REGIONAL WATER RESOURCES PICTOU COUNTY NOVA SCOTIA

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Regional Water Resources
Pictou County, Nova Scotia

by
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EXECUTIVE SUMMARY

Study Objectives

The objectives of the study were 1) to evaluate the occurrence, quality and quantity of surface and groundwater in Pictou County and 2) to assess the probability of contamination of water resources from human activities and to advise on measures to alleviate such problems.

Funding Agencies

The Pictou County Regional Water Resources Evaluation Project, conducted from April 1977 to November 1979, in conjunction with a companion study in Cumberland County, was co-funded by the Nova Scotia Department of Development and the Department of Regional Economic Expansion, and was implemented by the Nova Scotia Department of the Environment. This study represents part of an overall program by the Nova Scotia Department of the Environment to evaluate the Province's water resources.

Scope

The study involved the collection, collation and interpretation of existing and new data in the areas of streamflow, meteorology, surficial and bedrock geology, hydraulic characteristics of aquifers, surface and groundwater quality and land use in the study area. The acquisition of new data involved drilling of 10 test holes, conducting 4 pump tests and collecting about 25 additional groundwater, 44 surface water, and 40 soil samples. Three meteorological stations and 4 hydrometric stations were established.

RESULTS

Surface Water

The three major river basins in the study area are the West River (drainage area 239 km^2 or 92 mi^2), the Middle River (234 km^2 or 90 mi^2), and the East River (565 km^2 or 218 mi^2). Average annual yield on the West River is $1.19 \times 10^8 m^3$ (2.62×10^{10} gal.), average daily yield is $3.30 \times 10^5 m^3$ (7.26×10^7 gal.). Average annual yield for the Middle River is $1.17 \times 10^8 m^3$ (2.57×10^{10} gal.) or $3.2 \times 10^5 m^3$ (7.04×10^7 gal.) daily. The East River yields on the average $2.83 \times 10^8 m^3$/yr. (6.23×10^{10} gal./yr) or $7.8 \times 10^5 m^3$ (1.71×10^8 gal.) daily. Low flows approximate 2% of average daily flows, (based on the drought frequency curve for the Middle River).

Surface water quality is generally satisfactory according to the Guidelines for Canadian Drinking Water Quality, 1978 with the exception of possible turbidity problems after storms and high dissolved solids during very low flow on the West River.

Groundwater

The two most promising aquifers, the Pictou and Riversdale Groups, have potential to supply or augment supplies of major industrial or municipal quantities. Yields per 30 meters of drilling in the Pictou Group range from 0.0045 to 2.53 m^3/min. (1 to 557 igpm) and average 0.17 m^3/min. (38 igpm). In the Riversdale Group, the range varies from 0.0045 to 2.39 m^3/min. (1 to 526 igpm) and the average is 0.20 m^3/min. (44 igpm) per 30 meters of drilling.

Water quality is generally acceptable according to the **Guidelines for Canadian Drinking Water Quality, 1978**. However, minor treatment for iron and manganese removal may be desirable. Iron and manganese values average 0.40 and 0.08 mg/l respectively in the Riversdale Group, and 0.26 and 0.27 respectively in the Pictou Group. Increasing salt content with depth has been noted in certain regions underlain by the Riversdale Group. Dissolved solids in excess of 7000 mg/l have been reported in the Three Brooks area.

The Canso, Cumberland Groups and Stellarton Series have the potential to supply small to medium industries and institutions. The occasional well may yield more. Yields per 30 meters of drilling range from 0.0023 to 0.5 m^3/min. (0.5 to 102 igpm) in these bedrock units. The Stellarton Group may be of only limited value in some areas because of high iron, manganese and odour problems, although in some cases this is treatable. Some iron and manganese may occur in the Canso and Cumberland Groups, but this can be removed by treatment.

Yields from the Windsor Group per 30 meters of well depth range from 0.0002 to 0.054 m^3/min. (0.4 to 12 igpm) and average 0.039 m^3/min. (8 igpm). Hardness values of up to 564 mg/l (as $CaCO_3$), which is extremely hard, have been reported. For this reason and the lower expected yields noted, the Windsor Group should be given low priority as a potential aquifer.

In the Caribou area, just north of the Town of Pictou, a limited shallow sand and gravel aquifer has been identified. It is estimated that, with proper development, this aquifer can yield up to 1.46 $m^3/min.$ (300 igpm) on a perennially safe basis.

Project Implications and Recommendations

Regional Water Supply System

Information gathered during the study reveals various potential water supply options for the four towns of Westville, Stellarton, New Glasgow and Trenton. A 1975 proposal for a regional system involved using the East River as the source of supply and required the construction of treatment, transmission, and reservoir facilities. This project is estimated, in 1980, to cost $22,000,000 (twenty-two million). In view of the high costs associated with this proposal, alternative options should be considered:

East River Option: Water demand for the four towns was estimated to be, in millions of gallons per day: 4.40 by 1981, 5.08 by 1991, and 6.38 by 2001. These flows are considerably in excess of the low flow of 0.65 MGD which is expected to occur once in 50 years. An impoundment on the headwaters of the East River at West Branch Lake would store water which could be released to maintain required flows during low flow periods. There appears to be no water quality problems which would prohibit the use of the East River as a water supply. Detailed studies of the potential for impoundment and water quality are required to determine the practicability of this option and the costs of its implementation.

Groundwater Option: It should be possible to develop sufficient groundwater from the Pictou and Riversdale Groups of bedrock to significantly augment existing water supplies. A proper groundwater exploration and testing program is needed to ensure the best use of available supplies.

Further study including assessment of current supplies, optimal location of an impoundment, nature of the required impoundment, and a groundwater exploration and testing program will be required in order to determine the most cost efficient approach that will satisfy the towns' water demand.

Water Supply for the Town of Pictou

During the course of the study the opportunity arose to assist the Town of Pictou in obtaining additional supplies to overcome a chronic water shortage problem. Two alternative water sources were available for consideration: 1) the Causeway Reservoir, formed by the impoundment created by the Pictou Causeway, and 2) groundwater in the Caribou area, just north of the Town. A successful groundwater exploration program was conducted in the Caribou area. The conclusions are:

1) Sufficient additional groundwater could be safely withdrawn to meet the Town's requirements for at least 15 years and probably longer.
2) The aquifer is susceptible to contamination, but the effects of this could be minimized if steps are quickly implemented to control development, transportation of hazardous materials (chemicals and oil) through the area, waste disposal, and gravel extraction.
3) Treatment of water from the Causeway Reservoir would have cost about $900,000 (nine hundred thousand) in capital costs (plus operating expense) over and above the cost for development of the groundwater supply.

The Causeway Reservoir Option: Should the groundwater source fail to meet increasing demands in the future, the Causeway Reservoir may be the only practical source of additional water supply. With this possibility in mind, a study should be initiated to examine the relevant characteristics of the reservoir: physical makeup, (including rate of infilling), water quality, hydrology, and any factors which could reduce the reservoir's value as a water supply. This study should also design a comprehensive monitoring program to examine temporal changes in the reservoir.

Data Base Inventory

In conjunction with the preparing and publishing of the Water Resources Evaluation Project a Data Base Inventory System has been developed. This subject file and map index incorporates all the reference material in the report, along with information considered useful for any subsequent investigations. Included are such subjects as 1) well log data, 2) bedrock geologic information, 3) surficial geological information, 4) aquifer analysis, 5) water quality data, 6) hydrological information, 7) meteorological information and 8) basin analysis. This information resource is unique. For the first time, a comprehensive water resources data file for regions of Pictou County is organized and easily accessible in one place.

This information will serve to encourage rational development of an industrial base. It will assist in reaching decisions regarding municipal and domestic water supply and waste disposal services. Most importantly, it will help to define measures which will ensure protection of this region's water resources.

CHAPTER 1
Introduction

1.1 Purpose and Scope

The general objectives of the project were 1) the evaluation of the occurrence, quality, and quantity of surface and groundwater; and 2) the assessment of potential contamination of these water resources by man-made activities, with advice on measures to avoid or alleviate such problems. The terms of reference under which the project operated are included in Appendix A.

The study involved a regional assessment of the following:

1) bedrock and surficial geology
2) climatic data
3) hydrology, including streamflow and aquifer analyses
4) chemical quality of surface and groundwater
5) activities which may adversely affect surface and groundwater quality.

1.2 Previous Work

The bedrock geology of the county has been described by Williams (1914), Bell (1940), Maehl (1960), Gillis (1964), Benson (1967), and Donohoe and Wallace (1978). Previous investigations of the surficial geology include Cann and Wicklund (1950), who conducted a soil survey of Pictou County for the Canada Department of Agriculture (this survey is currently being updated by Agriculture Canada at Truro); MacNeil (1972), who has plotted glacial features from air photos on a series of 1:50,000 maps; Hogg (1953); and Fowler and Dickie (1977), who have provided a mapped inventory of the sand and gravel occurrences of Pictou County. Further information on the geology, such as the bedrock lithology and depth of till, is contained in water well records on file with the Nova Scotia Department of the Environment and diamond drill holes maintained by the Technical Records Library of the Nova Scotia Department of Mines and Energy.

Various aspects of the groundwater resources have been investigated for certain localities within the study area. These investigations include: Hennigar (1968), Groundwater Survey for the Town of Pictou; Vaughan (1976), Groundwater Survey for Three Brooks; Cross and Woodlock (1976), Callan (1978), Investigation of Groundwater Resources, Town of Pictou; and Callan (1979), Groundwater Investigation, Plymouth Park (1979).

Meteorological records have been maintained by the Atmospheric Environment Service, Environment Canada, at Truro for the past 40 years and at sites located at Stellarton, Trafalgar, and Hopewell. In 1965, the Water Survey of Canada installed a water level recorder on the Middle River at Rocklin (01DP004) to measure daily discharge. No other records of longterm continuous monitoring of meteorological data and streamflow are available in the study area.

1.3 Location, Area and Extent

Pictou County lies along the shores of the Northumberland Strait in the northeastern part of mainland Nova Scotia (See Figure 1.1). It is bounded by Colchester County on the west, Antigonish County on the east, Guysborough County on the south and the Northumberland Strait on the North. The total area of the county, including lakes and rivers, is 288,907 ha. (713,890 ac.).

The Town of Pictou (population 4,588) is the county seat; New Glasgow (population 10,672) is the largest town and the center of the urban area of the county, which also includes Trenton, Stellarton, and Westville. The Trans Canada Highway No. 104 forms the main link with Halifax, 161 km (100 mi.) distance via Truro. It also provides direct access to the Province of New Brunswick, 177 km (110 mi.) west, and to Cape Breton Island, 96 km (60 mi.) via the Canso Causeway to the east. Pictou County has more kilometres of roads and highways than any other county in the Province. Seventy-five percent of the county's 2,136.8 km (1,422 mi.) of roads are unpaved. The area is served by the Canadian National Railways line from Halifax to Sydney which provides daily passenger and freight transportation. There is one commercial airstrip operated by the Town of Trenton which has 945 m (3,100 ft.) of paved runway.

1.4 Physiography and Drainage

1.4.1 Physiography

The study area may be divided into two physiographic units, the Upland Plain and the Lowland Plain, each closely related to the underlying rock divisions and geologic structure.

Detailed descriptions of each unit and its components are given by Goldthwait (1924). The location and extent of each unit is shown in Figure 1.2.

Upland Plain: The Upland Plain comprises the Cobequid Mountains and the Pictou-Antigonish Highlands. The Cobequid Mountains form a long, narrow belt stretching 120 km (75 mi.) across Cum-

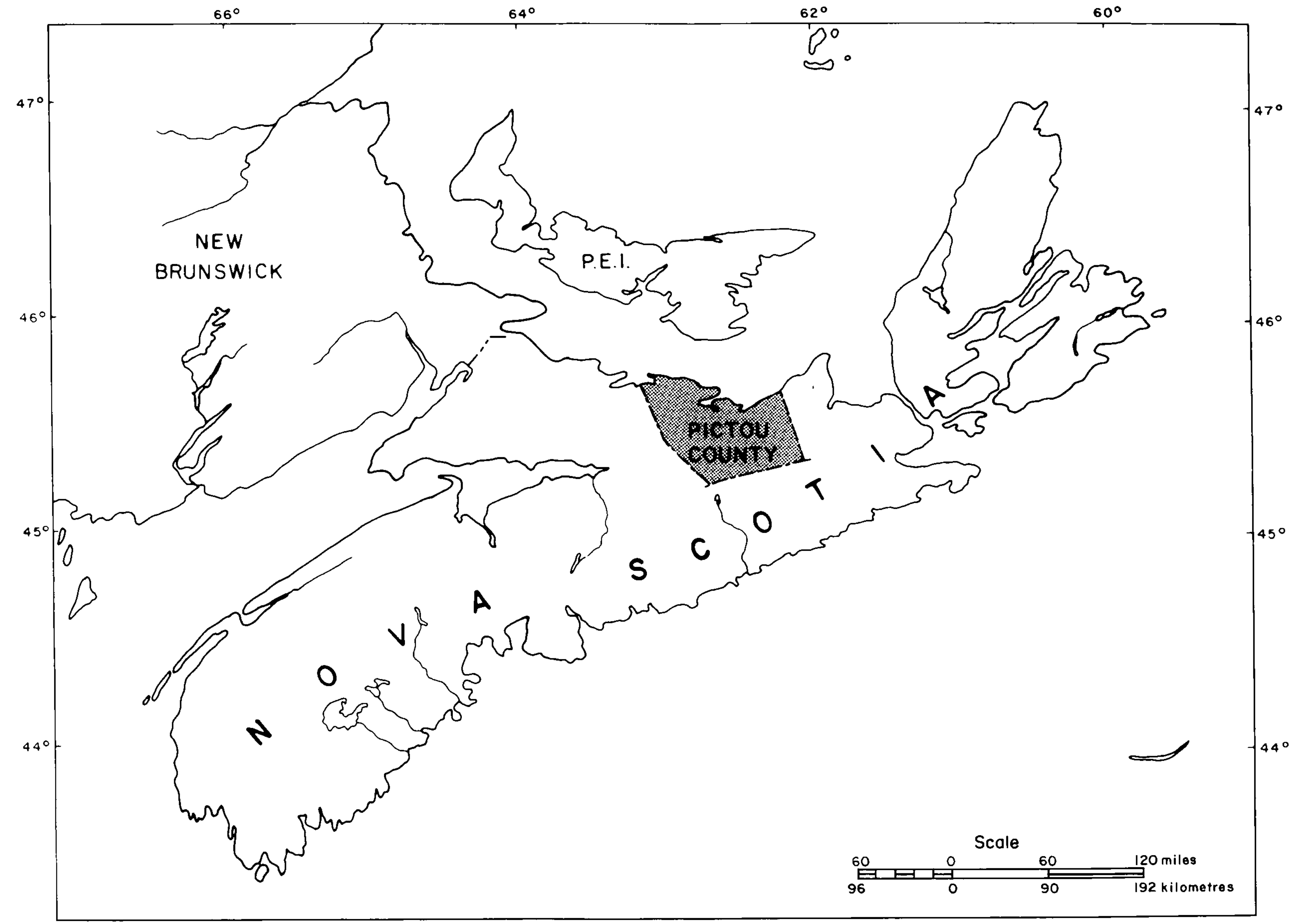

Figure 1.1 Key Map

berland and Colchester Counties, and extending into eastern Pictou County. The Pictou-Antigonish Highlands occupy the eastern part of the County, forming a triangle which narrows westward toward the East River. Both are underlain by resistant Paleozoic rocks. The Cobequid Mountains are composed of granite, syenite, diabase, and felsite. Hardened slates and quartzites are the main rock types associated with the Pictou-Antigonish Highlands. Till cover on the Upland areas is very thin and in several places the underlying bedrock is exposed.

The surface of the Upland Plain, when viewed from the Lowland, seems rough and irregular. However, it is actually a series of flat topped ridges with broad round summits, and resembles a dissected plain. Most streams in the study area originate in the Uplands and have eroded deep gorges and valleys in the surface while making their descent to the lowland. The elevation of the Upland Plain ranges from 250 to 340 m (800 to 1,100 ft), with the average elevation being 275m (900 ft).

Lowland Plain: The boundary between the upland and lowland plains is generally well defined, particularly on the north and southeast where the division is marked by a steep scarp several tens of metres high. The Cumberland-Pictou lowland and the Hants-Colchester lowland combine to form the Lowland Plain which covers two thirds of the area of the country (see Figure 1.2). The elevation of the lowland ranges from sea level to 150 m (500 ft). The main topographic features are low undulating hills which more or less reflect the underlying geologic structure, and glacial kames and eskers. In the southern part of the county, this low rolling topography blends with higher, more irregular terrain. The relief of these hills, at 120 to 150 metres (400 to 500 ft) is above that of other parts of lowland; nevertheless, they are classified with the Lowland Plain since their elevation is several tens of metres lower than the general elevation of the upland.

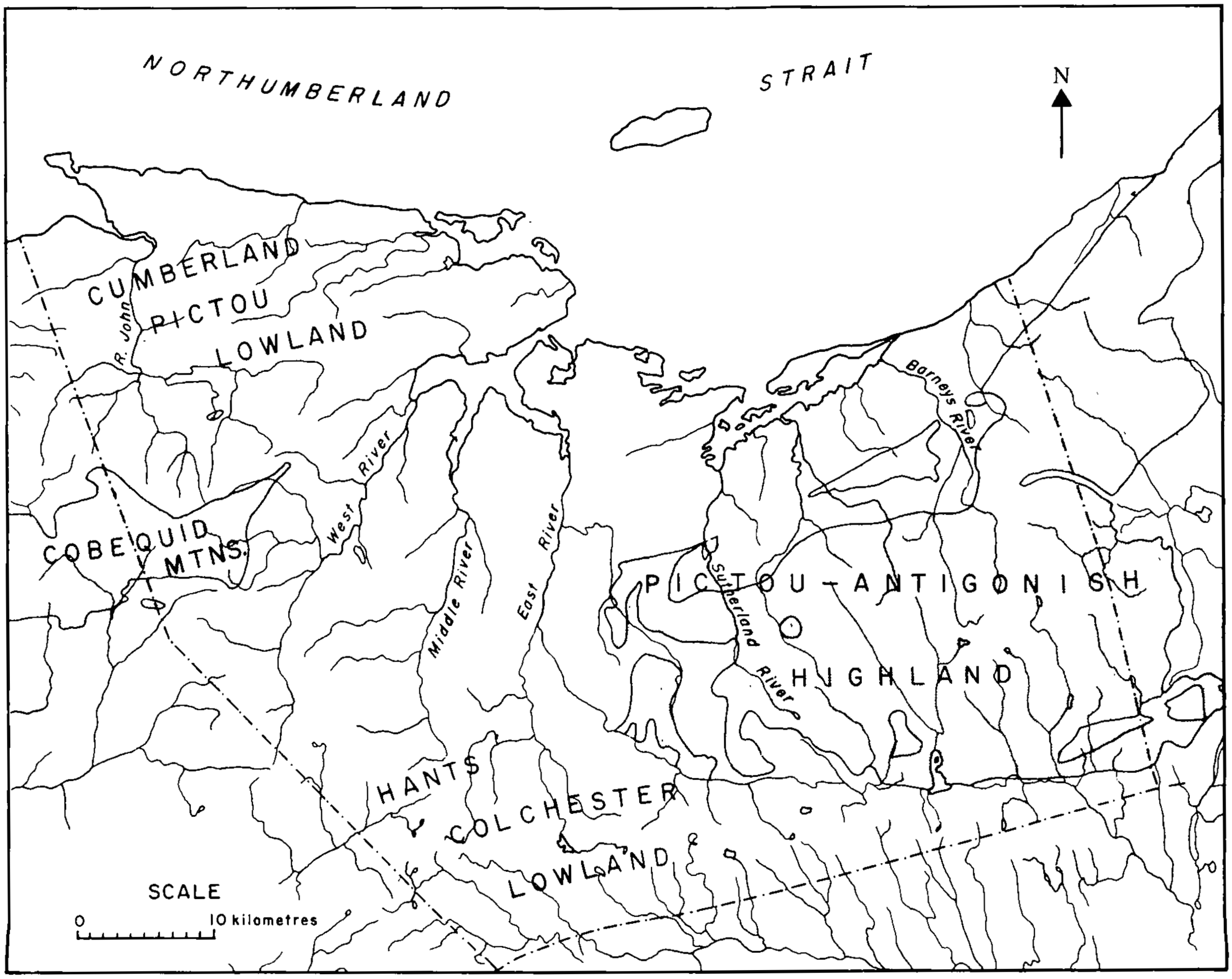

Figure 1.2 Physiographic Regions of Pictou County

1.4.2 Drainage

Most streams in the county originate in the lakes and bogs of either the Cobequid Mountains or the Pictou-Antigonish Highlands and feed the major rivers that flow northward to their point of discharge into the Northumberland Strait. The major drainage systems are outlined in Figure 1.3 and their drainage areas are given in Table 1.1. The discharge point of the West, Middle, and East Rivers is almost convergent along the central part of the shore. The East River watershed, which consists of the East and West Branches of the East River and MacLellan Brook, is the largest watershed within the study area. It receives water from both the Cobequid Mountains and the Pictou-Antigonish Highlands and drains the greater part of the Lowland Plain.

Drainage in the eastern part of the county is accomplished via the Sutherland, French, and Barney Rivers, which originate in the Pictou-Antigonish Highlands and flow northward. Smaller in area, these watersheds, with the exception of the Sutherland River, lie outside the boundary of the primary study area. Total drainage area of the watersheds (Figure 1.3) is 1723 sq km (745 sq. mi.).

1.5 Climate

The climate of the northern counties of Nova Scotia is described as a humid and temperate continental climate, modified by the region's proximity to the Atlantic Ocean and the Gulf Stream which runs parallel to the Atlantic Coast (Hennigar, 1972). Detailed climatic information is included in Chapter 4 and Appendix B. The average annual precipitation varies from about 1000 mm (39.4 in) on the coast to about 1500 mm (59 in.) inland at Trafalgar. Cann and Wicklund (1950) noted that local variations in precipitation and rainfall take place throughout the county, which was also noted in this study. Snowfall usually begins in November and continues intermittently until the end of March.

The average annual temperature varies from about 6.5°C (44°F) near the coast to about 4.5°C (40°F) inland. The maximum mean monthly temperature occurs in the month of July and the minimum mean monthly temperature occurs in January. The length of the frost-free period ranges from 100 to 120 days and the growing season extends from 180 to 190 days.

1.6 Population and Land Use

The population of Pictou County, according to the 1976 Statistics Canada Census, is 49,076 or almost 6 percent of the Nova Scotia total. Fifty-seven percent of the county's population reside in the five incorporated towns of New Glasgow, Trenton, Stellarton, Westville, and Pictou. Of the remaining population, 41 percent are classed as rural non-farm residents and only 2 percent are farm dwellers. In the period between 1966 and 1976, the farm population decreased by 6.4 percent, and the proportion of urban residents declined by 4.1 percent (Statistics Canada Census of Canada 1966 and 1976). This was offset by a corresponding increase, 10.5 percent, in the rural non-farm population which occurred over the same period. These figures reflect the move toward suburban development within commuting distance of the county's major employment centers. It is interesting to note that the population of unincorporated communities of over 200 residents has risen by 33 percent since 1966 (Statistics Canada, 1976 Census of Canada).

At present, manufacturing is the most important economic activity. The county produces about 15 percent of the total goods manufactured in the Province and in 1975 the value of goods shipped of own manufacture equalled $268,231,000 (Statistical Profile, Pictou County, 1979). Primary industry is conducted to provide raw materials for the manufacturing sector, particularly the production of pulpwood which yielded 106,164 cords in 1977 (N.S. Forest Products Directory, 1977). Statistics Canada Census (1971) figures report that $2,868,280.00 worth of agricultural products were sold in 1971. The fishing industry does not play a major role in the county's economy as compared to other industries. The total landed value of sea fisheries in 1977 was $1,014,000, 87 percent of which was made by the shell fishery, which operates on a part-time seasonal basis.

The total land area of Pictou County is 288,907 ha (713,890 ac). According to the Nova Scotia Forest Inventory of 1970, total productive forest land in the county is 235,654 ha (582,300 ac) or 81.6 percent of the total land area. Farm or other improved land accounts for 32,355 ha (79,917 ac) or 11.2 percent of the county's total. Most farming in the county is mixed, with dairy farms comprising the largest group, followed by cattle, sheep and hog farms. Approximately 13,000 ha (31,900 ac) is under crops, which principally include tame hay, oats for grain, barley, and small fruits and vegetables.

1.7 Field Work and Maps

The term of the project included both the 1977 and 1978 field seasons. Water resources information available from well logs on file with the Nova Scotia Department of the Environment were located and plotted on 1 inch = 1,320 feet base maps (Figure 1.4). The surficial deposits of the study area were mapped on a regional basis and representative till

Table 1.1
Drainage Areas of Pictou County Watersheds

WATERSHED	DRAINAGE AREA (SQ. KM.)	DRAINAGE AREA (SQ. MI.)
East River	564.7	298.1
Middle River	234.1	90.4
West River	239.2	92.4
Sutherlands River	100.0	38.7
Barney's River	160.8	62.0
River John	290.4	112.0
French River	134.8	52.0

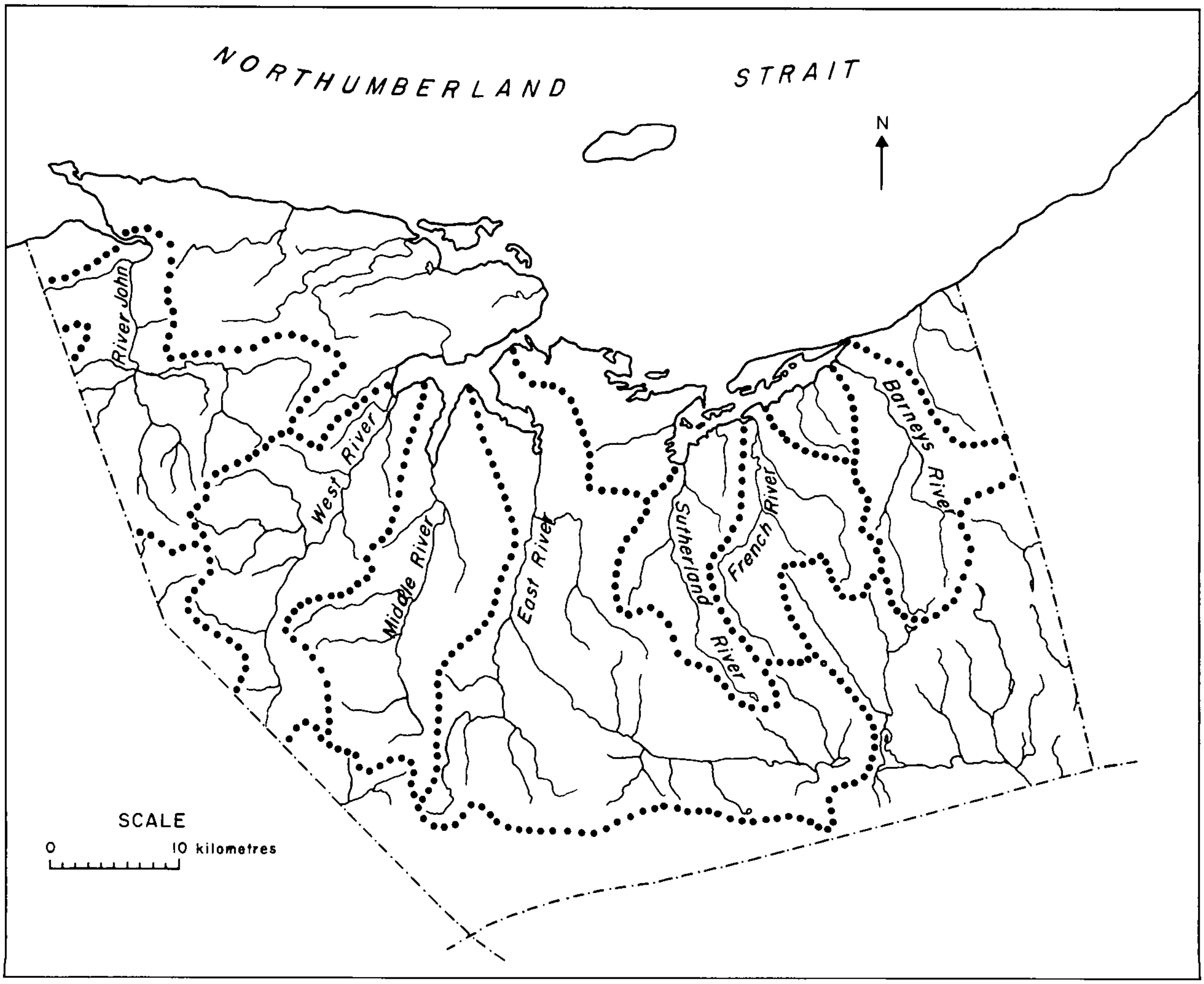

Figure 1.3 Watersheds, Pictou County

samples were taken and analyzed for grain size distribution. Meteorological stations were established at sites throughout the study area to collect bulk precipitation and temperature data. A network of stream gauging stations was installed at nine sites on the major rivers and streams, and surface water samples and groundwater samples were collected from bedrock aquifers. A program of test drilling was carried out during the summer and winter months of 1978, and pumping test data were analyzed from test wells in the Pictou and Riversdale Group aquifers.

A regional environmental survey was undertaken to examine the potential effects of human activities on the quality of the water resource. This survey considered industrial and agricultural pollution, urban and suburban development, waste disposal and treatment, and forestry and mining operations.

1.8 Water Resources Data Base Inventory

A comprehensive water resources data base inventory has been prepared as a second component and major objective of this project. This inventory is designed to make accessible the supporting information that was utilized in the preparation of this report, and to compile in one place the pertinent water resources data available for the study area.

The subject file index incorporates the following data:

a) Well Log Inventory Data - this list provides the locations, well specifications, yields and logs of approximately 2000 domestic, commercial, and industrial wells drilled within the study region.

b) Test Drilling - this index lists detailed specifications and logs of 10 test wells drilled during the course of this study as well as information provided by existing wells. Aquifer and well hydraulics, water quality, and detailed lithology are included.

c) Meteorological Data - this file includes temperature, precipitation and evaporation data obtained from stations established during the course of this investigation and from existing stations within the study region or incorporated in a regional analysis.

d) Hydrological Data - this file includes hydrographic records, rating curves and charts of stations established for study purposes and active hydrometric stations located

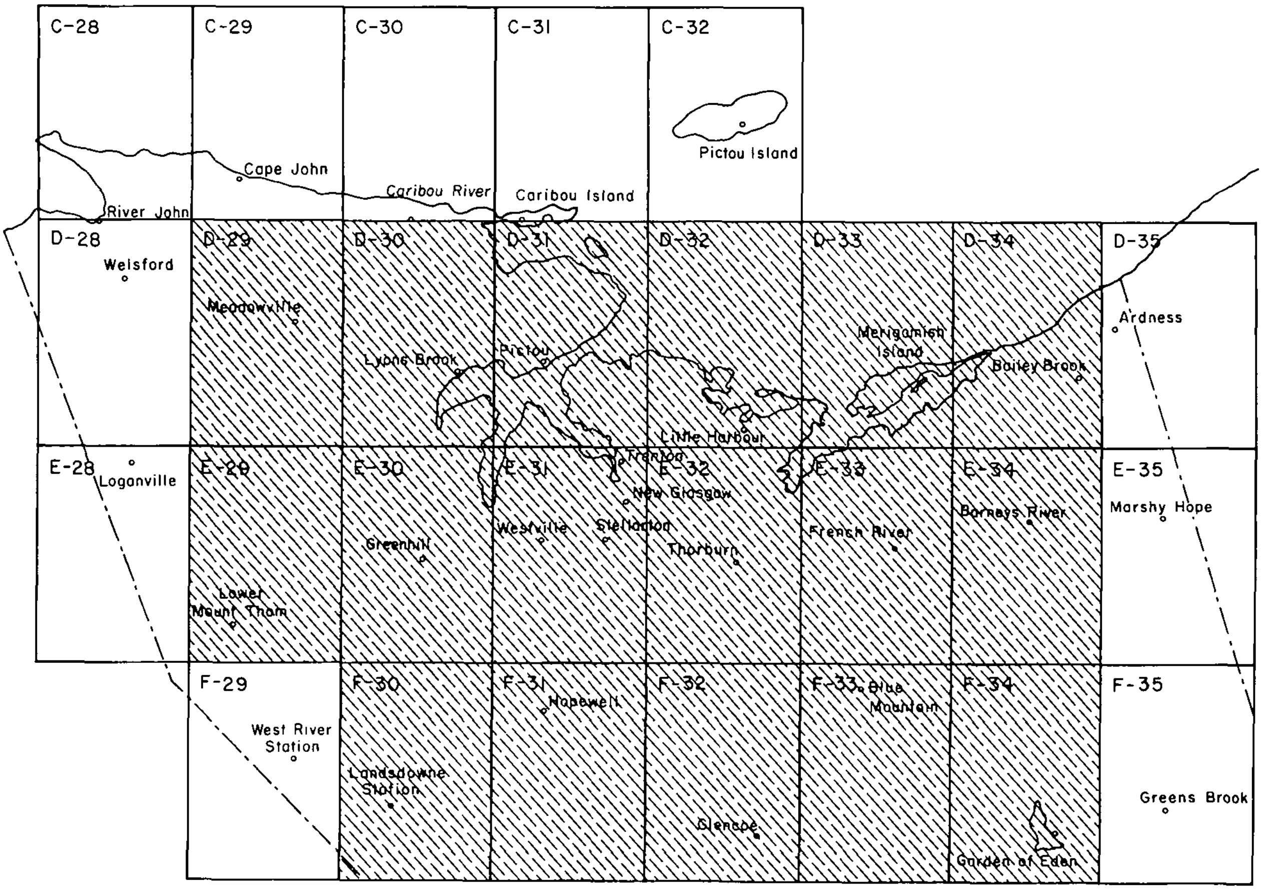

Figure 1.4 Inventory Map Sheet Coverage

within the study region and used for regional analysis.

e) Surficial Geology - detailed grain size analyses of selected sediment samples and descriptive analyses of overburden inspection test pit sites are listed in this index.

f) Water Quality - this file contains a two part water quality index providing detailed water chemistry of both surface water and groundwater. The file incorporates all available information, including historical data not presented in the report.

g) Map Index - the map index is comprised of 17 national topographic series grid maps (1:1320) which cover the study area (Figure 1.4). These maps are keyed to the inventory subject index and therefore portray information that is site oriented such as well locations, test drilling sites, water quality sampling stations, and hydrological and meteorological stations. Regional topography, bedrock and surficial geology are also provided at this scale.

This data base inventory is now on open file at the N.S. Department of Environment Library.

1.9 Acknowledgement

The authors would like to express their appreciation to several parties who have provided invaluable assistance to the completion of this project: The Project Monitoring Team, including Don Ambler of the Water Resources Branch, Water Survey of Canada, Inland Water Directorate, Environment Canada, Les Stewart of the N.S. Department of Development, George Dargie of the Department of Regional Expansion and John F. Jones of the Water Planning and Management Division, N.S. Department of the Environment, for their continued guidance and encouragement. Merle MacAuley of the Atmospheric Environment Service, Environment Canada, provided invaluable service with the establishment of the meteorological stations. Hydrometeorological instrumentation was capably monitored by Mrs. Clayton Hattie, Ray MacKinnon, Harry Brennan, and Rick Williams. Dr. Chang Lin of the Nova Scotia Department of the Environment and Dr. Howard Donohoe of the Nova Scotia Department of Mines and Energy assisted with review of the text. The assistance of personnel of the Stellarton office of the Nova Scotia Department of Mines and Energy is also acknowledged.

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Several persons were involved in the data collection and interpretation. Appreciation for these efforts is extended to Jill Mawdsley, Robert MacDonald, J. Wilfred Byers; and to summer students, Jim Dunsworth, Nicole Gillard, Murdock Rodgers, and Barbara Topp. Cartography was done by John A. Cameron. The manuscript was typed by Faye Landry.

CHAPTER 2
Bedrock Geology

2.1 Introduction

Geological mapping and information is available for most of Pictou County from various sources. During this study, the information has been consolidated and summarized in order to provide a general overview of the bedrock geology of Pictou County. More detailed information is available from the referenced sources.

2.2 Methodology

The bedrock geology of the Pictou Study area was compiled primarily from previously documented investigations conducted by the Geological Survey of Canada and the Nova Scotia Department of Mines. The regional bedrock geology has been plotted at a scale of 1:125,000 on Map No. 1, Bedrock Geology, Pictou County, Nova Scotia, which is included in the pocket at the back of the report. This map outlines the main stratigraphic divisions and major structural features of the county. These divisions are also outlined in Table 2.1. A simplified version of the map is presented in Figure 2.1 In addition, this information is available at a scale of 1:15,840 (1" = 1,320') through the Nova Scotia Department of the Environment (See Section 1.8).

2.3 Regional Setting and Geologic History

The Pictou Study area is underlain by a mixed assemblage of igneous, sedimentary, and metamorphic rocks ranging in age from lower Ordovician to mid-Pennsylvanian age. The older, more resistant metasedimentary and metavolcanic rocks are restricted to the Pictou-Antigonish Highlands and the Cobequid Mountains which flank the area on the east and west, respectively. The deposition of Ordovician and silurian sediments was accompanied by the extrusion of lavas and these rocks were uplifted, deformed, and intruded by granite as a result of the Acadian Orogeny during the Devonian period. An earlier period of deformation affected the Ordovician Browns Mountain Group producing intrusions of gabbro, diorite, and granite plugs and stocks.

