Drinking Water Operator Certification Training
Instructor Guide

Module 3:
Surface Water Sources

This course includes content developed by the Pennsylvania Department of Environmental Protection (Pa. DEP) in cooperation with the following contractors, subcontractors, or grantees:
The Pennsylvania State Association of Township Supervisors (PSATS)
Gannett Fleming, Inc.
Dering Consulting Group
Penn State Harrisburg Environmental Training Center

A Note to the Instructor

Dear Instructor:

The primary purpose of this course, *Surface Water Sources*, is to provide an overview of the sources of surface water supply, required considerations for use related to each type, and source water protection. This module has been designed to be completed in approximately 3 hours, but the actual course length will depend upon content and/or delivery modifications and results of course dry runs performed by the DEP-approved sponsor. The number of contact hours of credit assigned to this course is based upon the contact hours approved under the DEP course approval process. To help you prepare a personal lesson plan, timeframes have been included in the instructor guide at the Unit level and at the Roman numeral level of the topical outline. You may need to adjust these timeframes as necessary to match course content and delivery modifications made by the sponsor. Please make sure that all teaching points are covered and that the course is delivered as approved by DEP.

Web site URLs and other references are subject to change, and it is the training sponsor's responsibility to keep such references up to date.

Delivery methods to be used for this course include:

• Lecture • Small group and full group discussions	• Calculations • Exercises

To present this module, you will need the following materials:

• One workbook per participant • Extra pencils • Flip Chart • Markers	• Laptop (loaded with PowerPoint) and an LCD projector **or** overheads of presentation and an overhead projector • Screen

Icons to become familiar with include:

Participant Workbook	Instructor Guide
Exercise/Activity Case Study Discussion Question Calculation(s) Exercise Key Definition(s) Key Point(s)	Same icons for Participant Workbook apply to the Instructor Guide. **Ans:** Answer to exercise, case study, discussion, question, etc. PowerPoint Slide Overhead Flip Chart Suggested "Script"

Instructor text that is meant to be general instructions for the instructor are designated by being written in script font and enclosed in brackets. For example:

[Ask participants if they have any questions on how to read the table. Answer any questions participants may have about how to read the table.]

If your module includes the use of a PowerPoint presentation, below are some helpful controls that you may use within the Slide Show.

PowerPoint Slide Show Controls

You can use the following shortcuts while running your slide show in full-screen mode.

To	**Press**
Advance to the next slide	N, ENTER, or the SPACEBAR (or click the mouse)
Return to the previous slide	P or BACKSPACE
Go to slide <number>	<number>+ENTER
Display a black screen, or return to the slide show from a black screen	B
Display a white screen, or return to the slide show from a white screen	W
Stop or restart an automatic slide show	S
End a slide show	ESC
Return to the first slide	Both mouse buttons for 2 seconds
Change the pointer to a pen	CTRL+P
Change the pen to a pointer	CTRL+A
Hide the pointer and button temporarily	CTRL+H
Hide the pointer and button always	CTRL+L
Display the shortcut menu	SHIFT+F10 (or right-click)
Erase on-screen annotations	E
Go to next hidden slide	H
Set new timings while rehearsing	T
Use original timings while rehearsing	O
Use mouse-click to advance while rehearsing	M

INTRODUCTION OF MODULE: 5 minutes

[Display Slide 1—Module 3: Surface Water Sources.]

[Welcome participants to "Module 3 – Surface Water Sources." Indicate the purpose of this course is to provide participants with an introduction to the Hydrologic Cycle and the types of surface water, to the factors that should be considered when choosing a source of supply, to required data collection and analysis, to source water assessment and protection, and to drought contingency planning.]

[Introduce yourself.]

[Provide a brief overview of the module.]

This module contains 5 units. On page i, you will see the topical outline for **Unit 1 – Introduction to Surface Water** where we will cover the Hydrologic Cycle and the three types of surface water. Also on page i, you will see the outline for **Unit 2 – Considerations for Use of Surface Water as a Source of Supply** where we will study the various factors that must be considered for each source of supply.

The Unit 2 outline continues onto page ii where you will also see **Unit 3 – Data Availability**. In Unit 3, we will cover the types of data that are available, the data that must be collected, and how the data are analyzed. The outline for **Unit 4 – Source Water Assessment and Protection** begins at the bottom of page ii. In Unit 4, we will focus on the protection of raw water quality at the source.

The Unit 4 outline carries over onto page iii, where you will also see the topical outline for the final unit, **Unit 5 – Drought Contingency Planning.** In Unit 5, we will review how drought conditions are assessed, drought stages, drought contingency plan development, and demand reduction measures. The outline for Unit 5 continues onto page iv.

The final portion of Unit 5 is on supply extension measures. Now, let's begin Unit 1.

UNIT 1: <u>25 minutes</u>

[Display Slide 2—Unit 1: Introduction to Surface Water.]

At the end of this unit, you should be able to:

- Define the five components of the Hydrologic Cycle and illustrate them.
- Define Safe Yield and explain why estimating it is important to surface water supply.
- Identify and describe the treatment common to all surface water sources of supply.
- Define when a water allocation permit is required and specify how permits are obtained.

HYDROLOGIC CYCLE: <u>5 minutes</u>

We will begin this unit by reviewing the five components of the Hydrologic Cycle. Understanding the basics of this ongoing cycle will help you understand how surface water is formed.

[Review the definition]

[Display Slide 3 – Hydrologic Cycle[1].]

[Explain that the slide shows how the five components fit together. (Display slide through review of all five components.)]

Let's examine the first two components, precipitation and runoff, which appear on the page.

Precipitation

[Review the definition.]

[Point out that precipitation amounts vary, and Pennsylvania's average yearly precipitation. Also explain that "flush" is what happens when precipitation cleanses the air and runs off.]

[Ask the class why the factors for consideration in describing precipitation include total amount, intensity and duration.]

Ans: These factors affect the amount of water that soaks, or infiltrates, into the soil, and the amount that runs off.

So, precipitation reaches the earth where it either soaks into the soil or it becomes runoff.

Runoff

[Review the definition.]

[Point out that the amount of runoff is related to the amount and intensity of the precipitation. It is also dependent on how impervious the ground is and the slope of the ground. Very dry soil can be impervious to infiltration, which is why summer thunderstorms sometimes do little to replenish groundwater.]

Precipitation that does not run off will soak into the soil through the process of infiltration.

Infiltration

[Review the definition.]

What's the name of the process in which water is transformed into a gas?

Ans: Evaporation.

Evaporation/Transpiration

[Review the definition.]

[Point out the relationship between temperature and humidity concerning evaporation—higher temperatures accelerate evaporation, while higher humidity levels slow the rate of evaporation.]

Does anyone know the name for another process in which water is transformed into a gas?

Ans: Transpiration.

[Review the definition]

Let's move to the process in which water vapor is converted back into a liquid or solid state.

Condensation

[Review the definition.]

[Point out the cycle (or process) of condensation. When water droplets become large enough, they fall in the form of precipitation. Air temperature dictates whether the precipitation will be rain, snow, sleet, or hail. And, as this precipitation falls, part of it is immediately evaporated and returned to the atmosphere.]

[Figure 1.1: The Hydrologic Cycle (With Blanks for Participants to Complete).]

[Push the "B" key on the laptop and blank out the screen so participants can't see the slide. Direct the participants' attention to Figure 1.1: The Hydrologic Cycle. Ask them to take a minute and fill in the blank lines with the five components of the Cycle, showing them in the correct location.]

[When they are finished, touch the "B" key on the laptop again and re-display Slide 3 - Hydrologic Cycle so they can check their work.]

That concludes our introduction of the Hydrologic Cycle and its five components: precipitation, runoff, infiltration, evaporation/transpiration, and condensation. The relationship among these components is cyclical, with no beginning or end point. This cycle produces surface water that can be used for many purposes, including drinking.

TYPES OF SURFACE WATER: <u>5 minutes</u>

[Review the definition.]

