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DEVELOPING AN INDIVIDUAL PUBLIC WATER SUPPLY DROUGHT CONTINGENCY PLAN

Responsible public water supply system managers realize that in times of drought and other potential water shortage, it is necessary to take early action to extend existing water supplies and reduce unnecessary water usage. This ensures that sufficient water is available at all times to preserve public health, sanitation and safety. The process whereby these actions are taken should be outlined in a drought contingency plan.

During normal and wet periods, water supplies generally exceed system water demands with excess capacity available. However, during prolonged drought periods, supply and demand may become greatly imbalanced, with water demand exceeding available supplies. At that point, the public water system manager must implement measures to simultaneously extend existing supplies, develop additional supplies, and reduce demands. Measures available to increase supplies may include the purchase of water from adjacent water suppliers via interconnection, increasing the efficiency of the existing distribution system through accelerated leakage and loss reduction programs, the development and utilization of emergency sources of supply, including asking commercial or industrial customers to use their own emergency sources, and the approved reduction of passby or conservation releases. Demand reduction measures may include a call for voluntary conservation, installation of household water conservation devices, accelerated public education programs, water reuse and greywater recycling, mandatory nonessential water use bans, water rationing, the possible shedding of customers, and prioritizing competing uses. The goal of any water shortage emergency response plan must be to balance demands with remaining available supplies for the duration of the event.

Assuming that the public water supply manager knows what supply extension and demand reduction measures are available, and how these measures may be implemented, the greatest difficulty will be to know when to implement these measures. Therefore, each public water system manager must develop drought indicator criteria or triggers that will accurately identify the onset of drought occurrences in a timely fashion. The criteria or triggers must give sufficient warning for adequate drought response, but not trigger these actions so prematurely or so frequently that the public may become complacent and unresponsive. The drought triggers should be tailored to the sources of supply of each individual public water supply system, although regional drought indicators as monitored by the Department of Environmental Protection (DEP), can be utilized for additional confirmation of developing drought conditions. Drought triggers and responses should be staged with progressively stricter and more severe response measures reserved for true emergency situations. The initial triggers should allow for early response actions while there is still water available to conserve existing supplies. Subsequent triggers generally indicate the onset of a severe water shortage emergency, and water rationing may eventually be necessary. Good drought management can make a difference in the levels of curtailment required and can prevent a complete shutdown of local business and industry during severe drought.

An effective drought contingency plan should consist of a series of staged water supply extension and water demand reduction measures that would be triggered by monitoring key sources of supply. Generally, three stages would be identified, each triggered by a progressive decline of the source of supply. Included with the drought monitoring program would be a planned public education and awareness program to inform the public of the problem and instruct them in the actions or responses needed. See the “Drought Contingency Plan Example” at the end of this document for a general outline of a drought emergency plan.

DROUGHT INDICATORS AND TRIGGERS

A number of drought indicator parameters are available to the public water supply manager for monitoring and triggering drought stages. These include reservoir storage levels, groundwater levels and streamflows. Regional drought indicator criteria such as accumulated precipitation deficiencies and soil
moisture indices may be used in combination with individual system supply indicators. The public water supply manager as a starting point should choose an indicator(s) that can be used to monitor the system’s key supply source(s). If the water supply system has one or more reservoirs as sources of supply, the storage levels of these reservoirs should be used for principal monitoring. If the public water supply system utilizes wells for supply, the public water supplier should monitor through the use of groundwater pumping levels, well yields of the key well or wells in each wellfield. If the public water supplier uses a stream or river as the principal source of supply, the streamflow should be monitored. For those public water supply systems utilizing larger rivers or lakes with drainage areas greater than 2,000 square miles as sources of supply, where ample streamflow or water storage is available to supply all water supply and instream flow needs, the public water supplier should follow the DEP’s regional drought triggers. If the public water supplier’s service area is part of a drought emergency area declaration by the Governor, regional drought response measures designated by the Governor and Pennsylvania Emergency Management Council (PEMC) should be followed. These response measures may include bans on nonessential uses of water. For public water suppliers that utilize combinations of ground and surface water sources, the principal or key supply source should be monitored and used as the trigger. Public water suppliers purchasing most or all of their supply from other public water suppliers should respond to drought conditions as outlined in the predominant supplying water supplier’s drought contingency plan.

DEMAND REDUCTION MEASURES

The demand reduction measures implemented by a public water system manager generally follow a logical progression from voluntary water use restrictions to a mandatory nonessential use ban. However, if under severe water shortage conditions, water rationing maybe implemented. A water rationing plan is designed to reduce water usage within residential dwellings, commercial and industrial establishments, and institutions. It should also promote the continued reduction of water use under the nonessential use bans noted above. Water rationing may only be imposed if the water supplier’s service area is part of a drought emergency area designated by the Governor and approved by the PEMC. During drought emergency situations, large customers may be encouraged to use alternative supplies that may be available such as an on-site well supply. All options should be configured early on to determine their feasibility and should be included in the drought contingency plan.

Ongoing efforts to educate water customers about water conservation practices should be increased during early drought conditions. Customers should be alerted to drought conditions and informed of actions required to respond to water shortages. This may be accomplished through local newspaper, TV stations and presentations on water conservation and drought response activities to local organizations. Water conservation literature should be distributed to residential customers to discourage wasteful habits and to encourage the installation of water-saving plumbing fixtures in homes that are not already equipped. Household leak detection programs should also be instituted during early drought conditions, and meter readers should inform customers with unusually high readings. The public water supply manager should meet with major commercial and industrial users to plan strategies for demand reduction in these facilities. DEP’s water conservation brochure, “Drop by Drop: Use Water Wisely”, is available through the eLibrary at [www.elibrary.dep.state.pa.us/dsweb/view/Collection-8032](http://www.elibrary.dep.state.pa.us/dsweb/view/Collection-8032).

An important aspect to implementing a drought contingency plan is the early notification to appropriate municipal officials and employees of the provisions of the plan that they will be called upon to implement and enforce. These plans should be developed and adopted by the public water supplier or local municipal authority as soon as possible so that implementation is not delayed during a water supply crisis. It is important that the plans be adopted as a rule, regulation, by-law or ordinance to empower appropriate enforcement agencies with the ability to levy fines, surcharges or other punitive measures for violations of the stated water use restrictions.
SUPPLY EXTENSION MEASURES

At the onset of drought conditions, the first supply extension measure normally implemented by a public water supply manager is a systemwide leakage and loss reduction program. The objective of this program is to reduce source depletion by minimizing avoidable distribution system leakage.

A second supply extension measure that may be implemented in any of the drought stages is the purchase of water from a neighboring public water supply system through an interconnection. This alternative assumes that a neighboring water supplier is located in close proximity and that the supplier has surplus water supplies. The drought stage in which this measure is implemented depends upon the existence of a permanent interconnection or development of a temporary interconnection between the two suppliers, the cost of the water, the availability of supply, and the hydraulic capacity of the interconnection and the adjacent distribution systems.

