residents of Seal Harbour and Drum Head.

Information on "Species-at-Risk" and "Rare" species was obtained from:

- NSDNR, Wildlife Division;
- the Atlantic Canada Conservation Data Centre (ACCDC);
- EC;
- NSMNH;
- COSEWIC; and
- Atlas of Breeding Birds in the Maritime Provinces (Erskine, 1992).

Specific citations have been made at appropriate places in the following text.

8.8.2 Regional Setting

The proposed Keltic Site lies within the East Atlantic Shore Section of the Acadian Forest Region (Rowe, 1972) which is essentially the Atlantic Coast Terrestrial Theme Region described in The Natural History of Nova Scotia, Vol. 2, Theme Regions (NSMHN, 1996b). This region is characterized by stands of black spruce, balsam fir, white spruce, and larch in the wetter areas. Immediately north and parallel to the coast line is the Atlantic Uplands Region (Rowe, 1972), which effectively is also the Atlantic Interior Terrestrial Theme Region (NSMNH, 1996b). Meadow Lake is in the transition zone between these two areas with vegetation somewhat more akin to the coastal region. Different authors (i.e., Rowe, 1972; Loucks, 1962; and NSMNH, 1996b) ascribe different terminology and locations to the vegetation between the Atlantic Uplands and the area of Antigonish. Nonetheless, the basic pattern is that on the higher, better drained areas to the north, deciduous species become more common, especially red and sugar maples, white and yellow birches, and beech.

Wetlands are common in these areas and include marshes, bogs, and fens of various sizes and floristic composition. Barrens and areas of shrub species such as speckled alder, witherod, and various woody heath plants (Fam. Ericaceae) are relatively common. These heaths include rhodora, sheep laurel, lowbush blueberry, huckleberry, mountain cranberry, and checkerberry.

The Atlantic coast line near the proposed Keltic Site provides feeding and breeding habitat for a number of waterfowl, shorebirds, and sea birds. Both resident and migratory bird populations including woodland birds have a significant presence, as do several species of raptors. Meadow vole and snowshoe hare were at peaks in their population density cycles in 2004 and 2005 providing abundant prey for raptors and mammalian carnivores. White-tailed deer are abundant, with greatest winter concentrations observed at the shore of the Keltic Site and along the shore southeast to Drum Head.

8.8.3 Keltic Site

The Keltic Site includes an LNG terminal area southwest of Highway 316 and the larger site area northeast of Highway 316. The LNG terminal area is a peninsula (approx. 35 ha) and a strip (approx. 14 ha) southwest of Highway 316 from the base of the peninsula southeast to the site border (See Figure 8.8-1). Much of the peninsular area reflects past farming activity as indicated by the presence of old-field. There are several small scattered ponds (Map Site 12, Figure 8.8-1), mostly near the shore line, most of which are brackish to some degree. The shoreline vegetation is outlined in Table 8.8-1 and is typical of marine shores in this area of Nova Scotia.

TABLE 8.8-1 Marine Shoreline Plant Species Identified in Peninsular Area

Species Common Name
Seashore Buttercup
Spreading Orach
Sea-blite
Sea Rocket
Beach Pea
Sea Lungwort
Glasswort
Lamb’s Quarters
Sea Lavender
Seal Milkwort
Scotch Lovage
Seashore Plantain
American Dune Grass
Wild Rye Grass

The largest pond, not brackish, is Dung Cove Pond which provides breeding habitat for waterfowl species such as black duck and for semi-aquatic mammals such as muskrat, otter, and beaver. The southeast end of Dung Cove Pond is separated from the marine waters of Betty’s Cove by a cobble dike and beach (Map Site 1, Fig. 8.8-1) on the Betty’s Cove side. This dike, and especially the beach, is important habitat for migrating shore birds (see Section 8.8.6.3).

The southern half of the peninsula contains a mosaic of white spruce that has colonized previously open old-field. Also, heath vegetation and alder are dominant in much of this area. The southwestern tip of the peninsula is a promontory known as Red Head. Red Head was the only site where three-toothed cinquefoil was found. This is a species common to exposed sites such as Red Head.

A wetland area (Map Site 4, Figure 8.8-1) is at the base of the peninsula between the entry road and Dung Cove Pond. This is mostly a marsh dominated by several sedge (*Carex* sp.) and rush (*Juncus* sp.) species. Local residents constructed a now un-used hockey rink several years ago in the midst of this marsh area. Another (Map Site 13, Figure 8.8-1) is associated with a drainage that runs southwest to Dung Cove Pond with an extension into Betty's Cove.

A portion of the terminal area from the base of the peninsula southeast to the site boundary is forested by mosaics of black spruce, balsam fir, and some white spruce. Much of this area has been clear cut. Numerous warbler and other woodland bird species were observed in this area. This strip between Betty's Cove and Highway 316 once was the site of mining activity as evidenced by numerous excavations. During the winter visit of 2005, the greatest deer activity observed was on the peninsula as shown in Figure 8.8-1. This was corroborated by local residents, but the NSDNR (2005) website data do not indicate this.

The larger portion of the proposed site (estimated 353 ha) is northeast and uphill from Highway 316. This area, for the most part has been cut, re-cut, or actively cut with the result that it is an area of changing mosaics of coniferous stands, clear cuts, and shrubland. Much of the area has been subjected to mining activity, leaving excavations, partial excavations, tailings piles, and assorted mining equipment. The presently forested areas are mostly balsam fir. Three transects were sampled to provide some sense of species composition and age structure of these woodland mosaics. Balsam fir composed 84, 88, and 88%, respectively, with black spruce, white birch, red maple, and mountain ash accounting for the remainder. For the most part, these stands are of young age, with 75% of stems less than 20 cm diameter-breast height (dbh). Overall, black spruce is estimated at less than 20% and mostly in the lower, wetter sites, and white spruce (less than 10%). Areas previously clearcut, for the most part, are now dominated by speckled alder, and in some cases by young white birch. Other areas are dominated by heath shrubs.

Several wetlands are on, or functionally associated with, the site. Map Sites 5, 6, and 7 (Figure 8.8-1) are treed bogs with a sphagnous substrate and black spruce and/or tamarack. Map Sites 8 and 9 are level bogs, and Map Sites 3 and 10 are heath shrub fens. Short-eared owl and northern harrier were observed in the wetland area of Map Site 3. Wetlands 4 through 10 are small ranging from 0.2-2.4 ha in size. The wetland at Map Site 3 is part of a much larger area (est. 375 ha) extending south to Drum Head: most of this is offsite, but is important habitat for the short-eared owl (See Sections 8.6.3).

A single rare plant (*Equisetum variegatum*) location is on the site area (See Figure 8.8-1). This species was found earlier (Keltic, 2002) at Goldbrook Lake.

At Map Site 2, Figure 8.8-1, a gas pipeline is located between Gold Brook wetland, and the northeast edge of the site. Black duck and green-winged teal breed here in the wetland and greater yellowlegs breed on higher ground in the same area.

8.8.4 Meadow Lake Basin

Meadow Lake is located approximately 8 km NNE of the Keltic Site terminal area. Major vegetation types in the Meadow Lake Basin are shown in Figure 8.8-2. These were determined from NSDNR (2002) Forest Inventory Mapping, vertical aerial photography, and field observation. Coniferous forest units of various sizes and wetlands form most of the shoreline and the lake basin. Other vegetation includes brush, usually heath shrubs and or speckled alder, and barrens.

Vegetation types and their areas and proportions in the lake basin are shown in Table 8.8-2. Figure 8.8-2 is truncated at the north but, the vegetation of the missing map area is included in the Table.

TABLE 8.8-2 Meadow Lake Vegetation Types

Vegetation Type	Area (ha)	%
Coniferous stands	116	39
Wetlands	111	38
Brush/Barrens	50	17
Raised Bog	11	4
Intolerant HW/Conifer Mix	7	2
Total	295	100

Mixed stands of coniferous tree species, mainly balsam fir and black spruce, and intolerant hardwoods such as red maple and white birch are located variously in the southern part of the basin. Midway to the north, the coniferous stands are dominated by black spruce, and further to the north larch becomes increasingly prominent.

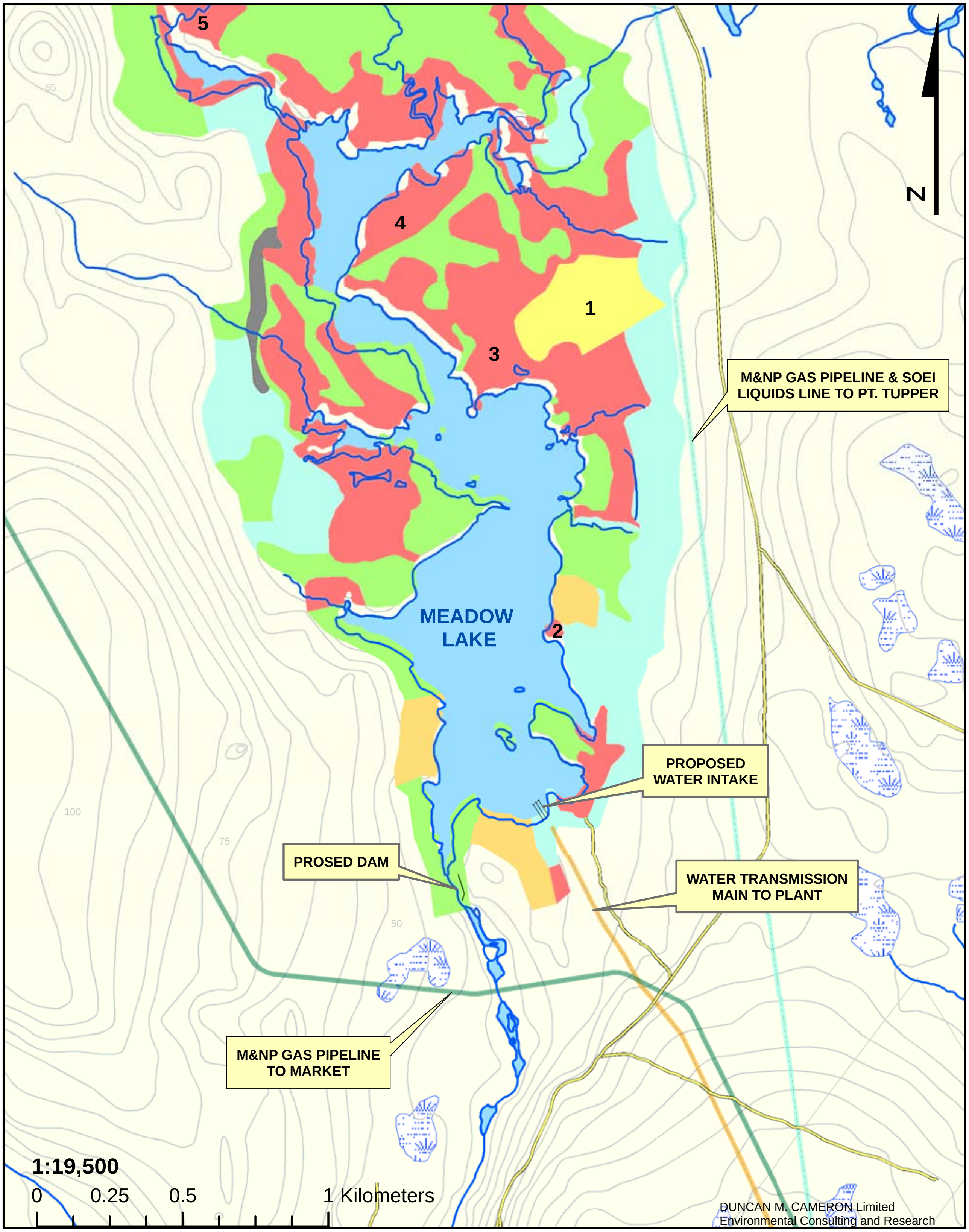
A raised bog is shown at Map Site 1, Figure 8.8-2, with typical vegetation and flarks (linear ponds) in some areas. Peat moss (*Sphagnum* sp.) forms much of the substrate with other plants including bakeapple, pitcher plant, hare's tail, deer grass, bog laurel, Labrador tea, narrow-leaved blueberry, common juniper, bog-rosemary, small and large cranberries, leather-leaf, bog huckleberry, rhodora, black crowberry, black chokeberry, round-leaved sundew, sheep laurel, horned bladderwort, and the orchids, dragon's-mouth and grass-pink. Toward the shore the species composition changes to fen with sedges (i.e., *Carex exilis* and *C. oligosperma*) becoming frequent. A small fen at Map Site 2 contains narrow-leaved sundew, found only at one other site on Goldbrook Lake.

The wetlands at the northern end of the lake are fens but approaching marsh-like characteristics dominated by reed grass, blue-joint, and sedge (*Carex stricta*). Swamp dewberry (*Rubus* cf. *hispidus*) is plentiful (absolute identification is not assured, some species of the genus *Rubus* can be difficult to identify).

Intolerant hardwoods such as red maple and white birch are often found with regenerating coniferous species in areas where there has been some disturbance such as cutting, fire, and blowdown. Brush areas are usually dominated by heath shrubs or by speckled alder, the latter often following clear cutting. Barrens are areas of low heath vegetation with shallow soil on a rock base. Vegetation often comprises reindeer moss (*Cladonia rangiferina*) and black crowberry (NSMNH, 1996a). In the general region, barrens may contain shrub specimens of rhodora, sheep laurel, checkerberry, and red maple.

A diversity of warblers and other woodland birds are along the shore (Appendices 8 and 10). Loon, ring-necked duck, and common merganser breed there, mainly in association with the wetlands at the north end of the lake.

FIGURE 8.8-2 Vegetation Types – Meadow Lake Basin



Legend

- Treed Bog
- Bush and Barrens
- Conifer Stand
- Fen and Marsh
- Intolerant HW/Conifer Mixed Stand
- Raised Bog

Note: See Text for Numbered Map Site Designations

FIGURE No. 8.8-2
KELTIC PETROCHEMICALS INC.
VEGETATION TYPES
MEADOW LAKE BASIN
July 2006

Bald eagle and osprey were noted at the north end of the lake. No nests of either species were observed directly, but it is likely that either or both species do breed in or close to the north end of the lake basin. Immature and adult eagles were observed, as were osprey, carrying prey.

A greater yellowlegs was observed at a wooded wetland at the north end and exhibited distress behaviour usually associated with the presence of young. This site is north of the area of anticipated impoundment.

Deer tracks were seen frequently and a large buck was observed swimming across the lake. NSDNR website data (NSDNR, 2005) indicate that the southwest shore is deer wintering habitat. Only one set of deer tracks was observed in this area during the February 2005 field studies. White-tailed deer are in the lake basin area in significant numbers (*pers. obs.*), but in winter, at least in 2005, activity was much lower than in the Keltic Site area.

8.8.5 Vascular Plants

The complete list of vascular plants noted in all sites is presented in Appendix 7. While during the course of the study, Goldbrook and Ocean Lakes and the New Harbour River system became no longer of concern, data had been collected and are presented in Appendix 7 for some comparison and to contribute to the regional context.

A total of 305 vascular plants were noted in all sites combined of which 259 (85%) are native plants. The number of species found in each study site is shown in Table 8.8-3.

TABLE 8.8-3 Number of Vascular Plant Species

Study Site	Native (%)	Introduced (%)	Total
Meadow Lake	110 (97)	3 (3)	113
Goldbrook Lake	86 (99)	1 (1)	87
Ocean Lake	111 (99)	1 (1)	112
New Harbour River	127 (98)	3 (2)	130
Keltic Site	189 (80)	46 (20)	235
Total*	823	54	677

*These values are greater than the total number in the overall Study Area as some will occur in more than one study site.

Not surprisingly the largest number of introduced species occurs in the Keltic Site/Terminal area. These are the areas that have been exposed to the greatest amount of human activity which introduces non-native species into an area, often inadvertently, and creates disturbances such as farming activity and road building where introduced species are at a competitive advantage.

The numbers of plant species in the three lake basins are statistically the same. The differences that do exist may be due to different intensities of sampling. The New Harbour River system is somewhat more diverse in terms of numbers of species in part because of a rich fern flora. The Keltic Site is most diverse, due especially to the LNG terminal area with its marine influence and the greater number of introduced species.

8.8.5.1 Rare Plants

No plant species observed is reported nationally rare or at risk, but one species, a horsetail (*Equisetum variegatum*), rare in Nova Scotia, (Zinck, 1998; Pronych and Wilson, 1993) was found in two places; i.e., near the shore of Goldbrook Lake (Keltic, 2002) and on the Keltic Site proper. The on-site location is shown in Figure 8.8-1. A second possibly rare species was noted, but the identification is tentative; i.e., sedge (*Carex atlantica* ssp. *capillacea*) found in the New Harbour River system. A concerted effort was made to find rare and otherwise significant species; i.e., at risk (red), and sensitive to human activities or natural events (yellow) (NSDNR, 2004). Northern commandra (*Geocaulon lividum*) considered rare in Nova Scotia (Pronych and Wilson, 1993) is purported to be in the general area, but it was not observed in this study.

It has been suggested by the Protected Areas Branch of the Nova Scotia Government that the Endangered (COSEWIC, 2005) boreal felt lichen (*Eriodermea pedicellatum*) may be in the Study Area, which at this point is the Keltic site and Meadow Lake basin. Both sites are in the historical range of this small lichen, but presently it has been known only from a single site in Halifax Regional Municipality (C & RNSSR: M & C Stewardship, undated). Recently a second location in Nova Scotia has been reported (Cameron, 2004). The likelihood of this lichen being in the Study Area would seem remote. It is known from only two small areas in the province, and it is thought to be threatened by forestry activities, of which there has been considerable in the two study sites, especially the Keltic site proper.

Plants are designated “rare” because it is presumed there are not very many of them. An extensive and intensive survey was carried out in this study, as evidenced by the finding of 305 species over a relatively comprehensive taxonomic range. Species known to be rare and the habitats in which they were likely to be found were given special attention. It is, of course, possible that there are other rare species in the Study Area that were not detected. The Bear Head LNG Terminal EA (ANEI, 2004) was carried out in roughly similar terrain and vegetation. Only two “rare” species were found; i.e., northern commandra and southern twayblade (*Listera australis*), but not *Equisetum variegatum.* This would seem to reinforce the point that “rare species” may indeed be rare.

8.8.6 Wildlife

Wildlife observations are reported for the four terrestrial vertebrate groups. Wildlife in the general region is abundant and diverse, as evidenced by the list of wildlife observed and presented in Appendix 8. Species designated red (thought to be at risk) or yellow (sensitive to human activities) by NSDNR (2002), and/or having an S-rank of S3 or less (ACCDC, 2004) will be so indicated in the following text. See also Section 8.8.6.5 for more detailed explanation of S-ranks.

8.8.6.1 Amphibians

American toad, green frog, pickerel frog, mink frog, and wood frog were observed directly. Green frog was especially abundant in all permanently wet habitats. Spring peeper (*Pseudacris crucifer*), leopard frog (*Rana pipiens*) and bull frog (*Rana catesbiana*) were not observed, but have ranges that may encompass the Study Areas. Special effort was made to locate salamanders, especially the four-toed salamander (*Hemidactylium scutatum*) as it is listed as yellow by NSDNR and S3 by ACCDC. None were observed. In addition to the four-toed salamander, eastern newt (*Notophthalmus viridescens*), spotted salamander (*Ambystoma maculatum*), redback salamander (*Plethodon cinereus*) and blue spotted salamander (*Ambystoma laterale*) and/or its hybrid with Jefferson salamander (*Ambystoma laterale-jeffersonianum*) are expected to be in parts of the larger Study Area. Amphibians observed are presented in Appendix 8.

8.8.6.2 Reptiles

Reptiles observed are presented in Appendix 8. Three species of snakes were observed; i.e., eastern garter snake and red-bellied snake on the Keltic Site, and smooth green snake near Meadow Lake. Ring-necked snake (*Diadophis punctatus*), though not observed, is probably present. Three turtle species that were not observed may be in the Study Area. Snapping turtle (*Chelydra serpentina*) is expected in all lakes and permanent streams and may be in Dung Cove Pond in the LNG terminal area. Similarly, painted turtle (*Chrysemys picta*) would be expected in bodies of permanent water where they often bask on old logs, rocks, and open shores. Wood turtle (*Clemmys insculpta*)(yellow; S3), the most terrestrial of the three species, is possibly present.

8.8.6.3 Birds

Bird surveys were conducted throughout the entire Study Area with the objective of 1) determining which bird species were on or adjacent to the study sites, and 2) characterizing the birds communities with respect to breeding activity, seasonality, location, and habitat use. These surveys were carried out most intensively during August, and early September. Generally they were initiated at sunrise but bird species presence was noted throughout the day and during the evening crepuscular hours. Birds were identified by song and direct observation. One person did all the song identification along with estimation of numbers. To meet objectives, it was felt that a transect method with limited time at each station was not the best approach. One reason for this is that we did not always have the luxury of good weather. Also, the Keltic site is not linear, rather it is a 390 ha (approx.) polygon with a peninsular (terminal area). Land uses have undergone considerable changers over time, and indeed are still being undergone, most recently by clear cutting with the result that the site is a collection of changing mosaical habitats; i.e., the site was manifestly different in 2005 than in 2004. It was felt that by varying the location and duration of observation over time that objectives would better be met.

It is submitted that the methodology was very effective. A rough count indicated that ± 104 species (using the Atlas of Breeding Birds of the Maritime Provinces, Erskine, 1952) were likely to breed in the general are. We observed 95 (91%) of these, along with three breeding species not designated as breeding in the area, plus 18 non-breeding migrants.

A total of 116 bird species was observed in all sites combined. Bird observations in each study site are presented in Appendix 8 and 10 along with spring and fall presence (note that these values are averages for all observations at a given study site). The number noted in each study site, and the number confirmed/probably and possibly breeding are shown in Table 8.8-4. Overall, 62 (53%) of the 116 species were deemed at least possibly breeding. Birds were considered breeding on the basis of the number and temporal pattern of observations, type of habitat, courtship, and nesting behaviour, and/or the presence of young.

TABLE 8.8-4 Number of Bird Species Observed

Study Site	Observed[1]	Breeding or Possibly Breeding (%)[2]	Migrants[3]
Meadow Lake	60	39 (65)	--
Goldbrook Lake	53	26 (49)	1
Ocean Lake	27	15 (56)	---
New Harbour River	71	22 (31)	5
Keltic Site	87	37 (73)	7
Offshore	17	7 (41)	4
Total[1]	315	146	18

1. These values exceed the total number noted in the overall Study Area as some will occur in more than one study site.
2. These percentages are relevant to each study site total, not to the overall area total observed.
3. Migrants are those species that do not breed in the maritime provinces, Nova Scotia (water pipet), mainland Nova Scotia (i.e., golden-eye) or probably not locally (i.e., hooded merganser) (Erskine, 1992).

Breeding estimates are probably low partly because there are 18 migrant species that by definition do not breed in the Study Area. Also, a subjectively conservative application of breeding criteria played a role in the low estimates and some events may simply not have been observed. Nonetheless, species diversity appears to be high and populations robust (See Appendices 8 and 10).

Appendix 10 shows the maximum number of birds observed at any one time in each of various habitat types at the Keltic Site proper and Meadow Lake. Goldbrook and Ocean Lakes, and New Harbour River have been removed from detailed consideration in the following discussion of wildlife.

Habitat types identified in Appendix 10 are based mainly on structural criteria (i.e., tall shrub vs. low shrub) and species composition. Except in the obvious cases (i.e., BF = Open Bog/fen) wetland characteristics are not used because of the wide variation of wet substrates in almost every habitat category.

For purposes of discussion birds have been divided into four groups including: Woodland/ Shrubland and Woodland/Edge Birds, Shorebirds, Raptors, and Seabirds and Waterfowl. These are discussed separately below. “Wetland” was not included as a category because most wetlands have a woodland/shrubland/edge component to them. Waterfowl by definition may be in the open water wetlands and/or nest in wetland areas, and certainly raptors forage in wetlands. Strictly wetland birds such as bitterns (*Botaurus lentiginasus*) were not observed, with the exception of great blue heron.

<u>Woodland, Shrubland, and Woodland Edge Birds</u>

Warblers and related birds were abundant in all woodland and woodland edge habitat at all sites. Thirteen species of warblers, two vireos, two kinglets, and two chickadees were noted and deemed breeding in most woodland areas. These are shown in Table 8.8-5.

TABLE 8.8-5 Warblers and Related Birds in Study Area

Species Common Name
Golden-crowned Kinglet
Ruby-crowned Kinglet
Solitary Vireo
Red-eyed Vireo
Black-capped Chickadee
Boreal Chickadee
Nashville Warbler
Yellow Warbler
Chesnut-sided Warbler
Magnolia Warbler
Bay-breasted Warbler
Yellow-rumped Warbler
Black-throated Green Warbler
Blackburnian Warbler
Palm Warbler
Cape May Warbler
Black-and-white Warbler
American Redstart
Common Yellowthroat
Canada Warbler

Other woodland/shrubland species present on the study sites include ruffed and spruce grouse, thrushes (veery, Swainson's, hermit and American robin), downy and hairy woodpeckers, winter wren, flycatchers (yellow-bellied, alder, and least), sparrows (savannah, song, swamp, white-throated), red and white-winged crossbills, purple finch, gold finch, and pine siskin.

A comparison (See Appendix 8) of June and post-August presence results in some not unexpected patterns. In 2004, insectivorous birds such as flycatchers, swallows, and most warblers were absent. Common yellowthroat, palm, and yellow-rumped warbler were exceptions. A number of types are resident the year-round, including corvids (jays, crows, and ravens), chickadees, and woodpeckers.

Habitats that woodland, shrubland, and edge birds occupied during both 2004 and 2005 are presented in Appendix 10. Woodland/shrubland birds were observed most often in mature and immature mixed forest. Table 8.8-6 shows the distribution within the six most used wooded habitats. The mixed forest habitats were used by both the greatest number of species and the greatest number of birds. Though not evaluated quantitatively, it is reasonable to assume that mixed forests have the greatest number of plant species and the greatest foliage-height-diversity. MacArthur and MacArthur (1961) demonstrated that bird diversity in deciduous forests correlated positively with these two parameters.

TABLE 8.8-6 Comparison of Habitat Use by Woodland/Shrubland Birds

Habitats	Keltic Site				Meadow Lake			
	No. species	Rank[2]	No. Birds[1]	Rank	No. species	Rank[2]	No. Birds[1]	Rank
Mature Coniferous Forest	6	6	29	6	9	3	69	3
Immature Coniferous Forest	12	3	72	3	6	6	66	4
Mature Mixes Forest	22	1	155	1	17	1	121	2
Immature Mixed Forest	17	2	98	2	15	2	151	1
Tall Shrub	11	4	60	4	7	5	12	6
Low Shrub	8	5	34	5	8	4	53	5

[1] The sum of the maximum number of birds per species at any one habitat type at any one time.
[2] Rank within the six habitat types.

Shorebirds

Shorebirds, both resident and migrating, were observed frequently in the LNG Terminal area and along the shore south and east to the mouth of New Harbour River.

The cobble dike and beach area on the Betty's Cove side of the LNG Terminal area is important habitat for migrating and other shore birds. Birds that use this area are shown in Table 8.8-7.

TABLE 8.8-7 Shorebirds Observed in Dike/Beach Area

Species Common Name
Semi-palmated Plover
Willet
Least Sandpiper
Greater Yellowlegs
Sanderling
Water Pipit (technically not a shore bird)
Snow Bunting (technically not a shore bird)
Whimbrel

These species with the exception of willet and greater yellowlegs were observed in the fall only, obviously during fall migration. Spring migration had likely occurred prior to June. Greater yellowlegs (S3B; rare as a breeder)(ACCDC, 2004) was observed exhibiting breeding behaviour in a conifer swamp north of Meadow Lake, near the north edge of the Keltic Site at Map Site 2, Figure 8.8-1, and at the edge of the cobble beach at Map Site 1, Figure 8.8-1. Willet was a common breeder near Betty's Cove and along the shore southeast of the terminal area. Semipalmated plover was observed on the shores of both the terminal area and Meadow Lake. Spotted sandpiper was observed during the spring on the marine shore of the Keltic Site, and the fresh-water shore of Meadow Lake. It also was observed breeding on the shores of fresh water streams in the area.

Raptors

Birds of prey observed are shown in Table 8.8-8.

TABLE 8.8-8 Raptors Observed in the Study Area

Species Common Name
Osprey
Bald Eagle
Northern Harrier
Sharp-shinned Hawk
Broad Winged Hawk
Red-tailed Hawk
American Kestrel
Merlin
Short-eared Owl

Osprey were observed in both study sites; i.e., Meadow Lake, and near the terminal area. No nests were observed on or adjacent to either site, but one is near Highway 316 northwest of Isaac's Harbour. Bald eagles were seen several times at Meadow Lake and the Keltic site, but no nests were located. See Section 8.8.4, Meadow Lake Basin, for additional comment on osprey and bald eagle. Local sources indicate that bald eagle is commonly seen on Harbour Island, but no nests have been found.

Red-tailed, broad-winged, sharp-shinned hawks and merlins were seen occasionally. One kestrel and one broad-winged hawk were observed near the heliport on the Keltic Site, and over the peninsular area, respectively. Northern harrier was noted once at Meadow Lake, and on several occasions over the Keltic Site. Northern goshawk (*Accipiter gentilis*) (yellow, S3B) is known from the general area, but was not observed in this study.

At least one pair of short-eared owls and a northern harrier foraged in the wetlands along Betty's Cove Brook and down to Drum Head. Short-eared owl is designated a "species of special concern" by COSEWIC (2005), and is protected under SARA (2005). Other owls were not observed but great horned owl (*Bubo virginianus*) and northern saw-whet owl (*Aegolius acadicus*) are in the general area (Erskine, 1992).

Seabirds and Waterfowl

Birds that nest and forage along the coastal shore, of which the LNG Terminal area is part, and on the off-shore islands (i.e., Country, Harbour and Goose), as well as waterfowl that breed inland but usually spend some time along the marine shore are considered in this category. Also included are migratory birds that stage in Isaac's Harbour.

The inland lakes, such as Meadow Lake, are not very productive for waterfowl (N. Seymour *pers. comm.*), a point that is reinforced by the observations in this study. Ring-necked duck, loon (yellow), and common merganser were noted in small numbers. American black duck and green-winged teal breed in wetland areas such as the Gold Brook wetland immediately north of the Keltic Site. An adult red-breasted merganser and young were seen once at Dung Cove Pond and Canada goose was observed occasionally at the LNG Terminal area.
Common loon is on all lakes in the original Study Area, with a nest observed directly in Goldbrook Lake. It is not known whether the young hatched or otherwise survived. Common loon was noted in small numbers along the marine shore of the Keltic site in both spring and early fall, with a flock of about twenty individuals off-shore on 7 November 2004.