There are three types of surface water sources: streamflow that is typically streams and rivers, impoundments that are lakes and reservoirs, and groundwater that is under the direct influence of surface water. The next section of this unit focuses on these three types of surface water.

Streamflow

[Review the definition.]

[Note that base streamflow is the flow that is seen during dry periods, and is fed by groundwater discharge. During wet periods, streamflow is a combination of base streamflow from groundwater discharge and precipitation.]

[Point out that the quantity of streamflow is generally related to the drainage area of the contributing watershed or the area over which precipitation falls. A larger drainage area can capture more runoff to feed rivers and streams than a smaller drainage area.]

Impoundment

[Review the definition. Tell participants that most impoundments are created by dams. Occasionally, natural lakes also serve as impoundments, but that this is not the norm.]

[Point out that impoundments serve as holding areas, and the quantity of water they will hold is considered in the design.]

Groundwater Under Direct Influence (GUDI)

The next source of surface water that we will discuss may appear to be a groundwater supply, but due to direct influence by surface water, may pose a public health threat if not treated as surface water.

[Review the definition.]

[Review bulleted information.]

[Point out that 1) groundwater sources close to streams or rivers, and 2) groundwater that is subject to rapid recharge from precipitation are both considered GUDI.]

[Review questionable well information. State that questionable wells require testing, and note the following for each bulleted point:

- *[Streamflow drawn into well would be surface water.]*
- *[Rock wells could intersect a fracture that could allow for infiltration of surface water.]*
- *[Unconfined wells in gravel or shale could allow surface water to enter through the screening at the bottom of the well casing.]*
- *[This type of well may be influenced by surface water because it is so close to the surface.]*

Next, we will examine what must be done to determine if a groundwater source is influenced by surface water, which would mean the source of supply must be properly treated to ensure that it does not pose a public health hazard.

Surface Water Influence Evaluation Plan

[Review information. Note that the water system is responsible for submitting a monitoring plan to DEP for approval.]

[Review information, including bulleted information. Note that raw, untreated water samples must be collected at the production pumping rate and during times when pumping conditions are established in the groundwater flow system. Also note that the water system is required to submit monitoring results to DEP monthly.]

[Review information.]

[Review information. Note that the water system is required to conduct a microscopic particulate evaluation.]

[Review information. Note that the water system may choose to correct the deficiencies that are causing the contamination or they may choose to abandon the source of supply.]

COMMON FACTORS TO ALL SURFACE WATER SOURCES: <u>10 minutes</u>

In the next section of this unit, we will be reviewing the factors in evaluating a surface water source of supply that are common to all surface water sources. The factors are quantity/volume, safe yield, quality/treatment, required hydraulic and treatment facilities, and source protection. Let's take a look at the first common factor, the quantity or volume.

Quantity/Volume

[Review the definition, including the bulleted information.]

[Review quantity of water information.]

The second common factor is Safe Yield.

Safe Yield

[Review the definition, including bulleted information. Emphasize the point that Safe Yield is important to preserving sources of water supply because it is based on the lowest flow (or yield) and the maximum demand. Note that Safe Yield takes into consideration the natural replenishment of the source as a result of the hydrologic cycle.]

[Review information. Note that the water system determines safe yield differently according to the type of supply.]

The third common factor is the quality and treatment of surface water sources.

Quality/Treatment

[Review information, including bulleted information about agents.]

Because surface water sources are susceptible to contamination, we must regard all sources of supply as unsafe for drinking until they are treated. The type of treatment necessary is related to the contaminants that are determined to be in the raw water. In other words, the treatment must match the type of contaminant.

[Display Slide 4 - Agents that Alter the Quality of Water.]

- *[Physical agents are those that affect the sensory qualities and include color, turbidity, taste, and odor.]*
- *[Chemical agents include minerals and other constituents such as fluoride, sulfate, iron, manganese, and total dissolved solids.]*
- *[Biological agents refer to the presence of organisms, including viruses, bacteria, and algae.]*
- *[Radiological agents refer to any radioactive substances.]*

[Review information about sanitary survey.]

[Note that the treatment methods required for all sources of surface water supply are filtration and disinfection. Specific treatment methods vary and are dependent on what contaminants are in the raw water.]

[Review information about water quality analyses.]

A number of factors must be considered to determine which filtration and disinfection technology is most appropriate. The water system must consider the space and personnel qualifications required by the method, as well as the cost. Many sources will require treatment in addition to filtration and disinfection. Some sources of supply may not be practical to use and the water system may choose to abandon them. Let's take a closer look at treatment facilities, the fourth factor common to all surface water sources.

Required Hydraulic & Treatment Facilities

[Review information about all surface water sources requiring treatment.]

All surface water sources require continuous filtration and disinfection. Beyond that, actual or potential contamination determines the type of additional treatment that is necessary.

[Review hydraulic head information.]

[Review information about well pumps delivering groundwater.]

The last factor common to all sources of surface water supply is perhaps the most important—protecting raw water quality at the source.

[Ask the class why this is so important.]

Ans: It is more cost effective to protect raw water at the source than it is to treat contaminated water.

Source Protection

[Review the definition, including bulleted information.]

[Review information about cost-effective protection.]

That concludes our overview of the factors common to all sources of surface water: quantity or volume, Safe Yield, quality and treatment, hydraulic and treatment facilities, and source protection. We will expand upon these later in the course. Next, we'll review the allocation permitting process.

RIGHT TO USE (ALLOCATION PERMIT): 5 minutes

Pennsylvania Department of Environmental Protection (DEP)

The Pennsylvania Department of Environmental Protection (DEP) is the state regulatory agency empowered to issue allocation permits for all surface water sources in Pennsylvania.

[Review information about allocation permits that are required by DEP, including bulleted information.]

[Review remaining information.]

Delaware River Basin Commission (DRBC)

[Display Slide 5 – Delaware River Basin Commission (DRBC) Area Map[2].]

[Explain that the map show the geographic area governed by the Delaware River Basin Commission.]

The Delaware basin drains parts of Pennsylvania, New Jersey, New York, and Delaware. Also included is the Delaware Bay. The DRBC is the agency that oversees a unified approach to managing the river system without regard to political boundaries. It includes the four basin state governors and a federal representative.

[Review information about DRBC approval, including bulleted information.]

[Review the DRBC project application requirements information. Note that all require the three descriptions listed.]

Susquehanna River Basin Commission (SRBC)

[Display Slide 6 – Susquehanna River Basin Commission (SRBC) Area Map[3].]

[Explain that the map show the geographic area governed by the Susquehanna River Basin Commission (SRBC). Point out that the map includes six (6) major sub-basins, which are all part of the SRBC.]

The Susquehanna River and its of tributaries span across three states: New York, Pennsylvania, and Maryland. Since the Susquehanna River flows through three states and is classified as a navigable waterway by the federal government, there are state, regional, and national interests involved. The SRBC is the agency that coordinates the water resources efforts of the three states and federal government.

[Review bulleted information about projects that require SRBC.]

[Review information about SRBC project application requirements.]

[Review information about SRBC allocation approval requirements.]

That concludes Unit 1. During this section, we've defined the 5 components of the Hydrologic Cycle. We've also defined Safe Yield and discussed its importance to preserving surface water supply for future use. We've identified continuous filtration and disinfection as the required treatment common to all surface water sources of supply. Finally, we've defined when water allocation permits are required and how to obtain them from the appropriate agencies. In the next unit we will take a closer look at how these common factors apply to each type of surface water.

Please turn to page 1-14, where you'll find References for this Unit.

[Review References.]

UNIT 2: 30 minutes

[Display Slide 7—Unit 2: Considerations for Use of Surface Water as a Source of Supply.]

[Introduce Unit 2 by reviewing the three types of surface water supply: streamflow in the form of rivers and streams, impoundments such as lakes and reservoirs, and Groundwater Under Direct Influence (of surface water) in the form of GUDI wells. Tell them that in Unit 2 they will learn about quantity, safe yield, quality and treatment, and facilities for each type of surface water supply.]

