

FINAL REPORT

Duck River Regional Drought Management Plan



Tennessee Duck River Development Agency

April 20, 2013

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GLOSSARY OF TERMS

ARAP	Aquatic Resource Alteration Permit
BCUD	Bedford County Utility District
CBER	Center for Business and Economic Research
CIP	Capital Improvements Program
CWA	Clean Water Act
D/DBP	Disinfectants/Disinfection Byproducts
DRA	Tennessee Duck River Development Agency
DRUC	Duck River Utility Commission
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
fps	Feet per Second
FY	Fiscal Year
gpm	Gallons per Minute
HAAs	Haloacetic Acids
IESWTR	Interim Enhanced Surface Water Treatment Rule
L	Liter
MCL	Maximum Contaminant Level
MG	Million Gallons
mgd	Million Gallons per Day
mg/L	Milligrams per Liter
NEPA	National Environmental Policy Act
psi	Pounds per Square Inch
SDWA	Safe Drinking Water Act
SRF	State Revolving Fund
SWTR	Surface Water Treatment Rule
TDEC-DWR	Tennessee Department of Environment and Conservation – Division of Water Resources
THMs	Trihalomethanes
TNC	The Nature Conservancy
TWRA	Tennessee Wildlife Resources Agency
TVA	Tennessee Valley Authority
µg/L	Micrograms per Liter
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEDA	U.S. Economic Development Administration
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey

WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant
7Q10	Seven-day Consecutive Low Flow with a Recurrence Interval of Ten Years

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Water Systems

Bedford County Utility District
Columbia Power and Water Systems
Duck River Utility Commission
HB&TS Utility District
Lewisburg Water and Wastewater
Manchester Water Department
Maury County Water System
Shelbyville Power, Water and Sewerage System
Spring Hill Water Department
Tullahoma Utility Board

Federal Agencies

Natural Resource Conservation Service
Tennessee Valley Authority
U.S. Fish and Wildlife Service
U.S. Geological Survey

State Agencies/Committees

Tennessee Department of Environment and Conservation
Tennessee Wildlife Resources Agency

Non – Government Organizations

The Nature Conservancy

Municipals

Columbia
Lewisburg
Manchester
Shelbyville
Spring Hill
Tullahoma

Strategic Team

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SECTION 1 - PLANNING PROCESS FOR DROUGHT MANAGEMENT PLAN

1.1. PURPOSE

The purpose of the Tennessee Duck River Development Agency's (DRA) Regional Drought Management Plan (DMP) is to ensure that stakeholders utilizing water supply sources in the Duck River region (Figure 1) plan appropriately to mitigate drought impacts and will respond in an organized, responsive and appropriate manner in the event of a drought-related water shortage. This DMP was one of the five recommended water supply alternatives in the DRA's Comprehensive Regional Water Supply Plan (March 2011). The DMP is a 10-year plan and will be updated every 5 years or as changes are made to water supply resources. The approach presented in this DMP is a combination of drought mitigation and drought response:

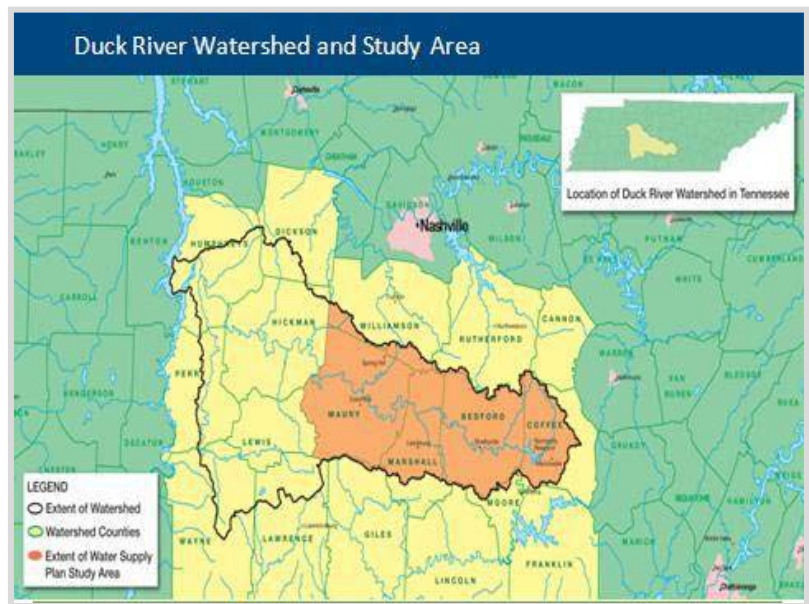


Figure 1. Duck River Watershed

- Drought mitigation refers to an assessment and subsequent action taken well in advance of a drought in order to lessen the impacts.
- Drought response (or water shortage contingency) outlines a thoughtful and useful pattern for how to respond to a shortage.

The process used for developing the DRA's Regional Drought Management Plan was established and agreed upon by the DMP Task Force and followed a "work session" approach similar to the one used in the DRA's Comprehensive Regional Water Supply Plan.

The DMP addresses how the water resources, Normandy Reservoir and the Duck River, will be managed during an extended drought period. For specific drought management information related to the potential impacts on the public water system customers, please refer to the drought management plans developed by each public water system for their designated service area.

1.2. AUTHORITY TO ACTIVATE DROUGHT MANAGEMENT PLAN RESPONSES

During the 2007/2008 drought, the water systems in the Duck River region collectively invoked water use restrictions and the regulatory and water resources agencies initiated a cutback in the downstream releases from Normandy Reservoir following much deliberation and establishment of a flow and habitat monitoring program at several locations along the Duck River. As part of this drought management plan, TDEC and the water resource management agencies have outlined water quality and habitat monitoring programs to allow for reducing the target flow constraint at Shelbyville which equates to a reduction in releases from Normandy Reservoir during severe droughts (Section 4).

The Executive Director of the DRA does not have the authority to activate drought management plan responses. However, each of the following water systems represented by the DRA has the authority to activate drought responses.

- Manchester Water Department
- Tullahoma Utility Board
- Shelbyville Power, Water and Sewerage System
- Bedford County Utility District
- Lewisburg Water and Wastewater
- Spring Hill Water Department
- Columbia Power and Water Systems

Consequently, the Executive Director of the DRA, in consultation with the DMP Committee (see description of DMP Committee in Section 4.2), will identify and monitor the drought stages for the Normandy Reservoir and Duck River supply sources and notify the water systems. At the outset of the drought, the Executive Director of the DRA will initiate discussions with the DMP Committee regarding development of hydrologic forecasts for the region's water supply sources using the OASIS model.

1.3. DMP TASK FORCE MEMBERS

At the outset of the DRA's Regional Drought Management Plan, DRA assembled a DMP Task Force to assist with development of the plan. The DMP Task Force shown in Table 1 reflects a multi-disciplinary team of stakeholders, water managers, advocacy groups, and independent experts.

Table 1. Task Force Members for the Duck River Agency's Regional Drought Management Plan

Task Force Member	Entity	Email Address
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SECTION 2 – WATER SUPPLY AND DEMAND

2.1. WATER SUPPLY CHARACTERISTICS

The Duck River Agency represents seven water utilities which serve approximately 250,000 people and industries that include car manufacturers, food processing plants, and other businesses utilizing water for production. In addition to public water supply needs, the river provides a wide range of other values including recreation, an excellent fishery, and some of the most biologically-rich freshwater habitat in North America.

The Duck River has been impounded since the mid-1800s. Currently, there are four low head dams located on the Duck River which were constructed in the early 1900s:

- Cortner Mill near Normandy (drainage area = 214 square miles at approximately Duck River Mile 245.1)
- Shelbyville (drainage area = 425 square miles at Duck River Mile 221.4)
- Lillard Mill near Milltown (drainage area = 919 square miles at Duck River Mile 179.2)
- Columbia (drainage area = 1,206 square miles at Duck River Mile 133.5)

Normandy Reservoir is located in Bedford and Coffee Counties about 1.5 miles upstream of Normandy, Tennessee and was constructed in 1976 by the Tennessee Valley Authority (TVA) from request made by the Tennessee Duck River Development Agency (DRA). Normandy Reservoir was designed to provide a variety of recreation, water supply, flood control and water quality benefits both upstream and downstream from the dam. Normandy Reservoir releases are the primary source of water for the Duck River upstream of Columbia during severe droughts and the reservoir has the following characteristics:

- Located in the upper portion of the Duck River watershed between Shelbyville and Manchester (Duck River Mile 248.6) and is fed by the Duck River.
- Normandy Dam is 2,248 feet in length and is about 95 feet in height.
- Storage volume is roughly 38 billion gallons at a Summer/Fall (June-November) pool level of 875 feet and 28 billion gallons at a Winter/Spring (December-May) pool level of 864 feet.
- Drainage area is roughly 195 square miles.



Figure 2. Normandy Reservoir

The Tennessee Valley Authority (TVA) manages and operates Normandy Reservoir, including the dam and its releases. TVA operates Normandy Reservoir based on an operating rule curve (Figure 3) for flood control and to meet all State designated uses for the Duck River, including domestic water supply, industrial water supply, fish and aquatic life, recreation, livestock watering and wildlife, irrigation, and trout stream (seasonal trout fisheries below Normandy Dam). Normandy Reservoir flood guide elevations are:

- Summer/Fall (June-November) pool level of 875 feet
- Winter/Spring (December-May) pool level of 864 feet for flood control

Public water systems upstream from Normandy Dam (primarily Tullahoma and Manchester) are served from the Duck River Utility Commission's (DRUC) water intake located in Normandy Reservoir while downstream water systems meet their needs with direct withdrawals from the Duck River. Normandy Reservoir (Figure 2) and the Duck River supply virtually all of the public water supply needs in the five county planning area.

The following direct public water supply withdrawals occur along a 116 river mile segment of the Duck River downstream of Normandy Dam (Duck River Mile 248.6) to Columbia:

- Shelbyville Power, Water and Sewerage System - Duck River Mile 221.9
- Bedford County Utility District - Duck River Mile 202.4
- Lewisburg Water and Wastewater - Duck River Mile 181
- Spring Hill Water Department - Duck River Mile 166
- Columbia Power and Water Systems - Duck River Mile 133.9

To estimate future public water supply needs for the region, the OASIS model developed by HydroLogics was used in the DRA's Comprehensive Regional Water Supply Plan to evaluate the current and projected water demands under the following reservoir and river constraints:

- Normandy Reservoir
 - » Release from Normandy Reservoir to maintain 25.8 mgd (40 cfs) minimum instantaneous flow just downstream of the dam.
- Shelbyville
 - » Release from Normandy Reservoir to maintain 77.5 mgd (120 cfs) minimum instantaneous flow at Shelbyville (December through May) at Duck River Mile 221.4.
 - » Release from Normandy Reservoir to maintain 100.2 mgd (155 cfs) minimum instantaneous flow at Shelbyville (June through November) at Duck River Mile 221.4.
 - » 6.5 mgd (10 cfs) allocation for Shelbyville's water supply intake at Duck River Mile 221.9.
- Columbia

Columbia Power and Water System's Aquatic Resource Alteration Permit (ARAP) identifies the following permit conditions:

 - » Columbia Power and Water System's maximum instantaneous withdrawal rate shall be limited to 19.4 mgd (30 cfs) at Duck River Mile 134.05.

