Water Quality

Where does drinking water come from?

- When you think about where your drinking water comes from, it's important to consider not just the part of the river or lake that you can see, but the entire watershed.
  - The watershed is the land area over which water flows into the river, lake, or reservoir.
- In rural areas, people are more likely to drink ground water that was pumped from a well.
  - the natural reservoirs under the earth's surface

Surface vs. Ground Water

- Ground water is naturally filtered as it passes through layers of the earth into underground reservoirs known as aquifers.
- Water that suppliers pump from wells generally contains less organic material than surface water and may not need to go through any or all of the treatments. The quality of the water will depend on local conditions.

The Source of the Water

- When a water supplier takes untreated water from a river or reservoir, the water often contains dirt and tiny pieces of leaves and other organic matter, as well as trace amounts of certain contaminants.
  - When it gets to the treatment plant, operators often add chemicals that act on the water as it flows very slowly through tanks so that the dirt and other contaminants form clumps that settle to the bottom. Usually, this water then flows through a filter for removal of the smallest contaminants like viruses and Giardia.

What contaminants may be found in drinking water?

- There is no such thing as naturally pure water. In nature, all water contains some impurities. As water flows in streams, sits in lakes, and filters through layers of soil and rock in the ground, it dissolves or absorbs the substances that it touches.
  - erosion of natural rock formations, substances discharged from factories, applied to farmlands, or used by consumers in their homes and yards.

contaminants in drinking water (cont.)

- Sources of contaminants might be in your neighborhood or might be many miles away.
  - Your local water quality report tells which contaminants are in your drinking water, the levels at which they were found, and the actual or likely source of each contaminant.

contaminants in drinking water (cont.)

- Similarly, some surface water systems protect the watershed around their reservoir to prevent contamination.
  - Chesapeake Bay Foundation

Tapping a source of water

- Large-scale water supply systems tend to rely on surface water sources, while smaller systems tend to rely on ground water.
  - Around 31 percent of the population served by community water systems (CWSs) drink water that originates as ground water.
  - Ground water is usually pumped from wells ranging from shallow to deep (50 to 1,000 feet).

Public water systems

- Public Water Systems (PWSs) are all different. They may be publicly or privately owned and maintained.
  - Their design may vary, but they all share the same goal to provide safe, reliable drinking water to the communities they serve.

How water is cleaned up

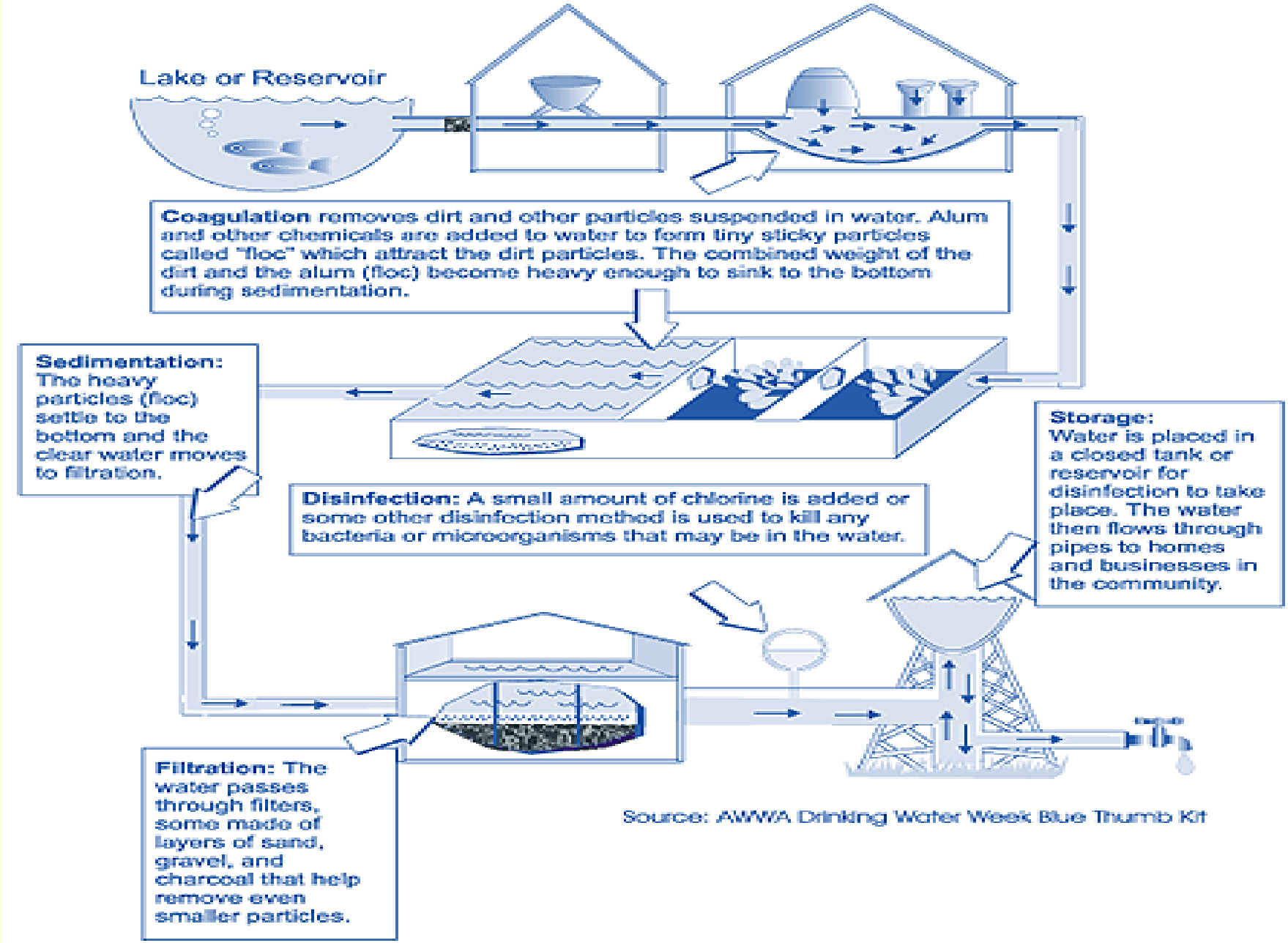
- The most common drinking water treatment, considered by many to be one of the most important scientific advances of the 20th century, is disinfection.
- Most water suppliers add chlorine or another disinfectant to kill bacteria and other germs.