At the end of this unit, you should be able to:

- Name and describe three types of surface water supply.
- Estimate safe yield for the three types of surface water supply.
- Describe the facilities that could be associated with each type of surface water supply.
- Describe some common water quality problems associated with each type of surface water supply.

RIVERS AND STREAMS : <u>10 minutes</u>

Streamflow (Quantity)

[Review the information about how streamflow is expressed. Emphasize the requirement that streamflow quantity must be adequate to meet the demands of many different users of rivers and streams.]

[Use the flip chart to demonstrate how flow is recorded. Write "$Q_{7,50}$" and explain that this is how to record the desirable minimal consecutive 7-day average low flow having a 50-year recurrence for an unregulated stream as presented in the first bullet point. Write "$Q_{1,10}$" and explain that this means the lowest average flow in one (1) day within a 10-year period. Write "$Q_{30,10}$" and ask the class what that means.]

Ans: $Q_{30,10}$ means the lowest average flow over thirty (30) consecutive days within a 10-year period.

How would you record the lowest average flow over seven (7) consecutive days within a 10-year period?

Ans: $Q_{7,50}$

[Discuss the information regarding the relationship between streamflow quantity and the land surface area. Emphasize the fact that it is unrealistic to expect a high streamflow quantity from a small stream. Explain that geology, soil type, land use, and topography affect runoff. For example, steeply-sloped or highly urbanized areas can allow for rapid runoff of precipitation, which would not sustain adequate streamflow during dry weather. Certain soil types are better at infiltrating precipitation that can sustain baseflow.]

[Inform participants that the United States Geological Survey (USGS) is a source of information available to them to use when calculating streamflow quantity.]

Safe Yield

[Review the information about streamflow safe yield. Explain the bulleted points by describing that in a stream there is water coming in and water going out. For example, there may be dam releases or wastewater discharge entering a stream, and an industrial user taking water out of a stream. All flow augmentations and diversions must be taken into consideration.]

[Review the information about using DEP or USGS publications to get estimates of low-flow statistics.]

Quality & Treatment

[Review the information about the necessity of considering upstream uses that may affect water quality. Note that, in addition to the standard treatment of filtration and disinfection, proper treatment is determined by water quality and the type of contaminants and potential contaminants.]

[Review the information about the importance of proper identification and treatment of streamflow as a source of supply.]

[Review the information about source water assessment. Explain that a watershed sanitary survey is critical to the determination of treatment needs and the facility requirements. Sometimes, treatment needs can affect whether or not a river or stream is even considered as a source of supply.]

Facilities

[Review the information about raw water intake. Note that this occurs before water enters a treatment facility. Review the bulleted points by explaining that the intake must be placed at a location where adequate water will always be available. If the channel shifts, an intake could be left "high and dry." Damage to an intake could occur if the intake is not protected or is placed at a point on the river that is susceptible to ice or debris build-up.]

[Display Slide 8—Intake Facility.]

[Tell participants that raw water is transferred to the treatment plant through the intake facility. Emphasize that the selection of the location of the intake facility is very important to the cost of building and running the treatment facility. It is most cost effective if the treatment facility can be supplied by gravity from the source. Pumping adds to the cost of construction and operation.]

Let's move on and examine capacity, safe yield, quality and treatment, and facilities when the source of surface water supply is an impoundment.

LAKES AND RESERVOIRS: <u>10 minutes</u>

Capacity (Volume)

[Review the information about how the volume of an impoundment depends on the water elevation and ground surface. Point out that inflow from the upstream watershed refills lakes and reservoirs. Tell participants that, in other words, the bigger the "bowl" and the fuller it is, the more water is available.]

[Review the information about water level-capacity curves. Explain that for existing lakes and reservoirs, water operators should be able to obtain an existing water level-capacity curve from design files. Water operators who are planning for a lake or reservoir must develop a water level-capacity curve to ensure sufficient capacity. Note that the participants will develop this water level-capacity curve in Unit 3.]

Next, we will examine how safe yield is determined for an impoundment.

Safe Yield

[Review the information about gross yield. Be sure to emphasize that this is based on a 50-year drought and that the drawdown rate is uniform. The gross yield required from the reservoir will dictate how much volume is needed. Total volume, however, may be limited by physical conditions of the valley where the dam would be located. Note that all inflows and outflows must be considered when determining gross yield.]

[Review the information on accessing yields through DEP Water Resources Bulletin No. 7.]

[Review the information regarding conservation release rates. Point out that conservation release rates are established to maintain the aquatic life (fish and other) downstream from the dam. Tell the participants that some water must be allowed to pass the dam in order to not dry up the stream. Note that conservation rates may be based on the low-flow characteristics of the inflow stream ($Q_{7,10}$) or on a unit flow per square mile of drainage area (x cubic feet per second per square mile).]

[Review the information about developing and applying detailed hydraulic models. Instruct the participants that different yields can be evaluated for various inflow and outflow conditions. Point out that the model developed will only be as good as the data that were used to develop it.]

Quality & Treatment

Lakes and reservoirs offer us a few advantages in terms of quality and treatment over rivers and streams. One is that the water quality doesn't change as quickly, and the other is that they allow contaminants to be more easily diluted.

[Review the information about the relationship between impoundment water quality and upstream land use in the watershed. Remind participants that raw water quality affects treatment requirements. Review the other factors that affect the water quality—bottom water turnover and algal blooms.]

[Explain the information about how treatment is enhanced by the ability to deliver raw water from the level within an intake tower where the quality is the best.]

Facilities

[Review the information about the need for dams.]

[Review the information about the functions and types of intake structures. Remind participants about the prior presentation of information regarding conservation releases and that, if raw water cannot be delivered by gravity, it will need to be pumped to the treatment plant.]

[Display Slide 9—Multi-level Intake Tower.]

[Direct the participants to look at Figure 2.3 in their workbooks. Using the slide, point out the three (3) intakes on the tower that allow for water to be withdrawn from the level with the best water quality.]

[Review the information regarding proper design and maintenance. Note the benefits in terms of safety and operating efficiency.]

GROUNDWATER UNDER DIRECT INFLUENCE: <u>10 minutes</u>

Groundwater Availability

[Review the information about groundwater wells. Note that variations in the underlying geologic formations affect quantity of supply.]

[Review the information about GUDI wells and the bulleted information about three (3) types of GUDI wells.]

Safe Yield

[Review the information about how the safe yield of a GUDI well is determined through a pump test. Emphasize the fact that the DEP permitted withdrawal rate may not be 100% of the pump test rate and that it must take into account potential drought conditions.]

Quality & Treatment

[Review the information. Remind participants that disinfection and filtration is the common treatment required by all surface water including GUDI well water.]

[Review the information about other possible contaminants of GUDI well water. Note that with GUDI wells, the type of possible contamination may be related to the type of formation that the well is constructed in.]

Facilities

[Review the information about the similarity of GUDI well construction to groundwater well construction, and the related regulatory requirements.]

[Review the information about filtration, disinfection, and other treatment required. Present the two basic types of pumping processes and how GUDI well water is circulated through each before being transmitted into the distribution system.]

[Review References.]

UNIT 3: <u>60 minutes</u>

[Display Slide 10—Unit 3: Data Availability, Collection, and Analysis.]

[Introduce Unit 3 by telling the participants that a variety of data must be collected and analyzed to secure permits for all types of surface water sources of supply. Required data may be available from the U. S. Geological Survey (USGS) or DEP. If the required data is not available from these sources, data must be collected at the site. Unit 3 will cover how to use existing data for analysis, and how to collect the required data if it is not available from another source.]

At the end of this unit, you should be able to:

- Name two agency sources of existing data for use in surface water supply analysis.
- Develop a rating curve to estimate streamflow.
- Develop a capacity curve to estimate the volume of a reservoir.
- Estimate the flow frequency of an ungaged stream location using U.S. Geological Survey (USGS) data.

AVAILABLE DATA: <u>5 minutes</u>

Streamflow

When a river or stream is proposed as a source of supply, flow characteristics of the stream are required in the permit application process to ensure adequate supply to meet not only the projected water demands of the water system, but also other users, including instream flow needs. USGS data is collected at gaging stations on many Pennsylvania rivers and streams.