The Acadian Orogeny affected the whole of the northern Appalachian geosyncline causing the develop-

Table 2.1
Table of Formations

Period	Group	Formation	Lithology
Recent	– – – –	– – – – – –	Stream gravels, residual soils, modified glacial gravels
Pleistocene	– – – –	– – – – – –	Till; stratified and unstratified sand and gravel
Pennsylvanian	Pictou (2,250m)		Red and grey sandstone, siltstone; red pebble conglomerate; minor shale
	Stellarton (series) (2,860m.)		Grey and black coal shale; red and grey sandstone; conglomerate
	Disconformity		
	Cumberland (580m.)	New Glasgow Conglomerate	Greyish red pebble to cobble conglomerate; sandstone and siltstone
	Disconformity		
	Riversdale (2715m)	Boss Point	Grey and red sandstone; pebble conglomerate; minor limestone pebble conglomerate
		Millsville Conglomerate	Reddish to brown pebble to boulder conglomerate; minor sandstone, siltstone
Mississippian	Canso (850m)		Grey and red-brown siltstone; argillite and minor sandstone, claystone; limestone; and limestone pebble conglomerate
	Disconformity ?		
	Windsor (580m.)		Shale; calcareous shale; grey limestone; gypsum, anhydrite; conglomerate
	Disconformity		
	Horton (2040m.)		Grey arenite, grey siltstone, shale; and conglomerate
	River John (1830m.)		Pebble to boulder conglomerate; siltstone, and sandstone
Devonian			Siltstone; sandstone; minor shale, pebble conglomerate, limestone conglomerate; oil shale; felsite; breccia
	Unconformity (?)		
Devonian (cont.)	– – – –	– – – – – –	Dark green, fine to medium grained diobase
	– – – –	– – – – – –	Grey biotite and muscovite granite; minor syenite; pink and green granite
	Cobequid Complex		Granodiorite, minor syenite, granite, meta-sedimentary rocks, andesite, minor felsite and tuff
		Knoydart (305m.)	Red sandy slate; grey sandstone
	Arisaig (1070m.)	Stonehouse	Blue-grey calcareous and argillaceous sandstones and siltstones
Silurian		Moydart	Grey mudstone; sandstone, siltstone, minor limestone; red calcareous mudstone
		McAdam	Grey shale, bluegrey siltstone, sandstone and calcareous siltstone
		French River	Blue-grey sandstone; blue-grey and green-grey muddy sandstone
		Ross Brook	Grey mudstone and shale; blue-green quartz sandstone and siltstone
		Beechhill Cove	Green and blue-grey sandstone and siltstone
Ordovician	— — —	— — —	Hornblende granite and quartz feldspar granodiorite
Cambro-Ordovician	— — —	— — —	Gabbro; medium grained hornblende diorite
	Brown's Mountain (760m+)	Brierly Brook	Dark green andesite; tuff, breccia, sandstone, argillite and dacite
		Baxter Brook	Red and grey sandstone and slate; schist
		Keppoch	Leuco-dacite torhyolite; breccia and tuff; minor grey quartzite and phyllite

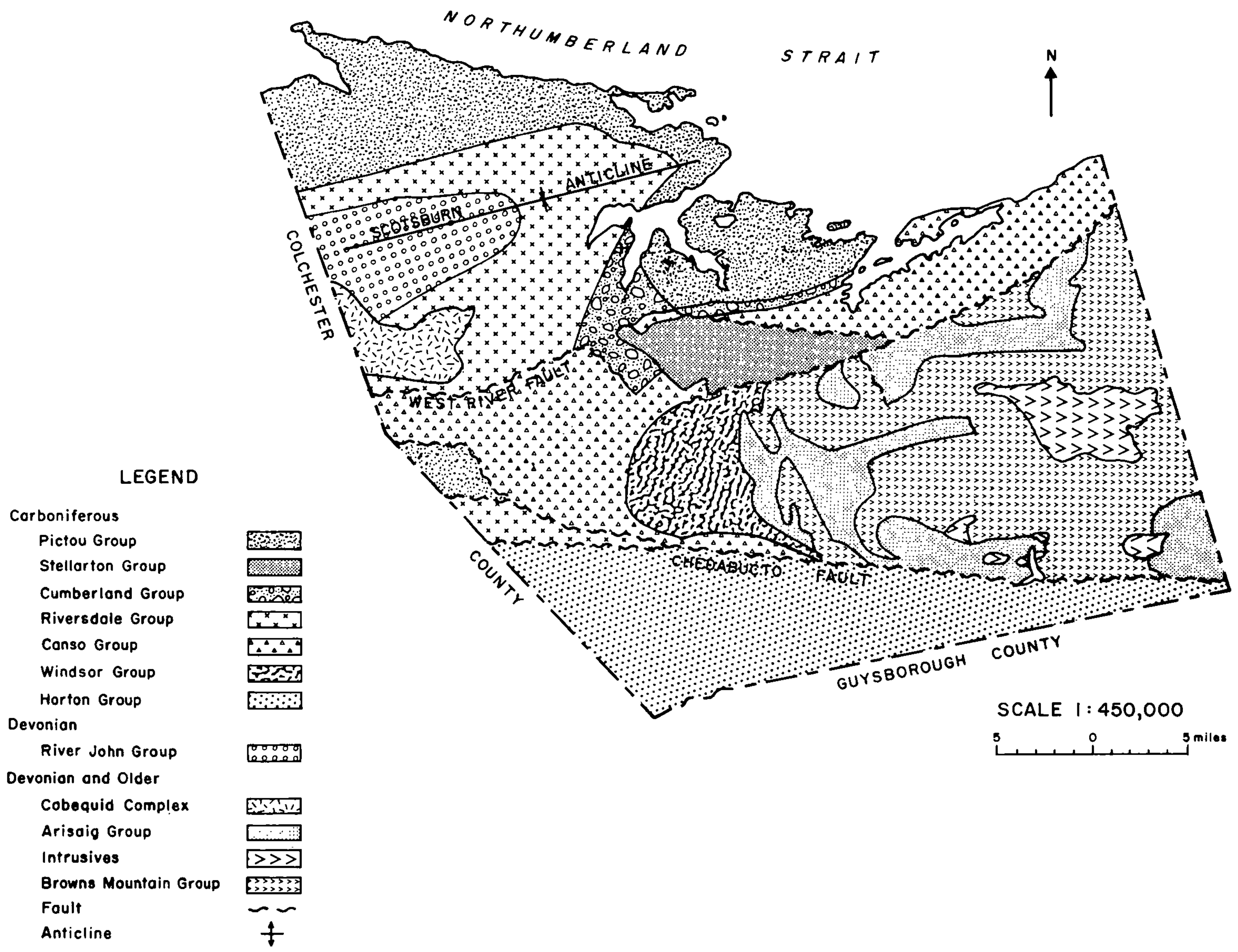


Figure 2.1 Regional Geology of Pictou County

ment of a series of depositional basins divided by linear uplands. The Stellarton Structural Gap was formed at this time as a fault-controlled basin connecting the Cumberland and Minas subbasins of deposition within the larger Fundy geosyncline. This basin was the site of predominantly continental Carboniferous sedimentation, a single episode of marine deposition being represented by the Mississippian Windsor limestone. The Carboniferous formations are largely undisturbed. Basin subsidence was nearly continuous and the uplands were subjected to intermittent periods of uplift resulting in a gentle warping and tilting of the beds. Increasing sedimentary thickness produced a series of eastwest trending faults, generally parallel to the regional fold axes.

Though no rocks younger than Carboniferous are found within the basin, their deposition is suggested by the presence of Triassic and Permian sediments in adjacent areas, particularly around Truro, Guysborough, and on Prince Edward Island. Post-Carboniferous activity within the basin was characterized by a long period of erosion which considerably lowered the surface elevation and may have also removed Post-mid-Pennsylvanian sediments.

A mantle of glacial drift covering the bedrock formations of the study area records regional and local movements of Pleistocene glacial ice. Regional movement occurred in a northwest-southeast direction; local advances of ice produced glacial striae of several different orientations.

Evidence of glaciation borne on the Cobequid Mountains and the Pictou-Antigonish Highlands indicates that the minimum thickness of the ice sheet in the area was 400 m (1,300 ft) (Goldthwait, 1924).

2.4 Stratigraphy

2.4.1 Browns Mountain Group

The rocks comprising the Browns Mountain group are the oldest in the study area. They are a resistant metamorphic complex of volcanic and sedimentary rocks ranging in age from Early Cambrian to Late Ordovician. The Browns Mountain rocks underlie the greater part of the Pictou-Antigonish Highlands and extend westward to MacLellans Mountain in the central region of the study area. They are unfossiliferous and are composed primarily of interbedded basic volcanic and pyroclastic rocks, argillite, and siltstone.

In several places the Browns Mountain Group contains diorite and gabbro bodies in the form of plugs and stocks (Benson, 1963). The Browns Mountain rocks are highly folded into anticlines and synclines with northeast trends. The strata generally strike northeast and dip at high angles to the northwest or southeast. The base of the formations has not been observed but the total thickness has been estimated to be more than 750 m (2,500 ft) (Benson, 1967).

2.4.2 Arisaig Group

The rocks of the Arisaig Group occupy a large area in the eastern part of Pictou County. These fossiliferous strata of Silurian age have an estimated total thickness of 1,070 m (3,500 ft) measured at the type section along the shore near Arisaig. The conformable relationships between each of the Arisaig Formations indicate a period of continuous and uninterrupted deposition.

The main rock types include; shale, siltstone, thin-bedded sandstone, and impure limestone upon a quartz pebble conglomerate or rhyolite base. Generally, grain size ranges from fine sand to clay and sorting is poor.

2.4.3 Knoydart Formation

Knoydart rocks occur to a limited extent in Pictou County, primarily in a small area around Bailey Brook. The strata consist mainly of fine grained arenaceous siltstones. These siltstones are a bright-red colour, and the bedding is most often obscured by the cleavage. The remainder of the Formation is a grey sandstone composed of sand size fragments of quartz and feldspar.

2.4.4 Cobequid Complex

The eastern end of the Cobequid Mountains extends into north-western Pictou County. A unit associated with the Cobequid Mountains, occurring in western Pictou County, is the Devonian Cobequid Complex, a metavolcanic-metasedimentary assemblage intruded by plutonic rocks grading from coarse grained granite to diorite. These rocks consist of fine-grained purplish argillites; red and grey sandy shales; green, grey, and brown sandstones; and felsites and tuffs. They are highly sheared and fractured, and cut by numerous quartz and felsite veins.

2.4.5 River John Group

The River John Group, which occurs in northwestern Pictou County, was sub-divided by Gillis (1964) into a lower unit and an upper unit. The lower unit consists primarily of siltstones, sandstones, and shales interlayered with greenish-black basalt. Minor amounts of reddish-brown pebble to cobble conglomerate, grey limestone, oil shale, light brown felsite and tuffaceous breccia appear. The upper unit comprises siltstones, sandstones, and brown pebble to cobble conglomerate. Based on outcrop width and thickness, Bell (1958) estimated the upper unit to be 1,370 m (4,500 ft.) thick. He also assigned a total thickness for the entire River John Group of 1800 m (6,000 ft). However, no estimation has been given of the thickness of the lower unit, as the base is not exposed and these rocks have been subjected to irregular small scale folding and faulting.

2.4.6 Horton Group

The continental sediments of the Mississippian (Early Carboniferous) Horton Group represent the first episode of Carboniferous sedimentation in the region. They are present in a wide band across the southern part of the map-area, and extend beyond the east and west boundaries of the county. To the north, Horton rocks are truncated by the Riversdale and Chedabucto Faults. Benson (1967) has described three distinct lithological units:

a) light grey arenite and siltstone.
b) light to medium grey shale and siltstone.
c) red and greenish-grey mudstone, siltstone, and grey and red conglomerate.

No complete sections occur in the area and most often exposures are cut by small faults. From these scattered small sections, Benson (1967) estimated a total thickness of 2,040 m (6,700 ft) for the Horton Strata.

2.4.7 Windsor Group

The Windsor strata have been divided into two lithological units: the lower Windsor, a marine facies, which consists of light grey to black argillaceous limestone overlain by white to light grey gypsum and anhydrite; and the upper Windsor, which is mainly a terrestrial, brownish-grey, slightly calcareous mudstone associated with a brownish grey siltstone and a calcareous silty shale. The mudstone beds are generally massive, moderately deformed and highly fractured. The Carboniferous marine sediments of the Windsor Group outcrop mainly to the south of the New Glasgow area, around Hopewell and the East River of Pictou. Despite the lack of outcrop and the structural complexity of the strata, Benson (1967) estimated a thickness of 240 m (800 ft) for the lower Windsor, and of 335 m (1100 ft) for the upper.

2.4.8 Canso Group

The rocks of the Canso Group are a series of fresh water strata deposited in a fluvio-lacustrine environment during the late Mississippian to early Pennsylvanian Periods. Two facies have been identified in the Pictou County area. One facies occurs in a broad wedge extending eastward from the New Glasgow district, along the Northumberland Strait, beyond the county line into Antigonish County. It consists of red and grey mudstones, shale, siltstone, and red and grey sandstone, accompanied by lenticular beds of intraformational limestone pebble conglomerate. The second facies occupies a large area west of Hopewell in the central part of the study area. Though lithologically similar to the Lismore facies, these rocks are characterized by the inclusion of dark grey argillaceous and silty beds. A highly fractured reddish-brown mudstone is the most common rock type. Outcrops and exposed contacts are rare; however, Bell (1944) estimated a thickness of 850 metres (2,800 ft) in the Lismore district of northeast Pictou County.

2.4.9 Riversdale Group

The Riversdale Group sediments are extensively distributed in the western part of the Cumberland subbasin, and outcrop in a horseshoe pattern around the nose of the Scotsburn anticline in the Pictou County area.

Bell (1944) divided the Riversdale Group into the Millsville Conglomerate and the Boss Point Formation. The Millsville Conglomerate consists of reddish-brown pebble to boulder conglomerate grading upward into sandstone and siltstone. Subangular to subrounded granite fragments, identical to the intrusive rocks of the Cobequid Complex, are the main constituent of the conglomerate. In general, grain size tends to decrease away from the Cobequid Highlands. Gillis (1964) estimated a thickness of 1,100 m (3,500 ft) on the southeast limb and 340 m (1,100 ft) on the northern limb.

The coarse conglomerates of the Millsville grade upward into the sandstones of the Boss Point Formation. The main lithological components of this upper unit are greenish grey and brownish red sandstone and siltstones, with minor pebble and limestone pebble conglomerates. An estimated thickness of 1,650 m (5,400 ft) has been given for the Boss Point Formation on the southeastern limb of the Scotsburn anticline and 910 m (3,000 ft) for the northern limb. (Gillis, 1964).

2.4.10 Cumberland Group

The mid-Pennsylvanian Cumberland Group is represented in Pictou County by the New Glasgow Conglomerate. The New Glasgow Conglomerate occurs in a narrow band at the eastern end of the New Glasgow district which broadens and extends toward the northwestern part of the study area. It thickens from 90 m (300 ft) at the eastern end near Merigomish to 580 m (1,900 ft) westward toward Greenhill.

The primary rock type is a reddish-brown pebble to boulder conglomerate, made up of subrounded sandstone, siltstone and minor limestone pebble conglomerate fragments. Minor amounts of reddish-brown sandstone, siltstone and shale also occur, particularly to the south near Union Center. These finer grained strata are commonly ripple-marked and crossbedded, and several beds of intraformational limestone pebble conglomerate are found.

2.4.11 Stellarton Series

The coal bearing strata of the Pictou coal basin, named the Stellarton Series, underlie an area 18 km (11 mi) long and 5 km (3 mi) wide in the southern part of the New Glasgow district. They are composed of grey and black shales; coals, red sandstone, mudstones, and shales; and grey sandstones and conglomerates. The conglomerates are restricted to the eastern half of the area, and are made up, in part, by detrital fragments derived from the Ordovician-Silurian complex to the southeast. Bell (1944) estimated the Stellarton Group to be 2,860 m (9,400 ft) thick.

2.4.12 Pictou Group

The rocks of the Pictou Groups are widely distributed throughout northern Nova Scotia. In Pictou County, these rocks occur in a broad band stretching almost the full width of the county along the Northumberland Strait. Mid-Pennsylvanian (Early Carboniferous) in age, they are largely contemporaneous with the Stellarton Group. The Pictou sediments are a non-marine assemblage of predominantly red rocks that include alternating bands of red and grey sandstones, siltstones, and shales, over a thin basal pebble conglomerate. Bell (1944) estimated a thickness of 2,250 m (7,400 ft) for the Pictou Group at the type section along the West Branch of River John.

2.5 Structural Geology

The Pictou study area can be divided into three structurally distinct and complex units; the Pictou-Antigonish Highlands to the east, the Cobequid Highlands to the west, and the Stellarton Structural Basin which separates them. The upland areas, underlain by older Paleozoic metasedimentary and metavolcanic rocks, are much more highly deformed than the younger Carboniferous sediments of the basin, having been affected by major regional deformation during the Acadian Orogeny. Intermittent uplift of the highlands throughout the Carboniferous resulted in gentle warping and tilting of the strata; and the Carboniferous strata were folded and faulted.

The Hollow Fault is a high angle fault extending in an almost straight line, a distance of 70 km (44 mi) from the eastern part of the Pictou area to Cape George and beyond, under the sea, and is topographically expressed by a scarp several tens of metres high. The Hollow Fault forms the boundary between the older Paleozoic units on the south and the Carboniferous sediments to the north.

The main structural trend of Western Pictou County is east-northeast. The primary structural features are the eastern end of the Cobequid Massif, the Scotsburn anticline, and the Alma and Loganville Faults. The Scotsburn anticline is a northeast plunging structure which occupies a large area in the northwestern part of the county. Rocks of the lower and upper units of the River John Group are exposed at the core, flanked by the Millsville Conglomerate, Boss Point Formation, and Pictou Group along the limbs. Unconformable relations between some of these units suggests that the fold developed as these rocks were being deposited.

The major fault of the area, the Alma Fault, separates Canso rocks to the south from the Boss Point Formation to the north. It extends 14 km (9 mi) in an east-west direction and may be an extension of the Cobequid Fault lying west of the area. The Loganville Fault extends eastward from Loganville to the Millsville district, separating the older Cobequid Complex to the south from the upper unit of the River John Group and the Millsville Conglomerate to the north. It is a high-angle reverse fault, with the relative movement being southside up. This movement is believed to have occurred at different times during the Carboniferous (Gillis, 1964).

The Carboniferous formations occupying the low lying Stellarton basin are generally low-dipping, but most outcrops exhibit minor fault movement ranging from a few centimetres to a few metres.

The Pictou coal measures are folded into a number of open anticlines and synclines, having undulating areas and trending northeasterly to easterly (Bell, 1940). They are cut by both major and minor faults; the coal basin itself is a down-faulted graben structure in which the coal bearing strata of the Stellarton Series occupy the surface.

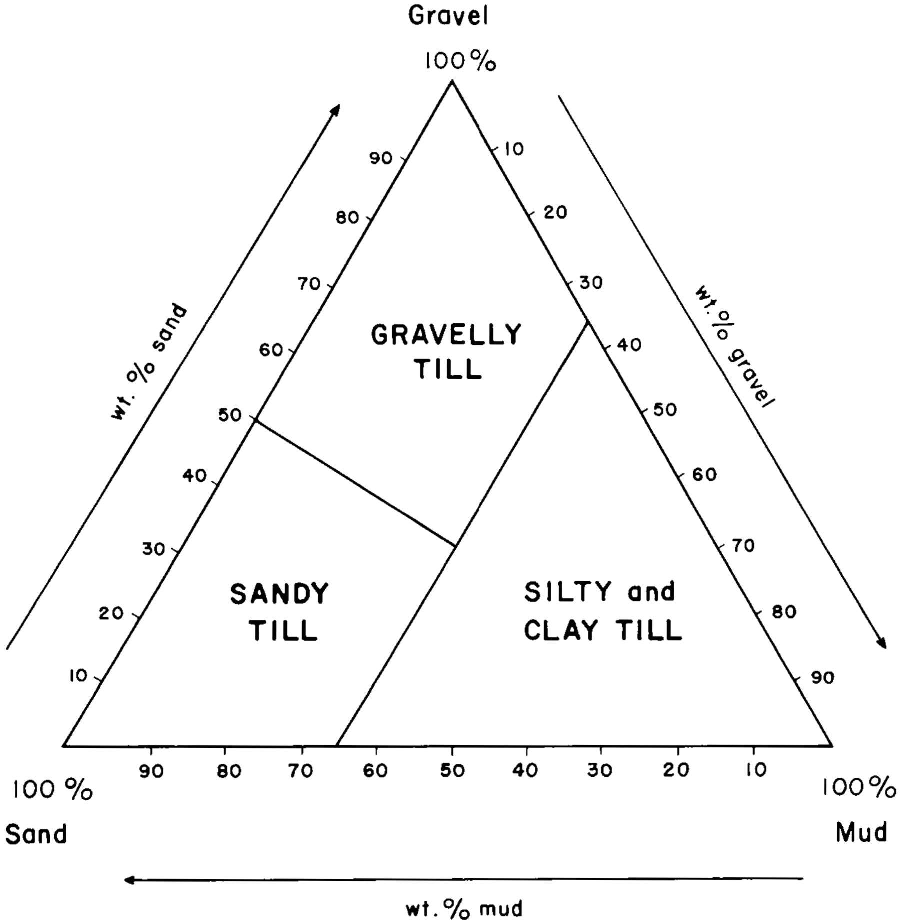
CHAPTER 3
Surficial Geology

3.1 Introduction

The surficial geology mapping program was conducted to examine the water bearing and transmitting properties of the surficial material, and the materials investigated were classified accordingly. No attempt has been made to construct a detailed and comprehensive surficial geology map.

3.2 Methodology

The surficial geology of the study area was compiled from existing information available through the Nova Scotia Department of Mines and Energy, Agriculture Canada, the Nova Scotia Research Foundation, and a mapping program conducted by project personnel to check the data obtained from these sources. A regional map of the surficial geology was prepared at a scale of 1:125,000 (see Map 2 in pocket). In conjunction with the mapping program, a series of 40 surficial samples were taken at points designated on Map 2. These samples were analyzed for grain size distribution using the dry sieve method described by Folk (1968). The detailed results of these analysis are avaiable in the data base inventory files. A more detailed presentation of the surficial geology is available at a scale of 1:15,840 (1" = 1,320') through the Nova Scotia Department of the Environment.



sandy till .... wt.% sand   wt.% gravel and wt.% mud<35%
gravelly till .... wt.% gravel   wt.% sand and wt.% mud<35%
silty and clay till* .... wt.% mud>35%

* Differentiation between silty and clay tills was made during field inspections, but was not done during the sieve analysis of the samples in which particles 0.0625 mm. or less were termed mud.

Figure 3.1 Classification of Till Types

3.3 Tills

3.3.1 Introduction

Till may be defined as unsorted, unstratified sediment, deposited by glacial ice (Flint, 1971). It consists of mechanically broken fragments whose texture and composition are a function of the rock type from which it was derived and the mode of its deposition. Local bedrock provided most of the parent material for the tills in the study area, and the complexity of these bedrock formations is reflected by the complex texture and composition of the tills.

Till depths range from 0.6 to 12 m (2 to 40 ft) and average 4.5 m (15 ft). In general, the deposits covering the less resistant Carboniferous rocks of the lowland have a greater thickness than those on topographic highs where the bedrock includes more resistant shales, igneous, and metamorphic rocks.

For the purposes of this investigation, the tills were divided into four textural classifications based on predominant grain size. These classifications are: gravelly till, sandy till, silty till, and clay till. A quantitative description of each classification is given in Figure 3.1 and, for comparison, representative grain size distributions of each class of till sampled are given in Figure 3.2.

3.3.2 Clay Till

A stoney clay till covers most of the lowland plain of the county, particularly those areas underlain by the shales and finegrained sandstones of the Windsor, Canso, and Stellarton Groups. A blocky red clay till, derived from Canso and Windsor Groups, covers the central part of the plain to a depth of 0.6 to 2.4 m (2 to 8 ft). Texturally intermediate between a sandy and gravelly clay, the till contains angular clasts of sandstone which increase in proportion northward toward the Woodbourne-Pinetree Brook area. A very poorly drained till is found near the Thorburn coal measures. This compact, stoney, grey till exhibits black carbonaceous streaking and has extremely poor drainage.

The deposits of clay till along the northwestern part of the Northumberland coast are considerably less stoney than those found in the central part of the county. This till is a dark reddish brown, has a blocky structure and contains very few clasts of red sandstone.

Around Egerton and Telford, in the eastern part of the study area, the till is a reddish sandy clay and silt which becomes coarser northward to the coast. The till is generally hard-packed and contains subangular clasts of sandstone, shale, and volcanics.

3.3.3 Silty Till

Silty till occupies only a small percentage of the study area. A light grey-brown silty till, derived from shales of the Arigaig Group, covers most of the area immediately north and west of the Pictou-Antigonish Highlands. The depth of the till ranges from 0.6 to 4.5 m (2 to 15 ft). It contains angular fragments of shale which vary in size from pebbles to boulders.

3.3.4 Sandy Till

Sandy till covers large but scattered areas of the county, the characteristics of the till varying with locality due to changes in the parent rock type. A thin cover of sandy till occupies a large area in southern and eastern parts of the study area. This grey-brown till has as coarse, stoney texture which may be largely attributable to the shallow depth of the till to bedrock.

Most of the coastal area of the county is covered by a reddish brown to brown sandy till. North of the town of Trenton this till is a fine to medium-grained sand which contains angular clasts of sandstone ranging in size from pebbles to boulders. Along the shore, near Chance Harbour, it becomes a light to medium brown colour and appears as a cleanly washed, medium to coarse-grained sandy till containing large angular boulders of sandstone. Further to the east, along the shore near Merigomish, Cann and Wicklund (1950) noted that the till locally contains lenses of sand, gravel, or clay, and may be roughly sorted. The clay content of the till is greater on the Pictou Peninsula where it has a firm baked appearance when dry. Grain size distribution of sandy tills is given in Figure 3.2

3.3.5 Gravelly Till

Shallow gravelly tills are found on the upland areas of the county which are underlain by resistant igneous and metamorphic bedrock formations. The till is dark grey-brown in colour and is composed of angular fragments of sandstone, shale, and volcanics. In the western half of the county, a similar till containing less stone is found southeast of Mount Thom.

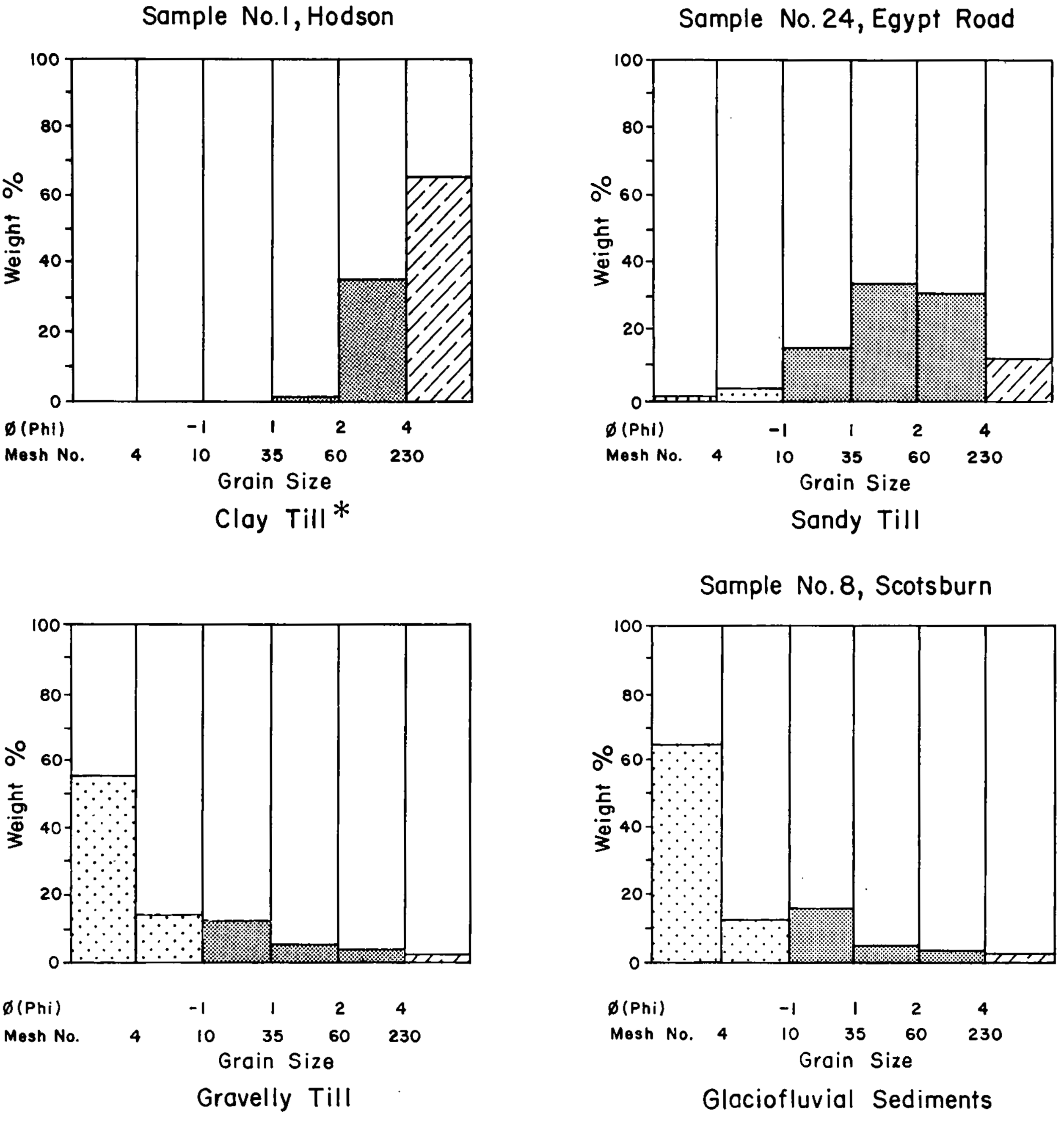
Also in the western half of the county, deposits of gravelly till, derived from a purplish red conglomerate, occur along the flanks of the Cobequids and in the vicinity of Greenhill. Analysis of samples taken of the tills at both of these locations shows that the gravel component is as high as 70 to 80 percent (see Figure 3.2).

3.4 Glaciofluvial Deposits

3.4.1 Introduction

Glaciofluvial deposits within the study area may be divided into two main groups: (1) ice-contact stratified drift and (2) outwash. Ice-contact stratified drift consists of deposits of stratified sand and gravel which were formed in contact with the edge of the wasting ice-sheet. Ice-contact features are characterized by a distinctive surface form and internal structure, and a wide range of grain size which is often subject to abrupt change (Flint, 1971). Deposits of this type include: kames, kame fields, kame terraces, and eskers. These terms are discussed in detail by Flint (1971).

Outwash is the term used to describe stratified drift built by streams beyond the terminus of the ice-sheet (Flint, 1971). Outwash deposits typically occur in the form of a broad plain of low relief that developed with the formation of glacially derived alluvial fans (Fowler and Dickie, 1977). Well-sorted,



* Differentiation between clay and silty clay tills was made during field inspections, but could not be from sieve analysis of samples because particles 0.0625 mm. or less are termed mud.

Figure 3.2 Representative Grain Size Distributions

well-rounded sand and gravel are the primary constituents of outwash deposits. Variations in grain size occur both horizontally and vertically, but to a lesser degree than in ice-contact stratified drift (See Figure 3.2).

3.4.2 Piedmont Valley: Barney's River Station

The largest single glaciofluvial deposit in the county was formed by glacial meltwater flowing northward through the Piedmont, Kenzieville and Barney's River Valleys. These three valleys merge at Avondale Station to form an outwash plain which extends 10 km (6.2 mi) from Lower Barney's River to Lismore on the Northumberland Strait.

The deposits along the three valleys which fed the plain consist of outwash interspersed with areas of stratified ice-contact material. The kame deposits of this area tend to be poorly washed, show little stratification and consist of light brown coarse-grained sand with angular fragments of gravel ranging from pebble to boulder size. One small esker at Barney's River Station, 0.8 km (1/2 mi) long and 17 m (55 ft) wide, is discussed by MacNeil (N.S.R.F., 1972). It consists of fragments of granite, sandstone, conglomerate, volcanics and some shales, ranging in size from sand to boulders. The outwash material consists of clean, well washed and sorted sand and gravel with subangular to subrounded clasts of sandstone, shale, volcanics, granite, and conglomerate which range in size from pebbles to cobbles.

The Lower Barney's River outwash plain, formed at the junction of the three valleys at Avondale Station, is covered by a well-washed and sorted gravel composed of well-rounded sandstone, shale, volcanic, and granite clasts with fine to coarse-grained sand. The silt content is very low and in general, the amount of sand increases toward the coast.

3.4.3 Pictou Peninsula

The glaciofluvial deposits of this area consist of a series of eskers interspersed with outwash material and segregated by areas of poorly drained swamp. Callan (1978) described two major ice-contact features; the north esker, and the south esker. The north esker covers an approximate area of 1.82 hectares (4.5 acres) and is composed of poor to locally well-sorted subangular materials ranging in texture from silt to boulders. The south esker is separated from the north esker by a deposit of silt and clay, and merges westward into an outwash complex and drumlin field. Considerable variation is shown in grain size as the materials in the base range from till to bouldery dirty gravel (Callan, 1978).

3.4.4 Brookland, Sixmile Brook, Fourmile Brook

A large body of outwash and ice-contact drift is located adjacent to the eastern end of the Cobequid Highlands around Eight, Six and Fourmile Brooks. At Brookland there is a series of kames associated with a small outwash deposit. The glacial material consists of light brown gravelly sand which contains fragments of crystalline rocks of the Cobequids up to pebble size. Northward, from Brookland to Sixmile Brook, an elongated kame and esker complex grades into outwash (Fowler and Dickie, 1977).

A sand and gravel deposit extends along Fourmile Brook and southeast toward Highway 376 at Central West River. This deposit consists of a kame and esker complex which grades downstream into a fragmented outwash body (Fowler and Dickie, 1977).

3.4.5 Landsdowne Station, Lorne, Meiklefield

Three smaller, isolated bodies of glaciofluvial material are found at Landsdowne Station, Lorne, and Meiklefield. At Landsdowne Station, in the southwestern part of the study area, are scattered ice-contact sand and gravel deposits in the form of eskers and kames. Kames and eskers also occur along the valley of Big Brook in the vicinity of Lorne. This material consists of clean, well sorted gravel and sand with well-rounded clasts of granite and quartzite. An extensive deposit of outwash sand covers an area 0.5 to 0.8 km (1/3 to 1/2 mi) square around Meiklefield (Fowler and Dickie, 1977). This deposit is composed primarily of clean, coarse-grained sand overlain by a fine gravel.

CHAPTER 4
Hydrometeorology

4.1 Introduction

During 1978 several temporary meteorologic and hydrometric stations were set up in the study area. Temporary and longterm stations are located on Figure 4.1. The purpose of these additional stations was to augment data from meteorologic stations monitored by the Atmospheric Environment Service and the hydrometric station at Rocklin on the Middle River, operated by the Water Survey of Canada. Accordingly, the network was designed to meter flows on the major rivers in the study area, and to fill in apparent gaps in the distribution of existing meteorological stations.

4.2 Methodology

Precipitation and temperature data were obtained from meteorological stations established by the Atmospheric Environmental Service. Two additional temporary stations were established at Lismore and Salt Springs. Precipitation at the Atmospheric Environmental Service stations is measured by standard precipitation gauges read daily; temperature is measured by maximum and minimum thermometers read daily. At Lismore and Salt Springs the precipitation was measured by Sacramento bulk precipitation samplers, on the average of twice weekly. The temperature was measured by a Lambrecht Type 251 continuous automatic recording thermographs. Lake evaporation calculations, based on evaporation pan data at Truro, were used in estimates of evapotranspiration.