A third supply extension measure available to many suppliers is the utilization of an emergency source of supply. This may involve bringing on line a reserve well for temporary use, or it could involve the temporary development of a new source of supply such as springs, reservoirs, lakes, ponds, quarries or trucking water. Water supply permits and water allocation permits must be obtained prior to the use of a new emergency source. The first points of contact in the development of a new emergency source of supply are the county sanitarian and regional technical services chief of the DEP’s water supply program, as well as the county emergency management coordinator. For those supplies requiring water allocation permits, the municipal notification requirements under Act 14 of 1984 (71 P.S. § 510-5) must be met, whereby each municipality in which the activities are located must be notified 30 days prior to the issuance of any new permit. If possible, the public water supplier should include all necessary chemical and bacteriological analyses and sanitary surveys in the drought contingency plan. The public water supply manager should begin to obtain all necessary agreements, rights-of-way, easements, etc required to gain access to proposed emergency sources and to secure water through proposed emergency interconnections. An inventory or directory of necessary emergency equipment and manpower required to implement the development and operation of an emergency source should be compiled by the public water supply manager, in consultation with the county emergency management coordinator, and updated as necessary. Equipment, including 8-inch pipe and water buffaloes, may be available on a loan basis from the National Guard or the Pennsylvania Emergency Management Agency (PEMA) to aid in accessing emergency supplies on a timely basis. Because this equipment is limited, it is best to plan ahead to secure all necessary equipment from private commercial sources. However, inquiries regarding the availability of the National Guard or PEMA equipment should be addressed to the county emergency management coordinator.

Another measure to conserve remaining supplies is reducing downstream conservation releases below public water supply reservoirs or passby flows downstream from stream intakes. This measure is only applicable under drought emergency conditions and represents a last resort measure to be utilized when all other supply extension and demand reduction measures have failed to achieve the desired results. Before a public water supplier makes a reduction in the conservation release below an impoundment or passby flow downstream from an intake, permission must be obtained from the commonwealth drought coordinator of the DEP, in consultation with the Pennsylvania Fish and Boat Commission (PFBC). Adequate notice must precede a proposed lowering of any downstream conservation release or passby flow so that the DEP can confer with the PFBC and other appropriate agencies.

A well-conceived drought contingency plan can greatly enhance a water supplier’s ability to provide adequate potable water for the health and safety of its customers, even during moderate to severe drought events. The adoption of a drought contingency plan prior to drought events may eliminate the need for emergency meetings, as well as the confusion and indecisiveness that often accompany last minute planning efforts. Consequently, effective planning can make the transition into and out of drought events easier for the water suppliers and customers.
Many water supply managers and community leaders across the commonwealth believe that water conservation or wise use of water should be practiced at all times. Because the competition for water among various users is becoming more and more complex, the efficient use of available supplies is essential. There are many benefits of implementing water conservation concepts throughout a water supply service area. Saving water will save money for consumers on water, sewer, and water heating bills. Demand for water has a pronounced impact on the environment by lowering streamflows and lake levels, depleting groundwater aquifers, and in certain cases, requiring the impoundment of free flowing streams or the diversion of water from one drainage basin to another. Reducing per capita water use will decrease the amount of wastewater generated and thereby maintain the operating efficiency of treatment plants over a longer period of time. Reducing water consumption will reduce operating costs for utilities and will delay costly capital improvements to water systems that typically involve the expansion of water treatment or pumping plants and storage facilities. When compared to the cost of expanding existing facilities or developing new water sources, the most cost-effective alternative is conservation.

These guidelines have been prepared by the DEP to provide assistance in designing an effective water conservation program and reveal some alternative methods of conserving water. Not all of the recommended conservation methods have application to every water purveyor. Instead, the guidelines should be considered a checklist that may be used to select the most applicable, economically-feasible conservation methods to implement within your service area or community.

These guidelines have been organized in two categories: 1) supply management methods, which include leakage/loss control and water meter management; and 2) demand management methods, which include pricing, water conservation education, and local water-use regulations.

I. SUPPLY MANAGEMENT METHODS

A. Leakage/Loss Control

1. Prepare a map of the water distribution system showing:
   a. Main transmission lines
   b. Street valves
   c. In-line metering locations
   d. In-line pressure-reducing valves
   e. Hydrant locations
   f. Locations of breaks/leaks repaired in last 10-year period
   g. Areas of potential system expansion or interconnection

2. List the name and age of all facilities to be monitored in conjunction with a leakage/loss program.

3. Show the number of full or part-time employees engaged in an ongoing leak detection program. If no ongoing program exists, report when the last leak survey was conducted, by whom, and on what portion of the distribution system.

4. Describe ongoing valve and hydrant maintenance activities. All valves and hydrants should be exercised and sounded for leakage at least annually.
5. Give the location of frost and subsidence prone areas and areas of pipe crossover or interference. Indicate transmission line age and composition in terms of materials used, diameter, lined or unlined, etc.

6. Institute a program that includes an accurate recording of system pressure for each separately operated pressure zone, leaks detected, and leaks repaired. A sample log sheet for recording leak detection/repair activities is shown on page seven for your consideration.

B. Water Meter Management

1. All sources and service connections should be metered to ensure accountability of water delivered. If sources or service connections are not metered, a plan should be developed that outlines a schedule for compliance. Institute a program that includes an accurate recording system of meters tested, repaired, or replaced. The following testing or replacement guidelines are recommended for each type or size of meter.

<table>
<thead>
<tr>
<th>Meter Size (Inches)</th>
<th>Test/Replacement Period (years)</th>
<th>Registration Variance (Less Than 4%) at Flow Rate (gpm)</th>
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<tr>
<td>Source Meter</td>
<td>1</td>
<td>--</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>300</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>180</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>50</td>
</tr>
<tr>
<td>1-1/2</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>3/4</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>5/8</td>
<td>20</td>
<td>6</td>
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A sample meter testing/replacement log sheet is shown on page eight.

II. DEMAND MANAGEMENT METHODS

A. Pricing

1. Investigate alternative pricing methods (i.e., declining block with a minimum number of cost/unit steps, uniform block, peak pricing, excess use charges, etc.) that discourage water waste.

B. Water Conservation and Efficiency Education

1. Consider participating in the U.S. Environmental Protection Agency's (EPA) WaterSense program www.epa.gov/watersense as a promotional partner to educate others about the value of water and water efficiency. WaterSense partners have access to materials and web information to promote WaterSense labeled products and programs to consumers.

2. Promote water conservation and efficiency benefits and techniques through public water supplier’s website, information centers at local fairs, shopping centers, and public displays or exhibits.

3. Seek the cooperation of local school officials in initiating a program of water education activities.

4. Sponsor water conservation poster, slogan, essay or exhibit contests for children within the service area.

5. Initiate a water conservation program in high-use facilities, such as schools and colleges, hospitals and institutions, country clubs and health clubs, involving a retrofit of existing plumbing fixtures with water saving models and the dissemination of water conservation literature.
6. Promote a campaign of household leak detection. Provide leak detection tips on billing cards. Distribute dye tablets to customers to encourage toilet leak checks. Direct meter readers to inform customers with unusually high recorded use to check for household water leaks.

7. Speak to local civic organizations (Boy Scouts, Jaycees, volunteer fire companies, etc.) about water conservation.

8. Conduct public tours of water treatment plants, reservoirs, pumping stations, and other related facilities.

9. Conduct a workshop for plumbers, plumbing fixture suppliers, builders, and major water users to discuss the benefits of water conservation and the importance of installing water-saving plumbing fixtures.

10. Meet with major water users to formulate demand management plans for their facilities.

C. Local Water Use Regulations

1. Promote adopting a water conserving ordinance that requires installing water-saving plumbing fixtures and fittings in all new buildings constructed or in existing homes where building permits are issued for kitchen or bathroom remodeling work.

2. Institute requirements for installing water-saving plumbing fixtures and fittings as a condition prior to hook-up for new customers.

3. Encourage wise use and management of water during peak use summer periods by restricting lawn/garden watering to non-daylight hours.