[Review the three (3) key points and bulleted information.]

Reservoir

Data from USGS is available for some reservoirs in Pennsylvania.

[Review the information.]

Groundwater Under Direct Influence (GUDI)

Again, USGS data may be used when available.

[Review the information.]

That concludes the basic information about using available data. During the next section of Unit 3 we will examine what must be done when the data is not readily available and must be collected.

DATA COLLECTION: <u>45 minutes</u>

The types of data that must be collected to obtain a permit and document usage vary among the three (3) surface water sources of supply. For rivers and streams, streamflow or discharge is measured. For lakes and reservoirs, volume is measured, and for GUDI wells, the groundwater level is measured.

Streamflow Measurement

[Review the first key point and bulleted information. Point out that "Q" stands for "streamflow." Emphasize that streamflow measurements must be taken for a full range of gage heights, during wet periods when the gage height is highest and during dry periods when the gage height is lower.]

[Review the second key point information.]

[Ask the participants why gage height should always be measured from a relative fixed point.]

Ans: The bottom of a stream or river could always be eroded or filled in with sediment. Gage height should always be measured from a fixed point, referenced to some data such as sea level. An arbitrary datum can be used, but each measurement of gage point relative to a fixed height is needed to develop a rating curve.

[Use the flip chart to demonstrate and explain the example of how subsection flow is calculated.]

[Write:] **Subsection Flow (CFS) = (1.0 Ft x 2.5 Ft) x 4 Ft/sec**

Subsection Flow = 10 CFS

[Tell the participants that during this sample exercise, flow was calculated for one subsection. Note that total streamflow is the total of all subsection measurements.]

[Direct the participants to calculate the subsection flow for the problem shown in their workbooks.]

[Ask the participants what the subsection area is. Ask what the flow is. Ask for a volunteer to provide their answer. If the answer is correct, ask them to demonstrate their calculations on the flip chart.]

Ans: Subsection Flow (CFS) = (1.5 Ft x 3.0 Ft) x 2 Ft/sec

Subsection Flow (CFS) = 4.5 Ft^2 x 2 Ft/sec

Subsection Flow = 9 CFS

Thanks for the work. Next, we will develop a Streamflow Rating Curve using gage height and streamflow measurements.

[Display Slide 11—Streamflow Rating Curve (Blank).]

[Use the slide to review the information. Point out the X-axis used for plotting streamflow, or discharge, and the Y-axis used for plotting gage height.]

Let's develop a Streamflow Rating Curve of our own. For this exercise, use Table 3.1 shown in your workbook and the blank graph shown in Figure 3.1.

[Demonstrate for the class how to plot the first two points, using the measurements provided for gage height and streamflow. Ask them to plot the remaining four (4) points on their own. Walk around the classroom and provide assistance as needed. After they have plotted the six (6) points, ask them to draw a "best-fit" straight line through the points to develop the Rating Curve.]

[Display Slide 12—Streamflow Rating Curve.]

[Tell the participants that their Rating Curves should look like the one shown. Ask the participants what questions they have. Clarify any areas of confusion. Continue to use the slide to demonstrate the following example of how to use the Rating Curve.]

We now have a Streamflow Rating Curve that can be used to estimate streamflow at any given gage height.

[Continue using the slide to demonstrate that, at 3.10 feet gage height, the estimated streamflow is 1.00 CFS.]

[Ask the participants to use the Streamflow Rating Curve provided in Figure 3.2 to estimate the streamflow for the two gage heights provided in Table 3.2 in their workbooks. Walk around the classroom and offer help when needed.]

Ans:

Table 3.2

Gage Height (Ft.)	Estimated Streamflow (CFS)
3.10	1.00
3.17	**1.65**
3.22	**2.09**

[Ask the participants for any questions they may have. Clarify any areas of confusion.]

Let's move on and see how we estimate volume in an impoundment.

Reservoir Volume Measurement

[Review the key point and bulleted information. Point out that there are six (6) steps required to calculate the volume of a reservoir. The first step starts with a topographical map like the one shown in the next slide.]

[Display Slide 14—Plan View of a Hypothetical Reservoir.]

Step 1: *[Explain that the Plan View shown on the slide and in Figure 3.3 in their workbooks is from a topographical map. A device called a plenimeter is used to estimate surface area at the specified contours or elevations. In Step 2, this information will be used to estimate the volume between elevations.]*

In order to be able to estimate reservoir volume, we must make a few calculations, and then we can graph a water level-capacity curve.

Step 2: *[Explain that Step 2 is a simple averaging of two numbers.]*

[Use the flip chart to demonstrate how the surface area at two levels are averaged together. Tell the participants you will calculate the average area between 746 Ft and 747 Ft.]

[Write:] **200 Ft^2 + 800 Ft^2 = 1,000 Ft^2**
1,000 Ft^2 divided by 2 = 500 Ft^2

[Demonstrate how to calculate the average area between 747 Ft and 748 Ft.]

[Write:] **800 Ft^2 + 2,100 Ft^2 = 2,900 Ft^2**
2,900 Ft^2 divided by 2 = 1,450 Ft^2

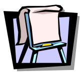
[Ask the participants to calculate the average area for the three (3) remaining pairs of elevations.]

Ans: Average area between 748 Ft and 749 Ft = 3,450 Ft^2
Average area between 749 Ft and 750 Ft = 6,650 Ft^2
Average area between 750 Ft and 751 Ft = 11,500 Ft^2

[Ask the participants for any questions they may have. Clarify any areas of confusion.]

Step 3 adds the third dimension to transform surface area, expressed in Ft^2, into volume, expressed as Ft^3.

Step 3: *[Explain the calculation for estimating volume at a specific level, using data from Table 3.3.]*



[Use the flip chart to demonstrate how to estimate the volume of water at 747 Ft and 748 Ft.]

[Write]: **Volume @ 746 Ft. = 0 Ft^3**
Volume @ 747 Ft. = 0 Ft^3 + [(500 Ft^2) x (1 Ft] = 500 Ft^3
Volume @ 748 Ft = 500 Ft^3 + [(1,450 Ft^2) x (1 Ft)] = 1,950 Ft^3

[*Ask the participants to calculate the volume of water for the three (3) remaining elevations using Table 3.4.]*

Ans: Volume @ 749 Ft = 5,400 Ft^3
Volume @ 750 Ft = 12,050 Ft^3
Volume @ 751 Ft = 23,550 Ft^3

[Ask the participants for any questions they may have. Clarify any areas of confusion.]

Step 4: *[Explain that Step 4 involves plotting surface area and volume at specific elevations on a graph, which yields a water level-capacity curve. Data points are plotted on the graph, and a "best-fit" curve is drawn.]*

[Display Slide 14—Water Level-Capacity Curve.]

[Use the slide to point out how volume is plotted along the bottom X-axis, how area is plotted along the top X-axis, and how elevation is plotted along the Y-axis.]

The data provided or calculated for our hypothetical reservoir was used to develop the Water Level-Capacity Curve as shown in this slide and in Figure 3.4 in your workbooks. This curve is what we will use in Step 5 to estimate volume, in gallons, for any elevation.

Step 5: *[Explain that in Step 5, the Water Level-Capacity Curve shown in Figure 3.4 is used to estimate volume at specific elevations, as shown in Table 3.4 in their workbooks. Also in Step 5, volume is converted from FT^3 to gallons. The difference in volume between the elevations is also calculated. The volumes shown in Table 3.4 are from the curve, not from the individual volume calculations. The conversion from cubic feet to gallons is based on 1 $Foot^3$ = 7.481 Gallons.]*

[Use the flip chart to demonstrate how to calculate the difference in volume between two elevations.]

[Write:]
Difference in volume between 746 Ft and 747 Ft is 2,990 Gal – 0 Gal = 2,990 Gal
Difference in volume between 747 Ft and 748 Ft is 14,960 Gal – 2,990 Gal = 11,970 Gal
Difference in volume between 748 Ft and 749 Ft is 41,890 Gal– 14,960 Gal = 26,930 Gal

[Ask the participants to calculate the difference in volume between the remaining two pairs of elevations.]