Common eider and great black-backed and herring gulls are common along the shore. Double-crested cormorants were very common in Isaac's Harbour. Three species (all considered yellow by NSDNR, 2005) of terns, common, arctic, and roseate, forage along the coast. Only one roseate tern was observed. Arctic and common terns are designated S3B (uncommon breeder) and roseate S4B (extremely rare breeder) (ACCDC, 2004).

Country Island is of special interest because of the presence of a roseate tern colony. Roseate terns are at low numbers in Canada, with 95% restricted to a few coastal islands in Nova Scotia (Leonard *et al*., 2004). In 2003, only one other location in Nova Scotia had more roseate terns than Country Island. CWS carries out a program of non-lethal control of predators on Country Island in a successful effort to maintain tern numbers. Common and arctic terns and Leach's storm-petrel (*Oceanodromo leucorhoa*) nest here as well. See also Sub-Section 8.8.6.5, "Species at Risk."

A radio-tracking study (Rock, 2005) revealed that the roseate tern was not foraging in any section of the Keltic foot print (See Figures 8.8-3). The closest foraging site was Harbour Island. Within the potential LNG shipping route the bird was not tracked in any of the shallow ledges

Local sources report that herring and great black-backed gulls and cormorant nest on Goose Island.

A number of migrants were observed and reported to occur in Isaac's Harbour and off-shore around the islands. Those observed are red-necked grebe, white-winged scoter, surf scoter, common scoter, old squaw, and black guillemot. Local residents reported dovekie (*Alle alle*), king eider (*Somateria spectabilis*), murres (*Uria* spp.), and northern gannet (*Morus bassanus*) as migrants.

Great blue heron, though neither seabird nor waterfowl, was seen frequently on the LNG Terminal area and the shoreline to the south. A heronry was reported to be near the northwest shore of Goldbrook Lake (NSDNR*, pers. comm.*)*,* but both aerial and ground level searches failed to locate it.

8.8.6.4 Mammals

A total of 21 mammalian species were observed directly or by sign in all areas combined. Mammal observations in each Study Area, respectively, are presented in Appendix 8. The species noted shown in Table 8.8-9.

TABLE 8.8-9 Mammals Observed in the Study Area

Species Common Names
Coyote
Red Fox
American Black Bear
Raccoon
Short-tailed Weasel (Ermine)
American Mink
Striped Skunk
River Otter

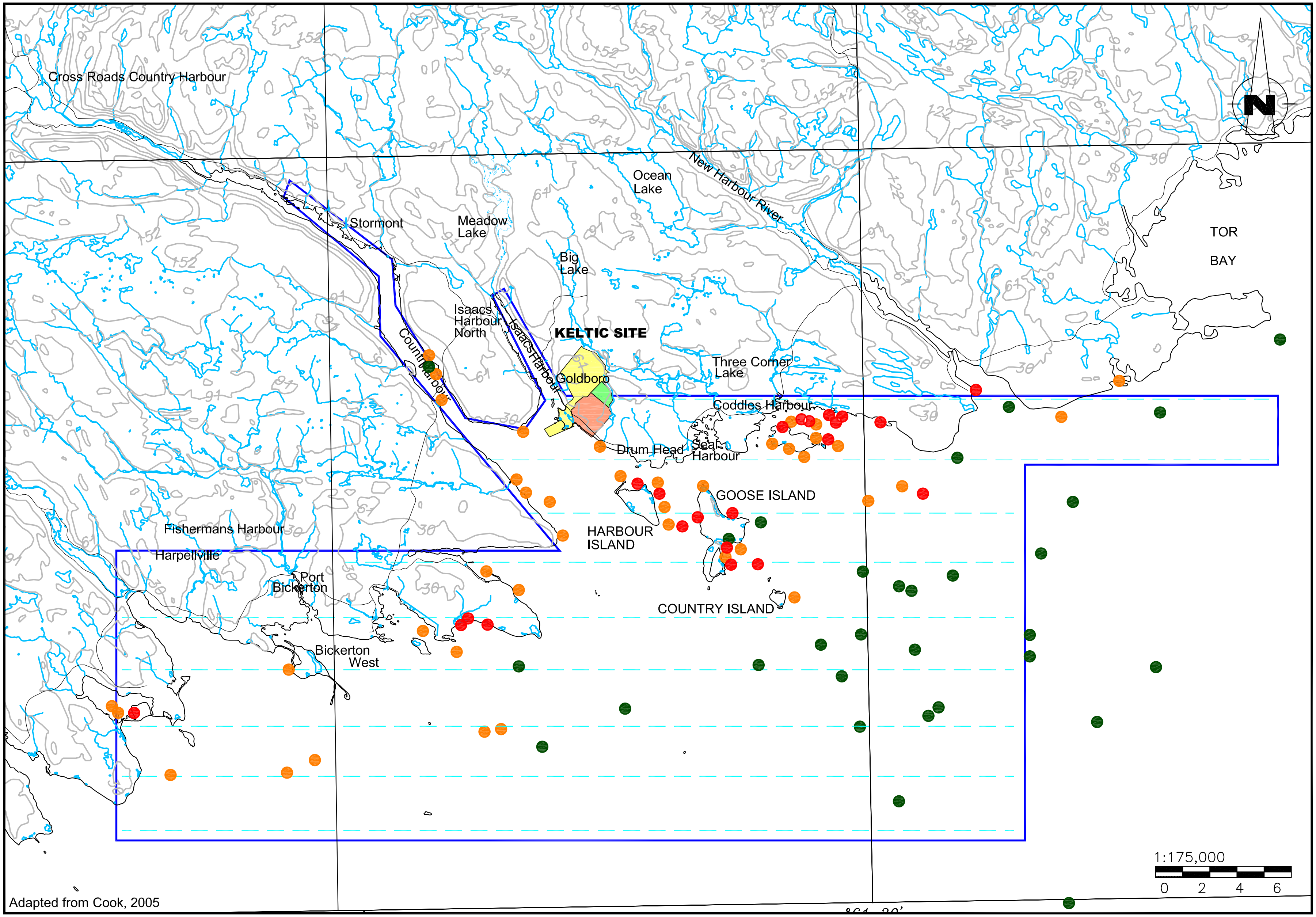
Species Common Names
Bobcat
Grey Seal (See Appendix 8)
Harbour Seal (See Appendix 8)
White-tailed Deer
Eastern Chipmunk
Woodchuck
Red Squirrel
Beaver
Muskrat
Meadow Vole
Red-backed Vole
Porcupine
Snowshoe Hare

Compatible habitat at various places in the study sites is present for a range of Nova Scotia mammals not observed directly or by sign. These include:

- Masked Shrew (*Sorex cinereus*);
- Smokey Shrew (*Sorex fumeus*);
- Arctic Shrew (*Sorex arcticus*) = Maritime Shrew (*Sorex maritimensis*) (Stewart et al., 2002);
- Water Shrew (*Sorex palustris*);
- Pigmy Shrew (*Sorex hoyi*);
- Short-tailed Shrew (*Blarina brevicauda*);
- Hoary Bat (*Lasiurus cinereus*);
- Red Bat (*Lasiurus borealis*);
- Northern Long-eared Bat (*Myotis septentrionalis*);
- Little Brown Bat (*Myotis lucifugus*);
- Northern Flying Squirrel (*Glaucomys sabrinus*);
- Deer Mouse (*Peromyscus maniculatus*);
- Southern Bog Lemming (*Synaptomys cooperi*);
- Meadow Jumping Mouse (*Zapus hudsonius*); and
- Woodland Jumping Mouse (*Napaeozapus insignis*).

Two other species of shrew, the Gaspé shrew (*Sorex gaspensis*) and long-tailed shrew (*Sorex dispar*) both COSEWIC (2005) “Species of Concern” are in Nova Scotia, but have been found only on Cape Breton Island and the Cobequid Mountains, respectively (Dr. G. Forbes, pers. comm.).

FIGURE 8.8-3 Roseate Tern Foraging Sites and Foraging Survey



LEGEND

Road
River/Streams
Contours
Common Tern
Arctic Tern
Roseate Tern
Transects
Survey Perimeter

FIGURE No. 8.8-3

KELTIC PETROCHEMICALS INC.

ROSEATE TERN FORAGING SITES AND FORAGING SURVEY

JULY 2006

No bats were observed but seven species are known from Nova Scotia, all of which are considered sensitive (yellow) by DSDNR (2004). These are:

- Little Brown Bat (*Myotis lucifugus*);
- Northern Long-eared Bat (*Myotis septentrionalis*);
- Eastern Pipistrelle (*Pipistrellus subflavus*);
- Silver-haired Bat (*Lasionycteris noctivagans*);
- Red Bat (*Lasiurus borealis*);
- Hoary Bat (*Lasiurus cinereus*); and
- Big Brown Bat (*Eptesicus fuscus*).

Broders *et al*. (2003) suggest that significant populations of only little brown bat, long-eared bat, and eastern pipistrelle occur in the province. Red, hoary, and silver-haired bats are migratory species represented by only a small amount of records, but red and hoary bats may be widespread in spite of seemingly low numbers. Big brown bat has been tentatively identified as being in the province, but it is unlikely to be in the area of the study sites. Most records of the eastern pipistrelle are from western and central mainland Nova Scotia (Scott and Helda, *circa* 2005). Broders (*pers. comm.*) is of the opinion that most of the bats in the general area of the Study Area are little brown and long-eared with little brown bats being most numerous. Little brown bats were most active over water, with long-eared bat being more of a forest interior species (Broders *et al*., *op. cit.*). This would suggest that Meadow Lake would support larger populations of these two bats than would the Keltic site.

Furbearer data were not gathered in 2004-2005 but the harvest numbers from 1994 (MacLaren Plansearch, 1996) are assumed to be a general reflection of the present circumstance. These are shown in Table 8.8-10. The presence of these furbearers, except striped skunk, was noted on the terminal area at some time during the course of the field studies. The four aquatic species were observed in association with Dung Cove Pond.

TABLE 8.8-10 Furbearer Harvest in Guysborough Country in 1994

Species	Number Harvested
Aquatic Furbearers	
Muskrat	323
Beaver	237
Otter	83
Mink	127
Terrestrial Furbearers	
Short-tailed Weasel	139
Bobcat	58
Red Fox	10
Raccoon	85
Skunk	5
Red Squirrel	187
Coyote	87
Snowshoe Hare	13,992

Snowshoe hare populations fluctuate dramatically, usually over an approximately 10-year period, with 2005 being a very high year providing an abundance of prey for coyotes, bobcats, and raptors. A raptor kill and a bobcat kill, respectively, were observed on the LNG Terminal area. Coyote populations appeared to be high throughout the Study Area, perhaps in response to the abundance of snowshoe hares.

Meadow vole populations also fluctuate with a roughly 3-5 year periodicity. High population densities evidenced by numerous freshly used runways were noted in both 2004 and 2005. Meadow vole is the primary prey for short-tailed weasels and many raptors including short-eared owl, northern harrier, and red-tailed hawk.

The range of Canada lynx (*Lynx canadensis*) (COSEWIC, 2002, status "Endangered") is restricted to Cape Breton Island (NSDNR, pers. comm.). Eastern cougar (*Felis concolor*) (COSEWIC, 2005; status "Data Deficient") has been reported in Nova Scotia, but with little substantial evidence corroborating its presence.

White-tailed deer were sighted frequently in all study sites during the summer. A deer herd estimated by local sources to be about 50 in number is between the LNG Terminal area and Drum Head. During the February 2005 winter survey, at least 35 deer were counted in this area. Nova Scotia Natural Resources (NSDNR, 2005) indicates deer wintering areas near Drum Head, and immediately west of Meadow Lake. The greatest area of winter concentration noted in February 2005 was at the Keltic terminal site (See Figure 8.8-1).

Moose in mainland Nova Scotia has been designated as "Endangered" (COSEWIC, 2005). It is reported to concentrate in the bogs just south of Ocean Lake (NSDNR, *pers. comm.*). This area was examined from the air during summer and winter and at ground level during summer, with no sign of moose, tracks, or droppings. No moose sign was noted anywhere at any time during field studies. One moose was reported by a local resident to have been seen near the mouth of New Harbour River during the late fall of 2004.

8.8.6.5 Species at Risk

The EC SARA website (EC, 2005c) lists plants and animals designated "at risk" by virtue of being "Extinct, Extirpated, Endangered, Threatened, or of Special Concern." COSEWIC determines whether a species is at risk, following which the federal Cabinet will determine whether the species in question will be protected under SARA. It then becomes illegal to kill, harass, capture, or harm individuals of the species; their critical habitats are also protected from destruction.

Four species possibly affected by the Project that are "at risk" under SARA are: roseate tern (endangered), short-eared owl (special concern), mainland moose (endangered) and wood turtle (vulnerable). A Newfoundland sub-species of red crossbill is also listed as "endangered", but the Nova Scotia sub-species is not.

Other organizations apply their own criteria to species thought possibly to be threatened by human activity. These include species designated "red" by N.S. Natural Resources (NSDNR, 2002) that are "known to be or thought to be at risk." Those designated "yellow" are "sensitive to human activities or natural events." Those designated "green" are "not believed to be sensitive or at risk." ACCDC (2004) designates "S-Ranks" as follows:

- S1 = extremely rare;
- S2 = rare;
- S3 = uncommon;
- B = if breeding;
- S4 = usually widespread; and
- S5 = demonstrably widespread, abundant.

The following two species, designated "at risk" are known to be on the site or potentially affected by the proposed project:

- Roseate Tern – Threatened (SARA)(COSEWIC, 2005); red; S1; extremely rare. A roseate tern colony on Country Island is about 9 km from the proposed LNG terminal. One roseate tern was observed flying near the shore south of the terminal area. According to A. Boyne, (CWS, pers. comm.) and Rock (2005) they forage along the mainland and island shores, where they feed predominantly on sand lance (*Amphioxus sp.*). No foraging site is known to be in or directly adjacent to the LNG terminal area. The closest documented foraging site is on the shore of Harbour Island about 3 km from the proposed terminal area (See Figures 8.8-3).
- Short-eared Owl – Special Concern (SARA) (COSEWIC, 2005); yellow; S1S2; extremely rare to rare. At least one pair was observed for much of the summer of 2005 foraging in the large wetland that extends from the Keltic Site to Drum Head.

There are two other species "at risk", but not observed on the study sites:

- Moose – Endangered (SARA)(COSEWIC, 2005); red; S1; extremely rare. Though no evidence of moose presence was encountered, it has been reported in the general vicinity.
- Wood Turtle – Vulnerable (SARA)(COSEWIC, 2005); yellow; uncommon. Wood turtles may be in the Meadow Lake System, and less likely in association with Dung Cove Pond. In summer they may be found well away from the rivers and streams where they hibernate in winter. No report of wood turtle are known from the vicinity of the study site.

Other species observed in the Study Area not protected by SARA, but designated to be sensitive in some respect by NSDNR (2002) or ACCDC (2004), are:

- Common Loon – yellow; S4BS4M – widespread as a breeder/non-breeder in low numbers on all lakes; frequents shore at terminal area.
- Red-breasted Merganser – green; S2BS5M – rare as a breeder, seen with young at Dung Cove Pond terminal area.
- Semipalmated Plover – yellow; S2BS5M. rare as a breeder; migratory non-breeder; observed on both marine and freshwater shorelines as a migrant.

- Merlin – green; S3S4B; uncommon, widespread breeder; observed on several occasions in flight.
- Least Sandpiper – green; S1BS5M – extremely rare breeder; widespread migrant; shoreline migrant.
- Greater Yellowlegs – green; S2BS5M – rare as a breeder, otherwise widespread as a migrant. Observed exhibiting breeding behaviour at three sites (See Figures 8.8-1 and 8.8-8):
  - the dike at the west end of Dung Cove Pond;
  - the northern boundary of the Keltic Site; and
  - in a wooded wetland north of Meadow Lake (this location probably would not be affected by inundation of Meadow Lake).
- Solitary Sandpiper – green; S1B - extremely rare breeder; probable migrant observed along fresh water streams.
- Common Tern – yellow; S3B – uncommon breeder, breeds on off-shore islands; may forage in terminal area.
- Arctic Tern – yellow; S3B – uncommon breeder, breeds on off-shore islands, but forages mainly away from shore. Seen once in small numbers along shore near terminal area.
- Black Guillemot – green; S3 – uncommon; off-shore migrant.
- Boreal Chickadee – green; S3S4; - uncommon breeder, but usually widespread, abundant; breeding at the main Keltic Site, especially in the forested areas on both sides of Highway 316.
- Red Crossbill – green; S3S4; - uncommon breeder, usually widespread, observed on main Keltic Site.

8.9 FORESTRY

The proposed Keltic petrochemical site is located in a forested area; however, it is considered non-merchantable at this time. A timber evaluation conducted by Scott and Stewart Forestry Consultants Ltd. (2003) indicated that the majority of the forest stand is immature, and has not reached commercial size (i.e., small diameter stems and low merchantable volume). Presence of steeper terrain and wetland areas also make some of the land base non-operational.

Scott and Stewart, Forestry Consultants Ltd. did a timber evaluation on a large portion in the Goldboro Industrial Park in 2003. They reported (letter to B. Mattie, 2003) that,
"We assessed a total of 170.4 ha. The assessed area can be broken into two categories:

- Category 1 – 80% of assessed area (135.8 ha) has no merchantable volume. There are merchantable trees and patches of merchantable trees scattered throughout these areas. The volume on these stands may reach 30 m^3 per ha, but are considered unmerchantable in the context of traditional forest harvesting practices.
- Category 2 – 20% of the assessed area (34.6 ha) is made up of stands that have enough trees growing in them to be considered merchantable. It should be noted that

> the stands are not of high quality due to the small size of most of the trees and the scattered nature of the larger trees..."

The area inventoried by Scott and Stewart comprises a large (approximately 45%) area of the main Keltic site. Some areas were excluded from the evaluation because of slope steepness and/or the relative proximity of wetlands, mostly off-site, but with an uninventoried buffer area that extends on-site on all but the northwest border of the site.

This same area was examined from a more strictly ecological perspective during the summer field work of 2005 (see Section 8.8.3). Essentially the same conclusions were reached; i.e., the tree vegetation is young and with small diameters which translates into very low merchantability in forestry terms.

8.10 WETLAND RESOURCES

Wetlands are important landscape features on the Keltic Site. Wetlands have several functions and values, including (Hammer, 1996):

- Life support for a broad spectrum of life forms, including many species that are endemic to wetlands; i.e., orchids such as dragon's mouth.
- Hydrologic modification such as ground water recharge and discharge.
- Water quality changes such as removal of pollutants.
- Erosion protection by absorbing and dissipating wave energy (especially in coastal areas).
- Open space and aesthetics including recreation, research, scenic influences.
- Geo-chemical storage including carbon and other sedimentary minerals.
- Life support and hydrologic modification and stability are probably the most immediately important functions on-site and throughout the entire Keltic Study Area.

The major types of wetlands encountered in the Study Area, according to the Canadian Wetland Classification System (1997) are:

- Bogs – peatlands with water from precipitation and not influenced by groundwater, peatmoss (Sphagnum sp.) is dominant vegetation.
- Fens – peatlands influenced by groundwater relatively rich in nutrients with vegetation dominated by graminoid species.
- Swamps – dominated by woody plants and may occur on peatland or mineral substrate; in the latter case free surface water may persist for considerable periods.
- Marshes – periodic or persistent standing water, usually dominated by graminoids and/or emergent forbs.
- Shallow water wetlands – free surface water up to 2 m deep at less than 25% cover by standing emergent or woody plants.

The wetlands identified on the Keltic Site are presented in Table 8.10-1. Information for this Table was derived from several sources including: The Canadian Wetland Classification System, Second Edition (Warner and Rubec, 1997); CWS Wetland Mapping (Hanson and Calkin, 1996); Wetlands Data Base Specification Draft (NSDNR, 1999); Nova Scotia Forest Cover Type Mapping (NSDNR, 2002); vertical black and white aerial photography; oblique colour photography; aerial reconnaissance; and ground level field work. It should be noted that there is some variability in the wetland surveys; i.e., not all were surveyed at ground level. This variability is explained in Section 8.10.1 in the discussion of individual wetlands. NSEL wetland directives (circa 1991) are no longer in effect, but apparently new ones are being drafted. A copy of the new directives was requested, to no avail. Nonetheless, it is submitted that the wetland descriptions in Section 8.10.1 below addresses the critical biological issues.

TABLE 8.10-1 Wetland Type and Area (ha)

Wetland Number[1]	Wetland Type[2]	On-site Area (ha)
Keltic Site Wetlands		
1	Coastal (Saline) Pond – vegetated (Pv)	2.4
3	Shrub fen and some bog (B) (Est. 375 ha)	3.5
4	Marsh/fen	2.0
5	Treed bog (1.2 ha)	0.9
6	Treed bog	1.3
7	Treed bog	0.6
8	Bog (1.5 ha)	0.2
9	Bog	2.4
10	Shrub fen	1.2
11	Bog (Goldbrook) (B) (Est. 20.0 ha)	0.0
12	Coastal (Saline) Ponds (Po)	0.8
13	Swamp/marsh	2.0

1. Wetland Number: Keltic Site, see Figure 8.8-1.
2. Wetland type (see text); and total area (ha) if part of wetland is off-site.

There is some difference in terminology between Hanson and Calkins (1996), Warner and Rubec (1997), NSDNR (1999), and NSDNR 2002; i.e., only NSDNR (2002) uses the term “treed bog,” and Hanson and Calkins (1996) CWS wetland mapping, revised 1988, do not use the term “fen.” The wetland types presented in Table 8.10-1 do not follow any particular nomenclatural method, but rather are often descriptive modifications of the basic Canadian Wetland Classification System; i.e., “treed bog” instead of simply “bog.” CWS terminology where available is also included in parentheses, as below:

Coastal Saline Ponds – P
- Po – pond open bottom undetermined
- Pv – pond vegetated

Freshwater Wetland Classes
- OW – open water
- DM – deep marsh
- SM – shallow marsh
- SFF – seasonally flooded flats
- M – meadow
- SS – shrub swamps

WS – woody swamp
B – bog

Specific vegetation characteristics are presented here for each wetland. Most of these wetlands have a significant component of heath shrubs; i.e., eriaceous (Fam. Ericaceae). Rather than identify these each time for each wetland, their presence may be noted as "heath shrubs" including the following species: Labrador tea, rhodora, sheep laurel, bog laurel, bog-rosemary, leather-leaf, lowbush blueberry, mountain cranberry, small cranberry, large cranberry, huckleberry, and bog huckleberry. Other shrubs not in the family Ericaceae but often associated with heath shrub vegetation include sweet gale, black crowberry, black chokeberry, bunchberry, false holly, and witherod.

No rare plant or animal species was found in any wetland. Four-toed salamander (yellow; NSDNR, 2005) is probably in some wetlands, but none was observed in this study. Meadow vole and common shrew are likely common inhabitants of most open wetlands. The sporadically occurring southern bog lemming may occur in bog/fen wetlands, but seems to prefer treed edges. Evidence of use by white-tailed deer and snowshoe hare are nearly always present.

8.10.1 Main Keltic Site and Terminal Area

Of the 12 wetlands identified on the Keltic site including the terminal area (See Table 8.10-1), eight are peatland systems; i.e., some combination of bog or fen. One is primarily marsh (No. 4), another primarily swamp (No. 13), and the remaining two are designated Coastal Saline Ponds by CWS mapping (Hanson and Calkins, 1996). Further, the on-site area of six of these wetlands is less than 0.20 ha in size. Only four (Nos. 1, 9, 11, and 13) are shown by CWS mapping. Other size classes are represented by a large shrub fen/bog (est. 375 ha) most of which is off-site to the east, Goldbrook Bog (est. 20 ha) north of the site, Coastal Saline Ponds (total 3.2 ha) and Wetland Nos. 5 and 8 that also have off-site areas. These specific wetlands have been discussed below. It should be noted that while several specific small wetlands have been identified, much of the entire site is "wet," probably due to past mining and forestry activities intercepting a shallow ground water table. The result is that there may be small irregular "wet" configurations of this sort that defy designation as wetlands.

8.10.1.1 Wetland No. 1

This is Dung Cove Pond, which CWS mapping refers to as (Pv), Vegetated Coastal Saline Pond, at 2.4 ha in area. This is Pond 6, discussed in Section 8.12.1.6, Red Head Peninsula Ponds. It is not saline as shown in Table 8.6-7, Section 8.6.4 (Water Quality in Study Area Lakes, Rivers and Ponds On-site).

The pond is relatively narrow with the long axis oriented NW-SE. The southeast end is contained by a cobble dike and beach and the northwest end grades into swamp/marsh/fen of Wetlands Nos. 4 and 13. The pond appears to be fed by a stream associated with Wetland 13 and Wetland 4. Some of the shoreline vegetation and aquatic vegetation has been described (Pond 6) in Section 8.12.1.6. Additional shoreline plants include marsh St. John's wort (Triadenum fraseri), turtle head, blue flag, soft rush, small bedstraw, blue-joint, and other rushes and sedges. Plants on the dike and beach include lamb's quarters, hemp-nettle, American dune grass, common ragweed, wild-rye grass, witch grass, and swamp rose.

Red squirrel inhabits the coniferous forest along the edges of the pond, and meadow vole runways were observed near the northwest end. Muskrat, mink, and beaver were observed along the shore or swimming in the pond. River otter tracks were abundant during winter of 2005. White-tailed deer winter activity was considerable in the coniferous edges on both sides of the pond (See Section 8.8.6.4, Mammals).

Red-breasted merganser, green-winged teal, black duck, herring gull, and great black-backed gull were seen on the surface of the pond, with black duck and red-breasted merganser possibly breeding here. Great blue heron was observed feeding here and kingfisher is present. Northern harrier foraged near the northwest end where old-field is in proximity of the pond. Spotted sandpiper was observed along the shore.

The dike and beach at the southeast end is an important migratory stopover for several shorebirds including semi-palmated plover, semi-palmated sandpiper, least sandpiper, whimbrel, and sanderling, as well as snow bunting and water pipet. Willet is here as well and breeds on the shoreline of Betty's Cove to the southeast. Greater yellowlegs probably breeds here, as it was observed exhibiting distress behaviour at the south end of the cobble dike.

Most woodland birds listed for the site at large (See Appendix 10) are associated with the shoreline vegetation.

No reptiles were observed in this wetland, although some turtles may be here. Green frog and wood frog were the only amphibians recorded.

Fish species are reported in Section 8.12.1.6, Red Head Peninsular Ponds.

No evidence of contemporary commercial or recreational use of this wetland was noted.

8.10.1.2 Wetland No. 2

There is no Wetland No. 2

8.10.1.3 Wetland No. 3

This wetland extends from the northeast edge of the Keltic Site along Betty's Cove Brook south to Highway 316 and Drumhead and is approximately 375 ha in area, of which 3.5 ha is on the Keltic footprint. It is attendant to Betty's Cove Brook, which has its origins in a forested area north of Sable Road, then passes under Sable Road into a narrow open shrub fen area that widens into the larger area of the wetland, thence to Crane Lake and south under Highway 316 and into the ocean at Betty's Cove. The lower, larger portion of this wetland is expansive with a heath shrub matrix, containing and bordered by elements of coniferous forest of balsam fir, black spruce, and tamarack. Conifers directly attend Betty's Cove Brook and are on hummocks scattered throughout the open wetland. Mosaics of open sphagnum bog are distributed throughout the shrub fen. Common juniper and meadow sweet are here. Sphagnum (Sphagnum spp.) and reindeer moss (Cladonia sp.) are evidenced on small hummocks. Other species include bog clubmoss, tawny cottongrass, deer grass, round-leaf sundew, pitcher plant, bakeapple, aster (Aster radula), bog aster, bog-goldenrod, poverty grass, sedges (Carex stricta and C. exilis), and path rush.

Deer and snowshoe hare sign were abundant, and the presence of short-eared owl and northern harrier indicated that meadow voles were numerous, especially in early summer 2005. Observation of at least a pair of short-eared owls, a species-at-risk (See Section 8.8.6.5, Species at Risk), emphasizes the importance of this wetland. Other bird observations were few, but included common yellowthroat and merlin. The nature of the habitat suggests that the range of woodland/edge bird species that occur on the rest of the site occur here as well.

No amphibians or reptiles were observed but four-toed salamander and green frog at least are probably in the wetland. Garter snake was observed on-site near the northern wetland boundary.

No evidence of present commercial or recreational use was noted, but the remnants of an old road from Drum Head into the centre of the wetland suggests some past activity, perhaps logging.

8.10.1.4 Wetland No. 4

This wetland is effectively a marsh dominated by graminoid species. Part of this wetland was a hockey rink constructed at some time in the past, perhaps 15-20 years ago (F. Manthorne, pers. comm.). The north end of this wetland system is adjacent to the main laneway into the peninsular area. The old hockey rink area is in the northernmost component, separated by a dike from a fen area to the west. These areas are bordered by speckled alder and white and black spruce. Another, but smaller fen-like area is to the west, again separated by alders. Graminoids in the northern portion of the wetland include primarily rushes; i.e., Juncus articulatus, J. arcticus, J. effusus, J. filiformis, J. canadensis, and the grasses blue-joint and reed grass. Other herbaceous species on the higher and relatively drier spots include field horsetail, sensitive fern in patches around the edges, New York aster, marsh St. John's wort (Hypericum fraseri) and bog aster. In addition to black and white spruce, trembling aspen, white poplar, American mountain ash, and pin cherry are located around the fen areas. The wetland grades into more swamp-like conditions to the south in the area of Wetland No. 13 and the north end of Dung Cove Pond.

River otter and white-tailed deer tracks were observed in February 2005 along the edge of the southern portion of this wetland. Otherwise no mammals were noted, but obviously snowshoe hare, muskrat, and meadow vole are in the system.

Eleven species of birds were recorded here; i.e., common yellowthroat, American goldfinch, cedar waxwing, black-capped chickadee, magnolia warbler, black-throated green warbler, hermit thrush, red-breasted nuthatch, golden crowned kinglet, sparrow, and white throated sparrow.

8.10.1.5 Wetland No. 5

NSDNR (2000), Forest Cover Type Mapping, indicates this as treed bog, part of which is off-site. The total wetland area is 1.2 ha, and the on-site portion is 0.9 ha. This area is associated with the brook that begins at Wetland No. 8 and flows southeasterly more or less parallel to the footprint boundary, then takes a sharp turn flowing southwesterly to the ocean.

The tree vegetation is almost totally balsam fir (15-20 cm dbh) and the forest floor is totally covered with sphagnum moss. The canopy is fairly open with some speckled alder, sheep laurel, and cinnamon fern.

Other than snowshoe hare droppings, no mammals were observed. A dark-eyed junco nest with eggs was found and merlin flew over.

A number of green frogs were in direct association with the aforementioned brook. No other amphibians or reptiles were observed.

No indication of recent commercial or recreational use was noted.

