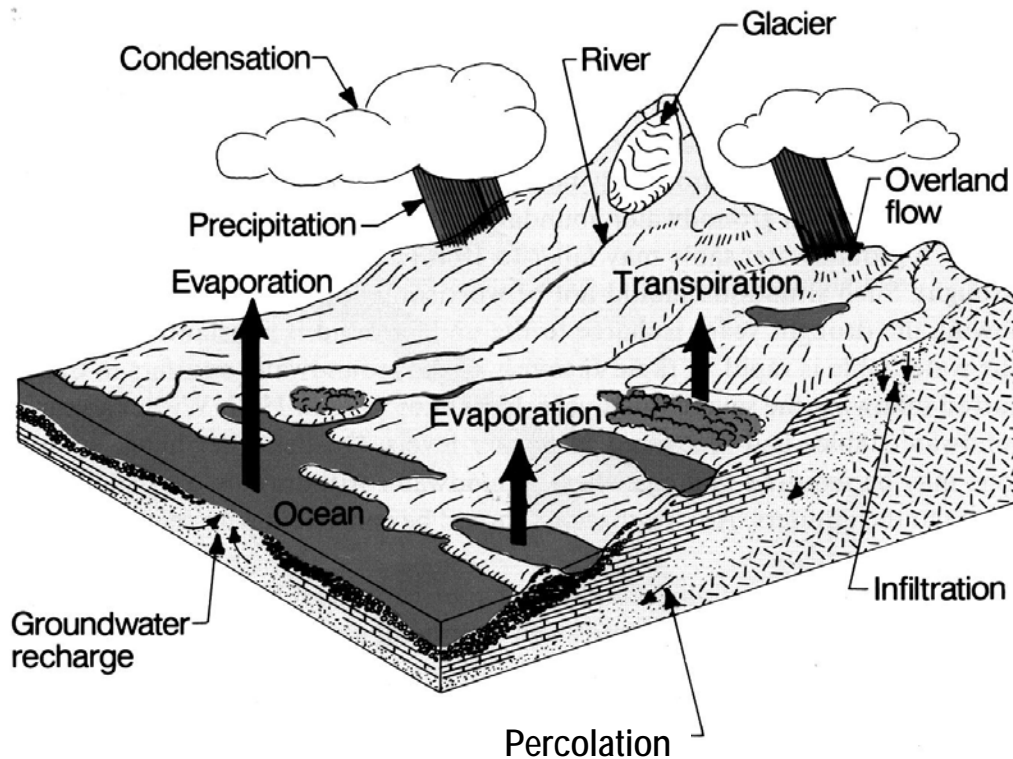


WATER SUPPLY MANAGEMENT

HYDROLOGIC CYCLE

Water is being exchanged between the earth and the atmosphere all the time. This exchange is accomplished with energy supplied by the heat of the sun. Water vapor enters the atmosphere from wet ground, lakes, rivers, and the ocean by a process called evaporation. Plants also release water to the atmosphere. This process is known as transpiration. When the water vapor cools and condenses, it changes from a gas to a liquid and falls back to earth as precipitation in the form of rain, sleet, snow, or hail. Evaporation from land and the ocean puts water back in the atmosphere, and the exchange goes on continually as water goes from ocean to atmosphere to earth. This exchange of water, from the oceans to the land and back again, is called the hydrologic cycle.

When precipitation falls, part of the water runs off into rivers and streams, part of it evaporates, and the remainder seeps or infiltrates into the ground. The amount of water that percolates farther into the ground water supply depends on the type of soil it must pass through and how much water is retained in the root zone. Plants retain the water in the root zone and release it back to the atmosphere through transpiration. Percolation is the most common means of recharging ground water supplies.



Water that is taken from lakes, rivers, or reservoirs is known as surface water. Many large systems make use of surface supplies because these rivers and lakes offer storage of large amounts of water. The chemical characteristics of surface water differ from ground water in several ways and generally require a greater degree of treatment to meet the Drinking Water standards. The minimum treatment required for surface water is filtration and disinfection.

