

Physical Components of Watersheds

Abstract

The physical components of a watershed are rivers, lakes, ponds and reservoirs, groundwater aquifers, snowpacks, glaciers, ice fields, wetlands and precipitation. This map shows the different hydrological components of a watershed, some physical components that affect watersheds and some components that describe watersheds.

Watersheds contain not only rivers but also several other accessible natural sources of freshwater including lakes, ponds, reservoirs, groundwater aquifers, snow packs, glaciers, ice fields and, at the most fundamental level, the liquid and solid precipitation that feeds and replenishes all these sources.

The map layers show different physical components of a watershed. The following descriptions of each layer demonstrate the importance of each component to watersheds.

Hydrological Components of Watersheds

Lakes and Rivers

There are a large number of interconnected and almost-connected lakes and rivers that make up the Canadian drainage network. These lakes and rivers are the legacy of the several advances and retreats of the Pleistocene ice front, before which meltwaters were escaping by any possible route, creating and abandoning drainage channels or simply filling every depression on the ground.

The easiest way to describe the network of rivers and lakes on a small-scale map is to show the watersheds. In Canada, there is a detailed hierarchy of watersheds, ranging from the largest (drainage into oceans and their equivalents), down to the smallest ramification.

Rivers, which form extensive networks across the country, are natural drainage channels for surface water. Surface water is received from two major sources: runoff and base flow. Runoff is that part of precipitation that flows toward the rivers or streams on the ground surface or within the soil. Base flow is the part of streamflow that enters the stream channel from groundwater.

Aside from glaciers, running water has had the most impact on shaping the Earth's landscape. In addition to the rivers, Canada has a huge number of lakes, the exact number being unknown.

A lake may be defined as any inland body of standing water, usually freshwater, larger than a pool or a pond. Canada is famous for its number of lakes. There are at least as many as two million lakes of all sizes covering, in total, 8.9 per cent of the country. Also, Canada has 563 lakes with a surface area greater than 100 square kilometres. A complete list is given in the Facts about Canada section of The Atlas of Canada. The largest set of lakes, the Great Lakes, straddle the Canada–United States boundary, accounting for 18% of the world's freshwater in lakes.

The importance of lakes lies in their ability to store water during times of plenty and release it gradually. Thus, lakes perform an extremely valuable task in balancing the flow of the rivers on which they are located. For example, the Saskatchewan River, with few lakes, has a maximum recorded flow of 59 times its minimum flow. On the other hand, the St. Lawrence River, which drains the Great Lakes, has a maximum flow of only twice its minimum flow. The difference in flow patterns in these two rivers is partly due to precipitation differences, but results mainly from the vast storage provided by the Great Lakes for the St. Lawrence River compared with the negligible lake storage on the Saskatchewan River.

Groundwater Aquifer

Groundwater is water found beneath the Earth's surface and located below the water table. In Canada, there is more water underground than on the surface.

Groundwater occurs in the tiny spaces between loose materials on top of bedrock, or in cracks in the bedrock. The most important concentrations are in aquifers, near the top level of the water table.

The natural connections of groundwater to the surface are varied: groundwater is interconnected with lakes and rivers, and it often also emerges naturally as springs.

Groundwater is a vital component of Canada's freshwater resource, supplying a substantial proportion of municipal, agricultural and other requirements for water. The origin and composition of aquifers are varied, as are their uses. Some important examples are given below:

- Many important Canadian aquifers are composed of thick deposits of sand and gravel previously laid down by glacial rivers. These types of aquifers provide most of the water supply for some large municipalities, including the Kitchener–Waterloo region in Ontario and the Fredericton area in New Brunswick.
- The Carberry aquifer in Manitoba, west of Winnipeg, is an old delta lying on what was formerly glacial Lake Agassiz. This aquifer is well developed as a source of irrigation water.
- Prince Edward Island depends on sandstone aquifers for its entire water supply.
- A major glacial outwash sand and gravel aquifer occurs in the lower Fraser Valley in British Columbia. It is extensively used for municipal, domestic and industrial water supplies.

- The Winnipeg and Montréal aquifers, both of which are used for industrial water supply, are composed of fractured rocks.

Wetlands

Wetlands are lands permanently or temporarily submerged or permeated by water and characterized by plants adapted to saturated-soil conditions. Wetlands include freshwater and saltwater marshes, wooded swamps, bogs, seasonally flooded forest, sloughs and peatlands — any area of relatively shallow water that can keep water long enough (and still enough) to let wetland plants and soils develop.

