

Hydrogeological Regions

Abstract

Hydrogeological regions are areas in which the properties of sub-surface water, or groundwater, are broadly similar in geology, climate and topography. Hydrogeology is the branch of geology that deals with the distribution and movement of water beneath the earth's surface. This map shows Canada's nine hydrogeological regions.

Canada can be subdivided into nine hydrogeological regions, in which groundwater conditions are broadly associated with similar geology, climate and topography. This hydrogeological subdivision emphasizes major geological provinces and rock formations. Fundamental water-bearing openings and rock-matrix properties help determine the quantity (storage), flux (transmission) and composition of groundwater formations beneath the surface. These same properties and any overlying sediment cover (along with climate and vegetation) affect distribution and recharge/ discharge rates for groundwater.

Each of the nine hydrogeological regions is described below in terms of its climate, vegetation, topography, geology and groundwater characteristics.

1) Cordillera Hydrogeological Region

The Cordillera hydrogeological region covers an area of about 1 million square kilometres, including most of British Columbia, the Yukon and southwestern Alberta. The region has dramatic physiographic, geological and climatic diversity. Population, agricultural and industrial pressure on water resources are focused along narrow coastal zones, river terraces and drier interior valleys.

Cordillera climate varies from humid temperate conditions along the southwestern coast to subarctic conditions in the high mountains and in the north. Climate is dominated by air masses from the Pacific Ocean and by the effects of mountainous terrain. In general, coastal areas have milder wetter conditions, whereas interior valleys have larger temperature fluctuations and are noticeably dryer. Along the Pacific Coast, precipitation can exceed 4000 millimetres, but locally can be as low as 600 millimetres (Gulf Islands). Eastward from the coast, annual precipitation decreases from 1200 to 1500 millimetres in mountainous regions to less than 300 millimetres in some intermontane valleys (Okanagan). Above the tree line (above 2000 metres), it is cold, windy and snowy, with areas of perpetual ice and snow cover. Vegetation in the region ranges from rainforest on the coast to extensive coniferous forest in the interior and shrub vegetation in the arid southern valleys.

It is a mountainous region consisting of a series of north-trending mountain ranges and intervening interior plains and intermontane valleys. The plains are most extensive in the north, whereas the larger intermontane valleys are more prominent in the south. Mountain relief is commonly 1000 to 3000 metres. Eastern mountains are dominated by deformed, folded and faulted sedimentary rocks, whereas coastal mountains have more volcanic and massive igneous rocks. North-central plateaus are predominantly underlain by large shield volcanoes and lava flows. Surficial deposits are thick (100 metres) in intermontane valleys and along major river valleys. Deposits include extensive glacial river and lake deposits and glacial marine sediment, below the former marine limit. In the mountains, sediment that has washed down slopes and covers valley bottoms is important.

Aquifers are exploited in both bedrock and surficial sediment. Flow in bedrock is typically along secondary fractures, such as bedding planes, joints or faults. Flow in karstic and volcanic bedrock may also occur in voids or cavities and in inter-bed zones, where a permeable rock type occurs between beds of other rocks. Numerous thermal springs occur in the region, and are typically localized along major faults or in association with areas of high heat flow in volcanic belts. Both types, deeper confined and shallow unconfined aquifers, are important. Groundwater recharge is seasonally dependent. In coastal areas, recharge occurs in winter and early spring when precipitation is greatest. Recharge in interior regions occurs in late spring to early summer and is related to snowmelt. Warm temperatures and vegetation promote high evaporation and transpiration losses throughout the summer. Groundwater quality is very good across the region, with local occurrences of elevated nitrate, arsenic, fluoride, boron and saline water. Coastal aquifers may experience saltwater intrusion; elsewhere, increased salinity is associated with increasing depth.

2) Western Plains Hydrogeological Region

The Western Plains hydrogeological region is a sedimentary basin, covering about 1.8 million square kilometres (18 per cent of Canada), that is bounded by the Cordillera to the west and Canadian Shield to the east and north. The region is sparsely populated with a few large cities; most land is used for agriculture. The semiarid south is dominated by dryland farming, along with significant areas of irrigation. Hydrocarbon exploration and development, potash and coal mining are the dominant resource-extraction activities across the region. Oil sands production is a significant concern for surface- and groundwater quality and quantity in northern Alberta. Surface-water allocation is no longer available in southern Alberta; thus, demand has increased on groundwater systems.

The climate is dominated by semiarid continental conditions. Moisture-bearing Pacific winds are blocked by the Rocky Mountains. This results in a subhumid to semiarid climate, with short, warm summers and very cold winters. Precipitation is lowest and evaporation and transpiration highest in the western Prairies, with net moisture accumulation increasing eastward from 250 millimetres in southwestern Alberta to about 700 millimetres in Manitoba. Periodic Chinooks are warm, dry winds from the



Rockies that bring spring-like temperatures to a semiarid region across southern Alberta and, to a lesser extent, southern Saskatchewan. Natural vegetation of tall, mixed, and short grasses with sagebrush gives way northward to aspen-poplar parkland, then to slow-growing open spruce forests. Small wetlands are critical for recharge in grassland prairies.

