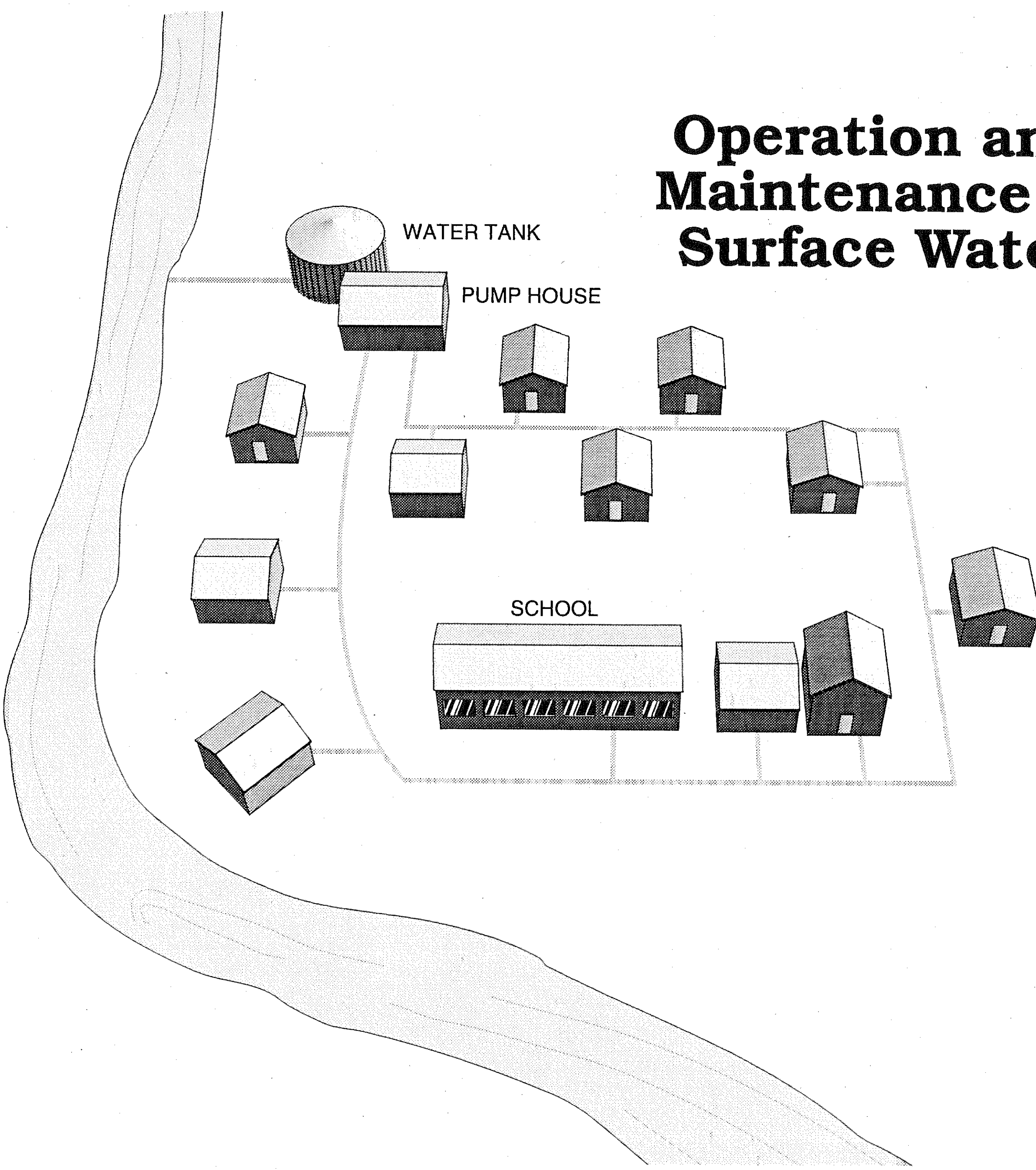
O & M of Small Water Systems



Operation and Maintenance of Surface Water

Alaska Department of Environmental Conservation
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O & M of Small Water Systems

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TABLE OF CONTENTS

O & M of Surface Water

O & M OF SURFACE WATER

WHAT IS IN THIS MODULE?

1. The process of watershed management and the two common watershed management programs.
2. The components of a water quality survey.
3. The use of a map to indicate potential sources of pollution, land use and watershed area.
4. Methods of gathering stream flows and precipitation data.
5. How to evaluate water quality data on raw water.
6. Routine operations of a watershed.
7. Routine water quality data collection recommendations for a surface water source.
8. Common water quality testing associated with a surface water storage facility.
9. How stored water deteriorates.
10. Routine inspection and data collection for a surface water storage facility.
11. Common techniques used to control algae problems in a surface water storage facility.
12. Routine inspection process of surface water intakes.

KEY WORDS

- Algae
- Ambient
- Baseline data
- Bed load
- Benthics
- Discharge measurement
- Dissolved oxygen
- Drainage basing
- Earth's mantle
- Epilimnion
- Flume
- Hypolimnion
- Infiltration galleries
- Inorganic
- Lithosphere
- Organic
- Overland flow
- Precipitation
- Parshall flume
- pH
- Raw water
- Recharge area
- Riparian
- Sanitary survey
- Spring
- Surface runoff
- Thermocline
- Velocity
- Water Quality Survey
- Water rights
- Watershed
- Weir

MATH CONCEPTS DISCUSSED

- Convert gpm to CFS
- Determine square miles
- Determine distance on a map
- Velocity
- Reading flow tables

SCIENCE CONCEPTS DISCUSSED

- Stratification
- Water stratification due to temperature
- The use of indicator organisms
- The function of benthic organisms
- Conversion of insoluble iron and manganese to a soluble form
- Conversion of velocity head to elevation head
- Life cycle of anaerobic and aerobic bacteria

SAFETY CONSIDERATIONS

- Working around water
- Electrical measurements
- Confined spaces

MECHANICAL EQUIPMENT DISCUSSED

- Screens
- Slide gates
- Shear gates
- Self cleaning screens
- End suction centrifugal pumps
- Submersible turbine pumps
- Lineshaft turbine pumps
- Check valves
- Air release valve

O & M OF SURFACE WATER

INTRODUCTION

Definition

Surface water is that water that is open to the atmosphere and results from **overland flow**[1]. It is also said to result from **surface runoff**[2]. These are two ways of saying the same thing.

Examples of Surface Water

Specific sources that are classified as surface water include:

- Streams
- Lakes
- Man-made impoundments - lakes made by damming a stream
- Rivers
- **Springs**[3] that are affected by **precipitation**[4] that falls in the vicinity of the spring. Affected means a change in flow or quality
- Shallow wells that are affected by precipitation. Affected means a change in level or quality
- Wells drilled next to or in a stream or river
- Rain catchments
- Muskeg and tundra ponds

Focus of Module

This module is focused on providing information on operation, maintenance and management of surface water systems for small communities. The key elements of the module are typical operation and maintenance routines on typical surface water impoundments and intake structures.

Not in the Module

There is little or no information provided on GWUD-ISW systems or on the pumping portion of the intake structures.

WATERSHED MANAGEMENT PROCESS

Introduction

The management of the watershed is the key to the maintenance of water quality and quantity. Unfortunately, in some cases, the watershed may be so large that direct management is not possible. For instance, it is very easy to manage a 200 acre watershed but nearly impossible to manage the drainage basin of the Yukon. When taking water from a river that drains a basin too large to reasonably manage, all that can be done is to make careful observations of

[1] **Overland Flow** - The movement of water on and just under the earth's surface.
[2] **Surface Runoff** - The amount of rainfall which passes over the surface of the earth.
[3] **Spring** - A surface feature, where, without the help of man, water extrudes from a rock or soil onto the land or into a body of water, the place of issuance being relatively restricted in size.
[4] **Precipitation** - The process by which atmospheric moisture is discharged onto the earth's crust. Precipitation takes the form of rain, snow, hail and sleet.

the upstream water quality. Therefore, this module is focused on the watersheds that are small enough to be managed by a small utility.

What is Watershed Management

Watershed management requires the conducting of four activities.

- Development of a use agreement with the land owners.
- Development of a watershed management policy.
- Gathering of **baseline data**[5].
- Performing an annual **water quality survey**[6] as part of an internal **sanitary survey**[7].

USE AGREEMENTS

Results

If the utility does not own the watershed they must have a use agreement with the owner. Failure to have a written use agreement places the utility at risk of having the watershed damaged by activities such as road building, logging or mining. These activities can have a significant negative impact on water quality resulting in increased treatment cost.

Content

A watershed use agreement must be between the utility and all of the land owners. The agreement should provide details about the types of allowed activities, road building standards, and standards that must be followed for those activities that could be carried on in the watershed. The agreement must spell out how notification of activities is to be done and within what time frame. The use agreement should be reviewed at least every three years.

WATERSHED MANAGEMENT POLICY

There are two basic watershed use policies; multiple use and restricted (single) use.

MULTIPLE USE POLICY

Description

The multiple use policy is the most popular because it places the least amount of restrictions on what types of activities will be allowed in the watershed. One of its major advantages is that it makes it easier to obtain support for funding to make improvements in intake structures and impoundments. Its major disadvantage is it makes it difficult to protect public health. People are the largest carrier of waterborne disease.

[5] **Baseline Data** - The water quality data, precipitation data and stream flow data that is accumulated from a drainage basin or groundwater supply before there was little or no activity in the area.

[6] **Water Quality Survey** - The investigative process of observing, sampling, testing, evaluating and reporting on the results of an investigation of a watershed and its associated streams. The process attempts to define the quality of the water and identify those items within the watershed, stream bottom and riparian area that can adversely impact water quality.

[7] **Sanitary Survey** - An on-site review of the water source, facilities, equipment, operation and maintenance procedures and management practices of a public water system for the purpose of evaluating the adequacy of each source, facility, equipment, operation and maintenance procedure and management practice for producing and distribution of safe drinking water.

Long Term Results

The US Forest Service and BLM have for years practiced multiple use policies with watersheds. In many cases this policy has placed various uses in conflict with one another. In recent years a restricted use policy with some watersheds has gained in popularity.

RESTRICTED USE

Description

The restricted use policy is also called the single use policy. Under this policy the watershed is managed for water quality and quantity as the specific use. The major advantage of this policy is that it normally produces the highest quality of water and offers the best results in protecting public health. There are two major disadvantage; one is the increased cost and effort needed in surveillance of the accesses into the watershed as well as surveillance of the watershed itself. The second major disadvantage is the public relations problems associated with sports users and tourist that wish to use the watershed.

Alterations

In most cases where a restricted use policy is in effect, there has been some alteration of the policy to allow limited use of the area and thus reduce the negative public relations associated with total restriction. One example is a community that gives a set number of access permits to the watershed during hunting season.

BASELINE DATA

Introduction

In order to have an understanding of why specific baseline data is necessary and how to develop this data, it is important to have a basic understanding of the hydrology of a watershed. The following data is a brief introduction to watershed hydrology.

INTRODUCTION TO WATERSHED HYDROLOGY

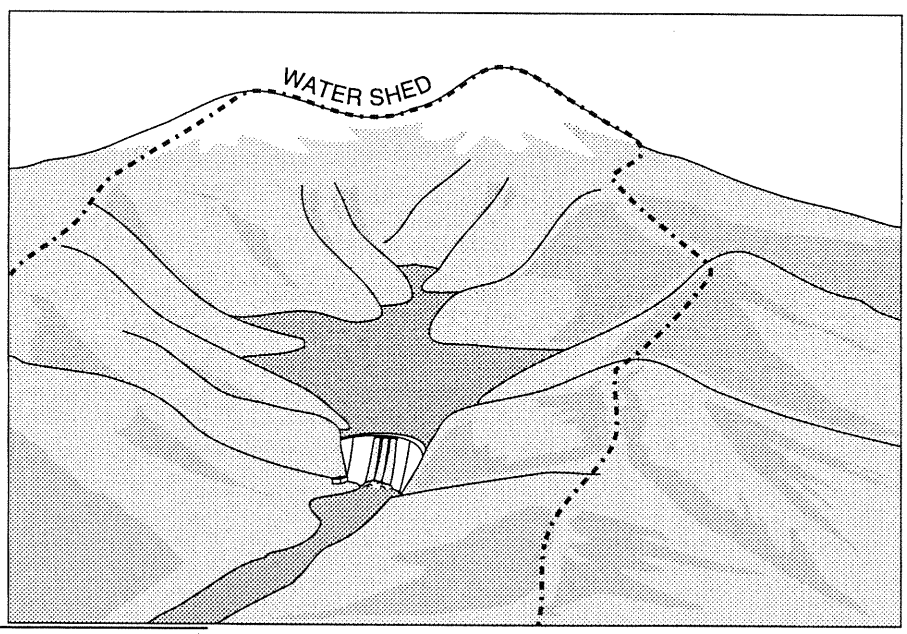
Introduction

A basic understanding of the movement of water and the things that affect water quality and quantity are important to those who manage and operate water systems. The study of these items is called hydrology. The components of hydrology include; the physical configuration of the watershed, the geology and soils, vegetation, nutrients, energy, wildlife and the water. The following is a brief discussion of these components.

PHYSICAL ASPECTS OF HYDROLOGY

Drainage Basin

The area from which surface water flows is called a **drainage basin**[8]. With a surface water source, this drainage basin is most often called the **watershed**[9]. When we are dealing with a groundwater supply or spring, this area is called the **recharge area**[10]. The drainage basin is also referred to a the watershed. The drainage basin is difficult to identify when we are referring to a large river such as the Yukon. However, on a smaller river, stream or lake, the area is defined by marking on a map an outline of the basin defined by the ridge of the mountains that surround the basin.



[8] **Drainage basin** - An area from which surface runoff or groundwater recharge is carried into a single drainage system. Also called; catchment area, watershed, drainage area.
[9] **Watershed** - A drainage basin from which surface water is obtained.
[10] **Recharge Area** - One from which precipitation flow into the underground water sources.

Area Measurements

The area of the basin is commonly measured in square miles, sections or acres. If you are taking water from a surface water source, it is desirable to know the basic size of the watershed.

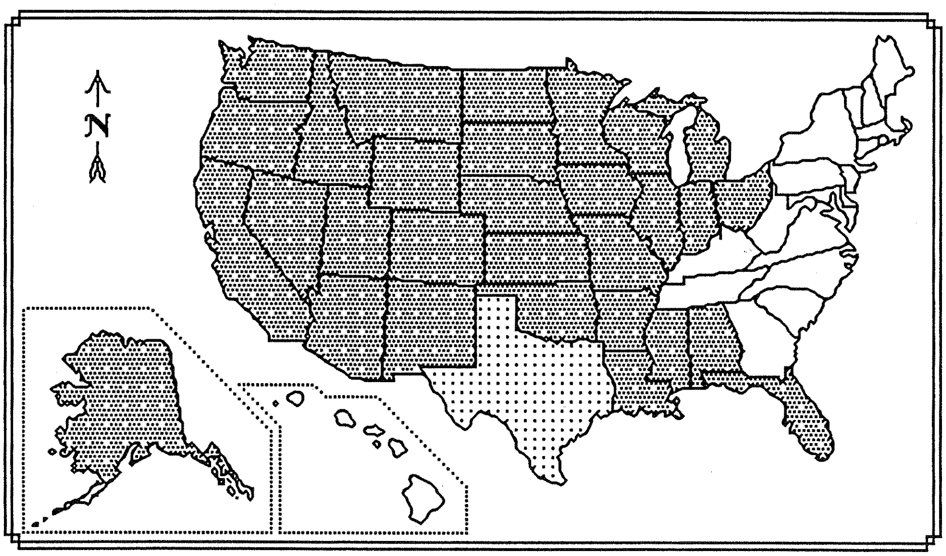
Location of the Basin

A parcel of ground such as a drainage basin can be identified by and described by standard terms used in land descriptions and surveying. This description is based on a series of horizontal and vertical lines that form a rectangle system. The ability to properly describe the location of a drainage basin, well or surface water intake is important when communicating with DNR and DEC. The process used to identify the location of a watershed is described below.