As ground water percolates through the soil, the natural filtering action removes most of the material responsible for turbidity in surface waters. This filtration and the tremendous retention time in the aquifer provide for the removal of many of the bacteria in ground water. The mineral content of the ground water may be greater than that of surface water. These minerals are dissolved in the water as it percolates through the soil.

Surface waters will generally have more bacteria and turbidity present than ground water. Taste and odor problems are usually greater in surface water due to algae, bacteria, and fungi that are present in the water. Ground water may also have taste and odor problems that are usually caused by hydrogen sulfide gas and minerals like iron.

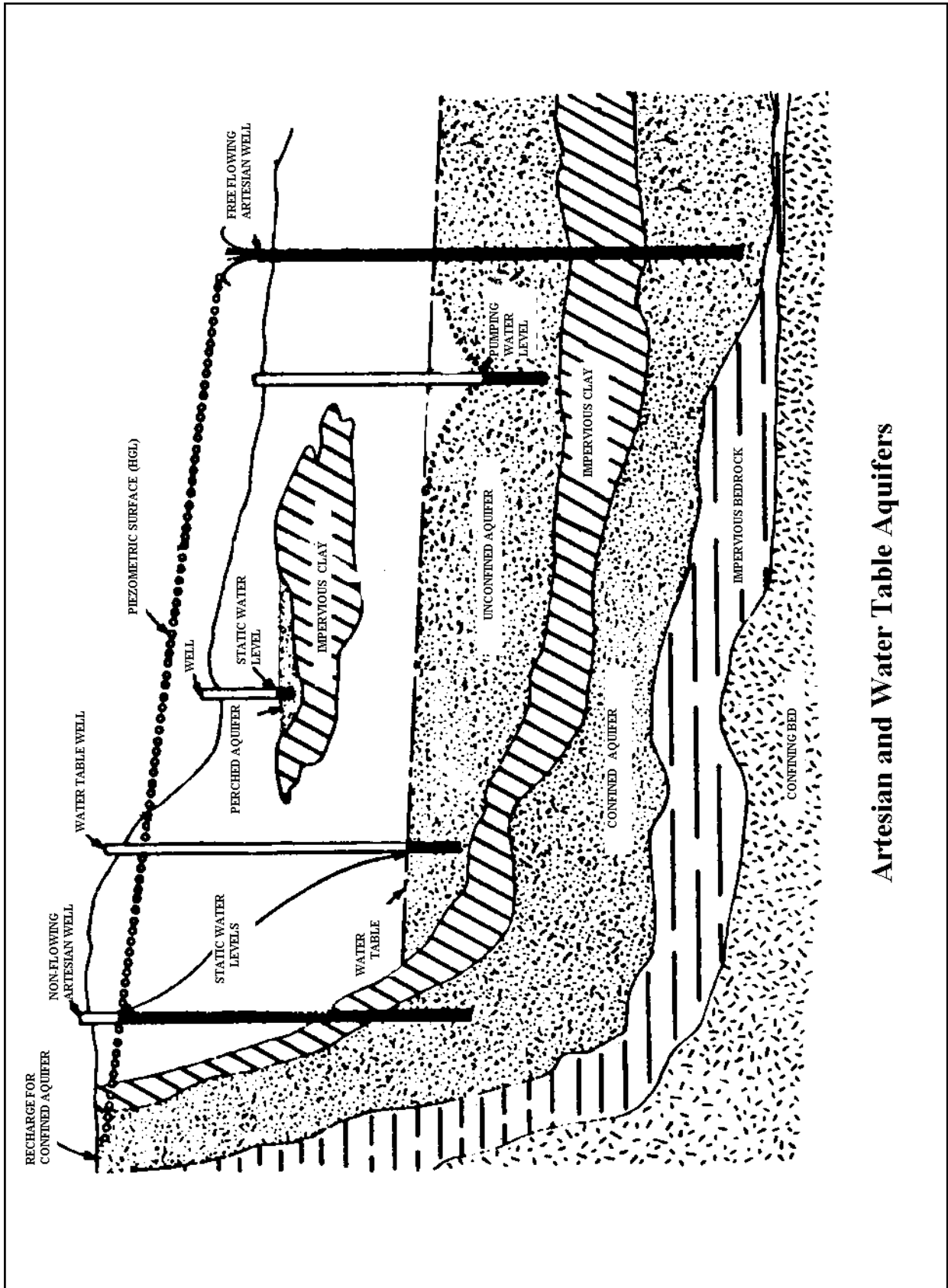
Some systems that were once thought to be groundwater may now find that the source water is classified as "groundwater under direct influence of surface water" or GWUDI by the SDWA regulations. These systems must now treat their water like a surface supply by filtering and disinfecting. Surface or boxed springs are now considered to be surface water supplies. Infiltration galleries are also considered to be surface supplies. These are wells that are located so close to a river or stream that the water in the surface supply percolates directly into the wells because the radius of influence overlaps the riverbed.