8.10.1.6 Wetlands No. 6 and 7

These two wetlands are identified as treed bogs by NSDNR (2000), Forest Cover Type Mapping, with areas of 1.3 and 0.6 ha, respectively. These were identified after the field work had ceased. These two small wetlands should be visited and evaluated prior to final design of the Keltic plant site.

As best as can be determined these areas are depressions with sphagnum moss forming the substrate with smaller trees, probably black spruce and tamarack, as compared to the surrounding areas that are dominated mostly by somewhat taller balsam fir.

8.10.1.7 Wetland No. 8

This bog is at the headwaters of the brook noted in the discussion of Wetland No. 5. The total area of the wetland is 1.5 ha with 0.2 ha being within the Keltic footprint. The bog forest edge and some areas within the wetland are composed of stunted black spruce and small tamarack. Sphagnum and reindeer mosses are here, especially noticeable on slightly raised hummocks. Shrubs in the bog are the expected heath shrubs including huckleberry, bog huckleberry, lowbush blueberry, black crowberry, Labrador tea, common juniper, bakeapple and serviceberry. Most abundant graminoids are deer grass and sedge (Carex exilis). Other herbaceous species are cinnamon fern, pitcher plant, round-leaved sundew, dragon’s mouth, and three-leaved false Solomon’s seal.

The wetland is located in a basin with gently sloping sides, and, in addition to its intrinsic value, its role as a headwater for a significant stream system is considerable.

Other than snowshoe hare droppings and white-tailed deer tracks, no wildlife was observed. The usual complement of woodland/edge birds can be expected in the surrounding vegetation.

There is no evidence of commercial or recreational use in or near this bog.

8.10.1.8 Wetland No. 9

A 2.4 ha open bog located near the north edge of the Keltic footprint, is much like Wetland No. 8, but with more floristic diversity. It is questionably the headwater area for Betty's Cove Brook; some maps, for example NSDNR (2002), show it as such. The surrounding vegetation is mainly balsam fir with black spruce and tamarack near the edge of the bog. Reindeer moss and sphagnum form the ground level matrix. Shrubs found variously throughout the bog are common juniper, leather-leaf, Labrador tea, sheep laurel, witherod, black crowberry, bog laurel, lowbush blueberry, rhodora, black chokeberry, false holly, bakeapple, and bunchberry. Herbaceous plants include pitcher-plant, pink lady's-slipper, hare's-tail, and deer grass.

No amphibians were observed, but a number of bird species were recorded from the immediately surrounding areas. These include common yellowthroat, American redstart, ruby-crowned kinglet, magnolia warbler, yellow-rumped warbler, hermit thrush, yellow-bellied fly-catcher, Swainson's thrush, black-throated green warbler, solitary vireo, American goldfinch, robin, Nashville warbler, boreal chicadee, palm warbler, and crow and raven as fly-overs.

Significant clear cutting has occurred around much of the southern half of the wetland, leaving a narrow band of trees directly adjacent to the wetland. This likely has changed the habitat characteristics of at least this portion of the wetland. Other than this, and the pipeline on the northeast side, there is no evidence of commercial or recreational use of the wetland.

8.10.1.9 Wetland No. 10

Wetland 10 is 1.2 ha in area, much of which is shrub fen very similar to the nearby (300 m) part of the Betty's Cove Brook system, but with a significant bog component. It is north of Sable Road, and approximately 600 m south of Wetland No. 9, and is somewhat dumb-bell shaped with the long axis running north-south. The wetland is bordered by balsam fir, red maple, black spruce, and tamarack, with some stunted black spruce and tamarack in the centre. Shrubs include rhodora, speckled alder, witherod, sheep laurel, bog laurel, lowbush blueberry, blackberry, red raspberry, false holly, Labrador tea, bakeapple, black chokeberry, sweet gale, bunchberry, common juniper, bog rosemary, black crowberry, creeping snowberry, small cranberry, velvet-leaf blueberry, and huckleberry. Herbaceous plants include bog clubmoss, pitcher-plant, round-leafed sundew, blue flag, cinnamon fern, bracken, tawny cotton grass, deer grass, bog aster, bog goldenrod, sedge (Carex folliculata) and bristly clubmoss. Sphagnum and reindeer mosses are ubiquitous.

No amphibians, reptiles, or mammals were seen, but the usual mammalian species are probably here; i.e., snowshoe hare, common shrew, meadow vole, and white-tailed deer. Purple finch was the only bird noted at the time of the survey, but the same birds that were associated with Wetland No. 9 are likely here as well.

No evidence of commercial or recreational use of the wetland was apparent.

8.10.1.10 Wetland No. 11

Goldbrook wetland, approximately 20-25 ha in area is located totally off-site, but adjacent to the north site border. It appears to be waterfowl breeding area of some importance, and for that reason is included in the discussion. Gold Brook runs south to the area of the site, then southeasterly parallel to the north site border where it is part of a wetland complex comprising raised bog, riparian marsh, and bog/fen forest. CWS (1988) designates this entire area of wetland as "bog". The marsh area in and attendant to Gold Brook was almost totally occupied by water-horsetail, with sedges (i.e., Carex nigra), broad-leaved cattail, grasses (i.e., blue joint) and rushes (i.e., Juncus effusus) along the shore. The wooded fen area contains heath shrub, especially close to the shore, and taller coniferous tree vegetation of balsam fir, black spruce, and tamarack. North of Gold Brook and the attendant vegetation as described, is a series of lobe-shaped raised bog communities. The description of raised bog in Meadow Lake in Section 8.8.4 is appropriate for describing these areas including the presence of flarks. These raised bogs were examined by the use of oblique colour aerial photography, with the riparian marsh and fen forest surveyed directly at ground and water level.

No amphibians, reptiles, or mammals were observed, nor were woodland/edge birds recorded. Black duck and green-winged teal were observed breeding, as evidenced by presence of young.

No evidence of commercial or recreational use of the wetland was observed.

8.10.1.11 Wetland No. 12

Wetland No. 12 is a complex of small coastal ponds that CWS mapping refers to collectively as Pv, Vegetated Coastal Saline Ponds, 0.8 ha in total area. These are Ponds 1-5, discussed in Section 8.12.1.6, Red Head Peninsular Ponds. Ponds 1 and 2 are not saline, Pond 3 is slightly brackish, and Ponds 4and 5 are saline.

Ponds 1and 2 are just west of Wetland No. 4 with Pond No. 2 the smaller. Pond No. 2 is a man-made pond dug to provide water for cattle when much of the peninsula was under agricultural land use. The aquatic and shoreline vegetation has been described in Section 8.12.1.6. Additional shoreline plants for Pond 2 include leather-leaf, soft rush and lowbush blueberry and blackberry on the slopes west of the pond. Plants associated with Pond 1, in addition to those listed in Section 8.12.1.6, include meadow rue and common, seashore and narrow-leaved plantains. While Pond 1 is not saline, there is some evidence of marine influence. The Pond empties through a culvert under the lane way into Webbs Cove. Sometimes, after strong winds, seaweed (Fucus sp.) can be found in the pond. Also, arrow-grass and seashore plantain are on the north shore of the pond close to the laneway.

Ponds 4 and 5 are at the base of, and northeast of, the Red Head promontory. Pond 5 is the more northeasterly of the two. The pond edge vegetation includes a number of marine shore species in addition to those mentioned in Section 8.12.1.6 (see Table 8.8-1, Marine Shoreline Species Identified in Peninsular Area).

Pond 3 , approximately 300 m north of Pond 5 is similar to Ponds 4 and 5 with respect to vegetation, but with a greater abundance of graminoids on the shoreline. These include spike rush (Eleocharis palustris), sedges (Carex canescens and C. hormathodes) and rushes (Juncus effuses, J.arcticus, and J.canadensis).

Great blue heron was observed feeding in these ponds. Gulls, crow and raven were observed occasionally.

Fish species are reported in all ponds in Section 12.2.5, Red Head Peninsular Ponds.

No evidence of current commercial use of the wetland was noted, but as indicated above Pond 2 was used to water cattle in the past. In early September 2004, a number of local people picked blackberries and blueberries on the slopes west of Pond 2.

8.10.1.12 Wetland No.13

Wetland No. 13 contains a drainage that begins on the northeast side of Highway 316 and flows into Dung Cove Pond near its junction with Wetland No. 4. Spatially associated with this is a low linear area that runs parallel to the northeast shore of Dung Cove pond, but separated from it by a forested ridge. The area is best designated as a swamp, but there are marsh elements at both ends, respectively. This swamp/marsh is 2.0 ha in area. This portion of the wetland drains into Betty's Cove south of the Keltic footprint.

Tree species associated with the wetland include black and white spruce, white birch, American mountain ash, and trembling aspen. Shrub include mostly speckled alder along with pussy, Bebb's, and bog willows, and dwarf raspberry. The southern more marsh-like portion contains scattered broad-leaved cattail, blue-joint, creeping bent grass, and fowl meadow grass. Other herbaceous plants include turtlehead, cinnamon fern, sensitive fern, bog willow-herb, sedge (Carex exilis), soft rush, and field horsetail.

Green frog was the only amphibian observed. No reptiles were noted. Deer tracks, snowshoe hare scat, and muskrat and meadow vole runways were in evidence. Coyote scat was seen, and during February 2005 a snowshoe hare kill by a bobcat occurred on the edge of the wetland.

On 8 June 2005, the following bird species were noted in or adjacent to the wetland: purple finch, American goldfinch, yellow-rumped warbler, white-throated sparrow, dark-eyed junco, American robin, pine grosbeak, magnolia warbler, Swainson's and hermit thrushes, black capped and boreal chickadees, black-throated green, black and white, and yellow warblers, downy woodpecker, golden and ruby-crowned kinglets, ruffed grouse, yellow-bellied fly-catcher, and herring gull and tree sparrow as fly-overs.

This is an area where there was a lot of mining activity and presently clear-cutting is occurring close to the edge of the wetland. A path from Highway 316 crosses the wetland and on to the dike at the end of Dung Cove Pond. Fishermen and hunters may use the path, but none were seen during the course of field work in this area.

8.10.2 Meadow Lake Wetlands

An estimated 42% of the Meadow Lake basin is wetland. Descriptions of these wetlands are in Section 8.8.4, Meadow Lake Basin.

8.11 FISHERY, AQUACULTURE AND HARVESTING RESOURCES

8.11.1 Freshwater

Nova Scotia is divided into six Recreational Fishing Areas; Guysborough County is located within Recreational Fishing Area 2, along with Antigonish and Pictou Counties. There were 1,632 fishing licences sold in the County in 2000. Of these, 87 were non-resident and the rest resident. Overall, 2.5% of the 64,078 provincial licences sold in 2000 were in Guysborough County (NSDAF, 2001a). Approximately 2000 licences were sold in 2005 (O'Neil, pers. comm., 2005).

Seventy-five logbooks were returned from Guysborough County license-holders in 2000. The logbooks showed that the primary fish species targeted was brook trout, making up 98% of the reported catch. Catch per unit effort (fish caught versus hours spent fishing) was 0.77 in the County, compared to the provincial average of slightly over one fish per hour. Within the Keltic Study Area, anglers reported fishing on various parts of the watersheds of the St. Mary's, Country Harbour, and Isaac's Harbour rivers. All catch was brook trout, with an average length of 24 cm and a catch per unit effort of 0.58. Many rivers in Guysborough County support sea-run trout, however a license is not required if caught in salt water (NSDAF, 2001a).

Atlantic salmon are managed on a river-specific basis within nine management areas in the Maritimes. The Keltic Study Area is in Salmon Fishing Area 20. Watersheds and rivers within the Keltic Study Area that supported salmon runs in the past decade include:

- Country Harbour River;
- Gaspereau Brook;
- Guysborough River;
- Isaac's Harbour River;
- New Harbour River; and
- St. Marys River.

Since 1996, the rivers have been open to catch and release only, and were closed altogether in 2000. In 1999, only six grilse and one adult salmon were caught on the St. Marys River. No salmon were caught on other rivers. In general, salmon returns to all rivers along the Atlantic Coast of mainland Nova Scotia were insufficient to meet conservation requirements in 2000, including those receiving hatchery stocking. Currently there is a hook-and-release salmon fishery on only the St. Marys River. The remainder of these rivers (O'Neil, pers. comm., 2005).

8.11.2 Marine

Stormont Bay (Figure 1.1-1a) and adjacent areas (including Country Harbour, Isaac's Harbour, and Red Head) support a diverse local fishery. Aquaculture, commercial and recreational shellfish harvesting and inshore fishing activities occur in the area.

8.11.2.1 Non-Commercial Species

Stormont Bay and the surrounding areas including Country Harbour and Isaac's Harbour support a diversity of fish species, some of which contribute to an active recreational fishery.

Common fish species in Stormont Bay include demersal fish (groundfish that tend to be associated with the seabed) such as tomcod, cunner, wolffish, and sculpins, as well as pelagic species (fish usually found inhabiting the water column), such as herring and mackerel (Scott and Scott, 1988; Gilhen, 1974; SOEI, 1998).

Estuarine habitats of Country Harbour support a variety of estuarial, freshwater, and pelagic fish species during their various lifestages. These include Atlantic salmon, winter flounder, American eel, gaspereau (alewife), smelt, and trout in addition to juvenile cod, pollock, and herring (Scott and Scott, 1988; Gilhen, 1974; SOEI, 1998).

Salmon are likely present in Stormont Bay throughout summer, while smelt are found in coastal and estuarine waters in the area throughout the year. In addition, six other species of fish are reported to be common in the estuarial habitats and the lower reaches of rivers. These species include Atlantic silverside, backspotted stickleback, northern pipefish, windowpane, smooth flounder, and winter flounder (Gilhen, 1974).

Several species of non-migratory fish are expected to be in the area including creek chub, white sucker and various species of dace and stickleback (Gilhen, 1974). While not considered commercial species, they can, however, provide important sources of food for larger fish.

8.11.2.2 Commercial Species

A 1995 study done for the SOEP on the winter distribution of selected species of adult fish in the vicinity of Stormont Bay showed congregations of cod and herring. Summer surveys showed the presence of adult cod. Inshore areas around and including Stormont Bay support a small commercial herring and mackerel fishery.

Lobster and rock crab are currently fished in Stormont Bay and surrounding areas. Lobster in this area is managed under Lobster Fishery Area 31B, one of three Lobster Fishery Areas covering the Eastern Shore. Stormont Bay supports a small rock crab fishery with a limited number of licensees. Generally, rock crab is managed as a by-catch associated with lobster.

Until recently, the green sea urchin (*Strongylocentrotus droebachiensis*) was also a major commercial species on the Eastern Shore of Nova Scotia; however, the Guysborough fishery has been traditionally underdeveloped in comparison. A significant decrease in sea urchin abundance occurred throughout most of the Eastern Shore of Nova Scotia, including Stormont Bay, in 1999, due to spread of Sea Urchin Disease (*Paramoeba invadens*) (DFO 2000). Few, if any, urchins are now located within Stormont Bay or in the vicinity of the proposed Marginal wharf and LNG terminal.

Blue mussel is also an important commercial species grown by Country Harbour Sea Farms in Country Harbour (see Section 8.11.2.6). Licences for other species, including sea scallop salmon and trout, have been issued historically within Stormont Bay, but no continued aquaculture for these species has occurred in the local area.

The aquaculture industry generally relies on harvesting of seed spat (larvae) from Country Harbour and Stormont Bay in the summer.

8.11.2.3 Inshore Fishery and Aquaculture

Information about inshore fisheries and aquaculture in the Keltic Study Area is available from the Guysborough County Inshore Fishermen's Association (GCIFA) website, http://www.gcifa.ns.ca/. GCIFA has partnered with St. Francis Xavier University, the Gulf Nova Scotia Bonafide Fishermen's Association (Lakevale), the Mi'kmaq Fish and Wildlife Commission (Afton), and the Interdisciplinary Studies in Aquatic Resources (Antigonish) in a cross-Nova Scotia collaborative effort to build participatory research capacity related to coastal communities and sustainable fisheries. As part of this effort, a profile of the Guysborough County Inshore Fisheries was prepared in 2001 (Boudreau and SFSF, 2001). Much of the following information in this section is drawn from that comprehensive report, however, catch and effort statistics have been updated with more recent information from DFO.

Most of the relevant available fisheries data is aggregated for Guysborough County as a whole, or the DFO statistical districts that border the county. The inshore fisheries Study Area was selected to include the region that could potentially be affected by Project activities, such as accidental releases from an LNG carrier or cargo vessel. Modeling carried out for the Deep Panuke Environmental Impact Assessment indicated that a slick dispersed to a concentration of 0.1 parts per million (ppm) would extend approximately 20 km from the point outside the approaches to Country Harbour in winter and 19.5 km in summer. Based upon this analysis, the coastal Study Area for the Keltic Project was delineated to extend approximately 30 km on either side of the proposed project site in Goldboro, i.e., from Berry Head to the St. Mary's River estuary. This Study Area is within DFO statistical districts 16 and 17.

Official data on catch and effort are based on two systems: reports of catches made by vessels and reports of purchases by buyers. Small vessels, common in inshore fisheries, are not required to supply log-books of catch or effort, so information is only available on sales made at a port of landing. Information on catches made by individual fishermen is confidential, so data are usually pooled by port of landing or by statistical district.

Fishing effort in the lobster fishery is regulated by limiting the number of traps allowed per vessel, the type of licence (full or part-time), and length of season. Other inshore fisheries, such as that for herring, are regulated by gear type, licence, season, and quotas. The sea urchin fishery is different in that licensed fisherman are allocated a specific area to which they have exclusive fishing rights, coupled with an obligation to manage the urchin resource within their fishing area. Statistical Districts, lobster fishing areas, and sea urchin lease areas are shown on Figure 8.11-1.

Locally, there are five aquaculture sites in Country Harbour and two in Indian Harbour. The two in Indian Harbour are the furthest from the proposed Keltic site at a distance of 17 km. The Country Harbour aquaculture sites range in distance from the Keltic site from 4.3 km to 12 km.

8.11.2.4 Home Ports, Numbers of Fishermen and Vessels

In 1999, Guysborough County had 257 registered fishing vessels ranging from 18 to 64.9 feet; twenty-five of these vessels were in the 35-44.9 foot class, and five were in the 45–64.9 foot class. All other boats were smaller, measuring less than 34.9 feet in length. The fishery directly employed 598 people of whom 345 were full-time and 253 part-time (Boudreau and SFSF, 2001; DFO, 2001).

Under the *Fisheries Organizations Support Act* of Nova Scotia, core fishers, holding licences for limited-entry fisheries such as lobster, groundfish, and scallops, can vote for an accredited organization of choice to which they agree to pay annual dues. In 1998, the GCIFA was accredited by the province to represent Region 3, the Eastern Shore (from Canso Causeway to Halifax Harbour) (GCIFA, 2001). Table 8.11-1 provides the number of core and non-core fishers for Guysborough County from 2000 to 2002.

TABLE 8.11-1 Number of Inshore Fishers, Guysborough County

	2000			2001			2002		
	Core	**Non-Core**	**Total Fishers**	**Core**	**Non-Core**	**Total Fishers**	**Core**	**Non-Core**	**Total Fishers**
District 16	13	43	56	13	37	50	13	41	54
District 17	56	119	175	56	128	184	56	123	179

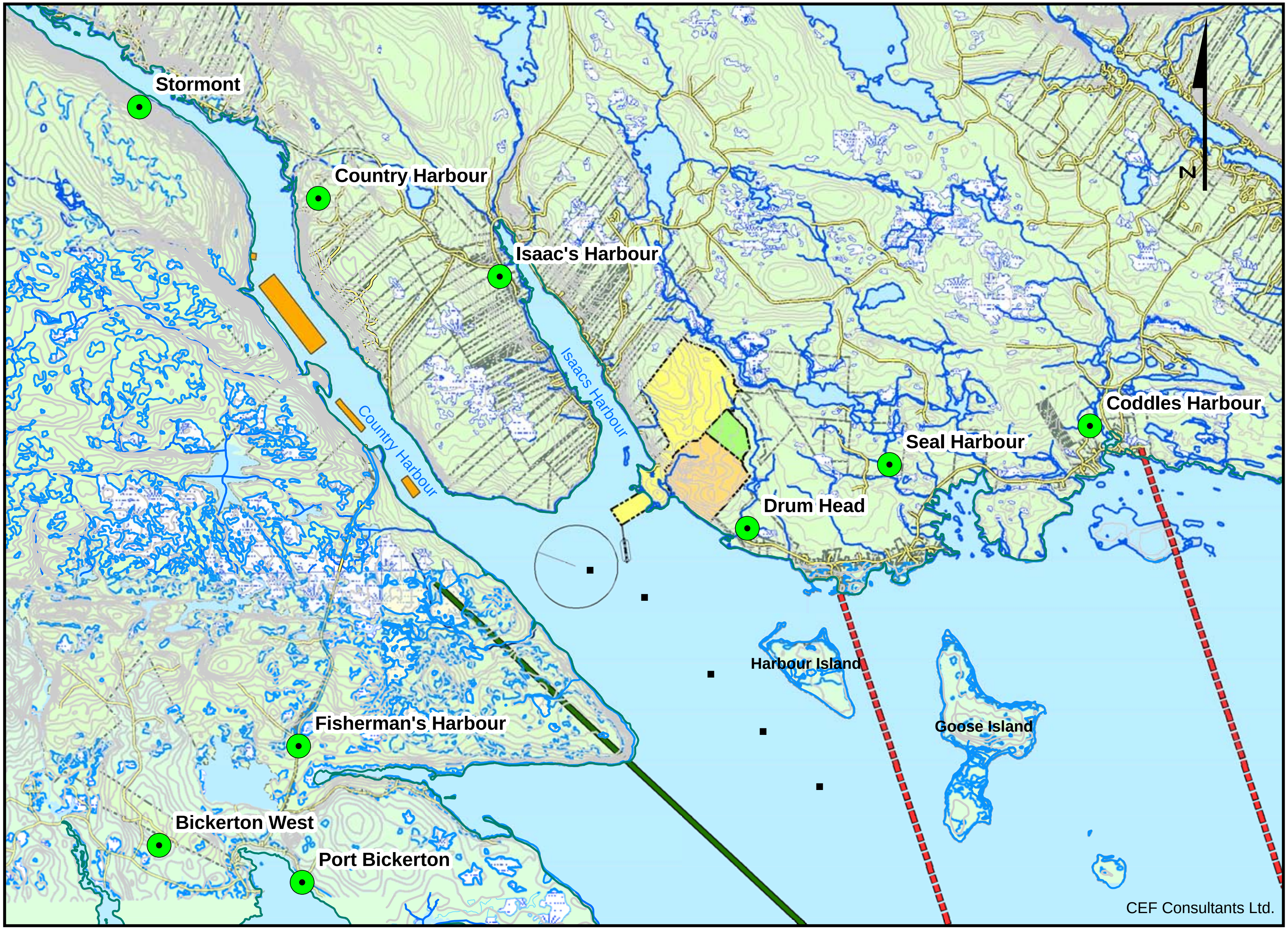
Source: GCIFA, 2001

Table 8.11-2 lists ports in the Study Area in 1999, with the number of registered vessels, and full-time, part-time, and core fishermen in each.

Responsibility for port and wharf management has devolved from the federal government to local Harbour Authorities. In the Keltic Study Area, these include:

- Harbour Authority of Port Bickerton;
- Harbour Authority of Drum Head; and
- Harbour Authority of New Harbour.

FIGURE 8.11-1 Fishing Areas and Aquaculture Near Country Harbour



Legend

Port

Urchin Lease Boundaries

Aquaculture Facility

Statistical District Boundary

1:95,000

0 1 2 4 Kilometers

FIGURE No. 8.11-1
KELTIC PETROCHEMICALS INC.
FISHING AREAS AND AQUACULTURE NEAR COUNTRY HARBOUR
JULY 2006

TABLE 8.11-2 Numbers of Fishermen by Port, 1999

Port	Vessels (<34.9 feet, unless otherwise noted)	Full-time	Part-time	Core
Bickerton West	2	3	1	1
Coddles Harbour	3	5	2	2
Country Harbour	2 (<34.9 ft), 1 (45-64.9 ft.)	17	2	1
Drum Head	5	8	1	3
Fisherman's Harbour	3	5	5	3
Isaac's Harbour	3	3	1	1
New Harbour	5 (<34.9 ft), 1 (35-44.9 ft)	9	5	
Port Bickerton	5 (<34.9 ft), 2 (35-44.9 ft)	16	11	9
Port Hilford	2	3	0	2
Seal Cove		2	1	
Sonora	9	11	29	6
Stormont		3	0	
Wine Harbour	3 (<34.9 ft), 1 (35-44.9 ft)	3	2	3
Total	49	88	60	

(Source: DFO, 2001; Boudreau and SFSF, 2001)

8.11.2.5 Landings and Values

The coastal waters of Guysborough County support fisheries for groundfish, small pelagic species, and invertebrates. Groundfish were historically important, but the stock collapses of the late 1980s and early 1990s, and the resulting moratoria, have largely eliminated those fisheries. However, with the collapse of the ground fishery, the inshore fleet shifted primarily into invertebrate fisheries like lobster and sea urchin (Boudreau and SFSF, 2001).

The most recent data on the value of landings in the Keltic Study Area are available by Statistical District (Table 8.11-3). Species include lobster, shrimp, and snow crab. Sea urchins are not included at present due to the recent collapse of this fishery. Landings of shrimp are from the offshore fleet, which are generally caught near Greenland and landed in Country Harbour.

Without groundfish, the total landed weight in the fishery dropped dramatically. However, the overall value of the Guysborough County commercial fishery is worth much more than it was in 1990 because of the high value per kilogram fetched for most invertebrates (Boudreau and SFSF, 2001).

TABLE 8.11-3 2000-2003 Value of Landings by Statistical District (SD) in Thousands of Dollars

Species or Group	2000		2001		2002		2003	
	SD 16	SD 17	SD 16	SD 17	SD 16	SD 17	SD 16	SD 17
Halibut	0	35	8	83	1	70	1	75
Other Groundfish	120	29	61	31	1	14	149	5
Total Groundfish	**120**	**64**	**68**	**114**	**2**	**84**	**150**	**80**
Alewives	0	1	0	1	0	1	0	1
Mackerel	0	1	0	0	0	1	0	0

Eels	7	21	16	17	15	82	2	35
Smelts	1	4	1	6	1	4	1	0
Tuna, bluefin	52	0	120	11	16	0	54	0
Total Pelagic/Estuarial	**59**	**27**	**137**	**35**	**31**	**87**	**57**	**37**
Lobster	570	1792	709	1888	823	1813	943	2478
Shrimp	15516	0	14307	0	14192	0	17775	0
Crabs, Snow	0	6219	102	3579	0	5275	0	3075
Other Shellfish	9	24	5	13	5	4	2	60
Total Shellfish	**16180**	**8147**	**15122**	**5481**	**15020**	**7092**	**18720**	**5613**
District Total	**16359**	**8240**	**15327**	**5630**	**15052**	**7263**	**18928**	**5729**

Lobster

The inshore lobster fishery has been a limited entry fishery since 1968 and is the most consistent of the Guysborough County fisheries. The majority of licences are Class A with a 250 trap limit, but there are some Class B licences with a limit of 175 traps. Class B licences cannot be sold or transferred.

Lobster season opens in April and closes at the end of June in the Keltic Study Area. Although landings have decreased by more than 50% over the past decade, the total landed value in Statistical Districts 16 and 17 increased to almost $3.5 million in 2003. Lobster fishermen in Guysborough County have actively participated in resource conservation focused on increasing egg production in Eastern Nova Scotia.

Sea Urchin

The sea urchin fishery developed in response to demand from the Japanese market. Shoreline areas are divided into leases assigned to individual operators who hire urchin divers and have a responsibility to adequately manage the resource. Management can include seeding urchins in new areas within their lease. Sea urchin are harvested for their roe. Harvesting is not restricted by season, but generally occurs from October to March. The legal minimum size limit for harvest is 50 mm. In the 1999-2000 season, there were 10 active and 5 inactive licences in Guysborough County. Lease areas within the Keltic Study Area are illustrated in Figure 8.11-1.

The 1994 to 2000 landings for eastern Nova Scotia (from Halifax east to Guysborough) are shown in Table 8.11-4.

Sea urchins are susceptible to parasitic amoebal infection. This infection spreads when waters remain unusually warm for a couple of weeks. Therefore, deeper water areas are less prone to infection and catch can be maintained (at least initially) by shifting the areas of harvest. Depopulated areas can also be reseeded from areas less affected. In the fall of 1999, large numbers of urchins died from parasitic amoebal infection and total landings fell 30% from the previous year. By 2000, the sea urchin fishery had collapsed and has not yet recovered.

TABLE 8.11-4 Sea Urchin Landings (t) for Eastern Nova Scotia from 1994 to 2000

Area	Year					
	94-95	95-96	96-97	97-98	98-99	99-00[1]
Eastern Nova Scotia	709	658	915	700	605	324

[1]Preliminary (Source: DFO, 2000)

Snow (Queen) Crab

Snow crab is a deep water, cold temperature species. They are fished on muddy or sand-mud bottoms at temperatures ranging from –1.0 to 6.0 °C and at depths ranging from 60 m to 300 m. Typical fishing depths off eastern Nova Scotia are 130 m to 250 m (DFO, 2005). The 2003 value of snow crab landings allocated to the inshore was $3,075,000 in Statistical District 17. No landings were recorded in District 16.

Finfish

Swordfish and shark licence holders are based in Guysborough County. The majority of these catches occur in the Country Harbour and Ecum Secum areas. Other finfish such as mackerel, alewives, and herring are fished opportunistically along the coast, primarily for bait.

Other Species

Other invertebrate fisheries now exist for species traditionally considered a nuisance (such as rock crab), or for species that were once supplements to the traditional fishermen's family diet. Additional fisheries have developed following exploration for underutilized species. Species such as crab, shrimp, scallop, and soft-shell clams have all contributed to an increase in the value of the invertebrate fishery.

8.11.2.6 Revenues and Earnings

Inshore Fishery

Revenues from the Guysborough County inshore fisheries were $30 million in 1999, compared to $12 million from the offshore fleet. These proportions were roughly equivalent to the split between the inshore ($418 million) and offshore ($175 million) fisheries throughout the Scotia Fundy management region of that year (Boudreau and SFSF, 2001).

Table 8.11-5 presents inshore landings in kilograms at the larger ports in the Keltic Study Area for 1999 and 2000. Data from adjacent communities was aggregated to preserve confidentiality. The Table highlights the near-absence of groundfish in the area compared to the high landings of lobster and sea urchin (prior to this fishery's collapse).