Topography of the region trends from 1200 metres above sea level in the southwest to 200 metres along the northeastern edge of the basin. Two prominent 'prairie steps' disrupt a landscape characterized by flat to gently rolling and hummocky terrain. Two large watersheds drain the region: the Saskatchewan-Nelson River flows to Hudson Bay and the Mackenzie River flows to the Arctic Ocean. The Saskatchewan-Nelson River drainage originates in the ice-fields of the Rocky Mountains; very little surface runoff, and modest groundwater baseflow, is contributed from the dry interior of the region. The geology is the Western Canada Sedimentary Basin, a layered sedimentary wedge that thickens from the edge of the Canadian Shield to about 6 kilometres in the southwest. Surficial sediment thickness varies, but is thickest along buried valleys. Surficial sediment can alternate from till to sand and gravel to silt and clay, resulting in complex shallow groundwater systems.

Hydrology in the region can be divided into bedrock and sediment-dominated terrains. Surficial aquifers, particularly buried valley aquifers, are important across the region. In western Alberta, glacial deposits are thin and shallow aquifers occur only in thicker, hummocky terrain. Near-surface bedrock aquifers, such as fluvial sandstone, are important but their yield and quality are variable due to interbedded marine mudstone and isolated channel sand deposits. Shallow groundwater flows to streams or to prairie sloughs.

3) Canadian Shield Hydrogeological Region

The Canadian Shield is the largest hydrogeological region in Canada, with an area of 4.6 million square kilometres, or nearly half the country. Approximately 10 per cent of this area is fresh water. It is a vast region that extends from the Northwest Territories to Labrador and includes the northeastern corner of Alberta, northern Saskatchewan and much of Manitoba, Ontario and Quebec. The region's population is low and centered in areas of mining, and pulp and paper activity. The Shield's rich natural resources—timber, mineral and water—attract recreational and industrial use.

Climate is continental, with long cold winters and short warm summers. Regions bordering large bodies of water tend to be warmer in winter and cooler in summer, except for those with winter ice cover. Precipitation is low to moderate and ranges from about 400 millimetres in the west to 1000 millimetres in the east. Precipitation and temperature both decrease from south to north. Forests of spruce, balsam fir and pine predominate, while broadleaf trees occur in southern areas. Open, permafrost-stunted black spruce forest occurs in northern terrains.



The regional landscape consists of a series of eroded uplands between 200 and 1000 metres above sea level with a relief of 50 to 100 metres. Greater relief, 150 to 300 metres, occurs along river valleys incised into uplands and plateaus. A series of large lakes occurs along the southern border of the Shield (for example, Great Slave Lake, Lake Winnipeg and the Great Lakes). The Shield is composed of Precambrian igneous, metamorphic and metasedimentary crystalline rocks formed during several phases of mountain building and other tectonic events. Much of the area has a discontinuous cover of thin glacial sediment. Thicker sediment occurs in areas of glacial landforms, such as moraines, that have variable amounts of sand and gravel, and less-porous till. Glacial lake deposits in parts of Quebec, Ontario and Manitoba form extensive clay basins with underlying sand and gravel deposits.

The ubiquitous crystalline rocks are characterized by low storage capacity and uncertain ability to transmit water in sparse fracture networks. Fracture zones yield modest and variable quantities of potable water to depths of about 100 metres. At greater depths, groundwater becomes progressively more saline. Sediment aquifers are important, particularly in eskers and beneath clay basins, and can provide municipal drinking water and agricultural supply from groundwater. Modest undulating relief on the Shield provides low driving force for slow groundwater movement and renewal. This affects water quality in bedrock fracture systems due to bedrock mineralization, particularly metals and uranium, the latter generating radon gas.

4) Hudson Bay Lowlands Hydrogeological Region

The Hudson Bay Lowland is the southern expression of a sedimentary basin centred on Hudson Bay. The terrestrial extent is about 250 000 square kilometres and it is bounded by Canadian Shield rocks to the south and west. It is most extensive in Ontario, with minor areas in Manitoba and the James Bay region of Quebec. Permafrost bounds the northern extension of the region. The area is sparsely populated and has little industry.

Climate is continental and is strongly influenced by cold, moisture-laden Hudson Bay and polar air masses. It is characterized by short cool summers and long cold winters. Mean annual temperature ranges from -4 to -2 degrees Celsius but is closer to -7 degrees Celsius in Manitoba. Annual precipitation averages 400 to 800 millimetres, increasing from northwest to southeast. The region supports the largest organic terrain in the world, since up to 75 per cent of the area is underlain by wetlands. Poorly drained areas support dense sedge-moss-lichen covers, and less common better-drained sites support open woodlands of black spruce and tamarack. Raised beaches are vegetated by black spruce and depressions are filled with bogs and fens.