Data from the active Water Survey of Canada automatic hydrometric station at Rocklin (No. 01PD004) were utilized. Temporary stations were set up at Salt Springs on the West River, at Hopewell on the East River, on McLellans Brook, and on the Sutherland River at Sutherland River. Flow was measured at the temporary stations utilizing a Price current meter and following procedures recommended by Water Survey of Canada. Staff type gauges, graduated in tenths of a metre, were used to measure the river stage. Based on flow and stage measurements, rating curves were constructed for

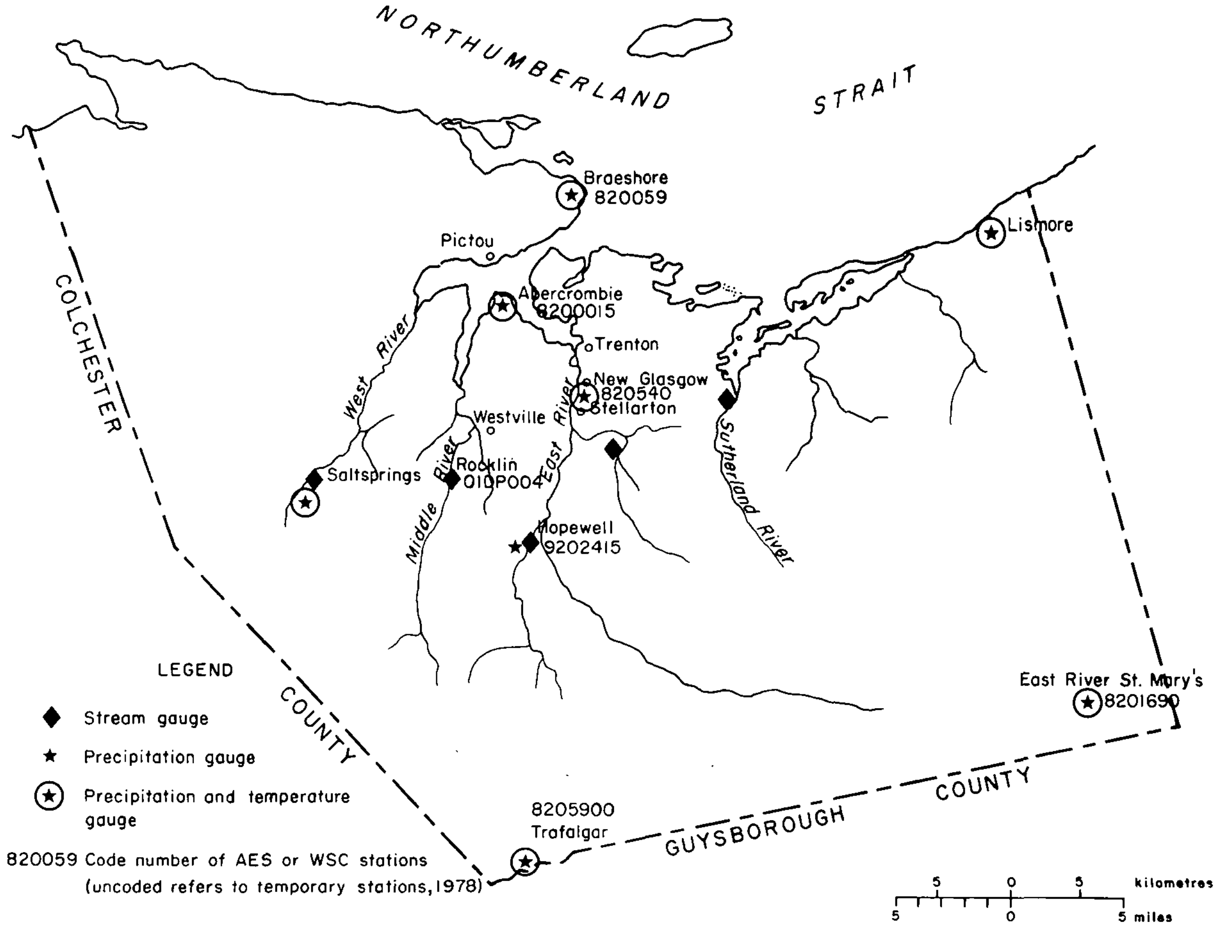


Figure 4.1 Hydrometeorological Stations in Pictou County

the West, East and Sutherland Rivers, and for McLellan Brook.

4.3 Meteorology

4.3.1 Precipitation

Annual precipitation data from the records of the Atmospheric Environmental Service stations at Trafalgar, Hopewell, and Stellarton (Lourdes) are presented in Table 4.1. Records from the stations at Abercrombie, Braeshore, and Lyons Brook were relatively incomplete. These data are presented in Table B.1, Appendix B. The three best stations were Trafalgar, Hopewell, and Stellarton (Lourdes).

These data show an average increase in precipitation from about 1000 mm (39 in), near the shore of Northumberland Strait, to about 1500 mm (59 in) inland at Trafalgar. The elevation increases from about 10 m (33 ft) at Lourdes to about 153 m (502 ft) at Trafalgar. The isohyetal map for the summer months, May to September 1978, is presented in Figure 4.2.2.

Monthly precipitation data for the year 1978 from the long-term and short-term stations are presented in Table 4.2. The Stellarton station was discontinued prior to 1978, leaving only the stations at Hopewell and Trafalgar. A comparison of the means of three periods of records is shown below in Table 4.3.

The ratios of 0.85 (Table 4.3) and the ratio of summer totals to 10-year means at the Hopewell station (337:451 mm or 0.75 from Table 4.2 and Figure 4.2), suggests that both annual and summer precipitation were relatively low.

The isohyetal map for the total annual precipitation in 1978 is presented in Figure 4.2.2. Figures 4.2.3 and 4.2.4 give isohyetal maps for the 10-year average annual precipitation (1967-76) and the 10-year average summer precipitation.

Although there is a general trend for increasing precipitation away from the coast, there tends to be considerable local variation. Some of the variations between Braeshore and Abercrombie in 1978 illustrate this (Table 4.2). In October, Braeshore recorded 123 mm (4.84 in) while only 56.4 mm (2.22 in) were recorded in Abercrombie. Lismore, another coastal station, recorded 40.6 mm (1.60 in) in June, while 90.2 and 87.4 mm (3.55 and 3.44 in) were reported in Braeshore and Abercrombie. Other such examples are apparent in Table 4.2. Such data suggest the occurrence of precipitation events in the form of short, intense local storms.

The annual precipitation of the region in 1978 is in the same order as that shown by Gates (1975, Figure 39, pg. 74). The total precipitation from May to September, inclusive, is significantly lower than Gates' averages (1975, Figure 43, pg. 80).

4.3.2 Temperature

Mean monthly temperatures for 1978 for the temporary stations at Salt Springs and Lismore, and the 10-year (1967-76) mean temperatures at Stellarton and Trafalgar are given in Table 4.4.

Records of temperature for Lismore and Saltsprings, during part of 1979, are given in Table B.2 in Appendix B.

The annual means in Table 4.4 indicate a tendency to be about 1 to 2°C (2 to 3.5°F) warmer in the coastal region (Lismore and Stellarton) than inland at Salt Springs and Trafalgar. Saltsprings averages 4.8°C (41°F) and Trafalgar 3.7°C (39°F), while, nearer the coast, Stellarton averages 6.2°C (43°F) and Lismore 6.7°C (44°F).

4.3.3 Evapotranspiration

Climatic maps (Atmospheric Environment Service, 1970) and Actual Evaporation calculated by Phillips (1970) were reviewed. During a water resources study conducted in Cumberland County (Vaughan and Somers, 1980), five methods were used to estimate evapotranspiration. Four of them were indirect; the fifth was based on calculated lake

Table 4.1

Precipitation in Millimeters for Three Atmospheric Environmental Service Stations (after O'Neill, 1980)

Station	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Mean
Hopewell	-	-	1234.19	1164.34	1451.61	1564.89	1239.77	1212.85	1103.55	1361.95	1317.50
Stellarton	1120.90	913.13	1038.61	1045.21	1275.84	1301.24	945.13	1153.92	1009.65	1182.37	1061.72
Trafalgar	1533.65	1326.90	1519.43	1402.84	M*	M*	1483.11	M*	M*	M*	1344.00

*M = missing

Mean of 1941 - 70 (Millimeters)

Stellarton	1034
Trafalgar	1351

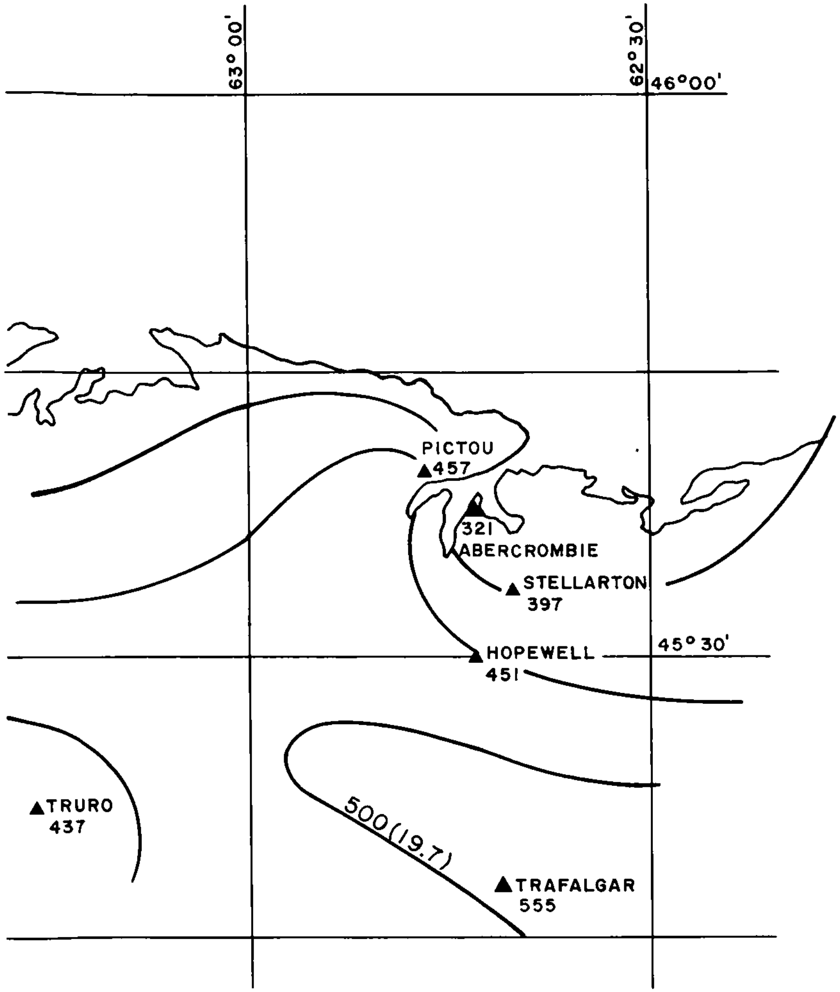


Figure 4.2.1 Isohyets of Summer Precipitation, Mean 1967 - 76

May to September inclusive
▲ Permanent Met Station
456 mm Total Precipitation

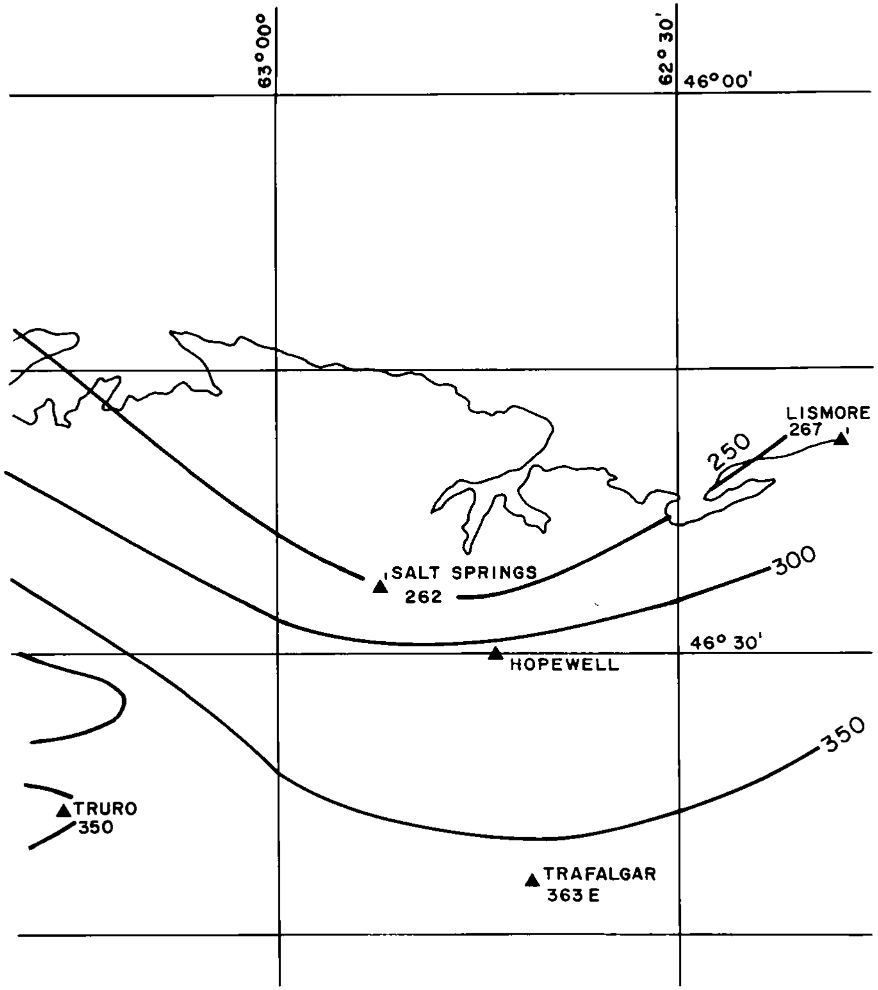


Figure 4.2.2 Isohyets of Summer Precipitation, Mean 1978

May to September 1978
▲ 1978 Met Station
▲ Permanent Station
280 4-Month Precip. mm

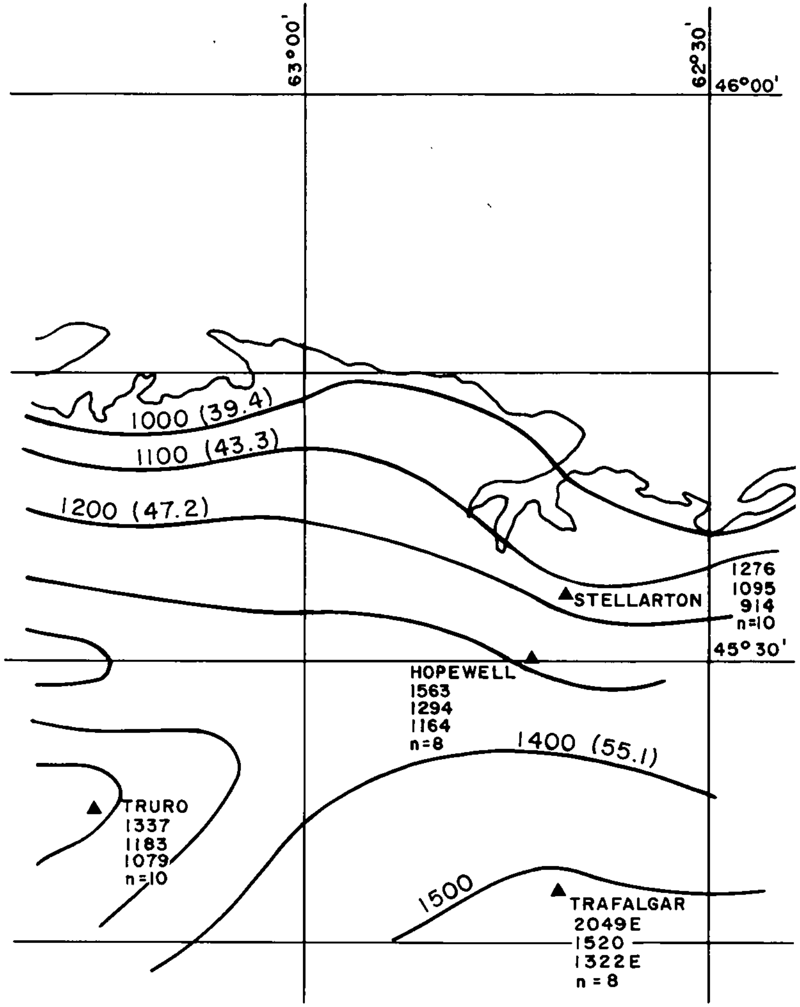


Figure 4.2.3 Isohyets of Annual Precipitation, 1967 - 76
▲ Permanent Met Station
1100 Annual Precipitation in mm.

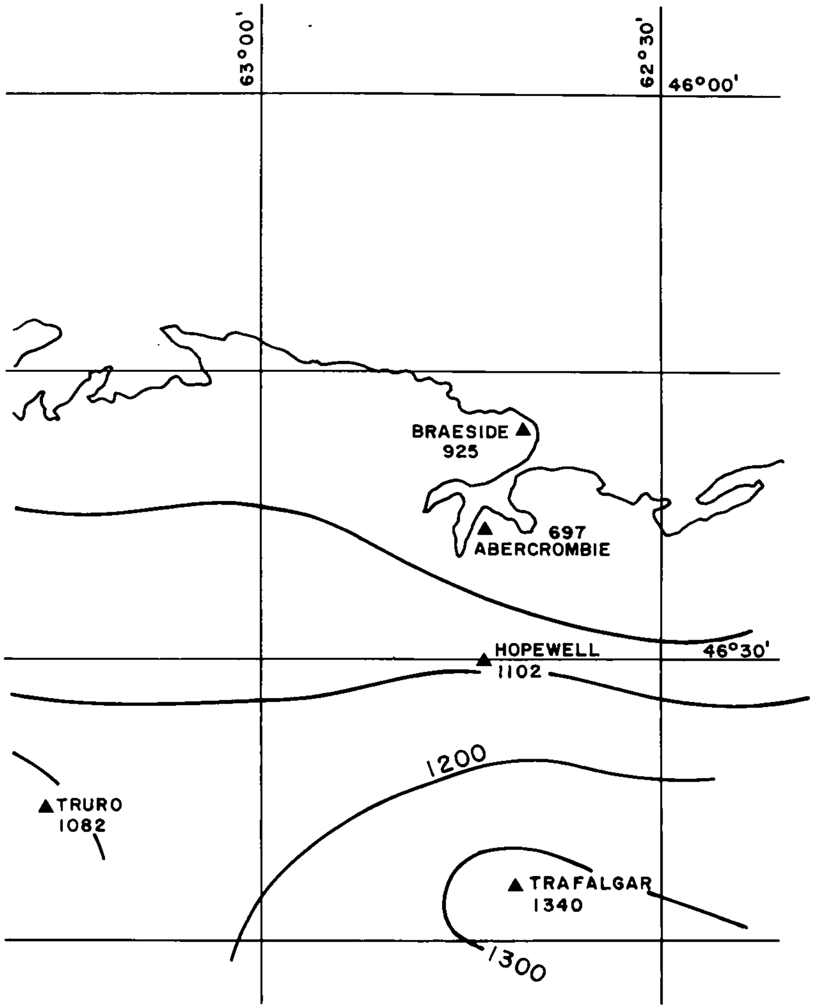


Figure 4.2.4 Isohyets of Annual Precipitation 1978
▲ Permanent Met Station
1000 mm Total Precipitation

Table 4.2

Monthly Precipitation for Long-Term and Short-Term Stations During 1978, in Millimetres.

Station	Jan.	Feb.	Mar.	Apr.	May	June	July
(A) Lismore	157	63.5	55.3	55.9	27.9	40.6	94.0
(B) Abercrombie	148	71.1	58.4	47.8	25.9	87.4	59.4
(C) Braeshore	213	81.3	46.5	68.3	18.0	90.2	70.9
(D) Saltsprings	124	66.0	71.1	83.8	53.3	81.3	66.0
(E) Hopewell	232	79.2	85.1	85.6	36.1	81.3	78.5
(F) East R., St. Mary's	259	96.0	150	89.2	29.0	96.5	81.8
(G) Trafalgar	283	85.1	122	128	39.6	103	78.0
Monthly Average	202	77.5	84.1	79.8	32.8	83.0	84.8

Station	Annual Totals	Mean Monthly	Total May-September
(A)	826	68.8	267
(B)	697	58.2	276
(C)	926	77.2	265
(D)	919	76.6	337
(E)	1103	91.9	301
(F)	1283	107	240
(G)	1296	118	—
Average	1007	85.3	

Table 4.3

Comparison of Means for Three Periods at Hopewell, Stellarton and Trafalgar (values in Millimetres)

Station 1	1967-76 Mean 2	1941-70 Mean 3	1978 Mean 4	Ratio (4)/(2) 5	Ratio (4/3) 6
Hopewell	1294	-	1103	0.85	-
Stellarton	1095	1034	-	-	-
Trafalgar	1529	1351	1269	0.85	0.94

Table 4.4

Mean Monthly Temperatures for 1978 at Lismore and Saltsprings, and for the period 1967-76 at Stellarton and Trafalgar.

Station	Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Lismore	1978	M	-7.5	-5.8	1.6	10.1	15.7	19.0	19.5	13.0	9.3	2.1	-3.1	6.7*
Salt Springs	1978	-6.6	-8.9	-4.7	1.5	10.0	15.0	18.2	18.7	11.4	8.1	-0.3	-4.5	4.8
Stellarton	67-76	-6.7	-6.6	-2.0	3.2	9.2	15.9	18.7	18.7	14.3	9.2	3.5	-2.7	6.2
Trafalgar	67-76	-7.8	-8.2	-3.1	2.1	8.0	14.3	17.9	M	12.4	7.1	2.0	3.5	3.7*

* 11 Months of records

M - Missing

evaporation from evaporation pan data at Truro. As a result of this study it was decided that lake evaporation calculated from the Truro data were acceptable to use for values of evapotranspiration in Pictou County. These data are given in Table 4.5.

4.4 Hydrology

4.4.1 Rating Curves

The rating curves at the stations are shown in Figure 4.3. In general the control was stable during the period, but significant changes could readily occur during following years. In all cases, the rating curves should only be used approximately in the range of the meterings. Extrapolation of the curves might cause serious errors in the resulting discharge. Records of meterings are given in Table B.6, Appendix B.

4.4.2 Hydrographs

Hydrographs of the Middle River at Rocklin (01DP004) were obtained from the Water Survey of Canada. Frequently, the discharges were reduced to $m^3/s\ km^2$ (cfs/ sq.mi.) and replotted, with the streamflows from another river superimposed on them (e.g. Figure B1, Appendix B). Special attention was given to the summer streamflows as 1978 was a dry year. There were insufficient streamflow data on McLellan Brook to plot a satisfactory hydrograph; however, there were enough data for the estimation of the discharge on the days of water sampling (See chapter 6).

Correlations were calculated between the daily flow on the Middle River (01DP004) and the daily flow on the streams metered during the study (Table B7, Appendix B). The correlations were used to fill in gaps in the data, and to make an estimate of the accuracy of using unit discharges ($m^3/s/km^2$) ($cfs/mi.^2$) of the Middle River on other basins within the study area.Though the measurements of one year have little statistical value, there was evidence that unit discharges from the Middle River could be used on other basins in the study area.

The hydrographs for the Middle River for 1978 indicate the "flashy" nature of the stream; the same characteristic appears in hydrographs of previous years. For example, in 1976 flow dropped from 6.3 m^3/s (223 cfs) on April 5 to 3.5 m^3/s (124 cfs) on April 6, and from 15.7 m^3/s (554 cfs) on October 27 to 7.6 m^3/s (268 cfs) on October 28. This "flashy" characteristic of the stream is primarily a result of the relatively steep topography and the lack of storage in the watershed.

4.4.3 Groundwater Hydrographs

Estimates were made of the groundwater component of streamflow by using two methods. One method, after Ward (1975), assumes that the most logical separation of the surface from the groundwater component is to draw a horizontal line from the point where the hydrograph begins to rise sharply after a storm to the same flow on the recession curve (Figure B.9, Appendix B). This method was applied to the lower flow period of May to September 1978.

The second method was devised by Kunkle (1962). His method utilizes a hydrograph for a complete water year, October 1 to September 30, or the period beginning and ending when the groundwater storage is at a minimum. This technique is illustrated in Figure B.10, Appendix B. One may note that an estimate of basin storage and short-term bank storage is possible in the Kunkle method, whereas Ward does not attempt to separate the two.

Groundwater yields estimated by Ward's method, from May to September, 1978, for the Middle West, and East Rivers are presented in Table 4.6. Groundwater component and estimates of bank and basin storage by the Kunkle method for the same rivers are given in Table 4.7. This includes the calendar year of 1978 for the three rivers and for comparison purposes, two water years on the Middle River. Insufficient data were available to utilize water years

Table 4.5

Lake Evaporation for Pictou County Calculated from Class "A" Pan Data at Truro.

Month	1965	1966	1967	1968	1969	1970	1971	1972	1973	1975	1977	11-year Average
May	93.2	73.7	69.1	87.9	83.8	86.4	87.6	116.	65.5	87.9	103.	86.6
June	111.	84.6	107.	92.7	113.	113.	106.	102.	110.	130.	69.1	104.
July	122.	122.	103.	141.	122.	136.	118.	109.	95.8	128.	121.	120.
Aug.	97.0	102.	92.5	112.	105.	95.3	104.	118.	85.3	110.	107.	103.
Sept.	64.0	68.3	62.2	67.1	71.6	51.6	75.7	72.6	67.8	69.3	64.3	68.2
Total	487.	451.	434.	501.	495.	482.	491.	518.	424.	525.	464.	480.

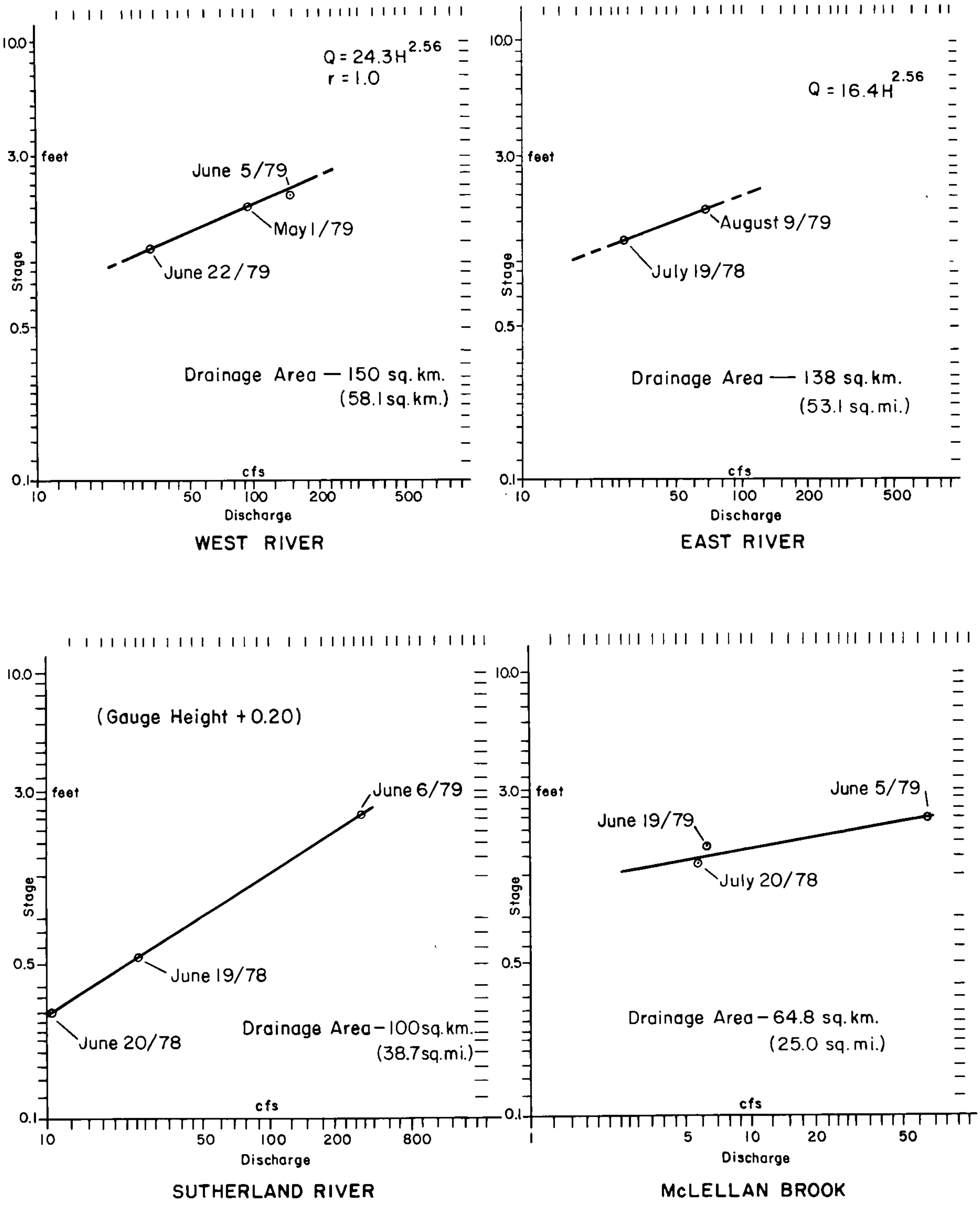


Figure 4.3 Rating Curves

Table 4.6

Estimate of Bank Storage, Basin Storage and Total Groundwater Component (After Kunkle, Y962)

River Basin		Middle			West	East
Drainage Area	km²	92.2			150	138
	mi²	35.6			58.1	53.1
YEAR		1967-68	1977-78	1978	1978	1978
1) Total Bank Storage	Ac-ft/mi²	486	465	279	184	369
	mm	231	206	133	88	176
2) Total Basin Storage	Ac-ft/mi²	20	21	19	54	27.
		9.5	9.9	9.1	25.4	12.9
3) Total Groundwater	Ac-f/mi²	506	486	298	292	397
	mm	240	231	142	139	189
4) Total Streamflow	Ac-ft/mi²	1810	2020	1471	934	727
	mm	862	963	701	445	345
5) Annual Precipitation (Hopewell)	mm	1152	1274	1105	1105	1105
6) Ratio: Bank Storage/ Total Streamflow		0.27	0.21	0.19	0.20	0.26
7) Ratio: Basin Storage/ Total Streamflow		0.011	0.010	0.013	0.057	0.019
8) Ratio: Groundwater/ Precipitation		0.21	0.13	0.18	0.13	0.17

Table 4.7

Estimate of Groundwater Component, May through September, 1978, Using Ward's Method (1975).

Month	Groundwater Flow AC-FT/mi²	mm	Total Run-off AC-FT/mi²	mm	Groundwater/Total Discharge
	Middle River at Rockliin		Drainage Area 9.2 km² (35.6 mi²)		
May	132	63	171	81	0.77
June	21	10	56.2	27	0.37
July	8.6	4.1	20.2	9.6	0.43
August	6.8	3.2	15.2	7.2	0.45
September	3.2	1.5	13.3	6.3	0.24
	West River at Saltsprings		Drainage Area 150 km² (58.1 mi²)		
May	90	43	113	54	0.08
June	24	11	38	18	0.63
July	22	10.5	33	16	0.67
August	21	10.0	26	12.4	0.81
September	17	8.1	22	10.5	0.77
	East River (West Branch) Hopewell		Drainage Area 139 km² (53.7 mi²)		
May	108	51	145	69	0.74
June	37	18	63	30	0.59
July	25	12	28	13	0.89
August	10	5	10.4	5.0	0.96
September	7.1	3	18.5	8.8	0.38

on the West and East Rivers. A comparison of Ward's and Kunkle's methods for the summer months for the West River gives similar results, except for May (Table 4.8).

Table 4.8

Comparison of the Groundwater Component of Streamflow Calculated Using the Methods of Ward and Kunkle, for the summer Months on the West River.

Total Groundwater: mm on drainage area

Month 1978	**Ward**	**Kunkle**
May	43	15.4
June	11	9.0
July	10.5	11.2
August	10	9.0
September	8.1	6.4
Total	82.6	51.0
Total	39.6	35.6 Omitting May

In Table 4.6 the ratio of estimated groundwater to total precipitation (precipitation at Hopewell) varies from 0.13 to 0.18, during 1978. The calendar year of 1978 indicates, for the Middle River, a ratio of 0.13, while for the water year 1977-78, the ratio is 0.18. Considering the flow correlations between the Middle River and the other rivers measured, the groundwater/precipitation ratios, measured during the calendar year, of 0.13 for the West River and 0.17 for the East River, would be expected to be higher for the water year. This ratio for the Middle River for the water year 1977-78 is 0.18. Based on the available data, a ratio varying in the range of 0.13 to 0.21 may be reasonable. Using the 10-year average for Hopewell of 1294 mm (50.9 in) of precipitation, then from 233 to 285 mm (9.2 to 11.2 in) of precipitation may end up as groundwater. These values are higher than the average value of 152 mm (6 in) suggested by Brown (1967), for the Appalachian Hydrogeological region, that is, all the Atlantic Provinces except Labrador.

4.5 Water Balance and Estimated Annual Run-off

An approximate water balance was calculated for the study area for 1978 and the results presented in Table 4.9.

The indicated change of storage is 20 mm, or only 2 percent of total precipitation. This result also suggests that values used for precipitation, run-off, and evapotranspiration are reasonable.

Table 4.9

Approximate Water Balance Over the Study Area for 1978.

Average annual precipitation over study area	1,000 mm (mean of all measurements)
Average annual yield	500 mm (based on West, Middle and East Rivers)
Estimated annual evapotranspiration	480 mm (based on Truro Class "A" pan)
s = P - R - ET	where s: change in storage
= 1000 - 500 - 480	P : precipitation R : run-off
= + 20	ET : evapotranspiration

Table 4.10

Estimate of Annual Runoff from the Study Area.

An estimate of annual run-off from the study area in 1978 is presented in Table 4.10. The study area, for this calculation, includes the West, Middle, East and Sutherland Rivers. The annual yield over the study area in 1978 was 550 x 10^6 m^3 (194 x 10^8 $ft.^3$).

Basin	**Area km^2**
East River	550
West River	240
Middle River	220
Sutherland River	96
Total to Outlet	1106
Total to Outlet	1100 (rounding off)

(NOTE: McLellan Brook was taken as a tributary of the East River)

CHAPTER 5
Hydrogeology

5.1 Introduction

A hydrogeological investigation was conducted in the study area in order to determine, on a regional basis, the water bearing and transmitting capacities of the major hydrostratigraphic units. A hydrostratigraphic unit is defined as geological materials that have similar water storage and transmitting properties. Water storage is measured in terms of the coefficient of storage, S (dimensionless), defined as the volume of water released from or taken into storage by an aquifer, per unit surface area of the aquifer, per unit change in the component head normal to that surface (Theis, 1935). In artesian aquifers, values of S commonly range from 0.00001 to 0.001.

An aquifer's water transmitting ability is called its permeability. The field coefficient of permeability is the rate of flow of water through a one square metre (one square foot) cross section of aquifer under a gradient of one metre per metre (one foot per foot) (or 100%), and is measured in dimensions of cubic metres per day per square metre (gallons per day per square foot). In artesian aquifers coefficients of permeability range from less than 5×10^{-7} in shale to 2.4 m^3pd/m^2 in sandstone (1×10^{-5} to 50 gpd/ft^2) (Walton, 1970). The permeability of geologic materials may be either primary or secondary, or both. Primary permeability is exhibited where water moves through interstices created with the formation of the geologic material, such as the intergranular openings in a gravel deposit or in sandstone. Secondary permeability is formed by subsequent alteration of the geologic material, such as by fracturing. In this report, reference is made to fracture permeability resulting from such fracturing processes as jointing and faulting.

A more practical term, which is related to permeability, is the coefficient of transmissibility, T, which is simply the permeability multiplied by the saturated thickness of the aquifer, with dimensions in cubic metres per day per metre (m^3 pd/m) or imperial gallons per day per foot (igpd/ft.). T values range from less than 0.15 m^3d/m (10 igpd/ft) in a material like shale to 75 m^3pd/m (5000 igpd/ft) in sandstone per 100 feet of saturated thickness. The coefficients of transmissiblity and storage are determined in practice from pump tests, such as those described in Appendix C. Once these properties are known, the safe longterm pumping rate for a well or wells drilled into the aquifer can be predicted.

The productivity of a well can be represented by its specific capacity, defined as the ratio of the pumping rate to the drawdown of water level in the well during pumping. High specific capacities tend to indicate high transmissibilities. Specific capacity data are useful in estimating well productivity where well data are limited to the short test of well yield (usually one hour) normally conducted by drillers on the completion of a new well. However, under these circumstances, specific capacity data cannot be relied upon to predict the performance of a well during sustained pumping. Other factors for which data are not available also limit the reliability of specific capacity data (Walton, 1970).

5.2 Methodology

In this study, pump tests were conducted in the Riversdale and Pictou Groups (Figure 5.1). In addition, the results of 18 pump tests conducted by various agencies or individuals were assessed (Table 5.1). The information from previous pump tests has been supplemented by drillers' bail or blow tests which are performed as part of the assessment and development of every well drilled. Specific capacity estimates were obtained by divided sustainable pumping rate by the total drawdown after a specified period of time (in this study, 1 hour). Specific capacity is measured in cubic metres per minute per metre ($m^3/min/m$) or imperial gallons per minute per foot (igpm/ft). In this report, specific capacity is multiplied by 30 m (100 ft) to give, in effect, the average capacity over 30 m (100 ft) of saturated thickness.

Data from wells in the various hydrostratigraphic units have been analyzed and this information is summarized in Table 5.2.

5.3 Bedrock Hydrostratigraphic Units

5.3.1 Horton Group

The Horton Group of rocks underlies the extreme southern part of Pictou County and consequently little hydrogeologic data are available. However, sandstone and conglomerate beds of the Horton Group have produced relatively high groundwater yields in other parts of the province. Wells in these strata have been reported to yield from 0.045 to 0.45 m^3/min (10 to 100 ig/min) (Trescott, 1968). An analysis of drillers' logs of wells penetrating the Horton Group in the Truro area indicates that yields should be in the order of about 0.16 m^3/min (35 ig/min) per 30 m (100 feet) of saturated thickness (Hennigar, 1972).

5.3.2 Windsor Group

Permeability in Windsor limestones, dolomites, gypsum, and shales elsewhere in the Province is probably all secondary, the result of fracturing and, for the limestones, dolomites and gypsum, the formation of solution channels. The diagenetic alteration of calcite to dolomite also results in an additional 13% increase in porosity (Davis and DeWiest, 1966). Reported yields in the Windsor Group are highly variable. Lin (1970) reports relatively low yields from limestone in the Musquodoboit Valley (about 0.03 m^3/min or 6 ig/min). Trescott (1969) reports that wells in Windsor rocks will average about 0.0045 m^3/min (1 ig/min) in shales to over 0.45 m^3/min (100 ig/min) where solution cavities are present in limestone and gypsum.

Available data from three pump tests conducted in shales of the Windsor Formation (Table 5.1) produced T values of 3.0, 0.22 and 7.5 m^3 pd/m (203, 14.7 and 500 igpd/ft.) which correspond to safe pumping rates of 0.050, 0.0036 and 0.12 m^3/min (11, 0.8, and 27 ig/min respectively per 30 m (100 ft) of saturated thickness. Analysis of 32 drillers' logs showed an average yield of 0.036 (8), a standard deviation of 0.032 (7), and a range from 0.0018 to 0.050 m^3/min (0.4 to 11 ig/min) per 30 m (100 feet).