Wetlands are unique ecosystems and are vital components of the hydrological regime. For example, they:

- modulate discharge regimes in rivers by reducing peak flow during floods and maintaining flow in rivers during dry periods
- recharge groundwater aquifers
- act as reservoirs in the cycle of production, release and storage of important greenhouse gases
- absorb, store and assimilate contaminants, such as heavy metals and sulphur from acid rain, that enter them via precipitation, surface-water flow and groundwater seepage
- serve an important remediation function because they permanently break down many contaminants, such as nitrate
- provide habitat for fish and wildlife and for many unique types of plants
- provide many recreational opportunities, such as fishing, hunting and bird watching

Glaciers and Icefields

Glaciers and icefields are huge masses of ice, formed on land by the compaction and recrystallization of snow, that move very slowly down slopes, or move outward due to their own weight.

Glaciers and icefields are only found in two regions of Canada — the Western Cordillera and the mountains of the eastern Arctic — an estimated area of 200 000 square kilometres, or about 2 per cent of the country's area.

A huge quantity of freshwater is frozen in these icefields and high mountain glaciers. This frozen water plays an important role in the western part of the country. In fact, glaciers exert a direct influence on the hydrological cycle by slowing the passage of water through the cycle. Like groundwater, glaciers are excellent natural storehouses of water. One form of release by glaciers is in sudden outburst floods called 'jökullhaups'. Usually, the release is more gradual, with glaciers having their highest rate of melting in the summer. Glacier-fed rivers, which include many of the largest rivers in Alberta and British Columbia, reach their peak flow during hot summer

weather when other sources of water in these regions may be scarce. They are, therefore, extremely important to the relatively dry Prairie region as sources of water for irrigation, electric power and communities located close to them.

Snow Cover

Snow cover is important for several reasons. First, it represents a major reservoir of water, which is released during the spring melt period. Knowledge of how much water is contained in snow cover and the rate at which it melts is critical information for flood forecasting, agriculture and optimal management of water resources. Semiarid regions, such as the Prairies and interior valleys of British Columbia, are especially dependent on snowmelt runoff, which can supply in excess of 80 percent of annual total runoff. So water levels are generally high after snowmelt and decrease during the summer due to evaporation and evapotranspiration, which are at their peak in the summer.

The quantity of snow received during the winter season directly affects the seasonal and annual cycle of streamflow and water availability, and is a key element for drought monitoring, forest fire potential, and flood and flow forecasting.

Components Affecting Watersheds

Relief

Relief is an important controlling factor for rivers and their watersheds. For example:

- Relief determines the continental divide, which is the line that separates waters flowing to the east and west.
- The orographic effect of the mountains of western Canada enhances precipitation on the windward side of the mountain range due to the vertical lifting (and cooling) of moist air. This phenomenon has an influence on the rain and snow received to feed lakes, rivers and groundwater.
- Glaciers that develop on high mountains have an influence on streamflow during the summer.
- During winter, snow falling on vast flat terrains is blown away by the wind. This causes uneven distribution of the water supply from one area to another, thus creating differences in water availability between areas.

Permafrost

Permafrost is defined as a state when the ground, whether soil or rock, remains at or below a temperature of 0 degrees Celsius for a minimum period of two years.



Permafrost thickness ranges from a few decimetres at the southern limit of the permafrost zone to more than 700 metres in the Arctic Islands. Permafrost plays an important role in hydrology through its influence on infiltration, runoff and groundwater storage and flow.

Many wetlands in Canada owe their existence, at least in part, to cold winters and the resulting impairment of drainage by the permafrost, as is the case for many subarctic and arctic wetlands.

Forests

The hydrological cycle consists of three major components:

- precipitation
- surface and subsurface water flow and storage
- evaporation from soil, vegetation, lakes, streams and oceans

Forests play a vital role in the hydrological cycle. In fact, the amount of forest cover, health of the forests and their maturity influence the patterns of evapotranspiration, soil moisture and rainwater transportation into groundwater and surface water. Forests also filter air and water, moderate climate, provide habitat for wildlife, stabilize soil and are an important component of Canada's economy, culture, traditions and history.

Terrestrial Ecozones

Ecozones are broad ecological zones on the earth's surface that cover a large range of ecosystems such as temperate forest, mountain ranges, grassland, taiga, arctic tundra, extensive river systems, coastline and farmlands. Each ecozone has its own climate, relief, soil, flora, fauna and distinct human activities. In Canada, there are 20 ecozones, 15 terrestrial and 5 marine.

