Module 2 Water and Watershed Concepts

Introduction

Looking at water, you might think that it's the most simple thing around. Pure water is colorless, odorless, and tasteless. But it's not at all simple and plain and it is vital for all life on Earth. Where there is water there is life, and where water is scarce, life has to struggle or just "throw in the towel." So what is it about water that makes it so important to us? Where does our water come from and what is it about water that makes it water?

In this module participants will examine Water and Watersheds: *Water facts, stream systems and watersheds, streams, stream channels, in-stream habitats, stream banks, ponds, lakes, reservoirs, rivers, and associated water quality issues.*

Water Facts

What is water? Water is . . .

- the most abundant, unique, and important substance on earth;
- essential to life;
- a large portion of all living materials;
- a universal solvent that makes all earthly biological functions possible;
- the only substance that occurs naturally in all three physical states (solid, liquid, and gas);
- odorless, tasteless, colorless, and transparent in its pure liquid state;
- two atoms of hydrogen and one atom of oxygen.

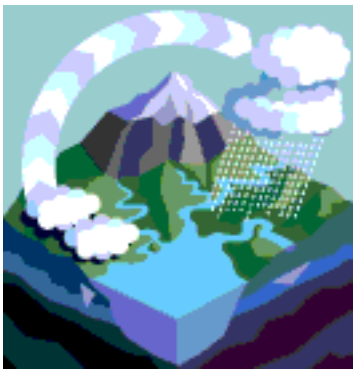
Basics of life in the water:

- Photosynthesis occurs underwater as well as on land.
- Green plants such as phytoplankton and algae absorb sunlight and convert it to sugar.
- Microscopic animals called zooplankton eat the phytoplankton and are in turn eaten by small fish or invertebrates, a process which forms the basis of the food chain.
- During the day, photosynthesis allows aquatic plants to oxygenate the water and then use this oxygen at night when there is no light.
- Oxygen dissolves in water. During the warmer months, deeper lakes often stratify into a layer of warm, high-oxygen water near the top, and colder, low-oxygen water towards the bottom.

Stream Systems and Watersheds

Stream systems are a dynamic part of the environment. They include surrounding watersheds, stream channels, in-stream habitats, stream banks, and ponds, lakes, and rivers. All of the components in the stream system influence living things within the water, so it is important to consider every element in the study of stream systems.

The Hydrologic Cycle



Water is continually recycled and transported by the hydrologic cycle. In fact the earth today contains the same amount of water as it did when all the earth's waters first formed! The process is as follows:

- Water from ocean and land surfaces are warmed by the sun and **evaporate** into the atmosphere as water vapor (its gaseous state). Water also enters the atmosphere through **transpiration** — evaporation of water through plant processes.

- Man contributes to the hydrologic cycle through the use of fossil fuels where the product of **combustion** is water (e.g. for every gallon of gasoline we burn we get one gallon of water).
- At locations of lower temperature and pressure, the water vapor **condenses** (changes from gaseous to liquid state) to produce **precipitation** (rain, snow, sleet, hail) or **sublimates** (changes from the solid state directly to the vapor state or vice versa).
- On land, the precipitation may run off surfaces into lakes, rivers, streams, or infiltrate into the soil or be absorbed by plants. Water not absorbed by plants becomes ground water that is often pumped back to the surface or may eventually emerge in the form of springs.
- The cycle is complete when water again evaporates and transpires.

Watersheds

Watersheds, geographic regions found in nature, are areas where surface water flows toward a particular water body, such as a stream. The total area of land that contributes runoff to the stream is determined by **topographic boundaries**. A ridge or other area of elevated land, called a **divide**, separates one watershed from another. Streams on one side flow a different direction than streams on the other side of the topographic boundary.

Watersheds are complex systems and each one responds differently when natural activities or human activities interfere with the system. In fact, most of what happens to a stream occurs outside its immediate channel but within the watershed. Because of their sensitive balance, streams are indicators of events that occur on the land in the watershed; activities in a watershed have the potential to affect not only the nearest stream, but the downstream water bodies as well.