5.3.3 Canso Group

In the Truro area sediments of the Canso Group exhibit secondary permeability resulting mainly from fault planes and joint systems (Hennigar, 1972). Yields from wells drilled into the Canso Group in the Truro area were found to vary between 0.023 and 0.11 m^3/min (5 and 25 ig/min). The results of three 72 hour pump tests (see Table 5.1) indicate T values of 0.44, 0.98 and 2.9 $m^3/pd/m$ (29.2, 66 and 195 igpd/ft) which corresponds to long term safe yields of 0.0090, 0.018 and 0.050 m^3/min (2, 4 and 11 ig/min) respectively per 30 m (100 ft) of saturated thickness. Analysis of eleven well drillers' logs in the Canso Group showed an average yield per 30 m. (100 ft) of saturated thickness of 0.050 m^3/min (11 igpm) a standard deviation of 0.027 m^3/min (6 igpm) and a range from 0.0023 to 0.068 m^3/min (0.5 to 15 ig/min).

5.3.4 Riversdale Group

Hennigar (1972) reported that the Riversdale Group in the Truro area would be expected to have similar hydraulic properties to those of the Canso Group, secondary fracture permeability and yields averaging

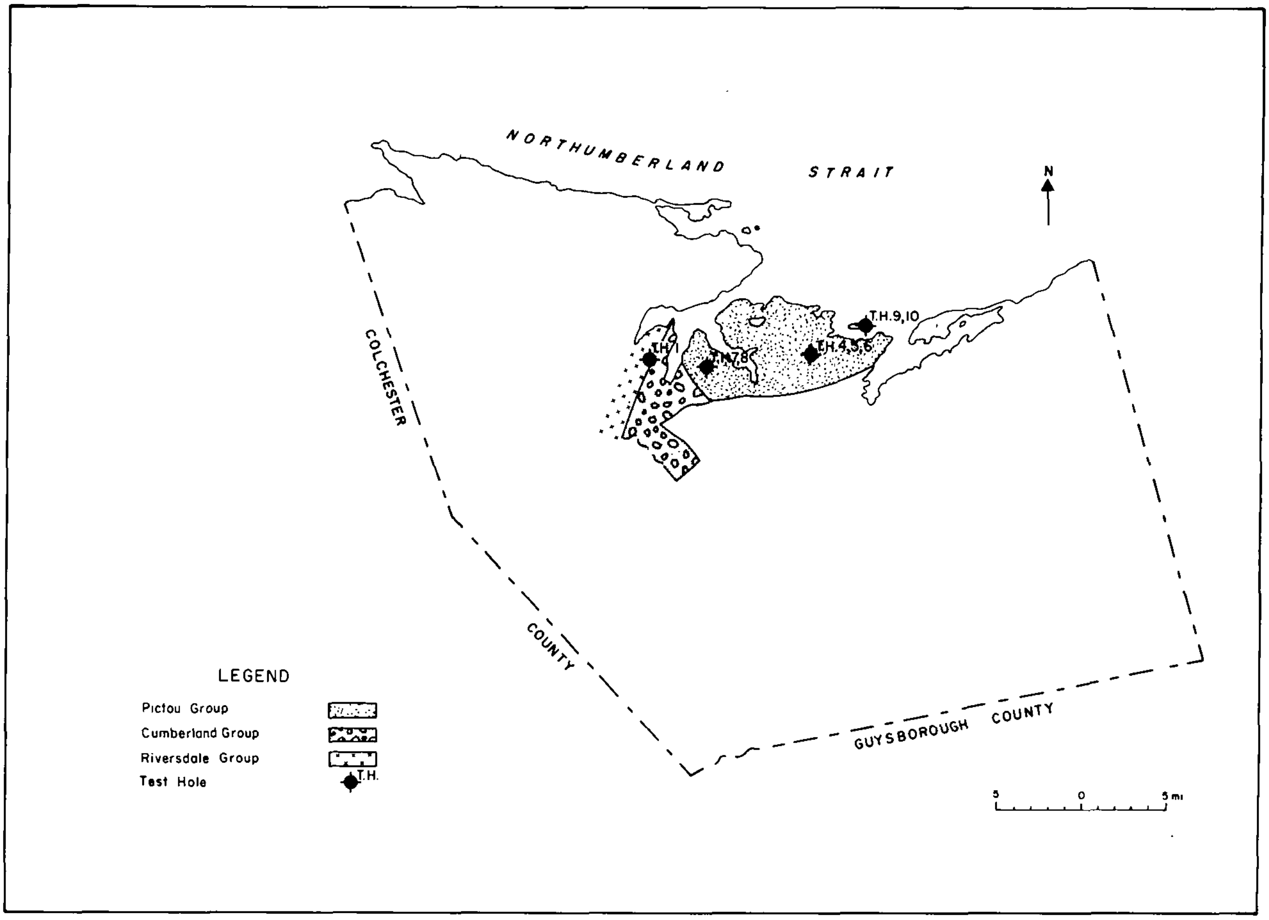


Figure 5.1 Test Hole Locations

Table 5.1

Results of Pumping Tests Conducted in Pictou County

Location	Hydrostratigraphic Unit	Well Depth m(ft)	Pumped at m^3/min	T m^{3}pd/mm^3/min	Safe Pumping Rate Per 30m (100 ft) Saturated	Remarks
Trenton	Pictou Group	107(350)	1.27 (280)	190 (12750)	2.5 (557)	Salt water intrusion
Trenton	Pictou Group	111(365)	0.38 (83)	5.2 (350)	0.09 (19)	
Trenton	Pictou Group	122(400)	0.38 (83)	2.5 (165)	0.04 (9)	
Pictou Landing	Pictou Group	30(100)	0.05 (10)	12 (800)	0.19 (41)	
Pictou Landing	Pictou Group	46(150)	0.05 (10)	6.1 (406)	0.10 (21)	
New Glasgow	Pictou Group	76(250)	0.05 (10)	3.1 (211)	0.06 (12)	
Caribou	Pictou Group	28(93)	0.009 (2)	0.5 (30)	0.009(2)	
Roy Island*	Pictou Group	30(100)	0.032 (7)	1.5 (103)	0.027(6)	
Marshville	Pictou Group	32(105)	0.027 (6)	2.7 (182)	0.05 (10)	
Pictou	Pictou Group	177(580)	0.34 (75)	85.3 (5730)	1.4 (297)	salt water intrusion
Abercrombie*	Pictou Group	63(205)	0.34 (75)	6.0 (404)	0.10 (22)	negative boundary 2520 min.
Little Egypt Rd*	Pictou Group	76(250)	0.14 (30)	3.0 (198)	0.05 (11)	well underpumped
Durham*	Riversdale Group	75(247)	0.46 (100)	17.4 (1168)	0.26 (58)	
Pictou Area	Riversdale Group	122(400)	0.46 (100)	4.6 (310)	0.08 (17)	
Scotsburn	Riversdale Group	137(450)	0.007 (1.5)	0.1 (7.2)	0.002 (0.4)	
Salt Springs	Canso Group	67(220)	0.023 (5)	0.4 (29)	0.009 (2)	
Linacy	Canso Group	44(144)	0.023 (5)	1.0 (66)	0.02 (4)	
Sutherland R.	Canso Group	61(200)	0.14 (30)	2.9 (195)	0.05 (11)	
Riverton	Windsor Group	49(160)	0.05 (10)	3.1 (203)	0.05 (1)	
Riverton	Windsor Group	93(305)	0.027 (6)	0.22(14.7)	0.005 (1)	
Satellite Slope	Windsor Group	106(347)	0.23 (50)	7.5 (500)	0.12 (26)	
Thorburn	Stellarton Series	41(135)	0.05 (10)	13.8 (926)	0.21 (47)	

*** Tests Conducted During Current Study**

Table 5.2

Analysis of Yields per 30 metres (100 feet) of saturated thickness in various hydrostratigraphic units in Pictou County. Specific capacities (pumping rate divided by total drawdown) were calculated and multiplied by 30 (100).

Hydrostratigraphic Unit	Mean m^3/min (igpmin)	Standard Deviation	Range	Number of wells
Horton Group	no data	no data	no data	no data
Windsor Group	0.036 (8)	0.032 (7)	0.002-0.054 (0.4-11)	32
Canso Group	0.050 (11)	0.025 (5.5)	0.0024-0.068 (0.5-15)	11
Riversdale Group	0.20 (44)	0.032 (7)	0.0045-2.39	33 (1-526)
Cumberland Group	0.064 (13)	0.12 (27)	0.0045-0.45 (1-100)	25
Stellarton Series	0.059 (12)	0.13 (29)	0.0045-0.46 (1-102)	44
Pictou Group	0.17 (38)	0.28 (62)	0.0045-2.73 (1-602)	86

from 0.023 to 0.11 m^3/min (5 to 25 ig/min). A 72 hour pump test conducted at Durham during the study (Appendix C) indicated a transmissibility of about 17.4 m^3pd/m (1166 igpd/ft) and a coefficient of storage of about 9 x 10^{-4}. Based on the T value, a safe long-term yield of about 0.30 m^3/min (65 ig/min) per 30 m (100 ft) of saturated thickness was predicted.

Available data from two other 72 hour pump tests (Table 5.1) indicate T values of 4.6 m^3pd/m (310 igpd/ft) (Town of Pictou) and 1.07 m^3pd/m (72 igpd/ft) (Scotsburn). From these T values, safe yields of 0.077 and 0.0018 m^3/min (17 and 0.4 ig/min) per 30 m (100 ft) of saturated thickness, were predicted. An analysis of thirty-three well drillers' logs suggests that per 30 m (100 ft) of saturated thickness average yields are in the order of 0.20 (44), with a standard deviation of 0.12 (26) and a range from 0.041 (9) to 0.73 m^3/min (160 ig/min).

5.3.5 Cumberland Group

The Cumberland Group in Pictou County is represented by the New Glasgow conglomerate, which consists mainly of conglomerate with minor sandstones, siltstones and shales. An analysis of 25 wells in the Cumberland Group showed, per 30 m (100 ft) of saturated thickness, an average yield of 0.059 (13), a standard deviation of 0.12 (27) and a range from 0.0045 to 0.45 m^3/min. (1-100 igpm).

5.3.6 Stellarton Series

The Stellarton Series are composed of shale, coal, mudstone, sandstone and conglomerate. Analysis of drillers' records of 44 wells in the Stellarton Series indicated an average yield per 30 m (100 ft) of 0.17 m^3/min (38 igpm), a standard deviation of 0.3 m^3/min (62 igpm) and a range of 0.0045 to 2.73 m^3/min (1 to 602 igpm). Data from one pump test in the Thorburn area indicated a T value of 13.8 m^3 pd/m (926 igpd/ft) and a safe yield per 30 metres (100 feet) of 0.21 m^3/min (47 igpm).

5.3.7 Pictou Group

In the Truro area, the Pictou Group of rocks, consisting of shale, sandstone and conglomerate, exhibit essentially secondary permeability along bedding planes and joints, though some primary intergranular permeability is suspected (Hennigar, 1972). In this area, well yields were estimated to vary between 0.023 and 0.11 m^3/min (5 and 25 ig/min). North of the Cobequid Mountains, where sediments are less consolidated, yields may range up to 0.34 m^3/min (75 ig/min) (Brandon, 1966). In the Amherst area, wells drilled into soft sandstone yield up to 1.4 m^3/min. (300 ig/min), about 75% of which may result from intergranular flow (Hennigar, 1972). During the Cumberland County study (Vaughan, Somers, 1980), wells drilled and pump tested in the Amherst area indicated T values from 7.5 to 178 m^3pd/m (500-12000 igpd/ft) and S values from 1 x 10^{-3} to 1.5 x 10^{-4}.

Three pump tests were performed on test wells in the Pictou Group during this study: at Abercrombie, Roy Island, and on the little Egypt Road behind Trenton (Appendix C). At Abercrombie, a significant negative boundary was encountered which resulted in the limitation of T to 6.0 m^3pd/m (404 igpd/ft). For this well the longterm pumping rate is predicted to be about 0.08 m^3/min (18 ig/min) per 30 m (100 ft) of saturated thickness. For the Little Egypt Road test T was estimated to be 2.95 m^3pd/m (198 igpd/ft), or a longterm pumping rate of about .054 m^3/min (12 ig/min) per 30 m (100 ft) of saturated thickness. Had this well been pumped at a higher rate, T would have been up to 1/3 higher.

At Roy Island, a relatively shallow well (30 m or 100 ft) drilled for the N.S. Department of Lands and Forests, was tested. The average of calculated T values was 1.4 m^3pd/m (94 igpd/ft) and the predicted longterm pumping rate was about 0.02 m^3/min (5 ig/min) per 30 m (100 ft) of saturated thickness.

During the drilling and logging of the test wells at Abercrombie and the Little Egypt Road site, it was apparent that fractures were the main source of water. At Roy Island, however, the discovery that water was being picked up steadily where coarse sandstone was encountered, indicates mainly intergranular permeability. The relatively low yield from the Roy Island well, compared to the others, further suggests that here, as for the Pictou Group in the Truro area, the significant permeability is secondary.

In addition to the above information, available data from nine pump tests indicated T values ranging from 0.45 to 190 m^3 pd/m (30 to 12750 igpd/ft). The higher values were from wells in the Town of Pictou known to be affected by salt water intrusion. This would also be reflected as a positive boundary that would tend to elevate T values. Excluding the two high values, T ranges from 0.45 to 11.9 m^3pd/m (30 to 800 igpd/ft) and averages about 4.5 m^3pd/m (300 igpd/ft). Corresponding safe pumping rates per 30 m (100 ft) of saturated thickness range from 0.0090 to 0.19 (2 to 42) and average 0.077 m^3/min (17 ig/min).

An analysis of specific capacities of a random sample of 86 wells in the Pictou Group showed an average yield per 30 m (100 ft) of saturated thickness of 0.17 m^3/min (38 igpm), a standard deviation of 0.28 m^3/m (62 igpm), and a range from 0.0045 to 2.4 m^3pd/m (1.0 to 526 igpm).

CHAPTER 6
Chemical Quality of Water

6.1 Chemical Quality of Groundwater

6.1.1. Introduction

The chemical quality of groundwater is affected primarily by the geochemical composition of the earth material with which the groundwater is in contact and the length of time of that contact. For example, groundwater moving through sandstone would be less mineralized than groundwater in contact with gypsum, a relatively more soluble substance. Similarly, water moving along a short flow path would tend to be less mineralized than that moving along a longer flow path (all other things being equal.) Water quality can also be affected by various human activities as highway de-icing operations, mining, and the operation of livestock feedlots, to name just a few.

The groundwater quality sampling program in the current study was designed to determine natural groundwater quality in the various hydrostratigraphic units. Sampling locations are presented in Figure 6.1.

6.1.2 Methodology

Samples were collected in 1.14 L (32 oz) acid washed polyethylene bottles from a cold water tap. The tap was run from 2 to 3 minutes, the bottle and cap rinsed, and the bottle filled to the brim. Sample

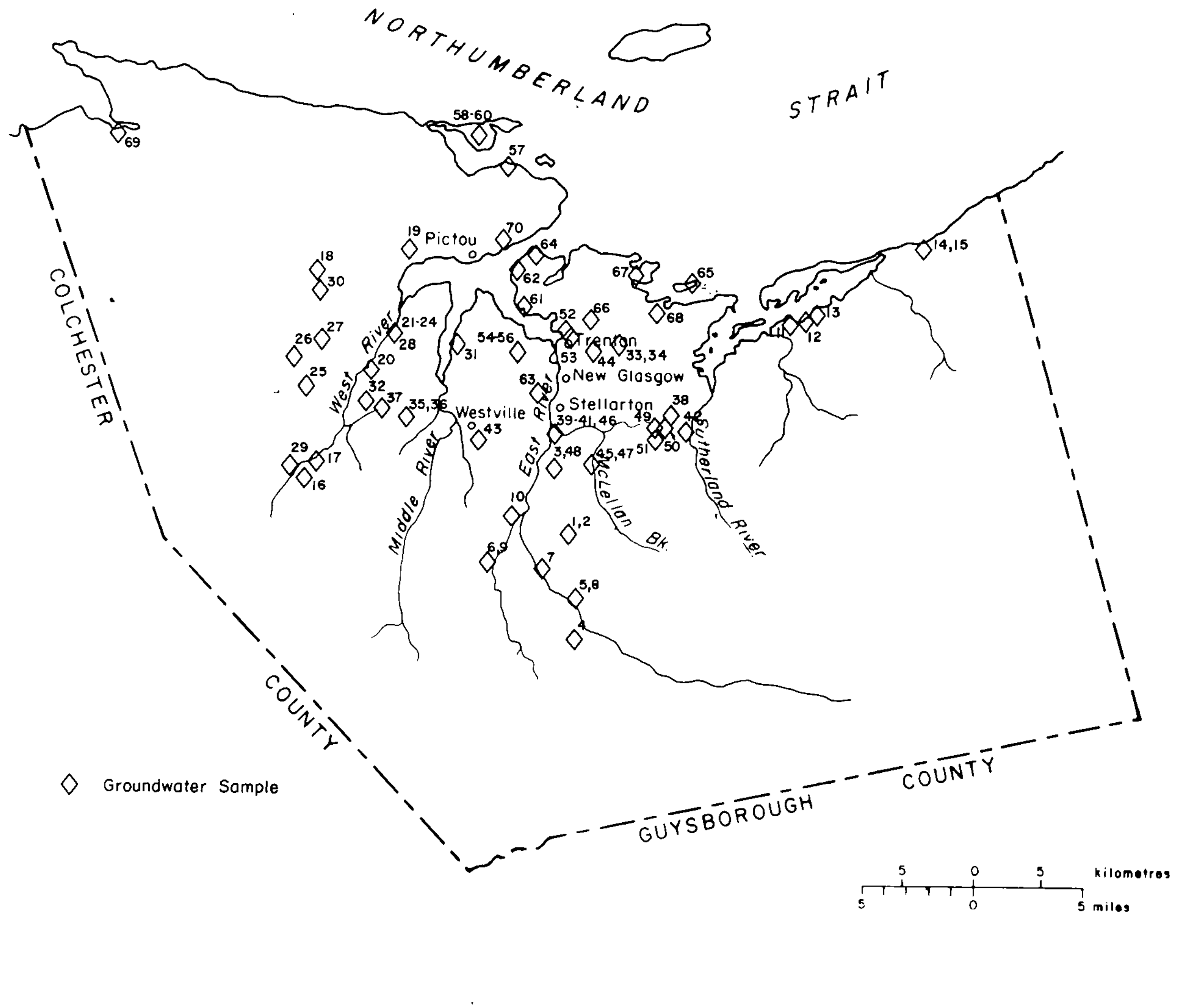


Figure 6.1 Groundwater Sampling Sites

Table 6.1

Mean Values of Constituents of Groundwater in the Hydrostratigraphic Units

Hydrostratigraphic Unit	Sodium	Potassium	Calcium	Magnesium	Ca Co_3 (Hardness)	Ca Co_3 (Alkalinity)	Sulfates	Chloride	Fluoride	Silica	Nitrate + Nitrite (as N)	Ammonium (as N)	Arsenic	Iron	Manganese	Copper	Zinc	Lead	Total Phosphates	Suspended Solids	Total Dissolved Solids	Colour T.C.U.	Turbidity J.T.U.	Conductivity Umhos	pH (Lab)
Windsor Group (10 samples)	261	5.0	92.4	16.4	270	123	320	235	.34	9.5	.38	0.1		0.25	0.12	0.02	0.04	0.005	0.04	2.3	102.3	15.6	6.46	1080	7.8
Canso Group (6 samples)	20.4	3.3	27.2	7.3	98.8	101	14.3	21	.18	8.8	.13	0.1		1.6	0.82	0.09	0.05	0.01	0.06	25.2	187.6	14	1.52	254	7.4
Riversdale Group (14 samples)	57.1	2.9	33.4	4.6	103	108	18.1	100	03	8 3	2.35	0.19	0.005	0.40	0.08	0.17	0.12	0.01	0.04	50.7	301.6	27.1	17.6	421	8.1
Cumberland Group (7 samples)	89.9	1.9	24.8	1.1	77.2	187	37.6	40.5	.63	6.7	.13	0.1	0.005	0.17	0.02	0.04	0.10	0.01	0.10	57.8	360	27	10.5	497	8.2
Stellarton Group (14 samples)	153.9	7.4	35.9	8.3	130	280	32.4	96.5	.36	7.1	7.84	0.39		3.2	0.27	0.05	0.02	0.02	0.05	18.5	581	16.3	49	611	7.8
Pictou Group (19 samples)	25.9	3.0	37.6	8.3	129	140	18.5	21.0	.30	10.1	.28	0.1	0.005	0.26	0.27	0.05	0.12	0.01	0.06	9.5	222	13	7.1	311	7.3

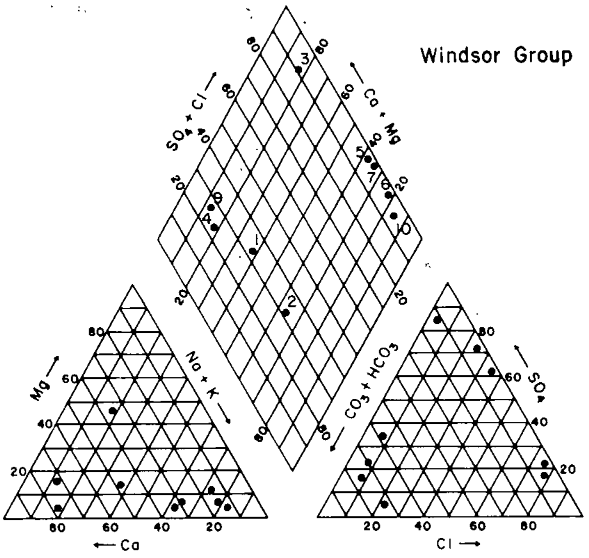
preservation techniques were not employed, but it is not felt that this introduced any significant error in the results. Samples were submitted for analysis within a week to ten days of sampling. Analyses were conducted at the Environmental Chemistry Section of the Division of Clinical Chemistry at the Dr. D.J. MacKenzie Diagnostic Laboratory in Halifax.

The general chemical quality of groundwater in the various hydrostratigraphic units was determined from mean values of selected parameters (Table 6.1) and from tri-linear plots utilizing values of magnesium, calcium, sulphate, chloride, bicarbonate, and carbonate (Piper, 1944). The bicarbonate and carbonate were assumed to be equal to the alkalinity of the sample. Since alkalinity is reported as calcium carbonate, bicarbonate and carbonate are 60 percent of this value. All parameters were then converted to milli-equivalents per litre before plotting. The tri-linear plots are presented in Figures 6.2 to 6.4

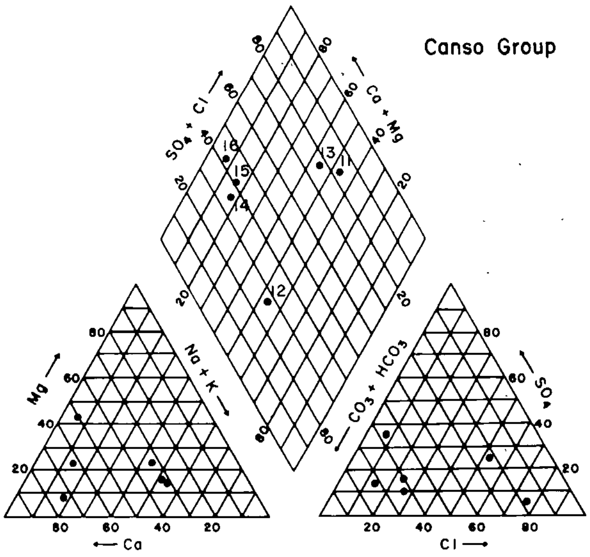
6.1.3 Expression of Water Analyses

The analytical results of the sampling program are presented in Table D.3, Appendix D. Most parameters are expressed as milligrams per litre (mg/1) which is an expression of weight of solute per unit volume of water. Physical parameters, colour and turbidity, are expressed as True Colour Units (TCU) and Jackson Turbidity Units (JTU). Hydrogen ion concentration is expressed as pH and conductivity as micromhos per centimeter (umhos/cm).

For the purpose of preparing tri-linear plots to classify the groundwaters of the various hydrostratigraphic units, selected parameters were converted to values in milli-equivalents per litre (meg/1). Milli-equivalents per litre is an expression of the chemical equivalence of constituent ions, facilitating the comparison of ions in the analyses (e.g. see Hem, 1970, page 80).

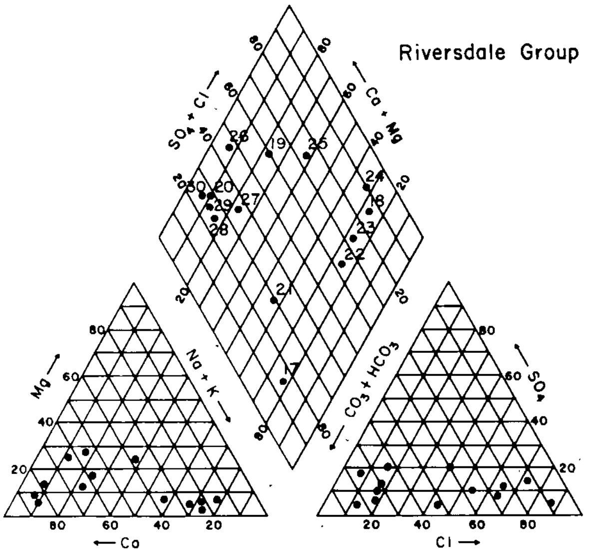


Per cent of total equivalents per million

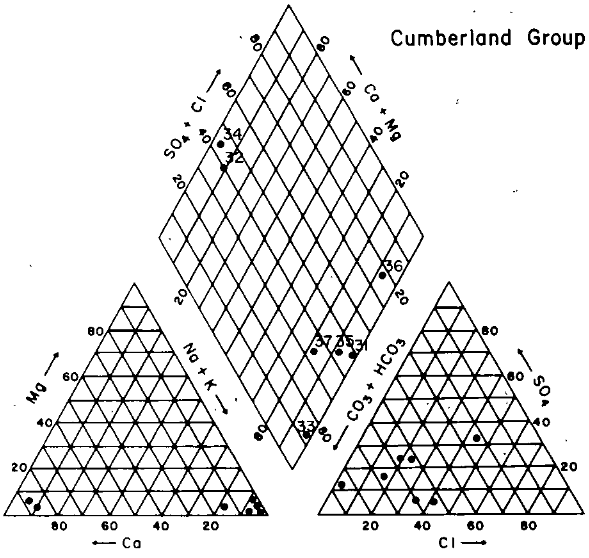


Per cent of total equivalents per million

Figure 6.2 Trilinear Plots of Groundwater Analyses of Samples from Windsor and Canso Groups



Per cent of total equivalents per million



Per cent of total equivalents per million

Figure 6.3 Trilinear Plots of Groundwater Analyses of Samples from the Riverdale and Cumberland Groups

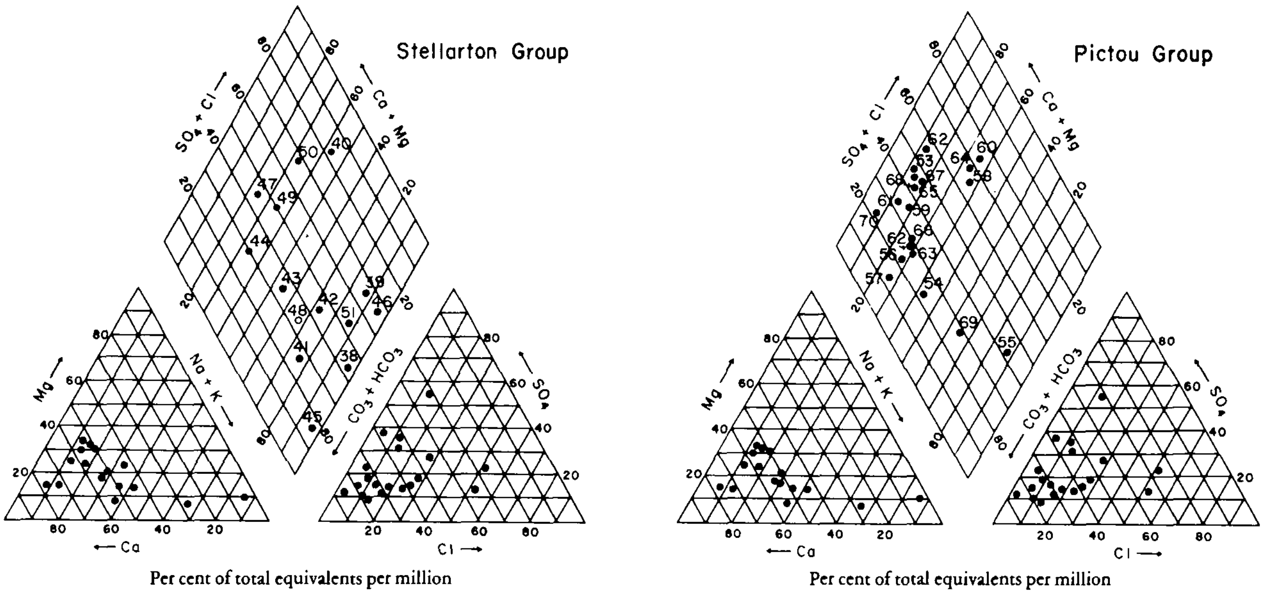


Figure 6.4 Trilinear Plots of Groundwater Analysis from the Stellarton Series and Pictou Group

6.1.4 Discussion of Selected Parameters

Several chemical parameters were determined for the water samples taken during the study and the more significant ones are described below. For comparison purposes, the parameters are referred to the **Guidelines for Canadian Drinking Water Quality, 1978** (Table 6.2).

6.1.4.1 Calcium

Calcium is found in igneous rocks in many minerals, such as the plagioclase feldspar group of minerals, and can be released to water during weathering processes. It is also a major component of some evaporites, limestone, dolomite, and carbonate material cementing some sandstones. A limit for calcium has not been established; however, calcium is usually the major contributor to hardness in water and, to total dissolved solids.

6.1.4.2 Magnesium

Magnesium can be derived from minerals such as olivine and pyroxine in igneous rocks, from chlorite and montmorillonite in altered rocks, and from such

Table 6.2

Recommended Limits for Selected Parameters (Guidelines for Canadian Drinking Water Quality, 1978).

Parameter	Maximum Acceptable Concentration
Calcium	no limit recommended
Magnesium	no limit recommended
Sodium	for people on sodium restricted diets a limit of 20 mg/l is suggested
Sulphate	500 mg/l
Chloride	250 mg/l
Iron	0.3 mg/l
Manganese	0.05 mg/l
Fluoride	1.5 mg/l
Nitrate (as N)	10 mg/l
Arsenic	0.05 mg/l
Hardness (as CaCo$_3$)	80 to 100 mg/l is considered the optimum range
Total Dissolved Solids	500 mg/l
pH	6.5 to 8.5

sedimentary rocks as dolomite. Magnesium is the second most significant contributor to hardness in most natural waters.

6.1.4.3 Sodium

Sodium is found in igneous rocks in such minerals as feldspar and in such evaporites as halite (or common salt). A major source of sodium from human activities is highway de-icing. A maximum limit has not been set in the **Guidelines for Canadian Drinking Water Quality, 1978**. However a limit of 20 mg/l is suggested for people on low salt diets.

6.1.4.4. Sulphate

Sulphate can be produced by the oxidation of sulphides such as pyrite. The evaporites, gypsum and anhydrite, are relatively soluble and can yield large amounts of sulphate to groundwater. Sulphate (greater than 500 mg/l) in drinking water can impart a noticeable taste and cause catharsis and gastrointestinal irritation.

6.1.4.5 Chloride

Most chloride in groundwater is derived from sedimentary rocks such as evaporites (e.g. halite) or ancient sea water trapped in marine shales. Highway de-icing salts can impart high chloride to groundwater locally. Chloride in excess of 250 mg/l may impair the taste of water and beverages made from it.

6.1.4.6 Iron and Manganese

Iron and manganese are commonly distributed in the earth's crust. Manganese can also be derived from decaying vegetation. Excessive iron and manganese can stain laundry and plumbing fixtures and can impart undesirable tastes to beverages. High iron and manganese however, do not pose a hazard to health.

6.1.4.7 Nitrate

Nitrate, expressed in this report as the sum of nitrate and nitrite (as nitrogen), is derived from the bacterial oxidation of organic forms of nitrogen, such as in animal waste. Nitrate in excess of 10 mg/l (as N) is considered to cause infant methaemoglobenimia (cyanosis).

6.1.4.8 Arsenic

Arsenic may be leached into groundwater from the oxidation of arsenic bearing sulphides. In Nova Scotia this has been related to the oxidation of the sulphide, arsenopyrite (Gibb et al 1977). Arsenic concentrations in excess of 0.05 mg/l are considered hazardous to health.

6.1.4.9 Fluoride

Fluoride in groundwater may be derived from a variety of minerals found in igneous rocks and resistate sedmiments, such as fluorite, apatite and amphiboles. Excessive fluoride in drinking water may produce dental fluorosis, or mottling of the teeth. However, small amounts of fluoride may contribute to a substantial reduction in dental cavities. The maximum acceptable concentration of fluoride is 1.5 mg/l.

6.1.4.10 Hardness

Hardness of water is characterized by excessive soap utilization and, in one type of hardness, the formation of incrustation on plumbing when water is heated. Extremely soft waters are usually corrosive. Hardness is caused by polyvalent metal ions, principally calcium and magnesium ~~manganese~~. Hardness in excess of 200 mg/l (as $CaCo_3$) is considered to be unacceptably high. Hardness in the range of 80 to 100 mg/l is considered to be optimum.

6.1.4.11 Total Dissolved Solids and Conductivity

Total dissolved solids (TDS) refers mainly to the inorganic solids dissolved in water. A limit of 500 mg/l has been established on the basis of aesthetic considerations; however, the actual effect of high TDS will depend upon the level of the various components, such as those contributing to hardness or taste.

Conductivity, or the ability of the water to conduct electricity, varies proportionally to the TDS and therefore serves as a quick, inexpensive means of estimating TDS. For practical purposes, TDS varies from about 0.55 to 0.75 of specific conductance (Hem, 1970, pg. 99). Conductivity is measured as specific (or unit) conductance and is expressed as micromhos per centimeter (umhos/cm).

6.1.4.12 pH (Hydrogen Ion Activity)

The hydrogen ion activity (or effective concentration) is used as a measure of the degree of acid or alkaline quality of water. Since very low concentrations of hydrogen ion are found in most natural waters, it is convenient to express the values as logarithms; "pH" means "the negative logarithm of the hydrogen ion concentration". A pH of 7 is considered to be neutral, anything lower is acid, and anything higher, alkaline. An optimum range for pH is considered to be from 6.5 to 8.5. Lower values may enhance corrosion and higher values, incrustation.

6.1.4.13 Alkalinity

Alkalinity in natural water is the capacity of the water to neutralize acid. Various chemicals can contribute to alkalinity, but in most natural waters carbonate and bicarbonate ions produce most of the alkalinity. There is no limit established for alkalinity. It is, however, significant in water treatment considerations.

6.1.5 Chemical Quality of Groundwater in the Hydrostratigraphic Units

6.1.5.1 Horton Group

No samples are available from wells in the Horton Group in Pictou County. Hennigar (1972) observed, for the Horton Group in Colchester County, that groundwater was typically calcium bicarbonate with moderate hardness and moderate levels of total dissolved solids. The waters were slightly basic and low in iron.

6.1.5.2 Windsor Group

Samples taken from the Windsor Group indicate some sodium and calcium chloride waters; in some of the samples, the bicarbonate anion predominates. The groundwater in the Windsor Group is characterized by high dissolved solids and is often very hard. The general poor quality water may be attributed to the widespread occurrence of evaporite deposits and limestone in the Windsor Group. Half of the analyses recorded "extreme" hardness values of over 300 mg/l as $CaCo_3$, reflecting the contribution of calcium carbonate and calcium bicarbonate from limestone.

Callan (1979) noted that an increase in total dissolved solids occurred with time during a pump test conducted on a test well at Satellite Slopes. This suggests more highly mineralized groundwater at depth within the aquifer, especially in view of the fact that shallow wells in the vicinity experienced no problems with total dissolved solids.

6.1.5.3 Canso Group

The groundwater from the Canso Group is generally of good quality. In the samples analysed, all the constituents were well below acceptable limits except *iron and manganese, which, in half of the samples,* were present in excessive concentrations. Mean values for iron amd manganese are .56 mg/l and .10 mg/l, respectively. Excluded from this calculation was sample No. 11, where contamination was suspected. Waters tend to be somewhat soft to moderately hard. The tri-linear plot in Figure 6.2 indicates calcium bicarbonate and some sodium chloride waters.

6.1.5.4 Riversdale Group

Analyses of samples from the Riversdale Group indicate that this bedrock unit yields two different chemical classes of groundwater. Half of the samples analysed may be classified as sodium chloride water, the other half as calcium bicarbonate water (see Figure 6.3). Highly mineralized groundwater has been reported from wells drilled in the Scotsburn and Saltsprings areas (files N.S.D.O.E.) and in the Three Brooks area (Vaughan, 1976). It has been suggested that this may be caused by deep seated evaporite deposits (Stevenson, 1959), although it is *possible the source of this problem is salt water in*trusion occurring in Three Brooks. Samples No. 21, 22 and 23 were taken at 24 hour intervals during the pumping of test wells at Durham. It was found that dissolved solids increased by 95 mg/l over a 72 hour period of pumping, which suggests that higher dissolved solids concentrations are found as water is drawn from greater depth. This situation is similar to that found by Callan (1979) at Satellite Slopes (previously described under the Windsor Group). Total Dissolved Solid concentrations are generally low to moderate, except in the areas described above where evaporite deposits may be affecting water quality. The water is moderately hard.

not in references

Mean values for iron (1.32 mg/l) and manganese (0.19 mg/l) exceeded acceptable limits of 0.30 mg/l for iron and 0.05 mg/l for manganese.