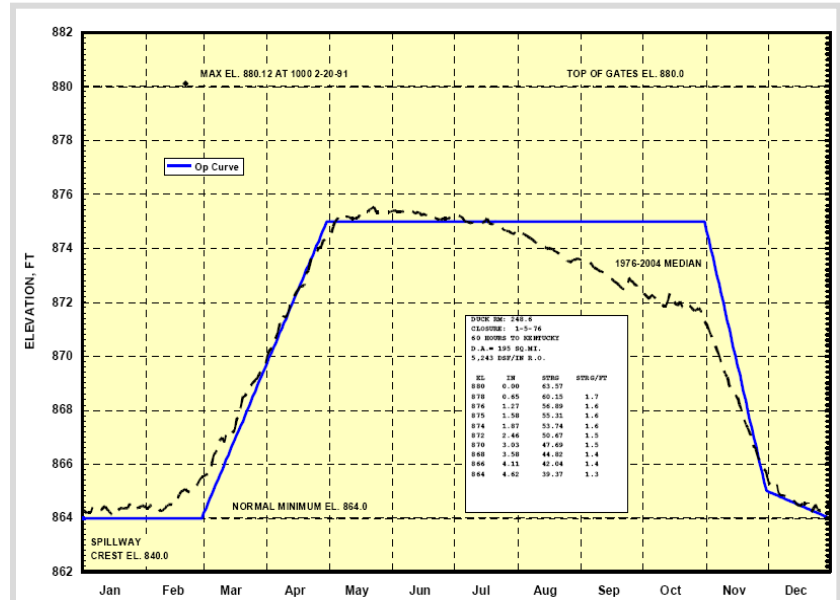


Figure 3. Normandy Reservoir operating rule curve

- » Columbia Power and Water System's withdrawal shall not result in a reduction of flow in the Duck River of less than 64.6 mgd (100 cfs) as measured downstream of the intake at Duck River Mile 133.9 (Figure 4).

2.2. PUBLIC WATER SUPPLY PROBLEMS ENCOUNTERED DURING MOST RECENT DROUGHT

The Duck River Agency's DMP focuses on the Normandy Reservoir and the Duck River supplies which serve the public water systems in the Duck River region. During the drought of 2007/2008, the public water systems identified the following issues associated with their intake structures:

- Normandy Reservoir at DRUC intake
 - » Reduced flow from raw water pumps in DRUC's intake in Normandy Reservoir due to increased lift (reduction in pump flow increases as reservoir water level drops).
 - » Increased power cost for raw water pumping from DRUC's intake in Normandy Reservoir including higher demand charges.
 - » Lower water levels caused higher raw water temperature and taste/odor issues.
 - » Low water levels eliminated withdrawal depth flexibility. Exposed gates normally used for water withdrawals caused water to only be available from the bottom gate which withdraws water directly from the bottom of the reservoir. Manganese, iron and low dissolved oxygen levels are significant problems at the bottom of the reservoir.
- Duck River at Spring Hill intake
 - » Organics and algae increase on the Duck River at the Spring Hill intake. Spring Hill did not experience any customer complaints; however, Spring Hill staff experienced a decrease in filter run hours. Disinfectant/Disinfection By-Products (DBPs) increased in late 2007 and early 2008 which may have been due to lower quality raw water.
- Duck River at Columbia intake
 - » More algae related issues at low flows which makes treating the raw water more difficult.

The public water systems in the Duck River region provide water that is excellent in quality and meets drinking water standards even during severe drought events when treatment is often more complex and costly.

In addition to the problems identified by the water systems, information on irrigation withdrawals from the Duck River for agriculture and golf courses is limited. Significant unmeasured withdrawals are suspected of altering Duck River flows during the 2007/2008 drought. Field monitoring during this period indicated impacts to aquatic life and habitat in a section of the river downstream of the remnants of the lower Hardison Mill Dam (Duck River Mile 165.8).

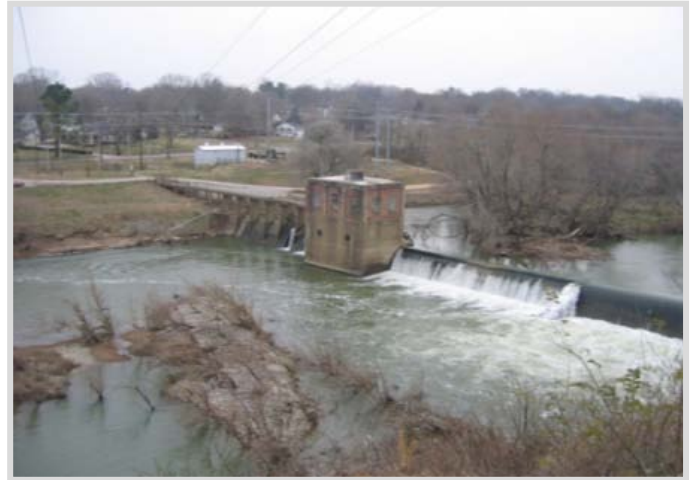


Figure 4. Columbia Dam

2.3. AQUATIC HABITAT IMPACT AND WATER QUALITY PROBLEMS ENCOUNTERED DURING MOST RECENT DROUGHT

The potential impacts of low flow on the habitat in the Duck River are an important concern. The Duck River is the longest river contained within the borders of Tennessee and provides habitat for one of the most diverse collection of fish, freshwater snails and mussels, and crayfish in the United States. The watershed drainage area of the Duck River is quite large; however, the limestone terrain – with sinkhole plains and sinking streams – reduces the amount of surface water available, particularly in times of drought (Environmental Assessment, Normandy Dam Drought Response Release Schedule Change, TVA, October 2007). Extremely low river flows during times of drought reduce available river habitat, increase water temperatures, and decrease the dissolved oxygen levels present for aquatic plants and animals. All of these conditions were observed by agency partners during the 2007 drought and continue to be concerns which must be monitored in future drought situations.

Drought conditions can result in extreme low flows which stress aquatic life, reduce available habitat, and exacerbate water quality issues. Because the Duck River provides important habitat for a variety of state and federally-listed species, managing instream flows for habitat and water quality needs are critical objectives. As part of the environmental assessments conducted by TVA during the 2007/2008 drought, the government agency partners determined that reductions in Normandy Reservoir releases did have the potential to negatively affect water quality and habitat, but that these effects would be mitigated by close monitoring of river conditions and modifying the flows based on monitoring results (Environmental Assessment, Normandy Dam Drought Response Release Schedule Change, TVA, October 2007 and Supplemental Environmental Assessment, Normandy Dam Drought Response Release Schedule Change, TVA, February 2008). In addition to these actions, the USFWS has undertaken a multi-year study of the instream flow and habitat needs for the Duck River. This study will help provide important information about the requirements of fish and mussel species during low flow and extreme low flow events. The data from this study will help guide future monitoring efforts in the river, particularly during times of drought.

Limited information on instream flows for maintenance of critical habitat for threatened and endangered species was documented in the Supplemental Environmental Assessment Normandy Dam Drought Response Release Schedule Change, TVA, February 2008 (Supplemental EA). Because so many listed species are found in the reach below Shelbyville, potential impacts to the instream habitat in this segment resulting from flow reductions at Shelbyville are a concern. In the Supplemental EA, data from surveys, gages, and observations of mussels at the site were used as the basis for TDEC's recommendation that the releases from Normandy Dam ensure that the flow at the Milltown gage be maintained at no less than 165 cfs (approximately 107 mgd).

2.4. POTENTIAL SOURCES OF UNCERTAINTY FOR WATER SUPPLY

Due to the inherent differences in the characteristics of the water supplies in the Duck River region, the possible sources of uncertainty that affect the assessment of the adequacy of supply (i.e., level of risk) are many-fold and include:

- Operation of Normandy Reservoir and travel times. TVA operates Normandy Reservoir along with many other reservoirs under their supervision. Recognizing that these systems are constantly changing and require significant supervision, TVA does its best to meet the downstream constraints in the Duck River given personnel limitations. The OASIS hydrologic model used in the Comprehensive Regional Water Supply Plan assumes that TVA can achieve nearly “perfect” releases (includes additional 5 cfs for buffer) from Normandy Reservoir to meet the Shelbyville constraint which is 27 river miles downstream of the dam (roughly 18 hours of travel time at low flow). In addition, the travel times vary depending on the volume of flow in the river.

- Water withdrawals at Shelbyville. TVA has a flow target of up to 10 cfs to meet the water supply withdrawals at Shelbyville. Water demands vary throughout the day and seasonally which makes it difficult for TVA to predict the quantity of water to release from Normandy Reservoir to match the Shelbyville water demand 27 miles downstream.
- Losses underground from river system below Shelbyville. Prior studies by USGS have indicated that there may be a significant “loss” of flow underground (up to 30% reduction during low flow periods) in the segment of the Duck River below Shelbyville. The magnitude of this loss under changing river flow conditions as well as the location of its return to the Duck River (if any) is not well understood.
- Inflows from tributary streams. Localized thunderstorms in the tributary streams to the Duck River below Normandy Reservoir can create the impression of “excess” releases from Normandy Reservoir because they can produce flows above the target levels at Shelbyville. Localized drought conditions downstream of the dam can also effect flow targets.
- Changes in return flows. The difference between the amount of water withdrawn and water returned to the source (or discharge) by the wastewater treatment plant is usually taken to represent “consumptive use”. The model assumes that the percentage of return flow from each of the wastewater plants will remain unchanged in the future.
- Accuracy of USGS stream gage data. The USGS calibrates the streamflow gages on the Duck River on a monthly basis while the flows in the river at Shelbyville and Columbia must continuously be met on an instantaneous basis.
- Variability of drought events. A drought more severe than the critical drought that occurred in the previous 87 years of record will occur in the future.
- Climate change. Shifts within the hydrologic cycle due to climate change are expected in the future, but the site specific impacts in the Duck River region are not well defined at this time.
- Changes in irrigation withdrawals. Irrigation withdrawals tend to be highest when conditions are dry. The model accounts for historic irrigation withdrawals by using actual stream gage data and assumes that the percentage of irrigation withdrawal will remain unchanged in the future.

In summary, the possible sources of uncertainty that affect the assessment of the adequacy of supply are many-fold and include not only demographics and water use, but uncertainty regarding weather, hydrology, accuracy of stream gaging, and many other factors. While the uncertainty of some of these factors can be mitigated, many cannot and therefore must be addressed in some other fashion such as optimization of existing water supplies or development of new supplies as outlined in the structural and non-structural recommendations in the Duck River Agency’s Comprehensive Regional Water Supply Plan.