TABLE 8.11-5 Inshore Fish Landings (kilograms) by Community in the Study Area, 1999 & 2000

Community	Year	Groundfish	Lobster	Sea Urchin	Pelagic Species	Other Invertebrates
Drumhead, Isaac's Harbour, Stormont	2000	–	17,612	19,303	–	4,886
	1999	–	8,291	82,690	–	2,855
Coddle Harbour, New Harbour, Seal Cove	2000	–	19,702	28,284	1,216 (bluefin tuna)	5,795 (scallop)
	1999	–	14,644	30,481	828 (bluefin tuna)	13,521 (scallop)
Country Harbour	2000	–	1,744	–	–	–
	1999	–	1,230	–	–	–
Port Bickerton, Bickerton West, Fisherman's Harbour	2000	6,186	38,680	24,768	–	–
	1999	1,952	24,244	26,926	771 (mackerel)	24,622 (queen crab)
Port Hilford, Wine Harbour, Sonora	2000	676	13,995	23,762	–	6,422
	1999	1,377	7,100	74,516	–	1,722

(Source: DFO, 2001)

First Nations Fisheries

First Nations peoples have historically harvested fish and wildlife resources in the Keltic Study Area. Recently, however, little native use of fish resources has been documented. The Millbrook First Nation has two commercial urchin leases in the vicinity of Country Harbour. One is located east of Port Bickerton, south of Cape Macodome, and the other to the west of Port Bickerton, south of Fiddlers Head (see Figure 8.11-1). The Afton First Nation has a lease near Indian Harbour/Wine Harbour. Licences that once belonged to a recently retired Country Harbour fisherman have been reissued to a First Nations band. These licences are applicable in the area from Ecum Secum to White Head.

Aquaculture

The GCRDA has targeted aquaculture as a key factor in regional economic development. A Regional Aquaculture Development Advisory Committee was established to review applications for coastal resources and resolve potential conflicts among resource users. Active growers produce blue mussels and blue mussel spat for sale to other growers. Scallops, and steelhead salmon are also farmed, but not within Stormont Bay (Boudreau and SFSF, 2001).

Table 8.11-6 shows aquaculture production and employment for Guysborough County and Nova Scotia as a whole in 2000. Aquaculture sites within County Harbour are shown on Figure 8.11-4.

TABLE 8.11-6 2000 Production Statistics, Aquaculture

Area	Weight (kg)	Value	Full-time jobs	Part-time Jobs (< 6 Months Duration)	Part-time Jobs (> 6 Months Duration)
Guysborough	325,842	$351,209	31	21	12
Nova Scotia	11,618,948	$50,469,494	361	504	194

(Source: Nova Scotia Department of Agriculture, Fisheries and Aquaculture (NSDAF), 2001b)

Cultivation of blue mussels is the most successful form of aquaculture in Guysborough County. Most shellfish farming in Guysborough County is done by suspension cultivation from longlines, as is the case with Country Harbour Sea Farms operating in Country Harbour. Cultures are hung at intervals along a longline, which is anchored at each end. Buoys and concrete blocks are tied along the line to provide mooring and regulate the overall height of the longline in the water. Growers sometimes sink the longlines at least one metre below the ice cover for the duration of the winter to avoid contact with surface ice (Boudreau and SFSF, 2001).

Most large-scale operations use a boat with a power-operated winch to lift, tend, and harvest the lines. SCUBA divers are also used, especially when the longlines are below the ice (Boudreau and SFSF, 2001). Aquaculture operations in Country Harbour are relatively small scale; employment varies seasonally, with a small core staff of less than five people.

Cultivation of finfish and scallops has been considered and attempted in some areas, but none of these species are currently produced within Stormont Bay.

8.11.2.7 Seasonality

Most inshore fisheries in the Keltic Study Area operate between April and October. The coast of the Keltic Study Area falls within Lobster Fishing Districts 31b and 32. The season opens April 19 for Districts 32 and 31b. Both close on June 20 (DFO, 2004). The rock crab season usually opens the week after lobster season closes and ends one week before it.

Historically, the inshore fleet's season began on July 1. Since a quota system is in place, most boats finish well before the formal end of the season. In 2001, for example, 80% of the quota for the temporary inshore associations off Guysborough County had been caught by early September (M. Eagles, pers. comm., 2001).

The inshore herring and mackerel fisheries are open throughout the year. A commercial herring roe fishery occurs in the fall on the Eastern Shore. Its location is dependent on where herring spawn. A review of landed values from 1996 onward showed almost no commercial landings in either District 16 or 17. Effort in the bait fishery for herring and mackerel is highest in the month before lobster season opens. Mackerel migrate out of the area in June, into the Gulf of St. Lawrence, and return in the fall on their way further south. Mackerel migration routes can change which can result in large variations in catch between years.

The inland waters sport-fishing season for speckled (brook) trout, brown trout, rainbow trout, landlocked salmon, chain pickerel, white perch, and yellow perch generally runs from April 1 to September 30 in the Keltic Study Area. The tidal waters season is from April 15 to September 30, to protect sea-run speckled trout, brown trout, and Atlantic salmon populations (NSDAF, 2001c).

8.12 AQUATIC SPECIES AND HABITAT

8.12.1 Freshwater Species and Habitat

8.12.1.1 Methods

Investigations of Keltic Study Area fishery resources began in the summer of 2001, when initial reconnaissance surveys were undertaken. The first fish collections were completed during

October 2001 at Gold Brook Lake, Seal Harbour Lake, and Meadow Lake, along with all major tributaries to these lakes. These lakes were targeted for study because they were identified as candidates for sources of cooling or process water or as potential receiving waters for the plant discharge. During the surveys, aquatic habitat characteristics were noted, and photographs of important features were taken. An aerial photo survey of the Keltic Study Area was also undertaken during this initial period, during which approximately 200 oblique colour aerial photographs were taken.

In the spring of 2004, more detailed fish surveys were initiated in Keltic Study Area lakes and rivers, specifically Meadow Lake, Ocean Lake, Goldbrook Lake, and associated tributaries. By this time, Meadow Lake had been identified as the preferred source of water for the Keltic Facility, with Ocean Lake and Goldbrook Lake as possible sources of emergency water supply. Fish and other aquatic surveys continued through the summer and fall of 2004 and into the spring and early summer of 2005.

In each lake, fish were collected with the use of experimental gill nets; and where possible, with hoop nets. Sampling details, dates, and timing of all net sets are presented in Appendix 9. Fish were also collected with the use of a backpack electrofisher, seine nets, and dip net in shallower waters of each lake, in the vicinity of most tributaries and discharges associated with each lake. As with the gill-net collections, collected fish were identified, enumerated, and released alive at the site of capture.

Throughout the fish and aquatic surveys, information about in-water and riparian habitat was noted, including substrates, vegetation, and structural-habitat features. Photographs of representative habitat and relevant or noteworthy features were also taken.

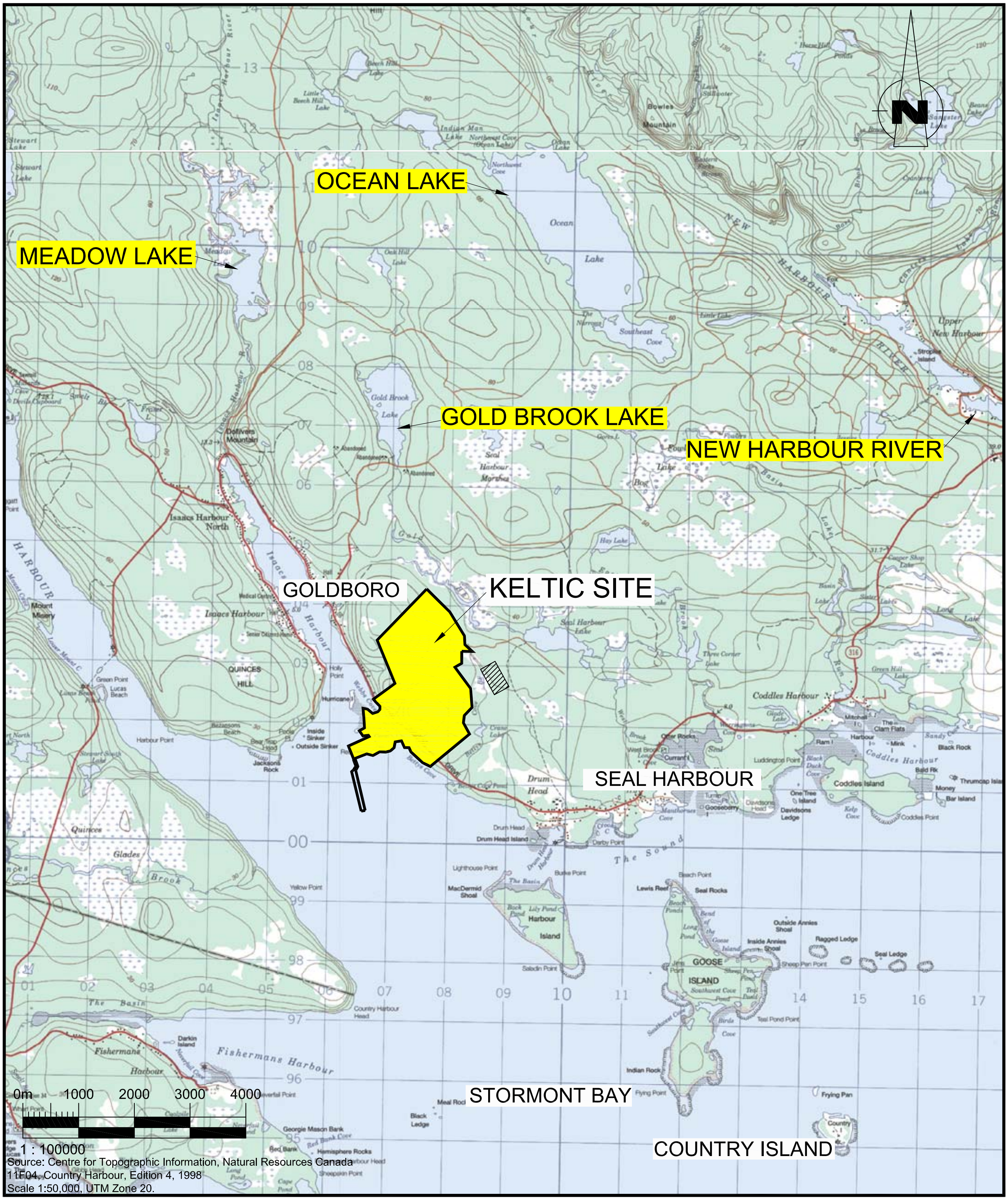
As required by the terms of the collection licence, the detailed results of the fish surveys were reported to DFO at the conclusion of each study period.

8.12.1.2 Meadow Lake

Meadow Lake is also known locally as Isaac's Harbour Lake. The headwaters of the Meadow Lake watershed originate in Garry Lake and Garry River located approximately 10 km north of Meadow Lake. The Garry River discharges to Big Stillwater Lake along with several other smaller tributaries; and from that lake, the discharge becomes Isaac's Harbour River which flows to Meadow Lake. The only other major tributary to Meadow Lake is that from Little Beach Hill and Beach Hill lakes located about 2 km north of Meadow Lake. The location of Meadow Lake is illustrated in Figure 8.12-1.

Meadow Lake is a relatively shallow lake, with the deepest sections of the lake reaching approximately 2 m. There are essentially two dominant riparian habitat types associated with Meadow Lake: forest and bogs. The forest is dominated by black spruce, white spruce, tamarack, leatherleaf and sheep laurel. The bogs are dominated by tamarack, bog laurel, hares tail, pitcher plant, bog rosemary, rhodora, small cranberry, sweet gale, sweetflag, steeplebush, peat moss and by a variety of grasses and sedges. Due to the shallow nature of the lake, aquatic macrophytes were observed throughout most of the lake, with observed species including yellow pond lily, fragrant white water lily, pickerel weed, and stonewort.

FIGURE 8.12-1 Study Area Lakes and Rivers



LEGEND

Project Location

FIGURE No. 8.12-1
KELTIC PETROCHEMICALS INC.
STUDY AREA LAKES AND RIVERS
JULY 2006

Substrates in the shallow waters around the lake are dominated by boulder and cobble, with occasional patches of sand and gravel. In deeper waters, the substrate is virtually all silt. Sand and gravel beaches are located along several stretches of the shoreline.

Nine tributaries discharge to Meadow Lake, the locations of which are illustrated in Figure 8.12-2. Following is a summary of key characteristics of each:

Tributary 1

Tributary 1, the Isaac's Harbour River originates 10 km north of Meadow Lake in the vicinity of Garry Lake. The Isaac's Harbour River is sinuous in nature and is generally characterized by riffle-pool-run sequences, undercut banks, and overhanging riparian vegetation. The substrates in the channel are dominated by gravel and sand. In the lowermost reaches of the watercourse, riparian vegetation consists of grasses, sedges, rhodora, speckled alder, and black spruce.

Tributary 2

Tributary 2 originates approximately 1.5 km northwest of its discharge on the west side of Meadow Lake. The channel associated with this first-order watercourse is well defined with a bankfull width and depth of approximately 2.9 m and 0.35 m respectively. Channel substrates in the lower reaches are dominated by organic fines and sands where the watercourse meanders through open wetland meadow habitat Riparian vegetation includes white and black spruce, rhodora, sweet gale, leatherleaf, grasses, moss and pitcher plant.

Tributary 3

Tributary 3 is a very small first-order drainage feature discharging to the southwest shore of Meadow Lake. The channel is generally well defined with an average bankfull width and depth of about 0.4 m and 0.25 m. Substrates in the channel consist mostly of sand, with occasional isolated cobbles and gravel. Riparian vegetation includes sweet gale, grasses, leatherleaf, rhodora, grasses, black and white spruce, tamarack, red maple, white birch, and speckled alder.

Tributary 4

Tributary 4 is a small first-order watercourse originating approximately 300 m east of Meadow Lake. The channel is moderately well defined with an approximate bankfull width and depth of approximately 0.5 m and 0.3. m in the lower reaches. Throughout much of its length, it meanders through open wetland meadow. Substrates in the channel are dominated by sands and organic sediments. Riparian vegetation consists of grasses, leatherleaf, rhodora, sheep laurel, black spruce, and tamarack.

Tributary 5

Tributary 5 is a small first-order watercourse that originates about 350 m east of Meadow Lake. The channel appears moderately well defined with an average bankfull width and depth of approximately 0.4 m and 0.25 m in the downstream-most reaches. Channel substrates are

FIGURE 8.12-2 Tributaries Feeding Meadow Lake

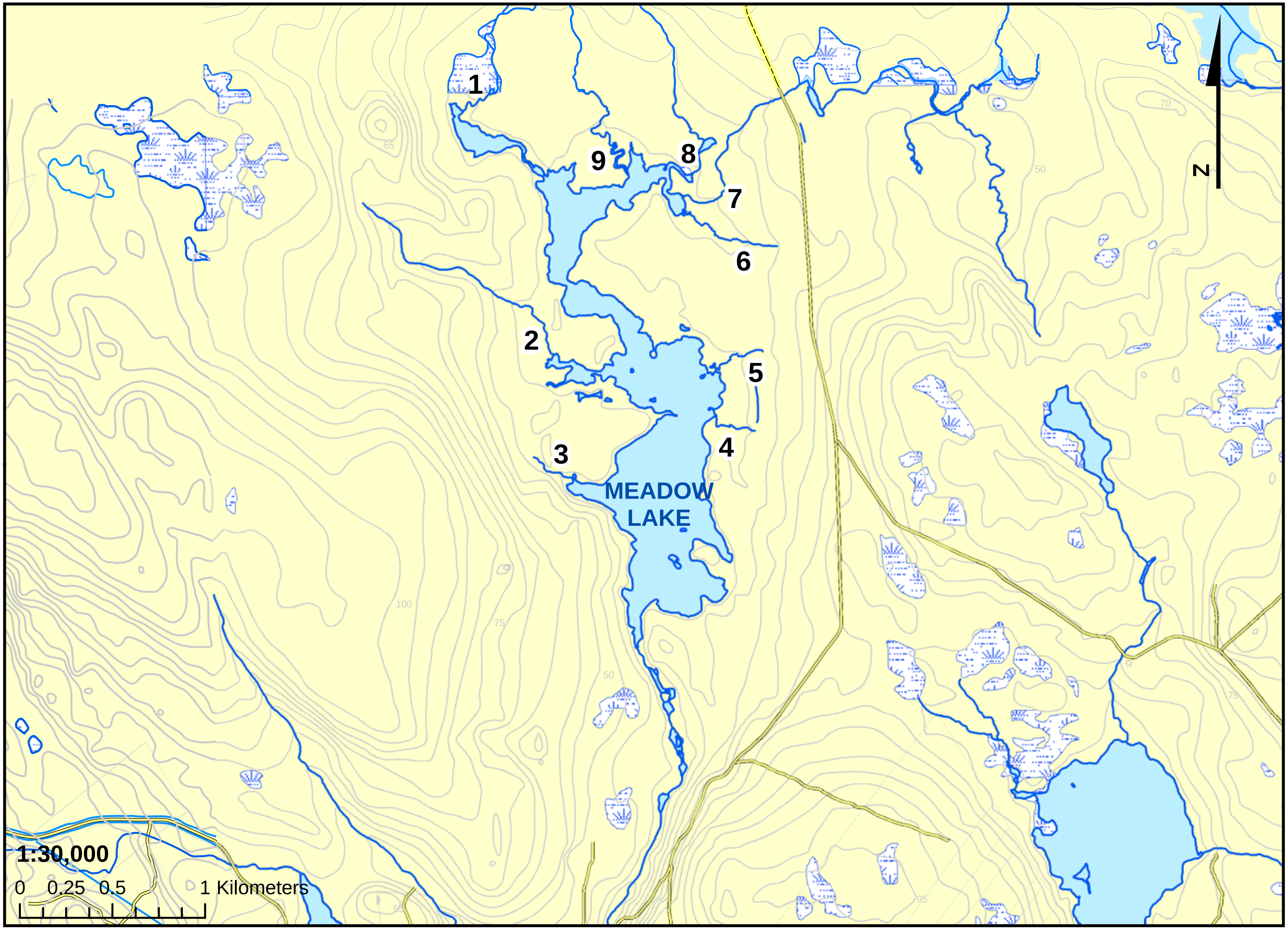


FIGURE No. 8.12-2

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TRIBUTARIES FEEDING MEADOW LAKE

JULY 2006

dominated by organics, silt and sand. As with Tributary 4, this watercourse is almost entirely located in an open area of wetland meadow with riparian vegetation consisting of grasses, leatherleaf, rhodora, wild grape, speckled alder, black spruce, and tamarack.

Tributary 6

Tributary 6 is a first-order watercourse which originates approximately 650 m east of Meadow Lake. In the downstream-most reaches, the channel is well defined with an average bankfull width and depth of about 2.5 m and 0.6 m respectively. Substrates are dominated by organic silts and sand with riparian vegetation including grasses, sedges, leatherleaf, speckled alder, and tamarack. Except for the headwater reaches of this tributary, it is located in open wetland meadow habitat.

Tributary 7

The headwaters of Tributary 7 are located northeast of Meadow Lake in the vicinity of Beech Hill Lake and Little Beech Hill Lake. This watercourse is the second largest draining to Meadow Lake after Isaac's Harbour River. The channel is well defined with an average bankfull width and depth of about 5.0 m and 0.6 m. Channel substrates in the downstream-most reaches are dominated by sand and gravel, with occasional deposits of silt. Riparian vegetation is dominated by alder, spruce, and tamarack. At the road crossing located approximately 1 km upstream, substrates consist of boulder, bedrock and cobble and riparian vegetation is almost entirely speckled alder.

Tributary 8

Tributary 8 is a first-order watercourse originating about 1 km north of Meadow Lake. The tributary appears to be relatively well defined in the vicinity of the lake, with substrates dominated by sand and organic silt. The downstream-most reaches of this watercourse are located mostly in woodland habitat, with riparian vegetation dominated by black spruce, tamarack, and alder.

Tributary 9

Tributary 9 originates about 1 km north of Meadow Lake. It is a first-order watercourse with a well defined channel and distinct meanders, particularly in the reaches upstream of the lake. For approximately the first 250 m upstream, the channel is located in an open wetland meadow and has substrates consisting mainly of fine organic silt with some sand. Riparian vegetation includes grasses, sedges, rhodora, speckled alder, black spruce, and tamarack.

A summary of fish species collected in Meadow Lake is presented in Table 8.12-1, and the detailed survey results are given in Appendix 9.

TABLE 8.12-1 Fish Species Collected in Meadow Lake

Scientific Name	Common Name
Anguilla rostrata	American eel
Pungitius pungitius	Nine spine stickleback
Catostomus commersonii	White sucker
Salvelinus fontinalis	Brook trout
Notemigonus crysoleucas	Golden shiner
Perca flavescens	Yellow perch
Salmo salar	Atlantic salmon

The fish community in Meadow Lake is dominated by yellow perch. White suckers are also a significant constituent of the community, with brook trout and golden shiners in relatively low abundance. The most notable result of the fish collections in this lake was the capture of an Atlantic salmon during the 2001 surveys - a mature male in spawning condition. Local residents report that this species has historically migrated up the Isaac's Harbour River from the Atlantic Ocean; and although Meadow Lake is not typical of Atlantic salmon habitat, it is likely that the salmon use Isaac's Harbour River upstream and perhaps downstream of Meadow Lake for spawning. Local residents also indicated that the low flows of some recent years have precluded salmon migration in this watercourse.

Although juveniles of most species were collected during the surveys, no juvenile Atlantic salmon were captured during any survey of 2001, 2004, and 2005 in Meadow Lake and associated tributaries. This, combined with the capture of only one adult in this watershed during the Keltic studies, may be indicators of the present status of Atlantic salmon in the Meadow Lake system.

With the exception of American eel which spawns at sea, all fish species collected in Meadow Lake would be expected to spawn in the Meadow Lake watershed. Nine spine stickleback likely spawns virtually anywhere in the watershed, and yellow perch, golden shiner probably spawn in Meadow Lake. Brook trout and white sucker likely use the tributaries to Meadow Lake for spawning purposes. Meadow Lake also provides abundant nursery and feeding habitat for all constituents of the fish community.

Invertebrates noted around the lake margins included mayfly, caddis fly, planaria, leaches, beetles, water striders, and chironomids.

8.12.1.3 Gold Brook Lake

The headwaters of Gold Brook Lake originate at Oak Hill Lake, a small lake situated almost midway between Ocean Lake and Meadow Lake. Gold Brook Lake has two main tributaries, both of which discharge to the lake along the north shore and one of which is the watercourse from Oak Hill Lake. Gold Brook Lake discharges to Gold Brook at Gold Brook Road, a location at which there are the remains of several former gold mines. Gold Brook flows generally south easterly to Seal Harbour Lake, and from there through East Brook and West Brook to the Atlantic Ocean at Warrington's Cove. The location of Gold Brook Lake is illustrated in Figure 8.12-1.

Riparian vegetation is generally dense, uniform and dominated by black spruce, balsam fir, tamarack, red maple, sheep laurel and leatherleaf, labrador tea, rhodora, pitcher plant, bog laurel, peat moss and horsetail and a variety of grasses and sedges. Stonewort was observed at several locations within the lake.

Shallow water substrates are dominated by boulder and cobble, with occasional small gravel beaches. Substrates in the vicinity of the Gold Brook Lake outlet consist primarily of fine sandy materials, much of which is tailings from the former gold-mining operations.

A summary of fish species collected in Gold Brook Lake is presented in Table 8.12-2, with the detailed survey results given in Appendix 9.

TABLE 8.12-2 Fish Species Collected in Gold Brook Lake

Scientific Name	Common Name
Fundulus diaphanus	Banded killifish
Perca flavescens	Yellow perch
Salvelinus fontinalis	Brook trout

The fish community in Gold Brook Lake is dominated by yellow perch. Brook trout are also present in the lake and in Gold Brook. Brook trout requires ground-water discharge for successful spawning. The presence of this species in Gold Brook Lake indicates that this is a spring-fed system and that the water quality is likely relatively high. American eels were not collected during any survey but have been reported as present by local residents and by previous studies. This species is catadromous, which means that they reproduce in the ocean and migrate to fresh-water rearing habitat. The presence of this species in Gold Brook Lake confirms that there is un-obstructed passage for eels between this lake and the Atlantic Ocean.

Invertebrates noted in Gold Brook Lake and in the vicinity of the discharge included mayfly and caddisfly, both of which are typical indicators of relatively good water quality. Blackflies, beetles, and leaches were also noted.

8.12.1.4 Ocean Lake

Ocean Lake is relatively deep, with maximum depth reaching approximately 20 m. Four small tributaries feed the lake, with the largest being that which originates at Indian Man Lake located approximately 2 km to the northwest. Ocean Lake discharges to New Harbour River. The location of Ocean Lake is illustrated in Figure 8.12-1.

Riparian vegetation around Ocean Lake is dense, uniform, and dominated by black spruce, balsam fir, tamarack, sheep laurel, and leatherleaf.

Aquatic macrophytes are relatively sparse in this area, although some stands are present in the shallower waters of Southeast Cove and near the discharge of the lake. Species included tape grass, pickerel weed, and yellow pond lily. The shallow-water substrates around the margin of Ocean Lake are generally uniform and consist of boulders, cobble, gravel, and sand.

A summary of fish species collected in Ocean Lake is presented in Table 8.12-3, with the detailed survey results given in Appendix 9.

TABLE 8.12-3 Fish-Species Collected in Ocean Lake

Scientific Name	Common Name
Anguilla rostrata	American eel
Pungitius pungitius	Nine spine stickleback
Fundulus diaphanus	Banded killifish
Catostomus commersonii	White sucker
Salvelinus fontinalis	Brook trout

In terms of biomass, the fish community in Ocean Lake appears dominated by white sucker, with banded killifish and nine spine stickleback contributing relatively large numbers to the catches White sucker and brook trout likely spawn in the inflowing tributaries and perhaps in the lake outlet, with killifish and nine spine stickleback spawning in those areas of the lake having aquatic vegetation. The entire Ocean Lake sub-watershed also provides nursery and feeding habitat for all constituents of the fish community.

8.12.1.5 New Harbour River

The headwaters of New Harbour River originate in the vicinity of Ephraims Lake. The Northeast Branch New Harbour River and the outlet of Ocean Lake both discharge into New Harbour River which eventually flows into Upper New Harbour. The location of New Harbour River is illustrated in Figure 8.12-1.

Riparian vegetation along most of the river is dominated by black spruce, red maple, balsam fir, speckled alder, rhodora, sheep laurel, peat moss, and a variety of grasses and sedges. Typical bank-full width in the river downstream of the Ocean Lake discharge is about 17 m with a bank-full depth of approximately 0.6 m.

Substrates throughout the river are relatively uniform, consisting of boulder, cobble, and gravel. Overhanging vegetation, undercut banks and deep pool and riffle-run flows provide high-quality habitat. The channel appears stable throughout all reaches examined.

A summary of fish species collected in New Harbour River is presented in Table 8.12-4, with the detailed survey results given in Appendix 9.

TABLE 8.12-4 Fish Species Collected in New Harbour River

Scientific Name	Common Name
Anguilla rostrata	American eel
Fundulus diaphanus	Banded killifish
Salmo salar	Atlantic salmon
Salvelinus fontinalis	Brook trout

The most noteworthy result of the fish collections in New Harbour River is the presence of numerous juvenile Atlantic salmon. This is the only aquatic system in the Keltic Study Area where salmon at this life-cycle stage were found. Adult and juvenile brook trout were also frequent constituents of the catch.

8.12.1.6 Red Head Peninsula Ponds

Several ponds are located on Red Head Peninsula situated near the entrance to Isaac's Harbour. Some are fresh water and some are brackish, and all ponds had fish - ranging from one to five species. Blue heron were frequently observed feeding in all ponds in this part of the Keltic Study Area.

Pond 1

Pond 1 is located on the northwest side of Red Head (Figure 8.12-3). Aquatic substrates are dominated by organic silt. Stumps, woody debris, and overhanging vegetation provide some structural habitat for aquatic biota. Vegetation associated with this pond includes tape grass, Richardson's pondweed, sweetflag, broad-leaved arrowhead, rushes, grasses, cinnamon fern, caraway, cow vetch, lily of the valley, wild strawberry, wild red raspberry, sweet gale, marsh cinquefoil, Canada thistle, Canada goldenrod, tall meadow rue, mountain holly, rhodora, leatherleaf, speckled alder, common juniper, tamarack, and white spruce.

A total of five fish species were collected in this pond during the fall of 2004 and spring of 2005; American eel, banded killifish, brook trout, mummichog, and ninespine stickleback.

Pond 2

Pond 2 is situated immediately south of Pond 1 on the northwest side of Red Head (Figure 8.12-3). Pond substrates are predominantly organic silt with cobble patches along the margins. Aquatic and riparian vegetation consists of tape grass, yellow pond lily, sweetflag, grasses, cinnamon fern, cow vetch, wild red raspberry, wild strawberry, sweet gale, Canada goldenrod, rhodora, speckled alder, smooth serviceberry, and white spruce. American eel was the only species found in this pond

Pond 3

Pond 3 is located on the western side of Red Head (Figure 8.12-3). Substrates in the pond consist of organic silt with small areas of cobble and gravel at places around the pond shoreline.

Aquatic and riparian vegetation within the pond include wild rice, grasses, beach pea, sea lungwort, common dandelion, grass leaved stitchwort, cow vetch, garden lupin, greater arrowgrass, wild strawberry, cinnamon fern, Canada goldenrod, sweet gale, leather leaf, speckled alder, and white spruce.

Three fish species were collected in this pond during the spring 2005 surveys; ninespine stickleback, threespine stickleback, and banded killifish.

Pond 4

Pond 4 is located southwest of Pond 5, and is the southernmost pond on Red Head (Figure 8.12-3). Pond substrates are dominated by cobble and gravel overlain by organic silt. A thick mat of filamentous algae was noted throughout the pond. Aquatic and riparian vegetation in the vicinity of the pond includes slender naiad, grasses, wild raspberry, sea lavender, lovage, common dandelion, thistle, beach pea, speckled alder, smooth serviceberry, and white spruce.

A total of three fish species were collected from this brackish pond in 2004 and 2005; threespine stickleback, fourspine stickleback, and ninespine stickleback.

Pond 5

Pond 5 is situated immediately to the north of Pond 4 (Figure 8.12-3). Substrates in this pond are dominated by cobble and gravel overlain by organic silt. The margins of the pond have cobble and boulder with occasional woody debris. Thick stands of filamentous algae were noted during the 2004 and 2005 surveys. Aquatic and riparian vegetation in the vicinity of the pond consists of fucus, slender naiad, grasses, wild raspberry, sea lavender, lovage, common dandelion, thistle, beach pea, speckled alder, smooth serviceberry, and white spruce.

Three fish species were found in this brackish pond; threespine stickleback, fourspine stickleback, and ninespine stickleback.

Pond 6

Pond 6 is located on the northeast side of Red Head near its junction with the mainland (Figure 8.12-3). Aquatic substrates are dominated by organic silt with scattered boulders around the perimeter of the pond. The shoreline is dominated by woody debris and grasses, with the exception of the eastern shore which is dominated by gravel, cobble, and boulder. Aquatic and riparian vegetation consist of common mare's tail, tape grass, yellow pond lily, common cattail, sweet flag, grasses, marsh cinquefoil, cinnamon fern, sheep laurel, smooth serviceberry, speckled alder, tamarack, white spruce, and black spruce.

