T8.1 FRESHWATER HYDROLOGY

Nova Scotia has no shortage of fresh water. The total mean precipitation is fairly high: approximately 1300 mm as compared to 800–950 mm in central Ontario and 300–400 mm in southern Saskatchewan. Frequent coastal fog, cloudy days and cool summers combine to moderate evapotranspiration. The result is a humid, modified-continental climate with a moisture surplus. Large areas of impermeable rock and thin soils and the effect of glaciation have influenced surface drainage, resulting in a multitude of bogs, small lakes and a dense network of small streams. Groundwater quality and quantity vary according to the type of geology in different parts of the province. The following topics describe the cycle of water and the various environments and forms in which it manifests itself. Fresh water as a resource is discussed in T12.8.

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Hydrology is the study of water in all its forms and its interactions with the land areas of the earth. It deals with snow and ice on the land, moisture in the air, liquid water in lakes and rivers, as well as water occurring below the ground in the spaces between soil and rock, and within the soil.

Limnology and hydrogeology are specialized branches of hydrology. Limnology is the study of surface freshwater environments and deals with the relationships between physical, chemical, and biological components. Hydrogeology is the study of groundwater, emphasizing its chemistry, migration and relation to the geological environment.[1]

THE HYDROLOGIC CYCLE

The continuous process involving the circulation of water between the atmosphere, the ocean and the land is called the hydrologic cycle (see Figure T8.1.1). Solar radiation and gravity are the driving forces that "run" the cycle.

As water vapour cools, condensation occurs and clouds form. When rain or snow falls over land, a number of things can happen to the precipitation: some of it runs off the land surface to collect in catchment basins, some is returned directly to the atmosphere by evaporation and by transpiration in plants (evapotranspiration), and some percolates underground (infiltration) to become groundwater.

Underground formations that readily give up their water for wells are called aquifers (see T8.2). The

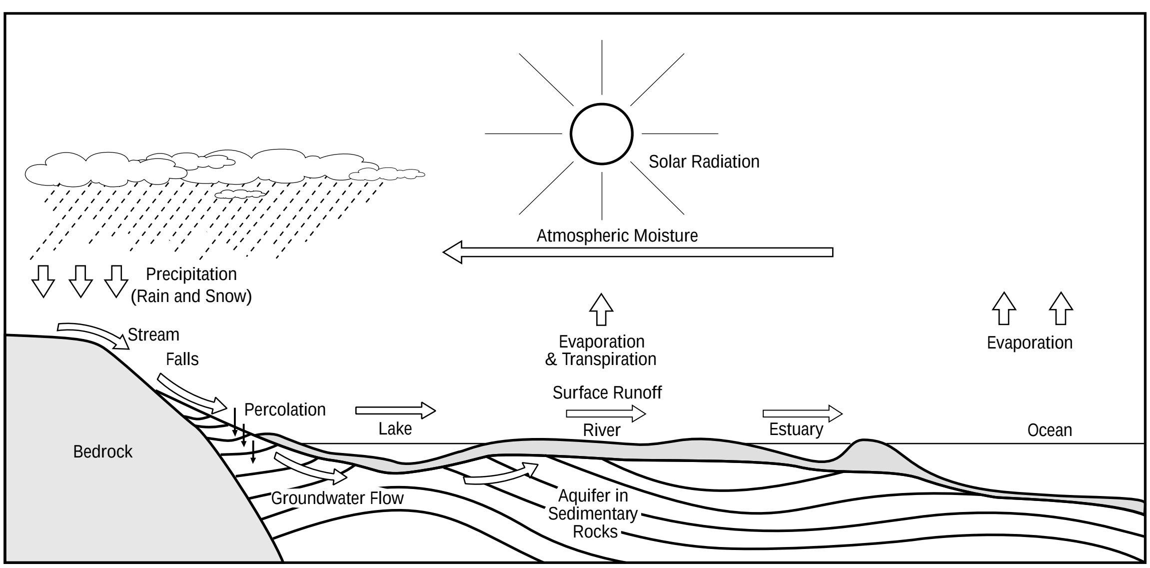

Figure T8.1.1: The hydrologic cycle.