2.5. REGIONAL PUBLIC WATER DEMAND CHARACTERISTICS

Due to the inherent differences in the characteristics of the water supplies for the public water systems served by Normandy Reservoir and the Duck River, the OASIS model was used in the DRA’s Comprehensive Regional Water Supply Plan to separately evaluate the adequacy of: (1) Normandy Reservoir for its public water systems (i.e., Manchester and Tullahoma), and (2) the Duck River for Shelbyville and the downstream public water systems to Columbia. For Tullahoma and Manchester which are served by DRUC’s direct withdrawal from Normandy Reservoir, average day demands were used to evaluate the capabilities of the supply due to the ability of the large volume of storage to buffer short-term peaks in demand. Water demands for the remaining public water systems which have direct withdrawals from the Duck River downstream of Normandy Reservoir were based on maximum day demands because these systems must withdraw water from the Duck River to essentially match customer demands throughout the day.

Water demands in the DRA's Comprehensive Regional Water Supply Plan were based on Center for Business and Economic Research (CBER) population projections. The actual average day water withdrawals for 2010 and the projected average day water withdrawals for the 10-year DMP (i.e., 2010 through 2020) are shown in Table 2.

Table 2. Average day water demands in million gallons per day (MGD)

Water System	2010	2020
Coffee County		
Tullahoma	3.5	3.9
Manchester	2.5	2.9
Bedford County		
Shelbyville	3.9	5.3
BCUD	1.9	2.5
Marshall County		
Lewisburg	2.9	3.5
Maury/Southern Williamson		
Spring Hill	2.6	3.2
Columbia	8.3	10.9
Total	25.6	32.2

2.6. POTENTIAL NON-CUSTOMER DEMAND DURING DROUGHTS

Many of the seven water systems in the Duck River region have legal arrangements in place with other water utilities to provide water to these entities (i.e., wholesale customers). In addition, interconnections exist between the seven public water systems represented by the Duck River Agency. Refer to drought management plans developed by each water system in the Duck River region for a discussion of partnerships that are in place for obtaining additional water via interconnections.

In addition to partnerships with neighboring water systems, many of the water systems represented by the Duck River Agency had requests for water from non-customers during the 2007/2008 drought. Table 3 summarizes how each of the water systems dealt with provisions for water for non-customers in the region needing water for failed wells and livestock watering.

Table 3. Drought Management Plan potential for non-customer use

Entity	Non-customer Requests
Coffee County	
Duck River Utility Commission	Numerous requests were received including by public officials on behalf of citizens with wells that went dry. Water was provided to customers on request and they were allowed to come to the water plant and haul water. There were no charges for the water. No records were kept of the number of customers or volume of water as it was insignificant to the DRUC. DRUC intends to respond only on request. See Manchester and Tullahoma responses.
Tullahoma and Manchester	Tullahoma had requests for water service in rural areas that were on wells. Those that were in the TUB service area were sold taps and became customers (approximately 10 customers). No bulk water was given away during the drought.
Bedford County	
Shelbyville	Three non-customers requested water during the drought and the water was picked up at the Water Plant in known quantities, supervised by plant operator.
BCUD	There were several wells and springs in the BCUD's service area that went dry. BCUD sold taps to residents where water was available to meet human and other needs. BCUD provided water at the Water Treatment Plant for residents to obtain water for livestock and other non-potable uses. The Bedford County Fire Services filled tanks at one of their stations in Wheel. Fire Services hauled some water to residents that had no way of hauling water. Very few people came to the water plant to get water and non-customers picked up less than 100,000 gallons. BCUD did not keep detailed records.
Marshall County	
Lewisburg	There were requests for water from non-customers during the 2007/2008 drought due to wells and springs going dry and for livestock watering. Lewisburg Water and Wastewater did not supply any water directly from their department. The Marshall County Emergency Management Agency hauled water to residents that needed water for household purposes, swimming pools and livestock watering. Area farmers and residents received water from the Marshall County Board of Public Utilities (MCBPU) which is a contracted wholesale purchaser of water from Lewisburg Water. The MCBPU maintained records of water used during the drought. Water was given to residents at no cost for those who provided their own containers and did their own hauling. The Marshall EMA purchased water from Lewisburg Water and Wastewater which they hauled to their customers who paid the standard rate for water and delivery. The MCBPU set up water stations for residents to receive water.
Maury/Southern Williamson	
Spring Hill	Spring Hill had one customer that requested water for his cattle. The customer hauled water by his own means and the volume was approximately 1,000 gallons.
Columbia	Columbia sold some bulk water to farmers and customers who had wells to go dry. Additional water was sold to the public golf course by making additional water taps – they were restricted by the size of the taps.

SECTION 3 - PLAN MANAGEMENT PHASES AND RESPONSES

3.1. TRIGGERS AND STAGES FOR DROUGHT MANAGEMENT PLAN

3.1.1. Development of Drought Triggers and Stages

One of the most significant components of the Duck River Agency's DMP is the establishment of trigger points (i.e., the points at which certain drought response actions are required) for the region with identified corresponding actions. Drought management actions are intended to be triggered on an as-needed basis, and not limited to drought of record conditions or when "all else fails". Because drought management responses do not actually produce any new water, the purpose of drought responses is to extend existing water supplies so that they will last throughout the drought period. At the outset of a drought, it is impossible to predict its duration or severity. In addition, drought response measures come at a cost. Consequently, most providers have drought plans with multiple stages that reflect the threat of drought damage.

For a drought progressing, triggers need to be able to provide advance warning while minimizing false alarms; that is, be able to detect incipient drought conditions yet provide some assurance that drought conditions were progressing (i.e., becoming more severe) before implementing actions. For a drought receding, indicators need to be conservative assuming more severe drought conditions while avoiding prolonged restrictions; that is, to be able to provide assurance that drought conditions were receding (i.e., becoming less severe) and recovering long term, before lifting restrictions or rescinding responses.

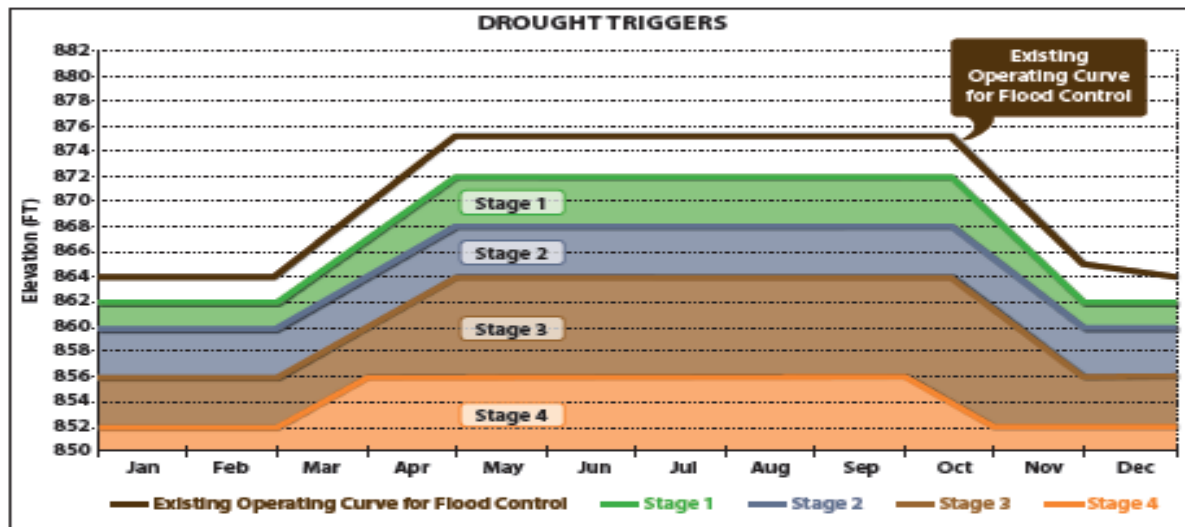
The drought of 2007/2008 highlighted the Duck River region's dependence on the water stored in Normandy Reservoir to meet all State designated uses. The dramatic decrease in rainfall during the 2007/2008 drought, combined with the multiple uses of the reservoir and the river, caused record low water levels in Normandy Reservoir (42% full) that resulted in temporary changes in dam operation to protect designated water uses. Because most of the water in the Duck River region upstream of Columbia originates from Normandy Reservoir during severe drought events, the water level of Normandy Reservoir is the key "bottom line" result of the factors affecting supplies (i.e., soil moisture, streamflow, water use, release requirements, etc.). Consequently, water levels in Normandy Reservoir were determined to be the best trigger for the Duck River region's water supplies during droughts.

The DMP Task Force agreed that the DRA's regional DMP should invoke responses only as often as needed and such that the responses avoid dropping water levels in Normandy Reservoir below the water levels experienced during the 2007/2008 drought. Through an iterative process and using the results of the OASIS model, the stages shown in Figure 5 and in Table 4 were established by the DMP Task Force. Figure 5 also summarizes the drought stages and the actions to be taken in each stage. Several key points can be made regarding the drought triggers/stages:

- Triggers change throughout the year to reflect time of year hydrologic conditions.
- The frequency of invoking drought stages is appropriate taking into consideration revenue, customer impacts and water supply sustainability.
- Triggers minimize impacts to environmental habitat and afford protection through water quality monitoring.

DROUGHT TRIGGERS

for Normandy Reservoir and the Duck River



DROUGHT TRIGGERS			
STAGE 1	STAGE 2	STAGE 3	STAGE 4
Drought Monitoring	Drought Alert	Drought Warning	Drought Emergency
<ul style="list-style-type: none"> Initiate Drought Monitoring 	<ul style="list-style-type: none"> Alert Drought Committee Initiate Public Awareness 	<ul style="list-style-type: none"> 10 cfs / week reduction of Shelbyville target (down to 120 cfs) 10% reduction of public water use 	<ul style="list-style-type: none"> 10 cfs / week reduction of Shelbyville target (down to 80 cfs) 20% reduction of public water use

- Impose 28 day waiting period between stages
- Move out of stage if above trigger for at least 7 days



Figure 5. Drought triggers

Table 4. DMP triggers and stages

Reduction in Water Use	Reduction in Shelbyville Target Flow Constraint	Frequency of Occurrence Based on 2020 Water Demand
Stage 1 – Drought Monitoring		
None	None	2 years
Stage 2 – Drought Alert		
None	None	9 years
Stage 3 – Drought Warning		
10% reduction of public water use	10 cfs/week reduction of Shelbyville target (down to 120 cfs)	30 years
Stage 4 – Drought Emergency		
20% reduction of public water use	10 cfs/week reduction of Shelbyville target (down to 80 cfs)	< 1 in 90 years

The reductions in public water use and the Shelbyville target would be activated upon entry into Stages 3 and 4. When streamflows are reduced at Shelbyville and water-use restrictions are initiated in Stage 3, streamflows at the Columbia Gage could possibly be reduced below the 100 cfs instantaneous flow in Columbia Power and Water System's ARAP permit as shown in Table 5 (note that 125 cfs average weekly flow used as surrogate for modeling 100 cfs instantaneous flow at Columbia). Reduced flows at the Shelbyville Gage target could impact Columbia Power and Water Systems (CPWS) withdrawal rate according to limits in their ARAP permit even with the 10% water-use restriction associated with Stage 3. Temporary modifications to Columbia Power and Water Systems ARAP permit will need to be addressed by TDEC during DMP Stage 3 and Stage 4 actions.