This is a freshwater tea-coloured pond. A total of five fish species were collected here during the fall 2004 and spring 2005 fisheries surveys; American eel, ninespine stickleback, banded killifish, mummichog, and juvenile and adult brook trout.

FIGURE 8.12-3 Red Head Peninsula Study Area

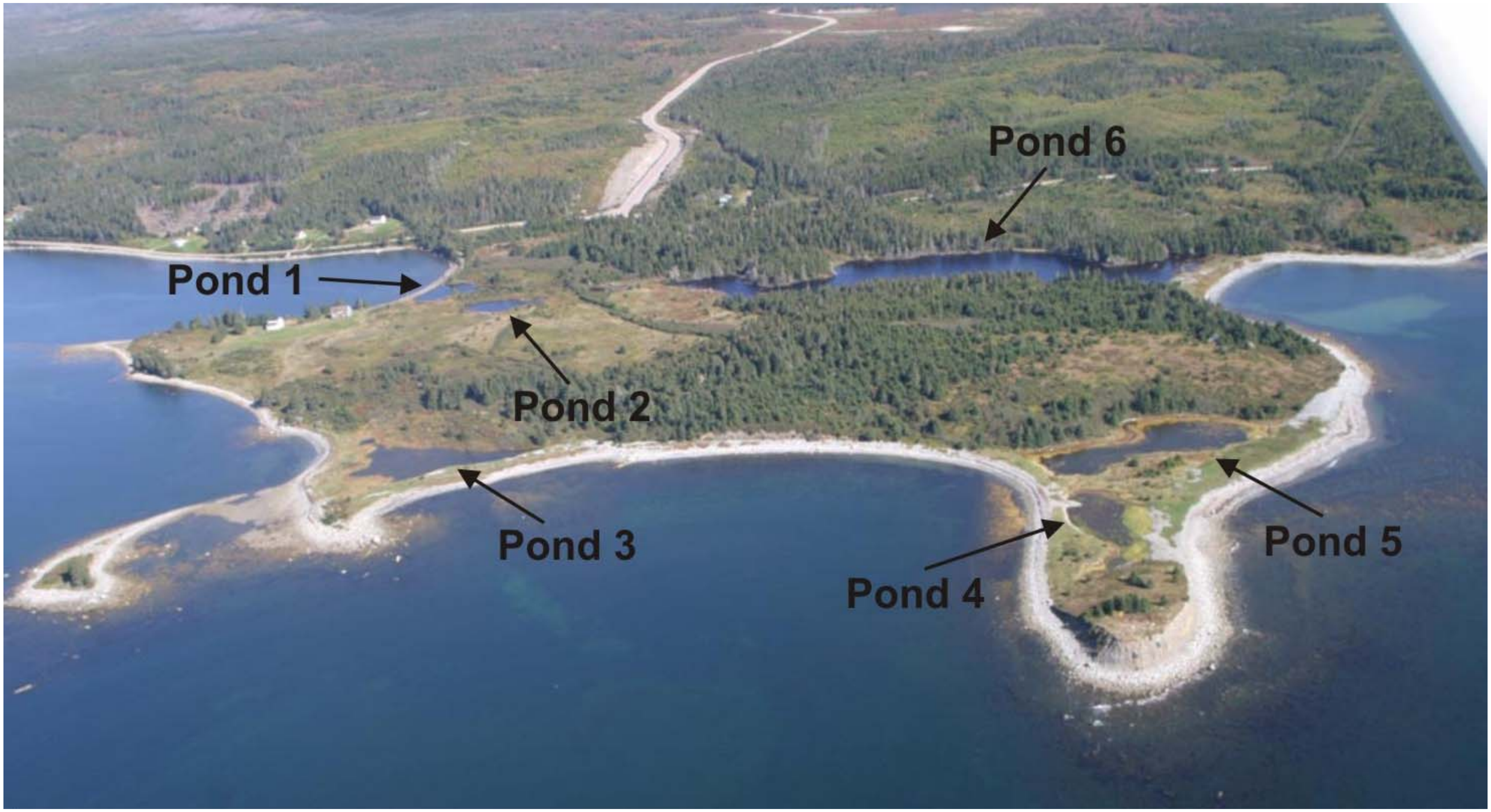

FIGURE 8.12-3
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RED HEAD PENINSULA STUDY AREA
JULY 2006

Betty's Cove Brook

A first-order headwater tributary of Betty's Cove Brook originates in the northeast corner of the Keltic Site. This drainage feature flows in a southeasterly, then off site in a southerly direction to Crane Lake, which discharges to the Atlantic Ocean at Betty's Cove Pond. This tributary supports a fish community consisting of brook trout, American eel, and nine spine stickleback. Brook trout and nine spine stickleback likely spawn in this watercourse. It also provides feeding and migratory habitat for American eel.

Although there is no indication that there is a fishery in the on-site reaches of this watercourse, the headwaters no doubt contribute to the fishery which exists further downstream, and which includes species such as brook trout, and American eel. There are no aquatic "species of concern" in this tributary.

8.12.2 Marine Species and Habitat

8.12.2.1 Previous Studies

In response to proposed and constructed industrial projects in recent years, several EAs and other studies have been completed over the past decade in order to assess the habitat of the area. These studies have led to an increased knowledge of the marine environment and a better understanding of fisheries capability. Results from these studies, in addition to other relevant marine and ecological research from elsewhere in the province, support general observations of the biophysical environment of Stormont Bay and surrounding areas.

Information has been compiled in order to help assess the habitat and biological productivity of Stormont Bay and surrounding areas, particularly in terms of its relevance to the proposed Keltic Facility. The types of studies carried out for each of these projects are described below.

Habitat Surveys

Between 1995 and 1997, the Guysborough County Coastal Resources Mapping Project mapped the fish habitat of coastal Guysborough County (including Stormont Bay, the Keltic wharf area, and adjacent areas) based on traditional knowledge of fishermen and other local residents and boaters. Areas of important fish habitat, including fishing areas for scallop, lobster, and sea urchin were identified.

Between 1996 and 2000, studies were carried out during the planning, design, and construction phases of the SOEP, which was constructed to bring offshore gas into Goldboro near the proposed Keltic Facility. Biophysical studies included plankton surveys, sediment transport studies, and habitat assessments for species such as lobster and urchin.

Encana's Deep Panuke Project also proposed bringing offshore natural gas to shore in a marine pipeline near Goldboro. Fieldwork for an environmental impact assessment was conducted in 2001 and included an offshore benthic habitat and community survey.

Between 1996 and 2000, Canadian Seabed Research collected bathymetric and geological data within Country Harbour and Stormont Bay using sonar and seismic sounding equipment.

In 2004, Keltic initiated studies on the proposed wharf and LNG terminal site. These studies included a Remote Operated Vehicle video survey (refer to Figure 8.12-4) of marine habitat in the proposed site, a detailed intertidal habitat study of the surrounding shore, and a benchmark quadrat survey of selected sites in the vicinity.

Sampling and analysis of ocean floor sediments in Isaac's Harbour was conducted by the Geological Survey of Canada (in association with the NSDNR) in May 2005. Work was performed to measure contaminant levels of mercury and arsenic in sediments associated with gold mine tailings. Due to the location of sampling sites, the work will not provide much information to characterize sediments in the area where Keltic is proposing to construct a marginal wharf. However, the collected information can be used to support broader inferences of ocean floor contaminants within the larger estuarial and bay ecosystems based upon biophysical factors such as sediment type and ocean currents.

Georges Bay

The St. Georges Bay Ecosystem Project (Kellman et al, 2000) is a DFO supported initiative to gather existing information related to various biophysical and human use components of the estuarial and coastal zones in the St. Georges Bay area. The research was designed to improve overall understanding of abiotic and biotic ecological functions of the St. Georges Bay Ecosystem. This knowledge can be used to complement research in other marine environments in Nova Scotia, such as the estuarial and bay habitats in the area of the proposed Keltic Facility.

Nova Scotia Museum of Natural History (NSMNH)

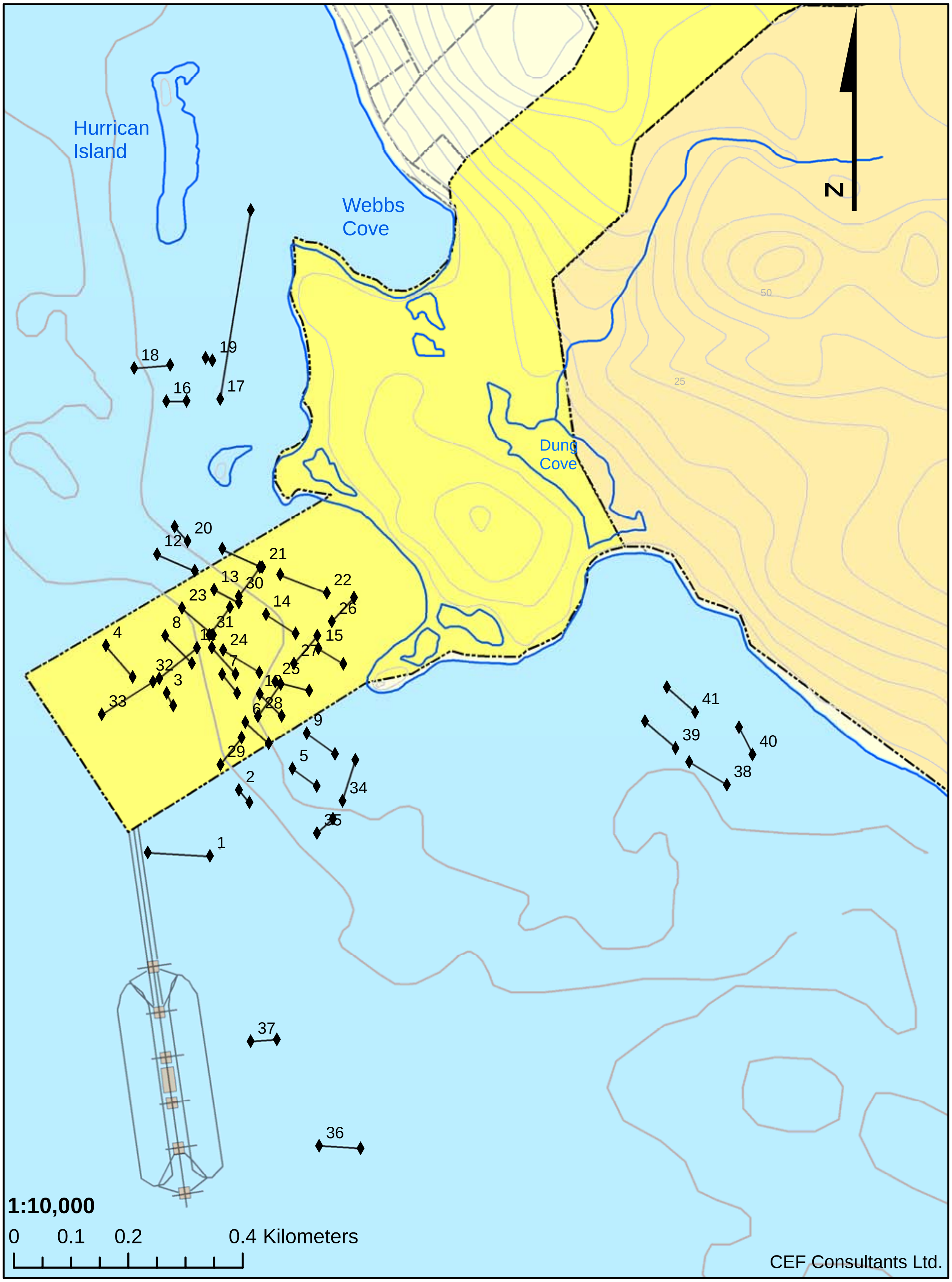
The NSMNH issued a two-volume publication in 1997 entitled, "The Natural History of Nova Scotia (NSMNH, 1996a, b)". Volume I describes general habitat types found within Nova Scotia, including typical coastal and benthic habitats that occur along the Guysborough coastline. Volume II contains more detailed information specific to the region surrounding the proposed Keltic Facility that can provide a more complete picture of the region's ecology, including oceanography, climate, landforms, coastal regimes, geology, plants, and animals.

8.12.2.2 Biophysical Environment

The proposed Keltic Facility is located near the coastal waters of Stormont Bay, Country Harbour, and Isaac's Harbour (Figure 1.1-1a). This area is located within the Guysborough Harbours Unit, a coastal ecological zone characterized by long, narrow inlets with steep valley sides. The coastline is submerged, with parallel inlets and estuaries separated by headlands typically composed of greywacke or granitic bedrock covered with a thin layer of quartzite till. Glaciofluvial deposits of coarse sand and gravel are found in many of the river valleys, while the coastline is generally rockier with few sand beaches (NSMNH, 1996b).

The Goldboro area is underlain by the metamorphosed sandstones and silts of the Meguma Group, principally the Goldenville Formation, with small intrusions of the granitic South Mountain Batholith. This bedrock is covered by glacial tills on land, and by silty to sandy loose sediments off the coast.

FIGURE 8.12-4 Remote Operated Vehicle Transect Locations



Legend

41 ROV Transects

FIGURE No. 8.12-4
KELTIC PETROCHEMICALS INC.
REMOTE OPERATED VEHICLE TRANSECT LOCATIONS
July 2006

Stormont Bay is predominantly covered with fine sand and silt with scattered rock shoals. The subtidal zone, generally extending to depths of about 15 meters below mean low water, has a predominantly sand and gravel bottom (NSMNH, 1996b). The near-shore marine habitat at Red Head has a substrate of boulders, cobbles, and pebbles, with finer materials such as sand and gravel in more protected bays.

The Goldboro area was historically a site of active gold mining. Evidence of this activity can still be seen in the form of abandoned mine sites and tailings dumps. Gold mine tailings tend to be high in arsenic and mercury as a result of the gold extraction process. Several tailings sites have been identified near the Project both on land and in the harbour. Sediment samples taken from the proposed wharf site do not show elevated mercury or arsenic levels and the terrestrial sites appear to be well contained.

A recent study by the NSDNR looked at mercury and arsenic contamination levels in Isaac's Harbour and found that while there is a layer within the near surface sediment with an elevated metal content, the concentrations are within acceptable limits (Parsons, pers. comm., 2005). The sampling site nearest to Red Head shows almost no change in arsenic levels throughout the sediment column with a slight elevation of mercury near the surface of the sea bottom.

Wave Climate

Stormont Bay and the estuarial heads of Country Harbour and Isaac's Harbour are relatively open to the ocean and are therefore exposed to significant wave action. Although inner landmasses (such as Harbour Island) offer some protection from wave action, most shoreline in Stormont Bay is exposed and unsheltered. The predominance of large, cobbled beaches is indicative of this high-energy wave environment. Finer substrates, including silts, sands, and smaller pebbles, have been eroded or washed away. Coastline in the vicinity of the proposed Keltic wharf follows this pattern with rocky, coarse substrates dominating the shoreline.

There is little fetch and hence limited opportunity for coastal wind driven current to develop except in storms. Offshore wave statistics (AES40) show that most wave energy comes from the southern quadrant with the largest storms and waves occurring during winter months. Wave energy near the Project site will be attenuated by the protection afforded by Country Harbour Head, other local protuberances, and by the effects of shoaling. However, it is expected that annual storm conditions may occasionally result in seas of 1-2 m in the deeper water near the face of the wharf and the LNG terminal.

Currents

Ocean currents transport water from one region to another region, generally within an organized geographical flow (pathway) over a period of time. Currents are influenced by large global phenomenon (such as the Coriolis effect), wind, tidal action, and also differences in pressure or density gradient caused by salinity, temperature, and water pressure. Tidal flow is the most dominant component affecting currents along inshore coastal regions (CIMAS, 2006).

Major currents on the Scotian Shelf are the Labrador Current and the Cape Breton current (which is the outflow of the Gulf of St. Lawrence). Mixing of these currents with more saline water from offshore creates the Nova Scotia Current, a southwesterly flow that predominates in

Nova Scotia's nearshore areas year round. In more localized coastal areas such as Stormont Bay, tidal currents are forced back and forth parallel to the shoreline. In addition, freshwater inflows from Country Harbour River and Isaac's Harbour River contribute to increased circulation of water within the marine environment.

Current energy in this area is dominated by tidal flows. Some 'freshet' flow, primarily from Isaac's Harbour and Country Harbour Rivers, may have an influence in the spring. Relatively strong tidal streams of the order 10 cm/s are predicted for near the proposed marginal wharf by simple models (i.e., based on the tidal prism) in response to the need for water to be transported upstream into Isaac's Harbour.

Marine Water Quality

The relative concentrations of major ions, such as sodium and chloride, are relatively constant throughout the oceans. Some differences in water quality occur as deeper more nutrient rich waters mix with surface waters, which are in turn influenced by major outflows, such as the St. Lawrence River and the Nova Scotia Current. Approximately 86% of the total salt content of seawater is due to sodium and chloride ions, with magnesium and sulphate ions contributing an additional 11%. Other major ions are present in much lower concentrations.

Seawater also has a high buffering capacity of acids and bases. During periods of high phytoplankton production, the uptake of CO_2 can cause localized changes in ionic balance.

The water quality near Keltic facilities is also influenced by freshwater discharge, primarily from the Isaac's Harbour and Country Harbour Rivers. During the low flow summer months, this influence is minor.

Habitat

There is a diversity of marine habitats in Stormont Bay and surrounding area that includes freshwater, estuarial, nearshore, and deepwater environments. These habitats are defined by vegetation, type and variability of ocean substrate, and shoreline and bottom topography. Habitat type is influenced by a number of factors including nutrient input, water temperature and salinity, depth and stability of the water column, tidal action, and wave action caused by wind and currents.

Freshwater inflow to Stormont Bay from the Country Harbour and Isaac's Harbour watersheds gives the harbours their estuarial characteristics. The entrance to these harbours is unimpeded by the thick, glaciofluvial deposits (sills) found in many other inlets in the area, so water flow and mixing is less restricted (NSMNH, 1996b). This results in greater circulation of water and nutrients between Stormont Bay and the estuarine heads of the Harbours. The estuarine environment also receives greater saltwater inflow due to its openness to Stormont Bay.

Country Harbour River and Isaac's Harbour River watersheds, in addition to smaller tributaries along the coastline, supply most of the freshwater to Stormont Bay. Freshwater inflow is highest in spring and winter, with peak flows occurring in April. In estuarial headwaters freshwater will layer overtop of the deeper saltwater column beneath. The degree of mixing and circulation that occurs depends upon a number of factors including tidal influences, freshwater inflows, storm conditions, and saltwater inflow characteristics. Therefore, circulation patterns can vary seasonally and annually. The complex interaction between freshwater, tides, and geology creates a number of different estuarine habitat types, resulting in a greater diversity of species and higher productivity in this environment.

The Guysborough County Coastal Resources Mapping Project (1995) mapped habitat types that support specific benthic invertebrates (such as lobster and scallop) in Stormont Bay and surrounding areas. Significant variation in the marine habitat occurs at water depths of less than 20 m and up to one kilometre from shore. The near-shore marine habitat at Red Head, the site of the proposed marginal wharf, has a substrate of boulders, cobbles, and pebbles, with finer materials such as sand and gravel prevalent in more protected bays. A narrow band of coarser sediment with relatively sparse macro algae cover stretches from the shoreline seaward for approximately 50 m. Marine plants such as kelp are associated with rockier areas, while eelgrass beds occur on sandy substrates (see Figure 8.12-5). These habitat variations are similar to what predominates in nearshore coastal areas elsewhere in Stormont Bay.

Stormont Bay is open to the ocean and is not as influenced by fresh water inflows as Country and Isaac's Harbours; however, it is more susceptible to wave and ice action along its coastline (NSMNH, 1996b). Stormont Bay is predominantly covered with fine sand and silt with scattered rock shoals. The subtidal zone, generally extending to depths of about 15 m below mean low water, has a predominantly sand and gravel bottom (NSMNH, 1996b). Water depth is significantly greater towards the central part of the bay, and the ocean floor here is covered in soft, silty mud. This area is not considered significant lobster habitat but it does support a herring and mackerel fishery. Shallow, sandier shoals occur on either side of the entrance to Stormont Bay, the largest of these occurring near Harbour and Goose Islands and in the vicinity of Country Harbour Head see (Figure 8.12-6).

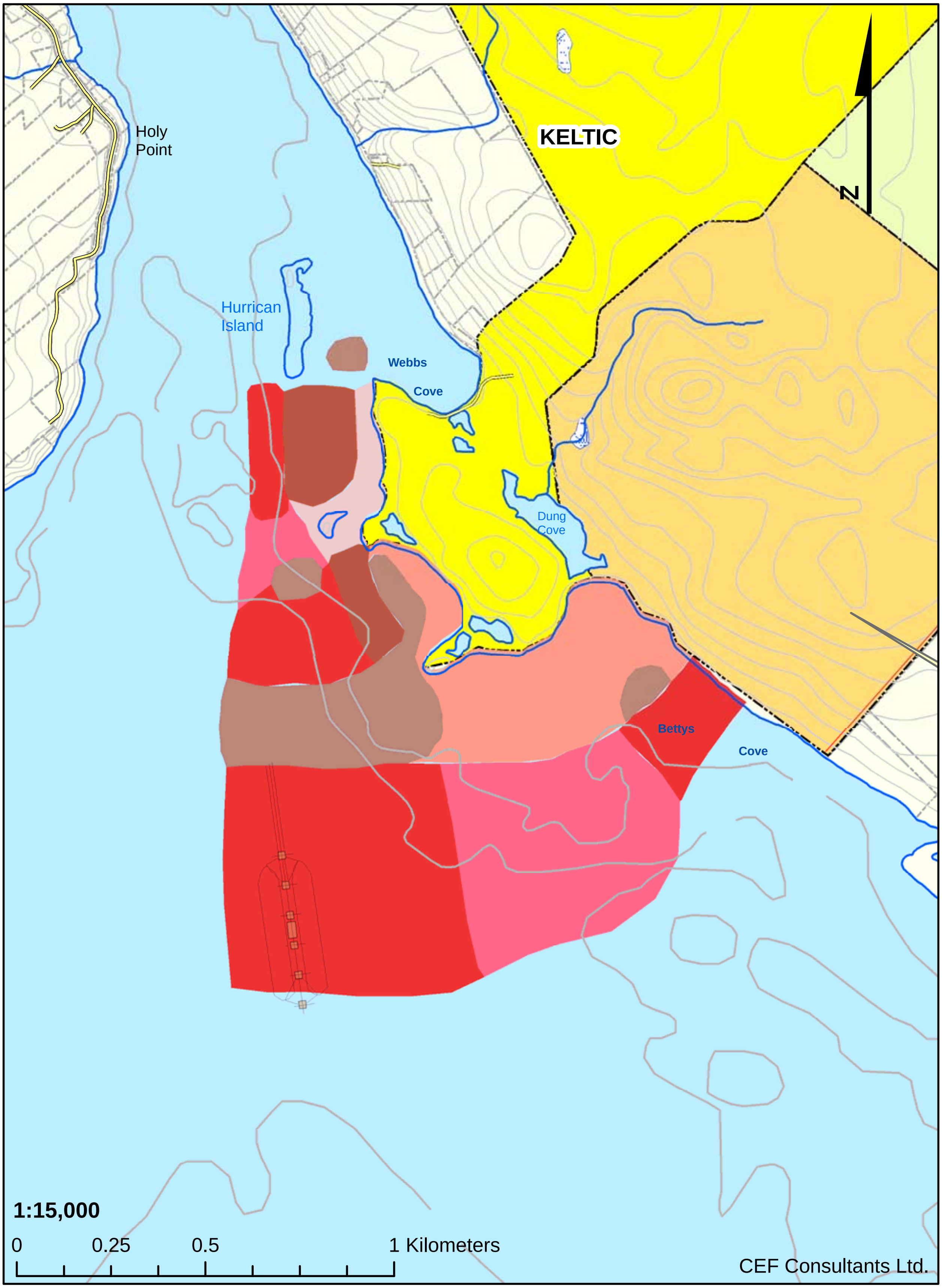
8.12.2.3 Marine Biological Environment

The nearshore marine habitats of Stormont Bay and the estuarial habitats of Country Harbour and Isaac's Harbour (Figure 1.1-1a) support a variety of marine organisms. Species include algae, phytoplankton, zooplankton, marine invertebrates, and estuarial, freshwater, and pelagic fish (refer to Tables 8.12-5 and 8.12-6). Although overall species diversity is limited by the cold water, the variety of seabed habitats in the nearshore and estuarial environments somewhat offsets this limitation. Additional nutrient inputs from coastal salt marshes, eel grass beds, and freshwater tributaries increases the area's biological production, abundance, and diversity (NSMNH, 1996b).

<u>Plankton</u>

Plankton includes two groups of generally free-floating, microscopic plants (phytoplankton) and animals (zooplankton). These species are an integral component of the ocean food chain as they are the major food source for many larger animals. Therefore, plankton is a major factor influencing overall ecological productivity of marine habitats.

FIGURE 8.12-5 Fish Habitat in the Vicinity of Keltic Facilities

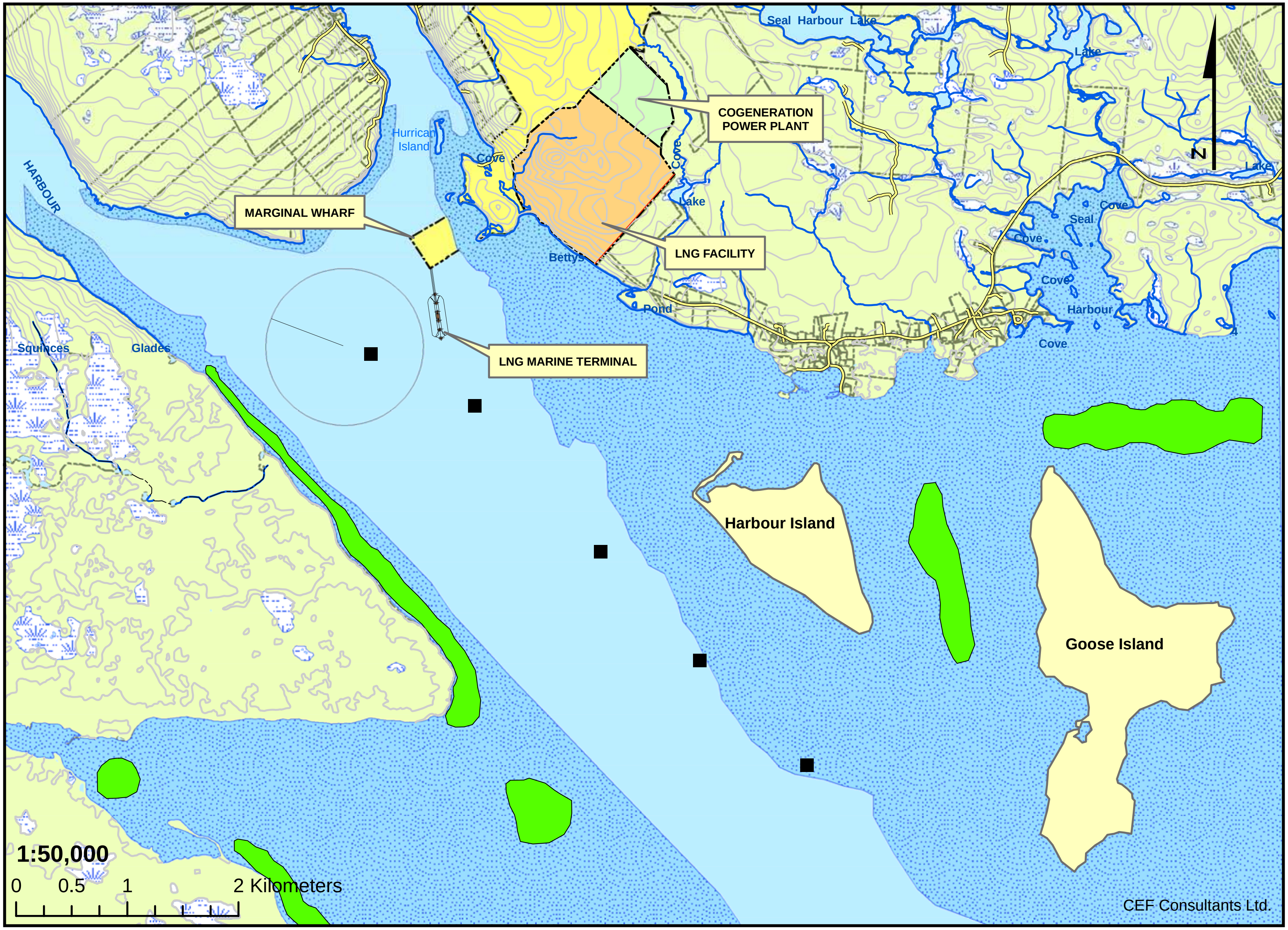


Legend

			Approximate Eelgrass and Sand Area
	Approximate Rock and Kelp Area		Inferred Eelgrass and Sand Area
	Approximate Sand and Silt Area		Inferred Rock and Kelp Area
	Inferred Sand and Silt Area		

FIGURE No. 8.12-5
KELTIC PETROCHEMICALS INC.
FISH HABITAT IN THE VICINITY OF KELTIC FACILITIES
July 2006

FIGURE 8.12-6 Fish Habitat in Stormont Bay and Adjacent Areas



Legend

Lobster and Urchin Habitat Region

Lobster Habitat Region

■ Ship Path

FIGURE No. 8.12-6

KELTIC PETROCHEMICALS INC.

