water

Water defines our planet, biology, and environment. Without it, neither we, nor any life as we know it, would exist. It is our planet's most distinctive, fundamental, and important resource.

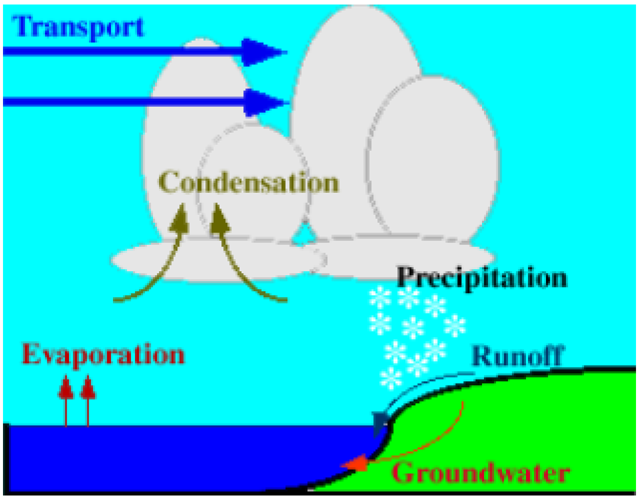
Water resources	Water pollution

I. Sources of Water

97.4%	in the oceans: too salty for most uses
2%	ice in glaciers and at the poles
0.01%	accessible, fresh, liquid water found in the atmosphere, streams, lakes, and underground

hydrologic cycle

Water moves through the various reservoirs of the **hydrologic cycle**. May take thousands of years to do this. Much of it is nonrenewable on a human time scale.



Non-equally distribution

Water not distributed equally. Some places have excess (**Canada; 20%** of world's fresh water); others have very little (**Middle East**). Leads to confrontations between nations over access to adequate supplies of fresh water. Abundant water often located where there are few people (Amazon) or visa-versa (Southern California)

Time table

Often get short periods of excess precipitation leading to flooding followed by long periods of little precipitation causing droughts: a feast or famine situation.

Battless for the water rights

In eastern U.S. there is a general water surplus, although much of it is polluted. Western U.S. has a general water deficit. Situation getting worse as population shifts to the west and as climate warms up. This has led to numerous and protracted legal battles over water rights.

A. Surface Water

Precipitation that does not infiltrate into the ground is known as **surface runoff**, which flows into lakes, rivers, stream, swamps, etc. Land is divided into distinct drainage basins or watersheds. These areas drain into a specific stream or lake.

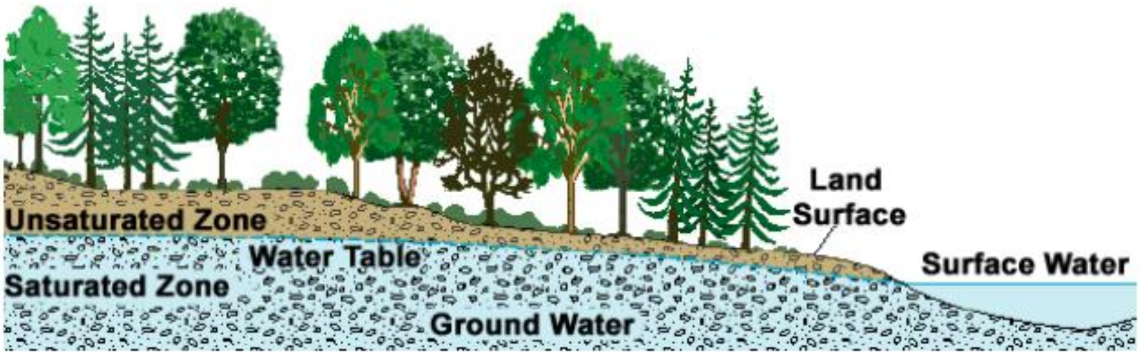
Surface water is the most easily accessible where available. Often it is polluted.

B. Groundwater

This water has percolated down, filling the voids in soils, sediments, and rocks.