The Hudson Bay Lowland rises gently from sea level to about 120 metres above sea level and is an area of low relief with poor drainage. A series of beach ridges occurs inland from the shoreline and forms a prominent topographic element of the region. Isolated bedrock knolls penetrate the surficial cover; the Precambrian Sutton Ridges

rise 150 metres above the surrounding landscape. Low relief is a reflection of nearly horizontal sedimentary strata of the Hudson Bay and Moose River basins that are up to 1500 metres and 900 metres thick, respectively. Both basins are dominated by carbonate bedrock. In the Moose River Basin, beds consist of poorly consolidated clastic sediment and local kaolinite mudrock and lignite. The sedimentary succession is cut by a number of intrusions, some of which are kimberlitic. Till occurs as a semi-continuous cover that is considerably thicker than in the Canadian Shield region. Broad buried valleys have been filled with more than 60 metres of sediment, some with as much as 145 metres. Surface sediment is commonly glacial marine clay and sand.

Glaciolacustrine and glacial marine clay and till units form regional aquitards; kaolinite-rich mudstone and lignite form a local aquitard in the Moose River Basin. Groundwater flows principally along joints, faults, fractures and bedding planes. Karst, where water flows in larger openings, can be common. Groundwater interacts with surface water 1) where shallow groundwater discharges at peat-sediment interfaces, and 2) where peat is underlain by sand and gravel. At intermediate depths, it discharges along bedrock-sediment interfaces, and deeper groundwater flows from bedrock aquifers to large rivers.

5) St. Lawrence Lowlands Hydrogeological Region

The St. Lawrence Lowlands extend along the St. Lawrence River and Ottawa valley, covering an area of about 50 000 square kilometres. They are bounded by Canadian Shield rocks of the Laurentian Highlands to the north and east, and the Appalachian Mountains to the south. This region includes Anticosti Island, archipelagos in the Gulf of St. Lawrence, and Newfoundland coastal lowlands. The area is highly populated and is industrially active along the Québec-Ottawa corridor. The western part of the region also has intense agriculture.

Climate ranges from continental (west of the city of Québec) to maritime. The northeastern part of the region is notably cooler due to the Labrador Current. Mean annual temperatures range from 2.5 to 5 degrees Celsius and mean annual precipitation ranges between 800 and 1100 millimetres per year. Spring arrives in the west in April, and snow may linger in the east into May. Mixed forests of sugar maple, yellow birch, eastern hemlock and eastern white pine form the most stable vegetation in the western part of the region, where not reduced in extent by extensive agriculture. The eastern part has boreal forest cover and, in Newfoundland, extensive wetlands cover more than 25 per cent of the area.

This region includes the central and eastern parts of the St. Lawrence Lowlands. The area has flat-lying to rolling terrain and rarely rises above 150 metres in elevation, except for the Collines Montérégiennes near Montréal and along sloped margins of the area. The hydrological system is dominated by the Ottawa and St. Lawrence rivers. The region is underlain by carbonate and clastic rocks that are up to 2300 metres thick. Extensive normal faulting offsets bedrock units by tens of metres and there is gentle, broad-amplitude folding of some formations. Karst is developed in

the carbonate rocks, most notably along major rivers or escarpments. Sediment cover is less than 20 to 30 metres thick from the Fjord du Saguenay to the city of Québec, and up to 150 metres in buried bedrock valleys.

Bedrock aquifers are common. However, fractures control flow and yields can decrease with depth. Water quality also decreases with increasing depth in bedrock aquifers. Local natural gas occurrences can compromise the quality and safety of groundwater. Muddy marine sediment, and local till, confine and protect most regional aquifers. The most common domestic aquifer target is the sediment-bedrock 'contact zone', where water is drawn from sediment and bedrock aquifers. Shallow carbonate aquifers have relatively poor yields. Esker aquifers, confined by mud deposits of the glacial Champlain Sea, are important municipal aquifers (for example, the Vars–Winchester aquifer). Locally, thin sheets of gravel may extend the esker aquifer laterally to include aquifers at the contact between sediment and bedrock. Groundwater is important in the western part of the region for maintaining summer stream flow (baseflow) in an area with a net moisture deficit for four months of the year.

6) Southern Ontario Hydrogeological Region

Southern Ontario is a sedimentary basin of about 72 000 square kilometres bounded by the Canadian Shield to the north and east and Great Lakes to the south. Widespread industry and high population density affect land use and surface hydrology. Well-drained soils and a mild climate support extensive agriculture. Even with proximity to abundant Great Lakes surface water, groundwater continues to be a pivotal resource for agricultural and potable water use. A particular issue, affecting a number of urban areas (for example, Waterloo) is water diversion, the taking of water from one Great Lake and its discharge to a different lake.