GROUND WATER SUPPLIES

Water will continue to percolate down through the earth until an impervious stratum is reached. An impervious stratum is a layer of material in the earth that will not allow water to pass through it. This material is usually made of rock formation or clay. As the water reaches the impervious stratum it will begin to collect and saturate the surrounding soil, forming an aquifer. It is a common belief that the water quality of an aquifer is constant throughout the aquifer. In fact, the water quality can change dramatically within the confines of a given aquifer. This can be attributed to changes in the medium or mineral deposits in the zone of saturation. Aquifers are generally classified as Water Table (unconfined), Artesian (confined) or Perched.

WATER TABLE AQUIFERS

An aquifer that is formed from a single impervious stratum and has an upper surface that is free to rise and fall with seasonal changes of pumping and recharge rates is known as a water table or unconfined aquifer. The water level in a well located in a water table aquifer will not rise above the initial point of encounter. Recharge for an unconfined aquifer can come from hundreds of miles away. Fluctuations in annual recharge may not affect the water table for years.



Artesian and Water Table Aquifers

ARTESIAN AQUIFERS

Artesian aquifers are created when ground water is trapped between two layers of impervious material. As the water flows between these strata it becomes confined and as recharge continues, the water backs up, creating pressurized conditions in the aquifer. Water in a well located in an artesian aquifer will rise above the point at which it is first located. If the water rises to the surface it is a free-flowing artesian well. If not, it is called a non-flowing artesian well.

PERCHED AQUIFERS

A perched aquifer is an unconfined aquifer that is formed by a small geologic formation of clay or rock that traps a relatively small volume of water. These small aquifers are quite common in mountainous regions. They generally only cover a few square miles of surface area. They can only receive recharge from precipitation that occurs directly above them. This may result in large drops in the water table during times of extended drought. Overpumping these aquifers as the system demands grow can cause them to dry up completely.

WATER SUPPLY AND WATERSHED MANAGEMENT

Proper management of a source water supply is an important part of operations and management of a public water system. Contamination of the supply is always a major concern. Aquifer protection and watershed management programs are tools used to prevent pollution of the drinking water supply. Resource management is another area that requires a great deal of attention. Depletion of the source water supply can be addressed through voluntary and mandatory conservation measures.

Depletion of groundwater supplies can create issues related to supply and equipment operations. Overpumping the aquifer will result in a drop in the water table. Anytime the water table drops, the system is said to be “mining” water. Water is being pumped out of the aquifer faster than it is recharged. This means that the supply is being depleted. It also means that the water table is getting closer to the pumps, which can result in pump related problems. Another problem that occurs when the water table is lowered is called subsidence. This results in sinkholes as the clay content in the saturated soils dries and shrinks as the water table drops.

A watershed is the area surrounding a source water supply that allows runoff to drain into the river or lake. The watershed for any source water supply must be maintained and managed properly to insure that the source water is protected from non-point sources of pollution. A non-point source of pollution could be runoff from an agricultural operation that uses organic herbicides or pesticides. The runoff after a major fire can also create non-point source pollution. Non-point source pollution is pollution that cannot be traced back to a particular point of entry into the water supply.

A watershed management program should be designed to insure the use of agricultural chemicals that might contaminate the water supply is permitted and regulated. Watershed management may also include removal of vegetation from the impoundment area. Chemical treatment of the reservoir to control algae growth and aeration for destratification are other examples of actions that might be considered as part of a watershed management program.