6.1.5.5 Cumberland Group

Groundwater from the Cumberland Group was found to be within acceptable limits for all chemical constituents and tends to be soft to moderately hard. Relatively high sodium concentrations have been noted in some samples, and this may result from a natural softening process such as ion exchange or membrane effects (Hanshaw, 1964; Hanshaw and Zen, 1965). The waters tend to be predominantly sodium bicarbonate although calcium predominates in two samples.

6.1.5.6 Stellarton Series

Wells drilled into the Stellarton Series often yield very poor quality groundwater. The water chemistry in this unit is probably strongly influenced by coal formations and abandoned coal mines. Fifty percent of the samples recorded concentrations of iron and manganese above recommended acceptable limits. Iron and manganese are probably the major contributors to high values of colour and turbidity.

The hardness of the groundwater varies from 4.8 mg/l to 282 mg/l as $CaCo_3$, averaging 130 mg/l. Bicarbonate and chloride are the predominant anions and may be represented as sodium and calcium bicarbonate and chloride in various samples.

6.1.5.7 Pictou Group

Groundwater from the Pictou Group is generally of good quality. It is typically calcium sulphate and calcium bicarbonate water (Figure 6.6) Total dissolved solids concentrations are moderate and the water may be classed as moderately hard to hard. Iron slightly exceeds the acceptable limit of 0.3 mg/l in 25 percent of the samples. Manganese exceeds 0.05 mg/l in 70 percent of the samples. In several instances manganese concentrations exceeded iron concentrations. During pumping of Test Hole No. 7 at Abercrombie, fluoride increased from 0.3 to 2.5 mg/l. Fluoride in excess of 1.5 mg/l has been noted for some wells sampled in the Plymouth area of Pictou County (Cross and Rushton, 1976.)

6.1.6 Salt Water Intrusion

Salt water intrusion into wells drilled near the coast of Pictou County is not as severe a problem as it is in other coastal areas of the province. Very few cases have been reported from Pictou County and these have either been in deep wells, pumped at a high rate, such as one well formerly serving the Town of Pictou, or wells drilled through significant thicknesses of shale, such as a cottage well on Caribou Island and a well drilled for the Nova Scotia Housing Commission in River John. The former was drilled 81 feet into shale and the latter was 125 feet deep and penetrated 76 feet of shale. An increase in the salt content of groundwater with pumping was observed during the pump test of test well No. 7 at Abercrombie. This may indicate incipient salt water intrusion or it may be related to the salt problem noted above for the Riversdale Group. All of these wells were drilled in the Pictou Group.

A large number of wells have been drilled along the coast into both the Pictou and Riversdale Groups. Because of bank erosion, the casing of one well in the area of the Pictou/Colchester County line is now practically in the intertidal zone and is surrounded with water during extreme high tides. This well, however is unaffected by salt water intrusion. There may be several explanations for this lack of salt water intrusion: moderate well depths, low pumping rates, intermittent pumping (cottages), relatively high freshwater head and relatively high transmissibilities.

6.1.7 Formation Salt

Locally, formation salt may be a more serious problem. As mentioned previously, problems with highly mineralized water have been reported from the Windsor Group, and sporadically in the Riversdale Group. Insufficient data is available to determine the mode, location and extent of occurrence of this problem in Pictou County.

6.2 Surface Water Quality

6.2.1 Introduction

Surface water is subject to extreme variations in quality with time and changing conditions in the watershed. These variations can result from natural changes in total flow in a river and in the ratio of baseflow to runoff contributions to the river. Excess runoff after a severe rainstorm can carry relatively high sediment loads to a river. Various human activities can cause short-term or long-term changes in the quality of a river.

The purpose of the sampling program was to provide an indication of the baseline water quality of four major rivers draining to the area of the five towns. Accordingly, the program sought to avoid collecting unrepresentative samples, such as after a rainstorm or immediately downstream from a possible source of pollution. It was, however, designed to observe quality during high flow and low flow periods, the higher river stages of early spring and the lower stages of late summer. The observation of representative bacterial quality would have required frequent sampling, and therefore bacteria were not studied. Lakes in the study area were felt to be too few and insignificant to be included in the study.

6.2.2 Methodology

Initially, in August 1978, samples were taken from 17 stations on the West, Middle, East, and Sutherland Rivers. Access problems allowed only 13 stations to be sampled in April 1979, and the number of stations sampled was limited to 15 in August

1979. The number of parameters was greatest for the low flow conditions of August 1978, when it was felt that any trace elements might tend to be at relatively high concentrations (i.e. highest base flow). It was felt to be reasonable to reduce the number of parameters for the subsequent samplings. The data are tabulated in Table D.4, Appendix D.

Samples were taken from the main flowage of the stream about midway in the water column. Acid washed polyethylene plastic bottles were used. Samples taken specifically for trace element analysis in August 1978, were treated in the field with 5 percent nitric acid. Samples were submitted for analysis within a week of sampling. Analyses were conducted by Geolimnos Consulting Limited, Halifax and at the Environmental Chemistry Section of the Division of Clinical Chemistry, Dr. D.J. Mackenzie Laboratories and Diagnostic Centre, Halifax.

Wherever possible, gauge heights were recorded at the time of sampling. Where there were no gauges, flows were estimated.

Sampling locations are presented on Figure 6.5 and in Table D.1, Appendix D.

6.2.3 Results and Discussion

Overall water quality is generally good by comparison with the **Guidelines for Canadian Drinking Water Quality, 1978.** The notable exception is the West River during low flow period. In August 1978, sodium was 155 mg/l, chloride 259, and total dissolved solids 548 mg/l at station No. 2 (Limerock). Samples taken the same day at station No. 1 (Durham) were of better quality, with sodium at 92 mg/l, chloride at 150 mg/l, and total dissolved solids at 249 mg/l. Upstream from Limerock at station No. 1, sodium was 4.8 mg/l, chloride 6.8 mg/l, and total dissolved solids 50.8 mg/l.

Somewhere between station No. 1 and No. 2 the West River is receiving relatively highly mineralized water, most likely in the form of baseflow; relatively mineralized groundwater is known to occur in that general area (files N.S.D.O.E.).

A problem common to all the rivers is a noticeable increase in turbidity after rainstorms. No samples were taken under these higher turbidity conditions, but this phenomenon should be studied, especially in the design of water treatment facilities.

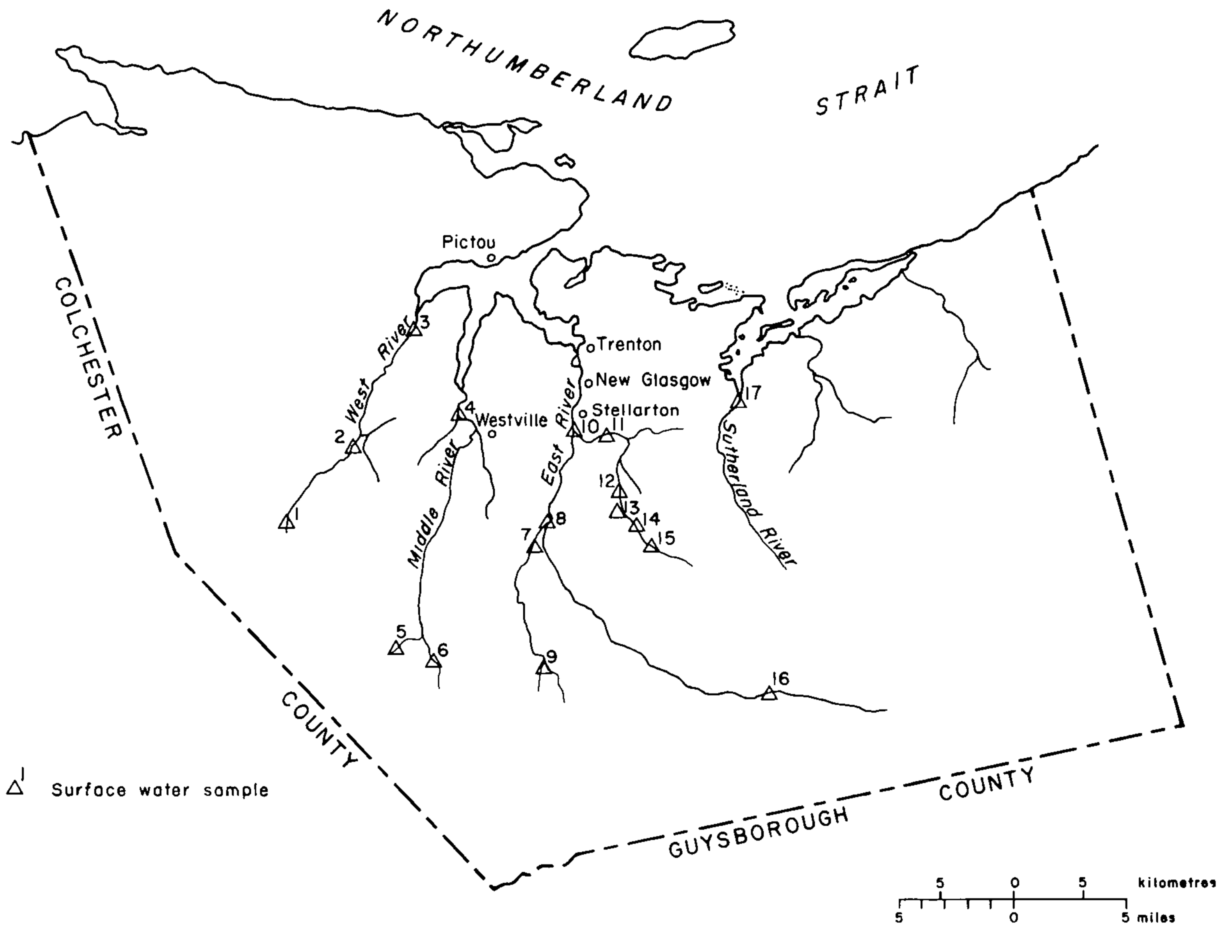


Figure 6.5 Surface Water Sampling Sites

Occasional elevated manganese values were noted, but these were only marginally above the limit of 0.05 mg/l, with the highest being 0.08 mg/l.

Two general trends in river water quality are suggested:

1) There is a tendency for total dissolved solids concentration to increase in the downstream direction on all but the West River, from station No. 2 to station No. 3, and the East Branch of the East River, from station No. 8 to station No. 10. (Figure 6.6). As discussed previously, the West River is receiving an influx of highly mineralized water. Less mineralized water discharging to the river downstream likely resulted in the dilution observed at station No. 1. The dilution trend from station No. 8 to station No. 10 on the East Branch of the East River appears to have been caused by mixing with more dilute waters from the West Branch of the East River (compare No. 3 and No. 4, Figure 6.6).

2) Water tended to be much more highly mineralized in samples taken during the very low flow period of August 1978, than during the higher flows of April and August 1979. The conductivity values represented in Figure 6.6 illustrate this. However, comparison of conductivities between samples taken in August 1979 to those taken in April 1979 indicates a less marked trend. In fact, in many cases the situation is reversed, with the conductivities greater for samples taken during the higher flows of April 1979. Note, for example, the East Branch of the East River in Figure 6.6.

It should be noted that the data, three sampling events, are limited, and therefore caution should be excercised in their interpretation and use. In order to be confident of understanding the quality characteristics of the rivers, information based on longer term monitoring at more frequent sampling intervals is required.

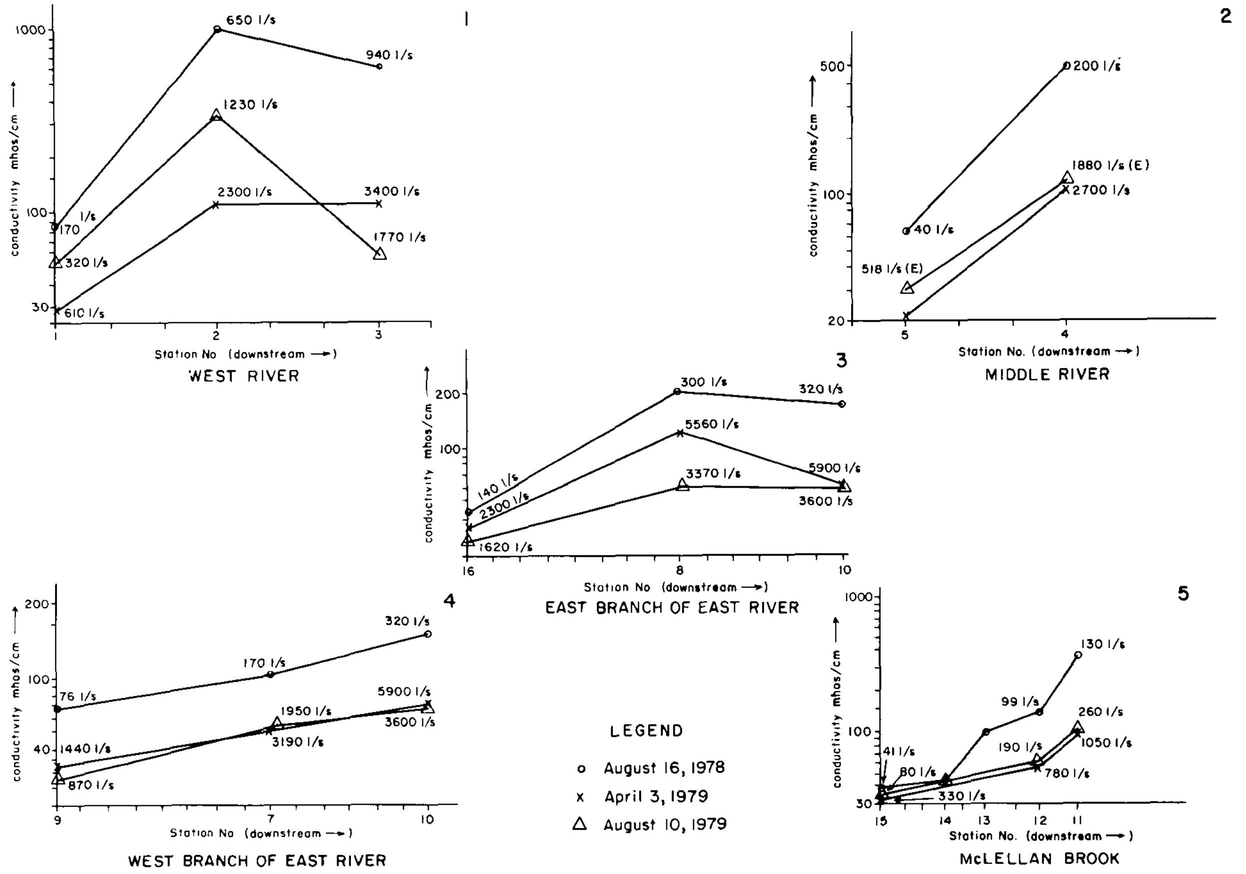


Figure 6.6 Conductivity and Flow Rates at the Stations During the 3 Sampling Periods

CHAPTER 7
Environmental Survey

7.1 Introduction

A general survey of the Pictou study area was undertaken to document human activities that might affect water quality. No attempt was made to quantify these effects.

7.2 Methodology

The environmental survey involved a review of the literature and field investigations.

The survey was conducted for each major watershed and other selected regions, and covered the following activities: agriculture, forestry, mining, solid waste disposal, domestic sewage, industrial effluent, and highway de-icing salt storage depots. Potential point sources of pollution are plotted on Figure 7.1. The results of the survey are summarized in Table 7.1.

7.3 Results

7.3.1 East River

The East River watershed is the largest in the study area comprising approximately 572 sq. km. (221 sq. mi.). It is also the most highly industrialized and urbanized basin in the county. Environmental stresses in the headwaters region of the East River could result primarily from agricultural and clear-cutting activities. A large area in the extreme southeastern part of the watershed has been denuded of forest cover as a result of a forest fire. Points have also been identified where unauthorized open dumping is occurring, particularly at the sides of back roads.

The towns of Trenton, Stellarton, and New Glasgow

Table 7.1

Survey of Human Activities Which Have Potential to Affect Water Quality

Activity	Watershed							
	Barney River	French River	Sutherland River	East River	Middle River	West River	River John	Other Regions
Mining	12	7	7	13	9	5	7	3
Sawmills	-	2	1	4	1	2	1	-
Treated domestic & industrial sewage out fall.	-	-	-	5	1	2	-	-
Untreated domestic & industrial sewage outfall	-	-	-	1	1	-	-	1
Authorized solid waste disposal site.	-	-	-	1		-	6	11
Unauthorized solid waste disposal	1	1	1	9	1	2	-	6
Industrial solid waste disposal	-	-	1	9	2	1	2	-
Feedlots	6	-	4	3	8	10	6	22
De-icing salt storage depot	1	-		1	-	1	-	1

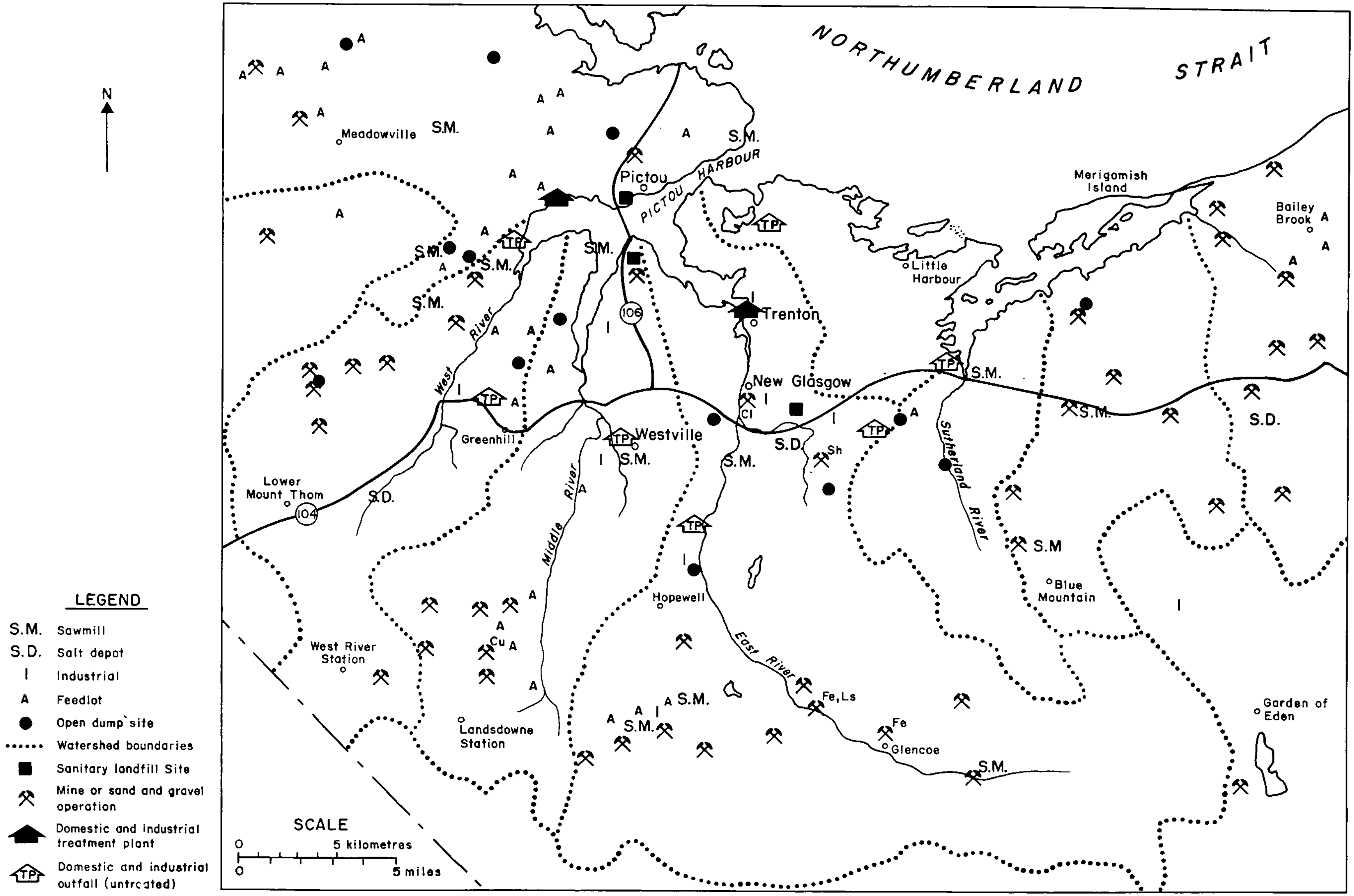


Figure 7.1 Environmental Survey, Pictou County

occupy the banks of the river in an area 3.2 to 11.3 km. (2 to 7 mi.) from its point of discharge into the Northumberland Strait. Most of the industrial activity within the study area is located here as well. The usual runoff associated with urban areas can be expected from these towns. This runoff typically includes de-icing salt, gasoline and oil products, sediment, leaves, grass clippings, and various bacteria and other microbes. The three towns utilize the sewage treatment plant located between New Glasgow and Trenton. The treated effluent is discharged into the East River. Communities lying outside of the serviced town rely primarily on individual on-site sewage disposal systems.

Refuse from the entire county is collected weekly and trucked to the 43 hectare (106 acre) sanitary landfill operation at Priestville. The landfill receives domestic, commercial and industrial waste. Routine monitoring of wells and surface water in the vicinity of the site has been conducted since its opening. To date, no pollution caused by the landfill has been observed (N.S.D.O.E. files).

The two major industries in the watershed, Scott Maritimes Limited kraft pulp mill and Canso Chemicals Limited calc-alkali chemical manufacturing plant, dispose of their industrial effluent via the provincially operated waste treatment facility at Boat Harbour. The system has been recently modified and tests to date indicate that the performance of the treatment process equals or exceeds design parameters. Both Scott Maritimes Limited and Canso Chemicals Limited dispose of their solid waste at on-site landfill operations.

A heavily industrialized area exists in Trenton situated on the east bank of the East River. This area includes the Hawker-Siddley Trenton Car Works, the Nova Scotia Power Corporation coal-fired generating plant, and several bulk oil and gasoline product storage facilities.

7.3.2 Middle River

Possible point sources of pollution in the headwaters region of the Middle River are mainly agricultural and clear-cutting activities, and points where people are dumping refuse along roads. There has been extensive quarrying of gravel north of Landsdowne Station.

The town of Westville is the only major urban center in the watershed. It operates its own domestic sewage treatment plant, which discharges its treated effluent into McCulloch Brook. The Drummond Colliery in Westville is, at present, the only operating coal mine in the County. Mine water from the colliery galleries is also pumped into McCulloch Brook. The workings of non-operational coal mines are a concern that could affect water quality in areas where drilled wells penetrate bedrock formerly mined for coal. The establishment of an hydraulic connection between water held in old workings and a pumping well could result in the appearance of an acidic water having a strong hydrogen sulphide odor and a high concentration of minerals ions.

The Michelin Tire Corporation operates a tire manufacturing plant in Granton, adjacent to the Middle River near its mouth. The plant treats its domestic sewage and disposes of its solid waste at an on-site landfill facility. The Company also utilizes the regional sanitary landfill at Priestville, where it disposes mainly rubber compounds and rejected tires.

7.3.3 West River

The West River originates in the highlands near Mount Thom and empties via Pictou Harbour into the Northumberland Strait. Forestry activity, agriculture and mining are the main environmental concerns in the upper watershed area. There is very intense aggregate quarrying in the Six Mile and Four Mile Brook areas and some of these quarry sites have become points of unauthorized dumping.

Active farming operations are conducted adjacent to the river and along the floodplain from Saltsprings to Durham. Highway de-icing salt is stored in a shed at Saltsprings. The construction of drainage ditches to help control surface runoff may be required to minimize the possibility of salt pollution.

7.3.4 River John, Sutherland River, French River, Barney River

The watersheds of River John, Sutherland River, French River, and Barney River, are outside the major growth areas of the county, removed from employment centers. The major concerns here are agricultural, forestry, and aggregate quarrying activities.

The River John watershed is largely devoted to farming. Statistics Canada figures indicate that the trend in this area is toward larger size farms. (Statistics Canada, Census of Canada, 1971) Dairy farming is the main agricultural activity, followed by pig and poultry operations. A large milk processing plant is located in Scotsburn. Untreated effluent from the plant is discharged into Black River.

The watersheds of the Sutherland, French and Barney Rivers are located in the eastern half of the county. There has been extensive clear-cutting in some locations. Several quarries, many of the bootleg variety, are located on Map 3. The main industrial operation is the Warren Maritimes Limited asphalt plant in Broadway. The plant retains its runoff in settling ponds prior to its release into the East French River. Several sawmills in the area are located on Figure 7.1.

7.3.5 Other Regions

These regions include the southern part of the county not drained by the previously mentioned rivers, and the area along the Sunrise Trail from River John to the town of Pictou.

The area in the southeastern part of the county is drained by the Moose and St. Mary's river systems. The activities in this region are mainly forestry and agriculture, with some aggregate quarrying. The amount of agricultural activity has decreased in recent years. The harvesting of pulpwood, however, has increased over the same period.

The shoreline along the Sunrise Trail has been the site of extensive cottage development, with large tracts of farmland subdivided and sold as small lots. Inland from the coast, agricultural activity is still prevalent, primarily in the form of high volume operations such as, piggeries, poultry, and sheep farming. Forestry operations include the production of pulpwood and lumber from small mills in the area.

The main urban center is the town of Pictou. The town operates an open dump within the town limits which handles a small volume of wood and non-organic refuse from commercial enterprises. There is a small incinerator on the site and combustibles are burned on the face of the dump as well. Untreated sewage from the town is discharged into Pictou Harbour.

7.4 Overall Effects

The results of the survey show that current human activities within the study area have not resulted in serious deleterious effects on regional water quality.

CHAPTER 8
Special Projects

8.1 Water Supply for the Four Town's Region

8.1.1 Introduction

A preliminary study has been conducted by the Department of the Environment of the water supply options available to the region of the four Towns of Trenton, New Glasgow, Stellarton and Westville. Information obtained during the Pictou County Study was utilized to denote and examine several such options, including both groundwater and surface water sources.

8.1.2 Previous Work

Various studies have been conducted into a water source for the four towns region.

In 1972, W.N. Horner and Associates Limited noted:

1. The average daily demand of New Glasgow is far in excess of the firm yield of Forbes Lake.

2. For the Town of Stellarton, the East River is capable of producing adequate quantities during low flow periods. However, during these periods and after heavy rains the quality of the water deteriorates.

3. The quantity of water available to the Town of Westville from the Middle River is not considered adequate for the projected population to design year 1991.

In 1975 Canadian British Consultants Limited recommended:

1. Installation of a pumping station on the East River below the confluence of the East and West Branches to pump water into Forbes Lake for storage. New pipelines would be installed to serve Stellarton, Westville, New Glasgow and Trenton.

2. Installation of a treatment plant at the outlet of Forbes Lake, with an initial capacity of 6.0 million gallons per day which may be increased to 9.0 mgd.

8.1.3 Current Study

8.1.3.1 Surface Water

The surface water options examined during the current study are presented in Table 8.1 and are located on Figure 8.1. The estimated yields are given in Table 8.1.

The estimates of yield in Table 8.1 were calculated from summer flows of the Middle River at Rocklin. Good correlation of flows between the Middle River and other rivers monitored in Pictou County in 1978 has been observed (see Chapter 4, Hydrometeorology). A drought frequency curve was constructed based on the summer flows from 1967 to 1975 (Figure 8.2). This indicates that flow practically dries up at a recurrence interval of 10 to 20 years. This suggests a need for additional storage.

Figure 8.3 gives potential lake storage per foot of increased lake level on MacPherson, McKinnon and West Branch Lakes and gives storages for various dam heights on West Branch East River, McLellan Brook and McDonald Brook. The reference maps were the NTS series at a scale of 1:50,000 and therefore the degree to which it is practical to increase storage (if at all) must be further investigated.

Total dissolved solids increases during very low flow periods, reflecting an increase in the baseflow component (see chapter 4, Hydrometeorology, and chapter 6, Chemical Quality of Water). Increases in algal growth during summer may be adversely affecting the taste of water in Stellarton. Increases in turbidity after rain storms have been observed.

8.1.3.2 Groundwater

An analysis of groundwater in Pictou County (see chapter 5, Hydrogeology and chapter 6, Chemical Quality of Water) has demonstrated that the Pictou and Riversdale Groups of bedrock have the potential to yield significant quantities of good quality groundwater from wells near the towns of Trenton, Stellarton and New Glasgow. Yields of 25 to 40 igpm (or higher) could be obtained from individual wells. Thus the development of well fields could significantly augment water supplies in the region at much less cost than additional surface water supplies.

8.2 Water Supply Project for the Town of Pictou

8.2.1 Introduction

In 1977 the Pictou County Regional Water Resources Evaluation Project participated with other government agencies in assisting the Town of Pictou to expand and improve its water supply. The Town of Pictou has been experiencing chronic water shortage problems for over ten years. Accordingly, C.B.C.L. Engineering Consultants were engaged to conduct a groundwater exploration and development project. The major findings of this study, found in detail in Callan (1978), are summarized below.

Table 8.1
Estimate Yields of Various Drainage Basins

BASIN	DRAINAGE AREA km^2 (mi^2)	YIELD[*] m^3 (ig/day) x 10^6
MacPherson Lake	1.74 (1.08)	0.00050 (0.11)
McLellan Brook	2.69 (16.7)	0.0077 (1.7)
McKinnon Lake	0.92 (0.57)	0.00026 (0.057)
McDonald Brook	1.22 (7.60)	0.0035 (0.76)
West Branch Lake	1.11 (6.90)	0.0031 (0.69)
West Branch East R.	2.38 (14.8)	0.00068 (0.15)

[*] Assumes a dry period in September when the yield is 0.284 m^3/km^2/day (0.10 mig/mi^2/day) which recurs about every 7 years. This avoids the lowest points on the Drought Frequency Curve.

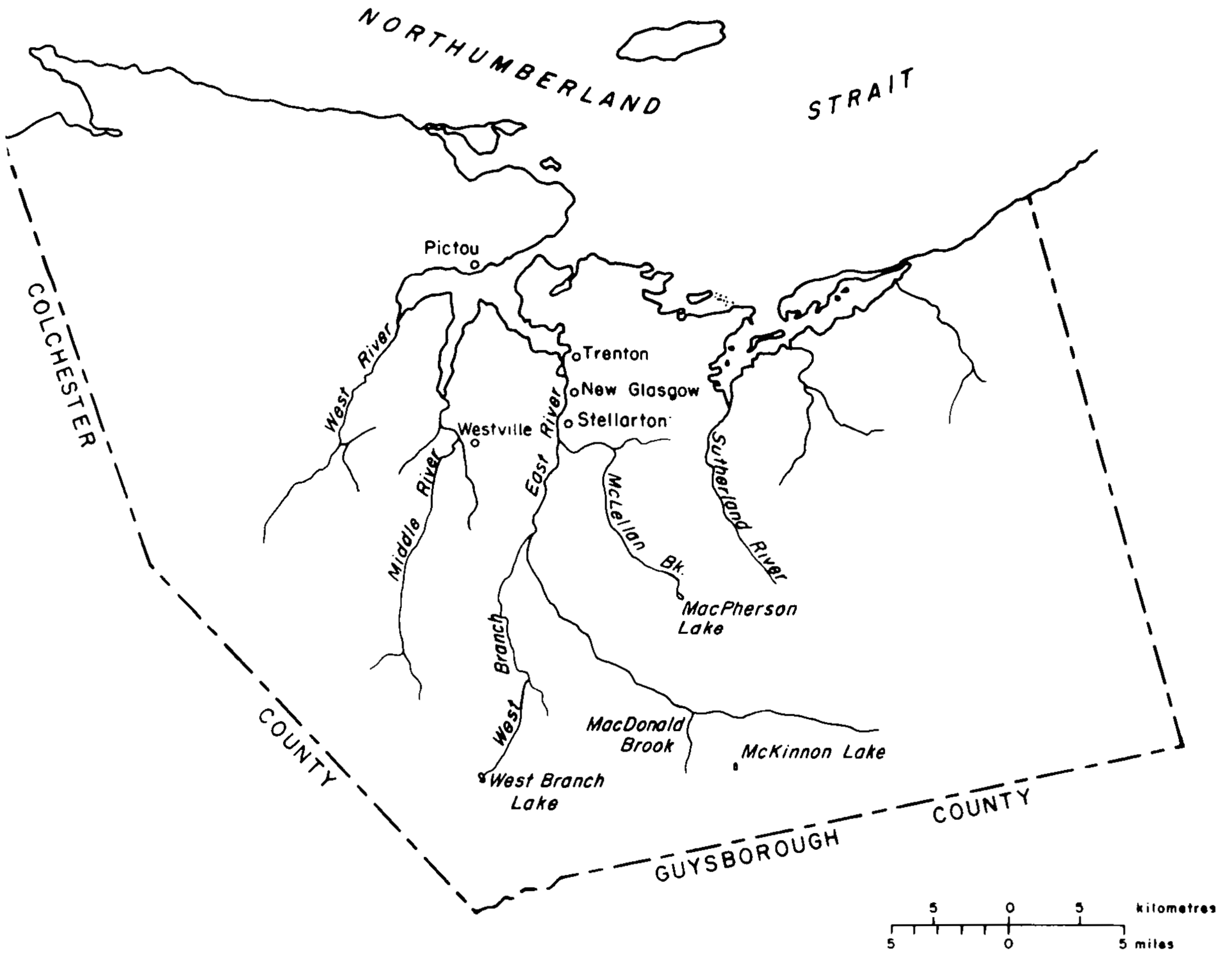


Figure 8.1 Surface Water Options

8.2.2 Results

1. In addition to the 1.23 m^3/min (270 igpm) currently being used by the Town, an estimated additional 1.36 m^3/min (300 igpm) is exploitable from groundwater in the Caribou area on a long term basis. This should serve the Town's future needs.

2. The quality of the water is generally good, although moderately hard; some treatment for reduction of iron and manganese may be required.

3. Further exploration may discover additional exploitable groundwater supplies.

4. The shallow aquifer is very susceptible to serious or even permanent damage from human activities. Therefore, a comprehensive Watershed Management scheme should be instituted.

8.2.3 Aquifer Protection

The problem of aquifer protection was addressed by Callan (1978) and MacDonald and Peck (1979) who outlined its nature and offered various recommendations for the management of the watershed area. Potential damage to the aquifer could result from such diverse activities as mining of aggregate on the watershed (which could reduce groundwater storage capacity), development on the watershed, road de-icing, disposal of waste materials, and possible spills of petroleum products or hazardous chemicals. Suggested preventive measures included purchase of watershed lands, restricted access to the lands, prohibition of aggregate mining, prohibition of waste disposal, restriction of the transport of petroleum and hazardous materials, construction of drainage facilities to divert highway run-off and the posting of caution signs in the watershed area.