Streams within a watershed originate from rain water, fog, springs, and snowmelt. Water may take many paths from the time it forms as precipitation in the sky until it flows back into a series of water bodies, and finally to the ocean. The path it takes determines the quality of the water and its fitness for drinking, recreation, industry, farming, and aquaculture (farming in water) along the way.

As water flows over a watershed, it recharges surface and ground water supplies by percolating into water-bearing layers of permeable rock, gravel, or sand called **aquifers**. This process may filter out impurities such as sediments (soil particles), oil and grease, and bacteria. It can also deactivate nutrients, pollutants, or organisms through biological processes. The concentration of these impurities, the speed and amount of water, the materials the water flows over or through, and the steepness of the land all contribute to the ability of a natural system to regenerate itself and maintain good water quality.

A watershed has three primary functions:

- capturing water,
- storing water, and
- releasing it safely.

Streams

As streams flow they all follow certain rules of drainage. Streams may begin from underground water coming to the surface as springs, from rainfall or snowmelt, drainage from a wetland, as meltwater from a glacier, or as an outlet of a lake or pond. Depending upon the physical nature of the land, streams may be crowded with vegetation and trees along their banks. Some streams actually dry up on the surface during periods of low rainfall. These are called intermittent streams.

As streams increase in flow and join with other streams, a branching network is established, much like the branches of a tree. This network from the headwaters to the river mouth is called a river or stream system. Several systems have been developed for identifying the relative positions of streams within a river system. The beginning of a stream is a first order stream. Two first order streams join to form a second order stream, and two second order streams become a third order stream.

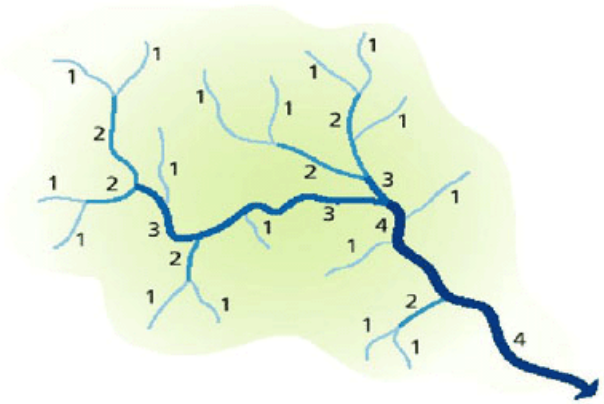


Figure 1.2.1 Stream ordering from the headwaters. From *Stream Corridor Structure* http://www.epa.gov/owowwtr1/watershed/wacademy/acad2000/stream/r11.html

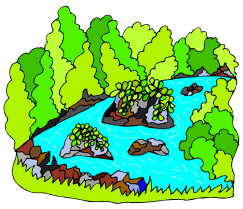
Stream channels

Stream channels are created as runoff from the watershed seeks a path of least resistance. If the watershed has very steep terrain, the resulting swift-moving water may cut a deep stream channel and keep the stream bed flushed of sediments. If the topography is flat, the stream may be shallow and meandering, with many sediments found suspended within the water.

In its natural condition, a stream channel provides a variety of aquatic habitats for many species of plants and animals. They provide areas for feeding, resting, and reproduction, and generally support a great diversity of organisms.

In-stream habitats

In-stream habitats include pools, riffles, root mats, plants, undercut banks, and a wide variety of growth material. These, along with the depth and flow of the water, usually determine the type of aquatic organisms found in the stream. Again, under natural conditions, a great variety of combined habitats means a great diversity of aquatic life.



Stream banks

Stream banks and riparian (river) zones serve many functions other than keeping the water in the channel. They are home to many plants and animals and, under natural conditions, help protect the stream from outside influences. When these areas are covered with trees, shrubs, and herbaceous (non-woody) plants, they provide erosion protection, sediment collection, and nutrient absorption, all of which contribute to water quality.

Hyporheic Zones

The hyporheic zone is generally understood to be part of the landscape that contains water of both subsurface and stream channel origin and can be visualized as 'substreams.' The water flowing within the hyporheic zone becomes a water connection between streams and catchments. This connection becomes a dynamic bidirectional link that consists of multiple flow paths. River and stream beds are formed of material that is often coarse and porous. Therefore, rivers, streams, wetlands, and lakes leak, exchanging water with the adjacent groundwater.