upper water level in an aquifer is known as the water table. Water is continuously flowing underground and can move back to the surface by capillary action or be transported horizontally by subsurface flow, until it reaches a surface water system.[2]

Nova Scotia's cool climatic conditions produce a cycle where precipitation exceeds evapotranspiration. Due to the high rate of annual precipitation, rivers, lakes and aquifers are replenished or recharged, although the rate varies, depending on the amount of precipitation, the type of soil, the topography and the geology of the area. In areas dominated by rocky land surfaces, such as in southwestern Nova Scotia (Regions 400 and 800), the amount of runoff is very high and, subsequently, groundwater recharge is slow. Where more porous soils are found, such as in the Carboniferous Lowlands (Region 500), infiltration is much greater, and thus groundwater is higher.

WATERSHEDS

A watershed, or drainage basin, refers to the area of land from which surface water drains into a common lake or river system or directly into the ocean. The flow is generally inwards and downwards, according to the topography of the surrounding landscape. The boundaries of a watershed area are known as a drainage divide: precipitation falling on opposite sides of a divide falls into different watersheds. The underlying geology and type and depth of surficial overburden of every drainage basin are major factors in determining its characteristic drainage pattern (see T3.2). The watershed has become the unit used by water-resource planners and managers in dealing with developments within an area that may have an impact on water quality and quantity. Any activities that occur in the upper portions of a watershed will have an impact on water quality in downstream areas.