Southern Ontario has a temperate continental climate that is strongly influenced by the adjacent Great Lakes, with warm summers, mild winters (mean temperature range from 5 to 8 degrees Celsius) and average precipitation of 720 to 1000 millimetres. Precipitation is highest east of the Great Lakes. Evapotranspiration ranges from about 600 millimetres per year in the south to about 500 millimetres per year in the north. Available moisture for runoff to streams or groundwater recharge varies from 200 to 400 millimetres per year. The original mixed coniferous-deciduous forest now covers only about 10 per cent of the region, with the remainder having been cleared for agriculture and cities.

Bedrock scarps (for example, Niagara Escarpment) are the most prominent areas of bedrock outcrop. Escarpment uplands have elevations of 550 metres above sea level and slope gently southwest on inclined rock strata. Secondary topography, such as the Oak Ridges Moraine, rises up to 300 metres above Lake Ontario to form an important drainage divide between Lake Ontario and Georgian Bay. East of the Niagara Escarpment, strata are predominantly sandstone, siltstone and shale, with secondary amounts of carbonate rocks. West of Niagara Escarpment, carbonate rocks are predominant in three formations that extend from the Niagara Peninsula to

Lake Huron: the Amabel-Lockport, Guelph and Salina formations. To the southwest of the Onondaga Escarpment, the succession is progressively dominated by carbonate rocks, shale and evaporites. Surficial sediment up to 200 metres thick buries most of the bedrock in the area and is thickest above buried bedrock valleys (for example, the Laurentian and Dundas valleys). Steep-sided, deeply incised meltwater valleys eroded in sediment trend south from the Shield margin and continue in the subsurface beneath the Oak Ridges Moraine. Extensive sand and gravel deposits also occur in other stratified moraines and eskers.

Bedrock and surficial sediment both serve as important local aquifers in the region. East of the Niagara Escarpment, most water is extracted from surficial aquifers in buried valleys and stratified moraines (for example, the Alliston aquifer and the Oak Ridges Moraine). Areas of thick sediment contain multiple aquifer-aquitard systems with local- and intermediate-scale flow systems and preferential flow paths. Bedrock aquifers are more important west of the Niagara Escarpment (for example, the Guelph-Amabel aquifer), although surficial aquifers are locally important (for example, the Waterloo Moraine aquifer). Where sediment cover is thin, upland carbonate aquifers are karstic and yield significant quantities of water. In the southwest, limestone and shale yield variable quantities and quality of water. Farther west, shale yields low quantities of poor-quality water from the upper few metres of weathered and fractured bedrock-sediment interfaces.

7) Appalachians Hydrogeological Region

The Appalachians hydrogeological region comprises Nova Scotia, New Brunswick, Quebec south of the St. Lawrence River and the island of Newfoundland. This 310 000 square kilometre area has a low population density and forestry operations are widespread. Extensive surface-water resources and high levels of precipitation ensure that surface water is the principal source of potable water outside agricultural areas.

Ocean water temperatures moderate the climate of the eastern part of the region. In winter, the extensive ice cover of the St. Lawrence River can contribute to a more continental climatic pattern for bordering regions. Temperatures vary between two distinct climatic regimes: the area of maritime climate has a temperature ranging from -2 to 17 degrees Celsius, whereas the more continental climate has average winter lows of -7 degrees Celsius and summer highs of 25 degrees Celsius. The highest precipitation values are in excess of 1600 millimetres along the south coast of Newfoundland and in the Cape Breton highlands. By contrast the continental area has a precipitation maximum of 1200 millimetres. Frequent thaws and rainstorms during mid-winter in the maritime area can contribute to a complex hydraulic regime, with large late winter run-off and recharge events triggered by moisture-laden snow packs.

Forests in continental areas are generally mixed conifers and deciduous stands of spruce, balsam fir, yellow birch and sugar maple. In Newfoundland, vegetation is diverse and ranges from the moss-heath of the Avalon barren to stands of balsam fir

and black spruce on steep, moist, upland slopes. Much of the coastal region and raised domed bogs are dominated by open patches of dwarf white spruce, black spruce and tamarack. Sphagnum peat bogs are a significant part of the landscape.

The region can be divided into three broad physiographic regions; highlands, uplands and lowlands. The region is dominated by a well-developed highland erosion surface that is highest in the northwest and slopes southeastward to the ocean from 1500 metres in Gaspé to less than half that in Cape Breton and Newfoundland. Uplands form the most extensive physiographic region. In New Brunswick, large river valleys (for example, the Restigouche River) are entrenched in the eroded upland. Lowlands generally correspond to the Maritime basin. The geology of the Appalachian region represents an old, extensively eroded mountain belt. Bedrock in the area reflects this paleogeographic and tectonic evolution, and comprises mainly metamorphic and volcanic rocks. Granitic uplands occur across the region and make up one-third of all exposed bedrock. The surficial sediment cover varies with each physiographic region. Highlands are predominantly bedrock with thin, discontinuous till cover, whereas rolling uplands have more extensive till cover. Eskers and other glacial landforms are common. Lowlands have thicker sediment cover that buries bedrock valleys.