PUBLIC LAND SURVEYS AND DESCRIPTIONS

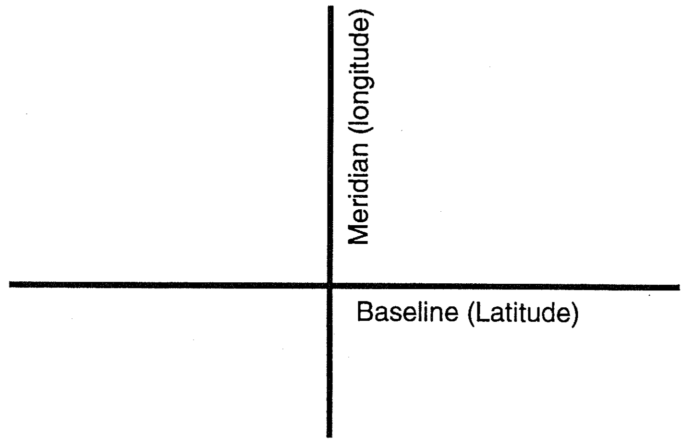
Brief History

In the Midwestern and far western states, the U. S. Bureau of Land Management devised a "rectangular system" for describing land. The states involved in the public land surveys are those indicated on the map below by the gray shading. In 1850, the federal government bought from Texas 75 million acres, which became public lands. The public-land states begin with Ohio. Its west boundary is the first vertical component of this system



The Basic Reference Lines

Each large portion of the public domain is a single "Great Survey," and it includes as much land as is reasonable. Each Great Survey is divided into horizontal and vertical lines. The horizontal lines are parallel to lines of latitude and the vertical lines are parallel to the lines of longitude. The initial point of each Great Survey is where these two basic reference lines cross. This point must be determined astronomically: a star-true point. The latitude line is called the "baseline and the longitude line is called the "principal meridian." There are 31 pairs or sets of these standard lines in the lower 48 states and three in Alaska.



The Township-Section System

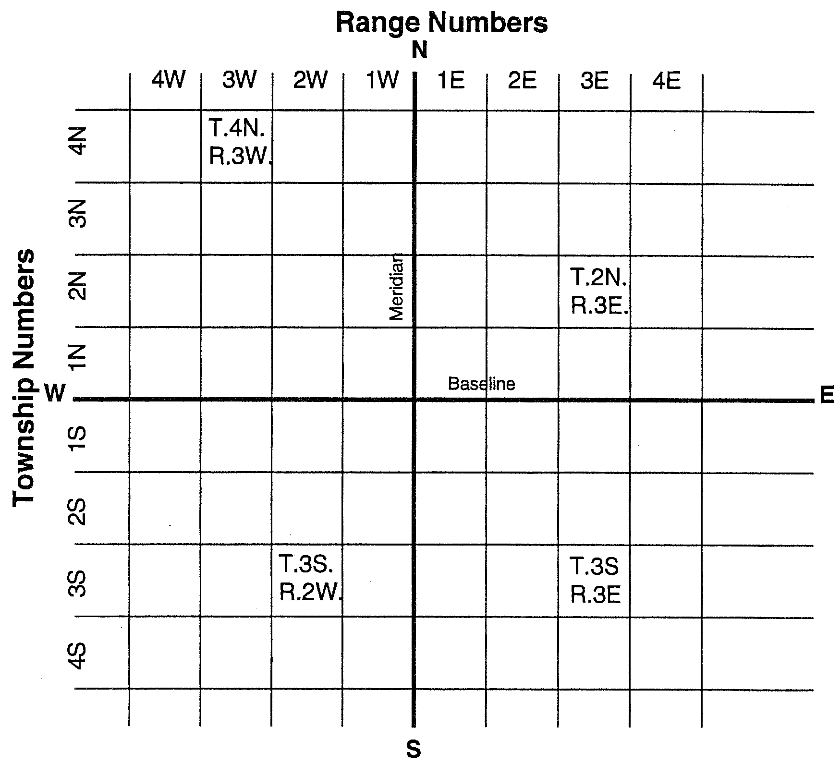
Using these baselines and meridians, the map arranges rows of blocks, called "Townships." These are each 6 miles square. They are numbered by rows, the rows or tiers run east and west. These tiers are counted north and south from the baseline. However, instead of saying "tier one, tier two, etc." we say "township." For instance, a township in the second tier north of the baseline will be named, "Township 2 North," or abbreviated as: T. 2N. similarly, for the second tier south of the baseline the township will be named, T. 2S.

Township and Range Numbers

Townships are also numbered according to which vertical (north-south) column they area in. These vertical columns of townships are called "Ranges." Ranges take their numbers east or west of the principal meridian. A township in the third range east of the principal meridian is: "R. 3E." said "Range Three East."

Numbering System

These directions north-south and east-west are combined to describe the location of the township in relation to the baseline and the principal meridian. For example, the township in the second tier north of the baseline and in the third range east of the principal meridian is: "Township Two North, Range Three East" abbreviate: T. 2N., R. 3E.



Township Identification and Location

The Division of Townships in Sections Each township is divided into 36 sections, each one-mile square containing 640 acres. Remember that the dimensions of a township are six miles by six miles giving us 36 sections in each township. Sections are numbered 1 to 36, beginning at the northeast corner of the township and going across from right to left, then left to right, then right to left and so on until all 36 sections are numbered.

6 miles Square

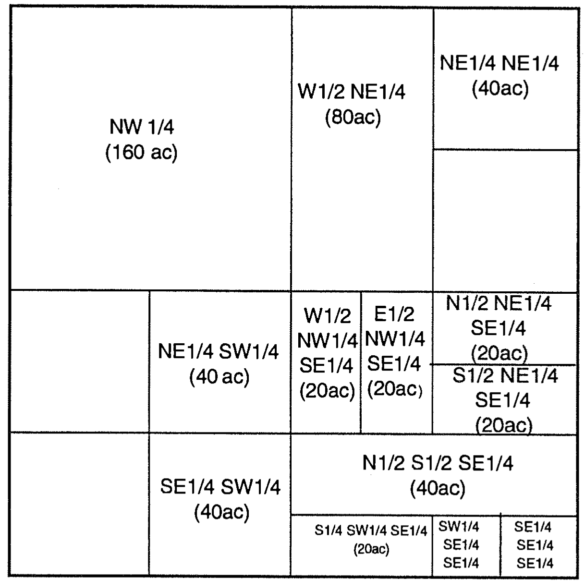
6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Division of Township into sections

The Subdivision of Sections Each section may be subdivided into "quarter sections." These are sometimes called "corners." For example, "Northwest Corner of section 16" or "NW 1/4 of Sec. 16". A quarter-section may be further divided into "quarter-quarters" for example, "NW1/4 SW1/4 of Sec. 36." Further subdivision of a section is accomplished in the same manner.

Written Descriptions

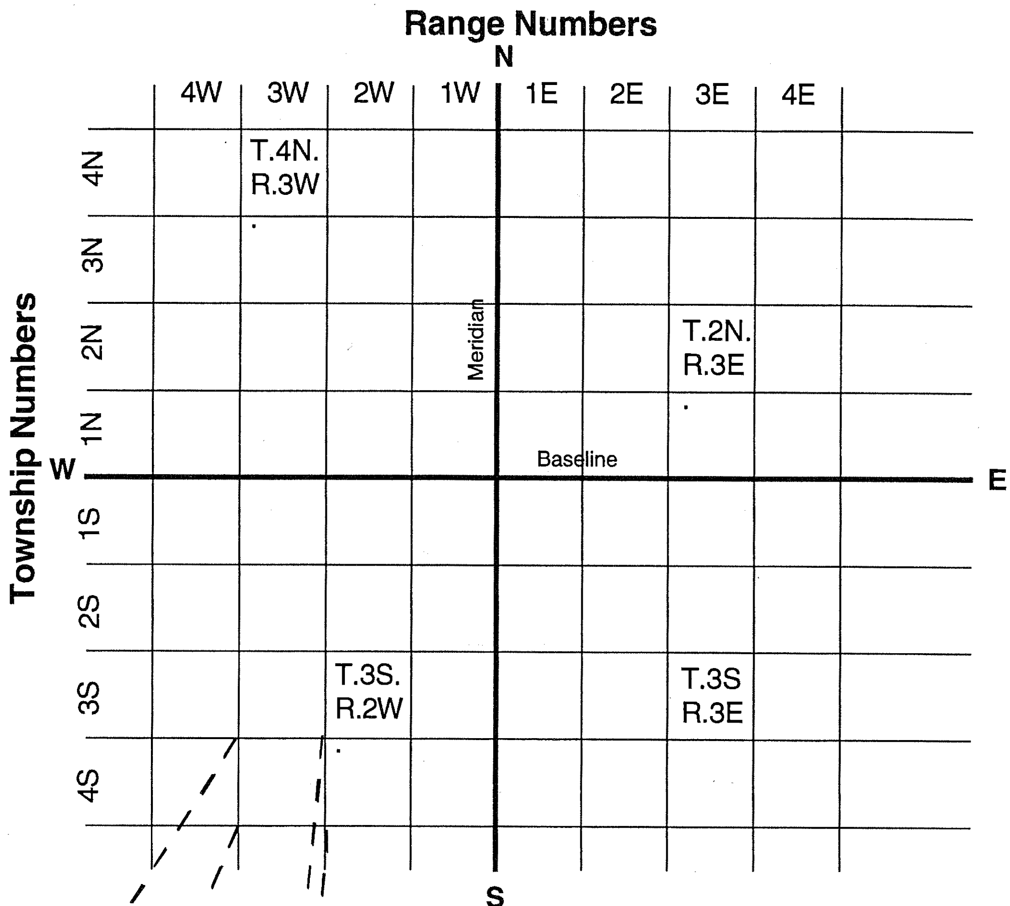
In a written description of a portion of land, the smallest portion of the description is written first, followed by the next largest portion and so on. For example "NW1/4 NW1/4 SW1/4..." This is read as the "Northwest quarter of the Northwest quarter of the Southwest quarter ... ."



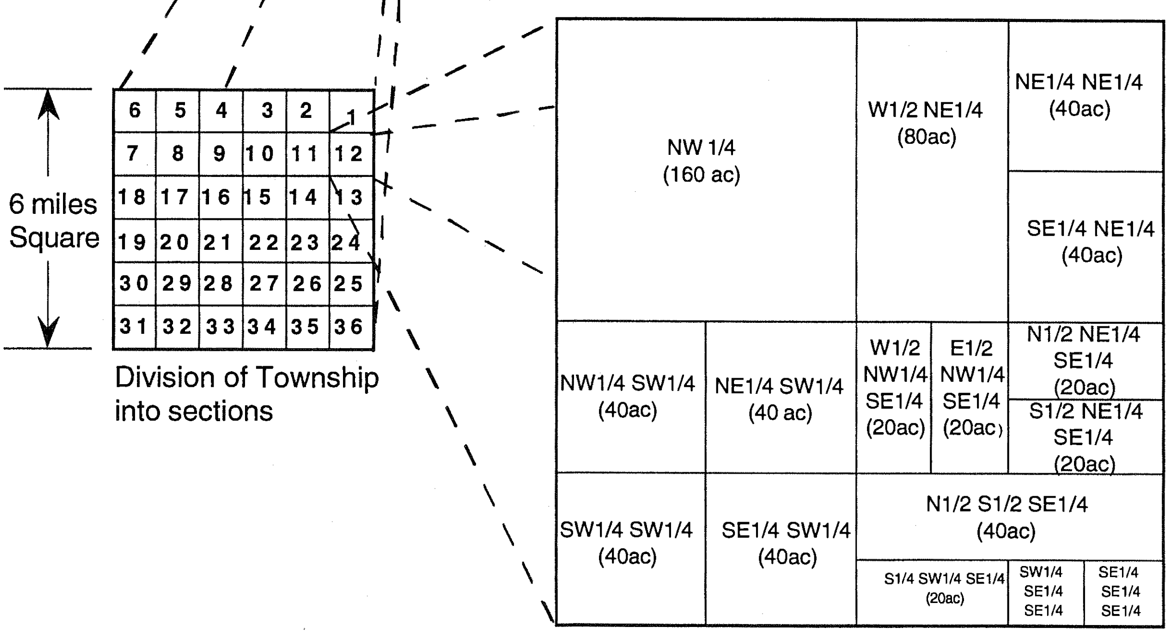
Possibilities for Divisions of a Section

The Complete Description

The description of a small subdivision of a section must include its relationship to the township and the reference lines of the great survey. An example of a description might be: "The SW1/4 of the SE1/4 of Section 33 in Township 16 South, Range 10 West of the Willamette Meridian, all being in Lane County, Oregon."



Township Identification and Location



Division of Township into sections

Possibilities for Divisions of a Section

DRAINAGE BASIN SHAPE

Components

Hydrologist have many different measurements and terms they use to describe the shape of a drainage basin. They do this so they can compare the performance of one basin to another. This is beneficial when making predictions of the impact of an activity like logging, road building or mining in a drainage basin. As an operator, you may not need to know the details associated with this process but having a basic understanding of the terminology can be helpful in discussing the drainage basin with agency personal. No attempt will be made here to discuss all of these various measurements. However, there are three typical and common measurements that are important and easy to determine they are.

Area

The area is commonly expressed in acres. One acre is equivalent to 43,560 ft^2.

Length

The length of a drainage basin is the length of a straight line from the mouth of the stream through the longest point of basin.

Width

Width is calculated by dividing basin area in square miles by length.

Slope

Slope is the angle between mouth and the point used to obtain length.

Stream Reach

Hydrologists define a piece of a stream as a **stream reach**[11]. There is no definable length to a stream reach. When talking about a stream reach, it is typical to state the length in feet or miles.

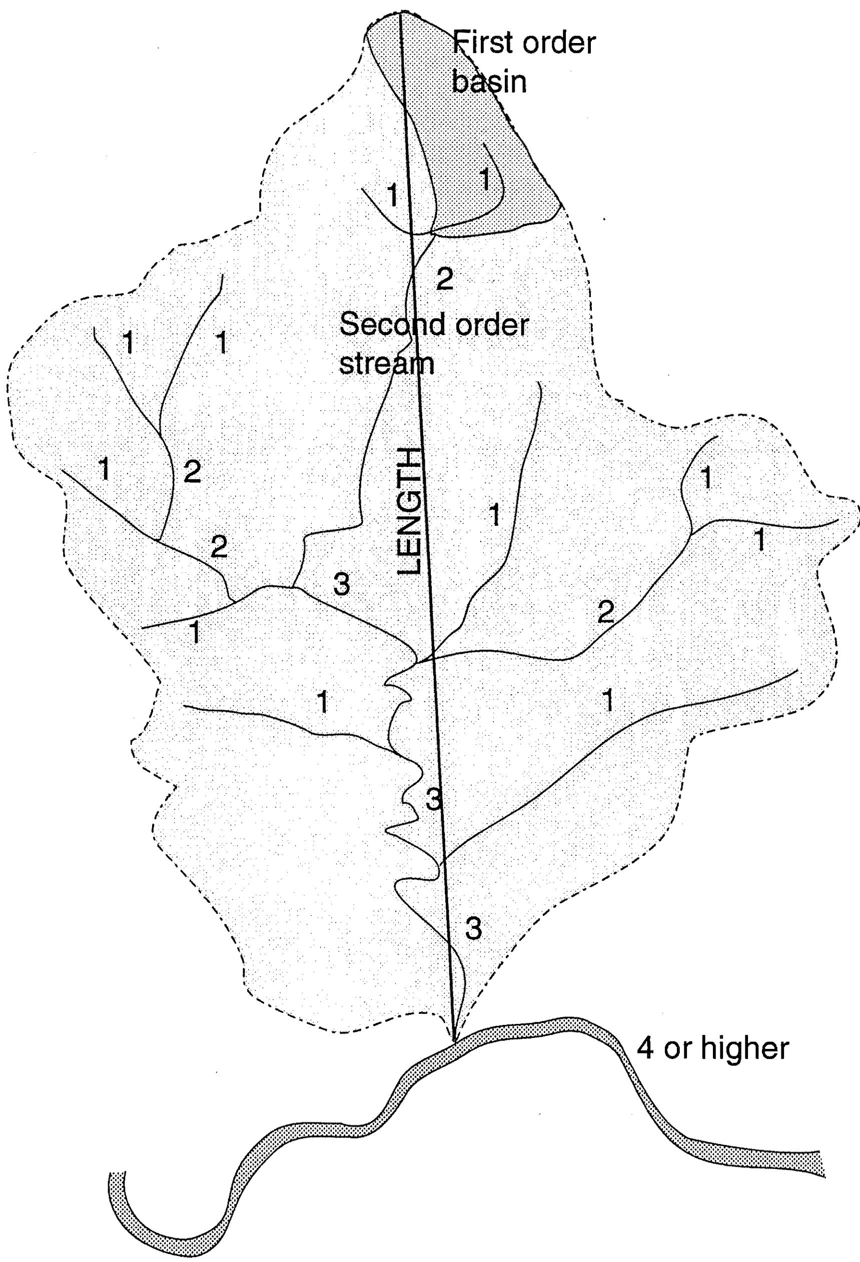
Stream Segments

A stream segment is a definable portion of a stream as indicated on a map. It is from its start until it combines with another segment.