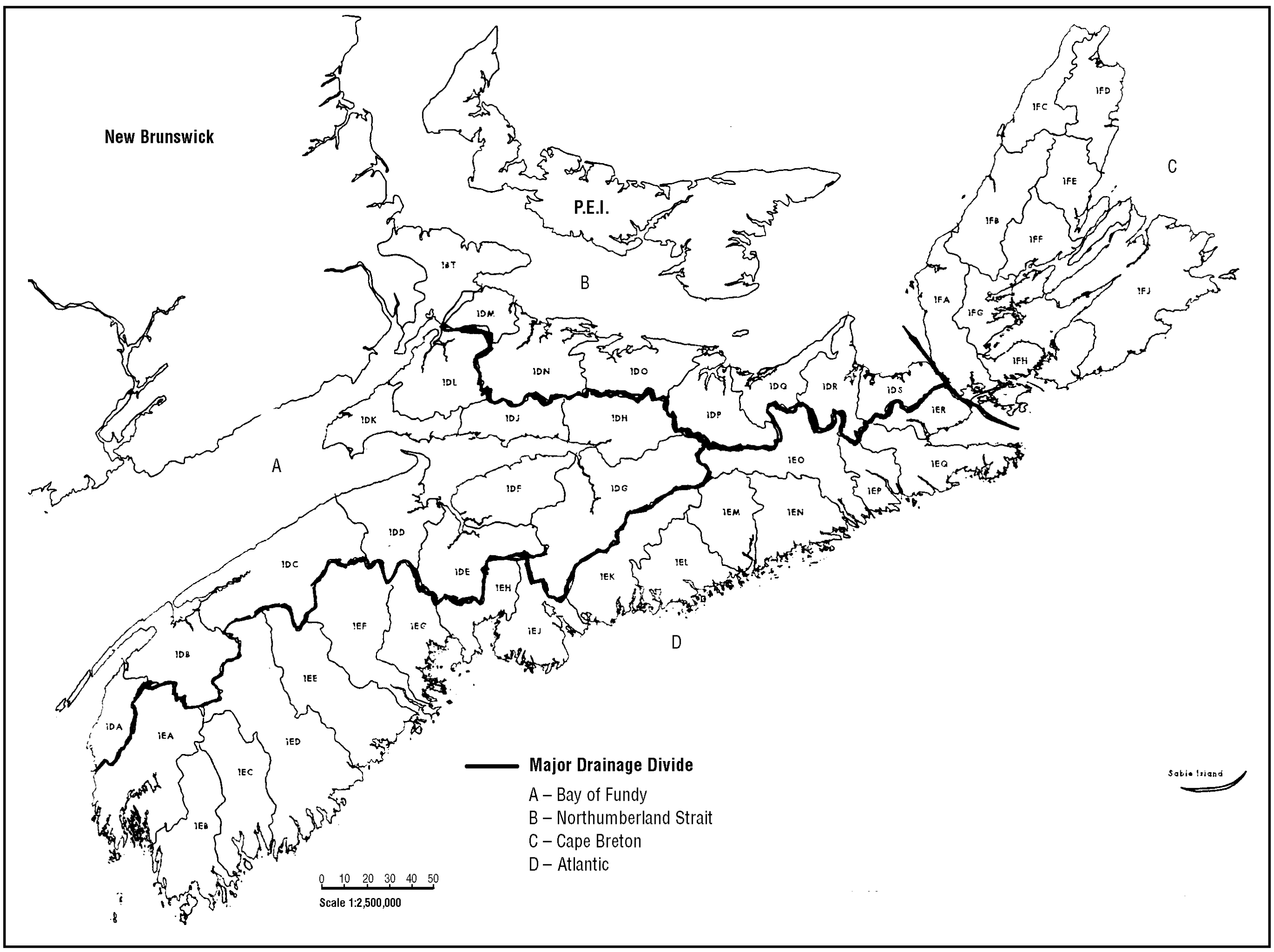

Figure T8.1.2: Locations of primary watersheds in Nova Scotia.

WATERSHED #	MAJOR RIVERS	TOTAL AREA (km^2)		
		Land	Water	Total
1DA	Meteghan	570	41	611
1DB	Sissiboo and Bear	1349	79	1428
1DC	Annapolis	2209	70	2279
1DD	Gaspereau	1316	58	1375
1DE	St. Croix	1306	61	1368
1DF	Kennetcook	1116	9	1125
1DG	Shubenacadie and Stewiacke	2540	73	2614
1DH	Salmon and Debert	1164	4	1168
1DJ	Economy	790	3	793
1DK	Parrsboro	856	2	858
1DL	Kelley, Maccan and Hebert	1295	9	1304
1DM	Tidnish and Shinimicas	475	4	479
1DN	Philip and Wallace	1475	19	1494
1DO	John	1111	6	1117
1DP	East, Middle, West (Pictou)	1190	7	1197
1DQ	French	735	1	736
1DR	South and West (Antigonish)	898	9	907
1DS	Tracadie	580	6	586
1EA	Tusket	1982	194	2177
1EB	Barrington and Clyde	1243	79	1322
1EC	Roseway and Sable and Jordan	1350	84	1435
1ED	Mersey	2690	339	3030
1EE	Herring Cove and Medway	1845	166	2012
1EF	LaHave	1611	89	1700
1EG	Gold	972	57	1029
1EH	East and Indian	695	69	765
1EJ	Sackville	924	71	996
1EK	Musquodoboit	1316	93	1409
1EL	Tangier	974	111	1086
1EM	East (Sheet Harbour)	914	74	988
1EN	Liscomb	1136	66	1202
1EO	St. Mary's	1505	43	1549
1EP	Country Harbour	550	18	569
1EQ	New Hbr./ Salmon (Guys.)	1019	70	1089
1ER	Clam Harbour/ St. Francis	517	14	532
1FA	Inhabitants	1193	10	1204
1FB	Margaree	1308	67	1375
1FC	Cheticamp	802	3	806
1FD	Wreck Cove	1057	15	1072
1FE	Indian	882	7	890
1FF	North, Baddeck and Middle	764	2	767
1FG	Denys and Big	792	2	794
1FH	Grand	739	33	772
1FJ	Salmon and Mira	2779	134	2914
*	Isle Madame	145	6	151

Table T8.1.1: Characteristics of primary watersheds in Nova Scotia. The figures were calculated by the Maritime Resource Management Service for the Nova Scotia Department of Environment in 1981.
*Isle Madame is classified as a shoreline direct inflow to salt water on the 1:50 000 watershed maps for Nova Scotia.