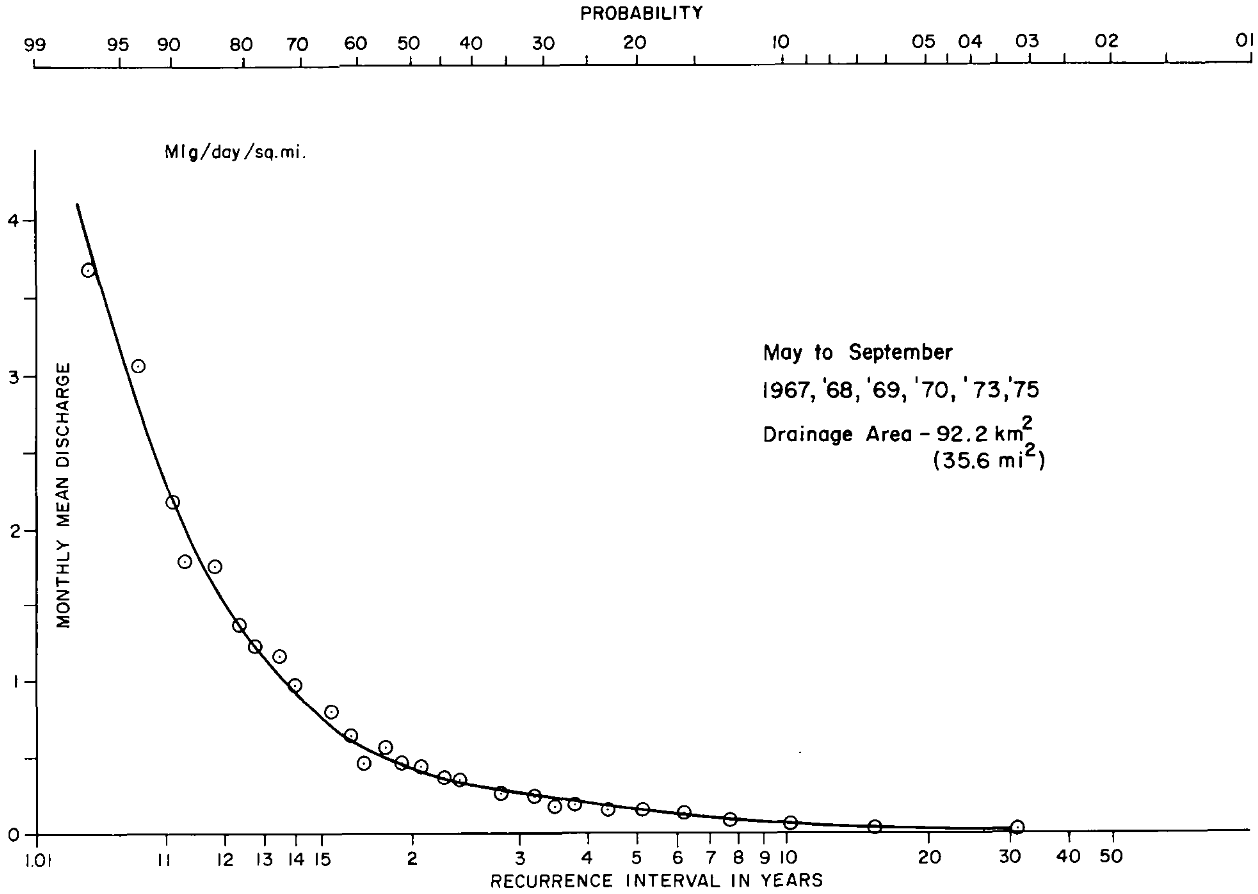


Figure 8.2 Drought Frequency Curve, Middle River

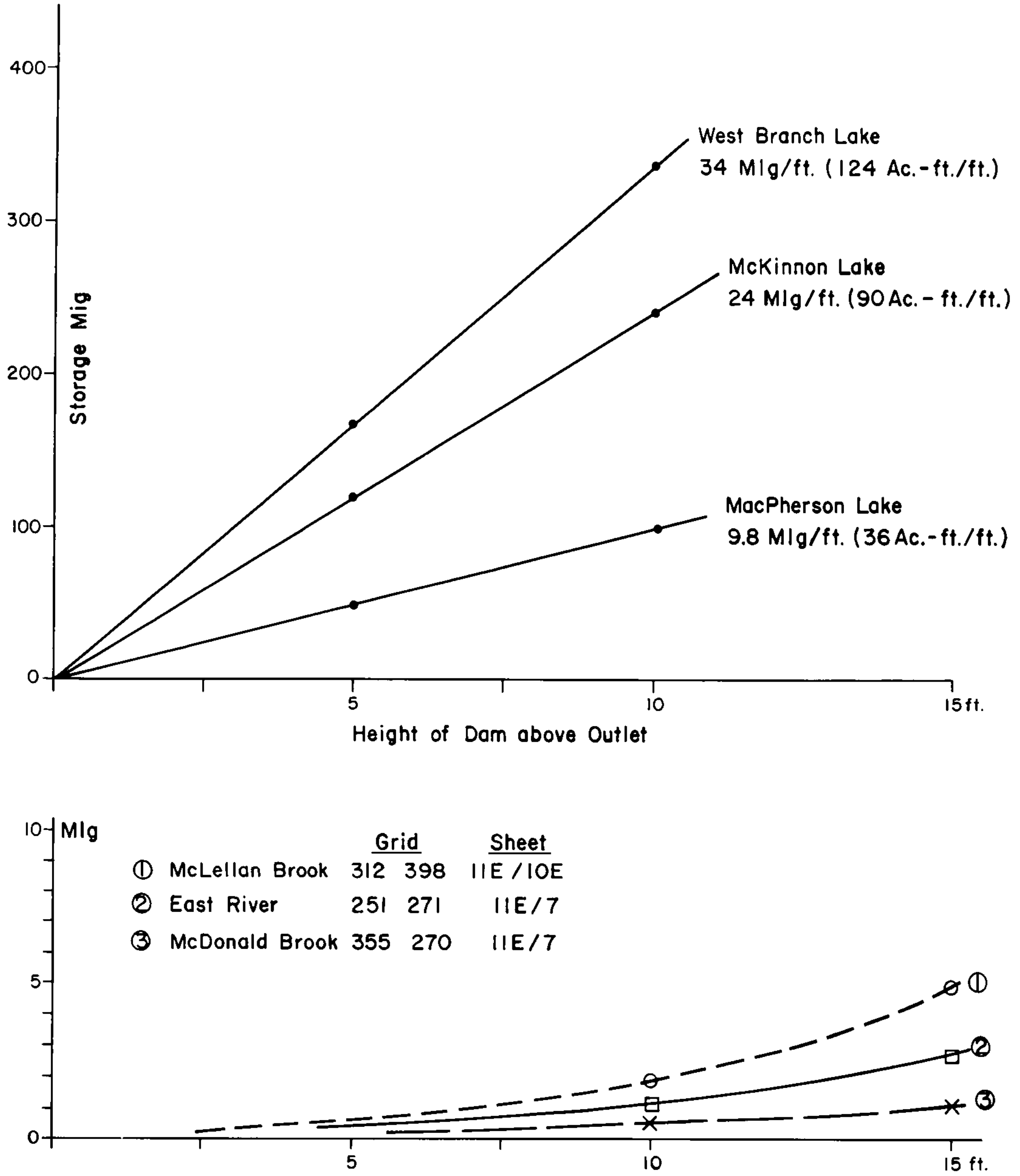


Figure 8.3 Increases in Storage with Dam Height

CONCLUSIONS

The Pictou County Water Resources Evaluation Project has identified a potential for adequate water supplies from both surface water and groundwater sources. Planners of water supplies should consider both of these options.

Three major river basins drain into the region of the population centres: the West River (drainage area 239 square kilometres), the Middle River (234 square kilometres), and the East River (565 square kilometres). Average daily yields are, from the West River 3.30 x 10^5 cubic metres (1.17 x 10^6 gallons), from the Middle River 3.2 x 10^5 cubic metres (7.05 x 10^6 gallons), and from the East River 7.8 x 10^5 cubic metres (1.71 x 10^7 gallons). However, summer low flows are about 2 percent of average daily flows. Additional storage would be required to ensure sustained minimum required flows during low flow periods.

The quality of the water is generally satisfactory with the exception of possible turbidity problems after storms and, on the West River at Limerock, high dissolved solids during low flow periods.

The Pictou Group and Riversdale Group aquifers may have potential to provide groundwater to supply or augment the supplies of major industrial or municipal users. Yields per 30 m (100 ft) of drilling in the Pictou Group range from 0.0045 to 2.73 m^3/min (1 to 557 igpm) and average 0.19 m^3/min (38 igpm). The Riversdale Group ranges from 0.0045 to 2.57 m^3/min (1 to 526 igpm) and the average is 0.22 m^3/min (44 igpm) per 30 m (100 ft) of drilling.

Water quality is generally acceptable according to the **Guidelines for Canadian Drinking Water Quality, 1978.** However, some treatment for iron and manganese removal may be desirable. Iron and manganese values average 0.40 and 0.08 mg/l respectively in the Riversdale Group and 0.26 and 0.27 respectively in the Pictou Group. Increasing salt content with depth has been noted in certain regions underlain by the Riversdale Group. Dissolved solids in excess of 7000 mg/l have been reported in the Three Brooks area.

The Canso and Cumberland Groups and the Stellarton Series have the potential to supply small to medium industries and institutions; the occasional well may yield even more. Yields per 30 m (100 ft) of drilling range from 0.0024 to 0.5 m^3/min (0.5 to 102 igpm) in these bedrock units. The Stellarton Group may be of limited value in some areas because of high iron and manganese content and odour problems, although in some cases this is treatable. Some iron and manganese may occur in the Canso and Cumberland Groups, but this can be removed by treatment.

Yields from the Windsor Group per 30 m (100 ft) of well depth range from 0.002 to 0.054 m^3/min and average 0.039 m^3/min (8 igpm). Hardness values of up to 564 mg/l (as $CaCo_3$), which is extremely hard, have been reported. For this reason and the lower expected yields, the Windsor Group should be given low priority as a potential aquifer.

In the Caribou area just north of the Town of Pictou, a limited shallow sand and gravel aquifer has been identified. It is estimated that, with proper development, this aquifer can yield up to 1.46 m^3/min (300 igpm) on a perenially safe basis.

Land use is diverse in the study area, including light and heavy industry, mining, agriculture, forestry and urban centres. There is no evidence of any serious degradation of water quality by the activities of man in the study area. Some individual cases of well contamination are on file with the Department of the Environment, but these problems have been local in nature and do not represent a regional problem.

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APPENDIX A

Planning Agreement

PROGRAM - Physical and Resource Planning
PROJECT - Water Resources Evaluation

1. Background

In 1964, the Province of Nova Scotia recognized the need for the evaluation of its groundwater resources to allow for long term planning to optimize their utilization. The Groundwater Section within the Nova Scotia Department of Mines worked towards that goal by investigating selected areas of the Province where high population densities and intensive land use were altering and increasing the demands placed upon the resource.

The following A.R.D.A. funded programs evaluated the natural potential within the respective areas:

Annapolis-Cornwallis Valley	1968
Western Annapolis Valley	1969
Windsor-Hantsport-Walton	1969
Musquodoboit River Valley	1970
Truro	1972
Strait of Canso	1975
Sable Island (funded by the Province)	1976

This represents coverage of approximately 17% of the area of province. In 1975, the incorporation of the section within the Nova Scotia Department of the Environment, and its subsequent alteration to the Water Planning and Management Division, increased its mandate to encompass not only groundwater, but surface water as well.

Two projects presently underway in the Sydney-Glace Bay and Halifax-Shubenacadie areas are designed to be total water resources evaluations. The completion of the latter two programs by April, 1977 will increase the coverage of the Province to approximately 22%.

With the recent termination of A.R.D.A., the ongoing programs in water resource evaluation have been carried on by the province. These programs have had to be curtailed, however, due to limited financial resources.

In conjunction with DREE and the Community Planning Division of the Nova Scotia Department of Municipal Affairs, two major areas of the province have been designated for future industrial growth and development. The water resources of these two areas have yet to be evaluated as a prerequisite for planned development.

While the priority areas have been identified and agreed to, it is recognized that there will be demands placed upon the Nova Scotia Department of the Environment for the preparation of detailed assessments of specific sites proposed or suggested for industrialization. These assessments are identified herein as "Special Projects".

2. The Project

A. Objectives

1. To undertake the evaluation of the occurrence, quality and quantity of surface and groundwater in specific areas of the Province.

2. To be able to assess the probability of contamination of the water resources by man-made activities and to be capable of advising on measures to be taken to alleviate these problems.

B. Rationale

Water is one of the major requirements of industry, usually in large quantities and of good quality. It may be for boilers, processing lines, sanitation or many other uses. Industry may also disgorge large quantities of water in a contaminated state.

At the present time, there are areas of Nova Scotia where there is insufficient knowledge of the water resources to advise potential industrial users of the quantity, quality and/or cost of developing adequate supplies.

It is not only necessary to know the water resources before industry moves in, but also the possible consequences on that resource after industry begins using it.

Because the geology of Nova Scotia, both morphologically and mineralogically, is very complex considerable study has to be made of the water resource before sound recommendations can be made to potential users.

In the first element of strategy of the Industrial Development Subsidiary Agreement it is stated that "In order to make development efforts more effective, it is necessary to take a more analytical approach, identifying opportunities and undertaking research on various factors relevant to a new industry, particularly analysis of financial and market feasibility, and determination of infrastructure requirements". Research into the water resources of an area and the resulting data bank will be a major tool for the encouragement and placement of industries.

Opportunity

This proposal designates two priority areas in the Province where a complete evaluation of the water resources both from the point of view of the potential for its use and the problems arising from its use, is necessary.

1. The Amherst, Springhill, Oxford Triangle
2. The Pictou, New Glasgow, Trenton area

The two areas are designated in the Industrial Development Subsidiary Agreement as areas where Industrial growth will be promoted as part of the "industrial corridor".

The Amherst, Springhill, Oxford triangle is now a growth region with the Amherst Industrial Park developing, a growing food processing industry in Oxford and some industry being promoted in Springhill.

Problems of water resource supply and management have already arisen there. The resulting data from the survey will provide a basis for the solution of these problems.

In Pictou, New Glasgow and Trenton there now exists a shortage of water supply. At the same time, the development of an Industrial Park is one of the priorities of the planners for the area. It is extremely important that the water supply for these three centers is resolved.

In the two foregoing areas there is envisaged considerable industrial growth with increased employment opportunities. This will create a growth in the urban population of the centers. The net result of this will not only be added pressure by industry on the water supply but also added pressure for domestic water.

It is understood that if funds for the Coastal Zone Inventory Mapping Program are not to be made available the province will make a further submission to DREE for funding a water resources evaluation of the South Shore, from Weymouth to Lockport. This region will be known as the Yarmouth-Shelburne area.

There is a third element in the proposal, designated as "Special Projects". From time to time there are going to be specific requests for water resource evaluations to be done in a rush for special industrial uses. This will require studies to be made in order to provide direction as rapidly as possible. Such studies could arise, for instance, as a result of a request for infrastructure support under the Industrial Development Subsidiary Agreement.

C. Description of Regional Programs

Data collection will be sufficient to permit an accurate assessment to be made at a regional scale of at least 1" = 1 mile. This will provide the initial, primary input into the regional development plans being created by the Provincial Department of Municipal Affairs.

All basic field data will be presented cartographically at a scale of 1" = 1320 feet; with associated files, that will form a departmental data base. The maps will be prepared in monotones on dylar film which will allow for rapid, inexpensive reproduction. This will facilitate the dissemination of data to governmental and private users. The province will absorb the costs of updating and maintaining the data base.

The co-sponsorship of DREE with the Province will be suitably acknowledged in any publications and/or maps resulting from these studies.

The formation of this base provides a format whereby:

1. the data presented on the maps is time independent, in that new information can be easily added and the interpretation thereof updated.

2. the much needed flexibility in the use of information is gained, i.e. from detailed site assessments to regional overviews. In terms of manpower, thus operational costs, the base will allow all users of the information the opportunity to arrive at accurate resource and environmental impact evaluations more efficiently. Because all information will be collected and desseminated from one departmental section, the time involved in research will be substantially reduced.

Investigations in each study area will encompass the following subprograms:

1. All subsurface data for the study area will be collected from 80-100 known sources and located in the field to provide data on: depth to bedrock, depth to water table or piezometric surface, minimum yields of various geological units, subsurface geology, possible sources for sampling groundwater quality, possible sources of contamination of groundwater and temporal as well as spatial distribution creation of water budgets.

2. If data is lacking precipitation, temperature and perhaps evaporation gauges will be installed. Gauge location and data assessment will be determined in conjunction with the Atmospheric Environment Service, Environment Canada.

3. If data is lacking stream sediment and water discharge gauging stations will be installed. Gauge location, installation and data assessment will be in conjunction with the Water-Survey of Canada, Environment Canada.

4. If data is lacking a stream sampling program will be carried out on dissolved sediment loadings.

5. HYDAC surveys will be carried out on major fresh water lakes/reservoirs which could be, or are being used, as a water supply to determine: bathymetry, storage capacity, surface area for evaporation, depth of unconsolidated bottom deposits and base line data for determining rate of sediment infilling, thus reservoir life.

6. Limnological studies will be carried out on certain fresh water lakes which either could be/are being used as a water supply or to quantify certain environments i.e. bedrock type underlying basin.

7. Bedrock geology maps will be updated by mapping new exposures, and interpretation of results from a groundwater quality sampling and test drilling sub-programs.

8. A groundwater sampling program will be carried out to delineate natural groundwater quality at least at the scale of bedrock "Groups".

9. A test drilling and pump testing program will be carried out to determine both the extent and thickness of gravel deposits and associated groundwater quantity and quality as well as the hydrogeological characteristics of major bedrock aquifers. Of these, certain wells will be selected for longterm monitoring of water level fluctuations through their assimilation into the Divisional Observation well network.

10. All known zones of mineralization and mining activity will be located as an aid to delineating zones of natural degraded water quality.

11. As the surficial geology has not been mapped in any of the three areas, a mapping program will be necessary, utilizing air photo interpretation and groundtruthing.

12. Sediment samples of major pleistocene deposits will be taken to quantify parameters such as: grain size, percent organic matter, ion exchange capacity, pH, conductivity, major cations and anions, and nutrients. This will enable:

(a) "K" factors to be determined for the Universal Soil Loss equation so as to determine spatial trends in erodibility.

(b) assessment of the effects of construction activities on increasing mineral concentrations in surface and groundwaters.

13. Environmentally sensitive areas such as outlined below will be delineated on national topographic sheets at 1:50,000 to add to the data base:

(a) all watersheds prescribed or unprescribed, upstream of sites where withdrawals are made for industrial, municipal or domestic purposes, (b) international biological program sites, (c) protected beaches.

D. Description of Special Projects

Due to the uncertainty of the projects which may be undertaken (i.e. extent of data available, type of data required, aerial extent and accuracy required), it is difficult to breakdown costs. Therefore a lump sum of money has been budgeted on a yearly basis. Any new data collected for these projects will be added to the Departmental data base previously described.

E. Phasing

Each of the two regional studies will require 2 years and 9 months to complete.

Based on DREE and provincial priorities the following schedule is proposed.

Amherst-Springhill-Oxford
January 1977 to October 1, 1979
New Glasgow-Pictou-Trenton
January 1977 to October 1, 1979
"Special Projects" will be undertaken as the need arises.

3. Cost Estimates/Funding

A. Project Costs

The cost of the project would be shared 50% by Canada and 50% by the Province under the terms of the Canada Nova Scotia Planning Subsidiary Agreement.

C. Commitment & Disbursement

Funds for the project are to be approved by the Management Committee. Disbursements will be made by the Department of Development for 100% of the incurred costs. The Department will, in turn, submit claims for 50% of the incurred costs to DREE Nova Scotia according to the terms of the Planning Subsidiary Agreement.

D. Tenders/Awards of Contracts

Subject to the approval of the Management Committee, the following procedures will be exercised in awarding contracts:

(A) Staff to be appointed on contract will be chosen by a selection board in accordance with standard Nova Scotia Civil Commission staffing practices. These contracts shall be terminal.

(B) Contracts for work under sections 2C and 2D of this Project Brief will be awarded following public tender in accordance with procedures established by the Nova Scotia Department of the Environment and the Planning Subsidiary Agreement. It is understood that General Development Agreement Procedures will take precedence.

E. Project Cash Flow

The project costs are estimated as shown in Table 1.

A detailed breakdown of estimated annual cost per project and the underlying assumptions are found in Table A1.

4. Organization & Management

A. Project Implementation

The project will be implemented by the Water Planning and Management Division of the Nova Scotia Department of the Environment.

B. Project Monitoring & Control

The project team will ensure that an annual progress report for the project is submitted to the Management Committee. The project team will consist of one representative of the N.S. Department of the Environment, one representative of the Department of Development, one representative of the Department of Regional Economic Expansion and one member from the Water Survey of Canada.

Table A.1

Estimate of Water Resources Evaluation Budget

Regional Evaluations **Phasing**	**3 months Amherst** **3 months New Glasgow**	**full year Amherst** **full year New Glasgow**	**fullyear Amherst** **full year New Glasgow**	**1/2 year Amherst** **1/2 year New Glasgow**
Salaries				
Full Time	7.750 - 2 people	103,600 - 8 people	113,860 - 8 people	29,954 - 4 people
Casuals (max.possible)		2,000 - 10 people	2,200 - 10 people	
Travel Expenses				
Room	480	3,840	6.108	2,000
Board	420	14,940	15,360	—
Travel	450	13,550	15,017	—
Special Services				
Drilling	—	22,000	24,000	—
Chemical Analyses	—	5,400	24,400	—
Physical Analyses	—	2,000	2,200	—
Gauges	—	24,400	13,200	—
Hydac Surveys	—	—	8,000	—
Reports	—	—	—	6,000
Equipment & Supplies				
Air photographs	1,100	300	—	—
Drafting equipment & supplies	13,280	—	220	440
Other	400	1,400	1,260	400
Total/Year	23,880	193,430	225,825	38,794

Total For Water Resources Evaluation Programs $481,929

Special Projects		50,000	—	—
Overall Yearly Totals	23,880	243,430	225,825	38,794

Grand Total $531,930

5. Tie-In With Existing & Proposed Programs

This program, as outlined, has been designed to:

A. provide necessary water resource data for the Regional Development Planning presently being carried out by the Provincial Department of Municipal Affairs.

B. augment the Coastal Zone Inventory Mapping program (to be carried out by the Provincial Department of the Environment) by providing data on freshwater resources to support the Socio-economic structure and to tie-in with the physical-biological coastal processes present in their study areas.

6. Conclusions & Recommendations

It is recommended that the Management Committee approve funds under the terms of the Planning Subsidiary Agreement for the implementation of this project.

APPENDIX B

Hydrometeorology

Table B.1

Annual Precipication (mm) at Atmospheric Environmental Services Stations

Abercrombie

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1973									26.92	78.99	59.44	105.41
1974	97.03	M	M	56.13	91.69	27.43	65.79	83.06	153.16E	105.92	95.00	122.43
1975	111.51	28.70	108.37E	39.88	61.21	M	21.08	48.26	102.87	121.16	100.33	110.24
1976	105.16	69.09	32.00	98.55	64.77	58.42	82.04	50.04	111.76	129.29	80.77	134.62
1976	TOTAL — 1016.51 mm											
						Braeshore						
1975									77.22	101.35	75.95	158.50
1976	136.65	73.41	44.96	84.84	85.60	52.83	84.07	64.77	99.06	135.64	168.15	157.23
1976	TOTAL — 1187.20 mm											

M = Missing

Table B.2

Mean Monthly Temperatures, Lismore, Stellarton and Saltsprings, °C

Month	Ratio (3)/(4)	Lismore 1978	Stellarton 1967-76	Salt-springs 1978	Ratio (5)/(4)
1	2	3	4	5	6
Jan.	-	-	-6.7	-6.6	0.9
Feb.	1.1	-7.5	-6.6	-8.9	1.3
Mar.	2.9	-5.8	-2.0	-4.7	2.3
Apr.	0.5	1.6	3.2	1.5	0.5
May	1.1	10.1	9.2	10.0	1.1
June	0.9	15.7	15.9	15.0	0.9
July	1.0	19.0	18.7	18.2	1.0
Aug.	1.0	19.5	18.7	18.7	1.0
Sept.	0.9	13.0	14.3	11.4	0.8
Oct.	1.0	9.3	9.2	8.1	0.9
Nov.	0.6	2.1	3.5	-0.3	0.1
Dec.	1.1	-3.1	-2.7	-4.5	1.7
Average	1.1*	6.7*	6.2	4.8	1.0

---

* 11 Months

Table B.3

Monthly Temperatures, Lismore and Saltsprings, 1978, °C

	.... Lismore			...... Saltsprings		
Month	Max.	Min.	Mean	Max.	Min.	Mean
Jan.	-	-	-	-1.2	-12.0	-6.6
Feb.	-3.8	-11.2	-7.5	-3.0	-14.8	-8.9
Mar.	1.7	-2.1	-5.8	0.1	-9.5	-4.7
April	4.4	-1.2	1.6	4.8	-1.9	1.5
May	15.7	4.6	10.1	16.5	3.6	10.0
June	20.5	10.8	15.7	20.1	9.8	15.0
July	23.7	14.2	19.0	23.5	12.9	18.2
Aug.	24.1	14.8	19.5	24.7	12.7	18.7
Sept.	17.3	8.6	13.0	17.0	5.8	11.4
Oct.	12.9	5.7	9.3	12.6	3.7	8.1
Nov.	6.3	-2.1	2.1	4.8	-5.3	-0.3
Dec.	0.9	-7.1	-3.1	-1.1	-7.8	-4.5
		(11-Month)			(12-Month)	
Average	9.1	3.2	6.7	9.9	-0.3	4.8

Table B.4

Monthly Mean Temperatures Stellarton, °C

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1967	- 4.7	-8.6	-5.4	-0.1	6.7	15.7	21.4	20.2	14.5	10.3	4.3	-1.9	6.1
8	- 8.3	-8.6	-0.2	5.9	8.2	13.5	19.6	16.6	15.2	10.4	1.9	-1.4	6.2
9	- 4.0	-2.0	-1.1	3.7	8.8	16.9	17.4	19.0	14.9	7.7	5.8	1.2	7.4
1970	-10.3	-5.1	-2.1	2.4	10.5	15.4	19.7	19.0	12.9	10.1	4.3	-6.0	5.9
1	- 8.9	-5.5	-0.2	4.6	11.1	14.4	19.4	18.8	14.6	9.9	3.0	-4.7	6.4
2	- 5.8	-8.6	-0.9	0.9	10.1	16.9	18.5	17.3	14.3	7.4	1.8	-4.7	5.4
3	- 6.2	-6.7	-0.9	4.1	9.3	16.9	20.9	18.2	12.6	8.1	1.9	1.5	6.7
4	- 7.1	-7.9	-2.1	4.3	6.2	15.1	17.2	19.1	14.2	6.3	3.7	-1.3	5.6
1975	- 5.7	-9.3	-2.7	1.9	9.4	14.8	21.6	18.7	14.8	7.9	5.3	-3.8	6.1
6	- 5.7	-3.9	-1.4	4.6	11.3	17.6	18.7	18.9	13.8	7.3	1.1	-5.1	6.4
Average	-6.7	-6.6	-1.7	3.2	9.2	15.7	19.4	18.6	14.3	8.5	3.3	-2.7	6.2

Table B.5

Monthly Mean Temperature, Trafalgar, °C

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average	No. Months
1965	- 8.1	- 8.6	-3.0	0.8	7.1	13.7	16.9	12.7E	11.2	6.0	0.1	-5.4	3.9	12
6	- 5.0	- 8.1	-0.9	1.8	8.6	13.8	16.6	16.9	11.3	7.8	4.9	-1.6	5.5	12
7	- 6.3	-10.7	-6.9	-1.0	5.8	14.4	19.7	18.9	12.8	8.3	2.4	-3.8	4.5	12
8	-10.1	-10.3	-1.6	4.7	7.0	12.3	18.3	15.8	14.3	8.9	0.7	-2.9	4.8	12
9	- 5.7	- 3.4	-2.6	2.7	7.3	15.3	15.8	17.5	13.2	6.3	3.8	-0.4	5.8	12
1970	-11.8	- 7.1	-3.1	1.3	9.2	14.4	18.3	16.9	11.7	8.7	3.1	-7.8	4.5	12
1	-10.3	- 6.7	-1.4	3.1	9.7	12.9	17.9	M*	12.7	7.9	1.8	-6.0	3.8	11
2	- 7.3	- 9.9	-4.8	0.2	8.6	15.4	17.4	M	12.2	5.9	0.1	-5.9	2.9	11
3	- 7.6	- 7.8	-7.7	3.1	8.3	15.6	19.4	M	11.1	6.6	0.7	-0.2	3.8	11
4	- 8.7	- 9.3	-3.6	3.5	5.3	14.2	15.9	M	M	4.8	2.2	-3.5	2.1	10
1975	- 6.8	-10.2	-4.0	0.9	8.7	13.9	19.9	M	M	6.7	3.7	-5.3	2.8	10
6	- 6.8	- 5.7	-2.7	3.7	9.9E	M	17.2	M	M	6.4	0.3	-6.2	1.8	9
Average	- 7.7	- 8.1	-3.6	2.1	8.0	14.2	17.9	17.2	12.1	7.0	2.0	-4.1	3.9	

*M = Missing

Table B.6

Record of Meterings at Temporary Hydrometric Stations

Date	River	Location	Drainage Area km²	Drainage Area mi.²	Discharge m³/s	Discharge cfs	Stage m	Stage ft.
July 20/78	McLellan Brook	At McLellan Brook	64.8	25.0	0.167	5.90	0.43	1.41
June 5/79					1.84	65.0	0.68	2.23
June 19/79					0.185	6.54	0.49	1.61
May 1/79	West River	At Saltsprings	150	58.1	2.67	94.2	0.45	1.71
June 5/79					4.16	147	0.53	2.01
June 22/79					0.92	32.6	0.34	1.12
July 20/78	Sutherland River	At Sutherland River	88.8	34.3	0.28	10.1	0.03	0.10
June 6/79					7.61	269	0.65	2.13
June 19/79					0.71	25.2	0.10	0.33
July 19/78	East River, West Branch	At Hopewell	138	53.1	0.83	29.2	0.38	1.25
Aug. 9/79					1.92	68.0	0.53	1.74

Table B.7

Correlation of Streamflow with the WSC Station No. 01DP004, on the Middle River at Rocklin, 1978.

Basin	Unit of Flow	Number Of Daily Mean Flows	Constants A	Constants b	Correslation Coefficient r
West River	cfs	44	11.4	0.44	0.87
*East River (W.Branch)	cfs	28	2.78	0.78	0.88
McLellans Brook	cfs	14	0.81	0.84	0.86
Sutherlands River	cfs	22	2.89	0.71	0.88

Equation: $Qx = AQm^b$ (Correlation curves)
where: Qx = flow on river compared
Qm = flow on Middle River
A = correlation constant
b = constant

Regression Calculated by: $InQx = 1nA + 1n\,Qm\,(b)$

* Flows based on two meterings.