Table 5. DMP triggers and Duck River streamflows at Columbia

Drought Condition	Number of Years at Least One Week Average Flow Less Than 125 cfs *	Maximum Number of Weeks in a Year with Average Flow Less Than 125 cfs *	Average Number of Weeks in a Year with Average Flows Less Than 125 cfs *
Current Demands without Drought Management Plan	27%	8	0.53
Current Demands with Drought Management Plan	27%	11	0.68

* 125 cfs average weekly flow used for modeling as a surrogate for 100 cfs instantaneous flow at Columbia

There are a number of possible metrics with which to describe water supply reliability. These metrics may include the minimum number of days supply remaining, the minimum stage (or percent usable storage remaining), as well as the number of times/durations that each drought phase had to be invoked. As illustrated in Table 4, the reliability of Normandy Reservoir can be based in part on the number of times that a drought stage would be invoked over the 90-year period of record for the Duck River. The DRA will use the OASIS model to develop forecasts of future conditions for Stages 2 through 4. These forecasts will predict the likelihood of attaining a defined water level for Normandy Reservoir based on a given set of boundary conditions (i.e., hydrology, water demands, etc.) and future timeframes (i.e., 2 weeks, 1 month, 6 months, etc.). This information can be used for advanced planning to gain insight on the possible timing for entering or leaving drought stages.

3.1.2. Lead Times for Drought Triggers and Stages

When establishing the lead times for invoking a drought stage (i.e., initiating a Drought Monitoring or moving from one drought stage to another), there are numerous advantages and disadvantages of taking early action versus a delayed response including the following:

- Customers and stakeholders are asked or required to take action frequently versus infrequently.
- Reservoirs stay relatively full versus less full.
- Raw water storage can be depleted during a severe drought versus a less severe drought.

For this DMP, hydrologic modeling was performed using the OASIS model with lead times included to test the triggers when moving into (i.e., progressing) and out of (i.e., receding) historical droughts of record.

- **Drought Progressing.** For the Duck River region, the DMP Task Force worked together to formulate stages and responses that generated desirable results from the OASIS modeling. The conditions used in the OASIS modeling included a 28-day waiting period as a timeframe for moving to a more restrictive drought stage. This condition means that even if the Normandy Reservoir water level crosses the line into a more restrictive stage, that stage is not activated until at least 28 days after the prior stage was activated. This approach affords the utilities and agencies sufficient time to inform the public of the upcoming changes. In summary, there are two conditions that must be met in order to move into a more restrictive drought stage:
 - » 28 days must have elapsed since moving into the prior stage.
 - » Normandy Reservoir elevation must be in the new stage.
- **Drought Receding.** In coming out of the drought (i.e., moving to a less restrictive stage), the new stage will not be invoked until a period of seven (7) consecutive days in the stage has elapsed. This condition prevents, to the extent possible, cycling into and out of a stage.

The results of the OASIS modeling indicate that the lead times for moving into (28 days) and out of (7 days) drought stages are appropriate for this regional DMP.

3.1.3. Water Use Restrictions for Drought Stages



Figure 6. Impact of reduction of Shelbyville flow target and water use restrictions on Normandy Reservoir

Water use restrictions for customers served by the public water systems are included in Stages 3 through 4 of the DRA's drought management plan. Detailed descriptions of the restricted and prohibited activities are presented in the drought management plans for each water system. The impacts of varying levels of water use restrictions on the volume of storage in Normandy Reservoir were evaluated using the OASIS model and are shown in Figure 6.

3.2. EFFORTS TO DEVELOP ADDITIONAL SOURCES OF SUPPLY

Drought mitigation refers to an assessment and subsequent action taken in advance of a drought in order to lessen the effects of impacts to water suppliers and end-users (i.e., development of new supply sources, etc.). In the Duck River Agency's Comprehensive Regional Water Supply Plan (March 2011), a list of 40 potential water supply alternatives identified in previous studies was reduced to 26 unique alternatives which were considered worthy of further consideration to meet a 2060 potential deficit of up to 32 mgd for users of the Duck River between Shelbyville and Columbia. Alternatives included a wide array of non-structural and structural measures such as:

- Implementing additional water efficiency measures
- Implementing a regional drought management plan
- Changing operation of Normandy Reservoir
- Modifying river constraints
- Raising Normandy Dam
- Constructing tributary reservoirs (Fountain Creek Reservoir)
- Building offstream storage reservoirs (pumped storage)
- Utilizing quarries
- Constructing pipelines from reservoirs, rivers or other water systems

A summary matrix was developed which described each of the alternatives and documented key aspects of the alternative related to seven criteria: reliable capacity, raw water quality, cost, implementability (permitting), flexibility (phasing), environmental benefits, and recreation. During public work sessions with stakeholders, the alternatives were discussed and sorted into four categories:

- Baseline (water efficiency, drought management, etc.)
- Fatally Flawed or Highly Unlikely (unreliable, permitting obstacles, etc.)
- Backup (alternative which may be suitable for implementation with a cornerstone alternative)
- Cornerstone (alternatives capable of satisfying entire river deficit in 2060)

Using the evaluation criteria and working closely with the stakeholders, a reliable, diverse, and flexible portfolio of water supply alternatives was developed which included the following non-structural and structural components shown in Figure 7:

■ Non-Structural Components:

- » **Drought Management Plan** – Develop and implement a regional drought management plan.
- » **Water Use Efficiency Program** – Develop and implement a water use efficiency program.
- » **Optimize Normandy Reservoir Releases** – Optimize releases from Normandy Reservoir to preserve storage in the reservoir for periods when it is most needed.

■ Structural Components

- » **Normandy Reservoir Capacity Improvements** – Increase the elevation of Normandy Dam by five feet and increase the Winter/Spring pool elevation by approximately five feet without increasing the Summer/Fall pool elevation. This component increases water storage during droughts, enhances flood protection while minimizing environmental impacts, and enhances the reliable yield available for all Duck River uses.
- » **New intake on the Duck River for Columbia Power and Water Systems** – Relocate Columbia's water withdrawals to a new intake approximately 25 miles downstream, near Williamsport, where there is adequate flow in the river during droughts to satisfy Maury County's projected needs. This component addresses the potential deficit in Maury County and southern Williamson County with a local, highly reliable supply and will eliminate their sole reliance on Normandy Reservoir during a severe drought.

The Duck River Agency is conducting investigations and developing implementation plans for the recommended alternatives.

3.3. IDENTIFY TIMING FOR CONNECTING TO ALTERNATIVE SOURCES

The objectives of the DRA's Regional Drought Management Plan is to address the water needs for the region over a 10-year planning period which is the timeframe for implementing the structural improvements outlined in the DRA's Comprehensive Regional Water Supply Plan (Normandy Reservoir capacity improvements and a new intake on the Duck River for Columbia Power and Water Systems). These structural improvements will not eliminate the need for DRA's Drought Management Plan, but could alter the drought triggers which are the cornerstone of the DRA's Regional Drought Management Plan.