Most of the forty-four primary watersheds in the province are relatively small, ranging in size from 151 to 3030 km^2, especially those near the coastal zone, where numerous small streams flow directly into the ocean.[3] There are three major drainage areas in Nova Scotia. One large divide runs in an east–west direction across the mainland of the province. A second divide cuts across the top of the Cobequid Hills and the Pictou/Antigonish Highlands (District 310). The Canso Strait serves as another divide by separating Cape Breton from the mainland. Figure T8.1.2 shows the distribution of the major watersheds. On Cape Breton Island, most of the watersheds are quite small, mainly due to the fragmented topography and the existence of the Bras d'Or Lake system (District 560, Unit 916). The two exceptions to this are the Margaree (1375 km^2) and the Salmon-Mira River system (2914 km^2)

Some of the largest watersheds are found in the Atlantic interior (Region 400), such as the Medway, 2012 km^2; the LaHave, 1700 km^2; and the Shubenacadie-Stewiacke River system, 2614 km^2. The largest watershed in the province belongs to the Mersey River, which drains an area of 3030 km^2. A complete list of primary watersheds is provided in Table T8.1.1. Primary, secondary and tertiary watersheds in Nova Scotia have been mapped at a 1:50 000 scale. These maps are available through the Nova Scotia Department of Environment.

In addition to the primary watersheds outlined above, Environment Canada has also divided the province into three separate hydrological zones.[4] The criteria for making these divisions are based primarily on mean annual precipitation.

Due to the Shubenacadie Canal, the Shubenacadie River is Nova Scotia's longest river. The canal cuts perpendicularly across a major drainage divide and consequently water flows both north towards Cobequid Bay and south into Halifax Harbour.

WATER BUDGET

Nova Scotia averages 1300 mm of precipitation annually; however, there are times when water levels in lakes and rivers are low and wells run dry. It is estimated that less than 20 per cent of the total amount of rain and snow seeps underground to recharge the water table.[2] This occurrence relates directly to the amount of runoff, which has been estimated at 1018 mm per year (based on the average annual value for data recorded by Environment Canada).[5] Runoff is influenced by many factors, including soil type, soil moisture conditions, slope of the land and the amount of vegetation cover. In general, coarse soils with low to moderate runoff potential occur throughout the province. The exception occurs in central and northern Nova Scotia, which have more finely textured soils with higher runoff potential. Runoff can be accelerated by the removal of vegetation or infilling of wetlands. The accelerated runoff can in turn increase erosion, leading to higher levels of sediment loading and turbidity within streams. Figure T8.1.3 shows the mean annual runoff pattern for the province.[4]

Evapotranspiration is the evaporation from soil and waterbodies combined with transpiration from