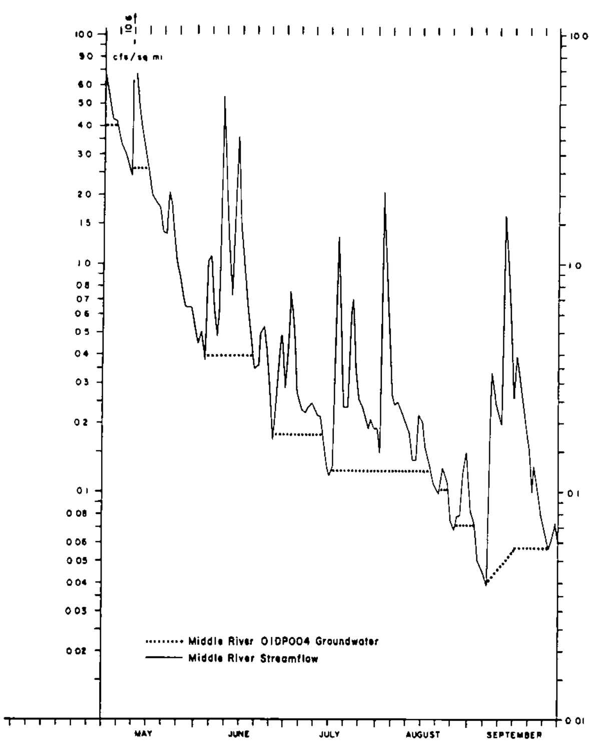

Figure B1 Hydrograph, Middle River at Rocklin, May - September, 1978

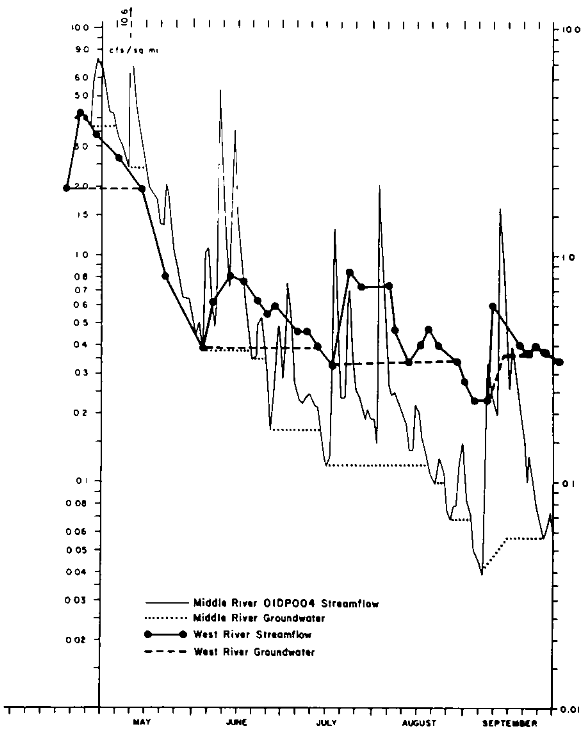

Figure B2 Hydrograph, West River at Saltsprings, May - September, 1978

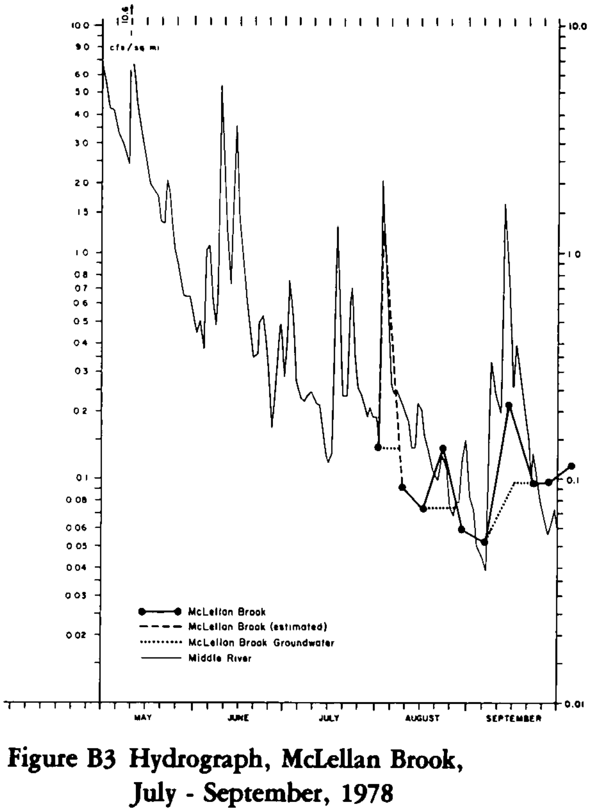

Figure B3 Hydrograph, McLellan Brook, July - September, 1978

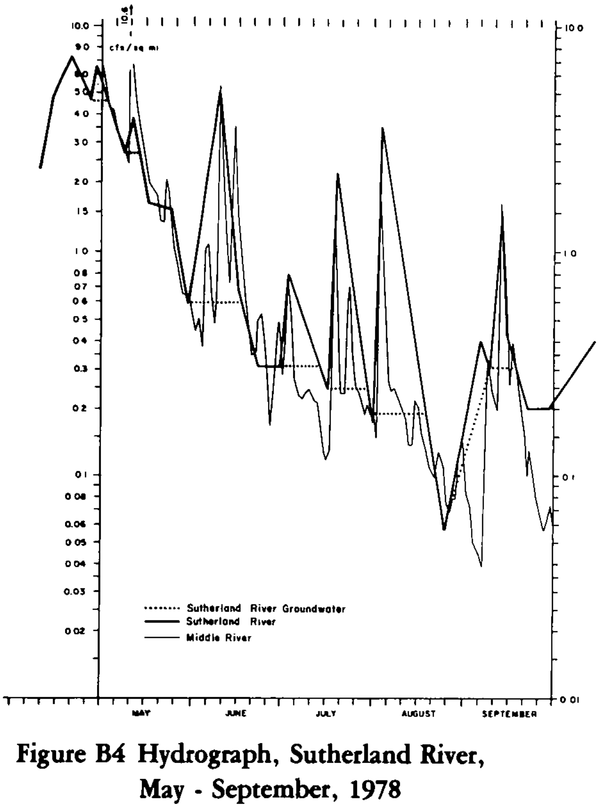

Figure B4 Hydrograph, Sutherland River, May - September, 1978

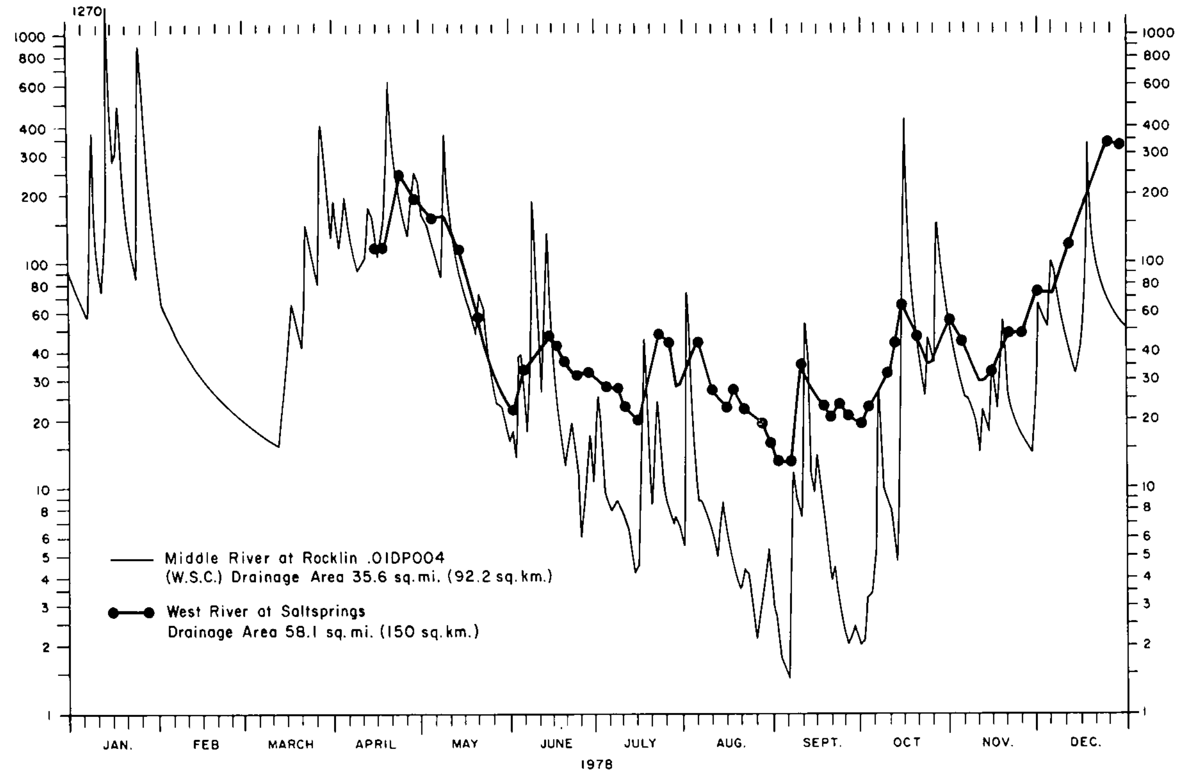

Figure B5 Hydrograph, West River at Saltsprings, 1978

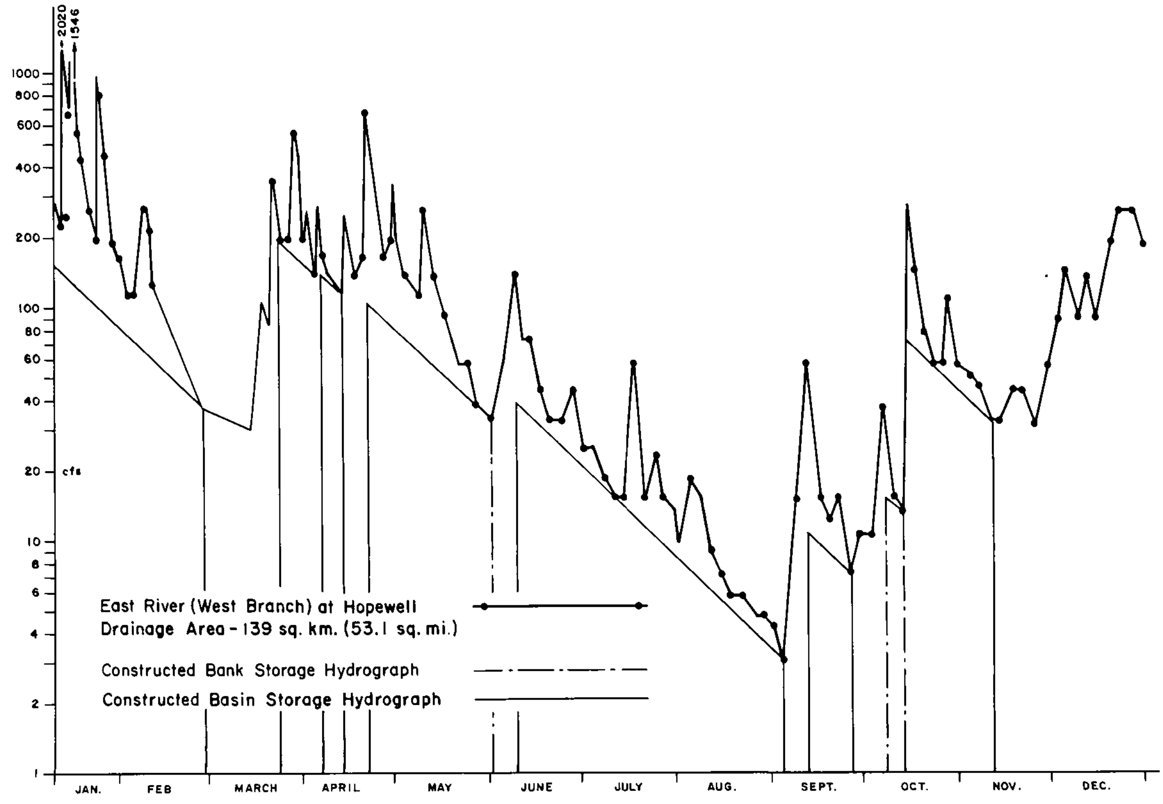

Figure B6 Hydrograph, East River at Hopewell, 1978

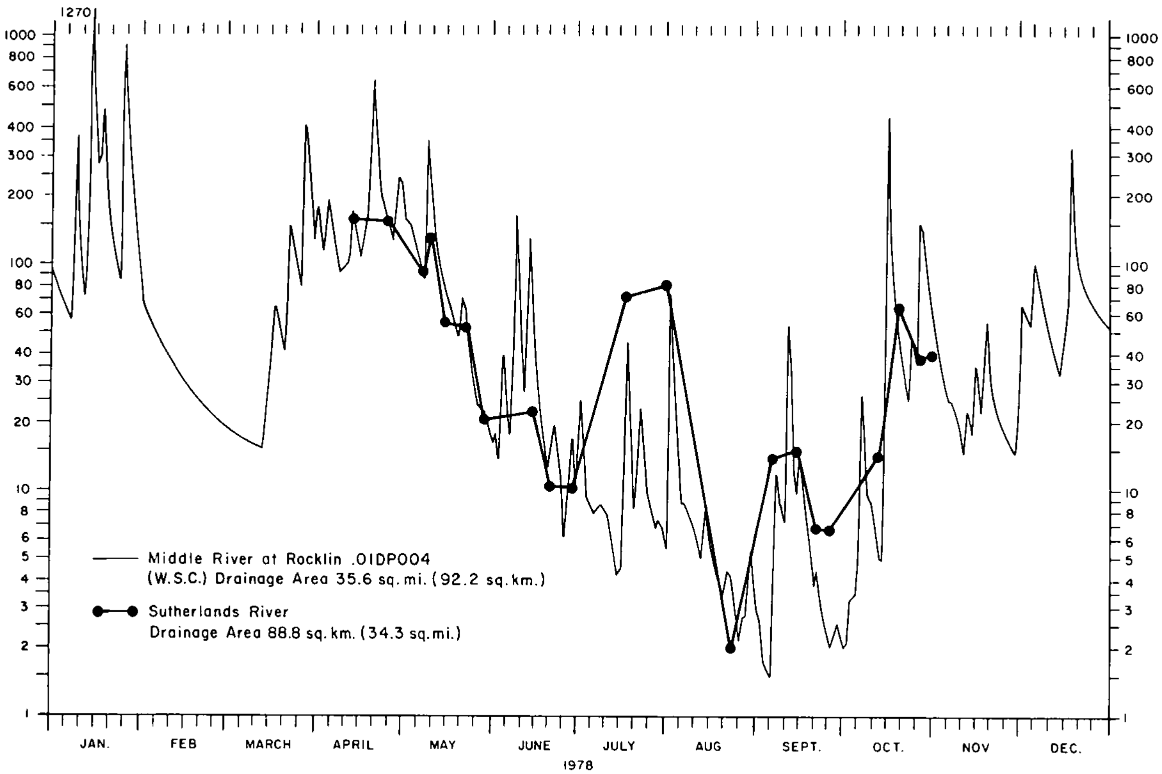

Figure B7 Hydrograph, Sutherland River, 1978

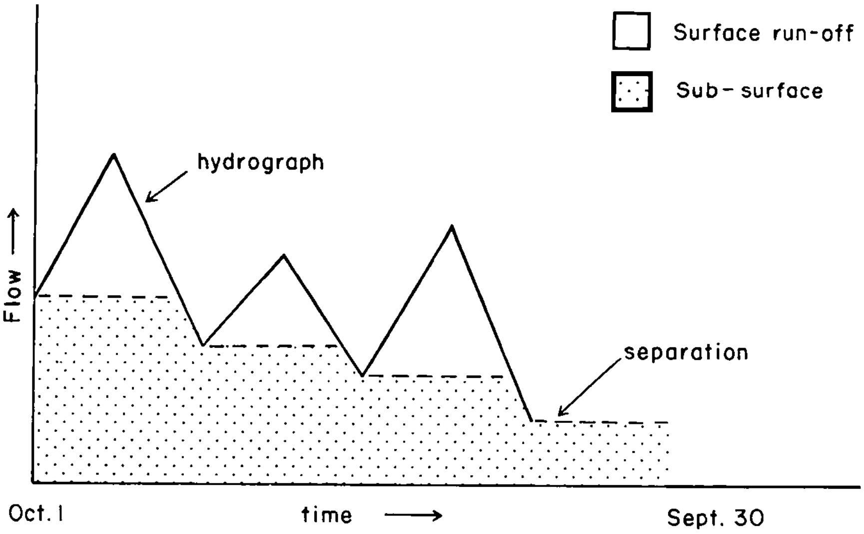

Figure B8 Wards Method for Separating the Surface Runoff Component of a Hydrograph from the Sub-Surface Component

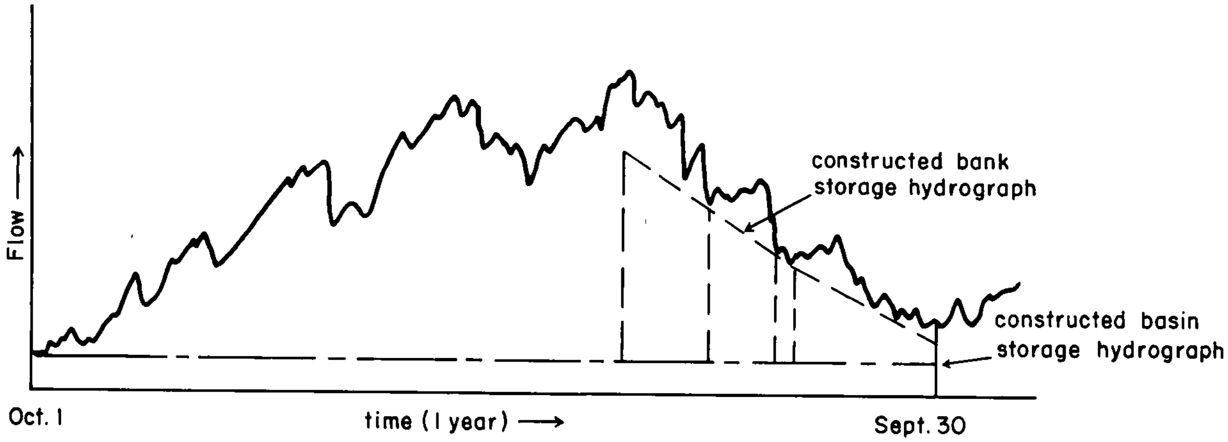

Figure B9 Kunkle Method for Separating Bank and Basin Storage from Total Runoff

APPENDIX C
Reports on Test Drilling and Aquifer Testing

Roy Island Pump Test

Two relatively shallow wells (100 ft. and 85 ft. deep) drilled by the N.S. Department of Lands and Forests at Roy Island (Figure 5.1) were pump tested. The 100 foot deep well was pumped and the 86 foot well used for observation. The stratigraphic logs are given in Figure C.1. The relative locations of the wells are shown in Figure C.2.

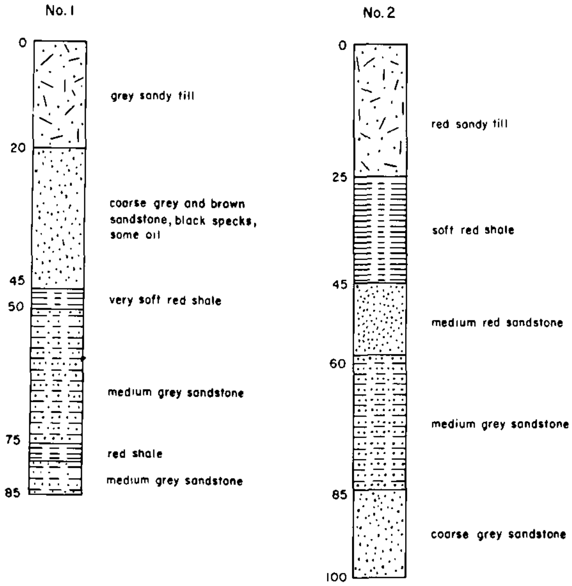

Figure C1 Stratigraphic Logs, Test Wells, Roy Island

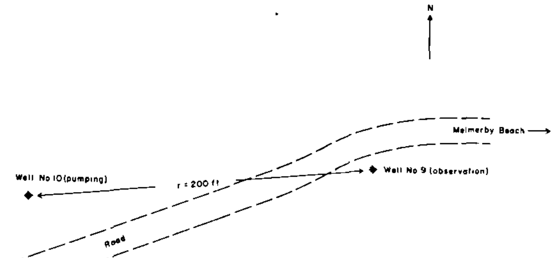

Figure C2 Relative Location of Test Wells at Roy Island

Plots of drawdown and recovery, calculations and data on pump test conditions are given in Figure C.3. Transmissibilities are 103 and 84 igpd/ft. from the drawdown and recovery data, or an average of about 94 igpd/ft. Based on this T value an estimated safe long term yield of 3 igpm per 100 feet of saturated thickness can be predicted. During drilling of the wells, water was picked up gradually and increased relatively steadily with depth where sandstone layers were encountered. This implies primary rather than secondary fracture permeability.

Durham Pump Test

A pump test was conducted at Durham, Pictou County, (Figure 5.1). Three wells were drilled to a depth of about 250 feet each into red and grey shales, sandstones and conglomerates of the Riversdale Group. Stratigraphic logs are presented in Figure C.4 and the relative spacing of the wells in Figure C.5. Figure C.6 represents plots of drawdown and residual drawdown vs time data for the pumping well on a semi-log plot for analysis by the Jacob method. Controlled changes in pumping rate at 60, 120 and 180 minutes produced corresponding increases in the rate of drawdown (slope of the curve). Temporary increases in slope also occur at 480 and 1200 minutes which could reflect discharge or negative boundary conditions or unrecorded increases in pumping rate. Likely this reflects boundary conditions as the nature of water pick-up during drilled suggested the predominance of fracture permeability. However, the slope of the recovery data curve is well defined. Transmissibility from the drawdown data is estimated at 800 igpd/ft. and from recovery data at 1257 igpd/ft.

Figure C.7 gives the plots of drawdown data in the observation wells and calculations of T and S. Using observation well No. 3, T is 971 igpd/ft. and S is 3.2 x 10^{-4}. Drawdown data in observation well No. 1 gives T at 1637 igpd/ft. and S at 1.5 x 10^{-3}. These differences may reflect lateral differences in lithology away from the pumping well. However, the rotary drilling method employed and the frequent and often subtle changes in the strata penetrated made precise logging difficult. Results of attempts to correlate among the stratigraphic logs have therefore proven too subjective to be reliable.. Well No. 1 is across strike and well No. 3 approximately along strike from the pumping well (Strata are dipping southeast at about 15°, or towards the pumping well from well No. 1). This could be delaying the response of well No. 1 to pumping over that of well No. 3. It is also possible that the differences in T and S are fracture controlled.

In view of the above it is safer to estimate T as being the average of the four calculated values or 1166 igpd/ft. and S the average of the two values or 9.1 x 10^{-4}.

Abercrombie Pump Test

A pump test was conducted at Abercrombie (Figure 5.1) on wells drilled in siltstones, shales and sand-

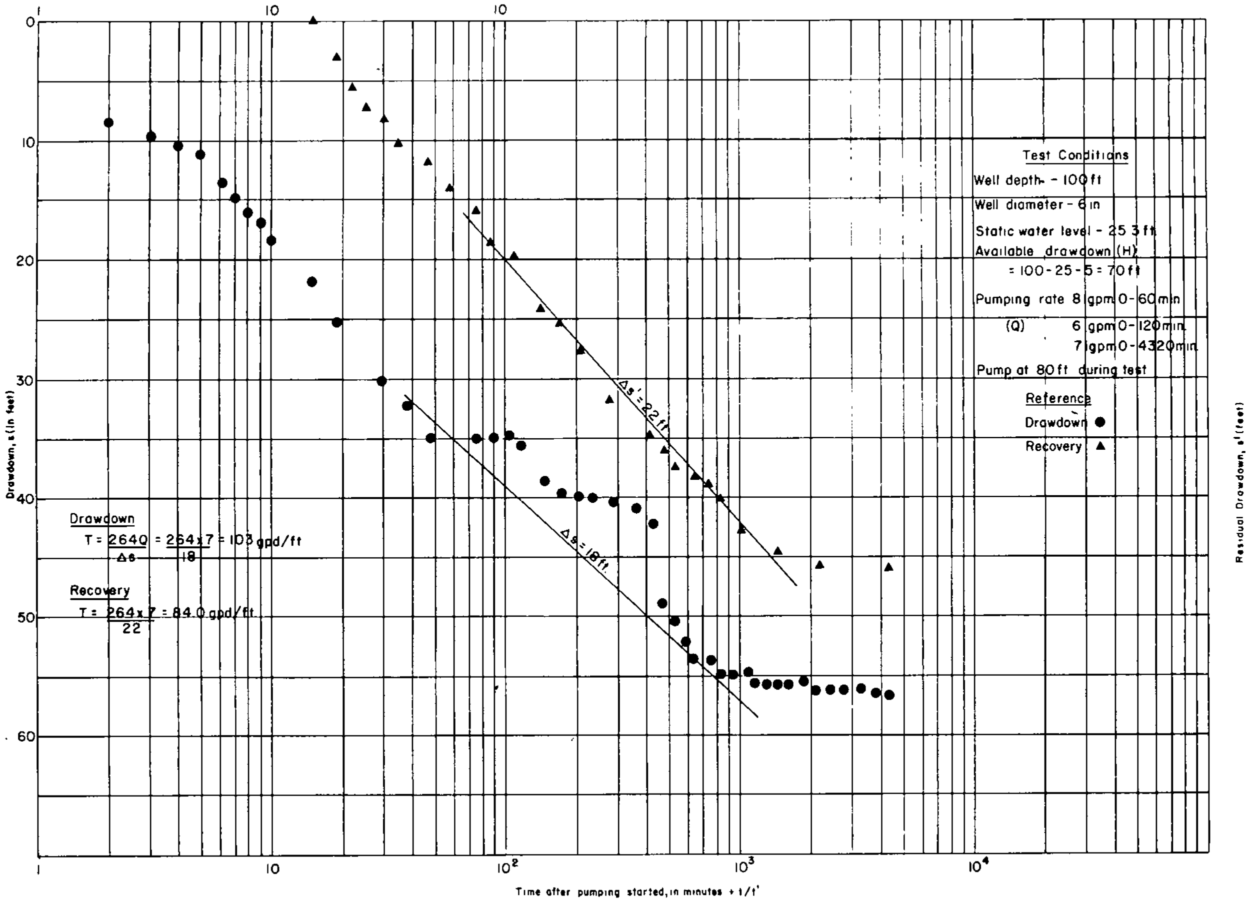

Figure C3 Pump Test, Roy Island

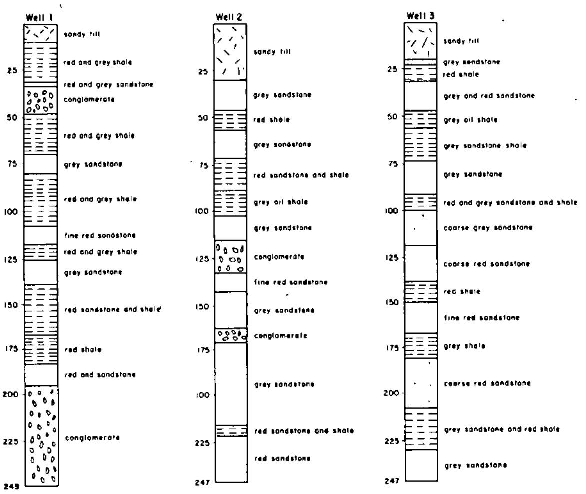

Figure C4 Stratigraphic Logs, Test Wells, Durham

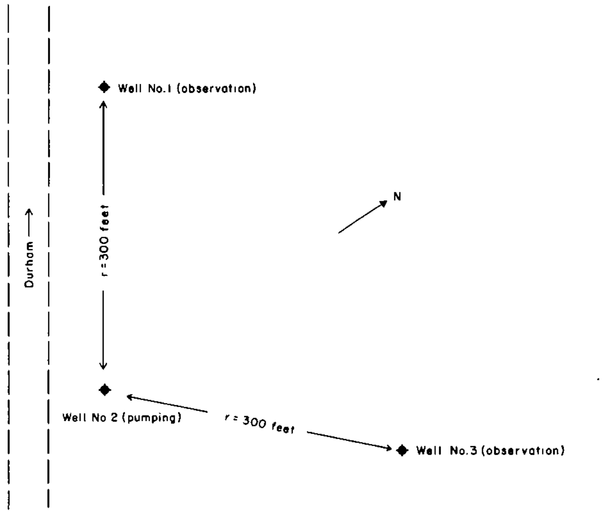

Figure C5 Relative Location of Test Wells, Durham

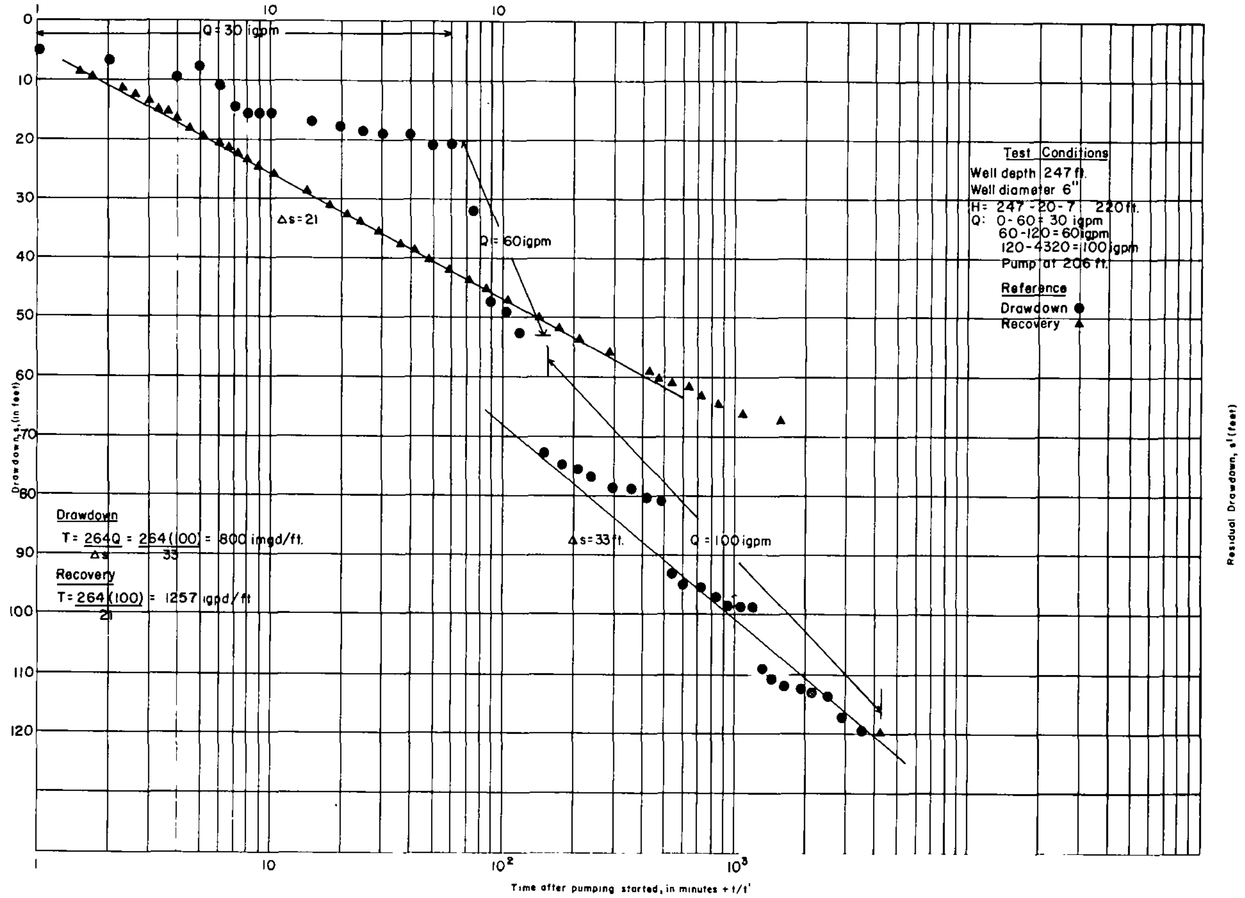

Figure C6 Pump Test, Durham

stones of the Pictou Group (Figure C.8) utilizing one pumping and one observation well. The relative locations of the wells are given in Figure C.9. Plots of drawdown data and calculations can be found in Figures C.10 and C.11.

Calculated T values by the Jacob and Theis methods are 404 and 423 igpd/ft. respectively and S is 1.4 x 10^{-4}. Average T is 414 igpd/ft. which corresponds to a predicted yield of 24 igpm per 100 feet of saturated aquifer. After about 1200 min. a discharge boundary was encountered and at 1680 the drawdown reached the pump intake, ending the test. Water flow increased noticeably at various depths during drilling rather than being picked up gradually. This suggests that fracture permeability is predominant.

Little Egypt Road Pump Test

A pump test was conducted at Little Egypt Road (Figure 5.1) utilizing one pumping and two observation wells. The wells were drilled to a depth of 250 feet into siltstones, conglomerates and grey and red shales and sandstones. Stratigraphic logs are given in Figure C.12 and the relative spacing of wells in Figure C.13. Data on well and pump test conditions are given in Table C.1.

Drawdown and recovery vs time data are plotted in Figure C.14 for analysis by the Jacob method. Observation well data were not adequate for analysis by the Theis method. Considerable difficulty was experienced during the test with the pump which eventually shut down after 2520 minutes or 42 hours). The test therefore, was not entirely satisfactory especially in that the well was underpumped. The drawdown stabilized at 150 feet which meant that only 60-65% of the available drawdown was utilized. The test should preferably have been run for a full 72 hours.

Estimates of T were made using the available data by utilization of four different S values determined, as indicated on Figure C14, and averaging the calculated T values. This resulted in an average T of 198 igpd/ft. This could likely be increased by up to 1/3 if data from a more rigorous test were available.

