

Principles of Hydrology

Hydrology is an earth science. It encompasses the occurrence, distribution, movement, and properties of the waters of the earth and their environmental relations. Hydrology has both applied and pure science aspects. On the one hand, it is an important science that studies how the water flows on the Earth. On the other hand, understanding of fundamental hydrologic processes is necessary for proper use and protection of water resources.

- ! Hydrological science has both pure and applied aspects.
- ! Until 1950, pragmatic considerations dominated hydrology.
- ! Theoretical approaches in hydrology have been increasingly developed due to the development of digital computers since 1950.
- ! An understanding of hydrology is the key to hydrology problems involved with water supply, flood control, water quality control, drought, recreation, and navigation.
- ! Traditional water management has focused on providing freshwater resources to the needs of humans, livestock, commercial enterprises, agriculture, mining, industry, and electric power.
- ! The focus now is on how best to optimize the use of existing surface-water projects and ground-water resources.
- ! Challenge for the 21st century in hydrology will still be maintaining water quantity and quality against to the increasing stress on water resources by the increasing world population, contamination, human induced climate-hydrology change, and extreme events (flood and drought).

Principal Water Resources Agencies and Data Resources in Hydrology

Federal:

U.S. Department of Agriculture (USDA) includes:

Soil Conservation Service (SCS): Develops techniques and structures for flood control and water supply on small watersheds.

Forest Service (USFS): basin studies in watershed management. Large builder of roads in the US.

Agricultural Research Service (ARS): Does basic research in all areas of small watershed hydrology. Collects and reports basic rainfall runoff data for small watersheds.

U.S. Coast and Geodetic Survey: Provides maps and charts of hydrographic data for use by marine vessels in coastal areas.

National Weather Service (NWS): Part of the National Oceanographic and Atmospheric Administration (NOAA). Conducts basic research in all areas of hydrologic cycle: particularly rainfall and runoff forecasting. Responsible for maintaining data network

for precipitation measurements. Reproduced in Climatological Data Summary by separate states.

Federal Highway Administration (FHWA): Conducts research on measures to reduce flood damages and erosion along highway right of ways.

U.S. Army Corps of Engineers (USCE) includes:

Office of the Chief of Engineers with many divisions and district offices throughout the country. Primary function is planning, construction and operation of works for navigation and flood control in rivers and harbors.

U.S. Army Waterways Experiment Station (WES): Conducts physical model studies of rivers and estuaries in Vicksburg, Mississippi.

U.S. Army Cold Regions Research and Engineering Laboratory (CRREL): Conducts research in moisture release and transport through snow and ice in Hanover, New Hampshire.

Hydrologic Engineering Center (HEC): Primary functions is to develop new computerized methods in water resource engineering which can be used by Corp District offices and by consulting engineers; located in Davis, California.

Environmental Protection Agency (EPA): Primary concern for quality of total environment including air and water. Hydrologic concerns include analysis of low flows for wastewater assimilation within river basins. Concern for urban hydrology and receiving water quality.

U.S. Geological survey (USGS): Measures and documents the quantity and quality of ground and surface waters through its regional office throughout the county. Most important documents by USGS are the Water Resource Data and Water Supply Papers.

U.S. Department of energy (DOE): Interested in both the quantity and quality of surface and subsurface flow to protect Nuclear Power Plant Sites and disposal sites from contamination.

National Aeronautics and Space Administration (NASA): Earth Observing System (EOS) - Develop a comprehensive understanding of how the Earth functions from global observations on sustained, consistent basis - Global Water Cycle.

Hydrologic Cycle

The hydrologic cycle is a global-scale process that continuously circles water in gas, liquid, and solid phases among the atmosphere, continents, and oceans. The hydrologic cycle is an endless cycle like rock cycle, no beginning and no ending. Solar energy and gravity along with other forces drive the hydrologic cycles. Components of the hydrologic cycle include precipitation, evaporation, transpiration, infiltration, surface runoff, ground-water flow, baseflow, river flow, ocean circulation, and global air circulation.

Water Budgets

$$\text{input} - \text{output} = \text{change} \in \text{storage}$$

A water budget within a system can be described as a form of mass conservation:

interconnections and components of the global hydrologic cycles: atmosphere, surface, soil, ground water, lithosphere, streams, and oceans.

interconnections and components of the basin hydrologic cycles: surface, soil, ground water, and streams.

! 97% of all water on the Earth is stored in the oceans; 0.001% in the atmosphere.

! 2.5% of the total storage is fresh water (concentration of TDS 0.5 parts per thousand).

! 69.6% is contained in the polar icecaps and glaciers; 30.1% is in groundwater.

! 0.26% is contained in surface water bodies such as river, lake, and marshes.

The residence time is a measurable parameter used to describe the time required for a water

$$T = \frac{V}{I}$$

parcel to move from one reservoir to another and can be expressed at a steady state as where V is the reservoir volume (m³) and I is the input rate to the reservoir (m³/day).

Example 1, in a watershed with an area of 7.29 km², the annual precipitation is 93.98 cm.

Assuming the runoff/precipitation ratio is 0.25, what is the average streamflow at the watershed outlet in a unit of cm^3/s ?

Example 2, in the WE-38 watershed with an area of 7.29 km^2 , the annual precipitation is 93.98 cm , the measured evaporation is 26.25 ? , and the simulated and observed streamflows are listed in Table 1.

Table 1. Comparison of Simulated and Observed Components of Water Balance.

	Simulation	Observation
Streamflow (m^3/s)		25.7
Surface Runoff	8.69 (34%)	38%
Ground-water Baseflow	66%	62%

note: % indicating percentage of total annual streamflow.

What are simulated and observed annual streamflows in the unit of cm ? What is the unit of measured evaporation based on your water balance calculation? Find out the annual transpiration with the WE-38 watershed.