4. Institute fines for the unauthorized use of water such as illegal hookups and hydrant discharges.

5. Promote land use regulations that protect critical groundwater recharge areas and potential well locations.
SAMPLE - RECORD OF WATER MAIN BREAKS

Report Number:
Break:

Reported by: ____________________________
Date: ____________________________
Location: ____________________________
Type: ____________________________
Obvious Cause: (e.g., construction blasting) ____________________________

Pipe:

Diameter: ____________________________
Thickness: ____________________________
Material: ____________________________
Joint: ____________________________
Corrosion or Siltation: ____________________________

Environs:

Soil Type: ____________________________
Depth of Pipe: ____________________________
Other Structures/Pipes in Contact: ____________________________

Repairs:

Start Time: ______ Date: ____________________________
Finish Time: ______ Date: ____________________________
No Repairs: __________
Why: ____________________________
Supervisor: ____________________________
Conditions at Break: ____________________________
Valves Shut Down: ____________________________

(number, size, location, time)
SAMPLE - RECORD OF METER TEST/REPAIR/REPLACEMENT

Meter Information:
ID Number: ________________________________________________________________
Manufacturer: ______________________________________________________________
Size: ______________________________________________________________________
Installation Date: __________________________________________________________________
Last Inspection Repair Date: __________________________________________________________________
Meter Reader Route: __________________________________________________________________
Reason for Testing: __________________________________________________________________

Test Information:
Date: ______________________________________________________________________
Test No.: ______________________________________________________________________
Pipe Size: ______________________________________________________________________
Rate During Test: __________________________________________________________________
Pitometer Results: __________________________________________________________________
Meter Reading: ______________________________________________________________________

Results:
1* GPM 6* GPM 10* GPM

☐ OK ☐ OK ☐ OK

% Fast % Fast % Fast
% Slow % Slow % Slow

Flow: Normal Induced
Length of Test:
Remarks:
______________________________________________________________________________

Examiner: ______________________________________________________________________

*Suggested Flow Rates for 5/8" meter
ESTABLISHING DROUGHT TRIGGERS FOR PUBLIC WATER SUPPLIERS UTILIZING STREAMS, RIVERS OR SPRINGS

For public water suppliers utilizing streams, rivers or springs as a principal source of supply with little or no storage available at the source, the gaged streamflow or springflow should be monitored. Where streamflow or springflow is limiting, it should be used for triggering the various stages of a drought contingency plan. On smaller streams, flows may be measured by installing a rectangular weir and computing flow using the basic weir equation (see Figure 1). For larger streams and rivers, streamflows, as measured from the nearest appropriate U.S. Geological Survey (USGS) gaging station, should be monitored. If available supplies can reasonably be expected to drop below system demands, streamflows should be used for triggering the stages of a drought contingency plan. The USGS should be contacted for guidance in locating or establishing an appropriate gaging station for the stream or river supply in question. A gaging station is comprised of a section or channel control with a staff gage. A series of stage versus discharge measurements at the section or channel control is used to develop a rating curve. The rating curve can then be used to convert gage height readings to discharge quantities.

RECTANGULAR WEIR FOR MEASUREMENT OF FLOW IN A SMALL STREAM

Where flows from stream or river are several magnitudes greater than current or projected usage and source adequacy is assured, the public water supplier should follow the commonwealth’s and/or the river basin commission’s basin or regional drought level triggers. In this case, when the commonwealth or river basin commission makes a basin or regional drought level determination, the public water supplier’s coinciding drought stage and appropriate emergency response measures should be triggered.

Where streamflow or springflow is a limiting factor and supplies during time of drought drop near or below current demands, drought response measures should be triggered. At what point these actions are triggered depends on the amount of reserve source capacity available within the public water supply system, including reserve wells, interconnections with other suppliers, and additional surface water sources. Certainly a no spill or no flow passby condition at the stream or spring intake, where little or no storage is available, would trigger appropriate response measures. Typically several drought stages would trigger this flow condition in order to cut demands, stretch available supplies, and consider additional source options. These flow triggers must be developed locally on a case-by-case basis, taking into account existing supply options, both within the system and via interconnections, and the reliability of those supplies. The flow triggers must be established at flow levels above or at the no spill or no passby level to trigger drought watch, drought warning or drought emergency conditions and the appropriate response measures.

The flow levels should be established so they trigger in a timely fashion, giving sufficient warning for an adequate emergency response but not triggering so frequently or prematurely that the public may lose confidence or become complacent. If it is found that drought triggering occurs every year, the public water supplier should consider additional source development and a more aggressive water conservation program for the system.
RECTANGULAR WEIR FOR MEASUREMENT OF FLOW
IN A SMALL STREAM

**BASIC WEIR EQUATION** \( Q = CLh^{3/2} \)

Where \( Q \) = The discharge in cubic feet per second

\( C \) = A coefficient dependent on the nature of the crest and the approach conditions (\( C = 3.33 \) for sharp crested weir)

\( L \) = the length of the crest in feet

\( h \) = the head on the crest in feet measured from the crest to the water level in the pool behind the weir

Figure 1
ESTABLISHING DROUGHT TRIGGERS FOR PUBLIC WATER SUPPLIERS
UTILIZING RESERVOIR SOURCES

Public water suppliers using one or more raw water reservoirs or impoundments as their principal source of supply should monitor, the storage levels of those reservoirs. Where storage is limited, storage levels should be used for triggering the various stages of a drought contingency plan.

A trigger is a device used to indicate the severity or stage of a localized drought. The stage is the main feature in the development of a drought contingency plan. There are three stages; Stage I, Stage II and Stage III, corresponding respectively to the local conditions of a drought ‘watch,’ ‘warning’ or ‘emergency.’ Each stage prescribes measures that can be taken to mitigate drought conditions on both the demand and supply sides.

However, if usable raw water storage provides less than a 90-day supply, streamflow becomes the limiting factor. It should be monitored and used for triggering the various stages of a drought contingency plan. Separate triggering guidelines are available for these types of sources.

In order to determine the amount of storage in a raw water reservoir, a reservoir storage curve (schematically shown in Figure 2) must be developed so that the water elevation (normally expressed in feet above mean sea level) may be converted to storage (usually expressed in million gallons or acre-feet). Reservoir storage curves are generally developed by taking soundings across a number of cross sections of the reservoir. A contour map of the reservoir bottom may then be plotted and storage volumes computed for given elevations. The spillway elevation’s equivalent storage is generally considered a 100 percent full condition. However, usable storage may not be the total amount of storage (gross storage) read from the reservoir storage curve due to siltation and sediment losses in the bottom of the reservoir pool. Some attempt should be made to periodically estimate the amount of sedimentation in the reservoir. Siltation measurements are made as outlined above by taking soundings across a number of cross sections of the reservoir. New siltation measurements should be taken if it has been a considerable length of time since the last measurement or if there is reason to suspect a significant change in siltation, such as after a severe flooding event. This sedimentation storage loss can then be deducted from the gross storage to determine usable storage.

Once the reservoir storage curve is developed, usable raw water storage conditions can be periodically monitored. Usable raw water storage should, at a minimum, be determined once a week, although many water suppliers monitor their reservoir storage levels daily. When more than one reservoir is utilized, the usable storage of all raw water reservoirs should be combined. Then, using the routing equation shown below, the number of days of supply remaining can be computed by dividing the total raw water storage remaining by the average daily depletion rate (net inflow minus demand). Net inflow is defined as the streamflow entering the reservoir minus evaporation, seepage, and conservation releases. The routing equation is defined as follows:

Routing Equation

\[(I - D) \Delta t = \Delta S\]

where:

- \(I\) = net inflow
- \(D\) = water demand
- \(\Delta t\) = change in time in days
- \(\Delta S\) = change in storage (million gallons).