Bedrock aquifers are the most significant source of groundwater in the Appalachians hydrogeological region. In Newfoundland, more than 90 per cent of water wells extract water from bedrock. Fractures provide primary groundwater storage, although karst solution openings are important locally. Groundwater yield from fractured bedrock aquifers is low and varied in Nova Scotia and Newfoundland. In areas of thick cover, well yields from sediment aquifers can be significantly higher, less variable and of better quality than from rock aquifers.

8) Maritime Basin Hydrogeological Region

The Maritime basin region of Atlantic Canada covers about 60 000 square kilometres. All of Prince Edward Island and Îles de la Madeleine are in this region. Isolated elements of the basin occur in Newfoundland, Nova Scotia, New Brunswick and along south shores of Gaspé in Quebec. In Prince Edward Island and Îles de la Madeleine, groundwater use approaches 100 per cent. Elsewhere, groundwater is used less than surface water.

The climate is humid continental, with long winters and warm summers. It is one of the wettest parts of Canada, where about 25 per cent of precipitation occurs as snowfall. Because of its low basin relief, distance to the sea is the major influence on weather. Indeed, coastal areas of Northumberland Strait are cooled in summer and warmed in winter by the ocean. Prevailing circulation of continental air masses from the west allows much wider fluctuations in temperature than would be expected in a purely maritime climatic region. Daily-average air temperature varies between 17 and 24 degrees Celsius during summer and between -12 and -4 degrees Celsius during winter. Average precipitation in summer is between about 900 and 1500 millimetres, with the highest values occurring along the Bay of Fundy. Mean annual evapotranspiration varies from 345 to 440 millimetres. The closed mixed forest is

composed mainly of red, white and black spruce, balsam fir, red maple, hemlock and eastern white pine. Sugar maple and yellow birch are found on larger hills. Wetlands support white elm, black ash and red maple, whereas bogs are dominated by open black spruce and tamarack.

The Maritime basin is part of the Lowland Appalachian physiographic region, and relief is commonly less than 150 metres above sea level, rising to 300 metres in New Brunswick and Nova Scotia. Coastal areas in eastern parts of the basin are dominated by beaches to the north and by peat bogs and salt marshes to the southeast. Near the Nova Scotia border, lowland plains are characterized by a series of subparallel ridges with a trend similar to that of the Cobequid Mountains but with lower elevations. Rivers occupy ancient valleys that broaden over extended flood plains as they approach the coast. The Maritime Basin consists of a series of sedimentary sub-basins that overlie older deformed Appalachian terrain. The sub-basins generally trend northeast to east and are separated by basement uplifts along large regional faults. The central part of the basin, termed the 'Maritimes Rift', features a thick sequence (up to 12 000 metres) of slightly deformed and reworked sedimentary rock. Main rock types are continental sedimentary and volcanic rocks. Locally, coal deposits are important and gas can occur at depth. Surficial sediment consists of till and glacial river deposits with small areas of marine clay. Sand and gravel occur as narrow zones near major streams and glacial meltwater corridors. Muddy to sandy tills are common and are up to 20 metres thick.

Groundwater is available in large quantities in the Maritime Basin, with flow occurring mostly in bedrock. Some layers of sedimentary bedrock act as aquifers, whereas others, within the same formation, limit flow. Groundwater flows mainly through fractures, yet significant quantities of water in sandstone and conglomerate are stored in matrix pores, which affects water chemistry. Till is thin and transmits recharge to bedrock aquifer systems where bedrock outcrops are rare. In areas of thick surficial sediment, well yields from aquifers can be significantly higher, of better quality and less variable (for example, buried esker aquifers in Fredericton).

9) Permafrost Hydrogeological Region

The permafrost region covers the northern part of Canada and is defined as that area where the rock and soil remains permanently frozen. Water in pores and fractures under this condition is normally frozen. This region includes all of the Queen Elizabeth Islands (Canada's Arctic Archipelago) and parts of Nunavut, the Northwest Territories, the Yukon, Manitoba, Ontario, Quebec and Labrador north of the tree line.

The climate of the permafrost region is dominated by continental and polar maritime regimes. The main constant is that the climate is affected by the extreme solar radiation conditions of high latitudes. The mean annual temperature ranges from -20 degrees Celsius on Ellesmere Island to -6 degrees Celsius along the southern boundary of the region. Mean annual precipitation varies from 100 millimetres in the north to 600 millimetres in the southeast. The low precipitation of the central Arctic



is the lowest in Canada, and this area is often referred to as a polar desert. The southern permafrost region is characterized by dwarf shrubs that decrease in size and variety to the north, where vegetation becomes dominated by herb and lichen.