FISH HABITAT IN STORMONT BAY AND ADJACENT AREAS

July 2006

TABLE 8.12-5 Marine Plant and Benthic Invertebrate Habitat

Group	Species	Habitat
Marine Plants	Irish Moss (*Chrondrus crispus*)	Sublittoral zone; rocky shores and tide pools, estuaries
	Sea kelp (*Laminaria longicruris*	Below low tide mark; shallow sub-tidal to deep water; source of food for sea urchin
	Eelgrass (*Zostera marina*)	Sandy substrate; denser growth in shallow, clear water; location and abundance change over time
Benthic Invertebrates	Blue Mussel (*Mytilus edulis*)	Attach to rocks, wooden structures below low tide line; brackish, shallow estuaries and bays with elevated nutrient levels and increased phytoplankton levels
	Lobster (*Homarus americanus*)	Inhabit shallow to deep water with rocky bottoms; usually associated with kelp beds
	Rock crab (*Cancer irroratus*)	Inhabit shallow water with sandy bottom
	Sea urchin (*Strongylocentrotus droebachiensis*)	Prefers shallow (0-10 m), cooler water with high salinity, with hard to rocky substrates; associated with algae (especially kelp) as preferred food source
	Softshell Clams	Settle in sandy or mud bottom substrate of bays and inlets; highest densities in shallow water
	Sea Scallop (*Placopectuun magellanicus*)	Found in sand or gravel substrate; water depths to 20 m

TABLE 8.12-6 Fish Habitat

Species	Habitat
Herring (*Alosa aestivalis*)	Anadromous (i.e., enters fresh water to spawn)
Mackerel (*Scomber scombrus*)	Juveniles in Stormont Bay throughout year, adults only spring/summer
Pollock (*Pollachius virens*)	Young (0-1 years old) move inshore during summer;
American Eel (*Anguilla rostrata*)	Catadromous (i.e., spawn at sea), lives most of life in freshwater as juveniles until spawning
Gaspereau (*Alosa pseudoharengus*)	Anadromous, enters fresh water to spawn in spring and leaves afterwards; inhabits bays, estuaries, and fresh water
Salmon (*Salmo salar*)	Anadromous; inhabits fresh water for first 2 or 3 years; prefers large, cool rivers with gravel bottom headwaters; present in Stormont Bay throughout summer
Cunner (*Tautogolabrus adspersus*)	Nearshore inhabitant; bottom /near bottom; shallow coastal waters; often around wharves, eelgrass, submerged seaweed; avoids brackish water
Tomcod (*Microgadus tomcod*)	Nearshore, shallow water; brackish or fresh water in estuaries and rivers
Winter flounder (*Pseudopleuronectes americanus*)	Nearshore inhabitant; shallow water, mud or sand; with or without vegetation; will feed in estuaries
Smelt (*Osmerus mordax*)	Anadromous; enters estuaries in fall and winter; present in Stormont Bay year round; spawns in freshwater in spring

Marine Plants

Marine plants, including algal and flowering species and phytoplankton are the primary producers in the ocean. In addition to being a major source of food energy in the ocean, marine plants also provide shelter and habitat for a variety of other marine animals. Major algal groups include encrusted algae and seaweeds, such as kelp. Marine algae generally require hard substrates to which to attach. Due to their requirement for sunlight, most marine algae are restricted to depths to which light can penetrate. Flowering plants include eelgrasses and coastal marsh grasses and are generally restricted to habitats with finer substrates, often within protected bays and inlets.

A shoreline survey conducted in November 2004 observed the presence of typical coastal intertidal communities dominated by rockweed (*Ascophyllum nodosum*) and bladder wrack (*Fucus sp*.). Kelp and other seaweeds are generally abundant in all nearshore areas of Stormont Bay.

Benthic Invertebrates

Coastal marine habitat in Stormont Bay can be divided into intertidal (littoral) and subtidal (sublittoral) zones. The littoral zone, which exists between high and low tide, contains habitat for invertebrates adapted to growing on rocky surfaces that are able to withstand tidal and/or wave action. These include a variety of species from microscopic zooplankton, grazers such as chitons and limpets, filter feeders like barnacles (*Semibalanus balanoides*) and blue mussels (*Mytilus edulis*), and larger crustaceans, such as rock crabs. Rockier areas within the sublittoral zone, which exists beneath mean low tide, support mussels, rock crab, lobster, sea urchin, and sea stars (McLaren, 1996). Other marine organisms typical of these areas include periwinkles (*Littorina littorea, L. saxatilis, and L. obtusatus*) and amphipods such as Hyale nilssoni and *Gammarus species* (Envirosphere Consultants Limited, 2004).

Marine Mammals

Whales and seals are found throughout the Scotian Shelf, with fewer species in inshore waters. The NSMNH's authoritative 'Natural History of Nova Scotia' (NSMNH, 1996a) listed 21 species of whales, dolphins and porpoises in Nova Scotian waters, and 6 species of seals.

Reasonably reliable whale catch and sighting data are available from Sutcliffe and Brodie (1977) based on the former commercial whaling operation out of Blandford, Nova Scotia. Whaling data are biased by effort, and are limited by poor spatial and temporal coverage. Few records exist for the eastern portions of the Scotian Shelf and Slope, or in the winter. These data were re-plotted by Kenney (1994) with additional data.

Intensive surveys for whales occurred during the DND frigate shock trials at latitude 42^{o} 05' N, longitude 61^{o} 20' W in November 1994 and provide additional information to Kenney (1994). The DND survey location was chosen for low overall marine productivity (i.e., to reduce the chance of impacts), in areas not known to be attractive to marine mammals (i.e., 4100 m deep water and low bottom relief).

Cetaceans are highly mobile animals, and whale distributions on the Scotian Shelf and Slope tend to vary seasonally. Most baleen whales that occur in the northern hemisphere feed in higher latitudes in summer, exploiting biologically productive areas in the northwest Atlantic and the Gulf of St. Lawrence. They move south for the winter; mating and calving usually take place on the winter grounds (NSMNH, 1996a). Nonetheless, some individuals could be found throughout the year, albeit in lower numbers in winter than in summer.

Small toothed whales, dolphins and porpoise, occur on the Scotian Shelf year round. In general, most species appear to frequent the Shelf during summer and early fall, moving to the southwest as winter approaches (Kenney, 1994). This probably coincides with seasonal distributions of favoured prey.

Atlantic harbour porpoise (*Phocoena phocoena*) are widely distributed in cold-temperate coastal waters of the Northern Hemisphere. They are nearly always found in relatively shallow water, less than 125 m deep on the continental shelf (Gaskin, 1992). They often come close to shore and into estuaries or harbours in the summer in pursuit of their favoured prey of herring, as well as mackerel, capelin, hake, pollock, and squid (Brodie, 1995). The harbour porpoise is at risk throughout its range, primarily as a result of bycatches in fisheries. The species was downlisted by COSEWIC from Threatened to Special Concern (COSEWIC, 2003). The long-finned pilot whale (*Globicephala melaena*), often traveling in herds of several hundred, is the whale most likely to occur in numbers on the Scotian Shelf throughout the year (Lucas and Hooker, 2000).

The minke whale (*Balaenoptera acuterostrata*) is the smallest baleen whale on the Scotian Shelf. It is widespread and seasonally abundant in the Northwest Atlantic. It has been identified in late spring and the summer months across the Shelf, with a preference for water less than 200 m deep (Hooker et al, 1999).

The grey seal (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*) are routinely present on the Scotian Shelf. Grey seals disperse widely after breeding on Sable Island in December and January. Harbour seals tend to remain in the vicinity of Sable Island year round, although young may disperse more widely.

Stormont Bay/Country Harbour is not an important area for cetaceans. Whales or seals may enter the area following schools of herring or mackerel from spring to fall, and seals frequently haul out on the shoreline.

<u>Plankton and Marine Plants</u>

Significant seasonal fluctuations in biomass and productivity of nutrients, phytoplankton, zooplankton, and fish occur within the nearshore and estuarine habitats of Stormont Bay. Studies conducted for the SGBP showed a temporal relationship between primary and secondary producers and predator species, as phytoplankton concentrations are controlled by zooplankton predation in the spring and fall, and zooplankton populations are controlled by fish predation. This results in productivity pulses and population peaks, including a fall phytoplankton bloom.

Many of these ecological dynamics are emulated in Stormont Bay and the estuarial environments of Country Harbour and Isaac's Harbour. Higher levels of phytoplankton exist in the mouth of Country Harbour compared to Stormont Bay, which coincides with higher nutrient levels found in estuarial habitats (SOEI, 2000). Zooplankton concentrations show three seasonal peaks in St. Georges Bay- in early summer, for fish eggs, in mid-summer for copepods, and in late summer for larger copepods. Larger-bodied zooplankton is more prevalent in colder months, and smaller-bodied in warmer months (Davis et al., 2000).

Kelp beds are known to provide important lobster habitat and are a source of food for sea urchin. Seaweed density in the Red Head area is variable. To the east, seaweed abundance is moderate and is restricted to lower intertidal and upper subtidal zones. Productivity northwest of Red Head was significantly lower (Envirosphere Consultants Limited, 2004). Other vegetated habitats, such as eelgrass beds, are also important and have a much higher abundance and diversity of species than adjacent non-vegetated areas.

8.12.2.4 Habitat Use and Productivity

The various habitat types of Stormont Bay (Figure 1.1-1a) and the surrounding areas support a diversity of organisms from phytoplankton to smaller benthic invertebrates to large commercial fish species. Seasonal fluctuations in habitat quality and use also occur resulting in highly variable diversity and abundance of species at certain times of the year. Fish species, depending upon their lifecycle and activities, often require a diversity of habitat types to provide food, cover, and other requirements.

Stormont Bay supports several local fisheries, one of the most important of which is the commercial lobster fishery. The value of these fisheries is linked to the productivity of the area which is influenced by the habitat quality of the marine environment that supports primary producers, prey, and predatory species. Changes to the marine environment, particularly within the vicinity of the proposed Petrochemical wharf, will have adverse effects upon habitat and productivity. Although the productivity of the Lobster Fishing Area that encompasses the proposed wharf and LNG terminal is relatively low compared to other areas in Nova Scotia, lobster is the dominant species of concern.

In general, the coastal plant and animal communities were more productive in rockier areas than in beach areas that had finer substrates. Along the coastline near Red Head, the most productive intertidal habitats were generally the mid to low intertidal and upper subtidal zones on partially exposed rocky shoreline (Envirosphere Consultants Limited, 2004).

Invertebrate Production

Studies completed in the area have identified important lobster habitat. In the shallower waters of eastern Stormont Bay between Red Head (the site of the proposed wharf) and Harbour Island there is a consistent mix of rock, boulder, kelp, and sand. In the outer, deeper areas (outside Country Harbour Head and past Harbour Island) lobster habitat is patchier. The Black Ledges area, a shoal on the western entrance to Stormont Bay (shown as a large dark blue patch off country Harbour Head in Figure 8.12-5) is considered good lobster habitat/urchin habitat with shoals surrounded by large sandy mud areas.

Habitat requirements for lobster change according to its various life stages. Lobster productivity depends upon a number of density independent factors such as temperature, time of hatching, predation, wind direction, and food supply. These factors have the greatest effect on larval survival and consequently lobster populations and area productivity.

Optimal habitat for lobster changes as they grow. Smaller postlarval lobsters prefer to live in tunnels or in natural crevices and then, as they grow larger, move to habitats with coarser substrates and a suitable amount of cover. Juvenile lobsters prefer areas with algae, stones and large crevices. Some larger lobsters have been observed on compact sand or mud bottoms consolidated by eelgrass. All sizes of lobster have been observed co-existing in areas with large stone size and heavy algal cover. Sand covered in eelgrass had a low abundance of juveniles and adults, while on bare sand bottoms no resident lobsters were observed (NOAA, 1994).

Lobster production is influenced by local factors more so than external ones and is therefore area specific depending upon the local habitat and conditions. The amount of postlarvae that settle in an area is the overriding factor in determining an area's productivity. Postlarvae in their burrows feed on plankton and may also prey on small benthic organisms. Density independent factors such as starvation, predation, and offshore winds transporting larvae out to sea and away from suitable habitat can play a large role in larval mortality (Miller, 1997).

Rock crabs inhabit intertidal zone to depths of up to 40 m. Rock crabs often spend winters in shallower waters on softer sand and mud substrates and then migrate to deeper waters during the spring and summer. Larvae float freely in the water column between mid-June to and mid-September until they settle on the ocean floor.

Sea urchins rely upon seaweed as their primary food source with the highest concentrations of urchins located near kelp beds. In Stormont Bay, kelp has increased in areas where urchins have formerly grazed. Management measures have recently been instituted to manage this fishery in Guysborough County.

Mackerel are a highly migratory, pelagic fish species. Most of the year fish inhabit offshore waters. However, they will migrate to inshore areas in spring to spawn. Mackerel are present in Stormont Bay year round with juveniles present throughout the year and adult fish in spring and summer. In winter, adult mackerel generally move to feed grounds on the Scotian Shelf southwest of Sable Island (Scott and Scott, 1988).

Fish

Several anadromous fish species migrate upriver at different times of the year. Gaspereau (alewives) begin their migration in early spring and are followed by smelt, eel, trout, and Atlantic salmon. Salmon and gaspereau begin to migrate up Country Harbour and Isaac's Harbour Rivers by April. Elvers migrate upstream in May and June (Miller, 1997) while sea-run brook trout migrate during July and August. Gaspereau and smelt leave freshwater after spawning in early spring.

Salmon and brook trout spawn in freshwater burying their eggs in gravel to cobble-size material. Atlantic salmon spawn between late October and mid-November. Atlantic salmon generally hatch in the spring and emerge from the gravel by early June. Atlantic salmon smolts migrate to the sea from mid-May to mid-June (Scott and Crossman, 1973). Adult salmon downstream migration is also variable. In some river systems, populations remain over winter; while in others; downstream migration takes place directly after spawning. Brook trout begin spawning by mid-to-late September and generally hatch and emerge from the gravel in late March or early April.

Blueback herring is an anadromous fish entering freshwater inlets and estuaries to eventually spawn in lakes, ponds, and rivers above the tide head. After spawning, adults return to sea where they spend most of their adult life. In Stormont Bay and surrounding areas herring are thought to be present between June and October. Blueback herring is similar to alewife and the two are often fished together sometimes being referred to collectively as gaspereau (Scott and Scott, 1988).

8.13 BEDROCK AND SURFICIAL GEOLOGY

An assessment of the surficial and bedrock geology of the proposed Keltic Site was performed by conducting:

- a review of all available published maps and reports, including relevant assessment files, other micro fiche reports, and mines inspectors' reports at the NSDNR Mines Branch library;
- interviews with NSDNR Mines and Energy Branch personnel regarding new mapping undertaken during construction of the Sable gas facilities, and information gathered during the more recent tailings environmental investigations;
- a review of current claims maps and of claims-holdings cards spanning back to the mid-1970's to identify areas with acid drainage potential;
- monitoring well installations and bedrock core logging at the proposed Keltic Site to help better characterize the local geology; and
- various field reconnaissance and detailed mapping visits to gain an understanding of the bedrock geology, past mining activities and associated legacies.

The current geologic studies of the Keltic Site served as precursors to various groundwater assessments, which are covered in Section 8.7 of this report.

Reconnaissance-level geologic assessments of the greater Keltic Site were done by a geoscientist during the periods of May 31 to June 6, 2004 and June 24-25, 2004. Due to the proposed industrial nature of the Keltic site, more detailed field mapping of parts of the site, bedrock core collection, core logging, and groundwater sampling was carried out as part of a monitoring well installation program during the period from April 4 to May 3, 2005.

8.13.1 Surficial Geology

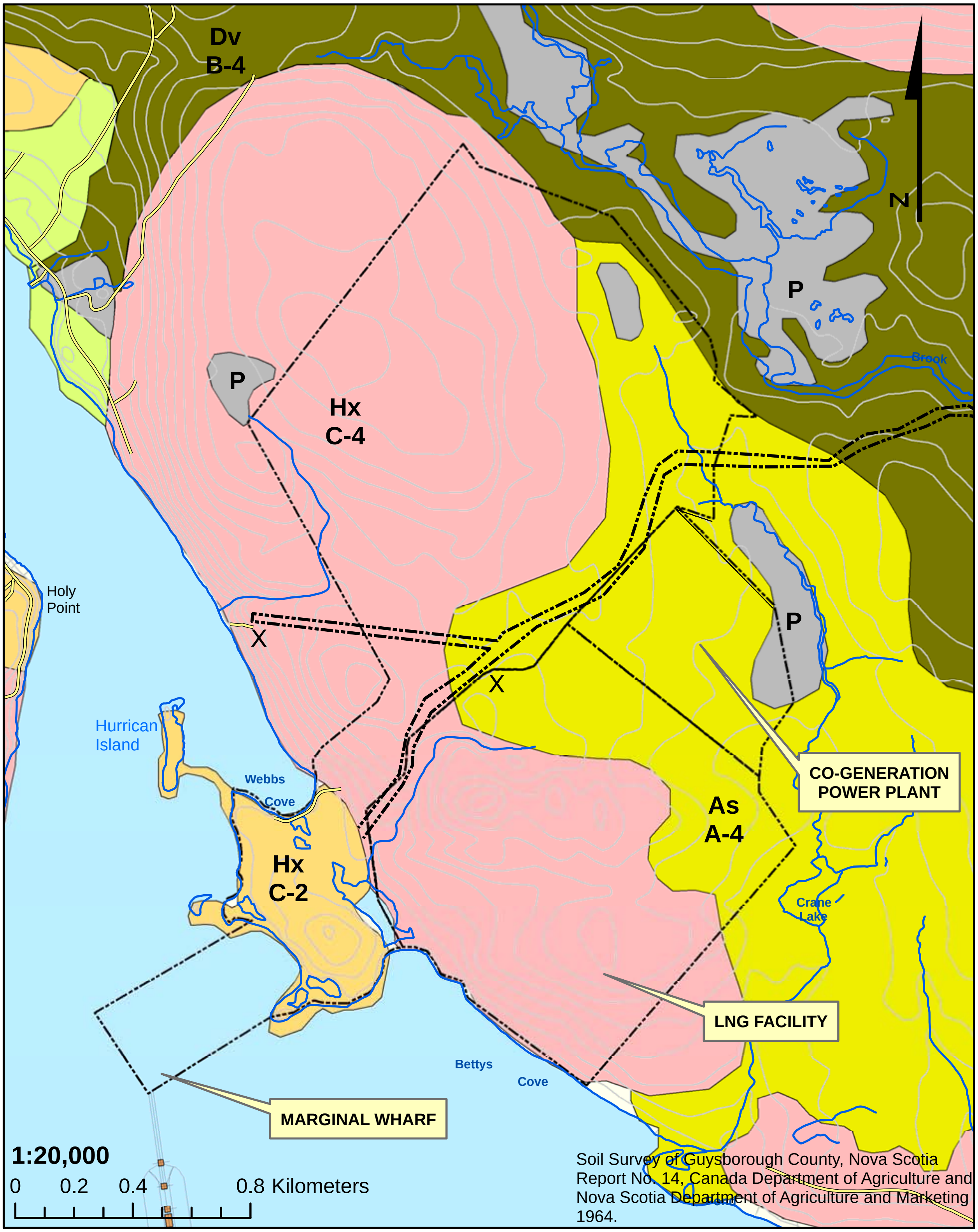
The soils and surficial geology of the Keltic Site and surrounding region were mapped by Cann and Hilchey (1954), Hilchey et al (1964), Stea and Fowler (1979) and Stea et al (1992).

8.13.1.1 A and B Soil Horizons

In Guysborough County, variably distributed Riverport, Thom, Halifax, Danesville and Aspotogan series soils and peat are present at the Keltic Site and in large portions of the watersheds studied. Danesville Series soil and peat are the predominant soil types in the southeastern portion of the Isaac's Harbour River watershed and near the Keltic Site, and Halifax Series soils are present in approximately the north half of that watershed. Figure 8.13-1 shows the distribution of these soil types within the Keltic Site.

The Queens Series soil is described as a light brown clay loam over reddish-brown clay loam. The Millbrook Series soil is a light brown loam over reddish-brown gravely clay loam. The Stewiacke Series soil is a reddish-brown silty clay loam over reddish-brown silt loam, and the

FIGURE 8.13-1 Soil Type Distribution (A and B Horizons)



Legend

Springhill	Aspotogan	---- Other Roads
Hebert	Peat	X Mine or Open Cut
Halifax		
Dansville		

FIGURE No. 8.13-1

KELTIC PETROCHEMICALS INC.

SOIL TYPE DISTRUBUTION
(A AND B HORIZONS)

July 2006

Woodborne Series soil is a reddish-brown gravely loam to sandy loam over dark reddish-brown gravely clay loam. The Kirkhill Series soil is described as a light brown loam over yellowish brown shaley sandy loam. All are generally well-drained soils, for which parent materials are generally the bedrock that underlies them. They are fairly well suited for various types of agriculture, although the relative shallowness of the Kirkhill Series soils makes it less suitable for agriculture than the others. The Riverport Series soil is described as a brown shaley loam over grayish brown shaley loam. It has imperfect drainage and is limited for agricultural use due to its stoniness, drainage, and shallowness. The Thom Series soil is a dark, reddish brown, friable sandy loam over dark, reddish-brown gravely sandy loam. It has rapid drainage and is unsuitable for agriculture but suitable for forestry (Cann and Hilchey, 1954).

The Danesville Series soil is described as a dark reddish brown mottled gravely sandy loam over dark-brown mottled gravely sandy loam. The Aspotogan Series soil is described as a mottled dark-brown sandy loam over olive-gray strongly mottled gravely sandy loam. The former has imperfect drainage, the latter has poor drainage. Both soils are derived principally from the quartzite glacial till parent material. The Halifax Series soil is a dark reddish brown friable sandy loam over strong-brown friable sandy loam. It is rapid draining and is derived principally from gravely sandy quartzite glacial till. All soils in the area are unsuited to agriculture (Hilchey et al, 1964).

8.13.1.2 C Soil Horizon

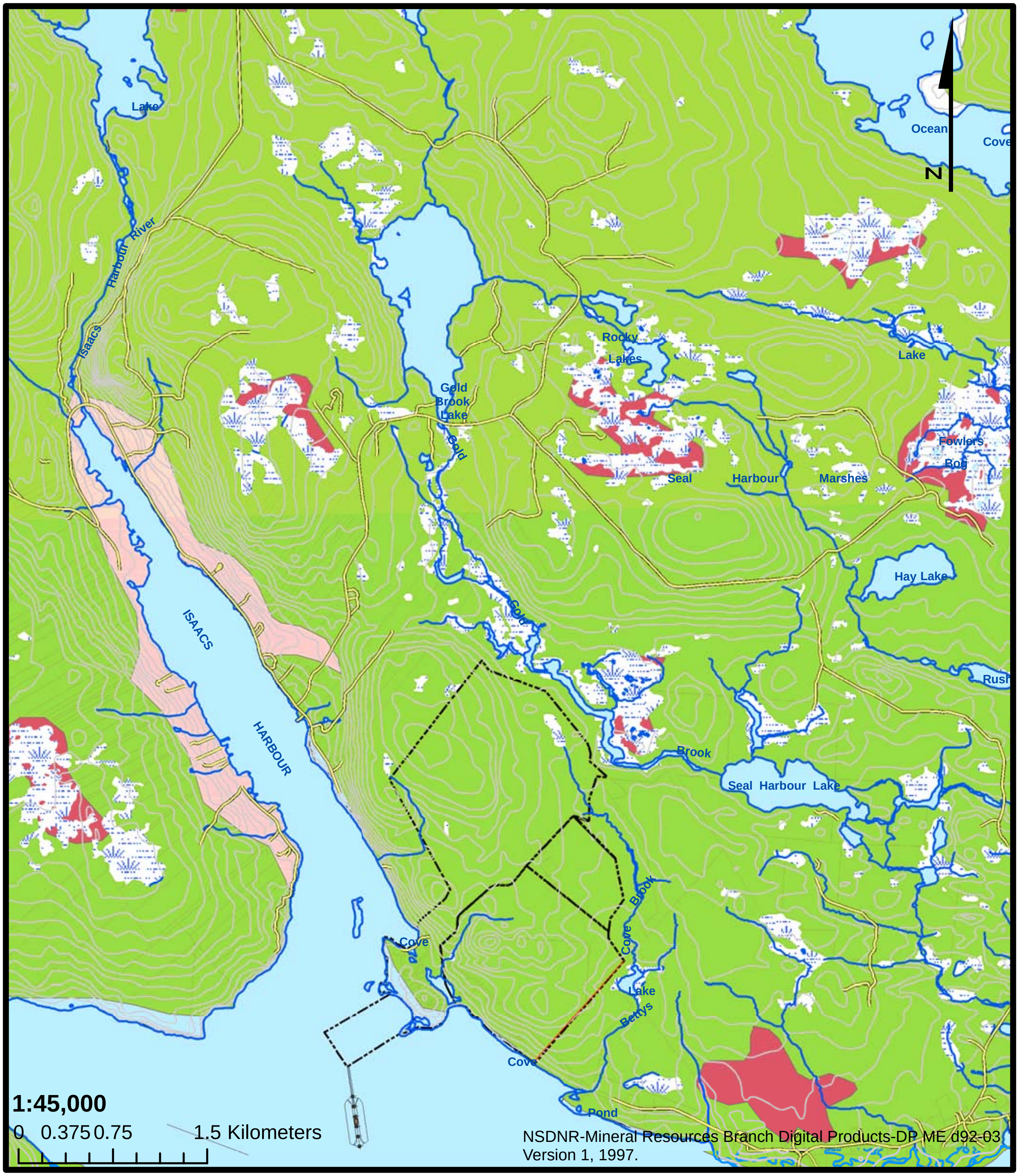
Beneath the A and B soil horizons, the C horizon materials or “mineral soil” consists generally of quartzite till and/or stony till plain deposits in Guysborough County. Glacial-age kame fields and esker systems, and post-glaciation alluvial deposits, are present at various locations throughout the Keltic Study Area (see Figure 8.13-2).

The ground moraine till material is comprised of a mixture of gravel, sand, and mud of direct glacial origin, which was released from the top, or within, stagnant ice masses by melting. It is variable in thickness from 2 m to 25 m and forms local ridges, depressions or pits (kettles). The stony till unit consists of material released at the base of ice sheets and is described by Stea (1979) as a bluish-greenish-grey, loose, cobbly, silt-sand till, which will grade into a sandier, coarser till, sometimes with red clay inclusions. It is generally thin (less than 10 m). Generally, the till matrix is made up of 80% sand, 15% silt, and 5% clay. It is derived of locally eroded quartzite and slate bedrock.

Quartzite till is shown by Stea (1979) and Stea et al (1992) to extend northward along the eastern half of the Isaac’s Harbour River watershed. Granite ablation till, or silty till plain deposits, are present along the western periphery in the upper reaches of the Isaac’s watershed. These deposits are described by Stea (1979) as yellow-grey, bouldery sand till.

A drumlin field is shown present south of the Antigonish-Guysborough County border. Locally at and around the Keltic Site, topographic features suggest that there may be a few low-lying drumlins. However, maps by Stea (1979), and Stea et al (1992) do not show any drumlins in this part of the Keltic Study Area.

FIGURE 8.13-2 Surficial Geology



Legend

- Bedrock
- Glaciofluvial
- Stony Till
- Orangic Deposits

FIGURE No. 8.13-2

KELTIC PETROCHEMICALS INC.

SURFICAL GEOLOGY

JULY 2006

8.13.2 Bedrock Geology

The nature of the bedrock geology of the Keltic Study Area is a direct result of complex tectonic events. The southern part of the Keltic Study Area was subject to a long history of mining activity.

8.13.2.1 Past Mapping Work

The following was reviewed and incorporated into this study. The bedrock geology of the Keltic Study Area was mapped by Schiller (1961) and Hill (1991). This includes the mapped area surrounding Forest Hills, and the north part of the Isaac's Harbour River watershed extending as far south as Cross Roads Country Harbour and Stormont, respectively.

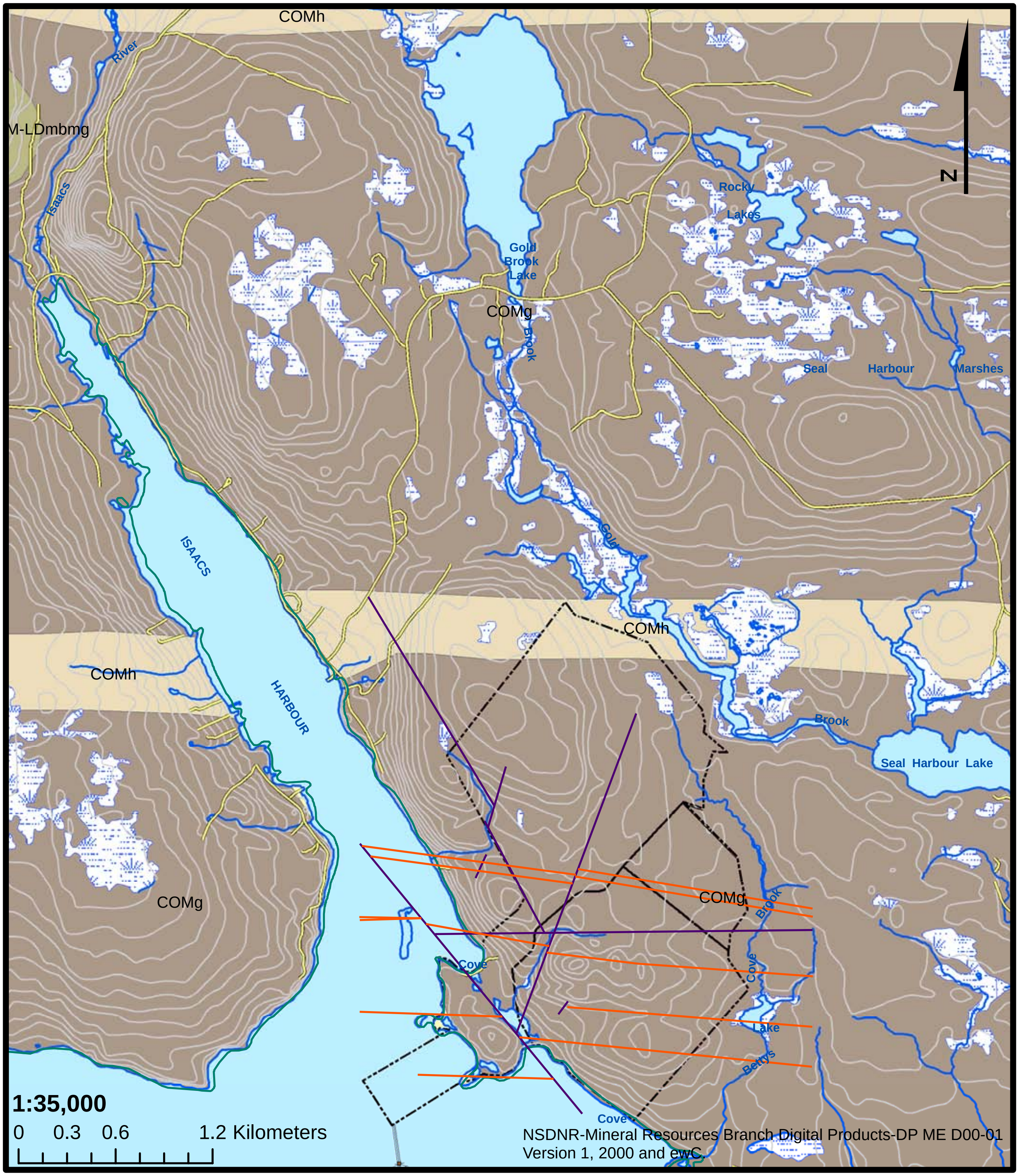
Notwithstanding the assessment reports described below and published by Geological Survey of Canada (GSC) (1985), work by Fletcher and Faribault (1891, 1893a, 1893b, 1893c, 1893d) and Faribault (1899, 1904) constitutes all that exists by way of appropriately scaled and sufficiently detailed published bedrock mapping for the proposed Keltic Site. Other works in the area include Stevenson (1959, 1964), who mapped the bedrock geology east of the Keltic Study Area. Finally, Keppie (1979, 2000) summarized the work of all others (see Figure 8.13-3).