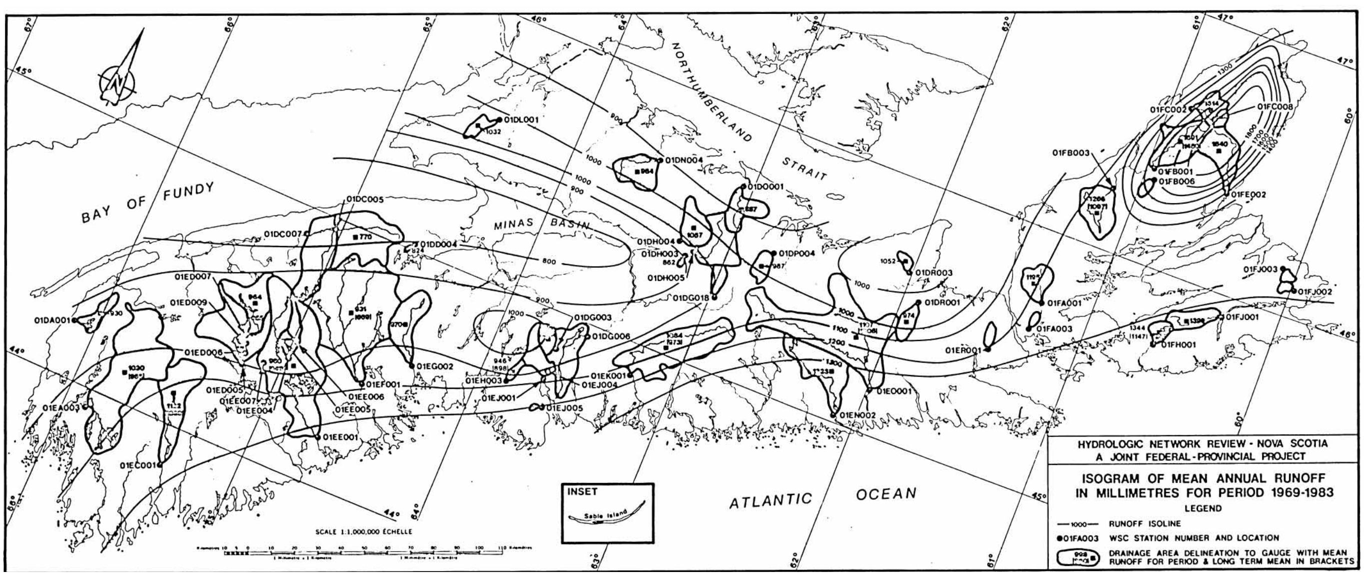

Figure T8.1.3: Mean annual runoff for Nova Scotia.

vegetation. Frequent coastal fog, combined with cloudy days and cool summers, results in moderate levels of evapotranspiration over most of the province. Levels have been estimated at between 200 and 400 mm a year. When this value is added to the runoff rate, it indicates that only a small percentage of the total rainfall infiltrates groundwater-storage areas or aquifers. The minimum annual groundwater recharge in Nova Scotia is estimated at 125 mm to 150 mm over a drainage basin, or approximately 10 per cent of the mean annual precipitation.[6]

DISCHARGE PATTERNS

Nova Scotia has a temperate climate which is characterized by ample and reliable precipitation, resulting in few prolonged dry seasons. There are, however, some notable variations in discharge patterns.

Precipitation is highest in the fall and winter months and usually lowest in June and July. It then begins to rise again during August with the arrival of the late-summer storms tracking up from the Caribbean region (see T5). Stream discharge normally peaks in March and April, as the result of snowmelt, and then drops dramatically to its lowest level in late summer and early fall. Figure T8.1.4 shows the mean monthly discharge pattern for selected Environment Canada monitoring sites throughout the province.[5]

The seasonal variation in water discharge has a direct effect on the chemical composition of surface water. The conductivity of lakes is often measured to determine the amount of dissolved solids (e.g., calcium, magnesium, sodium and potassium) which, in turn, may influence the level of productivity. Conductivity is high in the spring, when the amount of discharge is greatest, and low during the summer, when discharge is also very low. The *Historical Water Level Summary* published by Environment Canada provides water-level data for lakes in Nova Scotia.[7]

STREAMFLOW

Water flow in streams that drain the thin soils overlying igneous-rock formations is maintained primarily by surface runoff. As a result, the water level of these streams tends to drop during the drier summer months, and many smaller streams go completely dry. In contrast, the deeper soils found in areas of sedimentary rocks are drained by fewer streams.