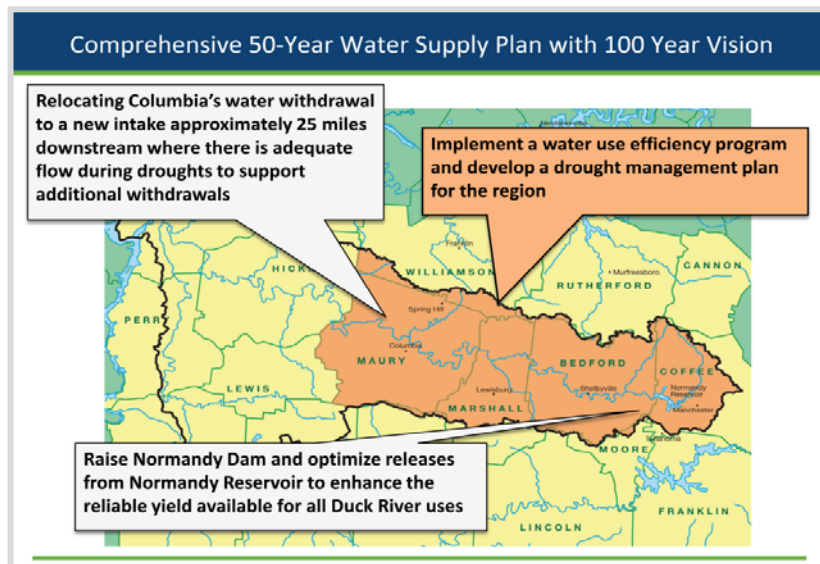


Figure 7. Recommended alternatives

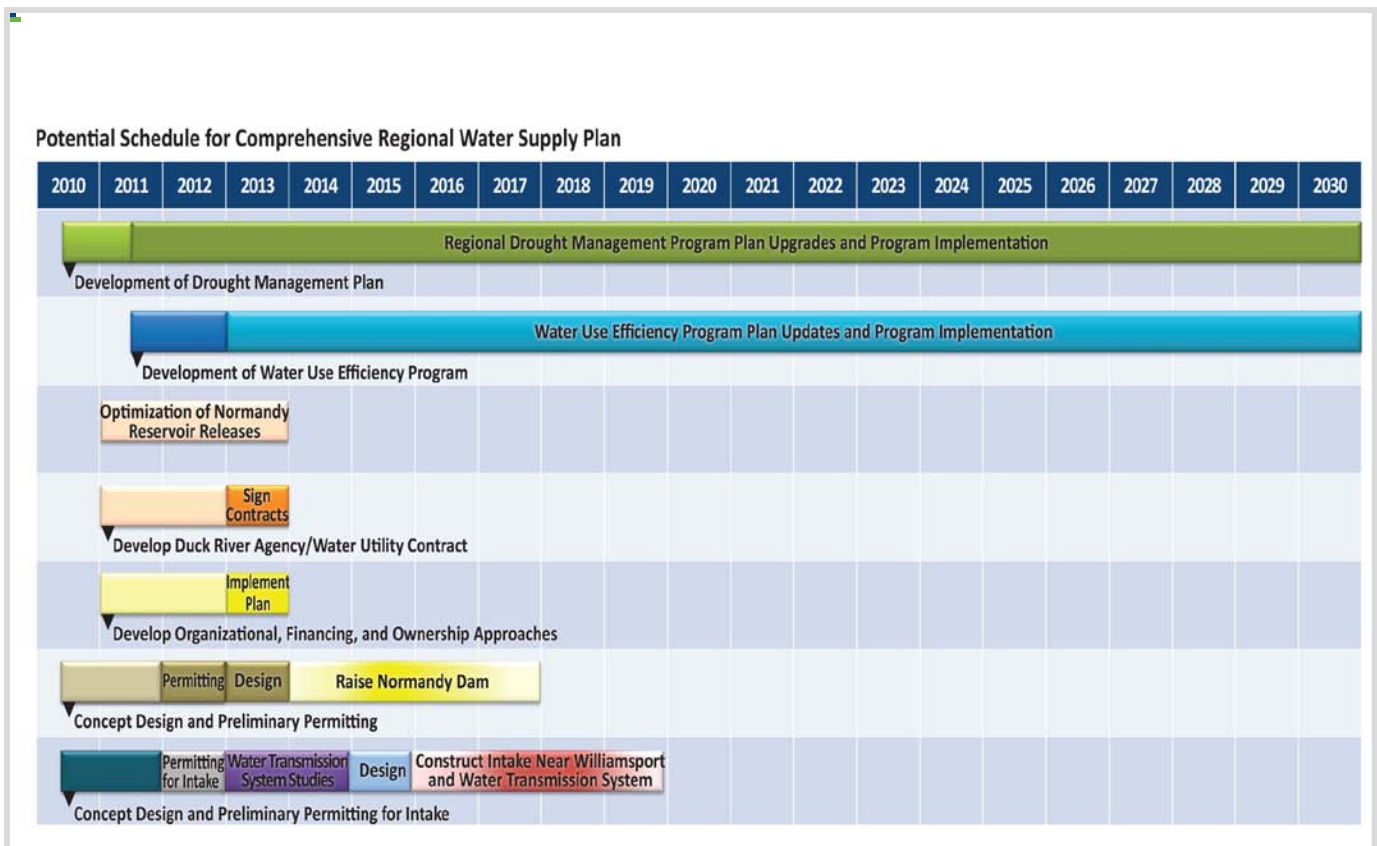


Figure 8. Potential implementation schedule

Figure 8 was included in the Duck River Agency's Comprehensive Regional Water Supply Plan (March 2011) and it shows the potential schedule for implementing new sources of water supply for the region. As shown in the potential schedule, the Duck River Agency is targeting 2018 and 2020 for bringing online the two new structural alternatives (i.e., Normandy Reservoir capacity improvements and a new intake on the Duck River for Columbia Power and Water Systems) and recognizes that potential delays could impact the schedule for implementation.

SECTION 4 - PLAN FOR IMPLEMENTATION – ACTIVATION, MONITORING, AND TRIGGER POINTS

4.1. REPRESENTATIVE RESPONSIBLE FOR ACTIVATION OF DROUGHT STAGES

The Duck River Agency recognizes that the level of communication and individuals involved (i.e., Mayor, fire department, hospitals, etc.) will depend on the severity of the conditions. The Duck River Agency will serve as the representative for the region and will coordinate with the DMP Committee. Table 6 identifies the representatives from the water systems that will have the responsibility for taking action under various stages of the drought.

Table 6. Water system representatives

Entity	Contact	Phone Number
Coffee County		
Tullahoma	General Manager	931-455-4515
Manchester	Director	931-728-1273
Duck River Utility Commission	Manager	931-455-6458
Bedford County		
Shelbyville	General Manager	931-684-7171
BCUD	General Manager	931-684-1667
Marshall County		
Lewisburg	Superintendent	931-359-6831
Maury/Southern Williamson		
Spring Hill	City Administrator	931-489-5791
Columbia	General Manager	931-375-7601

The Duck River Agency will routinely coordinate the drought status with the DMP Committee. The process for declaring or changing the drought stage will be as follows:

- At the outset of the drought (Stage 1 Drought Monitoring), the Executive Director of the DRA will initiate discussions with the DMP Committee regarding development of hydrologic forecasts for the region's water supply sources using the OASIS model.
- Based on discussions with the DMP Committee, the Duck River Agency will send an email to communicate the DMP Committee's decision on declaration of Stages 2 through 4.
- Throughout the drought, the Duck River Agency will provide weekly email updates on the status of the water supplies and work with the DMP Committee to monitor and reach agreement on the current drought stage.

Subsequent to the DMP Committee's receipt of the email from the Duck River Agency on the drought stage, the responses outlined in this DMP will be invoked or maintained. Water systems may assess their individual circumstances and determine that alternative drought stages should be invoked for their water system.

4.2. DROUGHT MANAGEMENT PLAN COMMITTEE AND THEIR ROLES

As part of this DMP, the DRA formed a Drought Management Plan Committee for the Duck River region to address drought-related decisions as needed. The representatives on the DMP Committee are shown in Table 7 and include regulatory agencies, water resources agencies, water system representatives, organizations, and independent experts. One of the primary roles of the DMP Committee will be to review available information on the status of water resources in the region and reach consensus on whether the drought indicators and water sources indicate that the region should enter into or exit a drought stage. It will also be the DMP Committee's responsibility to decide when a notification will be released for a drought stage for the region.

Table 7. Drought Management Plan Committee

Contact	Entity	Email
Regulatory Agencies		
David Money	TDEC-DWR	david.money@tn.gov
Chad Augustin	TDEC-DWR	chad.augustin@tn.gov
Ryan Owens	TDEC-DWR	ryan.owens@tn.gov
Water Resources Agencies		
Don Hubbs	TWRA	tnmussels@aol.com
Steve Alexander	USFWS	steven_alexander@fws.gov
Gary Springston	TVA	glspringston@tva.gov
Chuck Bohac	TVA	cebohac@tva.gov
Mike Eiffe	TVA	maeiffe@tva.gov
Rodney Knight	USGS	rrknight@usgs.gov
Water Systems (DRATAC)		
Scott Young	Tullahoma	syoung@tub.net
Bryan Pennington	Manchester	water@cityofmanchestertn.com
Randal Braker	Duck River Utility Commission	manager@druc.org
David Crowell	Shelbyville	dcrowell@shelbyvillepower.com
Martin Davis	Bedford County Utility District	bcudgm@bellsouth.net
Kenneth Carr	Lewisburg	Kenneth@lewisburgwater.org
Caryl Giles	Spring Hill	cgiles@springhilltn.org
Kelly Powell	Columbia	kelly.powell@cpws.com
Organizations		
Doug Murphy	DRA	doug@duckriveragency.org
Sally Palmer	TNC	spalmer@tnc.org

Contact	Entity	Email
Leslie Colley	TNC	lcolley@tnc.org
Independent Experts		
George Rest	O'Brien & Gere	george.rest@obg.com
Thomas Dumm	O'Brien & Gere	thomas.dumm@obg.com
Brian McCrodden	HydroLogics	bmccrodden@hydrologics.net
Casey Caldwell	HydroLogics	ccaldwell@hydrologics.net

For successful, proactive drought responses and lessened drought impacts, it is imperative that all the agencies and water systems continue to work together to manage the increasingly complex, interrelated and diverse uses of our water resources. The key roles of various entities during drought events were identified in TDEC's Drought Management Plan (Revised February 2010) and are summarized in Table 8. The roles and responsibilities of the various entities involved in the Duck River Agency's DMP are outlined in the remainder of this section.

Table 8. Key roles during drought events

Entity	Key Roles during Drought Events
TDEC	<ul style="list-style-type: none"> -Determine drought intensity - Communicate drought information via website - Require development of Community DMPs - Manage wastewater discharges - Provide guidance on Community DMPs - Encourage regional water resources management planning - Provide technical assistance related to water monitoring* - Provide regulatory oversight - Communicate with other state, regional and federal agencies
Water Resources Technical Advisory Committee	<ul style="list-style-type: none"> - Inform TDEC of impacts and responses - Inform the public - Relay drought information - Technical assistance
Water systems	<ul style="list-style-type: none"> - Develop drought management plans - Identify planned responses - Identify risks - Address all uses - Communicate with the public - Report conflicts
Local Governments	<ul style="list-style-type: none"> - Assist with planning - Implement drought responses - Inform the public
TN Emergency Management Agency	<ul style="list-style-type: none"> - Facilitate the Drought Task Force - Manage emergency drought situations

Entity	Key Roles during Drought Events
TN Department of Agriculture	<ul style="list-style-type: none"> - Emergency designations - Participate in Water Resources Technical Advisory Committee - Assistance to the public - Preventing fires during drought periods - Communication
TWRA	<ul style="list-style-type: none"> - Work with TDEC to monitor aquatic life - Work with TDEC to enforce protections of aquatic life - Provide data on conditions - Inform TDEC of impacts and responses - Exchange information - Assist with communications plans - Monitor endangered and sensitive species response
TN DOT	<ul style="list-style-type: none"> - Provide data on conditions - Inform TDEC of impact and responses - Exchange information on drought responses - Assist with communications plans
TACIR	<ul style="list-style-type: none"> - Participate in Water Resources Technical Advisory Committee - Assist with communications plans
Federal agencies	<ul style="list-style-type: none"> - Participate in Water Resources Technical Advisory Committee - Provide data on conditions - Assist with communications plans - Assist all entities with implementation of plans - Monitor endangered and sensitive species response - Communicate with public - Implement drought responses
Private sector	<ul style="list-style-type: none"> - Evaluate sources and uses - Identify risks - Identify measures in case of restrictions - Communicate with TDEC - Monitor drought and implement drought responses

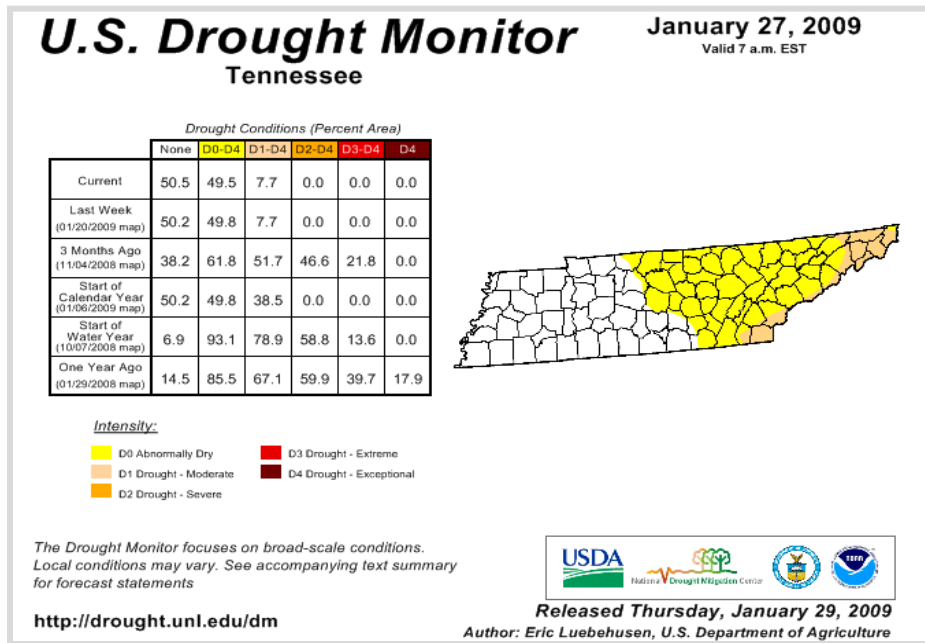
* - Action included in DRA's DMP, but not shown in TDEC's Drought Management Plan (Revised February 2010).