Solving the routing equation for \(\Delta t\):

\[\Delta t = \frac{\Delta S}{I-D}\]
or, transformed this equation becomes:

\[
\begin{align*}
\text{number of days until reservoir will be depleted} &= \frac{\text{Storage Remaining (mg)}}{\text{Depletion Rate (mgd)}}
\end{align*}
\]

In the transformed form of the equation it is assumed that "storage remaining" is the total quantity of water, which is yet reserved for depletion; therefore, it would represent a negative change in storage in the routing equation. "Depletion rate" assumes that water demand (D) is greater than net inflow (I); therefore, the term I-D would also be negative in the routing equation. Since both the numerator and denominator would be negative in the term \(\Delta S / (I - D)\), t would be positive. Multiplying the term \(\Delta S / (I - D)\) by \(-1/-1\) will leave \(\Delta t\) positive, while converting \(\Delta S\), the "storage remaining" to a positive value and converting I − D to D − I, or a positive "depletion rate."

As defined above, the number of days of supply remaining in a reservoir is an important parameter that can be used in triggering the various stages of a drought contingency plan. If inflow, evaporation, seepage and conservation releases are negligible or balance out the number of days of supply remaining. It can be approximated by dividing the total raw water storage remaining by the average daily system demand.

Before storage level triggers can be established for a raw water reservoir, it must be determined if the reservoir can be expected to refill every year or if there will be years during drought periods when the reservoir will not fill. Expressed another way, during a severe drought (50-year frequency or greater), will the drawdown and recovery (refill) period for the reservoir exceed 12 months? If the drawdown/recovery period exceeds 12 months, then the reservoir will be termed a large reservoir. If the reservoir's drawdown/recovery period is less than 12 months (i.e., it can be expected to refill each spring even in times of severe drought), it will be termed a small reservoir. Sometimes demand or draft rate can dictate whether a reservoir will refill annually or not.

A Rippl mass diagram can be helpful in understanding the difference between a large and small reservoir. Figure 3 shows a typical small reservoir's Rippl mass diagram. Cumulative runoff (inflow) is plotted against time for the drought of record. In practice, the recorded flows should be adjusted for evaporation, seepage and conservation releases. Thus, it is possible to exhibit a negative slope on the mass curve if the rate of losses as noted above exceed the available inflow. Typically, a sag in the mass curve occurs during late summer and early fall baseflow periods. A demand or draft rate (straight line for a constant draft rate) is superimposed on the runoff curve at a tangential point showing the rate at which water is withdrawn for use in a water supply system (see Figure 2). Where the runoff (mass) curve is steeper than the draft line, the natural stream flow is at a higher rate of supply than the rate of draft. Consequently, some of the streamflow is available for storage or it will spill if the reservoir is already full. Where the mass curve has a flatter slope than the draft line, water will be withdrawn from storage in order to maintain the required rate of draft. The storage required to supply a given demand or draft rate is therefore the maximum intercept between the demand or draft line and the mass curve. Again referring to Figure 3, the critical duration is defined as the length of time between the start of drawdown (tangent point of draft line) until the maximum drawdown is reached (maximum intercept) and recovery begins. The higher the demand or draft rate (Demand B), the greater the drawdown and storage required, and the greater the critical duration before recovery and refill can begin. Therefore based on Rippl mass diagram, steps taken towards water conservation early on in a drought occurrence can save significant amounts of reservoir storage and promote a much earlier recovery from the effects of the drought.

To demonstrate how a large reservoir behaves the Rippl mass diagram, such as the one shown in Figure 4, should be utilized. Here the draft rate is such that refill does not occur in the first year, or even the second or third year, of a prolonged drought. In fact, draft rates 1 and 2 are so great that the reservoir will empty prematurely in the first or second year of the drought, with little or no yield available for the remainder of the drought. The dependable yield of a reservoir is equal to the maximum demand or draft rate, which will allow eventual refill, which has a maximum intercept that equals the quantity of usable storage in the reservoir. Only if the draft rate is equal to or less than the dependable yield will the reservoir...

- 12 -
keep from going completely empty and experience total recovery in the fourth year of the drought, as in this example. Critical duration in this case is 3.25 years until final recovery begins leading to a complete refill and recovery. Under these circumstances, great opportunities exist for the conservation of storage through demand reduction and supply extension measures. If such actions are taken early to reduce the demand rate the critical duration and period of drawdown to total recovery can be substantially reduced, even to the point that the reservoir refills a year or two earlier during a drought of the magnitude of the drought of record.

The procedure for triggering the various stages of a drought contingency plan for the small reservoir case or a group of small reservoirs is basically tied to the routing equation with continuous storage level monitoring required. For small reservoirs with 90 days or less of storage, a no spill condition should be the first trigger whereby voluntary conservation measures are requested. If over 90 days of storage is available in a reservoir’s storage capacity, a no spill condition may only dictate that additional monitoring is needed. This condition should be viewed as an early warning. Certain other general guidelines may be concluded. When a small reservoir or group of reservoirs are drawn down to a 60-day supply or less remaining, a second stage of the drought contingency plan should trigger, calling for mandatory nonessential use restrictions and supply extension measures to be implemented. When only a 30- to 40-day supply is left in the reservoir or reservoirs, water rationing should be implemented.

Within this framework of general guidelines, other monitoring and computational procedures may be followed to determine when triggering should occur in a timely fashion. Figure 5, demonstrates the routing equation is solved for \( \Delta t \), the number of days until the usable reservoir storage will be depleted. Using existing storage and current depletion rates, calculate whether \( \Delta t \) is large enough to last until the end of February when reservoir refill and recovery typically can be anticipated to occur.

If \( \Delta t \) is computed to be too small to last until the end of February, appropriate contingency actions are needed to decrease the depletion rate or increase the storage, and Stage I of the contingency plan should be triggered. With Stage I response measures in effect, the computations are repeated on at least a weekly basis to determine if Stage II or III response measures should be triggered. For small reservoirs, any water conservation or supply extension measures that are triggered and in effect should not be lifted until the reservoir or reservoirs have completely refilled. Temporary gains in storage, resulting from individual storm events, should not be viewed as full recovery with a corresponding relaxation of contingency measures.

Figure 6 presents a tabular example of a typical reservoir monitoring and triggering procedure. In this case, the reservoir storage is measured weekly using the reservoir storage curve. Depletion rate is computed simply as the negative change in storage over the week. By computing depletion rate in this manner, inflow, evaporation, seepage, conservation releases and system demand are all accounted for. Next, \( \Delta t \), the number of weeks of storage remaining until the reservoirs are empty, is determined by dividing the depletion rate into the remaining storage. By comparing this with the number of weeks until the end of February, potential shortfalls may be determined. If the number of weeks of storage available falls below the number of weeks until the end of February (as occurs on August 9 in the example), a drought stage should be triggered and response measures implemented, including the cutting of demands and the extension of available supplies. Continued weekly storage monitoring and recording will dictate the triggering of Stage II and Stage III of the drought contingency plan.