Water treatment plant

- Follow a drop of water from the source through the treatment process. Water may be treated differently in different communities depending on the quality of the water which enters the plant. Groundwater is located underground and typically requires less treatment than water from lakes, rivers, and streams.

Video Clip

- http://www.waterandwastewater.com/videos/view_video.php?viewkey=84325132fca8edcdfb40


Lake or Reservoir
Coagulation removes dirt and other particles suspended in water. Alum and other chemicals are added to water to form tiny sticky particles called "floc" which attract the dirt particles. The combined weight of the dirt and the alum (floc) become heavy enough to sink to the bottom during sedimentation.
Sedimentation: The heavy particles (floc) settle to the bottom and the clear water moves to filtration.
Disinfection: A small amount of chlorine is added or some other disinfection method is used to kill any bacteria or microorganisms that may be in the water.
Storage: Water is placed in a closed tank or reservoir for disinfection to take place. The water then flows through pipes to homes and businesses in the community.
Filtration: The water passes through filters, some made of layers of sand, gravel, and charcoal that help remove even smaller particles.
Source: AWWA Drinking Water Week Blue Thumb Kit

Steps to Treatment

- Flocculation/Sedimentation
- Filtration
- Ion Exchange
- Absorption
- Disinfection (chlorination/ozonation)

Flocculation/Sedimentation

- Flocculation refers to water treatment processes that combine or coagulate small particles into larger particles, which settle out of the water as sediment. Alum and iron salts or synthetic organic polymers (used alone or in combination with metal salts) are generally used to promote coagulation. Settling or sedimentation occurs naturally as flocculated particles settle out of the water.

Filtration

- Many water treatment facilities use filtration to remove all particles from the water. Those particles include clays and silts, natural organic matter, precipitates from other treatment processes in the facility, iron and manganese, and microorganisms. Filtration clarifies water and enhances the effectiveness of disinfection.

Ion Exchange

- Ion exchange processes are used to remove inorganic contaminants if they cannot be removed adequately by filtration or sedimentation. Ion exchange can be used to treat hard water. It can also be used to remove arsenic, chromium, excess fluoride, nitrates, radium, and uranium.

Absorption

- Organic contaminants, unwanted coloring, and taste. and-odor-causing compounds can stick to the surface of granular or powder activated carbon and are thus removed from the drinking water.

Disinfection (chlorination)

- Water is often disinfected before it enters the distribution system to ensure that potentially dangerous microbes are killed.
  - Chlorine, chloramines, or chlorine dioxide are most often used because they are very effective disinfectants, not only at the treatment plant but also in the pipes that distribute water to our homes and businesses.

