

EARTH'S WATER BUDGET

- Our image of Canada is of a land of great lakes, rivers and glaciers
- Groundwater, which exists everywhere under the surface of the land, is not part of this picture
- Not surprisingly, Canadians focus more about the water quality of surface waters
- The less visible, but equally important, groundwater resources receive less public attention, except in regions of Canada where people depend on them

GROUNDWATER

- Groundwater is found in the spaces between particles of soil and spaces within rock
- Groundwater usually flows through saturated rock under the influence of a hydraulic gradient by which flow movement is from high to low pressure.
- A typical groundwater system consists of an area of rainfall recharge that percolates into the ground, eventually reaching the water table and then flows through rocks of varying permeabilities towards natural discharge points such as a spring or surface water body.
- The rate at which water flows through the system depends upon the above ground processes of rainfall and evaporation as well as geological conditions which determine permeability and many other factors of the underlying rock units.
- Often times, depending on the location and the nature of the aquifer or saturated rock unit, the residence time of groundwater can be as short as days up to thousands of years.

WATER BELOW THE GROUND SURFACE

- When precipitation falls onto the land a large amount of this water will percolate into the soil or ground surface.
- Directly below the land surface soil pores contain both air and water. This region is known as the vadose or unsaturated zone
- In this uppermost zone soil water is available to plant roots which is then transpired and returned to the atmosphere
- At some depth, depending on precipitation inputs and topology, the pore spaces of soil or rock are filled only with water. This is known as the saturated zone.
 - o Water stored within this zone is known as groundwater
 - o The water in this zone travels through rock and soil layers it discharges as a spring or as seepage into a surface water body such as a river, lake or ocean
 - o The rock or sediment unit in this saturated zone can be termed as an aquifer

- The designation between these unsaturated and saturated zones is termed the water table which constantly fluctuates according to recharge from precipitation and discharge by pumping or seepage into surface water bodies

AQUIFER

- An aquifer can be thought of as a geological formation that contains sufficient saturated permeable material to yield significant quantities of water.
- Aquifers come in various sizes ranging in areas of up to thousands of square kilometers and to hundreds of meters thick
- Unconsolidated sands and gravels, sedimentary strata of sandstones and limestones as well as fractured igneous and metamorphic rocks are examples of rock units that can serve as sufficient aquifers
- Aquifers perform two main functions
 - o Storage of water - which is a function of porosity
 - o Conduit of water – which is a function of the size or thickness of the aquifer and the permeability of the aquifer material

KEY HYDRAULIC PROPERTIES

- There are a few key hydraulic properties that must be considered in the study of groundwater
- The first is that of porosity
 - o The ratio of the volume of void spaces in a rock or sediment relative to the total volume of the rock or sediment
 - o This value is usually given as a percentage
- The second is that of permeability or hydraulic conductivity
 - o This is the capacity of a porous rock, sediment or soil to transmit a fluid through pore openings giving an idea of how connected pore space openings are within a rock unit
 - o This is used as a measure of the quantity of water that will flow through a porous medium
 - o In general the finer the grain size of the material, the lower the hydraulic conductivity
 - Clay materials may have a high porosity value, yet due to the very small grain sizes and subsequent small pore space openings are not efficient of transmitting water
 - Materials of larger grainsizes with often lower porosity values are able to transmit water much more efficiently as the connectedness of pore spaces is much greater

CONFINING LAYERS

- A confining layer is a geologic unit that has little to no permeability and are located stratigraphically adjacent to one or more aquifers
 - o These layers are important elements of groundwater flow systems in that they form the upper and lower boundaries of aquifers responsible for water storage.
 - o There are three main types of confining layers depending on the material that they are composed of
 - A confining layer composed of an impermeable material (such as granite) does not contain or transmit water and is known as an aquafuge
 - An aquaclude or aquatard is a low-permeability unit composed of materials like clay is often saturated yet cannot transmit water efficiently

AQUIFER TYPES - UNCONFINED

- There are two main types of aquifers – unconfined and confined
 - o Unconfined aquifers
 - These are often found close to the land surface with a lower confining layer
 - And thus the water is exposed to the atmosphere allowing the water table is free to rise and fall based on
 - Recharge from the surface by downward seepage from the unsaturated zone
 - Or upward seepage from underlying rock units

AQUIFER TYPES – CONFINED

- o Confined aquifers are
 - Those that are bound by impermeable rock units or confining layers and are often under significant pressure from these overlying sediments
 - Recharge to this type of aquifer can occur from
 - A recharge area where the aquifer crops out into the unsaturated zone
 - Or by slow downward leakage through a low permeability confining layer.
 - As a confined aquifer is often located at deeper depths below ground and are always bounded by confining layers, the residence time of these units can be upwards of centuries to thousands of years.

WATERSHED

- Simply put, a watershed or drainage basin, is an area of land where surface water from rain and snowmelt converges or drains to a single point at a lower elevation, usually the exit of a basin which can be in the form of a river, lake or ocean.
- A watershed is bounded and separated from neighbouring watersheds by higher elevation points on the landscape

- As water flows across a watershed it crosses all land types from forests to farmlands as well as cities and towns
- Thus, as water flows throughout a watershed system, activities or pollution sources upstream can influence the integrity of the water in downstream regions of the system
- Perhaps the most effective way to manage our water resources is on a watershed basis
- Soil and water testing upstream is a good preliminary step to understand the quality of water that is entering a particular region.
- Often times, in cases of unknown sources of contamination it can help to narrow down the sources of pollution

DELINEATING A WATERSHED

- When assessing the water quality in a region, it is important to know the general boundary of the watershed as it will give you an idea of exactly where your source water comes from
- This can be done by delineating a watershed
- There are a few ways to perform this task
 - o From simply doing it by hand with the aid of a topographic map
 - o Or by using a GIS program
 - o Or online from the MNR which links to an Ontario Flow Assessment tool website
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