Stream Order

Stream segments are numbered from the smallest to the largest within the watershed. This numbering system is called - Stream Order. The smallest stream is called a first order stream. When two first order streams come together you have a second order stream. A third order stream cannot exist until two second order streams come together. As you can see the order number given to a stream is relative to the detail of the map being used. The greater the detail the smaller the first order stream will be. Therefore, it is important when talking about stream order to reference the scale of the map.

[11] **Stream Reach** - A segment of a stream. There is no definite length to the segment.



TYPES OF STREAMS

Along with the physical data, it is important to mark on a map of the draining basin the types of streams present.

There are three types of streams they are:

Perennial - A stream that flows all year.

Intermittent - A stream that flows only during a season.

Ephemeral - A stream that only flows when there is a rain fall or snow melt.

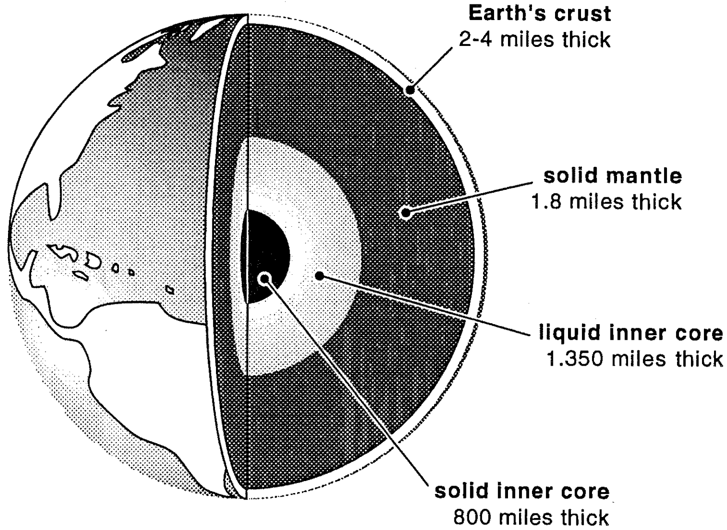
GEOLOGY & SOILS SEGMENT OF HYDROLOGY

Solid Portion of Earth

The center of the earth is filled with molten rock. The crust around this molten material is referred to as the earth's lithosphere. The contents and composition of the **lithosphere**[12] affects the quality, and to some extent the quantity, of water in a drainage basin.

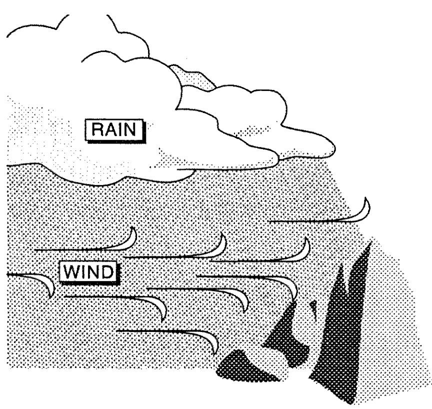
The Mantle

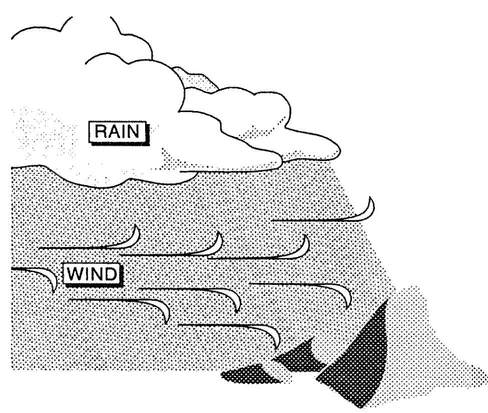
The outer portion of the crust is called the **earth's mantle**[13] and is five to 20 miles thick. It is composed of rocks and soil. Rocks are the basic parent material of that nature uses to make soil



Soil

Soil is composed **organic**[14] and **inorganic**[15] material. The organic material comes from decaying plant and animal life above and in the soil. The inorganic material comes from the weathering of the parent rocks. Weathering is caused by precipitation, abrasion from the wind and changes in temperature. One of the most common forms of weathering is water freezing in the cracks of a rock and breaking the rock.





[12] **Lithosphere** - The solid crust of the earth. It consists of the thin, loose layer known as soil and the mass of hard rock, several miles in thickness upon which soil lies.

[13] **Earth's Mantle** - The layer of loose rock material, subject to weathering, the surface part of which is called soil, which covers most of the earth's land area, and varies in thickness.

[14] **Organic** - Chemical substances of animal or vegetable origin, made basically of carbon structure.

[15] **Inorganic** - Chemical substances of mineral origin.

Soil Type

The chemical composition and hardness of the rock along with topography and weather determines the soil type and size of soil particles. While there are many different soil classification systems, one that is important to the water operator is the hydrologic soil types. These types give a reference to the rate water will infiltrate through the soil. The classification of soil types is commonly done by the US Soil Conservation Service.

Soil and Water Quality

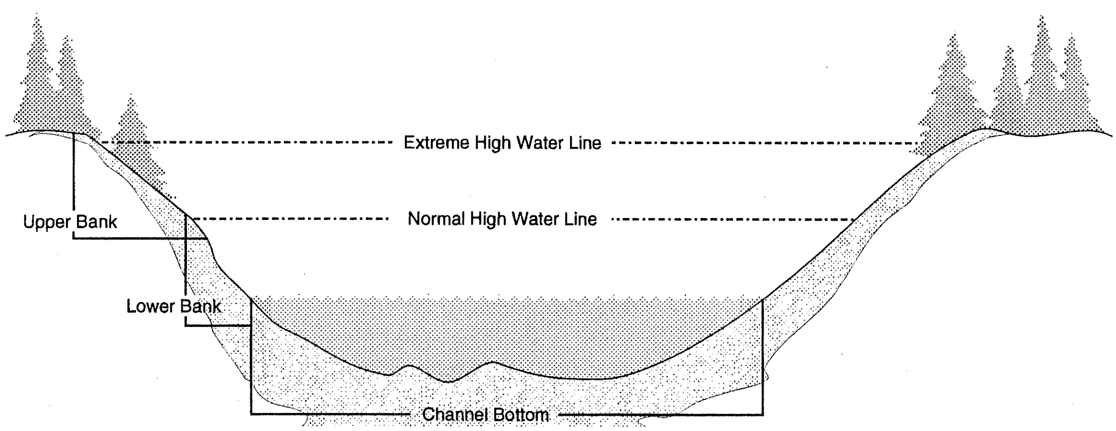
The size and nature of the particles of soil affect water quality and treatment. The smaller the particle, the higher the turbidity will be during runoff and thus treatment will be more difficult.

Water Quality

The chemical nature of the rock directly affects the chemical nature of the water. This is because the water will dissolve the rock and carry it with the water.

Stream Beds and Geology

The quantity and size of rocks and silt in a stream bed is referred to as the **bed load**[16]. A high bed load would be a stream bed that moves easily during a high flow and a low bed load would be a stream bed that moves very little, even at high flow.



IMPACTS ON THE DRAINAGE BASIN

Budgets in General

The drainage basin and the water quality are impacted by a number of factors such as the amount and type of vegetation, wildlife and water. These factors are called budgets. The following is a brief overview of the major budgets that impact water quantity and quality in a drainage basin.

Vegetation Budget

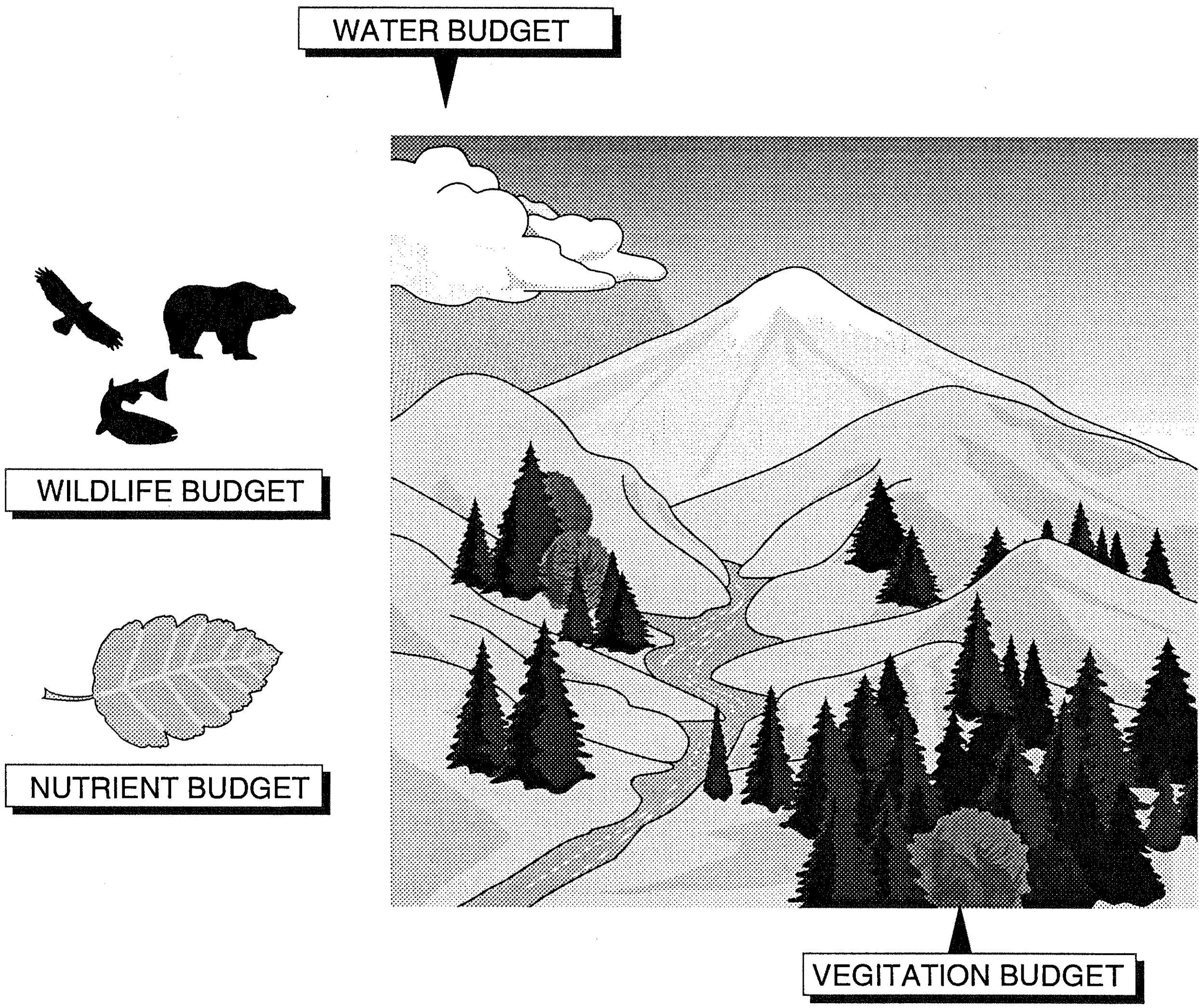
The vegetation budget includes all of the vegetation in the drainage basin. The growth, or removal of vegetation in the drainage basin can contribute to the impact that precipitation has on the amount of soil that is carried away during a rain storm or snow melt.

16 **Bed Load** - A measurement of the material on the bottom of the stream which can be moved by the force of the water but is not suspended by the water.

The vegetation can also impact other components of the drainage basin including stream temperature and the quantity of nutrients that enter the water. The nutrient level directly affects **algae**[17] growth and thus odor and taste considerations. Of special interest to the hydrologist is the vegetation next to the stream. This vegetation is called the **riparian**[18] vegetation and has direct impact on the stream temperature and on holding the stream banks stable during high water.

Nutrient Budget

The amount of nutrients in a drainage basin affects the growth of vegetation as well as impacting algae growth in streams and reservoirs. As mentioned above, algae growth in streams, rivers and reservoirs can impact the odor and taste of the water.



[17] **Algae** - Microscopic plants which contain chlorophyll and live in water.
[18] **Riparian** - An adjective pertaining to anything connected with or adjacent to the banks of a stream or other body of water.

Wildlife Budget

Most drainage basins are delicately balanced ecosystems. The wildlife in the basin can have positive and negative impacts to water quality supply. Wildlife can contribute to recreational activities while at the same time contribute to increases in pathogenic organisms such as Giardia.

Water Budget

Of all of the budgets, the water budget has the greatest impact and is the most important to the water works operator. The water budgets two main components are precipitation and stream flows. In well run water systems that utilize surface water, both of these components are measured and analyzed. Also, it is becoming common for systems utilizing groundwater to measure the precipitation in the recharge area.

BUDGET DATA COLLECTION

Baseline Data

Gathering physical information, observing the impact of the budgets, precipitation data, flow data and water quality data is called baseline data. This data is essential for long term planning and determining the impact of activities in a drainage basin. This process is part of a watershed management process.

Large Streams

The approach described below is based on the assumption that the watershed is small enough to be managed by the utility. If the utility is obtaining water directly from a large river such as the Yukon, it is not feasible to apply this process as describe. In this case, an attempt should be made to manage the water quality upstream one day. One day is the distance water will normally flow in a days time.

PHYSICAL INFORMATION

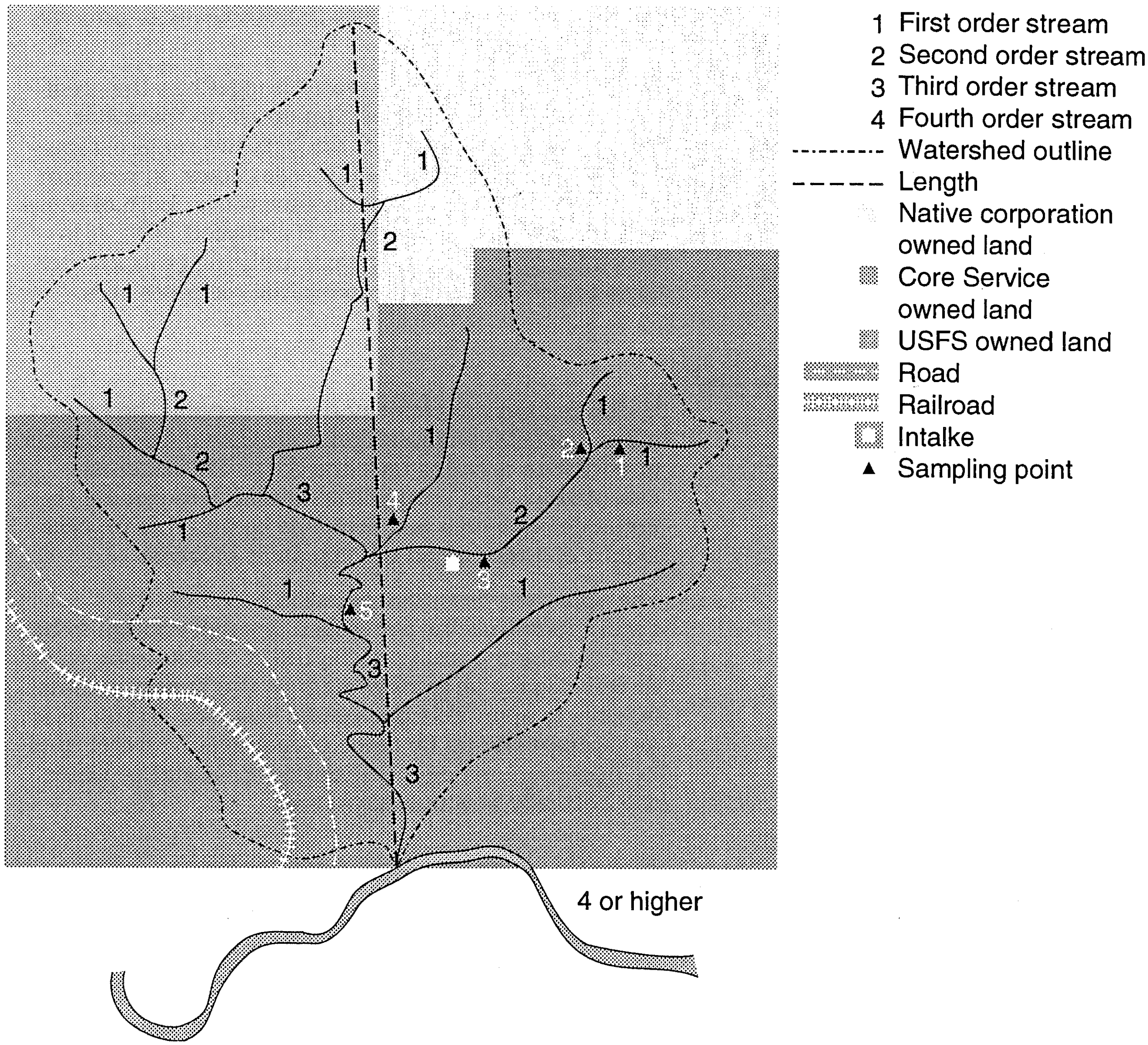
Using the Map

On a map of the watershed: (The clutter associated with this type of activity may be reduced by using plastic overlays for each major segment of data or by placing this information on a CADD system and using different layers for the different categories of data).