Ponds

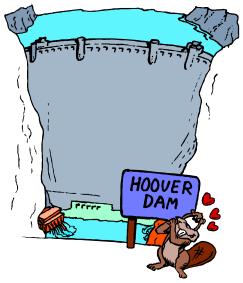
Ponds develop where streams have stopped flowing through old channels or where deposits of soil prevent water from entering channels. Ponds are small, quiet bodies of water that are usually shallow enough for sunlight to reach the bottom. The sunlight enables rooted plants to grow across a pond bottom from shore to shore.

Ponds have a great variety of animal and plant life. The wind and streams carry in eggs, seeds, and organisms that develop into various forms of life. Pond animals include birds, crayfish, fish, frogs, insects, and turtles. Many ponds have rooted plants that either grow entirely underwater or have parts that extend above the surface. Leafy plants float on the surface. Microscopic animals and plants also thrive in most ponds.

Lakes

Lakes are formed when streams are dammed, causing water to collect in large pools or can be periglacial potholes left over from the ice age. Naturally formed bodies of water are lakes, while man-made bodies of water are called reservoirs.

Lakes create little worlds of their own. Water plants live under the surface of lakes. Some of the plants are attached to the lake bottom, and others float free. This vegetation provides food for water creatures such as water insects, snails, turtles, and fish. Lakes are also a habitat for waterfowl such as ducks, geese, swans, cranes, and others. Land animals use lakes for drinking water. They also obtain food from lakes.



Reservoirs

Reservoirs are created when people erect structures to dam surface water. Most reservoirs consist of a retaining structure or dam and a spillway that limits the maximum water level. Many reservoirs also have outlet structures that allow the controlled release of water. Whatever the size, the primary function of a reservoir is to stabilize the flow of water from a watershed or to satisfy the varying demands of water consumers.

Rivers

Rivers are large natural streams that return excess rain or snow to the ocean. They are extremely important as sources of water supply, avenues for commerce, and sources of hydroelectric power, not to mention fish and wildlife habitat!

Water supply — for farms, industry, and in some cases, drinking water — is perhaps the most important resource provided by rivers. The amount of water a river will yield is the result of many factors. The size of the drainage basin is basic, because large catchment areas are necessary for large and reliable supplies. Climate is critical, for small river basins in humid areas may yield as much water as much larger basins in dry regions. When it is not raining, a river receives its water as subsurface flow from ground water; thus the waterstoring capacities of rocks and soil surrounding a river strongly influence its flow.

Many problems besides yield must be faced in using rivers for water supply. For example, people are almost certain to pollute the river with industrial waste, sewage, chemical fertilizers and insecticides, and even heat from the use of river water for cooling in power generation or for industrial

processes. During periods of low flow the river has a high content of dissolved minerals while during high flows it may be turbid from sediment.

In conclusion, all natural stream systems, whether in mountains or flatlands, possess a great diversity of plants and animals. A decline in the number of different organisms (diversity) or the total number of total organisms (abundance) occurs when the system is in some way disturbed, such as when polluted. Although there are some natural pollutants that can create problems for streams, ponds, lakes, and rivers, most problems result from human activities.

Water Quality Issues

There are many issues that impact water quality. Building a local index of indicator issues can help communities in the planning and action process related to good stewardship of our collective water resources. Water quality issues can be the result of human or natural occurrences, but left unattended can result in a severe impact on a community's quality of life.

- Drinking and ground water quality and quantity
- Natural land surface processes, evapotranspiration, sediment, estuaries
- Climatology / snow accumulation / flood events
- Wetlands and riparian zones
- Conservation, wildlife, fish habits and habitat
- Water rights, water regulations, water policy
- Scientific measurements. For example: the total maximum daily load (TMDL) of pollutants a water body can take and still meet a safe standard.

Sources of Pollution

Many forms of pollution affect water quality. Silt deposits, excess nutrient content, and introduced or concentrated toxins can injure or kill aquatic organisms and become a public health hazard. Observable signs of water pollution include discoloration, unpleasant odors, excess algae growth, cloudy or silty water, and dead fish, plants, or animals. All water pollution originates from two very different sources: point and nonpoint.