The region contains a diverse array of geological elements that include igneous and metamorphic rocks of the Canadian Shield, nearly horizontal sedimentary rocks of the central Arctic, and folded and faulted sedimentary rocks of the northwestern Arctic Islands. Surficial sediment consists of till layers and localized glacial lake, river and marine deposits. In the Yukon, large valleys are filled with coarse glacial meltwater sand and gravel, and lacustrine silt and fine sand.

The primary hydrogeological function of permafrost is to act as a barrier to groundwater flow. Thus permafrost can act as the cover for a confined aquifer, or it can form the base of an unconfined aquifer. The permafrost seasonal active layer functions as an unconfined aquifer during the time the active layer is thawed. Unfrozen ground within permafrost or areas (for example, ponds and rivers) connecting the ground surface with unfrozen ground beneath the permafrost is referred to as a 'talik'. Discharge of groundwater from taliks can result in 'icings', accumulations of ice on the ground surface that often occur along rivers. Relatively little is known about the control exerted by permafrost on groundwater flow. In the permafrost zone, groundwater is utilized most extensively in the southern Yukon. Many communities draw their municipal supply from coarse valley aquifers that are likely confined beneath permafrost; however, little documentation for this exists. Similarly, confined aquifers beneath permafrost may exist on north-facing slopes in the southern parts of the permafrost zone.

Definitions of underlined terms

Aquifer: The underground layer of water-soaked sand and rock that acts as a water source for a well; described as artesian (confined) or water table (unconfined).

Aquitard: A confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer; a leaky confining bed. (Source: Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Basement Uplift: A structural high area in the crust, produced by positive movements that raise or upthrust the rocks. (Source: Glossary of Geology, Fifth Edition. Neuendorf, K., Mehl, J. and Jackson, K. American Geological Institute. 2005.)

Bedding Plane: A planar or nearly planar bedding surface that visibly separates each successive layer of stratified rock from its preceding or following layer; a plane of deposition. It often marks circumstances in the changes in deposition. (Source:

Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Bogs: These are peatlands covered with mosses (mainly sphagnum) whose colours range from pale green to red. Bog cover also includes low shrubs, trees such as black spruce or tamarack, and other plants such as sundew, pitcher plants and cranberry plants.

Clastic: Consisting of broken pieces of older rocks. (Source: Oxford English Dictionary (online))

Clay: A naturally occurring material composed primarily of fine-grained minerals. It is generally plastic at appropriate water contents and will harden when dried or fired. (Source: Neuendorf, Klaus K.E., James P. Mehl Jr. and Julia A. Jackson, eds. 2005. Glossary of Geology, Fifth Edition. American Geological Institute.)

Confined Aquifer: An aquifer bounded above and below by confining beds; an aquifer containing confined groundwater ((Source: Glossary of Geology, Fifth Edition. Neuendorf, K., Mehl, J. and Jackson, K. American Geological Institute. 2005.)

Dryland: A type of farming that depends only on natural precipitation and soil moisture to water crops (i.e. non-irrigated). (Source: Agriculture and AgriFood Canada).

Esker: Sinuous ridges composed of glacial material deposited by meltwater currents in englacial tunnels. Their orientation is generally parallel to the direction of glacial flow, and they sometimes exceed 100 kilometres in length.

Evaporite: A nonclastic sedimentary rock composed primarily of minerals produced from a saline solution that became concentrated by evaporation of the solvent; especially a deposit of salt precipitated from a restricted or enclosed body of seawater or from the water of a salt lake. (Source: Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Fault: A surface or zone of rock fracture along which there has been displacement from a few centimetres to a few kilometres in scale. (Source: Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Fens: Fens are peatlands whose dominant plants are sedges (tall grass-like plants) accompanied by grasses, brown mosses and flowers such as iris. A fen is fed by streams or by ground water. Fens are less acidic and generally richer in nutrients than bogs. The water table is usually at or above the surface of the peatland.

Fluvial Sandstone: A sedimentary deposit consisting of material transported by, suspended in or laid down by a stream. (Source: Glossary of Hydrology. Wilson, W., Moore, J. Springer, 2003)

Fold: A curve or bend of a planar structure such as rock strata, bedding planes, foliation or cleavage. (Source: Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Fracture: A general term for any break in a rock, whether or not it causes displacement, due to mechanical failure by stress. (Source: Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Glacial Lake Deposit: Pertaining to, derived from, or deposited in glacial lakes. Deposits are commonly well sorted with shoreline deposits of sand and deeper water deposits of mud deposited from suspension and density underflows. (Source: Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Hummock: A rounded or conical knoll, mound, hillock or other small elevation, generally of equidimensional shape and not ridge like. Also, a slight rise of ground above a level surface. (Source: Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Igneous rock: Rocks that are formed from molten materials that come from the depths of the Earth. They are also referred to as magmatic rocks.