- Outline the watershed.
- Write a description of the watershed using the rectangular system.
- Calculate the area.
- Determine the length, width and slope.
- Order the stream segments.
- Identify the various owners of land within the watershed.
- Clearly mark all roads and railroads within the watershed.
- Mark the intake and write a physical description of

its location using the rectangular system.

- Mark all sampling points used to collect chemical and bacteriological **raw water**[19] samples.



- Identify all actual and potential sources of contamination. These sources should be placed into groups as either natural or man-made. Typical sources are:

  ❑ Natural

    ✓ Sources of high iron content, as observed by iron slime adjacent to or in the stream.

    ✓ Sources of color, such as decaying organic material, runoff from muskeg ponds, etc.

19 **Raw Water** - Water that has not been treated and is to be used, after treatment, for drinking water.

- ✓ Sources of turbidity, such as land slides, unstable ground, stream banks that have deteriorated, wildlife stream crossings, etc.
- ✓ Sources of natural radioactivity or other minerals that may deteriorate the quality of the water.

❑ Man-made

- ✓ Roads
- ✓ Mines
- ✓ Logging activities
- ✓ Fuel storage
- ✓ Solid waste disposal
- ✓ Sewage treatment plants
- ✓ Septic tanks
- ✓ Military sites, existing and abandoned

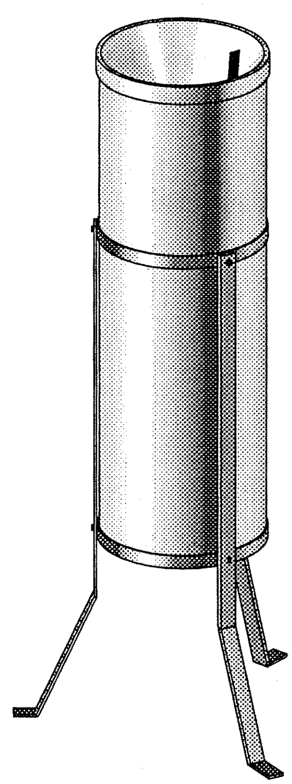
PRECIPITATION

Hydrological Event

The falling of precipitation, the melting of snow in the spring, and the seasonal low flow of a stream are all called a hydrological events. Determining the frequency and magnitude are part of the baseline data collected by well run water systems. The two most important data components required for a hydrological event are precipitation and steam flow.

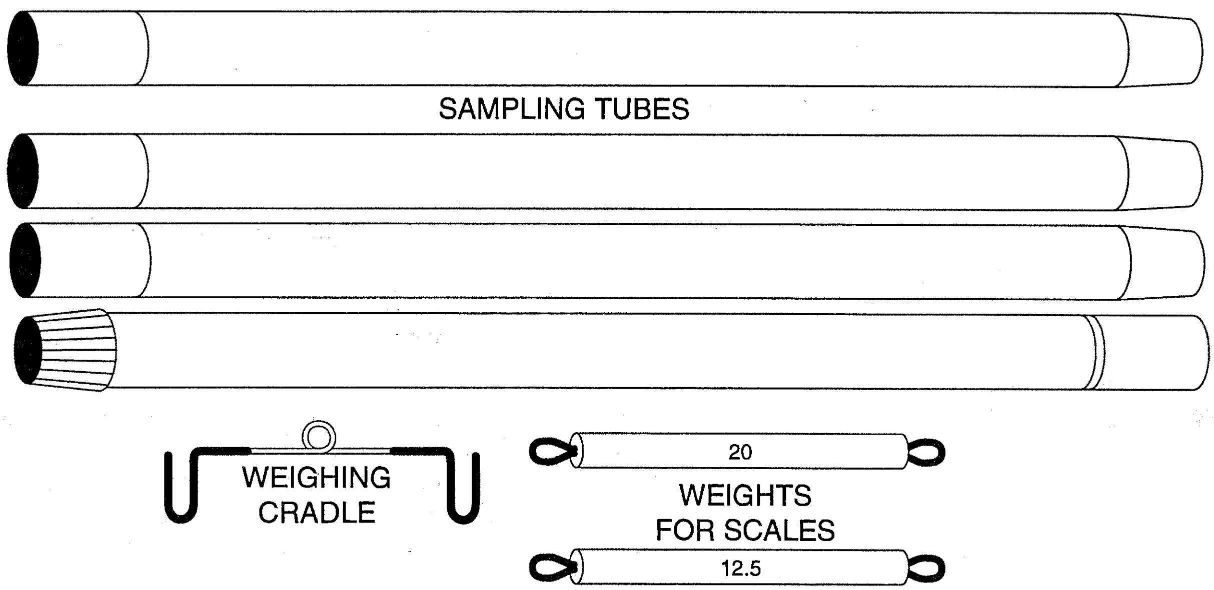
Precipitation Measurements

There are two types of precipitation that are measured; rain fall and snow depth. Rain fall is measured with a rain gage. Rain gauges can be simple volume devices that are read manually or the can be automatic devices that electronically measure volume or weight. Snow measurements like rain fall are obtained either manually or electronically. If the proper equipment is not available, a simple can type rain gauge can be used to determine rainfall.



Snow Data

Snow data can be collected by obtaining two pieces of data. First measure the depth of each event. Second measure the weight of snow after each event. This can be accomplished by simply gathering a sample of the snow using a piece of 2 inch PVC pipe. Weigh the pipe and note the weight. Push the pipe down through the snow until it touches the ground. Remove the pipe, remove any soil collected in the bottom of the pipe and weigh the pipe with the snow. The weight of the snow is the difference between the original weight and the weight with the snow in the pipe. Record the weight and the depth of the snow.



Use of Snow Data

While this data is not directly usable to the operator, it can be very useful to a hydrologist in attempting to determine the amount of moisture available in your area.

Math Practice

A watershed is composed of 120 acres. A rain storm of 0.5 inches was measured in the watershed. If 15% of this rainfall becomes runoff, how many gallons of water are produced?

120 acres X 43,560 ft^2/acre = 5,227,200 ft^2

0.5 inches of rain X 0.15 = 0.075 inches of water

0.075 inches/12 inches per foot = 0.00625 feet

5,227,200 ft^2 X 0.00625 ft = 32,670 ft^3 of water

32,670 ft^3 X 7.48 gal/ft^3 = 244,372 gallons

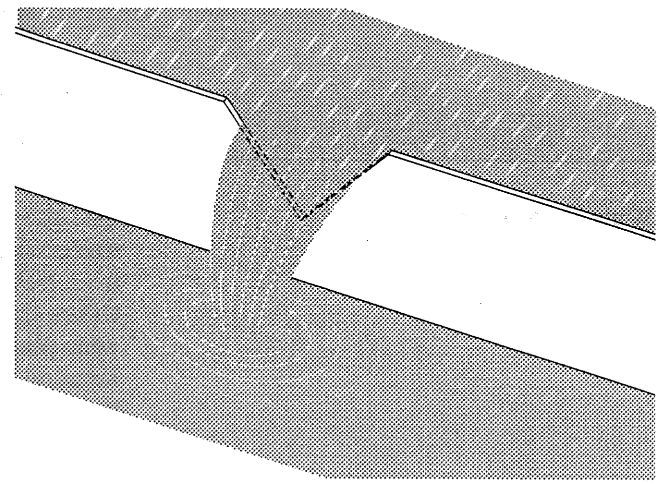
FLOW MEASUREMENTS

Introduction

The flow in a stream or river can be measured using primary devices such as **weirs**[20] and **flumes**[21] on small streams or secondary devices called current meters on larger streams.

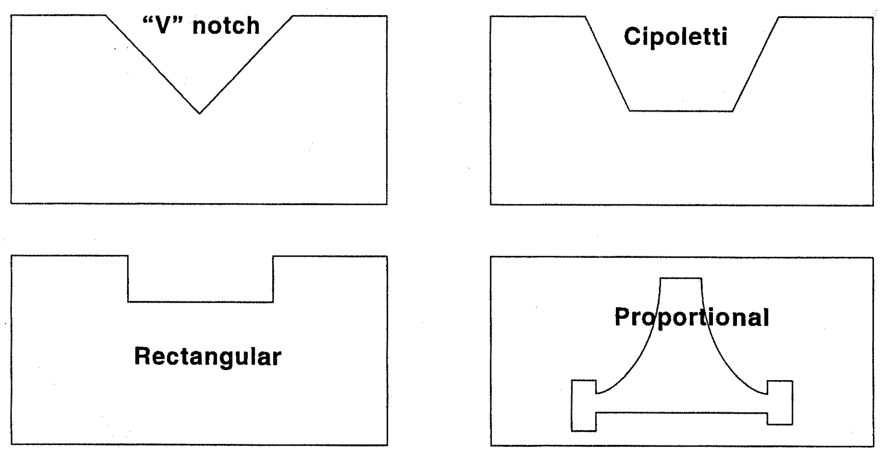
Weirs - Description

A weir is a plate made of wood or metal. The most popular weir plates used in small streams are made from three quarter inch plywood. These plates are placed in the stream plumb and level. Because the plates are typically only used during low flows, they are installed in a temporary manner, using rocks down stream of the plate to hold the plate and using visquine behind the plate as a seal on the stream bottom and the back of the plate.



Weir Types

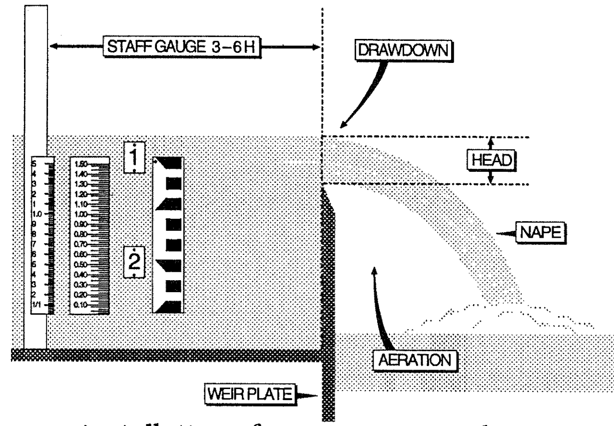
The weirs used in measuring stream flows are commonly called shape crested weirs. They are identified by their shape, typical shapes are; rectangular, "V" notch and cipoletti. The "V" notch and the cipoletti are the most common.



[20] **Weir** - A vertical obstruction, such as a wall, or plate, placed in an open channel and calibrated in order that a depth of flow over the weir (head) can easily be measured and converted into flow in cfs, gpm or MGD.
[21] **Flume** - A open conduit made of wood, masonry, or metal and constructed on grade, used to transport water or measure flow.

Weir Installation Components

The weir is called the weir plate. The top of the weir is the crest. The height of water above the weir is called the head and the difference between the head behind the weir and the head directly over the plate is called the drawdown. The water that flows over the weir plate is called the nape. The device used to determine the head on a weir is called the staff gauge.



Weir Function

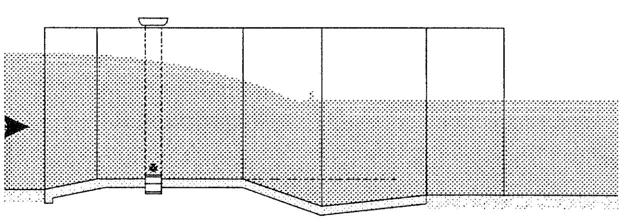
The proper installation of a weir requires that certain dimensions be maintained. For instance, the stilling area behind the weir must have a length at least six times the maximum height of water expected over the weir plate. The water flowing over the plate must be aerated. The flow through a weir plate is determined by measuring the head three to six times the height, back of the weir plate and either using this data in a formula or a table to determine the flow.

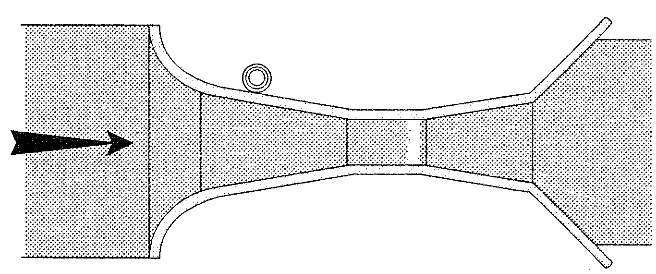
Flumes

Flumes are not as common as weirs. They are useful on very small streams, and in locations where the restriction caused by the weir would represent a problem to the habitat of the stream. Flumes must be installed perfectly level and plumb.

Flume types

There are two common types of flumes used to measure stream flow; rectangular and **Parshall**[22]. The Parshall flume is the most common and is also used in water and wastewater treatment plants to measure flow.





[22] **Parshall Flume** - A device used to measure flow in an open channel. The flume narrows to a throat of fixed dimension and then expands again. The flow is determined by measuring the difference between the head before the throat and at the throat.

Math Practice

A flume is 12 inches deep and 15 inches wide. The water level in the flume is 8 inches. The velocity is estimated at 0.75 ft per second. What is the flow in cfs and gpm?

Q = VA

A = H X W - The flume is 15 inches wide with 8 inches of water. First convert these dimensions to feet

15"/12" per foot = 1.25 ft

8"/12" per foot = 0.667 ft

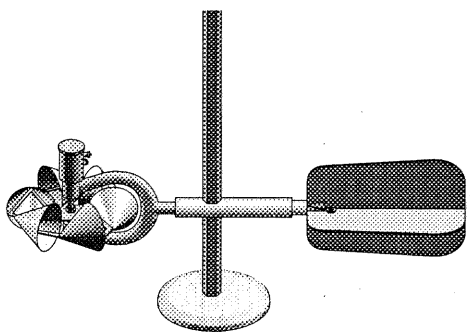
Multiply H X W = 0.667 ft X 1.25 ft = 0.8 ft^2

Q = 0.75 ft/sec X 0.8 ft^2 = 0.6 cfs

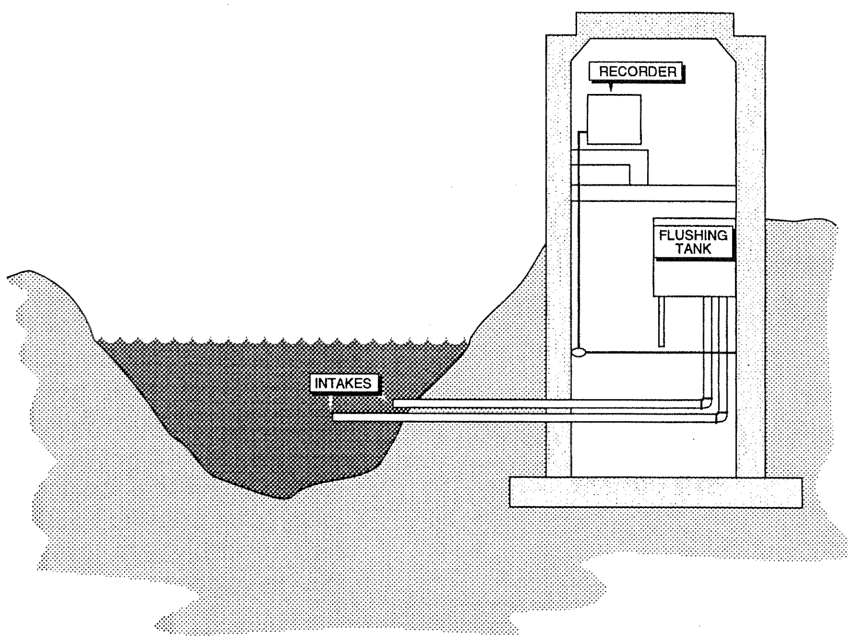
Since 1 cfs = 449 gpm

0.6 cfs X 449 gpm/cfs = 269 gpm

Discharge Measurements



Discharge measurements[23] determine the **velocity**[24] of the stream. By measuring the depth and width of the stream and using the classic flow equation Q = VA, where, Q is the flow is cubic feet per second (cfs), V is velocity in feet per second and A is the area in square feet (A = depth or stage X width) the flow can be determined. Once sufficient measurement relative to the stream depth have been made, the process can be automated by using a gauging station that automatically records stream height. The stream height is converted to flow by use of a formula derived specifically for the stream.