Point source pollution

As a basic guideline, if a single source can be identified as the cause of the pollution, such as a pipe or ditch, the pollution is said to have a **point source**. Easily identified, point sources have become the target of legislation because they are traceable to one discharge point. Examples of point sources of pollution are industrial plants and sewage outlets. Generally, pollution from point sources is controlled to some degree by treatment technology, either chemical or biological, at or before the point of discharge.

Point sources must obtain a National Pollution Discharge Elimination System (NPDES) permit for their discharge.

Permit holders must monitor and document chemical parameters of the effluent, which is wastewater discharged into the environment, to ensure that the water quality meets permit requirements. Violation of these requirements is punishable by fines.

Nonpoint source pollution

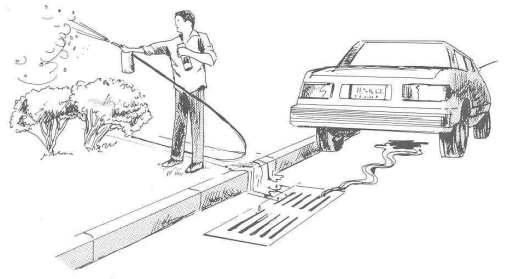
A **nonpoint source** means that pollutants come from a broader area so that their origins are not easily identified or controlled. Nonpoint source water pollution originates in water that runs in a thin layer or "sheet" over the land; in other words, it does not come from a stream, ditch, or pipe. This type of pollution occurs as rainfall runoff carries pollutants from the land, through the watershed, and on into the stream. As the runoff flows over the land, it picks up sediments, organic wastes, nutrients, toxic substances, bacteria, and other sources. Lawns, pastures, streets, parking lots, etc., all contribute pollutants that ultimately find their way through the watershed to the stream in this manner.

As watershed areas become more populated, natural surfaces become covered over with hard solid surfaces like streets, sidewalks, and rooftops. As a result, water that previously soaked into the ground to replenish underground and surface water supplies, flows over land in the watershed and enters the stream more rapidly. Some of the common pollutants that enter streams with this runoff are: pesticides and fertilizers from yards, oils from roadways and parking lots, and improperly disposed of wastes including hazardous materials from dumping grounds and storage areas. Also, the increased stream flow may cause flooding and erosion of stream banks, which can tear out vegetation, increase sedimentation, and reduce the quantity and quality of fish spawning and rearing habitat.

Just as many problems with point sources are being solved through legislation, programs addressing nonpoint source pollution are becoming increasingly important in water quality management. The U.S. Environmental Protection Agency estimates that over one-half of all water pollution originates from nonpoint sources. Identifying all of the small yet significant sources of nonpoint source pollution is impossible, since these activities are widespread across the land. Therefore, public education and involvement are crucial to making people aware of the impact their activities can have on the water supply.

As a result of the Clean Water Act, cities are now making plans to capture their urban runoff in order to treat the contaminated water in a wastewater treatment plant or other method before releasing it into a stream. Other management practices being promoted include modification of home and business activities, proper drainage practices, and stream maintenance. Other examples include adopting policies that address:

- Development and construction practices
- Natural resource activities (agriculture, forestry, mining, etc.)
- Yard waste
- Household hazardous waste
- Lawn and garden chemicals



Great Water Quality Resources for More Information

- **Water Basics** (http://ga.water.usgs.gov/edu/mwater.html)**.** This site explores physical and chemical properties of water and why water is so critical to living things. Take the true/false quiz on water properties.

- **Science in Your Watershed** (http://water.usgs.gov/wsc/)**.** The purpose of this site is to help you find scientific information organized on a watershed basis. This information, coupled with observations and measurements made by the watershed groups, provides a powerful foundation for characterizing, assessing, analyzing, and maintaining the status and health of a watershed.

- **Chehalis River Council** (CRC) (http://www.crcwater.org/)**.** See what the issues are in this watershed and review conditions and information presented about their issues.