Disinfection (ozonation)

- Ozone is a powerful disinfectant, and ultraviolet radiation is an effective disinfectant and treatment for relatively clean source waters.

Monitoring water quality

- Water systems monitor for a wide variety of contaminants to verify that the water they provide to the public meets all federal and state standards.

Standards are based on size of the persons served

- Drinking water standards apply to water systems differently based on their type and size:
  - Community water system - A public water system that serves the same people year-round.
  - Non-community water system - A public water system that serves the public but does not serve the same people year-round.

Laws

- The Safe Drinking Water Act (SDWA) was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply.
  - SDWA authorizes the United States Environmental Protection Agency (US EPA) to set national health-based standards for drinking water to protect against both naturally-occurring and man-made contaminants that may be found in drinking water.

Others?

- What other laws do you know of that protect our water?
  - CWA
  - NPDES

The State Water Control Law

- SWCB mandates the protection of existing high-quality state waters and provides for the restoration of all other state waters so they will permit reasonable public uses and will support the growth of aquatic life. The adoption of water quality standards under Section 62.1-44.15(3a) of the law is one of the State Water Control Board's methods of accomplishing the law's purpose.

VA DEQ Drinking Water Quality Standards

- Virginia Water Quality Standards

- Wastewater = water that has been used by people in some way
  - Sewage, showers, sinks, manufacturing, storm water runoff
- Septic systems = the most popular method of wastewater disposal in rural areas
  - Underground septic tanks separate solids and oils from wastewater
  - The water drains into a drain field, where microbes decompose the water
  - Solid waste needs to be periodically pumped and landfilled