Each terrestrial ecozone contains several watersheds. Like an ecozone, each watershed encompasses several types of ecosystems including aquatic, waterside (lakeside, riverside, riverain), forest, agricultural, urban and wetlands.

Land Cover

Each watershed is a component of the Earth. The land cover layer shows the predominant land cover type present in each watershed such as forest, shrublands, tundra, grasslands, and developed land types, including cropland, mosaic and built-up areas and water.

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).

Delta: Alluvial deposit at the mouth of a river

Pleistocene: An epoch of the Quaternary period, after the Pliocene of the Tertiary and before the Holocene. Pleistocene was between about 80 000 and 10 000 years before the present time.

Pond: A small natural body of standing fresh water filling a surface depression, usually smaller than a lake

Riverain: Relating to watercourses or small islands in riverbeds

Map Sources

Watersheds

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

Aquifer Areas

Hess, Paul J. 1986. Ground-Water Use in Canada, 1981. National Hydrology Research Institute: Ottawa. NHRI Paper No. 28, IWD Technical Bulletin No. 140.

Wetland Regions

Environment Canada. Data sets used: 1. The 1995 AVHRR land cover classification from Canada Centre for Remote Sensing; 2. The ecodistrict (circa 1985) database of Canada from Environment Canada; 3. The Soil Landscapes of Canada from the Canadian Soil Information System of Agriculture and Agri-Food Canada; 4. The Peatlands of Canada from the Geological Survey of Canada; and 5. Ducks Unlimited and other provincial agencies.

Glaciers and Icefields

GeoInsight Corporation. Selected Named Icefields and Glaciers.

Relief

Natural Resources Canada. Map. Relief. The National Atlas of Canada, 5th Edition.

Terrestrial Ecozones

Marshall, Ian. Ecosystems of Canada. Ecosystem Stratification Working Group, Agriculture and AgriFood Canada and Environment Canada

Land Cover of Canada (image)

Natural Resources Canada. 1995. AVHRR Land Cover of Canada. Ottawa: Canada Centre for Remote Sensing.

Forested Areas

Natural Resources Canada. 1993. Map.Canada - Vegetation Cover. The National Atlas of Canada, 5th Edition.

Permafrost

Natural Resources Canada. Map. Canada - Permafrost. The National Atlas of Canada, 5th Edition.

Average Maximum Snow Depth

Meteorological Service of Canada, Environment Canada.

Plant Hardiness Zones

Canada. 2001. Departments of Agriculture and Agri-Food Canada and Natural Resources Canada. Ottawa.

References

Environment Canada. 2004. Threats to Water Availability in Canada. National Water Research Institute, Burlington, Ontario. NWRI Scientific Assessment Report Series No. 3 and ACSD Science Assessment Series No.1.

Related Web sites (1999 – 2009)

Federal Government

Environment Canada. Freshwater Web Site

<http://www.ec.gc.ca/water/>

This web site gives access to the nature of water, water policy and legislation, the management of water, water and culture, and informational resources and services.

Environment Canada. National Water Research Institute

<http://www.ec.gc.ca/inre-nwri/>

The National Water Research Institute (NWRI) is Canada's largest freshwater research establishment. NWRI conducts a comprehensive program of research and development in the aquatic sciences, in partnership with the Canadian and international science communities.

Environment Canada. St.Lawrence Centre

<http://www.qc.ec.gc.ca/csl/>

The St. Lawrence Centre (SLC) is involved in a multitude of studies and research programs aimed at better understanding how the ecosystems of the St. Lawrence River function and at keeping this knowledge up to date.

Environment Canada. Water Survey of Canada

http://www.wsc.ec.gc.ca/index_e.cfm

The Water Survey of Canada is the national agency responsible for the collection, interpretation and dissemination of standardized water resource data and information in Canada

Government of Canada. RésEau : Building Canadian Water Connections

<http://map.ns.ec.gc.ca/reseau/en/index.aspx>

Statistics Canada. Canada's Watersheds: The Demographic Basis for an Urban-Rural Dialogue

<http://www.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=21-006-XIE2005006&lang=eng>

Other

Canadian Wildlife Federation. Watershed - more than just water- explore yours!

http://www.cwf-fcf.org/pages/wildprograms/wildprogramsweb_e.asp?section=6&language=e