23 **Discharge measurement** - A process of measuring stream flow. The stream is divided into segments, at least 20, the average velocity for each segment is measured using a current meter and the flow through the stream calculated using the formula Q=VA.

24 **Velocity** - The speed at which water moves, expressed in feet per second.

WATER QUALITY

Introduction

Water quality measurements and observations can be divided into three categories; chemical, bacteriological and **Benthics**[25]. Each category has its unique function in determining water quality.

CHEMICAL QUALITY

Comparisons

One of the major concerns associated with gathering raw water quality data, is how to evaluate the data. The most common method of evaluating the data is to compare the data against; the utilities needs and water quality criteria.

Constituents

The items found in water that are not H_2O are called constituents. Iron, manganese, **pH**[26], alkalinity, and microorganisms are all called constituents. They are not referred to as contaminants or pollutants because some level of many of these constituents is important to aquatic life.

Water Quality Criteria

Water quality criteria specify concentrations of water constituents which, if not exceeded, are expected to result in an aquatic ecosystem suitable for high uses of water. This includes the use of the water by humans. Criteria are derived from scientific facts obtained from experiments or observations. Criteria are not regulations. One popular publication listing water quality criteria is produced by EPA and is titled Quality Criteria for Water. This publication lists 53 constituents that are commonly found in water. For each constituent a numeric value is provided plus some written rational that defends the numeric value.

SDWA

One of the other items used to compare raw water quality data against, is the Safe Drinking Water Act listing of primary and secondary contaminants. When the raw water levels for these contaminates exceed the MCL established by the SDWA, the utility is assured that some form of treatment will be required.

Dissolved Oxygen

One of the most important measurements of water quality is the level of **dissolved oxygen**[27] (DO) carried by a stream. Under natural conditions, the level of DO is inversely proportional to the temperature of the water. As the water temperature goes down, the DO will go up. Dissolved oxygen is a direct indicator of organic pollution, the higher the level of pollution the lower the level of oxygen. This is because microorganisms consume the pollution as food and at the same time multiply and consume oxygen, thus the reduction in oxygen.

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[25] **Benthics** - Bottom dwelling macro-animals, including nymphs, larvae, sails, worms and clams.

[26] **pH** - An expression of the intensity of the alkaline or acidic strength of a water. Mathematically, pH is the logarithm (base 10) of the reciprocal of the hydrogen ion concentration. pH may range from 0 to 14, where 0 is the most acid, 14 most alkaline, and 7 neutral. Natural waters usually have a pH between 6.5 and 8.5.

[27] **Dissolved Oxygen** - The oxygen dissolved in water or other liquid, generally expressed in mg/L or percent of saturation. Usually designated as D.O.

Constituents and Criteria

Some of the common constituents that should be measured in the raw water and accepted criteria are:

Constituent	Criteria
Iron (Fe)	0.3 mg/L
Manganese (Mn)	0.05 mg/L
Hardness	Below 250 mg/L as $CaCO_3$
pH	6.5 to 8.5
Turbidity	Based on treatment capabilities
Temperature	Because of importance to water treatment it should be record routinely
Alkalinity	20 mg/L - for treatment 80 mg/L
Organics	Compare to SDWA
Inorganics	Compare to SDWA

BACTERIOLOGICAL QUALITY

Coliform

Raw water should be tested routinely for the presence of coliform bacteria. Coliform are our primary indicators used to determine the presence or absence of pollution. By knowing the coliform level the operator can estimate changes in chlorine demand and adjust feed rates appropriately. When the coliform level is high or the intake is downstream from a sewage treatment plant, fecal coliform sampling on a quarterly basis is also desirable. This data can be used to explain changes in chlorine demand.

Coliform Criteria

At the present time, there is no agreed upon criteria for coliform bacteria when the water supply is to be used for drinking water. However, there is criteria for swimming and raising shellfish. The criteria for fecal coliform for swimming waters is 200 per 100 mL sample and for shellfish it is 14 per 100 mL sample.

BENTHIC ORGANISMS

Description

Benthic organisms are macroanimals that live all or part of their life on the bottom of a stream either on the under side of rocks or in the silt. These would include may fly larva, snails, sludgeworms and fresh water clams. The presence or absence of certain organisms can be used as an indicator of water quality.

Presence in Alaska

Benthic organisms are very rare in Alaska, except in the streams of Southeast Alaska.

Use as Pollution Indicators

These organisms are good indicators of pollution because some groups are much more sensitive to pollution than others. In general, the larval stages of stoneflies, mayflies, and caddis flies are the most sensitive to organic pollution. Less sensitive are scuds, black fly larva, sowbugs, some snails and clams. The most tolerant are sludgeworms, bloodworms and maggots.

The Process

The process is quite simple, a screen attached to two handles is held to the stream bottom by one individual. A second individual, upstream simply uses their feet to scruff up the stream bottom, or rocks can be pick up and scrubbed with a brush. The benthic organisms are collected on the screen. They are removed from the screen and placed in a pan for counting and observation.

Interpretation

The presence of significant numbers of sensitive benthic organisms of typical size is a good indication of the lack of pollution. This process should be repeated quarterly and the results compared year to year. If the annual results change and there is no significant change in stream temperature further investigation is needed to determine the cause of the change.

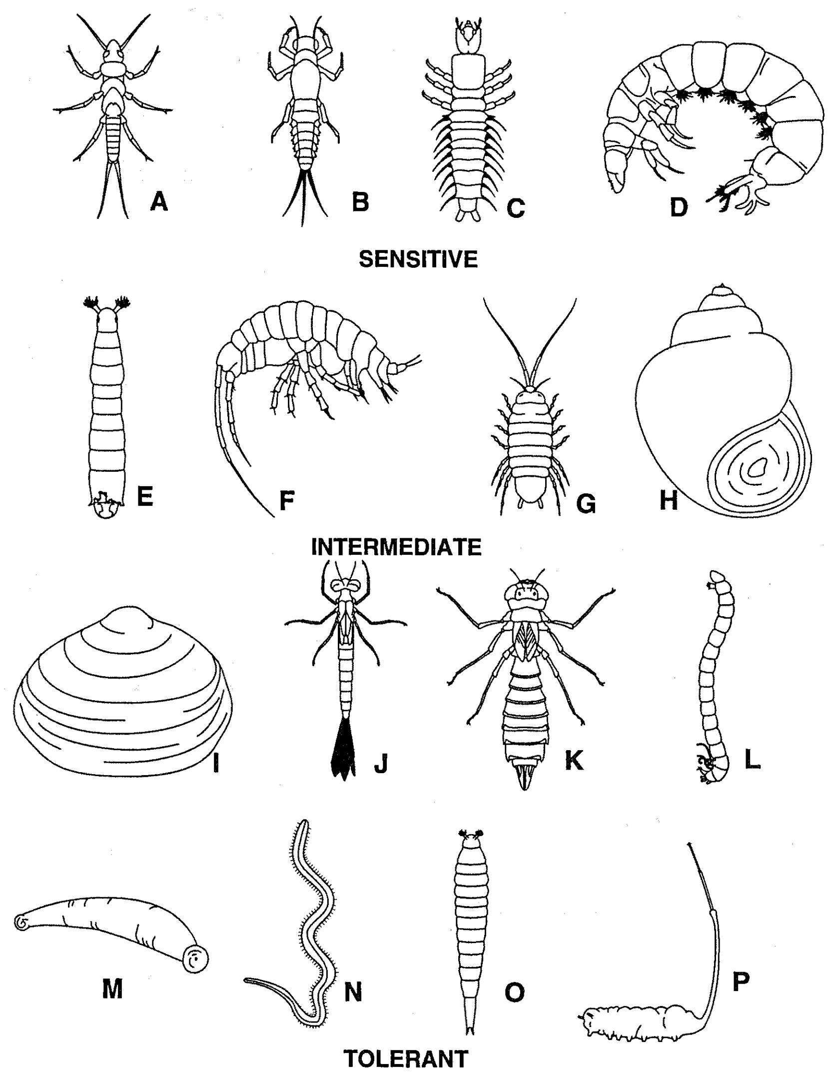
Representative Bottom Dewelling Macroanimals

Sensitive
A Stonefly nymph
B Mayfly naiad
C Hellgammite or Dobsonfly larvae
D Caddis fly larvae

Intermediate
E Black fly larvae
F Scud
G Aquatic sowbug
H Snail
I Fingernail clam
J Damselfly nymph
K Dragonfly nymph
L Bloodworm or midge fly larvae

Tolerant
M Leech
N Sludgeworm
O Sewage fly larvae
P Rate tailed maggot

Drawings from Beckler, J., K.M. Mackenthun and W.M. Ingram, 1963. Glossary of Commonly Used Biological and Related Terms in Water and Waste Watger Control, DHEW, PHS, Cincinnati, Ohio, Pub. No.



NORMAL OPERATIONS

Introduction

Normal operations of a surface water sources is composed of collecting and analyzing data and comparing the data to previous years. The process requires daily, weekly and annual tasks.

Daily Task

The following tests should be performed on the raw water of surface water sources on a daily basis;

- pH
- Temperature
- Turbidity
- Alkalinity

Ambient Conditions

Along with the raw water data the **ambient**[28] conditions, temperature, sky condition and wind should be measured or observed and recorded daily. As ambient conditions change, water conditions will be affected.

Weekly Task

Once a week the precipitation should be measured and recorded. During low flow periods the stream flow should also be measured and recorded weekly.

ANNUAL TASK

Water Quality Survey

Once a year, a water quality survey should be performed as part of an overall sanitary survey. A water quality survey is an in depth look at the conditions and activities associated with the watershed that could impact water quality. This should not be confused with a sanitary survey. A sanitary survey is an overall review of the operations, maintenance and management of a water system in an attempt to identify existing or potential sanitary risks that could adversely impact the quality of the water. The water quality is much more in depth than a sanitary survey and is focused specifically at the watershed.

Components of WQS

A water quality survey is composed of four steps:

- Data collection - This includes all of the water quality, physical and activity data associated with the watershed including a review of the water use policy and watershed use agreement.
- Observations - This requires a physical on-site visit to the watershed. It requires an observation of as much of the watershed and stream bed as is reasonable. The observations include looking for natural or man-made activities that can impact water quality.
- Evaluation - The evaluation portion of the WQS is an attempt to compare an analysis of the data and the physical observations in order to draw conclusions about the stability of the watershed to produce high quality water and the quantity required.

[28] **Ambient** - The surrounding atmosphere.

- Documentation - The final phase of the WQS is the preparation of a report that summarizes the data, findings and the evaluation. Most reports also include recommendations of actions that may improve water quality as well as identification of items or areas that should be looked at closely in the future.

Inorganic Samples

Once each year, a sample should be collected and tested for inorganic constituents. The results should be compared against the SDWA contaminant listing. Any levels above the existing MCL's will require treatment. If it is believed that the level of any of these constituents will vary from quarter to quarter, then this testing should be completed once each quarter.

Organic Samples

Once each year, a sample should be collected and tested for organic constituents. The results should be compared against the SDWA contaminant listing. Any levels above the existing MCL's will require treatment. If it is believed that the level of any of these constituents will vary from quarter to quarter, then this testing should be completed once each quarter.

Agreements

Once each year, the water use agreement and watershed management policy should be reviewed and updated as necessary.

Water Rights

Once each year, it is advisable to review the **water rights**[29] requirements and compare to actual use. Most water rights require the holder of the water right to use a specific amount of water for a specific use.

Records

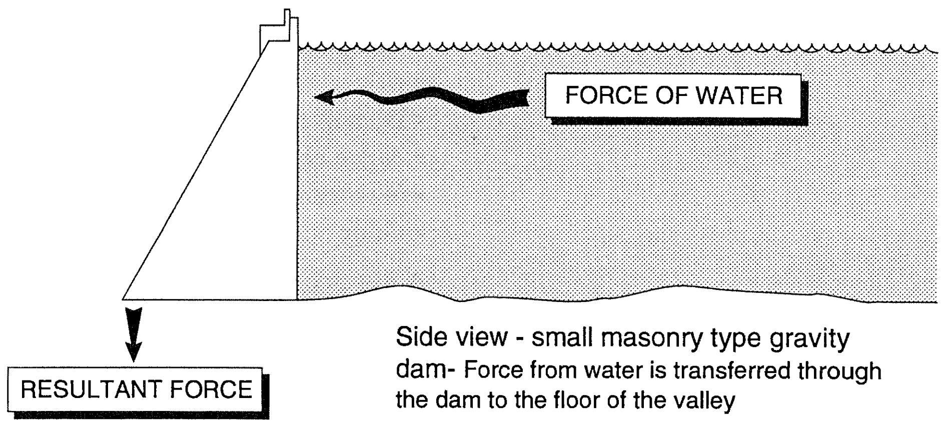
All records associated with water quality, any sanitary survey completed on the water system as well as water quality survey reports must be stored in a method that is easily retrieved and must be maintained for ten (10) years.

[29] **Water Rights** - The rights, acquired under the law, to use the water accruing in surface or groundwater, for a specified purpose an in a given manner and usually within the limits of a given time period.

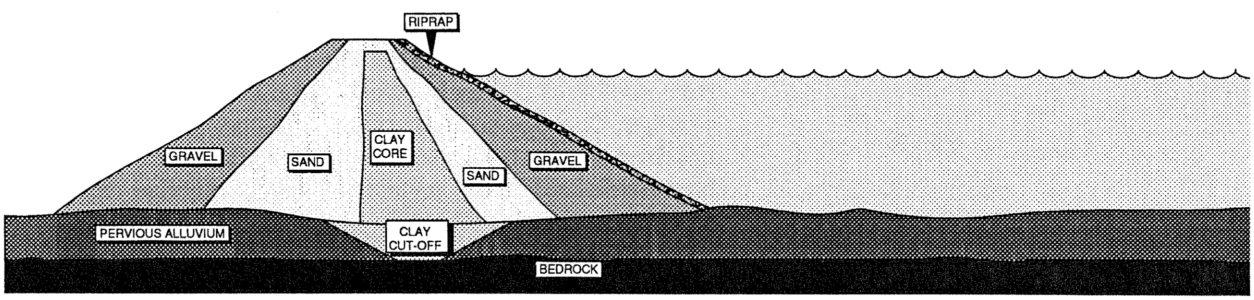
STORAGE FACILITIES

Description

Storage facilities used by small communities are commonly natural lakes, and man-made impoundments constructed with small (less than 30 feet high) masonry or embankment dams. Although small these storage facilities can be a major contributor to improvements and/or deteriorations in water quality, therefore should be managed in a manner that maintains or improves water quality.



Side view - small masonry type gravity dam- Force from water is transferred through the dam to the floor of the valley



Small rock and sand filled embankment dam

Quantity

The quantity of water in a reservoir is typically estimated in acre feet. An acre foot is the amount of water required to cover one acre, one foot deep. An acre is 43,560 ft^2, therefore an acre foot of water is 43,560 ft^3.

43,560 ft^3 X 7.48 gal/ft^3 = 325,829 gallons in 1 acre-foot.

Common Problems

There are several instances where well meaning individuals have planted unwanted fish in a storage reservoir. In many cases these fish have contributed to a drastic change in water quality. In one case, catfish planted in the reservoir have contributed to higher than usual turbidities and increases in manganese. They do this by slowly moving their tails back and forth on the bottom of the reservoir and bringing sediments into solution.

MAINTAINING WATER QUALITY

Sampling & Testing

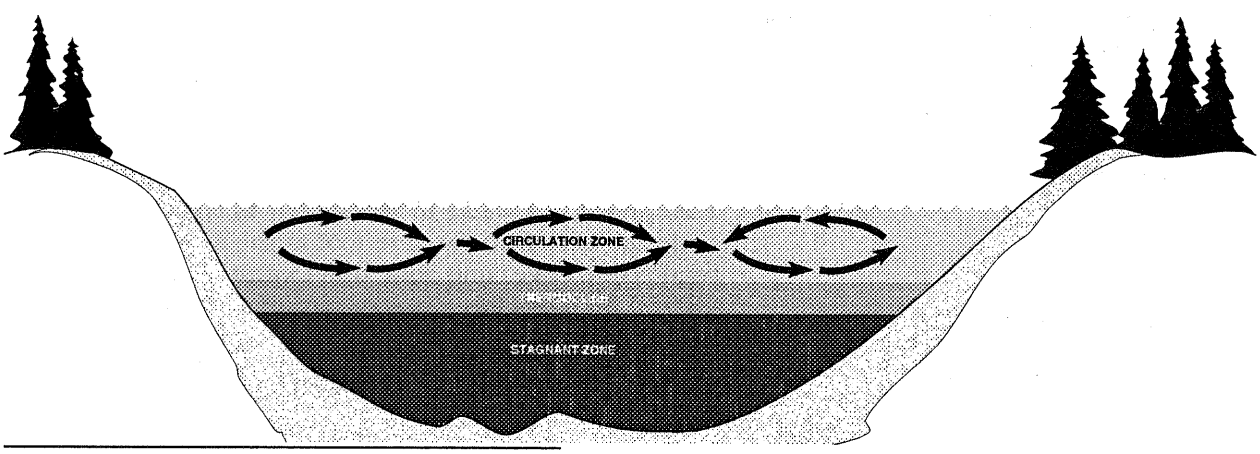
In order to determine the quality of the water in the reservoir or lake, the water quality should be sampled and tested at the surface and at each 10 feet of depth. The sampling and testing should be completed for at least the following constituents:

- Temperature
- pH
- Dissolved oxygen
- Algae count
- Nutrients - nitrogen and phosphorous
- Odor

A history of changes in this data can be very useful in predicting changes in water quality as well as determining changes that may be necessary in the treatment process.