Ans: Difference in volume between 749 Ft and 750 Ft = 47,880 Gal
Difference in volume between 750 Ft and 751 Ft = 86,030 Gal

Step 6: *[Explain that by interpolating between elevations, the volume at any level can be estimated.]*

[Use the flip chart to demonstrate how to estimate the volume, in gallons, for any elevation.]

[Write]: **Estimated Volume at 750.85 Ft = 89,770 Gal+ (0.85 x 86,030 Gal)**
= 89,770 Gal + 73,130 Gal
= 162,900 Gal

[Ask the participants to estimate volume at the levels shown in their workbooks, using the water level-capacity table. Tell participants to round the numbers off to the nearest ten (10) gallons.]

Ans: Estimated Volume at 749.50 Ft = 41,890 Gal + (0.50 x 47,880 Gal) = 65,830 Gal
Estimated Volume at 746.75 Ft = 0 Gal + (0.75 x 2,990 Gal) = 2,240 Gal

[Ask the participants for any questions they may have. Clarify any areas of confusion.]

That concludes the information about data collection for reservoirs. The last type of data collection we will cover is for groundwater, which is relatively simple.

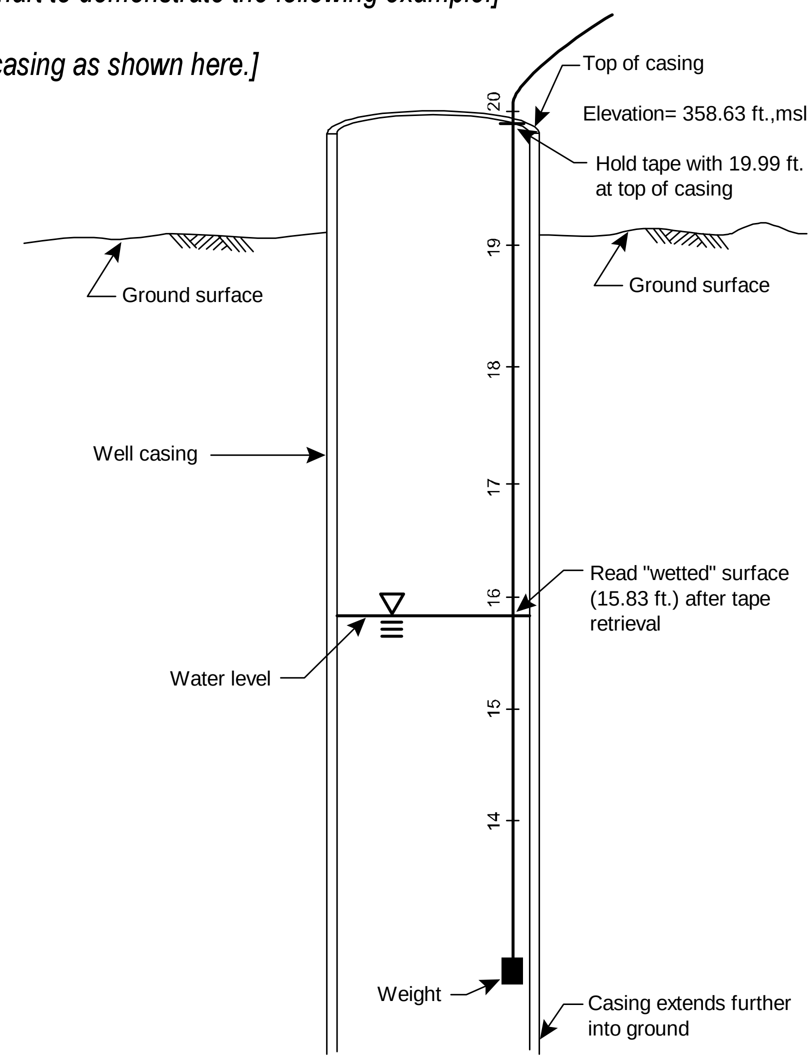
Groundwater Level Measurement

[Display Slide 15—Well Cross-Section.]

[Review the information.]

[Use the flip chart to demonstrate the following example.]

[Draw a well casing as shown here.]



Let's say, that for this example, the top of the casing is 358.63 Ft, mean sea level (msl). A steel tape is lowered into the well casing until it is submerged. The steel tape typically has a small weight attached to the end of it. Hold the tape against the top of the casing and record the tape reading. Let's say that for our example, the reading at the top of the casing is 19.99 Ft. (Note this on the flip chart.) Retrieve the tape and record the "wetted" surface reading. For our example, the reading is 15.83 Ft. (Note this on the flip chart.) The water level, therefore, is 19.99 Ft minus 15.83 Ft, or 4.16 Ft below the top of the casing (write this on the flip chart), which is 358.63 Ft minus 4.16 Ft which equals 354.47 Ft, msl.

DATA ANALYSIS: 10 minutes

The last section of Unit 3 is on data analysis using existing data available for streamflow and groundwater. The purpose for analyzing this data is to be able to estimate volume of water available from a stream or from a GUDI well.

Comparison with Long-Term Records

[Review the information.]

[Point out that data required to establish streamflow frequency and duration may be available from USGS gaging stations, USGS low-flow statistics, or must be collected and compared with USGS data.]

Flow Frequency Estimate

[Review the information.]

[Review the statistical terms $Q_{7,10}$, $Q_{30,10}$ and mean flow. Remind the participants that $Q_{7,10}$ is the 7-day average low-flow expected to occur once every ten (10) years, while $Q_{30,10}$ is the 30-day average low-flow expected to occur once every ten (10) years. Tell the participants that the USGS provides flow for statistical analysis on an average day basis. Mean flow is the average of all daily average flows. For example, if there are ten (10) years of data at a USGS gaging station, there would be 3,650 average daily flows. Mean flow would be the average of those 3,650 values.]

The next section of this unit will provide you with a few examples of how existing streamflow data can be used as a reference for estimating streamflow.

[Tell the participants that the next four figures shown in their workbooks are all screens printed from the USGS website, "http://pc13pahrb.er.usgs.gov//flowstats/." The website walks users through a series of steps where information can be entered about a site and low-flow statistics are provided for both gaged and ungaged streams.]

[Tell the participants that this first figure provides low-flow data for a gaged site on the Jordan Creek at 53.0 mi^2 drainage area. Point out that the Reference Gage is #01451800 and is located near Schnecksville, PA. Note that $Q_{7,10}$ is 2.58 CFS, $Q_{30,10}$ is 4.17 CFS, and the mean flow is 92.7 CFS. Tell the participants that this gaged site is used as a reference for an ungaged site on Jordan Creek at 26.9 mi^2 drainage area.]

[Tell the participants that Figure 3.7 is a screen print-out generated by USGS to estimate low-flow statistics for an ungaged site on Jordan Creek at 26.9 mi^2 drainage area site. The USGS calculated the data shown based on the gaged site data referenced in the previous figure. $Q_{7,10}$ for the ungaged site on Jordan Creek is 1.31 CFS, $Q_{30,10}$ is 2.11 CFS, and the mean flow is 47.0 CFS.]

[Tell the participants that Figure 3.8 provides low-flow statistics from Reference Gage # 01565000 located on the Kishacoquillas Creek at Reedsville, PA at 164.0 mi^2 *drainage area. Point out that this site was referenced by the USGS to estimate data for an ungaged site on Honey Creek in Mifflin County that is an ungaged stream. Note that, for the Kishacoquillas Creek,* $Q_{7,10}$ *is 18.5 CFS,* $Q_{30,10}$ *is 20.1 CFS, and the mean flow is 206 CFS.]*

[Tell the participants that Figure 3.9 estimates low-flow statistics for an ungaged site on an ungaged stream. Explain that the statistics shown on the prior figure were used to estimate the data shown for Honey Creek, Mifflin County, at 93.1 mi^2 drainage area. The low-flow estimate at this location for $Q_{7,10}$ is 10.5 CFS, for $Q_{30,10}$ is 11.4 CFS, and for the mean flow is 117 CFS.]