- **The NatureMapping Program** (http://www.fish.washington.edu/naturemapping)**.** The NatureMapping Program's vision is to create a national network that links natural resource agencies, academia, and land planners with local communities primarily through schools. Their approach is to train individuals to become aware of their natural resources and to provide the tools to inventory and monitor their resources. The program is sponsored by the Washington Department of Fish and Wildlife (WDFW) in partnership with the Washington Cooperative Fish and Wildlife Research Unit Gap Analysis Project at the University of Washington, Project WILD, Oregon Biodiversity Project, and the National Biological Information Infrastructure Program of the U.S. Department of the Interior's Cooperative Research Unit.

- **The Watershed and River System Management Program** (http://wwwbrr.cr.usgs.gov/warsmp/) is sponsored by the Bureau of Reclamation's Science and Technology Research Program and the U.S. Geological Survey's Water Resource Division. This program provides a data centered framework for water resources decision making. Today's complex water resource management issues require flexible, comprehensive decision support tools that display timely information to water managers. River systems operate under laws, compacts, treaties, and court decrees, while meeting increasing demands that compete for limited fresh water supplies. This interagency program supports development and application of decision support systems that will assist the resource manager to achieve an equitable balance among the following uses: municipal, fish and wildlife, agricultural, recreational, hydropower and water quality.

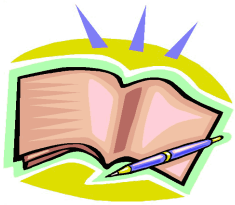
- **USGS Surface Water Information Pages** (http://water.usgs.gov/osw/)**.** The Office of Surface Water provides leadership in development and application of new techniques and tools for the collection, analysis, and interpretation of surface water and sediment data.

Discussion Points

- What are your primary water uses each day and how does this resource impact you, your family, and your community?
- From what part of your watershed does your drinking water come from?
- Do you know what your watershed looks like?
- What are some of the primary uses in the headwaters of your watershed, near the mouth?
- What issues were not raised that concern you about water quality?

Major Points to Remember

- Water comes in three forms (solid, liquid, and gas) and provides for the basics of life.
- The study of water (hydrology) involves physical, chemical, and biological conditions (parameters).
- Watersheds have topographic boundaries and recharge the surface and ground water supplies by percolating into water-bearing layers of permeable rock, gravel, or sand called aquifers.
- Water quality issues can be the result of human or natural occurrences, but left unattended can result in a severe impact on a community's quality of life.
- Point and nonpoint sources are causes of pollution in stream, river, and lake systems.
- There are several water quality web sites and references with great information for further study.

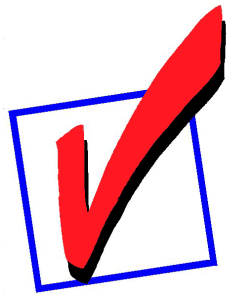


Journal and Evaluation

List and/or draw the major stream, river, lake, or pond in your watershed that is nearest to where you live. After reflecting on this list or drawing, record in your journal at least 10 of the major human and biological impacts on the chosen water resource in the last 1- 5 years. Why did you choose these impacts?

Short-course Presenters

In the Water and Watersheds section discuss watersheds in the community and those from nearby areas that impact community, county, or tribal water quality. Overview known point source and nonpoint source pollution concerns in the region, but do not make an example of an individual or an industry when leading short-course sessions.



Tips for Short-course Presenters

❖ A supporting 20 minute activity for this module is to obtain 3.5 minute map(s) from the USGS and the USGS guide to map interpretation to look at the key watersheds in your local community. Many will not have seen these types of maps and this is an excellent skill that they can come to appreciate through the short-course. Along with notes and pencils or pens have short-course participants, in groups of 2 or 3, identify the number of streams and drainages on their map. When all have completed these tasks have each group report out what they found. Often for the same map there will be from 1-40 drainages reported and it gives organizers an opportunity to discuss the concepts of continuous and intermittent streams, protocols, standards, and agreed upon terms. Have each group independently answer and report on these three questions.

1. How many drainages are on this map?
2. Determine the order of one of the streams on your map using the information on page 57 of your guide.
3. Identify all the other items on the map that might be of concern for water quality.

Encourage groups to use their estimates in answering the questions and clue them in on how the Learn-Plan-Act might be used in their community through a similar mapping activity before a public issues meeting. Alternately have them address the discussion points presented in this module.