Stratification

Some storage facilities have bodies of water that are deep enough to stratify. Stratification occurs when the water temperature of a layer of water on the bottom of the reservoir becomes significantly different than a layer of water on the top of the reservoir. A temperature profile of the water would show this sharp change. The upper layer of water is referred to as the **epilimnion**[31] the bottom layer is called the **hypolimnion**[32], the layer that separates the two is called the **thermocline**[33].



[31] **Epilimnion** - The upper layer of a stratified body of water. Commonly this layer is high mixed by the wind and is the warmest of the layers.

[32] **Hypolimnion** - The lowest layer in a thermally stratified body of water. In most cases this layer contains the colder and denser water. Normally no mixing occurs in this layer and the D.O. may be at or near zero.

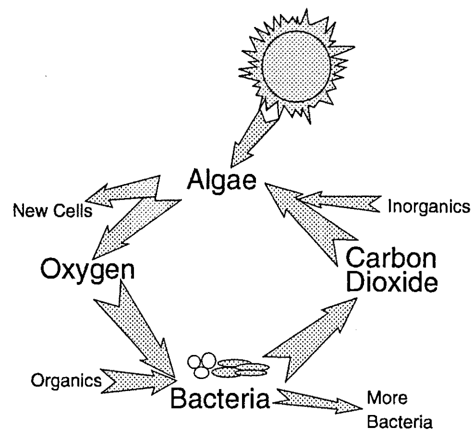
[33] **Thermocline** - The middle layer in a thermally stratified body of water. The temperature will decrease rapidly from top to bottom through this layer.

Epilimnion

The epilimnion, the upper layer, is usually mixed by the wind that blows across the surface and contains relatively warm water. This layer often contains high quality dissolved oxygen. However, when there are sufficient nutrients in the water, algae will increase in quantity (called a bloom) and cause a deterioration of water quality.

Algae - Life Cycle

Under normal conditions, algae and bacteria that live in the water have a symbiotic relationship. The algae produce oxygen and consume carbon dioxide, the bacteria consume oxygen and produce carbon dioxide. At night the algae use oxygen in order to stay alive. In a normal life cycle they consume about one-half of the oxygen they produce. When there is an excess quantity of nitrogen and phosphorous in the water, the quantity of algae can increase significantly.



The Result

High concentrations of algae cause odor and taste problems and can lower dissolved oxygen in the water to the level to promote the growth of anaerobic organisms that produce odor and taste by-products.

Hypolimnion

The hypolimnion, the lower layer, is commonly composed of lower temperature water. If the stratification remains long enough or the sufficient algae growth in the epilimnion to cut off the sunlight, the dissolved oxygen drops to near zero. When this happens the aerobic bacteria die off, contributing to odor and taste problems, and the anaerobic bacteria thrive. Anaerobic bacteria produce methane and hydrogen sulfide and thus provide odor and taste problems. The low DO conditions also contribute to conditions that lower the pH of the water sufficiently to allow insoluble iron and manganese to be oxidized and brought into solution.

Ice

In lakes and reservoirs that are covered with ice several months of each year, there may not be a stratification but simply a overall reduction in water quality as a result of the lack of sunlight and a deterioration of the dissolved oxygen in the lake.

CONTROL OF ODOR AND TASTE

From Anaerobic Conditions

Odor and taste problems associated from anaerobic conditions can be solved by portable aeration devices placed on the surface of the water. Long draft tubes extending nearly to the bottom of the water have proven to be very effective in treating small reservoirs and lakes. Lakes and reservoirs in Alaska are covered with ice for several months of each year, making mechanical aeration impractical. The addition of potassium permanganate at the treatment plant coupled with activated carbon can be an effective treatment. Prechlorination will typically cause and increase customer complaints.

From Algae

The complaints associated with odor, taste and algae are not normally the direct result of the algae but of the result of killing the algae with chlorination. The chlorine combines with some of the oils released by the algae to form very offensive odors and taste.

Other Algae Problems

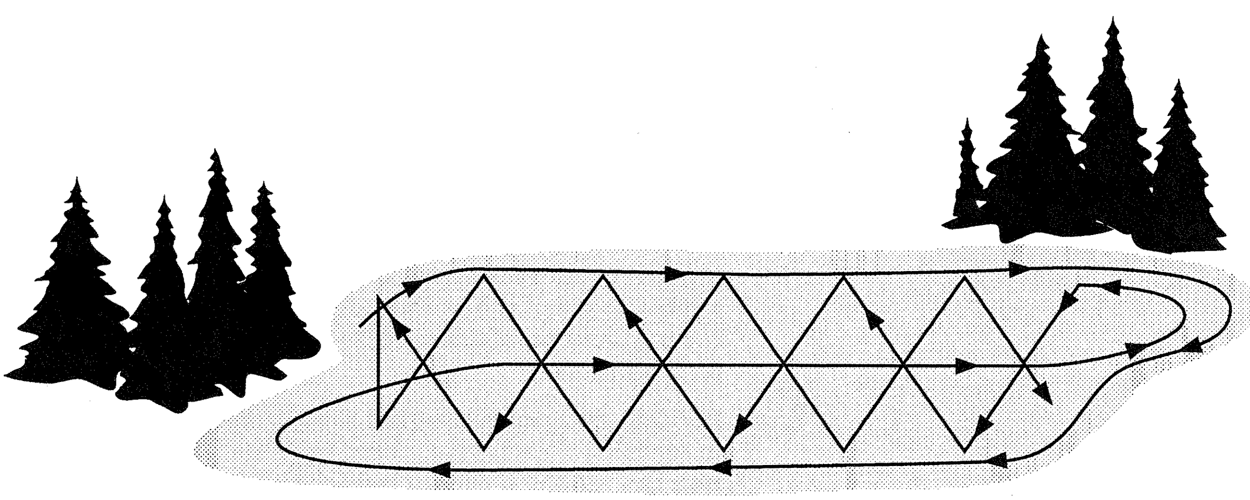
Besides causing odor and taste problems, algae can also plug filter media causing very short filter runs and high headloss.

Treatment

In Alaska, algae problems are very rare. The long winters and short summers do not contribute to conditions that allow algae to grow in great numbers.

Algae Treatment

There are two common treatment strategies, prevention and treatment. The prevention process requires the use of some form of algaecide on the reservoir or lake just before a predicted algae bloom. The most common algaecide is copper sulfate (also called blue stone). Copper sulfate is applied as a liquid spray or as a powder. Copper sulfate is applied from a boat in some type of specific pattern that allows the majority of the lake surface to be treated.



Problems with Copper Sulfate

As algae is killed, the nutrients are released into the water and can contribute to a second bloom that is worse than the first. Copper sulfate is a hazardous material. The disposal of the container used to ship and store copper sulfate is considered a hazardous waste. Therefore, there are special problems associated with handling and disposing of these containers. The secondary bloom and the difficulty of handling and disposing of a hazardous material has caused many utilities to abandoned this process in favor of one of the treatment techniques.

Weed Control

Some utilities have had good success in reduction of algae concentrations by removing the aquatic weeds from around the edge of the lake or reservoir and thus reducing quiet water areas that can contribute to high algae bloom.

Treatment Techniques

The most common treatment techniques require killing the algae with potassium permanganate, or chlorine dioxide and oxidizing the oils released from their cells. A second method is to kill and oxidize the organisms and their by-products, then strip the offensive materials from the water by aeration. A third process is to use activated carbon in place of aeration to remove the offensive organic material that is produced as a result of destroying the algae with chlorine.

Math Practice

A reservoir is 2800 feet in length and approximately 350 feet wide. The average depth of water is estimated at 15 feet. How many acre feet and how many gallons does the reservoir contain?

Find the surface area in square feet.

$2800 \text{ ft} \times 350 \text{ ft} = 980{,}000 \text{ ft}^2$

What is the surface area in acres?

$$\text{Acres} = \frac{980{,}000 \text{ ft}^2}{43{,}560 \text{ ft}^2/\text{acre}} = 22.5 \text{ acres}$$

The average depth is 15 feet

22.5 acres X 15 feet = 337.5 acre feet

Find the volume in gallons

$2800 \text{ ft} \times 350 \text{ ft} \times 15 \text{ ft} = 14{,}700{,}000 \text{ ft}^3$

$14{,}700{,}000 \text{ ft}^3 \times 7.48 \text{ gal/ft}^3 = 109{,}956{,}000 \text{ gal}$

ROUTINE OPERATION

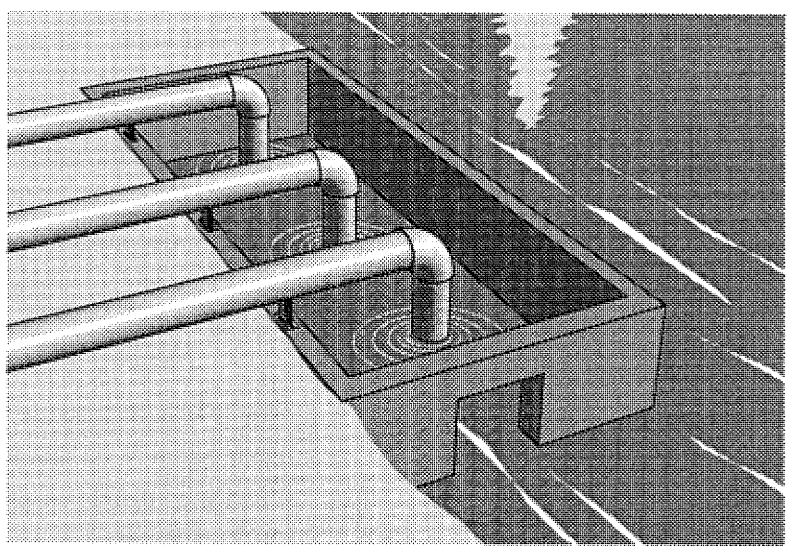
Besides the process described above for testing for water quality in the reservoir, the water and dam should be inspected on a routine basis. In many cases this inspection is done daily. The frequency depends on the potential for vandalism and damage. The inspection should include:

- Appearance of the water for clarity
- Vandalism
- Water level behind the dam
- Quantity of water going over the spillway
- Damage to the structure
- Quantity of vegetation growth on the edges of the water
- Potential ice damage at breakup

INTAKES

Types

The type of intake structure depends on the nature of the source. Different intake structures are used with steams than are used with reservoirs and lakes, however, they all have similar components.

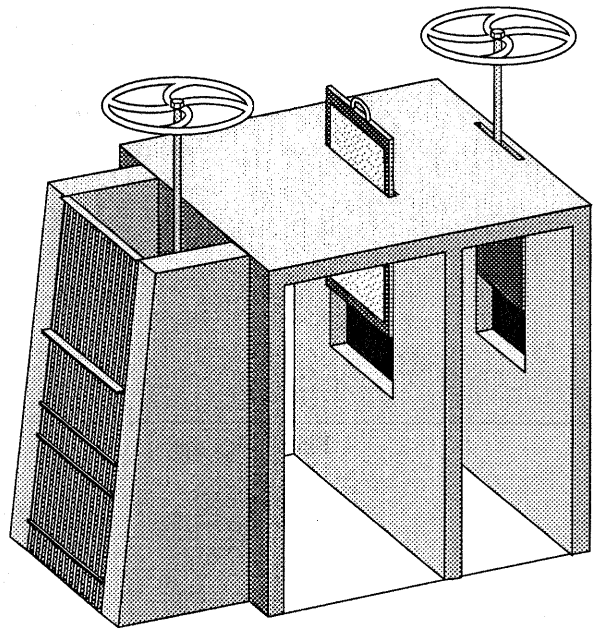


Collection Box

Most intakes have some type of intake box. This box is commonly a concrete box placed next to or into the stream, lake or reservoir. At the entrance to the box is a bar screen, used to keep large material from entering the collection box. Bar screens can be made from steel or concrete.

Valves

Behind the bar screen is commonly some type of valve that allows flow to the screen box to be shut off. Typical valves used for this are shear gates and sluice gates. A shear gate is a type of gate valve that is hinged on one side and opened and closed by lifting the other side using a long rod. Sluice gates are usually opened and closed by rotating a hand wheel. A threaded shaft is attached to the top of the gate and passes through the hand wheel.



Dewatering

Sluice gates are often installed on the upstream side of small dams and allow the operator to dewater the dam and so accumulated silt and rock can be removed.

Screens

Commonly, behind the shear or sluice gate is one or more screens. Most of the time these screens are made of stainless steel. In order to allow the screen to be removed along with the accumulated debris a trough is placed on the bottom of the screen. A typical routine process is to close the gate, remove the screen, dispose of the debris, replace the screen and open the gate. This prevents the debris from falling off of the screen and entering the collection box.

Automatic Screens

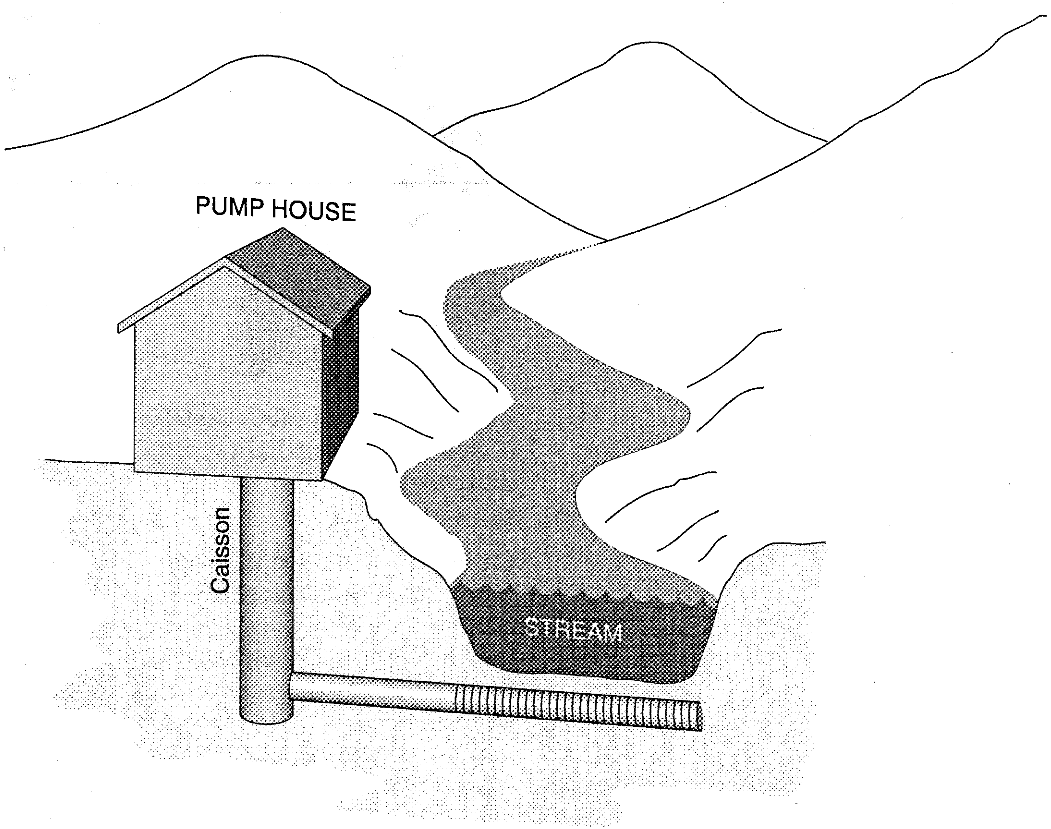
Some systems are fortunate enough to have self cleaning screens. These may be electrically operated continuous screens that use a high pressure nozzle for cleaning or screens that are rotated by the stream and cleaned by a water nozzle. If the flow is sufficient, large material may be prevented from being lodged on the screen by placing the screen at the appropriate angel in the stream. This allows the water in the stream to remove the debris.