LAKES AND RIVERS

There are certain advantages and disadvantages related to taking water from rivers or lakes. Lake supplies maintain a more constant quality of water. The turbidity, temperature, and pH do not fluctuate as much from day to day as they might in a river supply. Minerals tend to concentrate in lakes. Iron, manganese, and other dissolved metals are retained in the lake with the highest concentration being found near the bottom. This occurs due to the lack of dissolved oxygen at the lower depths. The dissolved oxygen from wind and algae growth near the surface will oxidize some of the dissolved metals so that they precipitate. The length of detention time in the lake aids in the natural bacteria removal. The detention time also aids in the natural removal of suspended material or turbidity by sedimentation. Water in a lake will stratify into temperature layers with warmer water on the top and colder water on the bottom. The layer of water in the middle is known as the thermocline.

The quality of the water in lakes is affected by an occurrence known as turnover. This happens once or twice a year, generally in the springtime and late fall, as the water temperature of the lake begins to change. The density of a liquid or solid is referred to as its specific gravity. The specific gravity of the water changes as the water temperature changes. Specific gravity is determined by comparing the weight of a given volume of any liquid or solid with the same volume of water at 4°C. This means that the specific gravity of water at 4°C is 1.0. Solids or liquids with a specific gravity of less than 1.0 will float. If a material has a specific gravity greater than 1.0 it will sink. The greater the difference in specific gravity, the faster it will settle.

Water is heaviest or most dense at 4°C or about 39°F. In a deep lake the water at the bottom will always be about 4°C because of its higher Specific Gravity. Stratification occurs as layers of water, at different temperatures, form in the lake. In the spring as ice on the surface melts, it becomes warmer (and heavier) and begins to sink. As this happens water at the bottom is forced to the surface. This mixing action stirs up silt and decaying organic material and as a result can cause serious taste and odor problems. In the late fall as water at the surface cools it also gets heavier and sinks to create the same situation. Changes in water temperature and density also affect chemical treatment and settling in surface water treatment plants.

The turbidity, temperature and pH of water taken from rivers may fluctuate on a daily, or sometimes on an hourly basis. Rainfall and run-off usually contribute to these changes. Changes in the quality can also result from waste discharged from upstream sources. Minerals do not accumulate in rivers as they do in lakes. Any water that is not used is carried downstream rather than being retained as it is in a lake.

A jar test is a simulation of the treatment process that allows several different chemical adjustments to be evaluated at the same time. The results can then be used to determine the proper chemical dosages needed to produce the best removal results. Jar testing should be done when the raw water quality changes. A jar test will help the operations staff determine adjustments in the treatment process when these changes occur.

INTAKE STRUCTURES

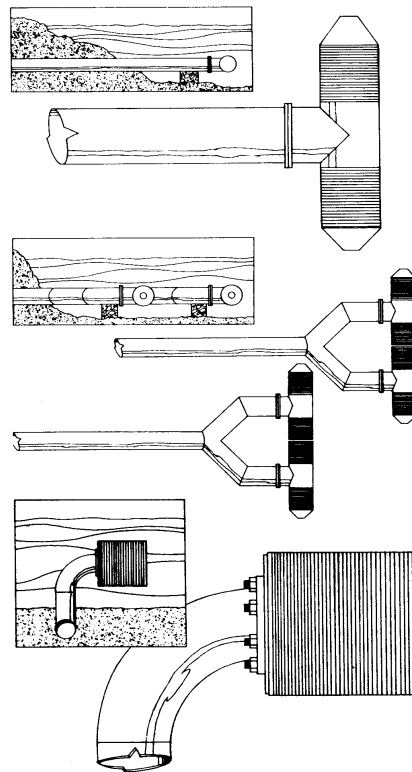
The type and location of the intake structure in the surface supply will determine the kind of treatment necessary for production of potable water. Ordinances should be passed to protect the water around the intake structure. Boating, swimming, and fishing should be prohibited in the area of the intake. Floating buoys should be placed as markers around the intake structure.

The intake structure should be designed to prevent the structure from freezing in the winter. Proper screening of the intake is also required to protect pumps and valves from serious damage. Periodic maintenance should be performed to keep screens from clogging and clear of restrictions. In some systems this is accomplished by flushing or backwashing the screen with water pressure supplied by a backwash water line located within the structure. Water is forced through the screen, washing the debris away from the structure.