4.2.1. Drought Monitoring

The roles of various entities during drought conditions are outlined in TDEC's Guidance Document and are presented in Table 8. In terms of monitoring, DRA will be responsible for the following activities during drought events:

- **Supply sources.** DRA will monitor the status of the Duck River region's water supplies during drought events (i.e., Normandy Reservoir water levels and drought stage) and conduct water supply forecasts using the OASIS model to predict the status of water supplies if the drought persists. DRA will provide weekly updates on the status of the region's water sources to the DMP Committee via email.
- **Drought status.** DRA will rely on information provided by TDEC, TVA, USGS, TWRA, USFWS, and the *U.S. Drought Monitor* produced by the National Drought Mitigation Center (NDMC) to assess drought conditions. The *Drought Monitor* was released in 1999 and was developed to provide a weekly assessment of drought conditions across the United States on a general scale. The *Drought Monitor* is one of the most convenient and widely used drought monitoring indices to alert officials and the public

of potential drought impacts. It is based on a synthesis of indices, outlooks and other inputs from the United States Department of Agriculture, National Oceanic and Atmospheric Administration, National Climatic Data Center and NDMC. In the map in Figure 9, the *U.S. Drought Monitor* - Tennessee provides a declaration of drought intensities across the state. It also includes some historical drought data for the state.



The *Drought Monitor* focuses on broad-scale conditions. Local conditions, or the situation for a specific community water system, may vary from the drought intensity designation for a region. It is critical for community water systems to have drought management plans that are specific to their circumstances.

Figure 9. U.S. Drought Monitor for Tennessee for January 27, 2009 (National Drought Mitigation Center)

4.2.2. Water Use Monitoring

DRA will monitor the status of water demands in the Duck River region during drought events. DRA will request overall weekly water use data via email from the water systems for Stages 3 and 4 of the drought in order to document reductions in water use by water system and for the region. Each water system has identified in their individual DMPs the water use by individual customer category and will monitor water use in order to target water use programs.

4.2.3. Water Quality Monitoring

Water quality monitoring during a drought period will be a critical program for making decisions entering or exiting the drought stages. The water quality monitoring program will provide timely and instantaneous data as required. If sampling is needed, the DMP Committee will determine if the sampling will be conducted by state and federal agencies or if the task needs to be conducted by a private firm.

All monitoring data will be reviewed by TDEC with comments provided by USFWS, TWRA and TNC. The DMP Committee will make the decisions regarding changes in drought stage using available information, including water levels in Normandy Reservoir, water quality monitoring data and the impact to the water quality due to low flows generated by reductions from releases at Normandy Reservoir.

4.2.3.1. Water Quality Monitoring Sites

Monitoring will be conducted at six locations (Figures 10, 11 and 12) with four sites at existing USGS stream gages that provide instantaneous data and two wastewater outfall sites.