Mine inspector's reports, exploration assessment reports and mining assessment reports dating from the late 1800's to the early 1990's were searched in the NSDNR, Mines Branch library database (for the Keltic Site and immediate area) using search words Isaac's Harbour, Meadow Lake, Goldboro and Lockerby. Approximately 200 documents were identified (see Appendix 11). Many reports included only a synopsis of exploration expenditures. The mine inspector's reports for the general plant-site area were often only a couple of lines long, with no reports at all in some years. Much of the data was for activities on Hurricane Island and on the other side of Isaac's Harbour, or for the Boston Richardson Mine at Gold Brook Lake a short distance north of the proposed Keltic Site. Very little data could be applied directly to this study, however, some data was found relevant and was incorporated into this study. This served to augment the general knowledge of the mining history and geology of the site and area, and was incorporated into this study.

8.13.2.2 Geologic Formations – Major Physiographic Regions

The Antigonish-to-Goldboro Study Area encompasses four physiographic regions that are largely a reflection of the underlying bedrock deposits and structures that developed during a complex history of tectonic activity that began before North America and Europe/Africa collided. These physiographic regions are bound by major fault systems that traverse much of mainland Nova Scotia. The Keltic Study Area encompasses at least 10 bedrock Formations, Groups or other formal or generally recognized bedrock types or units. Figure 8.13-3 is a bedrock geology map of the Keltic Study Area.

FIGURE 8.13-3 Bedrock Geology



Legend

Fault *(as mapped by ewC)*

Anticline axis *(as mapped by ewC)*

FORMATION

Devonian Granite

Halifax Formation

Goldenville Formation

FIGURE No. 8.13-3

KELTIC PETROCHEMICALS INC.

BEDROCK GEOLOGY

JULY 2006

8.13.2.3 Southern Upland

The region that extends from the Atlantic Ocean at Goldboro north toward Salmon River Lake, and in which the proposed Keltic Site and the entire water supply watershed are situated, is part of the Southern (or Atlantic) Upland physiographic region. The ground surface elevations in this region range from around 20 m at the Keltic Site to 140-145 m in the northern part of the region. This region is underlain by meta-sediments and granitic intrusions of the Cambrian-to-Ordovician age (~545 to 445 million years ago (Ma)) Meguma Group, which essentially form the basement rocks under much of mainland Nova Scotia. The Meguma Group is comprised of a sandy flysch (Goldenville Formation) overlain by a shaley flysch (Halifax Formation); the boundary between them is probably diachronous (Keppie, 1977).

The Goldenville Formation contains alternating layers of sandstone and finer grained beds and is interpreted as a submarine mid-fan deposit. The Halifax Formation consists of slate, siltstone, minor sandstone and represents a number of environments of deposition, including distal turbidite fan, basin plain, interchannel areas of the inner fan, continental rise and slope and outer shelf. Faribault (1914, in Keppie, 1977) recorded a thickness of at least 5,600 m for the Goldenville Formation, and about 500 to 4,400 m has been recorded for the Halifax Formation. However, this does not take into account the possible presence of early recumbent folds.

These rocks were intruded by granitic plutons during the Silurian (~460 Ma) and Late to Middle Devonian age (~370 to 340 Ma). In the Keltic Study Area, the plutons contain medium grained, equigranular to slightly porphyritic biotite (less than 4%), muscovite granite (Hill, 1991).

Steeply dipping rocks of the Goldenville Formation underlie most of the Keltic Study Area, including Goldboro, the proposed Keltic Site, and a large majority of the Isaac's Harbour River watershed and other local subwatersheds. Halifax Formation slates are present generally as narrow bands at major syncline axis (Fletcher and Faribault, 1893b): at the north boundary of the proposed Keltic Site, and within the Loon Lake Synclinorium, which encompasses two small (2 by 6 km) granitic plutons and one thin elongate pluton, all situated within the north-northwest part of the Isaac's Harbour River watershed. Other smaller bands of Halifax Formation or similar material may be present which have not been previously mapped.

The Halifax Formation is known for its acid generating potential, and so acid drainage may be a cause for concern should this material need to be excavated, or the groundwater level lowered within the formation during plant construction. The potential for acid drainage is expected to be greatest where the Halifax Formation is in contact with or in close proximity to granitic plutons. Certain rocks of the Goldenville Formation may also be a source of acid drainage, particularly (in small areas) where highly mineralized zones are present.

Borehole logs documented during the installation of monitoring wells for the Project (Appendix 6) indicate that much of the Keltic site is underlain by bedrock consisting of greywacke with some occurrences of argillite. Argillite with pyrite and arsenopyrite were identified at the extreme northern end of the site where the site overlaps the Halifax Formation.

8.13.2.4 Tectonic, Metamorphic and Structural Geology

The Meguma Group (which encompasses the majority of southern Nova Scotia) is part of an orthotectonic orogen (Keppie, 1977) that originated as continental rise deposits (S0) off a craton lying to the south (the South America portion of Gondwana (Irving, 1980)), with ocean to the north. During the Late Ordovician (~440 Ma) to Early Devonian (~360 Ma) times, the ocean began to close and southeasterly sea floor subduction took place beneath Gondwana (southern Nova Scotia), thus deforming (S1) the Meguma Group continental rise deposits (an early set of recumbent folds (F1) associated with an axial plane foliation, thrusting, and greenschist matamorphism).

As the ocean closed and Gondwana collided with Laurasia (North America, which included the Cobequid, Antigonish and Cape Breton highlands) during the Acadian Orogeny (~350 to 370 Ma) to create the Appalachians, materials within the present Guysborough Highlands were being deposited while the rocks of the Meguma Group were deformed (S2) by upright, northeasterly trending, sub-horizontal folds (F2), which are associated with axial plane cleavage, local gold mineralization (Keppie, 1977) and regional greenschist facies metamorphism (Taylor and Schiller, 1966).

Igneous intrusive activity within the Meguma Group began during the Silurian times (~425 Ma), but most granitic plutons cut across the major F2 folds and their metamorphic aureoles are superimposed upon them (Taylor and Schiller, 1966) (i.e., the contact metamorphism associated with the granite plutons is superimposed upon the regional greenschist facies metamorphism).

During the Upper Devonian to Lower Carboniferous (~345 to 330 Ma), following the Acadian Orogeny, there was large scale dextral transcurrent movement (S3 and S4) on the Gon fault (Keppie, 1977) as the north American plate (which now encompassed a piece of Gondwana, including the Meguma Group deposits of southern Nova Scotia) moved northeast and Africa became juxtaposed against Atlantic Canada in place of South America. This resulted in the development of the sinistral regional fault system present regionally throughout the Meguma Group. Finally, North America and Africa separated during the Triassic and Cretaceous (~230 to 75 Ma), since which time the land surface was eroded to its present form.

Many of the faults created and present within the Meguma Group have, to a degree, served to control the subsequent deposition of younger geologic units present to the north (many of the younger bedrock units described above) since it represents much of Nova Scotia's basement-rock-complex. Differential settlement and/or later motions along these basement-complex faults may have caused the displacements currently known to exist in these younger units.

8.13.2.5 Proposed Keltic Site

The remainder of this discussion will focus on the proposed Keltic Site and its immediate environs, since this part of the Keltic Study Area is slated to become industrial and subject to greater potential environmental risks overall. Thus, a greater knowledge of its geology is needed to better understand existing groundwater conditions, possible groundwater flow control characteristics, and mitigation needs.

The major F2 fold axis at the proposed Keltic Site and environs strike east-west and plunge east, with 3.5 km generally between anticlinal axis. Locally from south to north, the major anticlines and synclines shown by Fletcher and Faribault (1981, 1893a, 1893b, 1893c, 1893d), Schiller (1961) and Hill (1991) east of the Country Harbour and Isaac's Harbour Faults include: the Isaac's Harbour Anticline at Dung Cove; the Long Lake Syncline at roughly the south boundary of the proposed Keltic Site; the Upper Seal Harbour Anticline at the south end of Gold Brook Lake; the Little Lake Syncline at the south end of Ocean Lake and Meadow Lake; an unnamed anticline at the north end of Ocean Lake; and the Loon Lake Synclinorium at Big Stillwater within the Isaac's Harbour River watershed.

In larger scale (smaller area) mapping south of the Seal Harbour Lake area, Faribault (1904) shows the South, Middle and North Anticlines, and their associated synclines. These are smaller folds superimposed onto the Isaac's Harbour Anticline, where the distance between secondary anticlinal axis averages about 0.5 km.

The nearby Country Harbour Fault is the most prominent strike-slip fault on Nova Scotia's eastern shore. Roland (1982) suggests that there has been upwards of 8 km of sinistral displacement along it, although drag folding and shearing in strata of the Loon Lake Synclinorium (Hill, 1991) suggests that there has been more than 10 km, and perhaps as much as 18 km, of sinistral displacement along this fault. It extends up into Horton Group deposits to the north. The Isaac's Harbour Fault, which is another major regional fault, defines the east shore of Isaac's Harbour and may extend up to 4 km northwest of Stewart Lake. Sinistral displacement along the Isaac's Harbour Fault at Dung Cove was in the order of 600 m to 800 m (Faribault, 1904). There is an apparent displacement of about 1 km along the New Harbour Fault located about 10 km east.

Due to the large displacements that have occurred along the nearby regional faults, the structural geology within the proposed boundaries of the Keltic Site is expected to be complex. Faribault (1904) shows a fault along Dung Cove Brook, which is likely to be a synthetic fault to the Isaac's Harbour Fault and along which there has been 75 m to 125 m of sinistral displacement.

Other faults parallel the Isaac's Harbour and Dung Cove Brook Faults to the south and north of the proposed Keltic Site (Faribault, 1899 and 1904), and there is severe faulting in underground workings at Gold Brook Lake (P. Smith, pers. comm., 2001). Field mapping by a geoscientist along the gas plant access road has revealed yet another, north-south trending fault along which there may have been up to 50 m of strike slip displacement and also perhaps some normal displacement. The many lineaments identified by Tilsley (1996b) and which parallel the Isaac's Harbour and Dung Cove Brook Faults, such as those along parts of Betty's Cove Brook and Gold Brook, suggest a broad shear zone and/or other faults that are likely to be related to the Isaac's Harbour Fault. These cannot be directly mapped due to the thick till present.

8.13.3 Past Mining and Economic Geology

Auriferous quartz veins within the Goldenville Formation generally occupy fold-generated F2 dilation zones. The tension fissures produced by this mechanism are saddle reef veins in slate horizons, veins normal to bedding in meta-sandstone layers in the fold hinges, veins along faults in the cores of tight fold hinges, and zones of en echelon veins in slate horizons in the limbs of folds (Keppie, 1976).

The greater Goldboro area and locally, the southwestern part of the proposed Keltic Site have been the subject of gold mining activities during the late 1800's and early 1900's. Several mines were established in what was known as the Seal Harbour Lake and the Upper Seal Harbour Lake (now known as Gold Brook Lake) zones, including the Boston Richardson Mine and Dolliver Mountain Mine north of the proposed Keltic Site, the Seal Harbour Mine (Victoria Belt) east of the proposed Keltic Site, the McMillan Mine, west of Dung Cove, and the Mulgrave and Giffin Mines (also known as the Hattie Belt, Skunk Den Mine, or the Malloy, Eureka, Economy or Bluenose properties) within the proposed site boundaries.

Gold was first discovered on the west shore of Isaac's Harbour in the fall of 1861. Mining of small veins was carried out until about the turn of the century when work began on the Boston Richardson deposit at Gold Brook Lake. The Seal Harbour Mine at Lower Seal Harbour began operations in about 1934 and continued until 1942. Details of the gold mining history from discovery till 1920 are given in G.S.C Memoir 385, 1976 (see Appendix 12). Renewed interest in the area in the early 1980's resulted in a major exploration program at the Boston Richardson property. This work is on-going, with the latest drilling program on the property having been completed during the spring-to-early summer 2005.

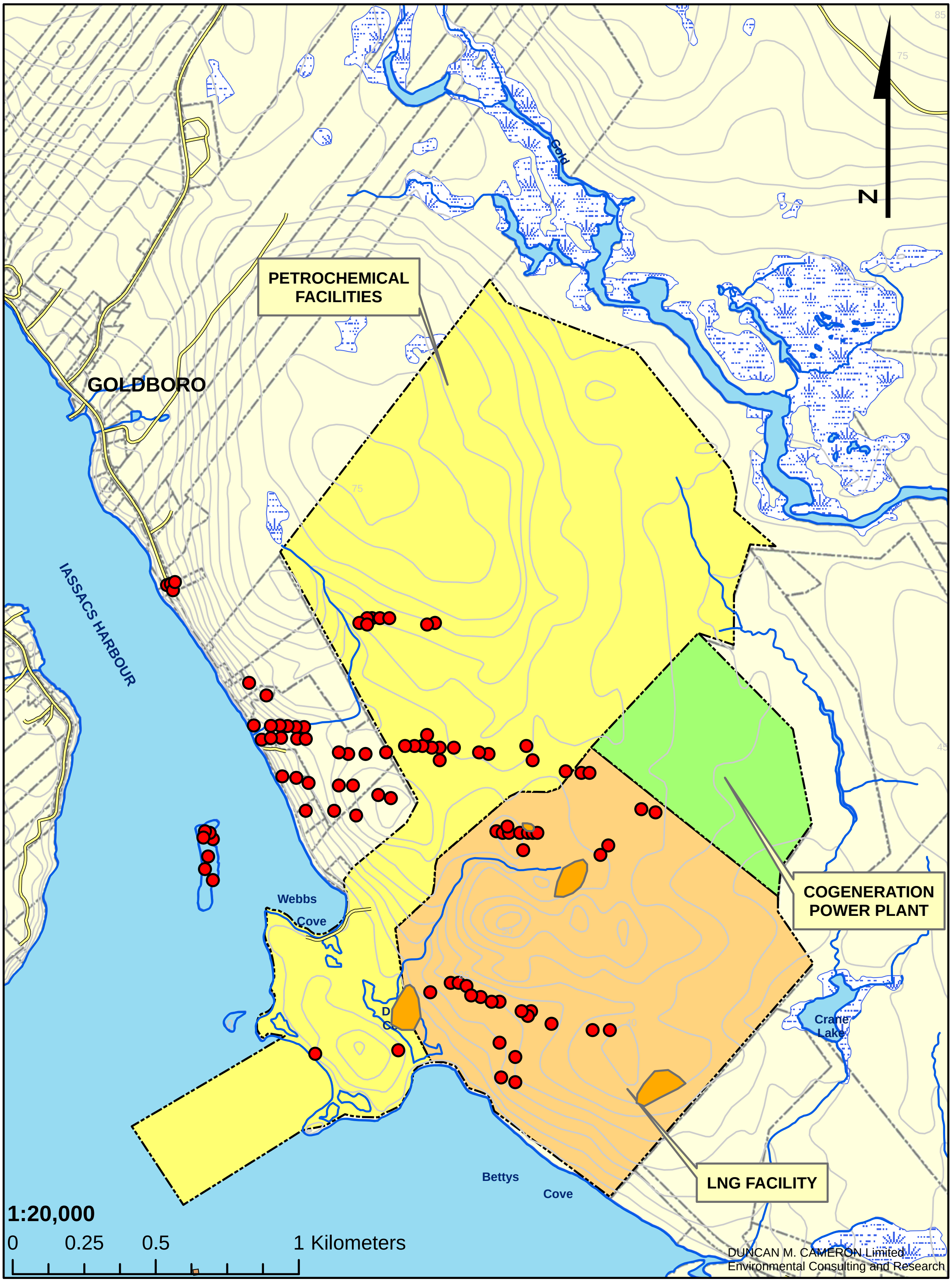
Very little information exists in the way of maps or cross sections of underground mine workings, of the actual quantities of ore removed from the underground, and gold recovered. Prior to about 1930, production statistics for Isaac's Harbour Gold District were recorded collectively with those from other nearby gold producing areas under the general heading "Stormont Gold District" (Tilsley, 1988). Included, in addition to Isaac's Harbour, were Forest Hill, Upper Seal Harbour, Lower Seal Harbour and Country Harbour areas. In addition, there is a general suspicion by geoscientists familiar with the area that as much as 50 percent of the total gold recovered from the region may have been removed by interveners – production which would not have made it to the records.

8.13.3.1 Old Mine Workings

Figure 8.13-4 is a map of the proposed Keltic Site that shows the location of former mine and associated workings inside the proposed Keltic Site boundaries as identified from an NSDNR Mines Branch database of mine workings and from direct observations in the field.

Two to four shafts or trenches were identified in the field for every one shown in the database in the southwestern most parts of the site along Route 316 and east of the SOEP gas plant road. This suggests that there may be other undocumented workings in other parts of the site, although they are expected to be concentrated mainly in the areas where workings have already been documented.

FIGURE 8.13-4 Abandoned Mine Workings/Tailings Disposal in Site Boundaries



Legend

Tailings

Approximate Location of Abandoned Mines

FIGURE No. 8.13-4

KELTIC PETROCHEMICALS INC.

ABONDONED MINE WORKING/TAILINGS DISPOSAL IN SITE BOUNDARIES

JULY 2006

There is very little information on the underground workings in the area, although on Hurricane Island, shafts and ore removal was extended 70 m underground (Fancy, 1911), and other workings inside the proposed Keltic Site boundaries may be up to 30 m or 45 m deep. Some of the old shafts and trenches are extremely dangerous, and some are known to be in direct hydraulic communication with the ocean (P. Smith, pers. comm., 2001). During the assessment field program, one resident reported a caving at the end of her driveway, just northwest of the site at Route 316, where her children normally stood waiting for the school bus. She reported hearing water moving about inside the open hole in response to wave action on the ocean about 40 m away.

In addition to digging into rock for gold, it is known that placers were explored, to a limited extent at least, off the shore of Red Head (Barrett, 1981), where some gold values and sulphide minerals were identified, albeit perhaps not in economic quantities. Mining activity also took place at Forest Hill about 20 km north of the site, within the Isaac's Harbour River watershed. It is located fairly far up the watershed and so any tailings from it should not have any effect on water quality at the site.

There has been an apparent increase in exploration interests in the area due to the recent increase in gold prices. There are currently exploration licenses and/or applications for licenses in place covering all of the proposed Keltic Site, as well as areas to the east (i.e., the former Boston Richardson Mine at Gold Brook Lake and other holdings west and north of Meadow Lake). Figure 8.13-5 shows the distribution of these exploration interests in the immediate area as at February 9, 2006.

8.13.3.2 Ore Mineralogy

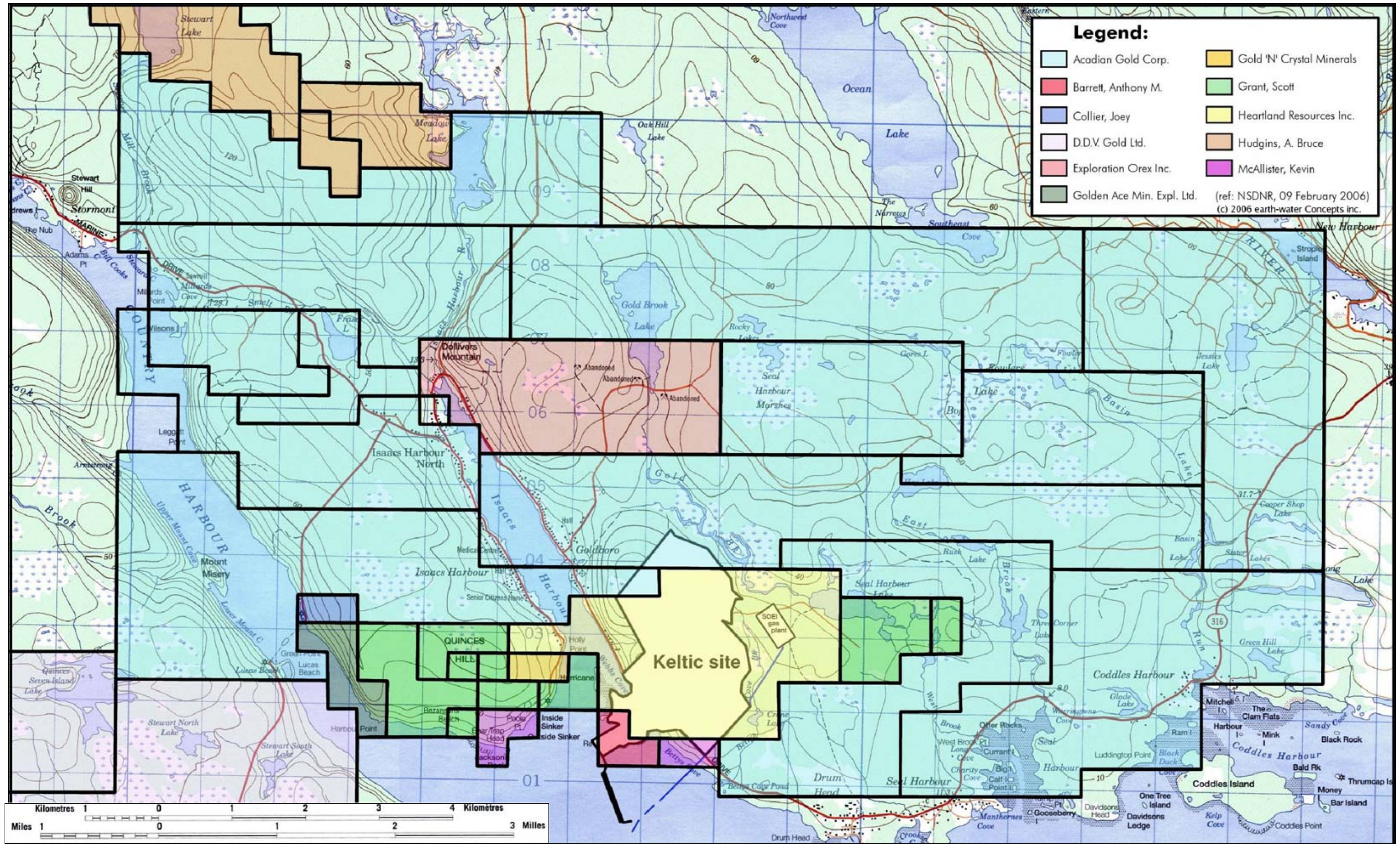
The geology and mineralogy of the area was described in detail by Corey (1992). Gold in the area is commonly found in nugget form, as flakes of visible gold, or as gold associated with arsenopyrite and to a lesser degree, pyrite. Locally, arsenopyrite is the predominant metallic mineral, usually making 65% to 75% of the total. Pyrite accounts for most of the remainder. Galena, sphalerite, and chalcopyrite may, together, be 2% of the total sulphides (Tilsley, 1996a).

8.13.4 Inactive Tailings Disposal Sites

Gold mill tailings deposits remain as a legacy of the past mining activity in the area.
Stamp milling and mercury amalgamation were the primary methods used for gold extraction in Nova Scotia and in the Goldboro area, much of which was done on-site; although there are reports that some sulphide mineral concentrate may have also been taken off site by boat to be processed elsewhere.

The stamp milling process involved crushing ore to sand or silt-size material, then washing the pulp over mercury-coated copper plates. Some of the free gold would combine with the mercury to form an amalgam, which was periodically scraped off the plates and heated in a retort to recover the gold. As a general rule of thumb, one ounce (oz) of mercury was used for each ounce of gold in the ore to obtain satisfactory recovery rates. At most stamp mills, 10-25%

FIGURE 8.13-5 Distribution of Exploration Licenses Issued



NSDNR Mines Registrar, Pers. Comm., 2005

FIGURE No. 8.13-5

KELTIC PETROCHEMICALS INC.

DISTRIBUTION OF EXPLORATION LICENSES

JULY 2006

of the mercury used in the process was lost to the environment by loss with tailings, by evaporation during heating to recover gold, or by direct spillage (Smith, pers. comm. 2005; Parsons and Percival, 2005). Historical records of mercury loss from several gold districts range from 0.07 - 0.177 oz (5.5 grams) of mercury per t of ore crushed.

Recent investigations by Parsons et al. (2004) just outside the proposed Keltic Site boundaries and at other sites in Nova Scotia have documented high concentrations of mercury (up to 350 mg/kg) and arsenic (up to 31% by weight) in mine wastes. The map in Figure 8.13-6 shows the location of tailings disposal areas identified by a geoscientist in the field within the proposed Keltic Site boundaries.

At the Boston Richardson Mine at Gold Brook Lake, there were no concentrated tailings – only a large, roughly 760 m long by 65 m wide area where the tailings sluice ran directly into Gold Brook. This was the largest mine in the area, which produced about 50,000 oz of gold from about 375,000 tonnes of mill feed. There are no production records for Dolliver Mountain Mine. However, tailings from it encompass an area that is reported to be 365 m long and 122 m wide.

At the Seal Harbour Mine just east of the proposed Keltic Site, tailings were concentrated in an elongate band about 800 m long. This was the second largest mine in the area, which produced 31,000 oz of gold from about 400,000 tonnes of mill feed. Extracts from the Annual Report of Mines suggest that about 20,000 oz of gold were recovered from within the general Keltic Site-to-Seal Harbour area. There are specific records of 5,939 oz of gold produced from the Mulgrave Zone.

The remains of three former gold mills and three (possibly four) tailings disposal areas were found within the proposed Keltic Site boundaries during the field work. All that remains of the two steam-operated and one water-operated stamp mills today are the stone and concrete foundations.

One mill was located at Universal Transverse Mercator (UTM) 5001788N/606744E on the peninsula (proposed marginal wharf area) west of Dung Cove a short distance north of Red Head. The foundation remains suggest that this mill was small. It appears that tailings from it were disposed of directly into the ocean as no traces of any tailings could be found on land.

Another mill foundation was located at UTM 5001948N/607073E, about mid-way between Route 316 and Dung Cove. The remains suggest that it may have been a small-to medium-size, water-powered mill. Tailings from it were disposed of directly into Dung Cove, and are easy to identify along a 50 m to 75 m stretch of the north shore of the cove, extending what appears to be some distance under water. Four samples were taken of these tailings for mercury and arsenic analysis as part of this EA; the results are presented in Table 8.13-1.

The third mill, a part of the Giffin Mine, was found at UTM 5002393N/607577E a short distance southeast of the SOEI gas plant road. Based on the foundation and boiler remains, this appears to have been the largest of the three mills. Tailings from it were disposed of in a 50 m by 30m area located a short distance down gradient and northwest of the mill (UTM 5002529/607507). This former tailings disposal area was assessed for possible gold reserves by Newbury (1974), and again about ten years later by Seabright Resources Inc. (1984). Seabright identified it as having an area of 1,584 m^2, a tailings thickness of 0.70 m, and a volume of 1,113 m^3, containing 1,570 tonnes of tailings grading 0.70 grams per tonne (g/t) gold. Nine samples were taken of the tailings for this assessment for mercury and arsenic analysis – the results are in Table 8.13-1.

A forth (possible) former tailings disposal area is present a short distance southeast of the third area. Based on Newbury (1974), and on the presence of healthier-looking vegetation than at the other sites, this was thought to be a water supply pond built for the mill described above, and thus no samples were collected. However, it was discovered after the field session that Seabright Resources Inc. (1984) had sampled this 65 m by 15 m pond and found gold to be present in it, thus suggesting that it was a tailings disposal pond and that it is likely to contain mercury and arsenic. Seabright identified this tailings pond as having an area of 1,026 m^2, thickness of 0.43 m and volume of 438 m^3 containing 617 tonnes of tailings grading 2.00 g/t gold.

All of the tailings samples collected during the assessment field session for which results are shown in Table 8.13-1 exceed the CCME guideline values for mercury for sediments in fresh water and marine environments. All of the samples exceed the CCME guideline values for arsenic for sediments in all aquatic environments and for soil under all land uses (agricultural, residential/parkland, commercial and industrial).

TABLE 8.13-1 Tailings Sample Results from Giffin Mine and Dung Cove Areas

Sample ID	Mercury		Arsenic		Location (UTM)	
	mg/kg	Detection Limit	mg/kg	Detection Limit	Easting	Northing
102F01-GMA1	24	1	1600	2	607496	5002544
102F01-GMA2	30	2	6700	2	607500	5002527
102F01-GMA2 Dup			6100	2		
102F01-GMA3	13	0.4	8000	2	607503	5002510
102F01-GMA4	11	0.2	2600	2	607516	5002513
102F01-GMA5	9.9	0.2	1100	2	607528	5002515
102F01-GMA6	19	1	2200	2	607525	5002527
102F01-GMA7	21	1	1600	2	607523	5002539
102F01-GMA8	26	1	1300	2	607510	5002541
102F01-GMA9	31	1	3400	2	607512	5002529
102F01-T1	4.7	0.1	1700	2		
102F01-T2	3.1	0.1	150	2	607056	5001928
102F01-T2 Dup			160	2		
102F01-T3	8.1	0.1	14	2	607069	5001912
102F01-T4	6.4	0.1	1100	2	607046	5001941
CCME*						
soil – agricultural	6.6		12			
soil – residential/parkland	6.6		12			
soil – commercial	24		12			
soil – industrial	50		12			
sediment – fresh water (ISQC)	0.170		5.900			
sediment – fresh water (PEL)	0.486		17.000			
sediment – marine (ISQC)	0.130		7.240			
sediment – marine (PEL)	0.700		41.600			

* December 2003. ISQC = interim sediment quality guidelines. PEL = probable effect level.

There is a fifth tailings disposal pond that appears to have been associated with the Mulgrave Lead mine workings. It is located just outside of the proposed Keltic Site boundary just east of Route 316 and south of Crusher Brook, centred at approximately UTM 5002775N/606750E. This tailings disposal area was not visited during the 2004 or 2005 field seasons, but it was included in the tailings gold resource assessments by Newbury (1974) and Seabright Resources (1984). It was shown by them to contain gold values and as such, is also likely to contain mercury and arsenic. Based on their reports and on more recent aerial photographs, this area currently serves as a junkyard.

8.13.5 Seismic Considerations

Eastern Canada is located within a stable continental part of the North American tectonic Plate and as such has a relatively low rate of earthquake activity. Nevertheless, within Canada's eastern seismic region, large earthquakes have occurred in the past and will inevitably occur in the future.