Joint: A surface of actual or potential fracture or parting in a rock, without displacement; the surface is usually plane. (Source: Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Kaolinite: A general term for those porcelain clays, found in masses of minute crystalline scales, of which kaolin is the typical variety. (Source: Oxford English Dictionary (online))

Karst: A type of topography that is formed over limestone and gypsum by dissolution and that is characterised by holes, caves and underground drainage.

Kimberlite: A rock formation where diamonds can be found. It is classed as a variety of potassic volcanic rocks and consists of minerals, rock fragments and magmatic components. The matrix that makes up kimberlite contains olivine, phlogopite, carbonate, serpentine, diopside, ilmenite and several other minerals. Kimberlite also contains fragments of the upper mantle rocks. (Source: Atlas of Canada, 2008)

Lacustrine: Pertaining to, produced by or formed in a lake or lakes (for example, 'lacustrine sands' deposited on the bottom of a lake). (Source: Glossary of Geology, Fifth Edition. Neuendorf, K., Mehl, J. and Jackson, K. American Geological Institute. 2005.)

Lignite: A brownish black coal that is intermediate in coalification between peat and sub-bituminous coal. (Source: Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Metamorphic rock: A metamorphic rock is derived from a pre-existing igneous or sedimentary rock that is transformed, to a greater or lesser degree, by the action of physical factors such as temperature and pressure, or chemical factors that include the addition of new minerals. Such transformations take place at depth in the Earth's crust.

Metasediment: A sediment or sedimentary rock that shows evidence of having been subjected to metamorphism. (Source: Gary, Margaret, Robert McAfee Jr. and Carol L. Wolf, eds. 1974. Glossary of Geology. American Geological Institute.)

Moraine: Ridge made of the accumulations of till and constructed by direct action of the glacier.

Mud: A slimy, sticky, or slippery mixture of water and silt- or clay-sized earth material, with a consistency ranging from semifluid to soft and plastic; a wet, soft soil or earthy mass; mire, sludge. (Source: Neuendorf, Klaus K.E., James P. Mehl Jr. and Julia A. Jackson, eds. 2005. Glossary of Geology, Fifth Edition. American Geological Institute.)

Mudrock: A blocky or massive, fine-grained sedimentary rock in which the proportions of clay and silt are approximately the same. (Source: Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Peat: A firm brown deposit resembling soil, formed by the partial decomposition of vegetable matter in the wet acidic conditions of bogs and fens, and often cut out and dried for use as fuel and in gardening. (Source: Oxford English Dictionary (online))

River Terrace: A planar surface along the sides of a stream valley representing the remnants of an abandoned floodplain, stream bed or valley floor produced during a former stage of erosion or deposition. (Source: Glossary of Geology, Fifth Edition. Neuendorf, K., Mehl, J., Jr. and Jackson, J. Editors. American Geological Institute, 2005)

Rock Matrix: The fine-grained mass of material in which larger grains or crystals are embedded. (Source: Wikipedia, 2008)

Sedimentary rock: Sedimentary rocks are the product of the consolidation of loose sediment that has accumulated in beds. These sediments settle gradually under the weight of overlying beds and are transformed into solid sedimentary rock by cementation.

Shale: A fine-grained sedimentary rock, formed by the compaction of clay, silt or mud.

Shield volcano: A volcano in the shape of a flattened dome, broad and low, built of very fluid lava.

Silt: A rock fragment or detrital particle smaller than a very fine sand grain and larger than coarse clay, having a diameter in the range of 1/256 to 1/16 mm (4-62 micrometres, or 0.00016-0.0025 inch, or 8 to 4 phi units; the upper size limit is approximately the smallest size that can be distinguished with the unaided eye). (Source: Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Siltstone: Indurated silt having a texture similar to shale but usually lacking its fine lamellar structure; at least two-thirds of the material should be silt size. (Source: Mitchell, Richard Scott. 1985. Dictionary of Rocks. Van Nostrand Reinhold, New York.)

Slough: A small marsh; esp. a marshy tract lying in a swale or other local shallow undrained depression on a piece of dry land. (Source: Gary, Margaret, Robert McAfee Jr. and Carol L. Wolf, eds. 1974. Glossary of Geology. American Geological Institute.)

Sphagnum: A moss growing in bogs and peat.

Stratified Moraine: A moraine composed of sand and gravel.

Tectonic: Related to the study of terrain deformations caused by internal forces, after the setting of the rocks.

Thermal Spring: A spring whose water temperature is appreciably higher than the local mean annual atmospheric temperature. (Source: Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Till: Any sediment that is transported and deposited by a glacier without being sorted by meltwater. It consists of clay, sand and large rock fragments that are deposited in irregular sheets or in ridges called moraines.