Vados – water table and saturated zones

Zone of aeration (**vadose zone**; water and air in voids) above is separated from **zone of saturation** (only water in voids) below by the **water table** (top surface of the groundwater). This may extend down thousands of feet until voids close up.



Water table may move up or down depending on the balance between the **inflow** (**recharge**) and **outflow** (**discharge**) of water.

Aquifers

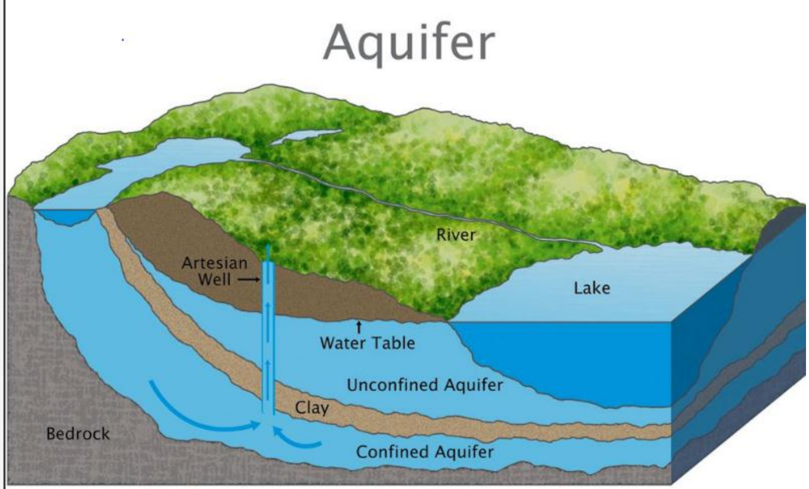
Most groundwater held in layers of **high porosity and permeability**. Known as **aquifers**. May be **unconfined** (aquifer extends to the surface) or **confined** (aquifer bounded on top and bottom by low porosity and permeability material. Groundwater moves slowly (meters/year) through aquifers from high elevation (or pressure) to low.

IMAGE

Aquifer Illustration

This illustration shows the two most common types of aquifers, confined aquifers and unconfined aquifers. An unconfined aquifer can receive water directly from the surface, while a confined aquifer is trapped between two layers of rock.

ILLUSTRATION BY TIM GUNTHER



Confined artesian and aquiclude

Confined (**artesian**) aquifers have water under pressure. They are cut off from surface recharge and pollution by overlying **aquiclude** (low porosity and permeability layer), except where aquifer is exposed at the surface. Known as a recharge area. These may be affected by local pollution and covering with impermeable material (buildings, parking lots, etc).

C. Human Uses of Water

Has increased about 500% since 1950. Will double again by 2025 at which point we will be using essentially 100% of all reasonably accessible fresh water.

Most water **(65%)** is used for **irrigation** where it is lost to the local hydrologic cycle (**consumed**) due to evaporation and infiltration. Value varies from place to place.

Another **25%** used for **energy and industrial production**. Most returned to the local hydrologic cycle but often it is polluted. Only **10%** used for **drinking, bathing, flushing, cooking**, etc. (municipal and domestic water supplies).

II. Water Shortages: Causes and Solutions

What is the problem?

Almost half of the world's population faces chronic water shortages due to climate, prolonged drought, soil desiccation (due to loss of vegetation), or overpopulation. Another 20% of the world's population uses water that is polluted. There are five basic ways to increase water supplies, each with their own pros and cons.

Basic ways to increase water

A. Dams and Reservoirs
B. Intrabasin or Watershed Transfer
C. Withdrawal of Groundwater
D. Desalination
E. Improving Efficiency of Water Use

A. Dams and Reservoirs

Pros:

Large year-round capacity
used for flood control
used for recreation
can generate electricity without pollution

Some of these uses conflict with one another.