The procedure for establishing triggers for large reservoirs which are not expected to refill every year, particularly during periods of severe drought and that typically have hundreds of days of supply available in storage is somewhat different. For these facilities, reservoir operation rules must be developed and implemented to prevent the loss of too much storage in any single year. These operating rules should be developed based on a hydrologic study of the reservoir system using flow simulation techniques for the period of record available and the routing equation discussed previously. Where historical flow records are not available or are insufficient, streamflows can be correlated with nearby, similar gaged watersheds with adequate records. If reservoir storage conditions enter a Stage III level, the weekly monitoring and computational procedure used for small reservoirs should be undertaken to assure that the reservoir does
not go dry. For large reservoirs, water conservation efforts which are in effect (including demand reduction and supply extension measures) should not be lifted or relaxed until the reservoir storage levels have recovered to a level at least 10 percent above the Stage I triggering zone.

A hypothetical large reservoir operating rule curve is shown in Figure 7 with sample trigger points in Figure 8. Typically, reservoirs should be full or at their highest levels during the period between May 1 and July 1 of each year. Reservoirs then draw down to their lowest levels, which historically occur between October 1 and December 1 of the year. Large reservoir operating rule curves generally follow this trend so that a given low reservoir level in June becomes a much more serious occurrence than the same low level in November. The reason for this is that in the months after November, one can reasonably expect reservoir refill and recovery to occur, while during the months following June, drawdown can reasonably be expected. It should be kept in mind, however, that an operation rule curve should always be based on a hydrologic study of the reservoir or reservoirs in question, using flow simulation over the period of record available and the routing equation. Reservoir drawdown for each year can then be computed, and using a statistical analysis, operating rule curves can be developed based on the historical probability of refill. Figure 8 shows typical operating rule curves which are based on reservoir flow routing studies and typify those currently in use for the New York City/Delaware River Basin reservoirs.
RESERVOIR STORAGE CURVE

Spillway Elevation

Elevation in Feet

Sediment

Usable Storage

STORAGE IN MILLION GALLONS

Figure 2
RIPPL MASS DIAGRAM
SMALL RESERVOIRS

Figure 3
(NET INFLOW – DEMAND)
INCREMENT OF TIME = CHANGE IN STORAGE, SMALL RESERVOIRS

Where net inflow = Streamflow entering reservoir minus evaporation, seepage and conservation releases

1) \((I-D) \Delta t = \Delta S\) (Routing Equation)

2) \(\Delta t = \frac{\Delta S}{(I-D)}\)

Storage Remaining, mg = number of days until reservoir will be depleted
Depletion Rate, mgd

Small Reservoirs
1. Whenever drawdown begins, solve equation (2) for \(\Delta t\).
2. Is \(\Delta t\) large enough to make it to the end of February?
   i.e., \(\Delta t\) calculated on Sept. 1st = 150 < 180 (days to Feb. 28)
3. If \(\Delta t\) is too small, then appropriate actions are needed to decrease the depletion rate or increase the storage.

Phase I of contingency plan begins
4. Repeat Steps are through three to determine if Stages II or III should be activated.
6. Don’t lift conservation efforts until reservoir is full.

Figure 5
## RESERVOIR STORAGE RECORDS

<table>
<thead>
<tr>
<th>Date</th>
<th>Storage, MG</th>
<th>Depletion Rate, MG/WK</th>
<th>Weeks of Storage Remaining</th>
<th>Weeks Until End of February</th>
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<tr>
<td>6-7</td>
<td>153.8</td>
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<td>6-14</td>
<td>151.5</td>
<td>2.3</td>
<td>65</td>
<td>38</td>
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<td>6-21</td>
<td>149.0</td>
<td>2.5</td>
<td>60</td>
<td>37</td>
</tr>
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<td>6-28</td>
<td>146.2</td>
<td>2.8</td>
<td>52</td>
<td>36</td>
</tr>
<tr>
<td>7-5</td>
<td>142.8</td>
<td>3.4</td>
<td>42</td>
<td>35</td>
</tr>
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<td>7-12</td>
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<td>3.6</td>
<td>39</td>
<td>34</td>
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<td>7-19</td>
<td>140.7</td>
<td>-</td>
<td>-</td>
<td>33</td>
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<td>7-26</td>
<td>137.3</td>
<td>3.4</td>
<td>40</td>
<td>32</td>
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<td>133.4</td>
<td>3.9</td>
<td>34</td>
<td>31</td>
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<tr>
<td>8-9</td>
<td>129.0</td>
<td>4.4</td>
<td>29*</td>
<td>30</td>
</tr>
</tbody>
</table>

*Begin Stage I of Contingency Plan

**Figure 6**
LARGE RESERVOIR OPERATING RULE CURVE

Figure 7
LARGE RESERVOIR OPERATING PLAN WITH TRIGGER POINTS

Figure 8
ESTABLISHING DROUGHT TRIGGERS FOR PUBLIC WATER SUPPLIERS
UTILIZING WELL SOURCES

TRIGGERS BASED ON PUMPING LEVELS

For public water suppliers utilizing wells for their supply, groundwater pumping levels, at least in the key wells, should be monitored and used for triggering the various stages of a drought contingency plan.

A trigger is a device used to indicate the severity or stage of a localized drought. The stage is the main feature in the development of a drought contingency plan. There are three stages. Stage I, Stage II and Stage III corresponding respectively to the local conditions of a drought ‘watch,’ ‘warning,’ or ‘emergency.’ Each stage will prescribe measures that can be taken to mitigate drought conditions on both the demand and supply sides.

The static water level, the pumping levels, and their associated drawdowns are schematically shown in Figure 9 and defined as follows:

Static Water Level. This is the level at which water stands in a well when no water is being taken from the aquifer either by pumping or by free flow. It is generally expressed as the distance from the ground surface (or from a measuring point near the ground surface) to the water level in the well. For a well that flows at
the ground surface the static water level is above the ground surface. It is measured after shutting off the flow of the well. The static water level in this case is sometimes referred to as the shut-in head.

When the static level in a well is 50 feet, it means that water stands 50 feet below the measuring point when there is no pumping. If a well has a shut-in head of 10 feet at the surface, it means that the artesian pressure in the well is such that water would rise 10 feet above the measuring point in a pipe extended above that point.

**Pumping Level.** This is the level at which water stands in a well when pumping is in progress. In the case of a free flowing well, it is the level at which water may be flowing from the well. The pumping level is also called the "dynamic water level." While less commonly used, dynamic water level is the more descriptive phrase of the two.

**Drawdown.** Drawdown in a well means the extent of lowering of the water level when pumping is in progress or when water is discharging from a free flowing well. Drawdown is the difference, measured in feet, between the static water level and the pumping water level. This represents the head in feet of water that causes water to flow through the aquifer material towards a well at the rate that water is being taken from the aquifer.

**Residual Drawdown.** After pumping is stopped, water levels rise and approach the static water level observed before pumping started. During such a recovery period, the distance that the water level is found to be below the initial static water level is called residual drawdown.

The static water level, pumping level and the associated drawdowns in a pumped well may be measured after the installation of an air line. The procedure for installing and operating an air line measuring device is presented in a separate paper entitled "Installation of Air Line for Water Level Measurement in Wells." Once a measuring device is installed, staged pumping level triggers should be established for the well. All of the staged triggers must be above the critical pumping level. The critical pumping level is defined as the lowest pumping level that can be tolerated in a well without producing conditions that would hasten deterioration or damage to the well or the pump. The critical pumping level, therefore, could be the top of the pump intake, the top of any well screen, or the top of any significant water producing zones. The location of significant water producing zones in a well may have been determined at the time of drilling and shown on a "well log" as in Figure 10. If the water-producing zone or zones are not known, the top of the pump intake or the top of any well screen will have to be used to determine the critical pumping level. Engineering geologists can be retained to determine the critical pumping level, but it is not essential.