RIVER AND STREAM INTAKES

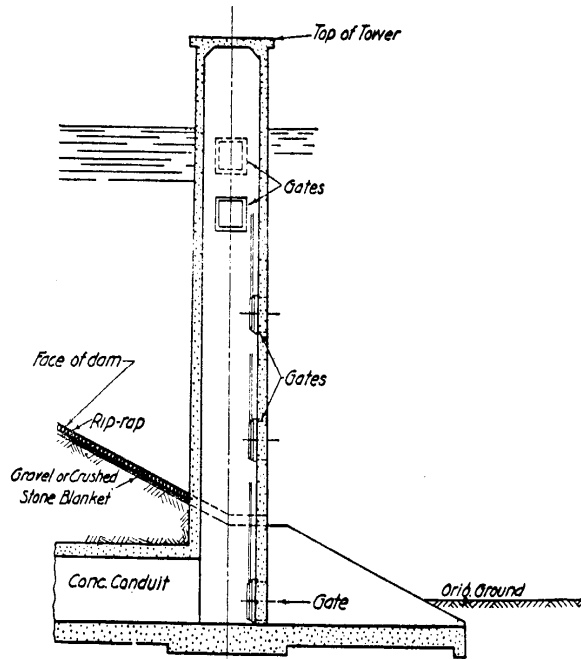
The most common type of intake in flowing water is a simple pipe extended into the water. This pipe or intake line feeds water to low service pumps usually located in a pump house on the bank. Provisions should be made to prevent floating material from clogging the intake screen. Intake screens should be small enough to prevent clogging and large enough to allow adequate intake flow.

The intake line should be located perpendicular to the flow or at a forty-five degree angle downstream. Intake lines that are pointed directly downstream may experience problems during high flows. A low-pressure area will develop around the intake restricting the flow of water into the structure. The intake pipe should be elevated off the bottom to avoid heavy concentrations of sand, silt and dissolved minerals.



LAKE AND RESERVOIR INTAKES

Intakes in lakes and reservoirs are generally located in 15 feet or more of water to provide multiple intake levels. These inlets are usually located 4 to 6 feet from the surface and at 5 to 10 feet intervals depending on the depth of the water. This will allow the operations staff to select water from different levels in the lake and minimize treatment costs by obtaining the best quality raw water. Inlets should never be located near the bottom of the lake to avoid high concentrations of dissolved minerals and gases, turbidity, and tastes and odors. Inlets are controlled by gate valves and operated from the top of the intake structure.



Lake Intake Structure



Lake Intake Structures
Floating (left) and Stationary (top)

BASIC STUDY QUESTIONS

1. What are the three types of aquifers?
2. What is transpiration?
3. What is a GWUDI water supply?
4. The best quality water is usually found where in a lake?

BASIC SAMPLE TEST QUESTIONS

1. Turnover in a lake is caused by changes in the specific gravity of water.

A. True
B. False
3. The specific gravity of water is highest at:

A. 32°F or 0°C
B. 39°F or 4°C
C. 72°F or 20°C
4. One of the problems found in water taken from the bottom of a lake might be:

A. Higher mineral concentrations
B. Tastes and odors
C. Less dissolved oxygen
D. Different temperature

ADVANCED STUDY QUESTIONS

1. What is non-point source pollution?
2. What is the disadvantage of pointing a river intake directly downstream?
3. What should be done when the surface water quality changes??
4. What is subsidence?
5. What is a thermocline?

ADVANCED SAMPLE TEST QUESTIONS

1. Runoff after a fire can result in:

A. Point source pollution
B. Non-point source pollution
C. Point of entry pollution
D. Creation of a thermocline
2. Some metal concentrations will be higher at the bottom of the lake because:

A. Metals sink to the bottom
B. The water is heavier at the bottom
C. They are oxidized at the top
D. Debris at the bottom is decomposing
3. The relationship between the flow and the drawdown is called:

A. Radius of influence
B. Cone of depression
C. Specific capacity
D. Total yield