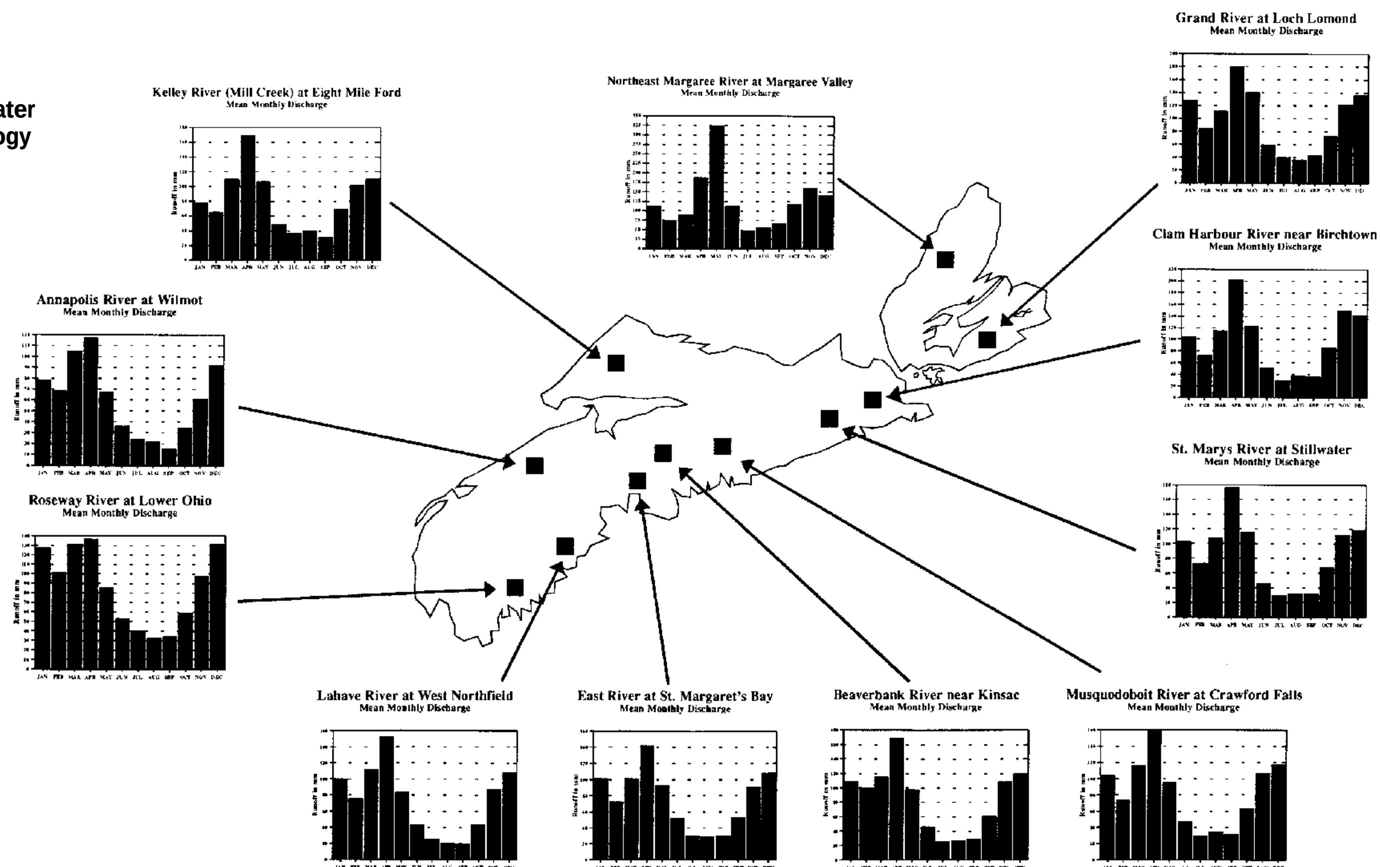

Figure T8.1.4: Mean monthly discharge pattern at selected monitoring sites.[5]

However, spring seepage from groundwater sources ensures a more constant flow of cooler water throughout the year.

The response of stream flow to precipitation controls the interaction between water, soils and bedrock, thus influencing chemical composition. Topography influences the collection of mineral sediments and the accumulation of peat deposits in and around lakes.