After the critical pumping level is defined, two or three staged triggers should be established some distance in feet above the critical pumping level to trigger local drought watch, drought warning, and drought emergency conditions and the appropriate emergency response measures. These levels should be spaced so that they trigger in a timely fashion, giving sufficient warning for an adequate emergency response. These levels should not, however, trigger response actions so frequently or prematurely that the public loses confidence and does not respond. The process by which the trigger levels are established may well be on a trial and error basis, with adjustments to the trigger levels being made as additional pumping level data becomes available. Trigger levels may be further adjusted for time of year, knowing that natural groundwater levels are typically highest in the spring of the year and lowest in the fall of the year. Still, drawdowns to the critical pumping level generally cause damage to the well or pump, therefore, all trigger levels must be above the critical pumping level. Figure 11 schematically shows the annual fluctuation of groundwater pumping levels and suggests that pumping level triggers for a given well be set at 40 percent, 30 percent and 20 percent of the distance between normal pumping levels and the critical pumping level for each month of the year. At 40 percent of the normal pumping level minus the critical level, a drought watch would trigger, at 30 percent a warning would trigger, and at 20 percent an emergency would trigger. It should be kept in mind that these percentage triggers are merely suggestions that may be used on an interim basis until a more refined set of triggers are developed, or they can be used permanently if they are found to be appropriate for the well(s) in question.
An example may be helpful in explaining the suggested triggering system. Again referring to Figure 11, assume that a given well has a critical pumping level at 40 feet below the land surface and normal groundwater pumping levels at 10 feet and 20 feet below the land surface in April and October, respectively. Therefore, in April, the distance (D) between the normal pumping level and the critical pumping level is 40 feet minus 10 feet or 30 feet, and in October, D is 40 feet minus 20 feet or 20 feet. Triggers are to be set at 40 percent D for drought watch, 30 percent D for drought warning and 20 percent D for drought emergency. Thus, in April, triggers will be 0.4 x 30 or 12 feet, 0.3 x 30 or 9 feet and 0.2 x 30 or 6 feet above the critical pumping level of 40 feet for drought watch, drought warning and drought emergency, respectively. Put another way, April triggers will be 40 feet minus 12 feet or 28 feet, 40 feet minus 9 feet or 31 feet and 40 feet minus 6 feet or 34 feet below the land surface for the three drought stages, respectively.

October well level triggers will be much more compacted since groundwater levels are normally expected to be lower during this time of the year. Triggers are again set at 40 percent, 30 percent and 20 percent of 0°, the distance between normal pumping levels and the critical pumping level. In October, this distance is only 20 feet so that triggers will be set at 0.4 x 20 feet or 8 feet, 0.3 x 20 feet or 6 feet and 0.2 x 20 feet or 4 feet above the critical pumping level for drought watch, warning and emergency, respectively. These triggers may be interpreted as 40 minus 8 feet or 32 feet, 40 minus 6 feet or 34 feet and 40 minus 4 feet or 36 feet below the land surface for drought watch, drought warning, and drought emergency in October.

This method is available for computing drought trigger levels for specific wells, if a critical pumping level and normal pumping levels are known. If normal pumping levels are not known, an air line should be installed and periodic measurements should be taken to determine those levels.

In the interim event that no air line exists and the depths to water levels are unknown, triggers can be based on the capacity of the system. These trigger levels must be developed locally on a case-by-case basis, taking into account existing supply options, both within the system and via interconnections and the reliability of those supplies. The trigger levels should be established so they trigger in a timely fashion, giving sufficient warning for an adequate emergency response but not triggering so frequently or prematurely that the public may lose confidence and not respond. If after implementing the triggers, drought triggering occurs every year, the public water supplier should consider additional source development and a more aggressive water conservation program for the system.

It is generally true for most aquifers within Pennsylvania that as groundwater pumping levels drop lower, well yield decreases. Ideally, therefore, each trigger level should be set so that the demand for water can be reduced sufficiently to be equal to or less than the yield at the respective depth. Some safety factors should be allowed, as in the example method shown above, to provide contingencies for other emergencies such as peaking resulting from main breaks or fires, or well and pump deterioration resulting from clogging, corrosion and microorganism growth. If after implementing the triggers, drought triggering occurs every year or for extended periods during normal conditions, the public water supplier should consider well rehabilitation or additional source development along with a more aggressive water conservation program for the system.
### SAMPLE WELL LOG

<table>
<thead>
<tr>
<th>WELL CONSTRUCTION</th>
<th>DEPTH</th>
<th>GEOLOGIC LOG</th>
<th>GPM BLOWN</th>
</tr>
</thead>
<tbody>
<tr>
<td>12” Casing</td>
<td>0'</td>
<td>Red silty shale overburden</td>
<td></td>
</tr>
<tr>
<td>8” Casing</td>
<td>15'</td>
<td>Red to grayish-red silty shale</td>
<td></td>
</tr>
<tr>
<td></td>
<td>58'</td>
<td>Medium gray sandy siltstone</td>
<td>5 at 68'</td>
</tr>
<tr>
<td></td>
<td>68'</td>
<td>Light gray medium – to coarse</td>
<td></td>
</tr>
<tr>
<td></td>
<td>88'</td>
<td>Grained sandstone</td>
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</tr>
<tr>
<td></td>
<td>113'</td>
<td>Red silty shale</td>
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</tr>
<tr>
<td></td>
<td>143'</td>
<td>Medium gray sandy siltstone</td>
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</tr>
<tr>
<td></td>
<td>158'</td>
<td>Red silty shale</td>
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<tr>
<td></td>
<td>173'</td>
<td>Medium gray silty sandstone</td>
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<tr>
<td></td>
<td>213'</td>
<td>Red to reddish-brown shaly siltstone</td>
<td>26 at 256'</td>
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<tr>
<td></td>
<td>248'</td>
<td>Grayish-red sandy siltstone</td>
<td>100 at 273'</td>
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<tr>
<td></td>
<td></td>
<td>Fractured 278' to 282'</td>
<td>200- at 292'</td>
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<tr>
<td></td>
<td>293'</td>
<td>Medium gray silty sandstone</td>
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</tr>
<tr>
<td></td>
<td>308’</td>
<td>Grayish-red shaly sandstone</td>
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<td></td>
<td>338’</td>
<td>Medium-light gray silty sandstone</td>
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<td></td>
<td>368’</td>
<td>Red shaly siltstone</td>
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<td></td>
<td>383’</td>
<td>Grayish-red to gray silty sandstone</td>
<td>200- at 413'</td>
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<tr>
<td></td>
<td>413’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7-7/8” Open hole

Vertical Scale 1 inch = 60 feet

Figure 10
GROUNDWATER DROUGHT TRIGGERS

Figure 11
INSTALLATION OF AIR LINE FOR WATER LEVEL MEASUREMENT IN WELLS

Reference: Ground Water and Wells
Published by Johnson Division, Universal Oil Products Company, St. Paul, Minnesota 55165 (Pages 90 and 91)

Figure 12 shows the installation of an air line in a well for the purpose of determining the depth to water. The air line consists of a small diameter pipe or tube of a length sufficient to extend from the top of the well to a point several feet below the lowest anticipated water level to be reached during the life of the well. The exact length of the air line must be measured as it is placed in the well. If flexible tubing is used, steps must be taken to be sure that the tubing hangs vertically in the well and does not spiral inside the well casing. The air line must be completely air tight throughout its entire length and connections to it at the ground surface must be air tight.