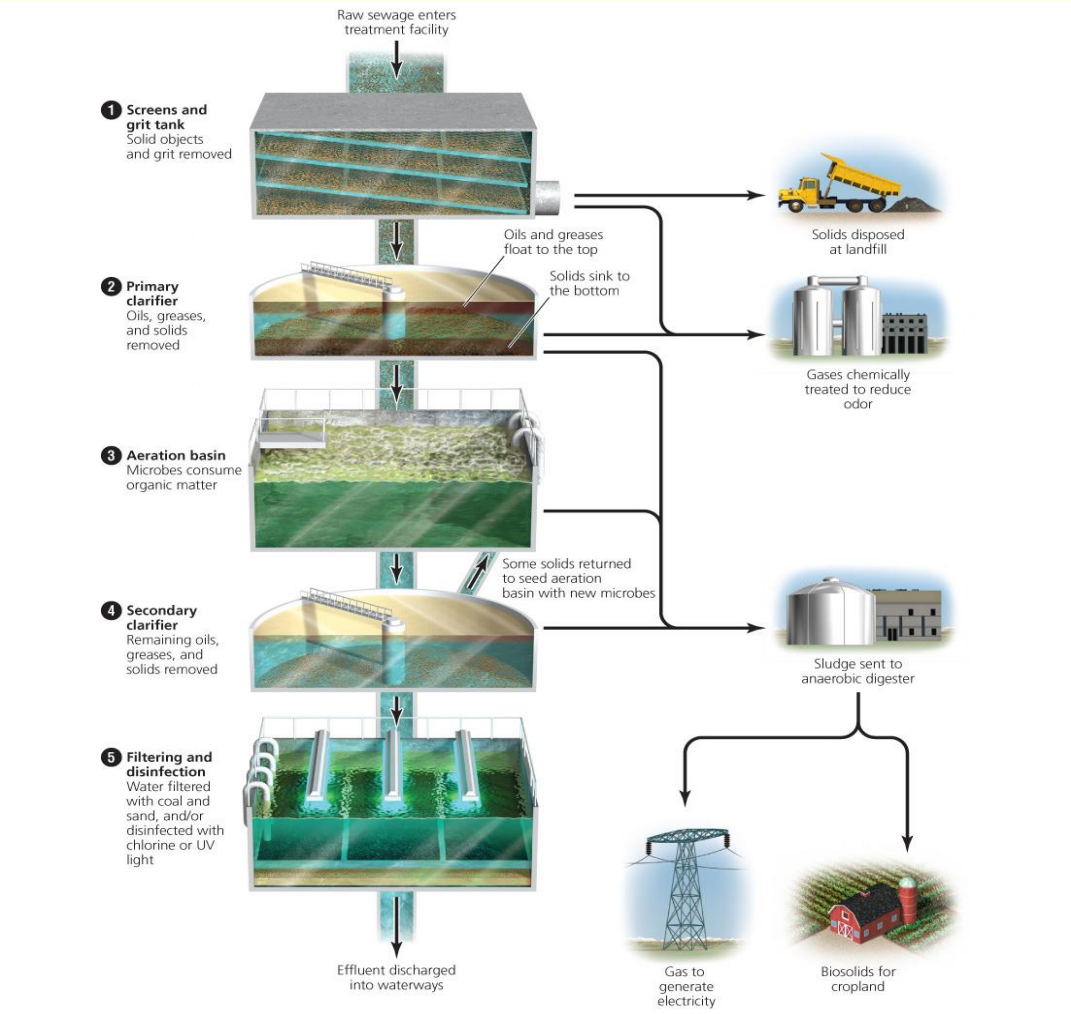
Municipal sewer systems

- In populated areas, sewer systems carry wastewater
  - Physical, chemical, and biological water treatment
- Primary treatment = the physical removal of contaminants in settling tanks (clarifiers)
- Secondary treatment = water is stirred and aerated so aerobic bacteria degrade organic pollutants

What is in wastewater?

- Solids: total, suspended, dissolved, settable
- Organic matter: bacteria, protozoans
- Proteins, carbohydrates, fats
- Nitrogen Compounds, Halides, Sulfur Comopunds
- Oils, and greases
- Hydrogen Sulfide

A typical wastewater treatment facility



Preliminary treatment

- Wastewater is sent through a bar screen, which removes large solid objects such as sticks and rags.
- Then the wastewater flow is slowed down entering the grit tank. This allows sand, gravel, and other heavy material that was small enough not to be caught by the bar screen to settle to the bottom.

Sludge Waste

- All the collected debris from the grit tank and bar screen is disposed of at a sanitary landfill or recycled.

Primary Clarifier

- Primary treatment is the second step in wastewater treatment. It allows for the physical separation of solids and greases from the wastewater.
- The wastewater flows into a primary settling tank where it is held for several hours. This allows solid particles to settle to the bottom of the tank and oils and greases to float to the top.

Excess Gas

- What do you do with the methane that comes off?
  - Outgassing can be diverted to a boiler and used as a fuel for heating purposes.

Secondary Clarifier

- Secondary treatment is a biological treatment process that removes dissolved organic material from wastewater.
- The partially treated wastewater from the settling tank flows by gravity into an aeration tank.

Bacteria do the work

- Here it is mixed with solids containing micro-organisms that use oxygen to consume the remaining organic matter in the wastewater as their food supply.
- The aeration tank uses air bubbles to provide the mixing and the oxygen, both of which are needed for the micro-organisms to multiply.

- From here the liquid mixture, composed of solids with micro-organisms and water, is sent to the final clarifier. Here the solids settle to the bottom where some of the material is sent to the solids handling process, and some is recirculated to replenish the population of micro-organisms in the aeration tank to treat incoming wastewater.

Final treatment

- Wastewater that remains is disinfected to kill harmful micro-organisms before being released into receiving waters. Although there are many methods available to kill these micro-organisms, chlorine and ultraviolet disinfection are the most widely used.

Disinfection

- Dechlorination occurs in the final wastewater treatment step. A solution of sodium bisulfite is added to the chlorinated effluent to remove residual chlorine.

Effluent flows out to the environment

- Following disinfection and dechlorination, the treated wastewater (now called final effluent) can be returned to the receiving waters from which it came. The flow is conveyed to an outfall and discharged through a series of diffusers into a surface water body or stream

Solids processing

- Primary solids from the primary settling tank and secondary solids from the clarifier are sent to the digester.
- During this process, micro-organisms use the organic material present in the solids as a food source and convert it to by-products such as methane gas and water.

Digestion

- Digestion results in a 90% reduction in pathogens and the production of a wet soil-like material called "biosolids" that contain 95-97% water. To remove some of this water and reduce the volume, mechanical equipment such as filter presses or centrifuges are used to squeeze water from the biosolids. The biosolids are then sent to landfills, incinerated, or beneficially used as a fertilizer or soil amendment.

Diagram of a Real WWTP

- DCWASA

- Primary Screening

- Primary Clarifier

- Aeration Tank

- Secondary Clarifier

Artificial wetlands

- Natural and artificial wetlands can cleanse wastewater
  - After primary treatment at a conventional facility, water is pumped into the wetland
  - Microbes decompose the remaining pollutants
  - Cleansed water is released into waterways or percolated underground

Artificial wetlands

- Constructed wetlands serve as havens for wildlife and areas for human recreation
  - More than 500 artificially constructed or restored wetlands exist in the U.S.