Dewatering the Box

Properly designed collection boxes have provision for dewatering so that they may be cleaned. This is commonly accomplished with a portable pump which pumps the effluent back to the stream. Entry into a collection box is to be considered as entry into a confined space and the appropriate permit process and safety equipment must be utilized.

Infiltration Gallery

One of the common methods of removing water from a small stream is the use of an **infiltration gallery**[34]. With this device the collection box is called the caisson and the inlet is through slotted or perforated pipe placed below the steam bed and covered with graded gravel. In many instances in Alaska, a Johnson screen is used for the collection pipe. It is desirable that the inlets into the caisson be controlled by valves and there be some means of dewatering the caisson so that it may be cleaned.



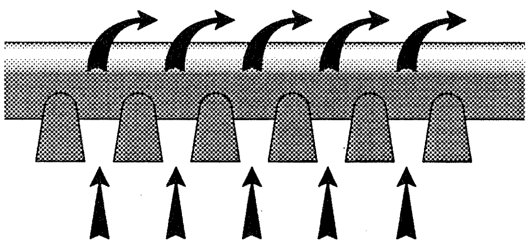
Johnson Screens

Johnson screens are a special screen designed and sold by the Johnson Division, UOP Inc. in Saint Paul, Minnesota. These screens can be made from various metals, stainless steel is the most popular in Alaska. The Johnson screen uses a V shaped wire that is wrapped around a series of vertical supports. The V shaped wire forms a V-slot that allows any grain of sand barely smaller than the width of the opening to pass freely through the screen without plugging.

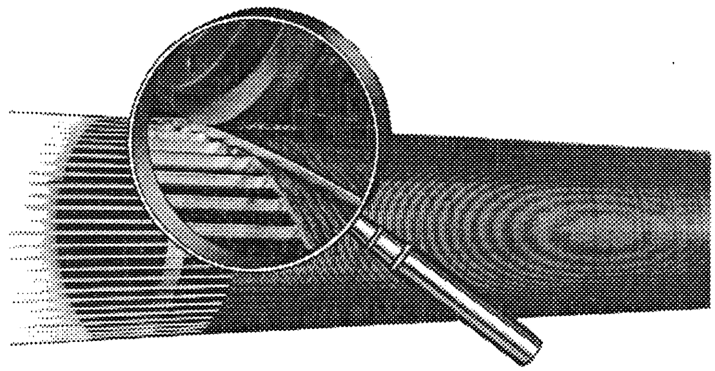
[34] **Infiltration Gallery** - A device used to obtain water from a water bearing strata. The device is typically composed of one or more perforated or screened pipes which lead to a central collection device called a caisson. Infiltration galleries can be used in the bed of a stream or as a means of collecting water from a spring.

Use of Johnson Screens

Johnson screens are can be placed directly into the stream, lake or reservoir. Often they are installed on a swing joint that allows the operator to raise and lower the screen to select the highest quality water and also to remove accumulated debris.



Cross-section of screen



Courtesy of UOP, Inc.

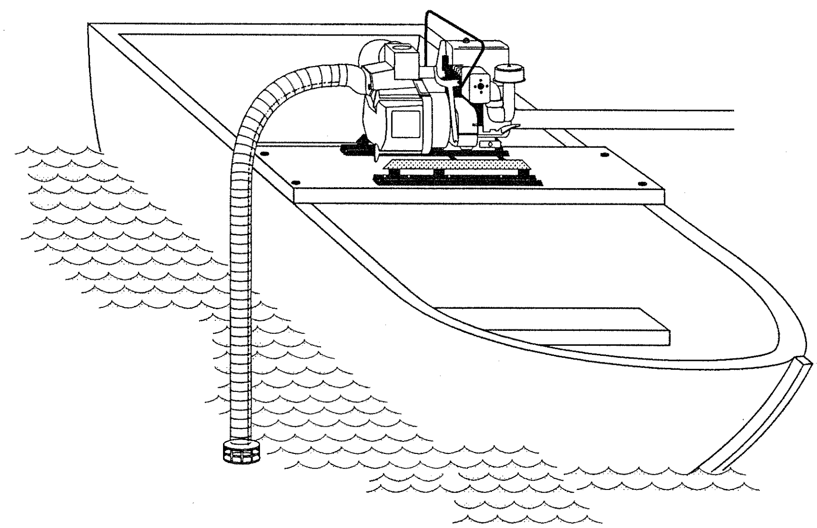
PUMPING SYSTEMS

Pump Types

There are three types of pumping installations used by small systems, end-suction centrifugal, submersible turbines and lineshaft turbines.

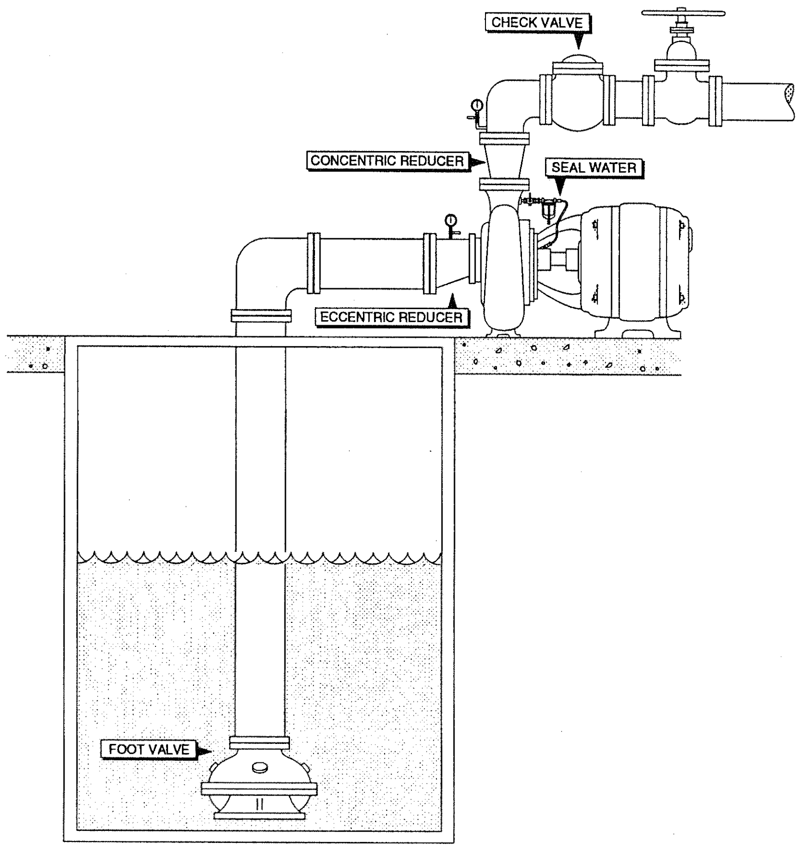
End-suction Centrifugal

The end-suction centrifugal may be a permanent installation or portable. In the Arctic it is very common to use a portable end-suction centrifugal pump to obtain water from a lake or river. The pump is placed on the ice during the winter and in a boat that is anchored to the bank during the summer.



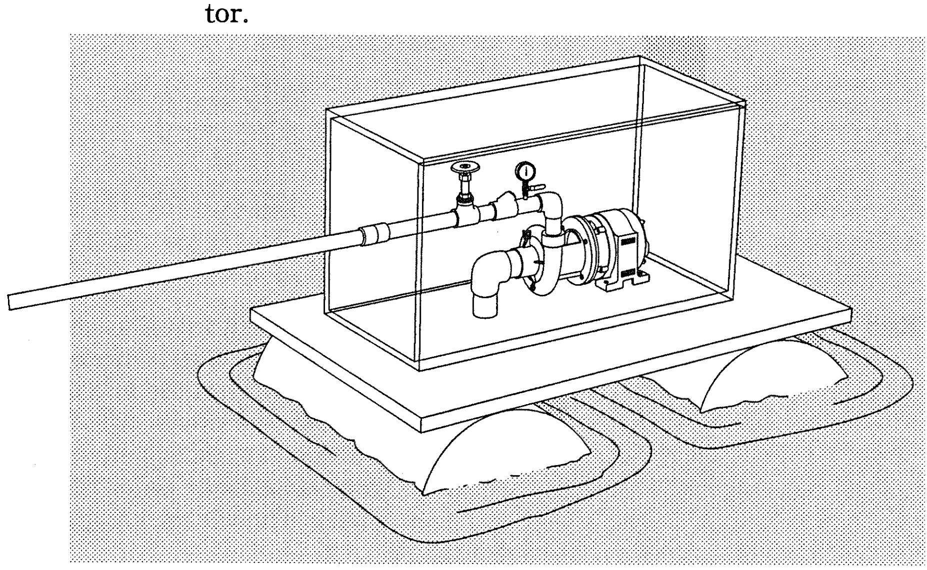
End-suction - Permanent

A permanent installation is used with a screened collection box. Water enters the pump through some type of foot valve on the end of the suction line and flows through the pump. The discharge piping contains a check valve, swing, silent, or wide body globe valve used to prevent water from running back through the pump. The wide body globe valve is used to reduce water hammer when the pump is shutdown. The discharge line should contain a flow meter, pressure gauge and gate valve. The flow meter may be installed at the plant instead of at the pump.



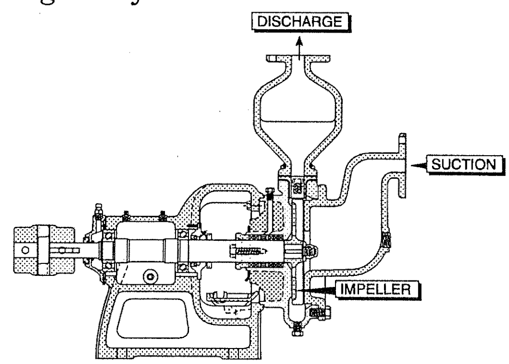
Floating Installation

One of the major differences between permanent and floating installations is the discharge connection. The most common discharge connection is made using Kamlock™ connectors. Using this quick connection, the pump is connected to a land line using floating pipe that is connected using the same time of connector.



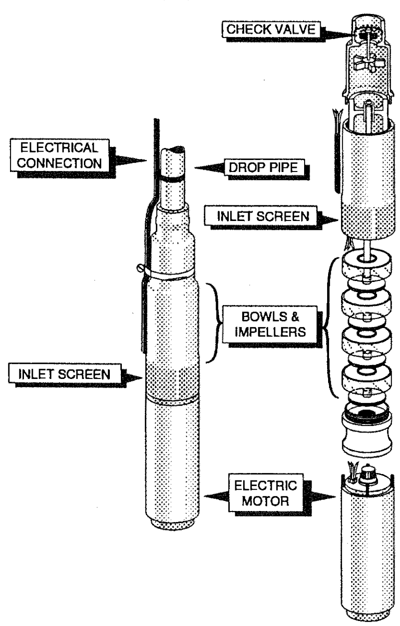
Self-Priming

One classification of pump used as raw water pumps for small systems is the self-priming pump. This is a name given to a specific style and does not describe the function of the pump. The pump must be primed initially before it can pump. The keys to identifying a self-priming pump are the lack of a foot valve and the suction pipe connection. Notice in the drawing below that the suction connection is above the eye of the impeller. Once this cavity around the impeller is filled with water, the suction line can be allowed to go dry. The flap gate at the entrance of the suction connection prevents the impeller from throwing water out of the case. If the case is air tight, no leakage at the mechanical seal or the priming hole, and the case is full of water, most of these pumps will lift water 12 to 15 feet in through a dry line.



Submersible Turbine

Many small systems, especially in the Arctic, use submersible turbines placed through the ice in the winter and through a float in the summer as raw water pumps. This style of pump has a screen on the inlet that must be maintained in order to prevent damage to the pump impellers. Water exits the pump through the drop or riser pipe and rises to the surface where it



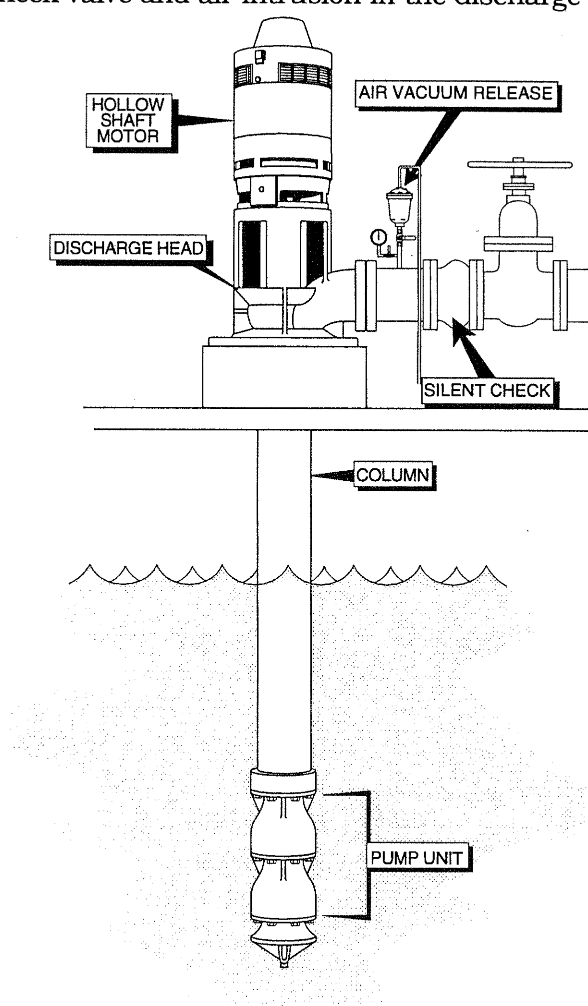
is commonly connected to a flexible pipe or hose. At the top of the piping should be a flow meter, check valve, gate valve, and pressure gauge.

Lineshaft Turbine

Lineshaft turbines are normally used as intake pumps on larger communities, but can be found in small systems. Seldovia uses two lineshaft turbines as raw water pumps on their stand-by water source. Most lineshaft turbines used in raw water supply pump water directly from the collection box. Water enters the pump through the suction bell, travels up through the column and exits at the discharge head. The discharge piping contains a check valve, or surge control valve, air release valve, pressure gauge, flow meter and an isolation gate valve.

Air - Release - Lineshaft

When a lineshaft turbine is shutdown, water flows from the check valve down through the column into the collection box. The air valve allows air to enter the line preventing a vacuum that could cause contaminants to be pulled in around the packing. When the pump is restarted, this same valve is used to allow air to exit the line and prevent water hammer through the check valve and air intrusion in the discharge line.



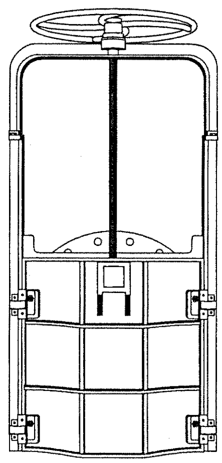
ROUTINE OPERATIONS - INTAKES

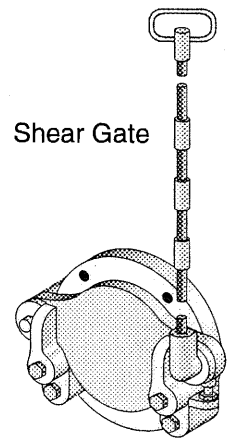
Screens

Screens at the intake need to be cleaned as frequently as is necessary to prevent them from becoming plugged. Where there is a large accumulation of leafs in the fall, this may be one or more times a day. With self cleaning screens, they should be lubricated based on the manufacturer's recommendation. Self-cleaning screens should be inspected at least once a week.

Shear Gates & Sluice Gates

Shear gates and sluice gates should be lubricated at least once each quarter with a water resistant grease. Lithium based #2 grease is a common water resistant grease.





Infiltration Gallery

The flow from the lines into the caisson should be monitored monthly. The level of the flow can be used to determine if the stream bed is clogging. Clogged stream beds can be cleaned by digging up the gravel over the pipes, washing the gravel and replacing it back on top of the perforated pipe.

Pumps & Motors

Pumps and their related piping should be inspected daily for leakage. Discharge pressure and flow should be observed and recorded on each visit, providing that the pump is running. The pump and motor noise and vibration should be noted as well as temperature. The two keys to finding bad bearings are vibration and temperature. With electric motors the amperage and voltage should be recorded once each quarter. With gas motors the engine oil, and air filters should changed based on the manufacturer's recommended frequency but at least once each quarter in which they operate.