Quarter-inch copper or brass tubing is commonly used for the air line. The upper end of the air line is fitted with suitable connections and valve so that an ordinary tire pump can be used to pump air into the tube. A tee is provided in the line to which a pressure gauge may be connected to measure the air pressure in the tube. A gauge calibrated to indicate pressure in feet of water serves better than one with a scale reading in pounds per square inch (psi).

The device works on the principle that the air pressure required to push all of the water out of the submerged portion of the tube, equals the water pressure of a column of water of that height. If this pressure is expressed in feet of water, the depth to water can be calculated.

A necessary first step is to determine accurately the depth from the top of the well casing or from some other reference point to the lower end of the air line. Once installed with the pressure gauge connected, air is then pumped into the line. The pressure shown by the gauge increases until it reaches a maximum value, which means that all the water has been forced out of the air line. At this point, the air pressure in the tube just balances the water pressure, and the gauge reading shows the pressure necessary to support a column of water of a height equal to the distance from the water level in the well to the bottom of the tube. If the gauge indicates feet of water head, then it shows directly the submerged length of the air line in feet. Subtracting the submerged length from the total length of the air line gives the depth to water below the measuring point chosen.

A measurement made before starting to pump the well indicates the static water level. Any change in water level is represented directly by a difference in pressure shown by the gauge in subsequent measurements. Drawdown during pumping and during recovery after pumping is recorded from the pressure readings.

Referring to Figure 12, the depth to water is always calculated from the following formula:

\[ d = L - l \]

where \( d \) = depth to water in feet
\( L \) = depth to bottom of air line in feet
\( l \) = pressure head in feet represented by a column of water of height equal to the submerged length of the air line

Suppose we have an installation where the distance from the top of the well casing to the lower end of the air line is 95 feet. As the air is pumped slowly into the line, assume that a maximum reading of 46 feet on the pressure gauge is reached. The depth to water is then the difference between 95 feet and 46 feet or 49 feet. Let's say that this is the static water level.

Assume now that the pump is started. As the water level in the well drops, the submerged length of air line decreases and the pressure indication on the gauge drops accordingly. A gauge reading of 34 feet, for example would mean that the submerged length of the air line has decreased by 12 feet, and the depth to water has changed to 95 - 34, or 61 feet. This indicates a drawdown in the well of 12 feet below the static water level.
water level. Each reading must be multiplied by 2.31, if the gauge reads in psi, to convert it to feet of water. A reading of 15 psi for example corresponds to a pressure head of 15 X 2.31, or 34.6 feet of water.

The dependability of the measurements made by the air line device varies with the accuracy of the pressure gauge, and the care used each time in operating the tire pump to get the pressure reading. Depth to water can be determined usually within 0.2 feet of the exact value. The air line is not accurate enough for use in observation wells during an aquifer test, but it is the most practical means for measuring water levels in a pumped well. To avoid disturbances from turbulence near the intake of the pump, the lower end of the air line should be at least five feet above or below the point where water enters the pump.

Where:
- $d$ is depth to water, in feet.
- $L$ is depth to bottom of air line, in feet.
- $I$ is pressure head, in feet, represented by a column of height equal to the submerged length of the air line.

installation of an air line

Figure 12
TRIGGERS BASED ON CAPACITY OF SYSTEM

For systems not having records of pumping levels for use in determining drought triggers, an alternative approach would be to develop triggers based on capacity of each system.

Worksheet

STAGE I

Present Capacity = \( \frac{\text{Peak Day Water Use} \times 100}{\text{Normal Capacity}} \) = ___% of Normal Capacity

STAGE II

Present Capacity = \( \frac{\text{Average Daily Water Use} - 10\% \times 100}{\text{Normal Capacity}} \) = ___% of Normal Capacity

STAGE III

Present Capacity = \( \frac{\text{Average Daily Water Use} - 20\% \times 100}{\text{Normal Capacity}} \) = ___% of Normal Capacity

Present Capacity - The current capacity of the well sources.
Normal Capacity - The expected maximum or optimum capacity of the well sources during an average year.
Peak Day Water Use - The highest day’s water use (including self-supplied and purchased water) for the report year.
Average Daily Water Use - Total water use for report year divided by 365 days.
PUBLIC WATER SUPPLY AGENCY
DROUGHT CONTINGENCY PLAN EXAMPLE

(Name of Public Water Supply Agency)

(Date Submitted)

1) Name, address, and telephone number of the public water supply agency.
   Name of Agency: ________________________________
   Address: ________________________________
   Telephone No.: ____________________ Fax: __________________

   Name, address, and telephone number of officers or other persons responsible for directing operations during a drought emergency
   Name and title: ________________________________
   Address: ________________________________
   Telephone No.: ____________________ Fax: __________________
   E-mail Address: ________________________________

2) A description, including locations and yields, of the water sources used by the facility as well as water available through interconnections with other public water supply agencies.

<table>
<thead>
<tr>
<th>Surface Water: (Stream, spring, reservoir, pond, quarry, etc.)</th>
<th>Name</th>
<th>Location</th>
<th>Safe Yield (gpd)</th>
</tr>
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<tbody>
<tr>
<td></td>
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<tr>
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</tbody>
</table>

<table>
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<tr>
<th>Ground Water: (Wells)</th>
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<th>Location</th>
<th>Safe Yield (gpd)</th>
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</thead>
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</tbody>
</table>
**Purchasing Interconnections** (names of water suppliers, locations and maximum amounts available)

<table>
<thead>
<tr>
<th>Name of supplier</th>
<th>Location</th>
<th>Maximum amount available</th>
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</thead>
<tbody>
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</tbody>
</table>

Description of the operation and how the above sources are used

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3) Water withdrawn or purchased from each source during the previous calendar year or most recent 12 month period for which data is available.

<table>
<thead>
<tr>
<th>Period of Record</th>
<th>Name of Source: Include all interconnections.</th>
<th>Total water withdrawn/purchased during year (MG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>12</td>
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</tr>
</tbody>
</table>

4) Data indicating the average Annual and Maximum Daily Water Use for the system for the previous calendar year or most recent 12 month period for which data is available.

<table>
<thead>
<tr>
<th>Period of Record</th>
<th>Average (annual) Daily Water Use</th>
<th>Maximum Daily Water Use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>_____________________________ gpd</td>
<td>_______________________ gpd</td>
</tr>
</tbody>
</table>
5) A description of criteria (Trigger Points) to be used by the Supplier in identifying the various onset of drought response levels in the system.

The three stages of response are when voluntary conservation measures are needed (Stage I); mandatory water use restrictions are needed (Stage II); and when water rationing (Stage III) is required to reduce water demand even further.

These triggers should be associated with what best would call for these responses. For a system relying mostly on wells, the triggers should be either well levels or lowered capacity of production. Similarly, systems using streams would use certain streamflow rates as their trigger.

In all instances, any state declaration of drought watch or drought warning should also be used to trigger Stage I. A Governor's declaration of Drought Emergency requires mandatory restrictions on non-essential water uses and must also be a trigger for Stage II. Going to Stage III (rationing) requires that the service area be included in a Governor's declared drought or water shortage emergency area. Also, a rationing plan must be submitted to the commonwealth drought coordinator for review and approval prior to actual implementation.