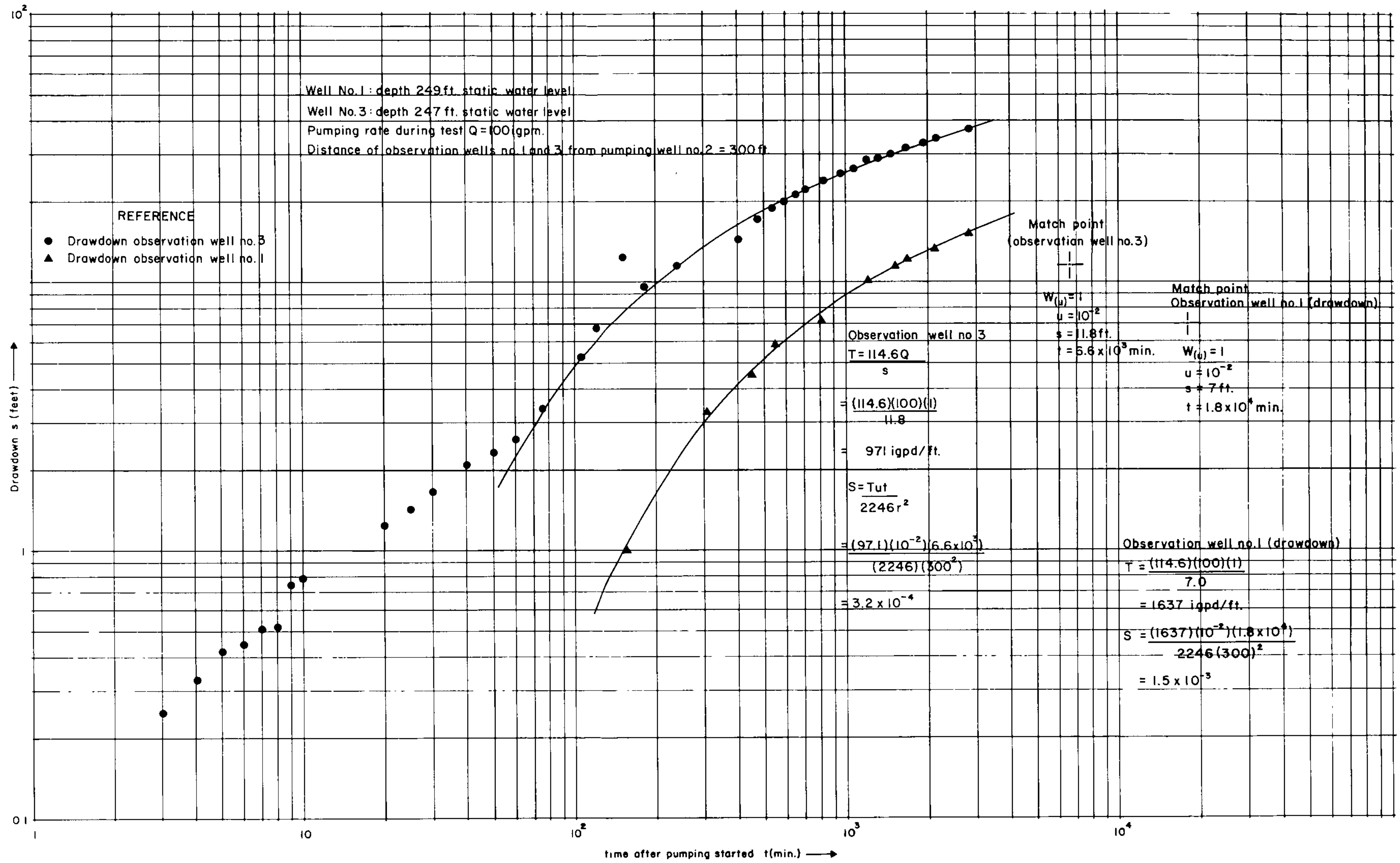

Figure C7 Pump Test, Durham

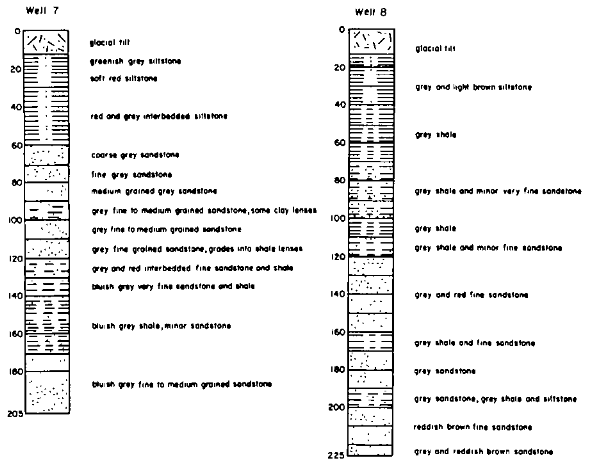

Figure C8 Stratigraphic Logs, Test Wells, Abercrombie

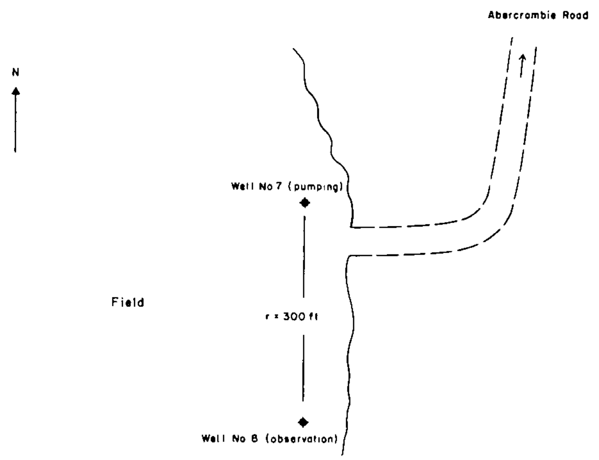

Figure C9 Relative Location of Test Wells, Abercrombie

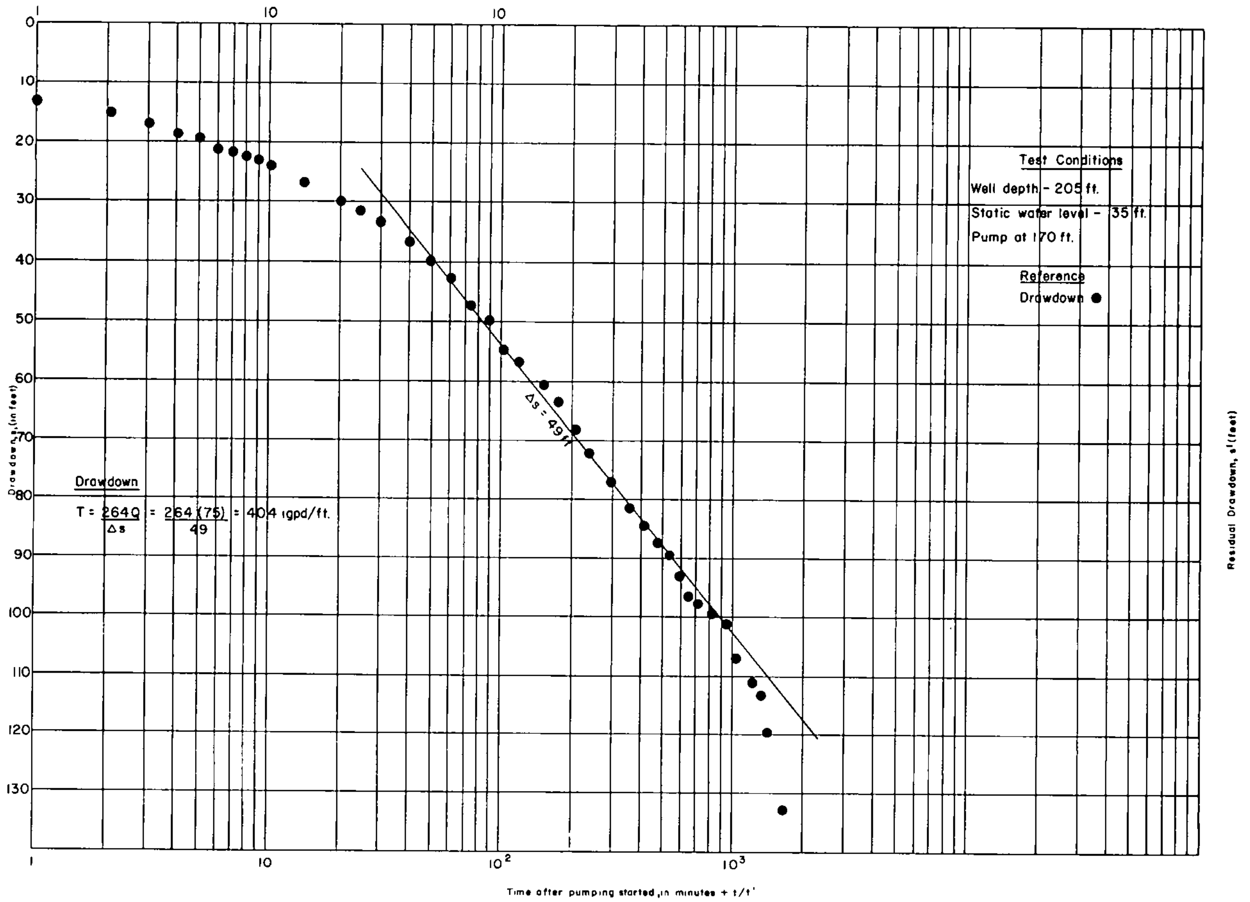

Figure C10 Pump Test, Abercrombie

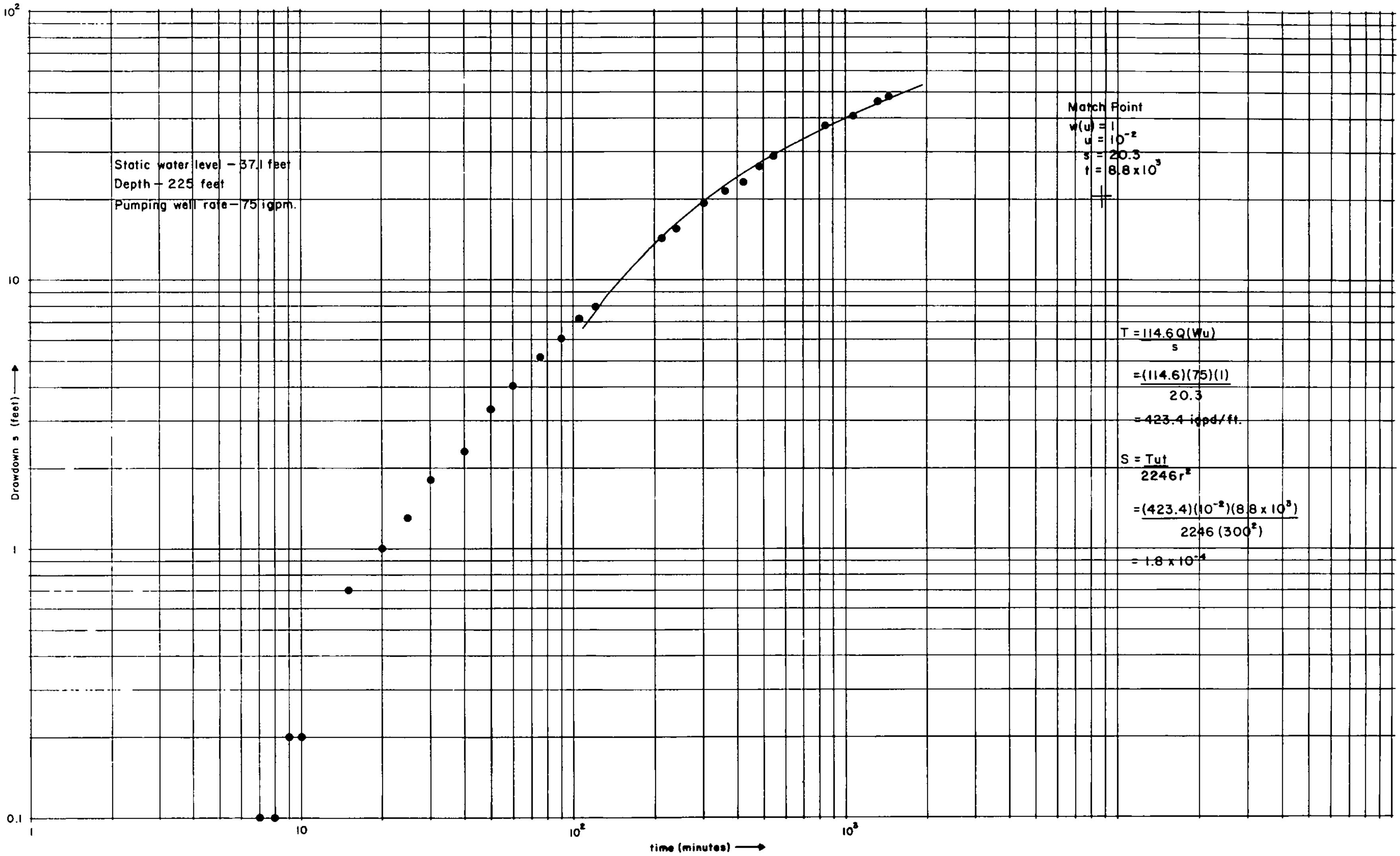

Figure C11 Pump Test, Abercrombie

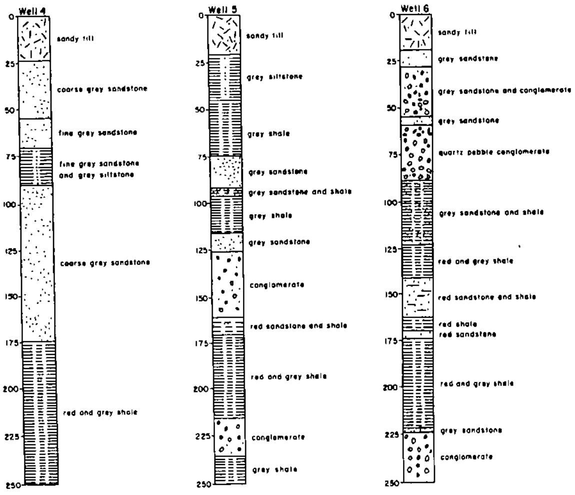

Figure C12 Stratigraphic Logs, Test Wells, Little Egypt Road

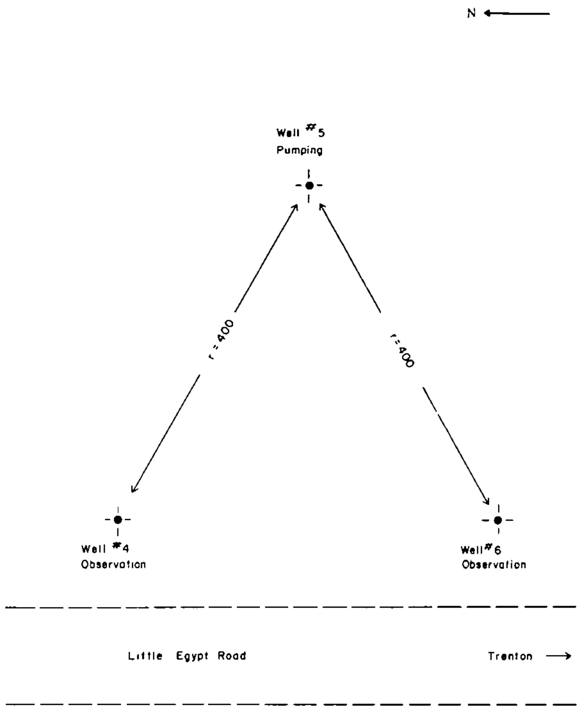

Figure C13 Relative Locations, Test Wells, Little Egypt Road

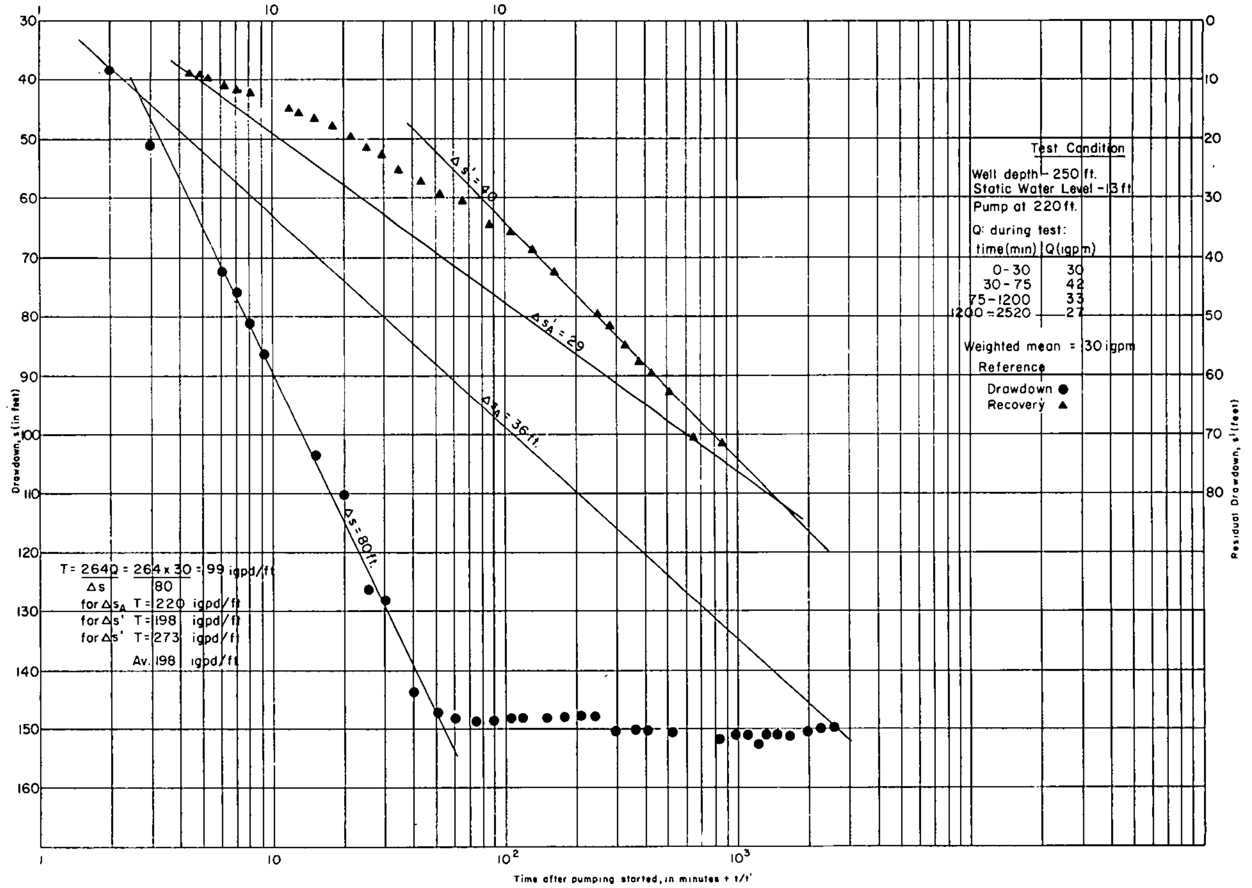

Figure C14 Pump Test, Little Egypt Road

APPENDIX D

Water Quality

Table D.1

Surface Water Sampling Stations

Ref. No.	Stream	Lat. ° ' "	Long. ° ' "	Drainage Area sq.km.	Drainage Area sq.mi.
1	West River	45° 28' 22"	62° 54' 54"	39.1	15.1
2	West River	45° 32' 44"	62° 52' 10"	150	58.1
3	West River	45° 36' 59"	62° 48' 41"	216	83.5
4	Middle River	45° 34' 46"	62° 45' 11"	115	44.5
5	Middle River	45° 25' 49"	62° 48' 38"	22.6	8.72
6	Middle River	45° 26' 16"	62° 46' 38"	16.4	6.32
7	East River (W.Branch)	45° 29' 53"	62° 40' 59"	144	55.5
8	East River (confluence)	45° 30' 12"	62° 40' 35"	249	96.2
9	East River (W.Branch)	45° 25' 21"	62° 40' 12"	64.2	24.8
10	East River	45° 33' 02"	62° 39' 43"	264	102
11	McLellan Brook	45° 34' 05"	62° 37' 30"	87.5	33.8
12	McLellan Brook	45° 32' 33"	62° 36' 22"	64.8	25.0
13	McLellan Brook	45° 31' 46"	62° 36' 31"	55.9	21.6
14	McLellan Brook	45° 30' 13"	62° 35' 27"	26.9	10.5
15	McLellan Brook	45° 30' 02"	62° 35' 14"	26.7	10.3
16	East River (E.Branch)	45° 24' 10"	62° 30' 15"	118	45.7
17	Sutherland River	45° 34' 37"	62° 30' 51"	88.8	34.3

Table D2

Streamflows on Water Sampling Dates

River	Ref. No.	Drainage sq.km.	Drainage sq.mi.	Aug. 16/78 cfs.	Aug. 16/78 litres/s	April 3/79 cfs.	April 3/79 litres/s	Aug 10/79 cfs.	Aug 10/79 litres/s
West River	1	39.1	15.1	6.0	170	40	1130	11.3	3.20
	2	150	58.1	23.1	650	150	4250	43.6	1230
	3	216	83.5	33.3	940	220	6230	62.6	1770
Middle	4	115	44.5	7.1	200	174	4920	67 E	1880E
	5	22.6	8.72	1.4	40	34	960	13.E	360E
	6	16.4	6.32	1.0	28	25	710	9.E	14E
East River	7	144	55.5	6.1	170	209	5910	69.4	1950
West Branch	9	64.2	24.8	2.7	76	94	2660	31.0	870
(East Branch)	8	249	96.2	10.6	300	363	10300	120	3370
	16	118	45.8	5.0	140	173	4900	57.3	1620
East River (below confluence)	10	264	102	11.2	320	385	10900	128	3600
McLellan Brook	11	87.5	33.8	4.7	130	69	1950	9.1	260
	12	64.8	25.0	3.5	99	51	1440	6.7	190
	13	55.9	21.6	3.0	85	44	1240	5.8	160
	14	26.9	10.5	1.5	42	21	610	2.8	80
	15	26.7	10.3	1.4	41	21	610	2.8	80
Sutherland River	17	88.8	34.3	8	230	130	3700	133	3740

Table D3

Chemical Analysis of Groundwaters Pictou County

Index No	Grid Location	Source	Na	K	Ca	Mg	$CaCO_3$ (Hardness)	$CaCO_3$ (Alkal.)	SO_4	Cl	F	SiO_2	NO_3+NO_2 as N	NH_4 as N	As	Fe	Mn	Boron	Copper	Zinc	Lead	PO_4 as Ortho	Suspended Solids	Total Dissolved Solids	Colour T.C.U.	Turbidity J.T.U.	Conductivity µmhos	pH (Lab)
1	E31-90	Churchville WINDSOR GROUP	24.0	3.6	30.0	5.5	98.0	120.0	32.0	6.0	0.2	0.9	0.1	<0.1		0.2	<0.05		0.02	<0.005	<0.005	<0.02	1.0	180.0	0	0.1	308.0	8.1
2	E31-92	Churchville	78.0	8.1	17.0	6.5	70.0	227.0	34.0	10.0	0.5	4.4	<0.1	0.1		4.9	0.2		0.02	0.04	<0.005	<0.02	5.0	294.0	25.0	25.0	473.0	8.3
3		Satellite Slopes	28.0	36.0	212.0	8.3	564.0	110.0	460.0	14.0	0.2	14.0	<0.05	0.08	0.03	0.31	0.14		<0.01	0.09	<0.005	<0.02	1.0	901.0	25.0	4.3	1050.0	7.8
●		Bridgeville	18.0	2.1	31.4	22.7	172.0	166.0	17.0	6.0	0.1	8.2	<0.1	<0.1		0.9	0.1		0.03	0.10	<0.005	<0.1	4.0	212.0	50.0	16.0	375.0	7.4
5	E31-39	Springville	325.0	11.0	148.0	19.0	448.0	80.0	765.0	200.0	0.8	7.0	<0.1	0.1		0.3	0.2		0.02	<0.005	<0.005	<0.02	1.0	1618.0	20.0	3.6	2185.0	7.0
6	F31-6	Hopewell	760.0	3.5	128.0	28.0	337.0	115.0	370.0	975.0	0.6	13.0	<0.1	0.1		0.1	0.1		0.008	0.02	<0.005	0.06	2.0	2283.0	5.0	0.5	3740.0	7.8
7		The Island	370.0	3.0	156.0	22.0	478.0	80.0	770.0	325.0	0.2	11.0	<0.1	<0.1	0.03	0.11	0.19	0.07	<0.01	<0.01	<0.006	<0.02	2.0	1675.0	5.0	2.2	2500.0	8.0
8	F31-35	Springville					113.0	100.0	150.0	30.0			3.0			0.28											58.0	8.2
9		Hopewell	4.4		23.1	3.2	70.8	76.0	4.0	7.1			<0.1			0.02	<0.01								<5.0		20.0	
10		Eureka	740.0		85.9	32.0	346.0	152.0	230.0	780.0			<0.1			0.04	0.05								5.0	0	87.0	7.5
11		Merigomish CANSO GROUP	25.0	3.3	15.0	4.5	56.0	39.0	6.3	54.0	0.1	10.0	<0.1	<0.1		6.8	4.4		0.02	0.08	<0.005	0.08	108.0	165.0	50.0	70.0	240.0	6.7
12		Merigomish	63.0	5.6	33.0	10.0	125.0	240.0	20.0	18.0	0.3	13.0	<0.1	0.1	<0.005	0.21	0.07		<0.01	0.07	0.02	0.02	2.5	292.0	10.0	4.1	475.0	8.2
13		Merigomish	11.3		7.2	2.9	30.0	20.0	12.0	17.7			<0.1												<5.0		10.0	6.2
14		Ponds	9.3	3.5	39.0	3.4	113.0	100.0	8.2	16.0	0.2	7.1	0.3	<0.1		1.2	0.2		0.01	0.04	<0.005	<0.02	7.0	150.0	30.0	70.0	270.0	7.6
15		Ponds	10.0	3.7	42.0	9.2	144.0	110.0	13.0	16.0	0.2	7.0	<0.1	<0.1		1.3	0.2		0.38	0.05	<0.005	<0.1	4.0	166.0	20.0	0.68	276.0	7.4
16		Saltsprings	3.8	0.4	27.0	14.0	125.0	95.0	26.0	4.3	0.1	7.1	<0.1	<0.1	<0.008	0.8	0.2		0.04	0.02	<0.005	0.1	4.7	165.0	5.0	1.3	250.0	8.3
17		Saltsprings Park RIVERSDALE GROUP	90.5	1.8	16.3	3.5	55.1	106.4	30.0	56.0	0.25	9.36				0.8	0.25		0.006	0.04	<0.005			336.0	6.0	1.5	35.0	8.4
18		Scotsburn	178.0	3.7	48.0	4.6	139.0	120.0	76.0	238.0	0.4	8.6	8.8	1.0		6.5	1.3		1.75	<0.005	0.04	<0.02	302.0	692.0	15.0		1276.0	7.6
19		Lyons Brook	9.1	1.8	23.0	4.6	76.0	55.0	13.0	19.0	0.1	3.0	0.3	<0.1		2.5	0.2		<0.005	0.01	0.03	<0.02	9.0	104.0	30.0	16.0	209.0	8.1
20		Greenhill	3.4	0.2	27.0	1.0	72.0	71.0	5.0	6.2	<0.1	5.3	<0.1	<0.1	<0.005	<0.02	0.02		<0.01	0.01	<0.005	<0.02	1.3	95.0	25.0	0.44	156.0	7.6
21		Durham	40.0	6.8	23.0	2.7	69.0	140.0	12.0	12.0	0.3	11.0	<0.1	<0.1	0.005	7.3	0.35	<0.02	<0.01	0.02	0.006	0.14	121.0	288.0	200.0	170.0	300.0	8.2
22		Durham	92.0	2.2	25.0	2.4	74.0	150.0	20.0	76.0	0.4	10.0	<0.1	<0.1	<0.005	0.65	0.10		<0.01	0.02	<0.005	0.02			15.0	12.0	525.0	8.0
23		Durham	105.0	2.2	29.0	2.7	85.0	145.0	23.0	118.0	0.4	10.0	<0.1	<0.1	<0.005	0.09	0.09		0.01	0.01	<0.005	0.02	2.0	373.0	10.0	2.2	650.0	8.1
24		Durham	232.0	4.9	82.0	8.8	240.0	140.0	30.0	450.0	0.4	10.0	0.2	<0.1	<0.005	0.10	0.15		<0.01	0.02	<0.005	0.05	11.0	933.0	5.0	0.71	1550.0	7.9
25		Four Mile Brook	20.0	7.5	21.0	7.6	84.0	69.0	16.0	66.0	0.1	5.6	15.0	<0.1	<0.006	0.02	<0.01		0.07	1.2	0.01	0.05	0	333.0	15.0	1.6	540.0	6.4
26		Four Mile Brook	3.7	0.9	35.0	35.0	103.0	74.0	3.1	23.0	<0.1	6.0	0.7	<0.1	<0.005	0.02	<0.01		0.05	0.02	0.005	0.02	2.0	131.0	10.0	2.0	240.0	7.0
27		Four Mile Brook	3.0	3.2	12.0	1.4	37.0	31.0	4.0	3.7	<0.1	6.5	0.8	<0.1	<0.005	0.24	<0.01		0.01	0.01	<0.005	0.03	8.0	67.0	15.0	2.7	62.0	6.7
28		Durham	8.7	1.3	26.5	7.9	98.7	100.0	10.7	3.4	0.25	13.9	0			0.23	0.13		0.005	0.002	<0.001			87.1	2.0	1.5	20.0	7.9
29		Saltsprings	6.6	1.5	38.0	10.0	137.0	143.0	4.5	13.0					<0.005	0.06	0.02							180.0			290.0	7.5
30		Scotsburn	7.4		62.3	3.5	170.0	164.0	6.0	14.2			2.0			0.06	0.02								5.0		36.0	7.3
31		Granton CUMBERLAND GROUP	150.0	1.8	3.3	0.4	10.0	245.0	57.0	41.0	1.3	6.7	<0.1	<0.1	0.03	0.27	0.02		0.04	0.08	0.02	0.15	11.0	405.0	15.0	12.0	660.0	8.9
32		Greenhill Park	4.0	<1.0	49.0	1.3	128.0	101.0	4.0	21.0	<0.1	6.5	0.2	<0.1		<0.1	<0.05		0.01	0.20	<0.005	<0.1	5.0	192.0	20.0	0.53	260.0	8.1
33	E32	Fraser Mountain	117.0	2.8	1.0	0.2	3.3	265.0	16.0	8.5					<0.005	0.01	<0.01							318.0			420.0	
34		Fraser Mountain	9.3	0.9	90.0	2.6	235.0	175.0	8.2	4.7					<0.005	0.15	<0.01							318.0			450.0	7.4
35	E30	Alma	90.0	3.7	3.4	1.3	14.0	182.0	30.0	27.0	0.5	7.0	<0.1	<0.1		0.2	<0.05		0.07	0.03	0.005	0.04	4.0	318.0	45.0	19.0	492.0	7.8
36		Alma	192.0	1.7	16.0	1.1	45.0	187.0	130.0	125.0					<0.005	0.31	0.02							610.0			900.0	8.3
37		Greenhill	67.0	1.4	11.0	0.9	31.0	155.0	18.0	14.0					<0.005	0.14	0.01						211.0				300.0	8.5
38		Thorburn STELLARTON GROUP	135.0	1.5	3.4	0.8	12.0	211.0	3.0	53.0	1.0	7.5	0.1	0.4		<0.1	0.06		0.16	0.009	0.006	<0.02	3.0	332.0	20.0	0.85	583.0	8.0
39		Stellarton Interval	330.0	5.8	22.0	10.0	96.0	450.0	9.0	325.0	0.3	2.1	<0.1	0.4		12.7	0.4		0.08	0.02	0.03	0.02	144.0	985.0	45.0	95.0	1740.0	8.2
40		Stellarton	92.0	3.6	66.0	23.0	259.0	133.0	270.0	5.0	0.3	1.0	26.3	<0.1		<0.1	0.07		0.01	0.01	<0.005	<0.02	3.0	667.0	5.0	0.75	902.0	7.8
41		Stellarton	265.0	3.6	46.0	17.0	175.0	720.0	19.0	80.0	0.5	6.6	<0.1	0.8		3.0	0.50					<0.02	42.0	1037.0			1350.0	7.6
42		Thorburn	71.5	2.3	21.5	1.72	161.0	161.0	10.0	36.0		10.2	0.53			0.21	0.017		0.04	<0.015	0.06			265.0	1.0	1.0	35.0	8.2
43		Westville	45.5		15.2	9.63	69.0	446.0	2.0	82.4						0.2	<0.01								<5.0		100.0	7.8
44		Linacy	21.1		46.8	7.9	149.0	176.0	12.0	17.8						0.06	<0.05								<5.0	0	40.0	7.6
45		MacLellan Brook	116.0		1.3	0.4	4.8	358.0	3.0	8.9						0.28	<0.05								10.0	50.0	62.0	8.9
46		Stellarton	520.0	8.0	18.0	11.0	92.0	580.0	20.0	435.0	0.4	4.0	0.1	0.6		23.0	1.0		0.06	0.03	<0.05	<0.02	612.0	1345.0	10.0	154.0	2310.0	7.9
47		MacLellan Brook	19.0	31.0	83.7	8.65	245.0	202.0	13.5	50.0		7.7	505			0.05	0.002		0.01	0.012	<0.015			409.0	10.0	0.9	54.0	7.1
48		Satellite Slopes	6.1	14.0	24.0	2.8	71.0	75.0	11.0	5.0	0.1	3.3	0.4	0.2		0.8	0.05		0.05	0.04	<0.005	<0.02	455.0	91.0	10.0	100.0	176.0	8.3
49		Thorburn	38.2		54.7	10.2	178.0	180.0	20.0	49.6						0.72	<0.05								5.0	10.0	54.0	7.1
50		Thorburn	44.0	2.3	92.0	13.0	282.0	95.0	44.0	168.0	<0.1	15.0	<0.1	0.5		3.2	1.1		0.04	0.02	0.01	<0.02	8.0	420.0	40.0	63.0	770.0	6.5
51		Greenwood	73.0	1.9	8.4	<0.1	21.0	127.0	17.0	33.0	0.2	14.0	0.2	<0.1		0.6	0.4		<0.005	<0.005	<0.005	0.20	242.0	262.0	55.0	110.0	378.0	8.5
52		Town of Trenton PICTOU GROUP	23.5	3.7	38.4	9.36	136.0	153.0	22.4	4.8	0.42	11.0	2.65			0.09	0.048		0.015	0.001	<0.015			259.0	3.0	1.5	23.5	7.85
53		Town of Trenton	9.5	1.5	48.0	11.5	167.0	130.0	42.6	12.0	0.36	11.0	0.79			0.78	0.89		0.0275	0.012	<0.015			266.0	30.0	7.1	288	7.5
54		Abercrombie	25.0	2.7	26.0	4.4	84.0	150.0	7.5	8.3	0.3	14.0	<0.1	<0.1	<0.005	0.26	0.07		<0.01	0.03	<0.005	0.04	7.5	171.0	5.0	7.4	275.0	8.2
55		Abercrombie	125.0	2.8	13.0	2.0	41.0	245.0	35.0	39.0	2.5	9.1	<0.1	<0.1	<0.005	0.31	0.03		<0.01	0.25	<0.005	0.04	5.3	368.0	10.0	12.0	545.0	8.4
56		Abercrombie	22.0	3.5	38.0	9.2	133.0	185.0	16.0	5.5	0.3	14.0	<0.1	<0.1	<0.005	0.27	0.11		0.04	0.03	0.02	0.02	1.3	236.0	5.0	4.3	370.0	7.8
57		Caribou Ferry Terminal	22.6		37.7	6.6	120.0	84.3	14.5	36.8	0.04	11.4	0.033			0.04	0.12							192.0	<5.0	0.25		7.2
58		Caribou Island	43.0	3.0	54.4	5.4	158.0	130.0	22.0	66.0	0.2	8.9	<0.1	<0.1		0.2	0.01		0.02	0.03	<0.005	<0.1		300.0	20.0	0.3	478.0	7.8
59		Caribou Island	14.0	1.8	41.4	9.7	144.0	148.0	15.0	22.0	0.2	12.0	<0.1	<0.1		0.2	0.4		0.03	0.18	<0.005	0.1		214.0	10.0	1.0	375.0	7.6
60		Caribou Island	23.0	1.3	29.0	5.1	93.0	67.0	24.0	43.0	0.1	6.2	<0.1	<0.1		<0.1	0.01		0.02	0.33	<0.005	<0.1	0	276.0	15.0	5.0	482.0	6.5
61		Pictou Landing	6.3	1.0	35.0	4.5	106.0	102.0	10.0	9.8	<0.1	10.0	<0.1	<0.1		0.15	0.27		<0.1	0.26	<0.005	0.11	1.0	142.0	5.0	3.3	230.0	7.4
62		Pictou Landing	8.5		38.5	11.7	144.3	60.0	18.0	13.3						0.25	<0.01								25.0		32.0	7.9
63		Abercrombie	25.0	4.2	43.0	7.6	139.0	167.0	23.0	7.2	0.2	15.0	<0.1	<0.1		0.2	0.09		0.03	0.02	<0.005	0.03	2.0	214.0	10.0	2.0	352.0	8.0
64		Pictou Landing	21.0	3.8	26.0	7.6	97.0	115.0	9.5	20.0	0.1	14.0	<0.1	<0.1	<0.005	0.98	1.0		<0.01	0.05	<0.005	0.14	4.5	166.0	35.0	17.0	275.0	7.1
65		Roy Island	16.0	3.1	51.0	19.0	208.0	190.0	7.0	36.0	0.1	11.0	<0.1	<0.1	<0.005	0.02	0.20		<0.01	0.01	0.008	0.02	3.8	252.0	10.0	0.51	460.0	7.9
66		Trenton	14.0	2.2	25.0	6.2	88.0	100.0	8.5	8.5	0.1	12.0	<0.1	<0.1	<0.005	0.44	0.31		<0.01	0.01	<0.005	<0.02	3.8	131.0	20.0	3.7	235.0	7.7
67		Little Harbour	18.0	1.0	56.0	20.0	226.0	185.0	30.0	31.0	0.1	7.5	<0.1	<0.1		0.3	0.5		<0.005	0.02	<0.005	<0.02	1.0	252.0	10.0	3.0	460.0	7.3
68		Kings Head	7.1	0.6	25.0	9.5	101.0	86.0	11.0	17.0	0.1	8.6	<0.1	<0.1	<0.005	0.36	0.93		<0.1	0.21	0.01	0.04	2.3	141.0	15.0	6.4	240.0	7.8
69		River John	60.0	2.8	24.0	2.8	72.0	185.0	21.0	11.0	0.3	11.0	<0.1	<0.1		8.7	0.1		0.56	0.63	0.05	<0.02	98.0	229.0	5.0	53.0	396.0	8.0
70		Pictou	7.9	1.6	64.0	5.7	184.0	183.0	14.0	8.6	0.1	8.5	<0.1	<0.1	<0.005	0.02	0.09		0.02	0.01	<0.005	0.08	2.0	193.0	10.0	0.3	325.0	8.2

Table D4
Chemical Analysis of Surface Waters Pictou County

CHEMICAL ANALYSES OF SURFACE WATERS PICTOU COUNTY

Index No	Sample No	Grid Location	Date Sampled	Source	Na	K	Ca	Mg	CaCO3 (Hardness)	CaCO3 Alkalinity	SO4	Cl	F	SiO2	NO3 + NO2 as N	NH4 as N	As	Fe	Mn	Co	Al	B	Be	Ba	Cd	Cr	Cu	Zn	Ni	Pb	Sb	Sn	V	PO4 as Ortho	Total PO4	Suspended Solids	Total Dissolved Solids	Colour T C U	Turbidity J T.U.	Conductivity Umhos	Ph (Lab)	Temp °C
					Analyses in mg/litre															Analyses in mg/litre																						
1	A		Aug.17/78	WEST RIVER	4.8	0.48	6.0	2.3	24.9	16.1	8.5	6.8			2.11		< 0.005	0.20	0.02	< 0.01	< 0.05	< 0.02	< 0.005	0.02	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	0.005	< 0.05	< 0.03	< 0.01			0.4	50.8	12	1.1	82	7.0	
	B		April 3/79		2.2	0.20	2.6	1.0	11.0	5.0	3.5	4.5			< 0.10	< 0.10	< 0.005	0.19	0.04															< 0.02		7.3	21.0	20	2.4	29	6.6	
	C		Aug.10/79		2.6		4.4			16.0	5.0	4.2			< 0.05	< 0.05																		0.03	0.04		44.0			52	7.1	
2	A		Aug.17/78	WEST RIVER	1555.0	1.95	21.5	5.3	75.8	23.2	21.7	259.7			1.52		< 0.005	0.02	0.01	< 0.01	< 0.05	< 0.02	< 0.005	0.11	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	0.008	< 0.05	< 0.03	< 0.01			0.1	548.1	3	0.2	1000	7.5	
	B		April 3/79		16.0	0.40	5.2	1.2	18.0	8.0	6.0	26.0			< 0.10	< 0.10	< 0.005	0.07	0.03															< 0.02		2.3	68.0	20	1.4	122	7.0	
	C		Aug.10/79		52.0		9.0			21.0	10.0	83.0			< 0.05	< 0.05																		< 0.02	0.02		193.0			340	7.7	
3	A		Aug.17/78	WEST RIVER	92.1	1.61	21.5	4.7	73.3	22.3	18.4	150.8			1.62		< 0 005	0.02	0.03	< 0.01	< 0.05	< 0.02	< 0.005	0.14	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	0.005	< 0.05	< 0.03	< 0.01			0.4	349.0	3	0.4	600	7.5	
	B		April 3/79		14.0	0.40	5.6	1.2	19.0	11.0	6.0	22.0			< 0.01	< 0.01	< 0.005	0.12	0.03															0.06		3.0	64.0	20	1.4	110	6.9	
	C		Aug.10/79		37.0		10.0			24.0	10.0	60.0			< 0.05	< 0.05																		< 0.02	0.04		164.0			57	7.5	
4	A		Aug.17/78	MIDDLE RIVER	69.0	1.61	17.6	5.9	68.4	42.2	58.0	80.5			0.64		< 0.005	0.04	0.06	< 0.01	< 0.05	< 0.02	< 0.005	0.06	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	< 0.005	< 0.05	< 0.03	< 0.01			2.2	269.7	8	0.9	485	7.8	
	B		April 3/79		12.0	0.50	5.4	1.6	20.0	9.5	3.0	18.0			0.10	< 0.10	< 0.005	0.19	0.04															0.03		7.0	57.0	30	4.9	104	6.9	
	C		Aug.10/79		16.0		6.2			21.0	11.0	22.0			< 0.05	< 0.05																		0.04	0.07		74.0			117	7.7	
5	A		Aug.17/78	MIDDLE RIVER	4.8	0.37	4.0	1.8	17.7	11.4	5.8	7.2			2.55		< 0.005	0.06	0.03	< 0.01	< 0.05	< 0.02	< 0.005	0.04	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	0.03	< 0.05	< 0.03	< 0.01			0.1	36.8	5	0.4	63	7.0	
	B		April 3/79		1.9	0.20	1.8	0.8	7.7	2.0	2.0	4.5			< 0.10	< 0.10	< 0.005	0.04	0.04															< 0.02		1.0	12.0	10	0.55	22	6.3	
	C		Aug.10/79		2.0		1.8			5.0	1.8	3.5			< 0.05	< 0.05																		< 0.02	0.03		23.0			30	6.6	
6	A		Aug.17/78	MIDDLE RIVER	4.7	0.30	3.8	1.5	16.0	10.2	6.1	6.8			5.20		< 0.005	0.06	0.02	< 0.01	< 0.05	< 0.02	< 0.005	0.006	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	< 0.005	< 0.05	< 0.03	< 0.01			1.6	35.0	8	0.6	62	7.1	
7	A		Aug.17/78	WEST BRANCH of the EAST RIVER	5.6	0.57	8.8	1.9	30.1	17.3	14.4	8.8			0.69		< 0.005	< 0.02	< 0.01	< 0.01	< 0.05	< 0.02	< 0.005	0.05	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	0.008	< 0.05	< 0.03	< 0.01			0.6	60.3	3	0.4	102	7.5	
	B		April 3/79		3.4	0.30	4.2	1.1	15.0	6.2	6.0	6.5			< 0.10	< 0.10	< 0.005	0.29	0.04															< 0.02		2.8	36.0	20	1.8	50	6.9	
	C		Aug.10/79		3.3		4.4			12.0	5.5	5.0			< 0.05	< 0.05																		< 0.02	0.04		33.0			52	7.2	
8	A		Aug.17/78	EAST BRANCH of the EAST RIVER	5 8	0.81	22.5	2.4	66.3	23.8	56.0	9.4			0.60		< 0.005	< 0.02	< 0.01	< 0.01	< 0.05	< 0.02	< 0.005	0.06	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	0.005	< 0.05	< 0.03	< 0.01				133.3	5	0.3	205	7.7	
	B		April 3/79		6.8	0.70	14.0	1.3	41.0	20.0	16.0	14.0			0.10	< 0.10	< 0.005	0.06	0.05															< 0.02		1.5	83.0	15	1.1	120	7.2	
	C		Aug.10/79		2.4		6.2			12.0	11.0	4.5			< 0.05	< 0.05																		0.05	0.07		44.0			60	7.2	
9	A		Aug.17/78	WEST BRANCH of the EAST RIVER	3.5	0.33	5.5	1.3	19.4	7.6	13.2	5.1			8.33		< 0.005	< 0.02	0.01	< 0.01	< 0.05	< 0.02	< 0.005	0.02	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	< 0.005	< 0.05	< 0.03	< 0.01			0.7	35.2	2	0.2	67	6.8	
	B		April 3/79		2.2	0.30	2.4	0.7	9.0	3.0	3.5	4.2			< 0.10	< 0.10	< 0.005	0.07	0.04															0.03		2.3	19.0	20	1.3	34	6.5	
	C		Aug.10/79		2.0		1.6			2 5	3.0	3.7			< 0.05	< 0.05																		< 0.02	0.03		24.0			27	6.4	
10	A		Aug.17/78	EAST RIVER	6.7	0.81	19.5	2.4	58.9	22.5	41.0	9.7			1.62		< 0.005	< 0.02	0.01	< 0.01	< 0.05	< 0.02	< 0.005	0.06	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	0.005	< 0.05	< 0.03	< 0.01			0.4	75.3	3	0.5	175	7.8	
	B		April 3/79		3.6	0.30	5.6	1.1	18.0	7.5	7.0	7.0			0.10	< 0.10	< 0.005	0.11	0.03															< 0.02		2.5	40.0	20	1.4	59	7.0	
	C		Aug.10/79		3.1		6.0			13.0	8.0	5.0			< 0.05	< 0.05																		< 0.02	0.04		45.0			58	7.7	
11	A		Aug.17/78	McLELLAN BROOK	37.8	1.52	22.5	5.3	78.4	53.0	18.4	57.6			0.44		< 0.005	0.02	0.01	< 0.01	< 0.05	< 0.02	< 0.005	0.13	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	< 0.005	< 0.05	< 0.03	< 0.01			0.4	187.0	4	0.7	360	7.9	
	B		April 3/79		9.8	0.60	6.4	1.4	22.0	11.0	8.0	16.0			0.20	< 0.10	< 0.005	0.16	0.05															0.03		3.5	65.0	20	2.5	94	7.1	
	C		Aug.10/79		10.0		7.8			24.0	7.0	15.0			< 0.05	< 0.05																		< 0.02	0.04		81.0			106	7.6	
12	A		Aug.17/78	McLELLAN BROOK	8.4	0.88	12.1	1.9	38.3	28.8	12.4	13.6			8.92		< 0.005	< 0.02	0.02	< 0.01	< 0.05	< 0.02	< 0.005	0.17	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	0.007	< 0.05	< 0.03	< 0.01			0.9	75.2	4	0.4	138	7.6	
	B		April 3/79		3.8	0.40	5.0	1.0	17.0	8.0	6.0	7.5			0.20	< 0.10	< 0.005	0.11	0.02															< 0.02		1.8	31.0	20	1.5	55	7.9	
	C		Aug.10/79		4.0		5.0			16.0	5.5	6.5			< 0.05	< 0.05																		< 0.02	0.03		40.0			60	7.2	
13	A		Aug.17/78	McLELLAN BROOK	5.8	0.72	8.8	1.6	28.8	19.7	13.2	8.2			3.43		< 0.005	< 0.02	0.02	< 0.01	< 0.05	< 0.02	< 0.005	0.10	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	< 0.005	< 0.05	< 0.03	< 0.01			3.2	57.1	7	0.3	100	7.4	
14	A		Aug.17/78	McLELLAN BROOK	3.2	0.45	3.0	1.1	12.3	10.4	2.8	3.8			3.68																					0.4	26.8	7	0.2	43	7.3	
15	A		Aug.17/78		3.0	0.35	2.4	1.0	10.4	9.8	3.4	2.6			4.75		< 0.005	< 0.02	0.02	< 0.01	< 0.05	< 0.02	< 0.005	0.02	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	< 0.005	< 0.05	< 0.03	< 0.01				24.7	7	0.2	37	7.1	
	B		April 3/79		2.4	0.30	2.6	0.8	9.7	4.0	3 4	4.5			< 0.10	< 0.10	< 0 005	0.06	0.08															0.06		1.3	20.0	20	1.0	33	6.8	
	C		Aug.10/79		2.4		2.2			7.2	4.0	3.5			< 0.05	< 0.05																		< 0.02	0.04		22.0			35	7.2	
16	A		Aug.17/78	EAST BRANCH of the EAST RIVER	4.0	0.24	2.6	0.9	10.5	6.5	3.9	6.5			4.56		< 0.005	0.03	0.02	< 0.01	< 0.05	< 0.02	< 0.005	0.01	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	0.008	< 0.05	< 0.03	< 0.01			0.7	26.3	8	0.5	44	6.9	
	B		April 3/79		3.0	0.40	2.4	0.7	8.8	3.5	2.5	6.2			< 0.10	< 0.10	< 0.005	0.06	0.03															0.05		1.5	26.0	20	0.66	35	6.3	
	C		Aug.10/79		2.4		1.9			5.5	2.0	4.0			< 0.05	< 0.05																		0.05	0.13		30.0			29	6.4	
17	A		Aug.17/78	SUTHERLAND RIVER	15.6	0.93	8.4	2.1	29.9	14.4	7.7	29.2			3.97		< 0.005	0.02	0.02	< 0.01	< 0.05	< 0.02	< 0.005	0.04	< 0.005	< 0.01	< 0.01	< 0.01	< 0.02	0.008	< 0.05	< 0.03	< 0.01			1.6	80.3	3	0.4	148	7.2	
	C		Aug.10/79		5 6		4.0			14.0	3.0	8.5			< 0.05	< 0.05																		< 0.02	0.03		45.0			60	7.2	