Existing data on groundwater levels can also be used for comparison purposes.

Water Level Comparison

[Review the information.]

That concludes Unit 3 on data availability, collection and analysis. In this unit, we have covered the data that is available from USGS and DEP, how to develop a Streamflow Rating Curve, how to estimate the volume of a reservoir, and how to estimate flow frequency using USGS data.

[Ask the participants what questions they have. Clarify any areas of confusion.]

In Unit 4, we will examine Source Water Assessment and Protection.

[Review References.]

[Tell the participants that in Unit 4 they will be learning about source water assessment and protection.]

UNIT #4: <u>30 minutes</u>

[Display Slide 16—Unit 4: Source Water Assessment and Protection.]

At the end of this unit, you should be able to:

- List the three key components of the Source Water Assessment and Protection (SWAP) program.
- Identify the information that should be collected during a wellhead protection sanitary survey.
- Explain why public participation is important to the success of a Source Water Protection (SWP) program.
- Describe the additional benefits of a Source Water Protection program.

We will begin by reviewing the legislation that requires states to assess and protect water sources that serve public water systems.

OVERVIEW: <u>2 minutes</u>

Required by 1996 Safe Drinking Water Act (SDWA) Program

[Review definition.]

The 1996 SDWA spells out the "who, what, where, and why" of source water assessment and protection. DEP staff and contractors are required by the Environmental Protection Agency (EPA) to assess all public water systems within two (2) years of EPA approval, and all Pennsylvania drinking water sources must be assessed by June 2003. Assessment information will be used to prevent drinking water contamination.

Directed at Raw Water Quality

[Review information. Emphasize the point that the SDWA was established to assess and protect raw water at the source and that is not an assessment of the water supplier.]

DEP and its contractors may use Geographic Information System (GIS) database information available from most municipalities. GIS databases provide important information about the different attributes of water quality at varying levels.

There are three (3) key components of the SWAP program: delineation of source boundaries, identification of potential contaminants, and determination of source susceptibility to contamination. We will talk about the importance of delineating source boundaries first.

KEY COMPONENTS OF SWAP PROGRAM: 15 minutes

Delineate Source Boundaries

[Ask the participants to describe what a watershed is.]

Ans: It is the area of land from which a rain drop will drain into the source of supply. The surface features and contours of the land determine which watershed a drop of water drains into.

In order to best assess and protect a surface water source of drinking water, DEP must identify the watershed boundaries for each source.

[Review the information.]

[Explain that watershed areas for all surface water intakes serving public water systems have been delineated. This area represents over 90% of the entire state.]

[Note that there are over 115 watersheds over 100 mi^2 serving public water systems including sixty (60) intakes in the main stems of the major Pennsylvania river basins.]

[Explain that watersheds over 100 mi^2 will be segmented into three (3) zones for the inventory and susceptibility analyses primarily to address spills. Major tributaries (those that contribute significant flow to the intake, and, therefore, the greatest risk for contaminant loading) will be investigated in greater detail.]

[Point out that the delineated areas for GUDI wells used as a source of drinking water supply are defined in state regulations and the Wellhead Protection Program (WHPP).]

[Explain that a GIS analysis is used to assess at-risk sources. GIS databases can be used to show existing sources of potential contamination within the delineated area, such as urban areas, land use, or specific facilities.]

Now that we know that the first key component of SWAP is the identification of source boundaries, let's take a look at the second key component, the identification of what is in the area that could potentially contaminate a source of supply.

Identify Origins of Potential Contaminants

[Review the information and the list of contaminants. Note that the list is prioritized from more common and greater health risk to less common and lesser health risk.]

[Review the information.]

[Explain the importance of identifying the activities within a watershed that could be a source of potential contaminants. Point out that all activities that involve the use, storage, transportation, or disposal of potential contaminants should be identified. Note that certain contaminants are typically associated with certain land use and potential contaminant sources. . Explain that SOCs and VOCs are often associated with industry, nitrates with agriculture, pathogens with wastewater or sewage, and radionuclides with mining or nuclear power plants.]

[Ask the participants to identify some potential sources of contaminants that exist in their watershed areas.]

Ans: *[Possible answers could include farms, hog farms, dry cleaners, gas stations, nuclear reactors, various industries, and roads with tanker traffic.]*

So, we have discussed the first two (2) key components of SWAP: the importance of identifying source boundaries, and potential contaminants and their origins. The third key component of SWAP is the determination of the source susceptibility to contamination.

Determine Source Susceptibility to Contamination

[Review the information.]

[Emphasize the greater risk of contamination associated with surface water sources of supply, especially rivers and streams. Note that reservoirs offer more protection from contamination because of the dilution factor afforded by the impoundment and the potential lag time between the contamination point and the withdrawal point.]

[Review the information. Explain that in performing the susceptibility analyses, three questions can be asked:]

1. *How sensitive is the source to contamination?*
2. *What happens if the contaminant gets into the source of supply?*
3. *How likely is it that the contaminant will get into the supply?*

[Review the information. Point out that contamination could occur accidentally or deliberately.]

[Note that assessment of the potential for contamination includes consideration of such factors as the fate, transport, amount, and distance from the source of supply. Explain that fate refers to what would happen to a given contaminant if it were released (i.e., will it evaporate, be absorbed, lay in a pond? etc.) Explain that transport refers to how it travels (i.e., through a storm drain versus a closed basin). The amount and distance from a source of supply should be considered when determining the urgency of the situation.]

[Review the information.]

[Point out that EPA has established the MCL for regulated contaminants and that DEP is responsible for insuring compliance. Note that source "sensitivity" is based on analysis of the samples collected at the point of withdrawal.]

Now that we know what the three (3) key components of the SWAP program are, let's take a look at how DEP sanitary surveys are beneficial to source water assessment.

Enhanced by Sanitary Surveys

[Review the information.]

Although water suppliers are the best source of information about their source of supply, DEP staff does come out to the site and will conduct sanitary surveys that provide helpful information.

A DEP sanitary survey is particularly helpful when a water supplier is considering drilling a new well. Prior to drilling, contact DEP to request a wellhead protection sanitary survey to make sure the well will be acceptable to DEP and that a permit to construct and operate it as a public supply well can be obtained.

[Ask participants if anyone can identify the information that should be collected during a wellhead protection sanitary survey.]

Ans: A wellhead protection provides information about:

1. Local geology
2. Potential sources of local contamination
3. Factors effecting the supply
4. Potential for flooding
5. Proximity of other wells

[Review the information.]

That concludes our discussion on the SWAP program. In conclusion there are three (3) key components: source boundary delineation, origins of potential contaminants, and source susceptibility. Now, let's look at some of the additional benefits of the SWAP program.

ADDITIONAL BENEFITS OF THE SWAP PROGRAM: <u>10 minutes</u>

There are four (4) additional benefits of the SWAP program. The SWAP program helps to:

1. Facilitate emergency response
2. Improve land use planning
3. Prioritize regulatory agencies action
4. Educate the general public about protecting source water

Let's take at look at how the SWAP program helps to facilitate emergency response if it's necessary.

Facilitate Emergency Response

[Review the information.]

[Emphasize the value of identifying the point sources, or specific locations, of potential contaminants to the development of a contingency plan that is proactive, and that identifies who to call and what to do in the event of a spill.]

The second benefit of the SWAP program is the potential for improved land use planning.

Improve Land Use Planning

[Review the information.]

[Explain that municipalities can protect sources of supply through proactive land use planning and appropriate zoning.]

[Review the information.]

[Explain the importance of municipalities working together cooperatively, especially when the source of supply is in one municipality and the users are in another municipality.]

[Ask the participants if they can think of any examples of municipalities working together cooperatively. Discuss any they suggest.]

Ans: *[Present the example of the Chester Water Authority, where the water supply is in the Susquehanna River Basin Watershed, and the users are in the Delaware River Basin.]*

The third benefit of the SWAP program is the ability to prioritize actions from regulatory agencies.

Prioritize Regulatory Agencies Action

[Review the information.]