Unconfined Aquifer: An aquifer having a water table; an aquifer containing unconfined groundwater. (Source: Glossary of Geology, Fifth Edition. Neuendorf, K., Mehl, J. and Jackson, K. American Geological Institute. 2005.)

Volcanic Rock: A generally finely crystalline or glassy igneous rock resulting from volcanic action at or near the Earth's surface, either ejected explosively or extruded as lava (for example, basalt). The term includes near-surface intrusions that form a part of the volcanic structure. (Source: Glossary of Geology, First Edition. Gary, M., McAfee, R., Jr. and Wolf, C. Editors. American Geological Institute, 1974)

Map Sources

Annual Mean Total Precipitation (mm)

This map layer shows the annual mean total precipitation over the time period from 1971 to 2000. This map layer is intended to represent average conditions only, as the weather in any given year would or could vary. The 1971 to 2000 precipitation climate normals were calculated by Environment Canada in a manner consistent with the methodology of the World Meteorological Organization. The normal is a simple arithmetic average of the monthly or annual precipitation for the specified period. These spatial models have been developed using the thin plate smoothing spline algorithms of ANUSPLIN, which is a mathematically sophisticated approach to generating climate maps at varying spatial and temporal scales. The Canadian Forest Service has been working in partnership with several staff in Environment Canada's Meteorological Service of Canada, the Australian National University (the creator of ANUSPLIN) and others to develop a variety of climate models that cover both Canada and North America.

Hydrogeological Regions

Natural Resources Canada. 2007. Groundwater Mapping Program. Hydrogeological Regions.

Land Cover

This layer is based on satellite data obtained in 1995 by the Advance Very High Resolution Radiometer (AVHRR) on board the NOAA-14 (National Oceanic Atmospheric Administration) satellite. To achieve this image, a complicated data process, which consists of two main phases, is performed. A noise-free data set is prepared and land cover information is extracted. The spatial resolution is about 1 kilometre square. This means that one pixel on the map is equal to one kilometre square on the ground.

Moisture Regions

This layer was created from the map 'Canada - Climatic Regions Thornthwaite Classification Moisture Regions', The National Atlas of Canada 5th Edition, Energy, Mines and Resources Canada.

Physiographic Regions

Map. Physiographic Regions of Canada. 1254A. Scale 1:5M compiled by H.S. Bostock. 1967. Geological Survey of Canada.

Relief

This map layer shows relief (land elevation in metres) in Canada relative to mean sea level by means of hypsometric tints (different colours for each elevation range). Elevation data were derived from the Relief map, published in the 5th edition of The National Atlas of Canada.

Surficial Hydrogeological Materials

This layer was generalized from the Map of Surficial Geology 1880A, from the Geological Survey of Canada. It portrays broad generic categories of surface material such as alluvial, lacustrine, marine and glacial. The units are subdivided according to different characteristics: texture, thickness and landform.

Watersheds

Natural Resources Canada. 2006. Atlas of Canada Watershed Framework.

Wetland Regions

Shows the percentage of wetlands within polygons which are representative of wetland concentration. This layer has been developed by integration of data from several thematic specific sources. It was prepared for use by Environment Canada to provide first order measures of wetlands distribution and conservation. Data sets used: 1. The 1995 AVHRR land cover classification. 2. The old ecodistrict (circa 1985) database of Canada. 3. The Soil Landscapes of Canada. 4. The Peatlands of Canada. 5. Ducks Unlimited and other provincial agencies.

References

Sharpe, D.R., Russell, H.A.J., Grasby, S.E., Wozniak, P.R.J. 2008. Hydrogeological regions of Canada: Data release. Geological Survey of Canada, Open File 5893. 20 pages, 1 CD-ROM.

Related Web sites (1999 – 2009)

Federal Government

Environment Canada. Groundwater

http://www.ec.gc.ca/Water/en/nature/grdwtr/e_gdwtr.htm

Information on the nature and extent of groundwater in Canada.

Environment Canada. Groundwater - Nature's Hidden Treasure

http://www.ec.gc.ca/WATER/en/info/pubs/FS/e_FSA5.htm

Fact sheet describing where groundwater is found, how it's found and problems and issues associated with it.

Library of Parliament. Freshwater Management in Canada: iv. Groundwater

<http://www.parl.gc.ca/information/library/PRBpubs/prb0554-e.html>

Natural Resources Canada. Groundwater Mapping Program

http://ess.nrcan.gc.ca/gm-ces/index_e.php

Natural Resources Canada. Groundwater Program

http://ess.nrcan.gc.ca/2002_2006/gwp/waltergordon_e.php

Other

Canadian Ground Water Association

<http://www.cgwa.org/index.htm>

The Canadian Ground Water Association (CGWA) is "The national voice of the ground water industry in Canada."

West Coast Environmental Law. Groundwater Use in Canada

<http://www.wcel.org/wcelpub/2004/14184.pdf>