Streamflow data is usually obtained by measuring the velocity of flowing water with a current meter. The cross-sectional area of the stream multiplied by its velocity yields the flow rate or amount of discharge.

Records of streamflow have been collected in Nova Scotia since 1915. At present, a network of gauging stations operates throughout the province under the direction of a joint federal/provincial program. These stations provide continuous data allowing for the determination of mean and extreme discharge for natural and regulated flow. The network is maintained by Environment Canada, and updated information is available as computer data or in hard-copy format. Historical data are available from the *Historical Steamflow Summary* and the Surface Water Data Reference Index.

GROUNDWATER PROCESSES (SUBSURFACE FLOW)

Underground water flows both vertically and horizontally. Earth materials below the land surface can be divided into two zones: the upper, unsaturated zone and the underlying saturated zone[6] (see Figure T8.1.5). When saturation level is reached in the upper-soil-water belt, gravity pulls the water down vertically through the unsaturated zone until it hits the water table. On the way, water passes through an intermediate zone which contains variable amounts of water in the soil openings. In dry periods, the capillary action may draw the moisture back to the upper layer. If enough water is present, it passes through the intermediate zone to the saturation zone. The water table is the upper boundary of this zone and it can vary in depth seasonally. The water which fills all of the pores in this zone is the groundwater. Groundwater can flow horizontally through the medium depending again on gravity as the driving force.

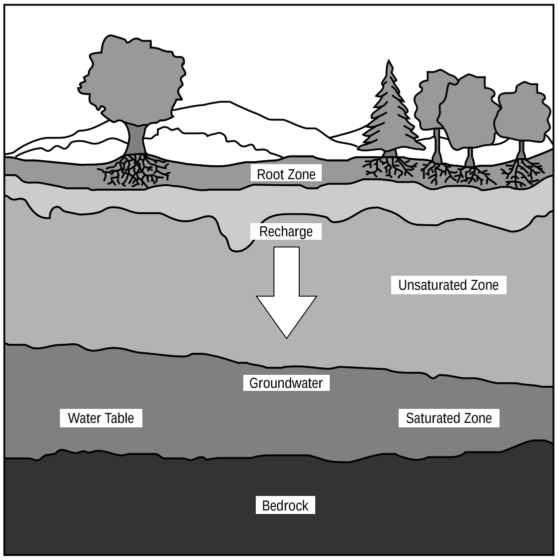

Figure T8.1.5: Groundwater originates from recharge, which is water percolating downward through the soil.

The province has initiated a number of regional-groundwater studies since 1964. These were begun by the Department of Mines, but later carried out by the Department of the Environment. Qualitative and quantitative groundwater data were collected from a number of test wells constructed for these projects.[8] Areas surveyed include the Annapolis–Cornwallis Valley (District 610);[9] the Musquodoboit River valley (unit 511a);[10] the Truro area (District 610);[11] Pictou County (Regions 300 and 500);[12] Cumberland County (Districts 520 and 580);[13] the Windsor –Hantsport–Walton area (Unit 511a);[14] southwestern Nova Scotia (Region 400);[15] the Sydney Coalfields (Unit 531);[16] and Sable Island (District 890).[17]

The Nova Scotia Department of the Environment maintains a groundwater-observation-well network. This currently consists of thirty-six stations across the province, some of which have been monitoring groundwater levels since 1965.

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Associated Topics

T3.2 Ancient Drainage Patterns, T5.1 The Dynamics of Nova Scotia's Climate, T5.2 Nova Scotia's Climate, T6.1 Ocean Currents, T6.2 Oceanic Environments, T8.2 Freshwater Environments, T8.3 Freshwater Wetlands, T11.5 Freshwater Wetland Birds and Waterfowl, T11.13 Freshwater Fishes, T11.15 Amphibians and Reptiles, T11.16 Land and Freshwater Invertebrates, T12.8 Fresh Water and Resources

Associated Habitats
H3 Freshwater, H4 Freshwater Wetlands

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