[Explain that, through the SWAP program, point sources of potential contamination, such as dry cleaners, industries, etc. have been identified. Non-point sources, such as drainage off a farm field containing nitrates and microbiological contaminants, must also be identified. To assess these, critical area analyses have to be conducted. Integration of this information with watershed management enables regulatory agencies to develop plans for watershed protection and remediation.]

The fourth benefit of the SWAP program is the education of the general public about why source water should be protected.

Educate the General Public

[Review the information.]

[Ask the participants for examples they may have of how to make everyone aware of the need to protect the water supply source.]

Ans: *[Potential answers include bill stuffers, holding an open house, newspaper articles, or the Consumer Confidence Report.]*

We've just reviewed the four (4) additional benefits of the SWAP program. Next, let's take a brief look at local Source Water Protection programs.

LOCAL SOURCE WATER PROTECTION (SWP) PROGRAMS: <u>3 minutes</u>

General

SWP programs seek to engage local community members in voluntary efforts to protect drinking source water through education, promotion, grants, and technical assistance. Local level efforts are tailored to the local water quality data and potential sources of contamination.

[Review the information.]

Requirements

SWP grants are available from DEP. In order to qualify, grant recipients must take the assessment data and use it to create a plan to manage existing and potential sources of contamination.

[Review the information shown for both keys.]

[Point out that a local steering committee can be comprised of anyone with a knowledge or interest in source water protection. Note that some of the information required for a SWP program will be available from the SWAP report to be provided by DEP.]

[Ask the participants if anyone is currently involved in a SWP. Ask for examples of how the participants protect their source of supply.]

Ans: ***[****Potential answers include posting "No Trespassing" signs in watershed areas, not allowing boating on a reservoir, fencing, zoning restrictions in a delineated watershed area, and regular sanitary surveys.]*

SWP Funding and Promotion

If you are interested in developing a SWP program, this next section provides some basic information about assistance that is available.

[Review the information.]

That concludes Unit 4: Source Water Assessment and Protection. During this unit, we've focused on the following learning objectives.

[Re-display Slide 16—Unit 4: Source Water Assessment and Protection.]

- *[Listed the three key components of the Source Water Assessment and Protection Program.]*
- *[Identified the information that should be collected during a wellhead protection sanitary survey.]*
- *[Explained why public participation is important to the success of a Source Water Protection Program.]*
- *[Described the additional benefits of a Source Water Protection Program.]*

[Ask the participants what questions they have. Clarify any areas of confusion.]

Please turn the page, where you'll find the References for this unit.

[Review References.]

[Tell the participants that in the next and final unit, Unit 5, they will be learning about Drought Contingency Planning.]

UNIT 5: <u>30 minutes</u>

[Display Slide 17—Unit 5: Drought Contingency Planning.]

At the end of this unit, you should be able to:

- Name the five hydrologic conditions used by DEP to assess drought status.
- Name the three drought stages and describe the major actions required by each.
- Describe the major components of a Drought Contingency Plan.
- Define the triggers for each type of surface water supply that are used in a local drought contingency plan.

We will begin by reviewing the five hydrologic conditions, or parameters, used by Pennsylvania DEP to monitor water supply drought conditions.

DEP ASSESSMENT OF DROUGHT CONDITIONS: 13 minutes

[Review key information.]

As we discussed in the Unit 3, Data Analyses section, there are three stages for drought conditions: drought watch, drought warning, and drought emergency. We will explore each of those stages in more detail later in this unit.

[Point out no one parameter or combination of parameters is used to indicate a drought stage. Review of indicator parameters, along with other considerations is necessary for drought proclamation.]

Now that we know the five indicators used to monitor water supply drought conditions, we will take a closer look at each one, beginning with Precipitation.

Precipitation

A deficit in precipitation is the earliest indicator of potential drought conditions.

[Review information.]

[Review three definitions.]

The National Weather Service updates the "normal" monthly precipitation records at the end of each decade. These long-term monthly precipitation averages are important since they are used to identify precipitation deficits.

If you look at Table 5.1, you will see the relationship between Drought Stage Conditions and amounts of Actual Precipitation Deficit. As the deficit percentage increases, for both 12-month and 3-month periods, the Drought Stage becomes more serious.

Now let's turn to the next earliest indication of a potential drought situation, **streamflow**.

Streamflow

[Review information. Mention that if a surrogate streamgage is used, it is one located in similar hydrologic conditions.]

[Using the script information below, provide background information about DEP's streamgage network and why specific gages were selected to be part of its drought-monitoring network. You may want to record the 4 criteria on an easel.]

DEP selected the 73 gages used in the drought-monitoring newtwork from all the gages across the State by asking: 1) which gages are most representative of the hydrologic conditions of the area?, 2) which gages have long-term records?, 3) which gages are spatially distributed to cover entire state, and 4) which gages have been found to be the best indicators of drought conditions in the past?

[Review definition.]

If you look at Table 5.2, you will see that Exceedance Flow Values are positively correlated with Drought Stage Conditions. The higher the Exceedance Flow is, the higher or more critical the Drought Stage is.

Now let's move on to the third indicator, **Groundwater levels**.

Groundwater Levels

[Review information.]

Because suitable monitoring wells with adequate periods of record do not exist in each of Pennsylvania's 67 counties, you'll see that a surrogate monitoring method may also be used for this indicator of drought stage.

The 2-3 month groundwater lag occurs because precipitation deficits can accumulate for several months before the resultant lack of groundwater recharge becomes evident in lowered groundwater levels.

[Review definition.]

On Table 5.3, you can see the relationship between Groundwater Level Exceedance values and Drought Stage Conditions. Groundwater Level Exceedance, like Exceedance Flow Value for a stream, is positively correlated to the drought stage.

Now let's move on to the fourth indicator, **Palmer Drought Severity Index or Soil Moisture.**

Palmer Drought Severity Index (Soil Moisture)

[Review the Palmer Index information.]

I would like to share additional information about Palmer Index with you. Pennsylvania is divided into ten (10) Palmer regions, with multiple Counties in a particular region. A Palmer Index is calculated weekly for the soil moisture for each Palmer region.

Computed values of Palmer Index range from +6.0 to -6.0, with -2.0 signaling the potential onset of drought stage conditions. Table 5-4 illustrates how Palmer Index Values indicate the three (3) drought stage conditions.

Now, let's turn to the fifth and final parameter, **Reservoir Storage**.

Reservoir Storage

[Review information.]

[Explain why there is no accompanying table showing a one-to-one relationship for reservoir storage parameter values and drought stage condition. Use the script below.]

The use of reservoir storage as a drought stage indicator is complicated because it varies seasonally. For example, a lower reservoir level in the Spring is less of a concern than it would be at the end of Summer due to expected refill from Spring rainfall.

We've finished our review of the five (5) hydrologic conditions used by DEP to assess drought status. DEP uses these parameters to monitor water supply drought conditions in Pennsylvania's counties.

Let's take a closer look at the three (3) **Drought Stages** and major actions required by each.

DROUGHT STAGES: 7 minutes

[Review information.]

Drought Watch

Let's begin our focus on Drought Stages with **Drought Watch**. We'll see how the five parameters (5) we just discussed play an important role in the three-stage process used to identify a drought stage.

[Review the Drought Watch information, including its Purpose. Mention that specific water suppliers may request more stringent water conservation actions, due on varying conditions. Also note the 5% water reduction objective for voluntary water conservation measures.]

[Point out that both DEP and the Task Force increase their monitoring and reviewing activities during a drought watch.]

[Ask the class how many drought indicators are required to signal a drought watch condition.]

Ans: Three or more.

[Ask the class to name the five (5) drought indicators.]

Ans: Precipitation, Streamflow, Groundwater Levels, Palmer Drought Severity Index (Soil Moisture), and Reservoir Storage.

Now, let's turn to the second drought status condition, **Drought Warning**.

Drought Warning

[Review information.]