Safety Considerations

When making electrical measurements be sure to either use a licensed electrician, exterior panel voltage and amperage meters or follow the prescribed precautions for making electrical measurements. These precautions include:

- The removal of all jewelry, watches and metal rimmed glasses.

- Wearing shirts with tight fitting sleeves.
- Fastening the panel door open.
- Wearing safety goggles.
- Wearing electrical safety gloves.
- Having a second person standing by when making the measurements.
- Keeping one hand in your pocket.

Remember 120 volts from arm to arm can generate a current flow between 400 and 500 ma. A 200 ma current is sufficient to kill.

Confined Space

Valve pits, caissons, and collection boxes are confined spaces. These specific confined spaces may have low oxygen levels. OSHA requires that the oxygen level in any work environment be at least 19%. Entry into a confined space requires following the existing permit system, using safety equipment, having two people present, testing the atmosphere and having proper rescue equipment available.

SPRINGS

Spring intakes are composed of several common components. A typical spring collection system is composed of one or more perforated pipes, either laid into a water bearing strata or driven horizontally into the side of a hill.

Surface Protection

To protect the source from surface contamination, a clay cap should be placed over the perforated pipe. A diversion ditch should be placed above the water bearing strata and designed in such a way as to channel any surface runoff away from the intake. To prevent contamination by livestock and wild animals, an appropriate fence should be placed above the intake structure.

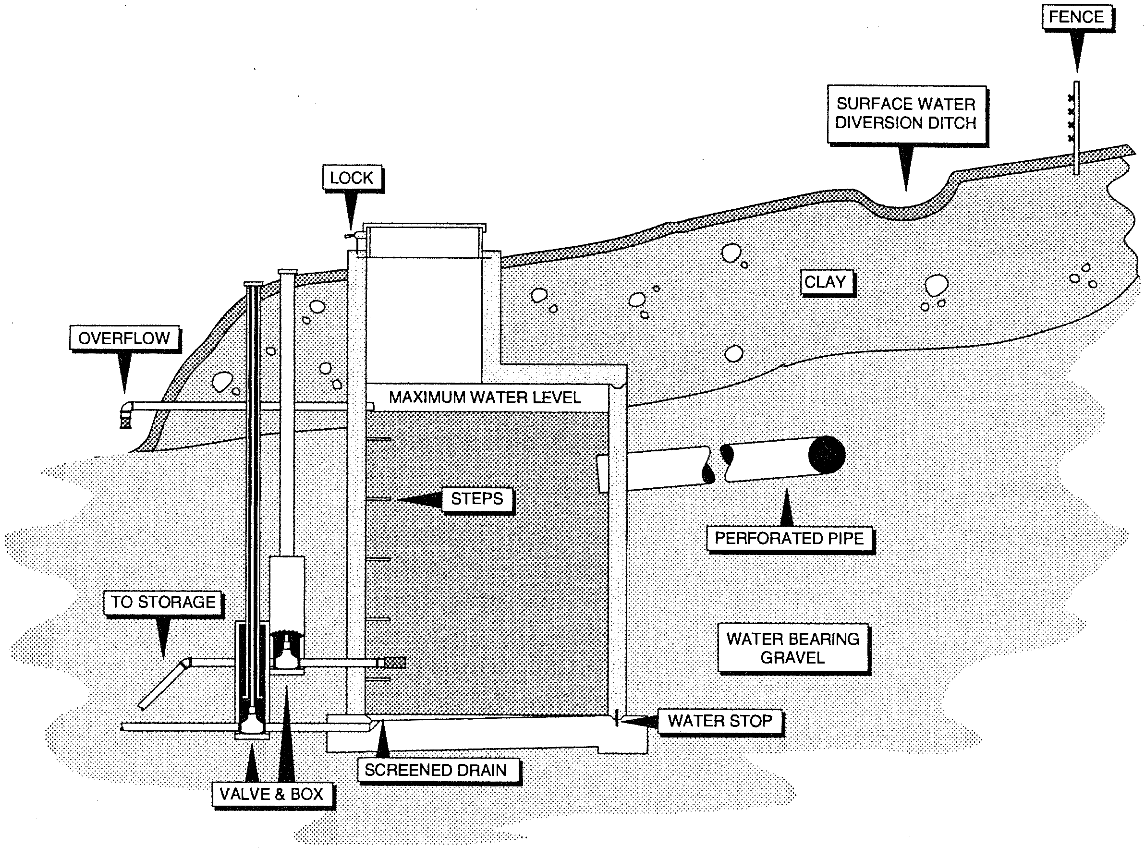
COMPONENTS

Intake

The intake structure commonly used to collect water from a spring is composed of either perforated pipe or Johnson well screen. One or more pipes are placed into the water bearing strata. A second method used, where the water bearing material is fractured rock or the slope is too steep for digging, is the insertion of horizontal wells screens. A specially designed well rig is used to drill a hole horizontally in the bank. A well casing and well screen are grouted into the bank and water removed.

Spring Box

The water from the intake structure is piped into a concrete spring box. The box is equipped with a vandal resistant, shoe box type lid. The lid should remain locked except when the box is being entered by a member of the utility crew. The outlet from the box should be off of the floor and valved. A vent and overflow are typically installed in the box and are protected from outside contamination by a #22 mesh screen. A valved drain should be installed, flush with the floor and the end of the line protected from contamination by an outside source with a screen or flap gate.



ROUTINE OPERATIONS

Water Quality

The chemical and biological water quality from the spring should be sampled and tested in the same manner and frequency as any other surface water source. The recommendations for sampling and testing are provided above.

Inspection & Cleaning

The spring box should be drained, inspected, cleaned with clean water and disinfected once each year. The disinfection can be accomplished by mixing one (1) gallon of household bleach with water in a five (5) gallon bucket. The solution can be sprayed or mopped onto the walls and floor of the basin.

Screens

The screens on the vent, overflow and drain should be inspected once each year. Any damaged or deteriorated screens should be replaced.

Hatch

The hatch, like the screens should be inspected annually and replaced or repaired as necessary.

Valves

All valves should be located and exercised once each month.

Above Intake

The area above the intake should be inspected for damage to the diversion ditch and fence once a year. This area should also be inspected for activities that could contaminate the water source.

Recharge Protection

The recharge for the spring should, if possible, be identified, and the procedures describe above in the performance of a water quality survey applied to this area.

ROOF CATCHMENTS

Introduction

While not popular with large water systems, the roof catchment is found in the US Virgin Islands, Hawaii, central plains of the US, Central Oregon and Southeast Alaska. These are one of the few effective means of collecting rain water. The basic concept is to collect the rain water from the roof of a structure and pipe it directly into some type of holding basin.

Components

Diversion Box

One of the safest and most effective designs of a roof catchment includes a screened diversion box. The water must fill the diversion box before any water enters the catchment. This allows the first water from the roof to be piped to waste and thus reduces the amount of debris carried into the catchment. A screen on top of the diversion box catches large material.

Inlet

Once the diversion box fills to the top, water is directed into the catchment box.

Catchment

The catchment box may be concrete, plastic, wood or metal. Any commercial containers should be NSF approved. The catchment box is designed in much the same way as a spring box or storage reservoir. The entrance is protected with a shoe box type hatch that is kept locked except for inspection and maintenance. The overflow, drain and vent are screened with #22 mesh noncorrosive screen. The outlet is screened and up off of the floor. A valve drain is flush with the floor and allows dewatering and cleaning of the basin.

ROUTINE OPERATIONS

Water Quality

The chemical and biological water quality from the spring should be sampled and tested in the same manner and frequency as any other surface water source. The recommendations for sampling and testing are provided above.

Inspection & Cleaning

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Screens

The screens on the vent, overflow and drain should be inspected once each year. Any damaged or deteriorated screens should be replaced.

Hatch

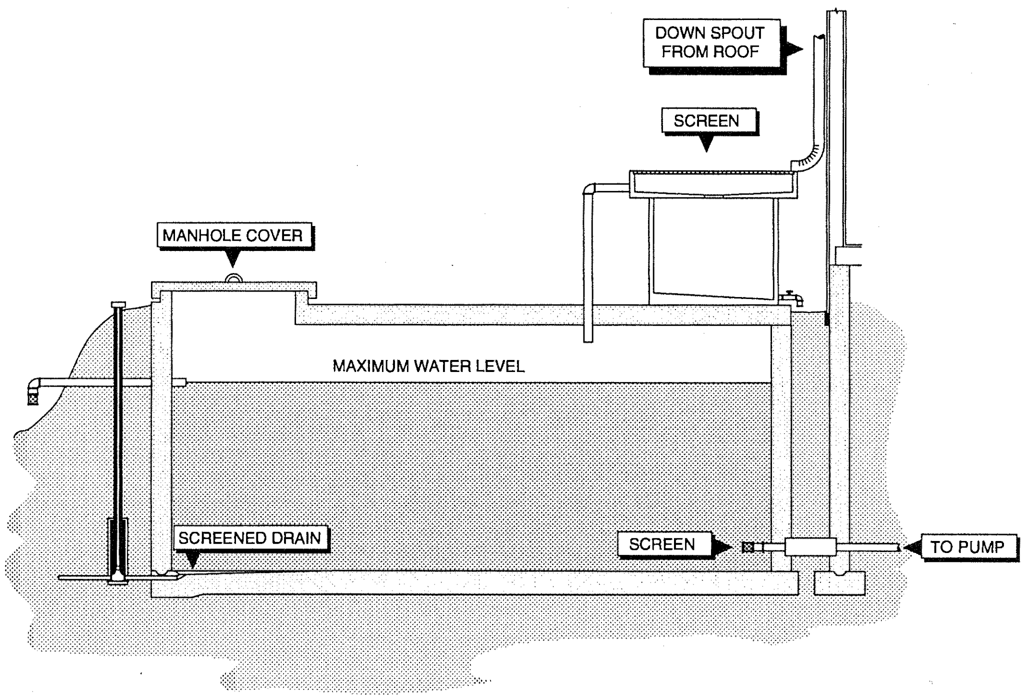
The hatch, like the screens should be inspected annually and replaced or repaired as necessary.

Roof

The roof should be inspected once each year for sources of contamination. As various roof material deteriorate, they can contribute to increased levels of contaminants.

Valves

All valves should be located and exercised once each month.



O & M OF SURFACE WATER SOURCES

Worksheet

1. A water use agreement is between the water purveyor and the .....

_______ a. US Forest Service

_______ b. Bureau of Land Management

_______ c. Land owners

_______ d. Loggers that are working in the area

_______ e. Mine owners

2. What is the name used to describe information that is gathered to determine the activity level in a watershed and water quality of a stream.

_______ a. Sanitary Survey

_______ b. Water Quality Data

_______ c. Watershed use and quality data

_______ d. Baseline data

_______ e. Background information

3. The area of a watershed is measured in what units?

_______ a. Square townships

_______ b. Townships and ranges

_______ c. Acres

_______ d. Square feet

_______ e. Acre feet

4. The height of water in a stream is called:

_______a. Steam depth

_______b. Stream stage

_______c. Stream velocity

_______d. Stream discharge

_______e. Stream magnitude

5. Good vegetation cover in a watershed will:

_______a. Reduce the quantity of water in the stream

_______b. Increase the turbidity in a stream

_______c. Reduce the impact of precipitation on water quality

_______d. Allow the water in the stream to evaporate at an accelerated pace

_______e. Keep birds out of the stream

6. Nutrients can be carried out of the soil and into the water by:

_______a. Birds

_______b. Wildlife

_______c. Runoff

_______d. Groundwater movement

_______e. Removing logs

7. A surveying system used in the United States divides the land into rectangles. The vertical lines in this survey are called the:

_______a. Vertical line

_______b. Latitude

_______c. Baseline

_______d. Great survey line

_______e. Meridian

8. A section of land contains ______________ acres.

_______a. 120

_______b. 240

_______c. 360

_______d. 640

_______e. 840

9. The description of a parcel of land,

_______a. is given starting with the largest portion and then working into the actual location.

_______b. is given by starting with the location and working outward to the prime meridian.

10. The numbering of streams on a map is called:

_______a. ordering the streams

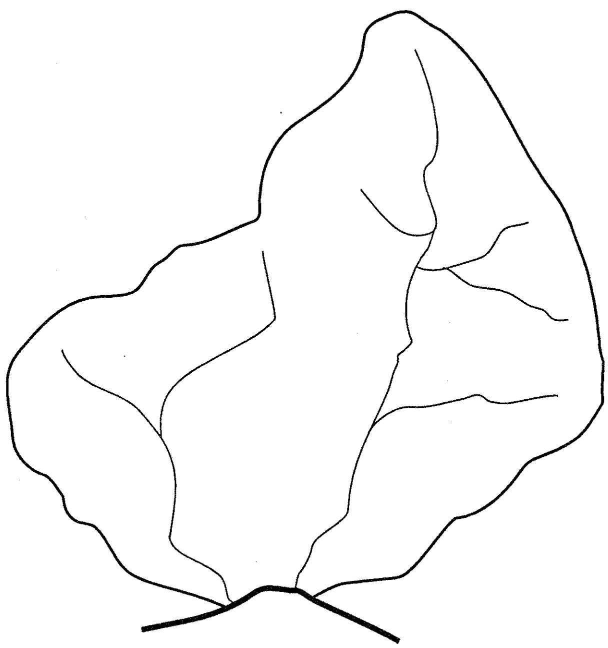
_______b. counting the streams

_______c. baseline criteria

_______d. numbering the streams

_______e. stream numbers

11. On the map below order the streams:



12. A stream that flows all year long is called a __________ stream.

_______ a. Perennial

_______ b. Intermittent

_______ c. Ephemeral

13. The quantity and size of material on the bottom of a stream is called the ___________.

_______ a. Stream bottom

_______ b. Benthics

_______ c. Hypolimnion

_______ d. Epilimnion

_______ e. Bedload

14. A watershed is composed of 210 acres. If 20 % of a 0.6 inch hydrological event runs into the stream, how many gallons are in the runoff?

_______ a. 731,808 gallons

_______ b. 648,240 gallons

_______ c. 5,473,923 gallons

_______ d. 12,229 gallons

_______ e. 14,620 gallons

15. The height of water above a weir plate is called the ____________.

_______ a. Drawdown

_______ b. Nape

_______ c. Aeration

_______ d. Staff gage

_______ e. Head

16. Water is flowing at 1.2 ft per second through a 12 inch wide and 16 inch deep flume. The depth of water in the flume is 6 inches. What is the flow in cfs?

_______ a. 1.6 cfs

_______ b. 0.6 cfs

_______ c. 230 cfs

_______ d. 0.4 cfs

_______ e. 86.4 cfs

17. The city has a water right for 1.5 cfs from a stream. How many gallons per minute is this?

_______ a. 299 gpm

_______ b. 450.5 gpm

_______ c. 674 gpm

_______ d. 11.2 gpm

_______ e. 743 gpm

18. Organisms that are found under the rocks in a stream bottom and can be used as indicators of water quality are called ____________.

_______ a. Benthics

_______ b. Coliform bacteria

_______ c. Algae

_______ d. Flagellates

_______ e. Free swimming ciliates

19. The material found in water that is not water are called ______________.

_______ a. Contamination

_______ b. Pollution

_______ c. Organic

_______ d. Inorganics

_______ e. Constituents

20. To determine the desired level of hardness in a raw water supply the test results should be compared to ______________.

_______ a. AWWA standards

_______ b. Water Quality Criteria

_______ c. Existing water quality standards

_______ d. SDWA

_______ e. APWA standards

21. When a body of water stratifies due to thermal differences the bottom layer is called the...

_______ a. Thermocline

_______ b. Benthics

_______ c. Hypolimnion

_______ d. Epilimnion

_______ e. Bedload

22. One acre-foot of water contains how many cubic feet?

_______ a. 7,48 ft^3

_______ b. 325,829 ft^3

_______ c. 16, 450 ft^3

_______ d. 43,560 ft^3

_______ e. 5,824 ft^3

23. A common chemical used as an algaecide in drinking water reservoirs is commonly called blue stone. What is the correct name for this material?

_______ a. Aluminum sulfate

_______ b. Soda Ash

_______ c. Copper sulfate

_______ d. Sodium Hexametaphosphate

_______ e. Potassium permanganate

24. How many gallons of water are in a reservoir that covers 8 acres and averages 10 feet in depth?

_______ a. 80 million gallons

_______ b. 598,000 gallons

_______ c. 5.4 million gallons

_______ d. 43,560 gallons

_______ e. 26 million gallons

25. Which of the following could be considered a confined space?

_______ a. Infiltration gallery caisson

_______ b. Spring box

_______ c. Roof catchment

_______ d. Valve pit

_______ e. Intake collection box