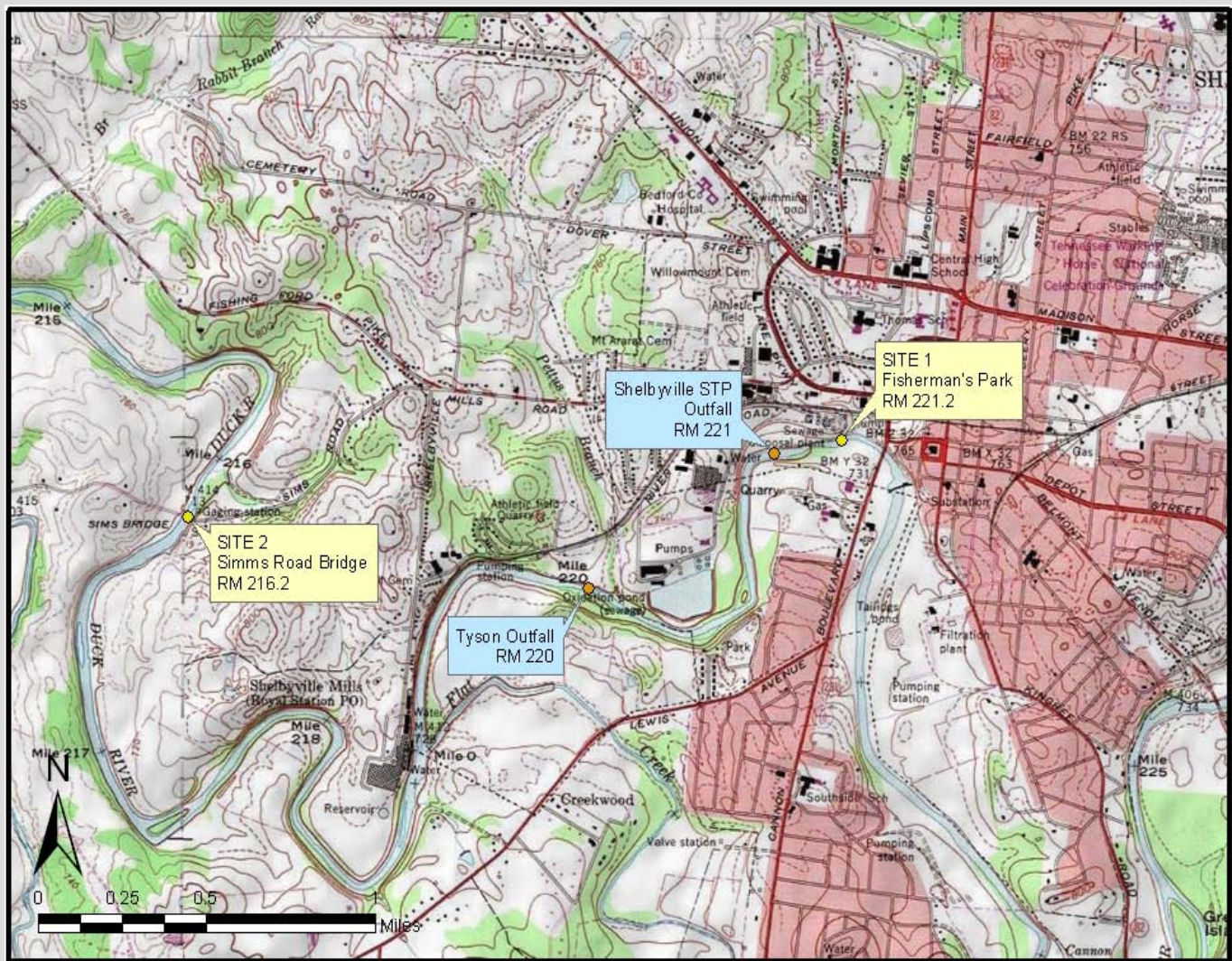


Figure 10. Water quality monitoring sites

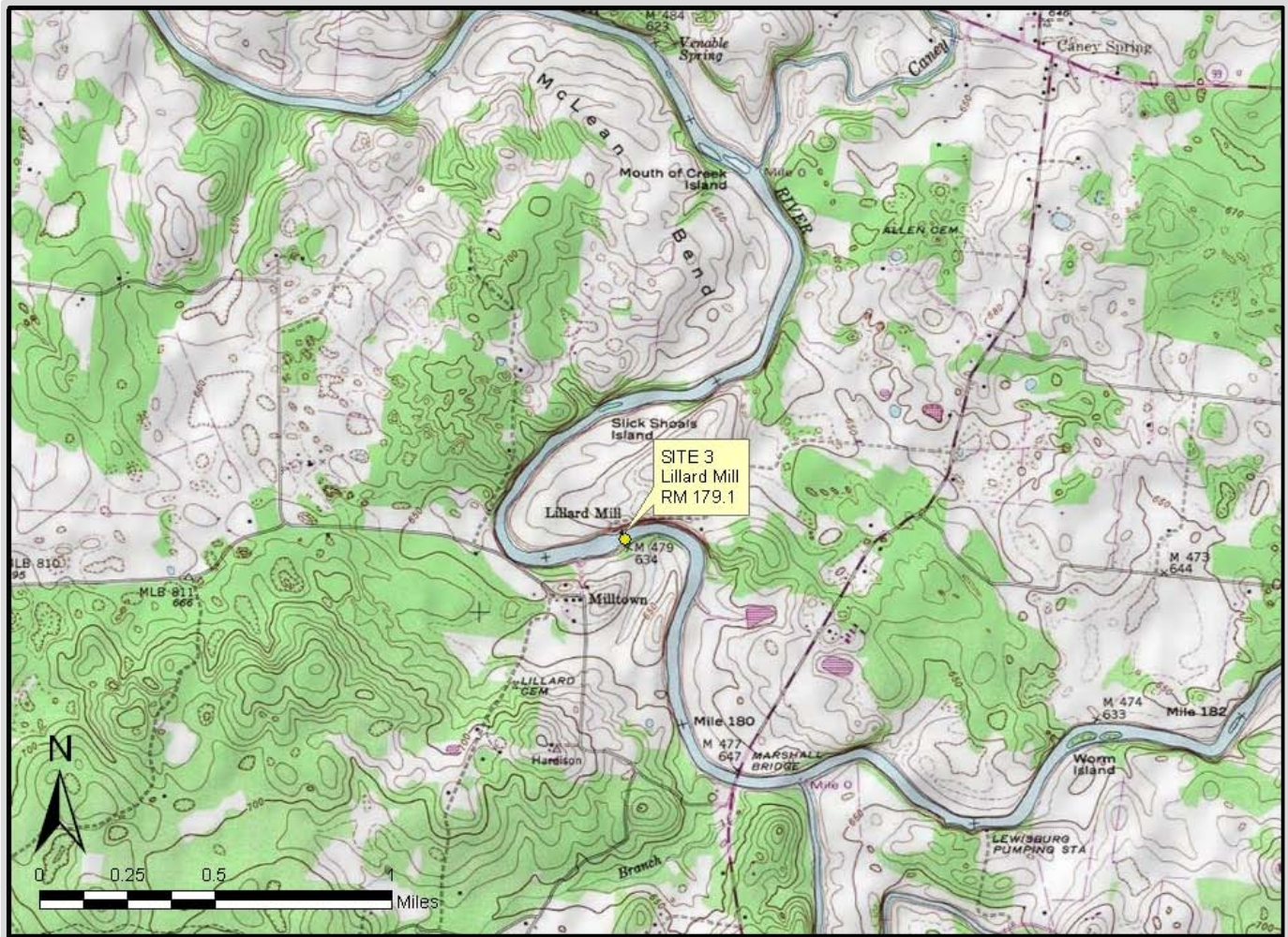


Figure 11. Water quality monitoring sites

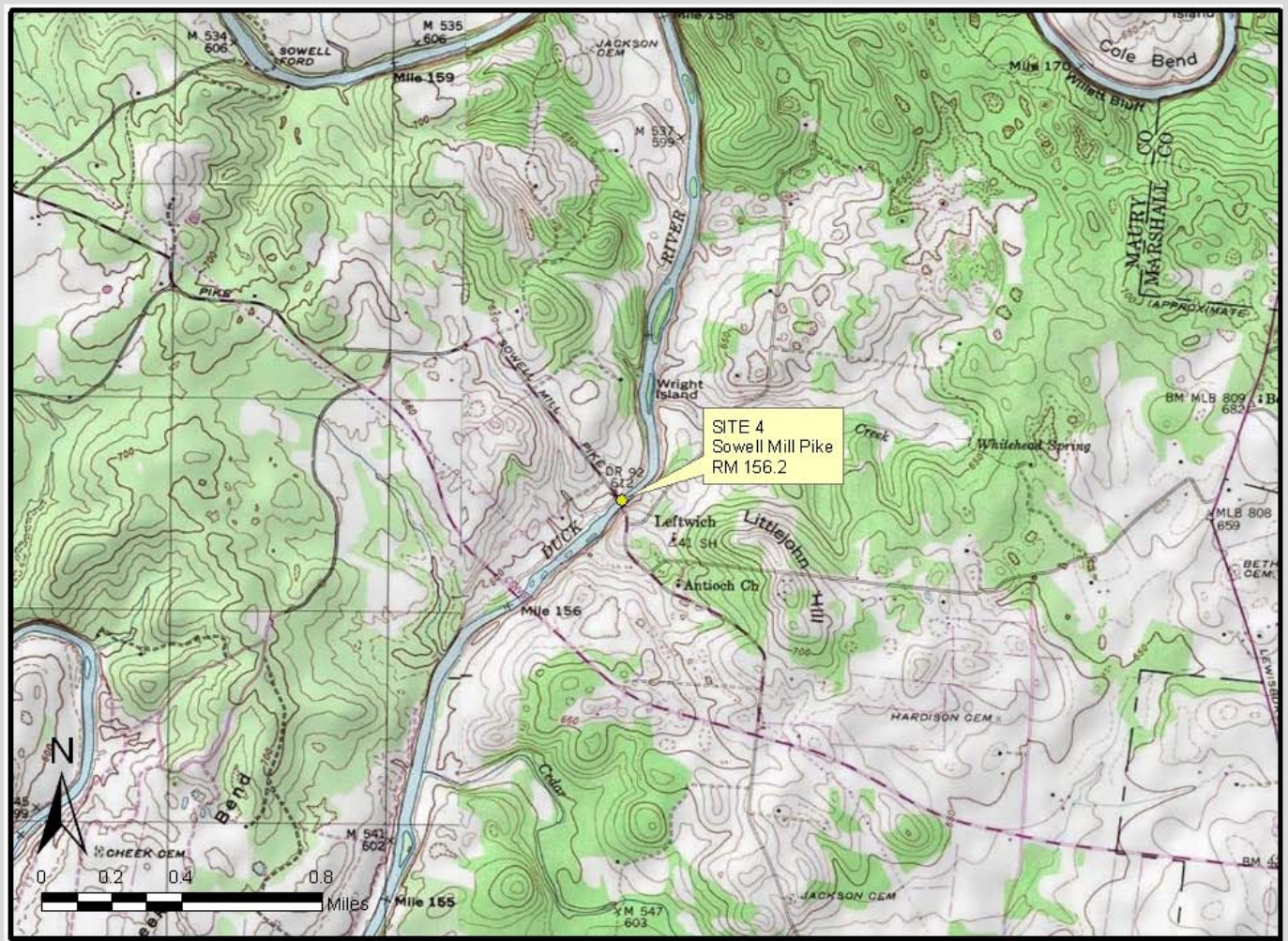


Figure 12. Water quality monitoring sites

4.2.3.2. Water Quality Monitoring for each Drought Stage

Monitoring flow and water quality at the sites identified in the Duck River during Stages 3 and 4 is critical to provide the information needed to assess whether additional reductions in the target flow constraint at Shelbyville are feasible. Table 9 outlines the water quality monitoring program.

Table 9. Drought Management Plan water quality monitoring

Drought Stage/Description	Parameters	Location	Agency Participation
Stage 1 – Drought Monitoring			
No demand/flow reductions – no water quality monitoring	None.	None.	None.
Stage 2 – Drought Alert			
No demand/flow reductions – no water quality monitoring	None.	None.	None.

Drought Stage/Description	Parameters	Location	Agency Participation
Stage 3 – Drought Warning			
<p>-10% reduction in public water use</p> <p>-10 cfs/week reduction of Shelbyville target (down to 120 cfs)</p> <p>- Water quality monitoring (grab samples and field determinations) beginning within 48 hours of initiation and weekly thereafter. Shelbyville STP and Tyson discharges collected through grab samples weekly.</p>	<p>Grab Samples</p> <ul style="list-style-type: none"> - Total Alkalinity - Ammonia mg/l - BOD, 5 Day - Nitrate - Nitrite - Orthophosphate - Total Suspended Solids - Total Kjeldahl Nitrogen, TKN - Total Phosphorous - Total Organic Carbon, TOC - Total Chlorine <p>Field Determinations</p> <ul style="list-style-type: none"> - pH - Conductivity - Temperature - Dissolved Oxygen 	<ul style="list-style-type: none"> - Site 1 at Fisherman's Park (DRM 221.2) - Site 2 at Simms Road Bridge (DRM 216.2) - Site 3 at Lillard Mill (DRM 179.1) - Site 4 (gage data only) - Shelbyville STP outfall (DRM 221) - Tyson outfall (DRM 220) 	TDEC, USFWS, TWRA, TVA
Stage 4 – Drought Emergency			
<p>-20% reduction in public water use</p> <p>-10 cfs/week reduction of Shelbyville target (down to 80 cfs)</p> <p>– Water quality monitoring (grab samples and field determinations) conducted bi-weekly. Continuous monitors may be deployed immediately upon initiation of Stage 4 at monitoring Sites 1 and 2. Shelbyville STP and Tyson discharges to be collected through grab samples bi-weekly. Once target reaches 80 cfs field determinations (pH, conductivity, Temp and DO) change from bi-weekly to daily at monitoring Sites 1, 2 and 3.</p>	<p>Grab Samples</p> <ul style="list-style-type: none"> - Total Alkalinity - Ammonia mg/l - BOD, 5 Day - Nitrate - Nitrite - Orthophosphate - Total Suspended Solids - Total Kjeldahl Nitrogen, TKN - Total Phosphorous - Total Organic Carbon, TOC - Total Chlorine <p>Field Determinations</p> <ul style="list-style-type: none"> - pH - Conductivity - Temperature - Dissolved Oxygen 	<ul style="list-style-type: none"> - Site 1 at Fisherman's Park (DRM 221.2) - Site 2 at Simms Road Bridge (DRM 216.2) - Site 3 at Lillard Mill (DRM 179.1) - Site 4 (gage data only) - Shelbyville STP outfall (DRM 221) - Tyson outfall (DRM 220) 	TDEC, USFWS, TWRA, TVA

4.2.3.3. Field Work and Reporting Costs

Private Firm

Field monitor during an extended drought period could become a burden if the work was left to one agency or organization. It is expected several agencies and non-governmental organizations would work together to provide personnel for monitoring. It is also possible the agencies could be understaffed to handle the magnitude of monitoring needed and a private environmental firm would be contracted for monitoring. Estimates to contract with a private firm for water quality monitoring would range from \$2,000 to \$3,000 per day depending on sampling regime.

Agencies

State agencies, federal agencies, and the Duck River Agency could possibly offer financial support or in-kind assistance to collect some or all of the monitoring samples depending on available resources. The initial contact will be the TDEC field office in Columbia, TN. TDEC along with USGS may deploy continuous monitors upon initiation of Stage 4 at Sites 1 and 2.

4.2.4. Habitat Monitoring for each Drought Stage

The USGS stream gage at Shelbyville can provide certain real-time monitoring parameters with a week notice. In conjunction with the current stream gage monitoring program, a new gage will be added at Pottsville (Site 4 - Sowell Mill Pike Bridge at DRM 156.2). The new gage is located downstream of a significant losing stretch of the river and in the Designated Federal Critical Habitat section. The Pottsville gage along with Lillard Mill gage will be used to indicate needs for field monitoring for aquatic biological habitat.

Recent historical drought conditions provided opportunities for resource managers to collect critical low flow water quality and stream channel profile information. The period of January 2007 to January 2008 was among the driest on record in 118 years. Because of these historic drought conditions across the Tennessee Valley, TVA released only enough water to protect aquatic species and to provide adequate water supply and assimilative capacity for the municipal and industrial outfalls downstream. During this period, requests were made to reduce the flow constraints in order to reduce releases (i.e., preserve storage) from Normandy Reservoir. This action provided regulatory agencies the opportunity to collect data during low flow conditions in the Duck River that would benefit modeling and decision making.

During the 2007/2008 drought, three sites were selected by TDEC and USFWS for monitoring to establish wetted perimeter requirements for critical habitat. The three locations were Dement Bridge (DRM 243.0), Lillard Mill (DRM 179.1), and Venable Springs (DRM 176.7). Additional sites will possibly be needed in the future and will be selected by the DMP Committee. Because the Duck River is an alluvial river system and the streambed changes over time, the habitat monitoring sites will likely require new channel measurements for each drought event which will define the stream gage flows to be used for maintaining critical habitat. During the 2007/2008 drought, a second stream gage flow control point was established downstream of Shelbyville at the Milltown gage (DRM 180.2)

Field information was collected and used to establish critical low flow requirements in the "Supplemental Environmental Assessment Normandy Dam Drought Response Release Change, February 2008". Following are comments for the alternative release schedule:

- In order to protect listed species and critical habitat present in the Duck River, TVA would manage discharges to maintain no less than 165 cfs as measured at the Milltown gauge located at DRM 180.2 (80 cfs minimum flow at Shelbyville plus additional local inflow). This would protect sensitive species and their habitat downstream of the Milltown gauge. If at any time, the flow measured at the gauge at

Milltown is less than 165 cfs, releases from the dam would be increased until the flow at Milltown reaches 165 cfs. Releases from Normandy Dam would be increased to bring flows above 165 cfs within 24 to 48 hours. Analysis of flow data from 1999 - 2008 indicates that it is unlikely that flows below 165 cfs would be seen at Lillard Mill.

- If the measured ammonia concentration at Halls Mill (DRM 202.1) is greater than 0.3 milligrams per liter (mg/L), TVA would increase releases from the dam until ammonia concentrations are less than 0.3 mg/L or until 120 cfs is measured at Shelbyville. Flow increases would occur within 24 to 48 hours of TDEC's notification to TVA that ammonia levels have been exceeded.

The above information will give federal, state, and regional agencies background information to develop field monitoring activities as needed. Each drought will have different characteristics that will require decisions to be made during the drought period as to the level of monitoring requirements. Not only do the droughts differ, but the river's aquatic habitat changes due to periods of flooding which changes the wetted perimeter. During Stage 3 of the DMP, the designated agencies will need to meet and develop field monitoring plans for drought risk management. It is expected that different levels of monitoring will be required in Stage 3 compared to Stage 4 in the DMP.