The process followed for a drought warning is similar to the process for a drought watch. First, three or more indicators signal a potential drought condition—however, the indicator levels, or values, are now elevated to the warning level. (We saw the breakdown of watch, warning and emergency levels on the parameter tables we reviewed.) Second, the drought warning process ends, if necessary, with DEP issuing an announcement for the affected Counties.

[Review the drought warning Purpose. Mention that individual water suppliers or municipalities may request more stringent conservation actions.]

Now, let's turn to the third, and final, drought status condition, **Drought Emergency**.

Drought Emergency

[Review information.]

There are two important points I'd like to make regarding drought emergency proclamations: First, drought emergency proclamations are made by the Governor, and not DEP as in drought watches and drought warnings. Second, in conjunction with a proclamation, the Governor has the authority to order <u>mandatory</u> restrictions on nonessential water use.

[Review the Purpose of a drought emergency, including the objectives of mandatory or voluntary conservation measures. Note the increased water reduction objective of at least 15%.]

[Review information. Point out that during a drought emergency, there is a concentrated management phase of operations for DEP, PEMA, and the Task Force.]

[Ask the class how they could reduce water demand through conservation measures.]

Ans: *[Possible answers include:*

- *Reduce outside use of water, such as washing cars and watering yards,*
- *Check for leaks in pipes, faucets, and especially toilets,*
- *Take shorter showers,*
- *Install water-saving showerheads or flow restrictors,*
- *Turn off the faucet while brushing teeth or shaving,*
- *Use the dishwasher or washing machine only with full loads, and*
- *Keep a bottle of water in the refrigerator for drinking rather than running the faucet.]*

In some cases, water conservation measures and restrictions may not be sufficient to protect the water supplies. In these instances, **Water Rationing** may be imposed.

Water Rationing

[Review information for both keys.]

[When reviewing the water rationing information including Water Rationing Plans, stress that only the Governor has authority to ration water resources.]

As you can see, the primary purpose of water rationing is to protect the limited water supply sources for essential uses.

Next, we will focus on **Drought Contingency Plans**—their content and implementation.

DROUGHT CONTINGENCY PLAN: <u>5 minutes</u>

[Review the information.]

There are a two points I want to mention about Plans and a drought emergency proclamation. First, following proclamation of a drought emergency, each water supplier that has a source of supply or service area in the drought emergency area is required to develop, adopt, and submit a Drought Contingency Plan to DEP for distribution to appropriate agencies. Second, a Drought Contingency Plan prepared and approved within 3 years of the proclamation satisfies Plan submission requirements; however, an approved Plan can be updated or amended by the water supplier and resubmitted to DEP for approval.

Plan Contents

[Display Slide 18—Drought Contingency Plan Contents]

[Review Plan Contents.]

<u>[Water Supplier Information]</u>
- *[Name, address and telephone number]*
- *[Staff or officers responsible for drought emergency operations]*

<u>[Source Information]</u>
- *[Description of all water sources used by the system]*
- *[Locations and yields of the sources]*

[Display Slide 19—Drought Contingency Plan Contents]

[Continue reviewing Plan Contents.]

<u>[Withdrawals for Previous Year]</u>
- *[Monthly average and peak day withdrawals from each source]*

<u>[System Water Demands for Previous Year]</u>
- *[Monthly average and peak day system demands for each month during the previous year]*

<u>[System Criteria to Identify Water Shortage]</u>
- *[Description of criteria to be used to identify the onset of water shortage problems in the system]*

[Display Slide 20—Drought Contingency Plan Contents]

[Continue reviewing Plan Contents.]

[Plan of Action]

- *[Description of actions that will be taken to respond to drought or water shortage conditions, including a phased reduction of total system withdrawal and use.]*

[Procedure for Granting Variances or Exemptions]

- *[Procedures to be taken by a water system customer to receive a variance or exemption from Plan provisions.]*
  - *[Purpose: Address extraordinary hardships that may result from implementation of Plan measures.]*

Now, let's look at **Plan Implementation**, and drought indicators (or triggers).

Plan Implementation

[Review information for both keys.]

We know that there are five (5) parameters that are used by DEP to assess drought stages. We also know that a combination of parameters (or indicators), along with other considerations, are used to determine drought stage condition for a county.

Next, we will discuss Local Drought Indicator Triggers (used by water suppliers since these triggers concern local surface water supply), and 2) Regional Drought Indicators.

[Review information.]

[Review Table 5.5.]

Following approval of its Drought Contingency Plan, a water supplier should trigger its appropriate emergency response measures when DEP (or a river basin commission) makes a basin or regional drought-level determination. However, for drought emergency situations, the water suppliers should follow drought measures designated by the Governor or PEMA.

Which local drought condition indicators should water suppliers use? Why?

Ans: Reservoir storage levels, groundwater levels, and streamflow; because these indicators are related to their key sources of supply.

Now that we've reviewed Drought Contingency Plans, let's begin focusing on ways to reduce water demand—**Demand Reduction Measures**.

Demand Reduction Measures: <u>3 minutes</u>

Voluntary to Mandatory to Rationing

Voluntary and mandatory demand reduction measures are important strategies for drought status conditions. Although we've discussed reduction and conservation measures throughout the unit, let's look at a concise summary that illustrates the progression of reduction measures.

[Review information.]

In addition, it is important to focus on large users since they consume a significant amount of water.

Large User Alternative Supplies

[Review information.]

What are some examples of large users in this area?

Ans: Possible answers could include large service and health care organizations such as hotels, restaurants chains, and hospitals; specific industries such as the manufacturing industry; and business organizations that employ a significant number of employees.

[Review information.]

Although large users are a significant consumer of water supplies, it is equally important to consider individuals and smaller groups. An effective way to reach these types of water customers is through **Public Education** strategies.

Public Education

[Review information.]

What are some ways to reach customers in order to provide public education?

Ans: *[Possible answers could include bill stuffers, articles in local newspapers, news broadcasts, and presentations to local civic organizations.]*

We've just discussed three strategies to reduce water system demands (Voluntary to Mandatory to Rationing, Alternative Supplies for Large Users, and Public Education). Now we will turn to ways to extend the water system supply—**Supply Extension Measures**.

SUPPLY EXTENSION MEASURES: <u>3 minutes</u>

Leakage and Loss Reduction Program

[Review information.]

In addition to minimizing water loss through the detection and repair of leaks in water systems, it may be possible to extend the water supply by connecting with another nearby water system.

Bulk Purchase from Interconnected System

[Review information for both keys.]

A water supplier, located in a County experiencing a drought condition, is considering using water from an interconnected or neighboring system. What should the supplier consider?

Ans: *[Possible answers could include:]*

- *[Availability of surplus water at the neighboring system,]*
- *[Existence of a permanent interconnection point,]*
- *[Potential to develop a temporary interconnection point at a feasible location,]*
- *[Hydraulic capacity of the interconnection and adjacent distribution systems, and]*
- *[The cost of water.]*

So far we've discussed two measures to extend water supply (Leakage and Loss Reduction, and Bulk Purchase from Interconnected System). Next, we will look at the third measure--**Emergency Sources of Water**.

Emergency Source of Supply

[Review information for both keys.]

The fourth and final supply extension measure is **Reduction of Conservation Releases**, and is only applicable under drought emergency conditions.

Reduction of Conservation Releases

[Review information for both keys.]

We have now completed Unit 5: Drought Contingency Planning. During this unit, we've focused on the following learning objectives.

[Re-display Slide 17—Unit 5: Drought Contingency Planning.]

- *[Named the five hydrologic conditions used by DEP to assess drought status.]*
- *[Named the three drought stages and describe the major actions required by each.]*
- *[Described the major components of a Drought Contingency Plan, and]*
- *[Defined the triggers for each type of surface water supply that are used in a local drought contingency plan.]*

Does anyone have any questions about anything we've covered in Unit 5?

[Answer questions appropriately.]

Please turn the page, where you'll find References for this unit.

[Review keys points.]

[Review References.]

[Ask participants if they have any questions. Thank them for their participation and wish them well as they prepare for the plant operators test. Remind participants that this workbook has been designed not only for instructional purposes but as a reference resource.]