If local triggers can occur before State Declarations (use drought contingency plan summary Model I for Section 6), the triggers used in the plan should include both local and state (e.g., Stage I, well #5 drops to 75 feet for two weeks or the commonwealth declares a drought watch or drought warning). If the supplier's sources provide much more water that the system uses (use drought contingency plan summary Model II for Section 6), then the triggers for Stage I and Stage II should only be state declarations. Stage III is normally needed when an individual public water supplier's sources have depleted such that demands can no longer be met under mandatory restrictions or health and safety is being threatened by inadequate water supplies.

**Write a brief description of the triggers used and the reason for their selection**


6) A plan of actions (Supply Extension Measures and Demand Reduction Measures) which will be taken by the public water supply agency to respond to drought or water shortage conditions. Use Model I or Model II.

The basic/required minimal demand reduction measures and supply extension measures are outlined on the following **Drought Contingency Plan Summary Models I and II** under columns labeled “Demand Measures” and “Supply Measures”. **Model I** is for systems vulnerable under drought conditions (supply limited). **Model II** is for systems where supply is considered abundant even under drought conditions (supply easily meets demand even in drought conditions).
# Drought Contingency Plan Summary

## Model I

<table>
<thead>
<tr>
<th>Trigger Point</th>
<th>Demand Measures</th>
<th>Supply Measures</th>
</tr>
</thead>
</table>
| **Local Triggers for Drought Watch**<br>(well depth or % capacity)<br><br>Or<br><br>**Commonwealth Declares Drought Watch or Drought Warning for Area** | **STAGE I**<br>Voluntary Restrictions on Nonessential Water Use<br>Conduct Public Notices | **Systemwide Leakage and Loss Reduction Survey**<br>**Commonwealth Declares Drought Watch or Drought Warning for Area**<br><br>**STAGE II**<br>Implement Mandatory Restrictions on Nonessential Water Use<br>Identify Customers That Could be Shed from System:<br>**Insert as needed**<br><br>Or<br><br>**Governor Declares Drought Emergency for Area**<br><br>**STAGE III**<br>Implement Water Rationing Plan After Approval by the Commonwealth Drought Coordinator<br><br>Shed Customers Identified in Stage II<br>Work Closely with Local Officials and Have Intense Public Relations to Keep All Customers Informed on Daily Basis | **Utilize Reserve Sources of Supply and/or Interconnections:**<br>**Insert as needed**<br>**List Emergency Sources and Equipment Necessary to Utilize Each Source:**<br>**Insert as needed**
| **Local Triggers for Drought Emergency** | **STAGE III**<br>Implement Water Rationing Plan After Approval by the Commonwealth Drought Coordinator<br><br>Shed Customers Identified in Stage II<br><br>Work Closely with Local Officials and Have Intense Public Relations to Keep All Customers Informed on Daily Basis | **List Emergency Sources and Equipment Necessary to Utilize Each Source:**<br>**Insert as needed**
| **Or** | **Local Water Supplies Available Cannot Meet Demand**<br><br>**List Emergency Sources and Equipment Necessary to Utilize Each Source:**<br>**Insert as needed** | **List Emergency Sources and Equipment Necessary to Utilize Each Source:**<br>**Insert as needed**

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# Drought Contingency Plan Summary
## Model II

<table>
<thead>
<tr>
<th>Trigger Point</th>
<th>Demand Measures</th>
<th>Supply Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commonwealth Declares a Drought Watch or Drought Warning for Area</td>
<td>STAGE I</td>
<td>Systemwide Leakage and Loss Reduction Survey</td>
</tr>
<tr>
<td></td>
<td>Voluntary Restrictions on Nonessential Water Use</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conduct Public Notices</td>
<td></td>
</tr>
<tr>
<td>Governor Declares a Drought Emergency for the Area</td>
<td>STAGE II</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Implement Mandatory Restrictions on Nonessential Water Use</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Identify Customers That Could be Shed from System:</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Insert as needed</em></td>
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<tr>
<td></td>
<td>If Stage III appears Imminent, submit Water Rationing Plan to the Commonwealth Drought Coordinator</td>
<td></td>
</tr>
<tr>
<td>Local Supply Cannot Meet Demand because of Local Drought or Water Shortage Emergency</td>
<td>STAGE III - RATIONING</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Implement Water Rationing Plan After Approval by the Commonwealth Drought Coordinator</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Insert as needed</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>List emergency sources and equipment necessary to utilize each source:</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Request Instream Flow Requirement Reduction, if Applicable (To submit request to the Commonwealth Drought Coordinator for approval – use the Drought Emergency Application available at <a href="https://www.ahs.dep.pa.gov/DEA/">https://www.ahs.dep.pa.gov/DEA/</a></em></td>
<td></td>
</tr>
</tbody>
</table>
7) **Procedure for Granting Variances**

Whenever mandatory water use restrictions or water rationing is imposed on users, the potential for hardships occurs. Therefore, a procedure for granting variances to those requirements is necessary.

All drought emergencies declared by the Governor, which require mandatory restrictions on non-essential water users, have a procedure for variance administered by the commonwealth drought coordinator. Similarly, the variance procedure for local rationing plans is administered by the public water supplier, as outlined in that plan. However, if mandatory restrictions (Stage II) are called for by a public water supplier following its drought contingency plan, a variance procedure is needed. That procedure, which must be used by public water suppliers, is as follows and must be included in drought contingency plans using Model I (Section 6).

This procedure will be implemented if mandatory water use restrictions are imposed and the Governor has not declared a drought emergency in our area.

(1) If compliance with the prohibition of non-essential use of water would result in extraordinary hardship upon a water user, the water user may apply for an exemption or variance, which would expire with the termination of the mandatory water use restrictions, unless otherwise specified in the exemption or variance. For purposes of this section, extraordinary hardship means a permanent damage to property or other personal or economic loss which is substantially more severe than the sacrifices borne by other water users subject to the prohibition of non-essential use of water.

(2) A water user believing he suffers an extraordinary hardship and desiring to be wholly or partially exempt from the restrictions on the non-essential use of water shall submit a written request with full documentation supporting the need for the requested relief to the public water supplier responsible for adopting and implementing this plan. The application shall contain information specifying:
   
   (i) The nature of the hardship claimed and reason for the requested exemption or variance.
   
   (ii) The efforts taken by the applicant to conserve water and extent to which water use may be reduced by the applicant without extraordinary hardship.

(3) The public water supplier or a designee will review the application and may request the applicant to provide, within a reasonable time, additional information as necessary to review the application. A written decision will be provided within seven working days, when possible, or if perishable products are involved, within one working day of submission of an application; or a request will be made for additional information as necessary to review an application. The evaluation will consider impacts on public health and safety, food and fiber production and preservation, pharmaceutical processes, electric generation, maintenance of employment, measures already taken by the user to conserve and store water, and the ability to further implement conservation measures. An exemption or variance will be granted only to the extent necessary to relieve extraordinary hardship.

(4) Any person aggrieved by a decision relating to such an exemption or variance rendered by a public water supplier or designee may file, within 30 days of the decision, a complaint with the Public Utility Commission, if the supplier is regulated by the Public Utility Commission, and in all other instances with the Court of Common Pleas in the County where the water service is provided, in accordance with 2 Pa. C.S. §§551 – 555 and 751 – 754 (relating to the Local Agency Law).

(5) An appeal from an initial decision of the public water supplier or designee will not act as a supersedeas, stay or injunction of that decision.

(6) An exemption or variance may be modified or rescinded by the public water supplier if public health, safety and welfare require further reduction in water use.

(7) An exemption or variance granted to a water user for a specific property, purpose, or person is not transferable to another property, purpose, or water user without approval from the public water supplier.