Cons:

Large evaporative loss
loss of habitat
displacement of people due to flooding by reservoir
may cause earthquakes, risk of collapse and catastrophic downstream flooding
blocks fish migration
traps sediment
causing increased downstream erosion and loss of beaches
expensive to build and maintain

B. Intrabasin or Watershed Transfer

Pros:

Take water from where it is abundant to where it is scarce
This may be the only large supply of fresh, non-polluted water available to large populations

Examples are the New York City and Southern California water supply systems.

Cons:

May require the construction of dams and reservoirs
may destroy river and lake habitats in basins where water is being taken due to reduced flows (i.e. Aral Sea and Colorado River),
and they are very expensive systems ($100+ billion).

C. Withdrawal of Groundwater

Pros:

Largest single source of unpolluted fresh water
Provides about 50% of drinking water and 40% of irrigation in the U.S.

Cons:

Lower water tables
aquifer depletion
aquifer destruction
Subsidence
saltwater intrusion
increased pollution
drying up of streams and lakes

Parts of the **Ogallala Aquifer** (source of most water for agriculture in central U.S) will dry up by 2050. Withdrawing groundwater at 4X its replacement rate in the U.S.

D. Desalination

Pros:

Done by **distillation** or **filtration**
7,500 installations in 120 countries provide 0.1% of human consumption

Cons:

Expensive (3-10X more than standard sources)
requires large amounts of energy to make
leaves large amount of concentrated waste brines and salts behind

E. Improving Efficiency of Water Use

Pros:

Roughly 2/3 (1/2 in the U.S.) of the world's fresh water is wasted, largely through leaks and evaporation
Reducing this to 15% would keep water demand at present levels well into the next century and reduce the need to use other methods

Reduce irrigation evaporation

Best way to cut water use is to reduce irrigation evaporation. Typically 40-50% of the water never reaches the plant roots (in some places 90%). **Center-pivot and drip irrigation** systems lose much less water. Efficiencies of 90-95% are possible. Also grow crops requiring less water (fruits, vegetables) in areas where it is scarce.

Reuse

Can also reuse gray water (non-sewage waste water; 75% of the water discharged from the home) and treated sewage for irrigation. Industry can recycle wastewater. Also, water needed for processing recycled metals is much less than the amount needed for processing original ores.

Homeowners, lawns, public supplies fixation

Homeowners can use low-flow showerheads and toilets. Lawns can be replaced with plants requiring less water. Public water supplies can fix their leaks. These methods can save up to 50% of domestic use and 25% of industrial use.

Cons:

Start-up costs may be high, but payback times are short

Usually it is much cheaper to pay for conservation than to pay for new water supply systems.

III. Too Much Water: Flooding

coastal	Stream
is caused by coastal storms, sea level rise, and coastal development.	usually caused by excess precipitation or snow and ice melt
Both are natural processes often enhanced by human actions.	
	Streams naturally overflow their banks and flood their adjacent floodplain
	People settle there because of fertile soils (due to the sediment deposited by floods)
abundant water, flat land, and the stream can be used for transportation. Civilizations start along rivers, but this puts people in harms way.	

A. Human Impacts on Flooding

Human activities increase frequency and severity of floods. Destroy vegetation, increasing soil erosion and surface runoff.

Build **levees**, **dams**, **floodwalls**, and **channelize** streams to try to control floods and protect property. Make things worse by blocking off floodplain. Bigger floods result. Build more flood-control structures. Make things even worse. Cycle repeats.

Flood-control structures are equally good at keeping water in the floodplain as keeping it out. Once breached they often prolong the flood. In many instances, solving the flooding problem in one area only makes it worse in another.

In the U.S. we spend billions of dollars every year on flood control and still wind up with billions of dollars in damages. Also destroying natural habitats along streams.

B. Alternative Ways to Reduce Flooding Risks

We are now rethinking the logic of flood control. Ultimately may be cheaper to let streams go back to their natural condition and move the people out of flood-prone areas. Practice floodplain management (i.e. people control) rather than flood control.

Restrict development in flood-prone areas, zone out activities not consistent with flooding, create a natural floodway, make flood insurance more expensive and harder to get (in another words, stop encouraging people to live and work on floodplains).