4.3. WATER USE RESTRICTIONS AND LEVELS OF ENFORCEMENT FOR DROUGHT MANAGEMENT STAGES

The water systems in the Duck River region have the authority to activate and enforce violations of drought responses. Detailed descriptions of restricted and prohibited activities for the drought stages are described in the drought management plans for each water system and are summarized in Table 10. Enforcement measures for water use are presented Table 11.

Table 10. Summary of Drought Management Plan restricted and prohibited activities for water systems

Drought Stage	Restricted Activities	Prohibited Activities
Stage 1	None.	None.
Stage 2	Customers to be notified of drought conditions. Public education of water conservation measures will begin.	None.
Stage 3	All customers are requested to reduce normal consumption of essential, domestic, and non-essential use by 10%.	None.
Stage 4	<p>All customers are required to reduce normal consumption of essential use and domestic use by 20%, and all non-essential use by 50%.</p> <p>Commercial nurseries and vegetable gardens will be restricted to absolute minimum usage to keep plants alive</p> <p>Water served for drinking purposes at restaurants or other public or non-public eating establishments is restricted to be served only as requested by the patron or customer.</p>	<p>Residential watering of trees, shrubs, lawns, or flower gardens.</p> <p>Watering of golf courses and ball fields.</p> <p>All non State-mandated line flushing by utilities and fire departments.</p>

Table 11. Summary of Drought Management Plan enforcement policy for water systems

Water System	Enforcement
DRUC, Tullahoma and Manchester	<p>The staff will have available to them the use of vehicles, fuel, and equipment contained within the organizations to inspect and enforce violations to the plan.</p> <ol style="list-style-type: none"> 1. Warnings – Any person violating the mandatory restrictions or prohibited activities will be issued a warning on their first violation. 2. Penalties/Shut-off – After the receipt of a warning, any person violating the mandatory restrictions or prohibited activities shall be issued an assessment fee up to \$200 and shutoff of their water service. The fee must be paid as well as the standard reconnect fee in order to continue service. 3. Discontinuance of water service - The third offense will result in an assessment fee up to \$300 and discontinuance of water service for a period up to 30 days for the willful disregard of the provisions. 4. Termination of water service – The fourth offense will result in the removal of the water meter and discontinuance of the water service until drought conditions are relieved. 5. For non-wholesale customers, the reduced-rate tier for usage over 100,000 gal/month will be eliminated during the drought conditions of Stage 4, and the standard-rate tier for usage less or equal to 100,000 gal/month will apply until drought conditions are relieved.
Shelbyville and Lewisburg	<p>The staff will have available to them the use of vehicles, fuel, and equipment contained within the organizations to inspect and enforce violations to the plan.</p> <ol style="list-style-type: none"> 1. Warnings – Any person violating the mandatory restrictions or prohibited activities will be issued a warning on their first violation. 2. Penalties/Shut-off – After the receipt of a warning, any person violating the mandatory restrictions or prohibited activities shall be issued an assessment fee up to \$50 and shutoff of their water service. The fee must be paid as well as the standard reconnect fee in order to continue service. 3. The third offense will result in an assessment fee up to \$100 and discontinuance of water service. The fee must be paid as well as the standard reconnect fee in order to continue service. 4. Termination of water service – The fourth offense will result in an assessment fee up to \$500 and shut-off of their water service. The fee must be paid as well as the standard reconnect fee in order to continue service (each additional offense will be an additional \$1000). 5. For non-wholesale customers, the reduced-rate tier for usage over 100,000 gal/month will be eliminated during the drought conditions of Stages 3 and 4, and the standard-rate tier for usage less or equal to 100,000 gal/month will apply until drought conditions are relieved, and discontinuance of water service for a period up to 30 days for the willful disregard of the provisions.
BCUD	<p>The staff will have available to them the use of vehicles, fuel, and equipment contained within the organizations to inspect and enforce violations to the plan.</p> <ol style="list-style-type: none"> 1. Warnings – Any person violating the mandatory restrictions or prohibited activities will be issued a warning on their first violation. 2. Penalties/Shut-off – After the receipt of a warning, any person violating the mandatory restrictions or prohibited activities shall be issued an assessment fee up

Water System	Enforcement
	<p>to \$50 and shutoff of their water service. The fee must be paid as well as the standard reconnect fee in order to continue service.</p> <ol style="list-style-type: none"> The third offense will result in an assessment fee up to \$100 and discontinuance of water service. The fee must be paid as well as the standard reconnect fee in order to continue service. Termination of water service – The fourth offense will result in an assessment fee up to \$500 and shut-off of their water service. The fee must be paid as well as the standard reconnect fee in order to continue service (each additional offense will be an additional \$1000). For Commercial customers, the reduced-rate tier for usage over 100,000 gal/month will be eliminated during the drought conditions of Stages 3 and 4, and the standard-rate tier for usage less or equal to 100,000 gal/month will apply until drought conditions are relieved, and discontinuance of water service for a period up to 30 days for the willful disregard of the provisions.
Spring Hill	<p>The staff will have available to them the use of vehicles, fuel, and equipment contained within the organizations to inspect and enforce violations to the plan.</p> <ol style="list-style-type: none"> Warnings – Any person violating the mandatory restrictions or prohibited activities will be issued a warning on their first violation. Penalties/Shut-off – After the receipt of a warning, any person violating the mandatory restrictions or prohibited activities shall be issued an assessment fee up to \$50 and shutoff of their water service. The fee must be paid as well as the standard reconnect fee in order to continue service. The third offense will result in an assessment fee up to \$100 and discontinuance of water service. The fee must be paid as well as the standard reconnect fee in order to continue service. Termination of water service – The fourth offense will result in an assessment fee up to \$500 and shut-off of their water service. The fee must be paid as well as the standard reconnect fee in order to continue service (each additional offense will be an additional \$1000). For non-wholesale customers, the reduced-rate tier for usage over 100,000 gal/month will be eliminated during the drought conditions of Stage 4, and the standard-rate tier for usage less or equal to 100,000 gal/month will apply until drought conditions are relieved, and discontinuance of water service for a period up to 30 days for the willful disregard of the provisions.
Columbia	<ol style="list-style-type: none"> Most water waste cases begin with a complaint from the public. Water waste is observed and documented by CPWS enforcement staff. A notice of violation is given to customer either by door hanger, personal contact, and/or written notice. The notice will inform customer that customer has violated CPWS Service Agreement and cut-off procedure is initiated. A customer may contact CPWS to ask questions or arrange to discuss the violation in person. A customer who received a Notice of Violation may contest the cut-off by filing a written request for a due process hearing with the CPWS General Manager and/or delegate. CPWS must receive the customer's written request within twenty-four (24) hours of

Water System	Enforcement
	<p>the Notice-of-Violation delivery to the customer's premise. The request must state the property address, customer account, and reasons why the customer thinks they were not violating the water waste restrictions.</p> <ol style="list-style-type: none"> 7. The due process hearing will be scheduled within twenty-four (24) hours of the request during CPWS normal working hours (Monday through Friday, 7:00 AM – 5:00 PM). 8. If the Notice of Violation is not contested or upheld, CPWS will discontinue service to the customer. A warning will be issued for the first offense. 9. Customers may reapply for water service but will be subject to any normal or special charges set by the Board of Public Utilities. 10. Customers may appeal the results of the "Due Process Hearing" to the Board of Public Utilities. Any appeal must be in writing. The Board may conduct the appeal hearing at its regular scheduled meeting or at a special call meeting at its discretion. CPWS is under no obligation to continue water serviced after disconnection (due to water waste restrictions) during any Board appeal process. Any customer not contesting the Notice of Violation may elect to pay the reconnect charges/fees in-lieu-of cut-off actually being performed.

4.4. PUBLIC NOTICES

At the outset of the drought as agreed upon by the DMP Committee, the DRA will be responsible for notifying the following agencies, organizations, community leaders, and legislators:

- Agencies
 - » NRCS
 - » County EMA
- Organizations
 - » Farmers Bureau
- Community Leaders
 - » City mayors
 - » County mayors
- Legislators
 - » State Representatives
 - » State Senators

Public notifications on the stages of the drought will be conveyed to the public through a variety of media sources (i.e., newspapers, radio, television, Internet, etc.). Media releases from DRA will be reviewed by the DMP Committee and then a recommendation will be made for date of release. The DRA will also designate a page on their website for drought alerts, communication issues and education. DRA recognizes that water systems will endeavor to convey an accurate and consistent message on the status of the drought event to their water customers based on their individual circumstances. It will be the responsibility of each water system to notify and monitor customers in their service areas of restricted and prohibited activities. Each water system has identified in their individual DMPs the specific media sources which will be contacted.

SECTION 5 - REVIEW, EVALUATE, AND UPDATE THE DROUGHT MANAGEMENT PLAN

5.1. PLAN FOR EVALUATING EFFECTIVENESS AND INCORPORATING CHANGES

A drought plan, like a fire evacuation plan, will be most effective if exercised regularly. Like a fire drill, a virtual drought exercise can show new people and remind veterans how the details of the plan and roles of the stakeholders are defined. But unlike a fire drill, the stakeholders for the virtual drought exercise are apt to find the conditions have changed; water uses diversify and intensify in the years between droughts, and new stakeholders must be brought into the process. When droughts do occur, the plan will be tested, and stakeholders will have a unique and valuable opportunity to learn if they consciously record the events during the drought and compare them to their expectations.

A *Virtual Drought Exercise* can be designed to test the Drought Management Plan Strategy based on a recent historic drought. The Virtual Drought Exercise should have the following elements:

- Facilitator - explains the rules and manages time spent on negotiations.
- Participants - stakeholders in the DRA's Regional Drought Management Plan.
- Media - member of the press to represent the needs or influence of the media.
- Data - synthesized for the simulation exercise may include forecasts, water demands, reservoir storage volume, etc. Uncertainties of real droughts will be included to solicit responses such as river irrigation withdrawals, precipitation changes, streamflow losses in the Duck River, etc.
- OASIS model - facilitator uses model results to track performance based on decision-making and to estimate the impacts from alternative management decisions.

Although the DRA's Regional Drought Management Plan has well-defined triggers and responses for each stage of the drought response, using them still requires human monitoring and judgment. It is recommended that a Virtual Drought Exercise be conducted after the DRA's Regional Drought Management Plan is finalized and once every five (5) years thereafter.

5.2. EXPIRATION DATE AND UPDATE PERIOD FOR PLAN

The Duck River Regional Drought Management Plan was adopted by:

on

and will be reviewed and updated (as needed) based on the following:

- Annually at the 1st quarterly meeting of DRATAC in January.
- Within 6 months of invoking Stage 3 of the regional drought management plan.
- Subsequent to the virtual drought exercise for the region.
- Subsequent to significant changes in conditions, such as changes in water demands, construction of capital improvements, changes in regulatory requirements, etc.

At a minimum, the DRA's Regional Drought Management Plan will be reviewed and updated (as needed) every five (5) years.