8.13.5.1 Seismic Regions

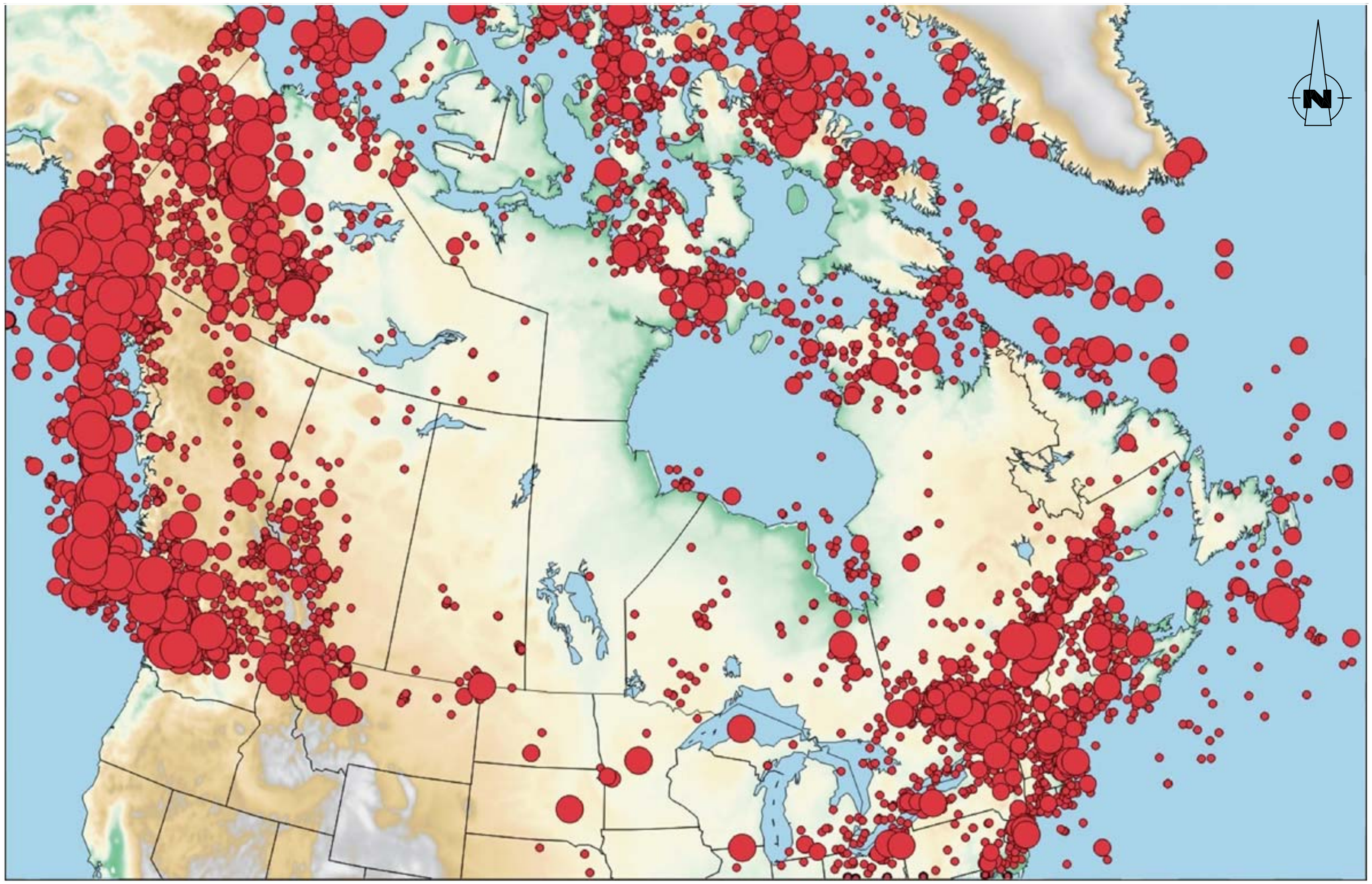
Figure 8.13-6 shows the distribution and size of earthquakes recorded in Canada, and the extent of the country's western, stable, and eastern seismic regions. Figure 8.13-7 shows the size and frequency of events and boundaries of the subregions within which earthquakes occur most frequently in Canada's eastern seismic region.

Each year, approximately 300 earthquakes occur in the eastern seismic region, of which perhaps four will exceed magnitude 4, thirty will exceed magnitude 3, and about fifteen will be reported felt (GSC, 2003). A decade will, on average, include three events greater than magnitude 5 (generally the threshold of damage).

The known earthquake seismic source zones of most concern to the populated areas of eastern Canada are the Charlevoix, Passamaquoddy and offshore Laurentian Slope seismic zones where major earthquakes of magnitudes 7.0, 5.7 and 7.2 occurred in 1925, 1869 and 1929, respectively. The Passamaquoddy area experienced a 5.9 event in 1904 and the Charlevoix area a 6.0 event in 1988 with the Laurentian Slope having had about nine events 5.0 or greater since 1929 up to 1977 (Ruffman, 1995). In 1929 a magnitude 7.2 earthquake on the Laurentian Slope (known also as the Grand Banks earthquake of 1929) triggered a large submarine slump, which ruptured 12 transatlantic cables and generated a tsunami that was recorded along the eastern seaboard as far south as South Carolina and across the Atlantic Ocean in Portugal, and caused the loss of 28 lives on the Burin Peninsula in Newfoundland.

The causes of earthquakes in eastern Canada are not well understood: unlike at plate boundary regions where the rate and size of seismic activity is directly correlated with plate interaction, seismic activity seems to be related to the regional stress fields (Ruffman, 1994), with the earthquakes concentrated in regions of crustal weakness (Bent, 1995) at depths varying from surface to 30 km (GSC, 2003).

FIGURE 8.13-6 Historical Earthquakes in Canada



Adams and Halchuck, 2003

Legend:

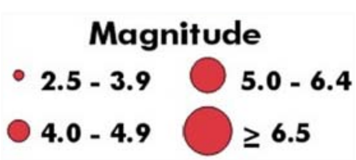


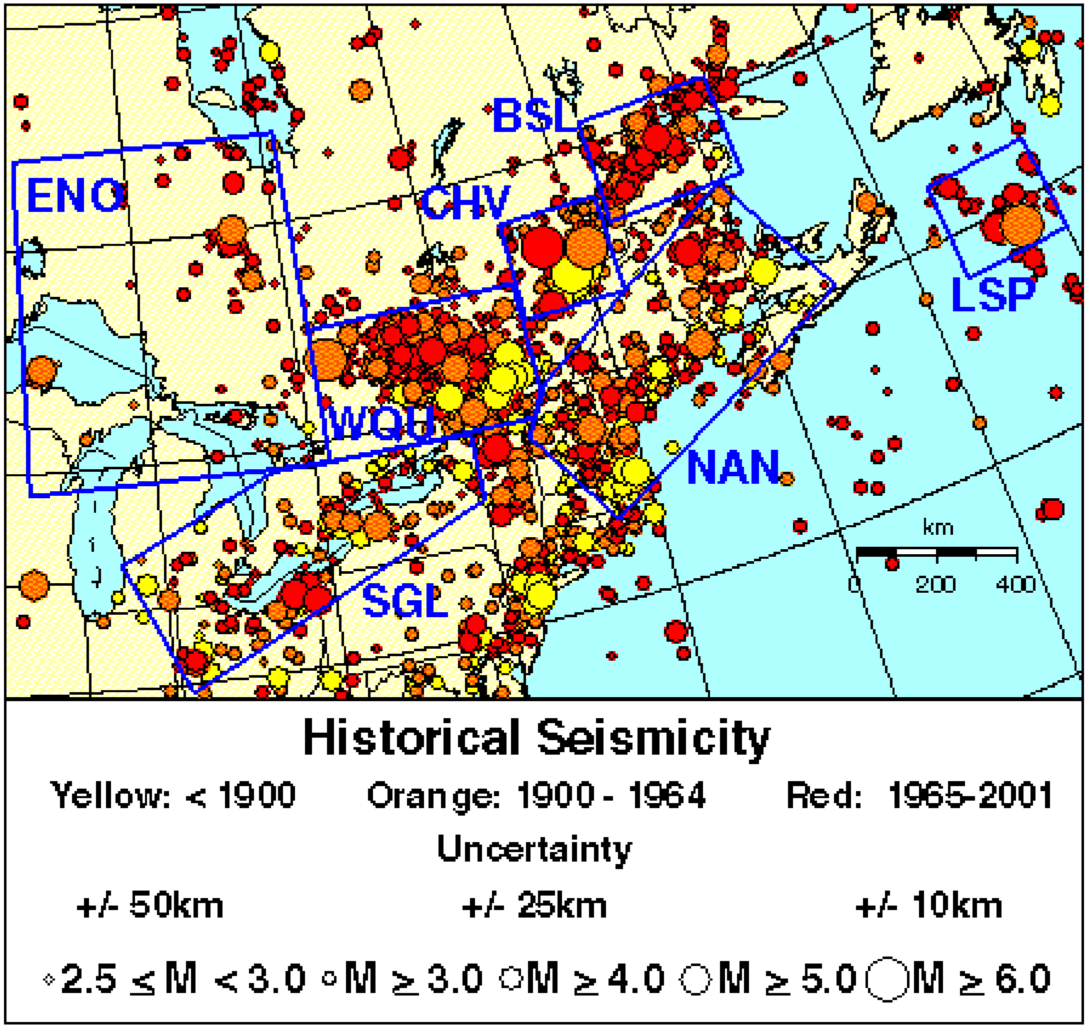
FIGURE No. 8.13-6

KELTIC PETROCHEMICALS INC.

HISTORICAL EARTHQUAKES IN CANADA

July 2006

FIGURE 8.13-7 Seismic Sub Regions



Geological Survey of Canada

FIGURE 8.13-7
KELTIC PETROCHEMICALS INC.
SEISMIC SUB REGIONS
JULY 2006

8.13.5.2 Tsunami

Ruffman and Tuttle (2005) have noted that written history of tsunami by European settlers on the western side of the Atlantic Ocean is relatively short and little oral history from first nations peoples or Viking visitors survives. The following is summarized from their work:

- The first known historic local tsunami is that caused by the November 1, 1755, Lisbon offshore earthquake;
- Tele-tsunami is known on September 24, 1848, from Fishing Ships Harbour, southern Labrador, to St. John's;
- A local tsunami was noted on June 27, 1864, at St. Shotts on the southwest extremity of the Avalon Peninsula, Newfoundland;
- On November 17, 1872, tide gauges on the Fox Islands in Penobscot Bay and in North Haven, Maine registered a train of tsunami-like waves for about six hours;
- On August 10, 1884, a magnitude 5.6 earthquake in southern New York State created a tsunami that was observed in Philadelphia, along the coast at Trenton and Highlands, New Jersey, and through to New York Harbour;
- On October 4, 1884, three trans-Atlantic cables south of the Tail of the Banks broke at the same time over a down-slope distance of 10 nautical miles suggesting a slump; a possible tsunami may have resulted, however no tsunami reports are presently known;
- On January 9, 1926, an apparent tsunami was seen at Bernard, in Bass Harbour on Mount Desert Island, and at Corea in Maine;
- On November 18, 1929, the magnitude 7.2 "Grand Banks" earthquake (epicentre of 44.5°N, 56.3°W) triggered a large submarine slump that generated a tsunami and caused the loss of 28 lives. It represents Canada's largest documented loss of life directly related to an earthquake; and
- In 1940, a small tsunami-like event observed on the Island of Saint-Pierre may have been associated with the Laurentian Slope Seismic zone (LSP in Figure 8.13-7).

Other tsunami which preceded these are known from studies of the offshore geologic record (Campbell et. al., 2003; Bornhold et. al., 2004; Finea et. al., 2005).

The tsunami that is most relevant to the proposed Keltic plant site is that of 18 November 1929, in which a magnitude 7.2 earthquake occurred along the southern edge of the Grand Banks (epicenter of 44.5°N, 56.3°W) that was felt as far away as New York and Montreal (GSC, 2005). On land, damage due to earthquake vibrations was limited to Cape Breton Island, where chimneys were overthrown or cracked, and where some highways were blocked by minor landslides. However, the earthquake triggered a large submarine slump that generated a tsunami that was seen in Cape Breton Island, where it did minor damage; it was physically seen as far southwest as Lunenburg, Nova Scotia, and in Bermuda. It was recorded on tide gauges as far south as Charleston in the US, in the Azores, and across the Atlantic Ocean in Portugal. (Ruffman, 2001).

The tsunami traveled at speeds up to about 500 km/hr through deep water, and over the continental shelf at about 205 km/hr toward Halifax and 140 km/hr toward Newfoundland, where two-and-a-half hours after the event, three main pulses arrived along the coast of the Burin Peninsula with amplitudes of 3 to 8 m (Finea et. al., 2005) and a runup that rose 13 m (Ruffman, 2001) above sea level and perhaps as much as 27 m (GSC, 2005) above sea level in narrow bays. It claimed a total of 28 lives in Newfoundland, one life in Cape Breton, Nova Scotia, and caused more than $1 million (1929 dollars) damage (estimated as nearly $20 million 2004 dollars). This represents Canada's largest documented loss of life directly related to an earthquake.

The proposed Keltic plant site was shown by the GSC (2005) to be just at the edge of the "minor damage" zone for the 1929 tsunami.

8.14 ARCHAEOLOGICAL RESOURCES

An archaeological resource impact assessment of the Keltic Study Area was conducted under Heritage Research Permit A2004NS76 (LNG plant site) (Appendix 13). A full assessment including a historical background study and field survey were conducted for the proposed plant site which resulted in the discovery of twelve previously unrecorded archaeological sites, at least three of which are expected to be impacted by construction of the LNG plant.

8.14.1 Historical Background Research

8.14.1.1 Keltic Site

Historical research was conducted at Nova Scotia Archives and Records Management (Halifax), NSDNR, the NSMNH Heritage Division, and local libraries. Historic maps, manuscripts, land grants and deeds, archaeological reports, and published sources were consulted. This background study revealed a long settlement history pre-dating the arrival of Europeans to the province.

Before the arrival of European settlers to Goldboro in the nineteenth century, the area was home to at least two Mi'kmaq encampments, at Schoolhouse Brook and at the head of the harbour on Isaac's Harbour River. Local residents have also indicated the possibility of a third encampment at Webb's Cove. The district was known to the Mi'kmaq as "Eskegawagik" meaning "skin-drying place" (Cook, 1976). In the seventeenth and eighteenth centuries, this area was visited by the French and English although there is no documented European settlement in Isaac's Harbour prior to 1817.

In about 1817, a Black Loyalist settler, Isaac Webb, moved his family from County Harbour to the east side of Isaac's Harbour (then known as Port Hinchingbrook) which was unsettled save for the few native encampments. Webb built a large white farmhouse there (Hart, 1975).

In 1831 some fishermen from the western end of the province settled on the west side of the harbour and the community became known as Isaac's Harbour after the pioneer the settlers found there. Several families of Black Loyalists settled around what is now known as Webb's Cove. Most of these early Black Loyalists were fishermen (Cook, in PANS, undated).

The Black Loyalist settlers were buried in a cemetery at Red Head on the east side of the harbour. No burial records for the cemetery at Red Head have been located and only one headstone was ever known in the cemetery, although an archaeological excavation in 2001 (NSMNH, 2001) resulted in the discovery and removal of 24 burials. The single carved headstone in the cemetery was that of Henry Webb who died in 1935 and was the last surviving descendent of the original settlers remaining in Isaac's Harbour East (Niven et. al., 2001).

On March 11, 1898 Isaac's Harbour East was renamed "Goldboro" by an act of Legislature, due to the discovery of gold there in the mid-nineteenth century (Statutes of Nova Scotia, 1898).

Historic maps reveal little about the settlement history of the Keltic Study Area. Land was not granted by the province until the late nineteenth century. The 1776 Atlantic Neptune does not show any settlement on Isaac's Harbour (Port Hinchingbrook), nor does the 1834 Great Map of Nova Scotia, although the main road along the shore is shown. Ambrose F. Church's map of Isaac's Harbour, published in 1876, shows several wharves and stores along the shore, along with a lobster factory and an "old crusher" just north of Webb's Cove. A cookhouse, blacksmith shop, "old mines" and a few residences are situated within the Keltic Study Area on the east side of the main road (Church, 1876).

Gold was first discovered on the west side of Isaac's Harbour on September 14, 1861. It was discovered a short time later on the east side of the harbour by two natives, on what became known as the Mulgrave lead. By 1862, several leads had been discovered and were in operation throughout the district including the Mulgrave and Victoria leads in Goldboro. The Mulgrave lead continued to be mined at varying rates and under various management firms well into the twentieth century (Malcolm, 1912).

In 1887, a quartz vein was discovered on Hurricane Island and three shafts were sunk and worked by the Island Mining Company. A gold lead was discovered in the Skunk Den in 1890 and was being mined by 1892 (Hunt 1868). Mining in Goldboro halted for the last time in 1943 (Hunt, in Malcolm, 1912).

8.14.2 Archaeological Field Survey and Reconnaissance

8.14.2.1 Keltic Site

Prior to the field survey of the proposed Keltic Site, two archaeological sites were recorded during previous archaeological assessments. Archaeologist Laird Niven recorded the remains of the late nineteenth century Skunk Den Mine located on the south side of Sable Road within the Keltic Study Area. The site includes the remains of several stone crusher piles and irregularly-shaped depressions likely associated with open-pit mining.

In response to concern by citizens of the Lincolnville community, in 2000 and 2001, a crew of archaeologists and community members, lead by archaeologist Laird Niven, conducted an excavation of the cemetery at Red Head. The purpose of the excavation was to identify and remove burials which were being impacted by severe erosion of the table land on which the cemetery was located. Twenty-six burials were encountered over the two seasons and the skeletal remains were moved to a laboratory where forensic analysis and identification (gender, age, and pathology) was conducted before the remains were reburied at the Goldboro Baptist Cemetery.

No additional burials were encountered at Red Head during subsurface testing for the proposed Keltic Facility. Twelve archaeological sites were encountered during the survey of the remainder of the Keltic Study Area including eight sites on the peninsula, one on Hurricane Island, and the remaining three within the Industrial Park (Figure 8.14-1).

Five unidentified features were discovered and recorded at Sculpin Cove north of Red Head. All five features are comprised of irregularly-shaped depressions with no structural elements or associated artefacts visible on the surface. The age and function of these features is not known.

On Hurricane Island, at the mouth of Isaac's Harbour, archaeologists discovered and recorded the remains of a late nineteenth century gold mining operation. The site is very extensive and includes numerous mine-related features spread out over the island including several irregularly shaped depressions associated with air shafts or surface prospecting. There are also several large deep rectangular depressions which may be related to open-pit mining, a possible powder magazine, a stone-lined well, and numerous other unidentified features. The site is associated with the Hurricane Island Mine which was opened in 1887 by the Island Mining Company.

The McMillan Mine is located north of Red Head and appears to be relatively modern (early twentieth century) as the main feature is comprised of a square footing of stone and concrete construction with wooden block supports inside. To the south of the main feature is a mine shaft adjacent to the shoreline.

Above Dung Cove archaeologists discovered a site likely associated with settlement which includes a rectangular stone-lined feature. The feature is obscured by low tree cover and is surrounded by three stone piles resulting from field clearing. The land appears to have been cultivated at some point. The age of this site is not known but given its proximity to Webb's Cove, it may be associated with Black Loyalist settlement.

The Giffin's Mill site is located above Dung Cove on the north side of an old roadway that runs south-westward from Highway #316. The site is comprised of a shallow rectangular depression which is bounded on the east by a wooden structure of vertical posts and on the north and south by a mortared stone wall. A sluice runs parallel to the old roadway from the highway and leads to the feature. This area is marked on historic maps as "Griffin's Mill" (GSC, 1904).

The Hattie's Belt site is located adjacent to Highway #316 on the east side, south of Sable Road. The site encompasses an area approximately 50 m by 50 m and includes several stone crusher piles, air shafts, and/or open pits associated with gold mining. At the west end of the site immediately adjacent the highway is a surface tunnel which is marked on the 1904 gold district map for Isaac's Harbour (GSC, 1904).

The Giffin lead is located adjacent to Sable Road on the south side. The site stretches for approximately a 50 m radius and includes more than a dozen irregularly-shaped depressions, likely associated with surface prospecting for gold. There are also at least six stone crusher

FIGURE 8.14-1 Location of Heritage Resources

Legend

Heritage Resources

FIGURE No. 8.14-1

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LOCATION OF HERITAGE RESOURCES

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piles scattered throughout the site. Two of the depressions have rectangular wooden structures inside which are constructed of vertical posts. The function of this aspect of the feature is unknown, although it may have served as some sort of bracing support for open-pit mining.

The Giffin Lead is located on the south side of Sable Road which consisted of more than a dozen water-filled depressions possibly related to open-pit mining. Several stone crusher piles were also observed in the surrounding area. This site stretched a radius of approximately 50 m.

The South Mulgrave lead is located on the north side of Sable Road adjacent to an old roadway that runs northwest from Sable Road out to Highway #316. This site stretches for approximately 100 m along the old roadway and consists of several stone crusher piles, those on the east end of the site having been recently levelled. On the west side of the site are a stone crusher pile and open mine shaft with wooden structural remains. This site is likely the “old crusher” indicated on Church’s 1876 map.

In addition to those archaeological sites that were recorded, several areas of cultural activity were noted. At the head of Betty’s Cove, mining activity likely associated with surface prospecting was encountered. Several depressions were noted but no open mine shafts or structural remains were found.

On the north side of Sable Road approximately 350 m east of the South Mulgrave lead site, seven air shafts were discovered which are likely associated with the Mulgrave lead. Additional air shafts were discovered at the west end of the industrial park approximately 100 m east of the highway and 50 m north of Sable Road.

On the north side of Sable Road, west of the old roadway leading to the South Mulgrave lead, a linear stone alignment was discovered oriented north-northeast by south – southwest adjacent to a NSDNR Survey marker (#4447). No other heritage features were found in the surrounding area.

Two areas of recent dumping were encountered near the east end of the Keltic Study Area on the north side of Sable Road along a recently abandoned roadway opposite the Sable Offshore helipad. Midden materials included a wood stove, tires, a chemical storage drum, vinyl mini-blinds, tar paper, mechanical parts, plastic containers, and plastic buckets. Newspapers dated March 1995 were also found among the refuse.

Finally, an early- to mid- twentieth century midden was found approximately 30 m south of Sable Road behind a standing abandoned house on Highway #316. The house is built on a fieldstone foundation which has been mortared in spots to repair it, and later boarded over. The house is likely of late nineteenth-century vintage. Across the highway opposite the house is a poor-grade concrete foundation with cast iron pipe running through it. Behind the foundation is a 1930s truck and scattered remains of other early automobiles, suggesting this may have been a commercial garage or a garage associated with the house across the street. Fifteen metres northeast of this feature is a mine air shaft.

8.15 HUMAN HEALTH AND SAFETY

No assessment of existing human health and safety was undertaken to record baseline conditions. Human health and safety will be addressed based on anticipated project-related effects.

8.16 TRANSPORTATION INFRASTRUCTURE

Transportation infrastructure includes the existing and proposed roads in the Keltic Study Area that may be used during the construction and operation of the Keltic Project.

Transportation infrastructure that may be used for the following purposes has been included:

- worker and equipment access during construction activities;
- worker access to the LNG and petrochemical plants during operation of those facilities;
- transportation of maintenance equipment and production materials needed during operation;
- transportation of finished products from the petrochemical plants to Highway 104; and
- local traffic.

8.16.1.1 Description of Existing Road Conditions

The existing road route most likely to be used to travel from Antigonish to Goldboro is Trunk 7 from Highway 104 to Route 276, Route 276 from Trunk 7 to Route 316, and Route 316 from Route 276 to Goldboro. The travel distance from Highway 104 to the Sable Gas Plant Road by the existing route is about 76.7 km, and the majority of posted speed limits are at or below 80 km/h.

Trunk 7 is considered a Trunk road and Routes 276 and 316 are Collector roads. All are two lane paved roads with one lane for each direction of travel. Pavement width typically is between 6.4 and 6.8 m, and gravel shoulders are usually between 1.0 and 1.5 m wide. The roads do not have any control of access and private driveways occur frequently, averaging up to about seven accesses per km.

The Trunk 7 section of the route is rated as a Maximum Weight – Spring Exempt road, meaning that trucks can carry maximum registered loads all year. While Routes 276 and 316 are designated as ‘B-Train’ routes, a considerable section of Route 316 from south of Route 276 to north of Goldboro is subject to ‘Spring Weight Restrictions,’ which means that gross allowable weights will be reduced considerably below registered weights for about six to eight weeks each spring.

It is essential that a Maximum Weight – Spring Exempt road be provided from Highway 104 to the proposed petrochemical complex. An estimate prepared by NSTPW in 1998 indicated that it would cost about $8.0 million to upgrade the entire 76.7 km long Trunk 7 - Route 276 - Route 316 Access Route to allow Schedule C load carrying capabilities. Although a current cost estimate is not available, upgrading costs would be significantly higher considering the elapse of almost eight years since the previous estimate was prepared.

8.16.1.2 Speed Zones

The existing Trunk 7 - Route 276 - Route 316 route has about 65% of the length posted at 80 km/h or less. Table 8.16-1 illustrates distance, posted speed limits, average speed, and travel time for the existing route.

The existing Trunk 7 - Route 276 - Route 316 route from Highway 104 at Antigonish to the Sable Gas Plant Road at Goldboro is about 76.7 km long. Assuming one can travel at the posted speed limits, the average travel speed is 81 km/h and the travel time is about 57 minutes.

TABLE 8.16-1 Route Length, Travel Speed and Travel Time

Road and Section	Speed Limits km/hr	Lengths km/hr	Totals
Trunk 7 - Highway 104 to Route 276	70	1.352	
	80	1.632	
	90	26.513	29.497
Route 276 - Trunk 7 to Route 316	70	0.713	
	80	4.593	5.306
Route 316 - Route 276 to Sable Gas Plant Road	60	3.814	
	70	9.831	
	80	28.279	41.924
Total Route Length			**76.7 km**
Average Travel Speed			**81 km/h**
Travel Time			**57 minutes**

Source: Unpublished data obtained from NSTPW

8.16.1.3 Traffic Volumes

NSTPW has periodically obtained traffic counts on the Transport Study Area highway sections using automatic traffic counters. Historical count data for many areas in Nova Scotia indicate that traffic volume growth rates are typically about 2 % per year.

Estimated 2005 and projected 2015 Annual Average Daily Traffic (AADT) volumes for Study Area roads are included in Table 8.16-2. While volumes on Trunk 7 and Route 316 near Highway 104 are moderate, volumes on all other road sections are low to very low.

TABLE 8.16-2 Annual Average Daily Traffic Volumes for Study Area Roads

Road Section	Estimated and Projected AADT Volume, vehicles per day	
	2005	2015[1]
Trunk 7 - 1 km south of Highway 104	4,510	4,960
Trunk 7 - 1 km south of Salt Springs	2,830	3,110
Trunk 7 - Antigonish - Guysborough County Line	1,020	1,120
Route 276 - Halfway Trunk 7 to Route 316	530	580
Route 316 - 1 km south of Route 276	420	460
Route 316 - 1 km north of Isaac's Harbour	400	440

1. An annual growth rate of 2.0% has been used

Source: Unpublished data obtained from NSTPW

8.16.1.4 Seasonal Variation in Traffic Volumes

Daily volumes fluctuate from one time of year to another, with volumes typically higher in the summer and lower in the winter. NSTPW maintains a number of permanent count and vehicle classification stations throughout the Province. Permanent counters are grouped in accordance with their seasonal variation patterns, with Group AA counters having the least seasonal variation and Group H counters the greatest seasonal variation. While most roads in the Study Area are considered to be in Group C and D, seasonal variations for Groups A, B, C, and D permanent counters are included in Table 8.16-3. These factors indicate how the average weekly volumes vary from season to season in comparison to the AADT. For example, a Group C road with an AADT of 1000 vehicles per day, will have average volumes of 730 vehicles per day during the winter, 920 vehicles per day during spring and fall, and 1240 vehicles per day during the busier summer months. However, since volumes in the Study area are generally low, the seasonal variation in average weekly volumes will have little impact on traffic performance.

TABLE 8.16-3 Seasonal Variation in Average Daily Volumes

Season	Average Daily Volume as a Percent of AADT by Counter Group			
	A	B	C	D
Winter (December, January, February, March)	0.82	0.78	0.73	0.69
Spring / Fall (April, May, October, November)	0.96	0.95	0.92	0.91
Summer (June, July, August, September)	1.11	1.18	1.24	1.29

Source: Unpublished data for Average 2005 Counter Group Factors; NSTPW

8.16.1.5 Vehicle Classification

The traffic stream on arterial and collector roads is composed of a mixture of passenger cars, vans, light trucks, heavy single unit trucks, and tractor trailer units. When calculating the percent trucks for a road, passenger cars, vans, and light trucks (four tires) are classified as 'passenger vehicles', and heavy single unit trucks (six or more tires) and tractor trailer units are classified as 'trucks.' While vehicle classification counts are not available for all road sections in the Study Area, NSTPW obtained a classification count on Route 316, south of Route 276 during 2005 that indicate 95% passenger vehicles and 5% trucks can be assumed as the vehicle classification values for existing access roads between Highway 104 and the Keltic site.

8.16.1.6 Collision Rates

The relative safety of a section of highway is evaluated by comparing Keltic Study Area collision rates to the average collisions rates for all similar highways in the Province. Collision rates are generally expressed as number of collisions per hundred million vehicle kilometres (hmvk). NSTPW calculates five year average collision rates for highway sections, as well as Provincial average collision rates by severity and highway class.

Available collision data for the existing Trunk 7 - Route 276 - Route 316 Access Route road sections for the five years 1999 to 2003 (the most recent data available) are included in Table 8.16-4. The combined collision rate for the entire 76.7 km road length, as well as Provincial average collision rates for road classes included in the Transport Study Area, are also included in that Table.

While the combined collision rates for the existing 76.7 km long Trunk 7 - Route 276 - Route 316 Access Route are lower than provincial average rates for Trunk and Collector road classes, collision rates for the existing route are considerably higher than the provincial average rates for two-lane controlled access highways.

TABLE 8.16-4 Five Years (1999 to 2003) Collision Data for Transport Study Area Roads

Road Section	Number of Collisions by Severity				Collision Rates by Severity [1]			
	PDO [1]	Injury	Fatal	Total	PDO [1]	Injury	Fatal	Total
Trunk 7 - Highway 104 to Route 276	42	24	1	67	29.6	16.9	0.7	47.2
Route 276 - Trunk 7 to Route 316	5	1	0	6	57.8	11.6	0.0	69.4
Route 316 - Route 276 to Sable Gas Plant Road	19	21	2	42	45.2	49.9	4.8	99.9
Trunk 7 - Route 276 - Route 316 Access Route Combined Collision Rates					34.3	23.9	1.6	59.7
Provincial 1999 to 2003 Average Collision Rates for Road Classes in the Transport Study Area								
100 series - Two Lanes					21.9	11.0	0.9	33.8
Trunk Road - Rural (Trunk 7)					46.9	28.4	0.9	76.2
Collector Route - Two Lanes (Routes 276 and 316)					59.5	32.8	0.5	92.8

NOTE: 1. PDO means Property Damage Only
Source: Unpublished data obtained from NSTPW