FINAL REPORT

Optimization of Normandy Reservoir Releases





Tennessee Duck River Development Agency

September 26, 2013

O'BRIEN & GERE

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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

ACKNOWLEDGEMENTS

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Federal Agencies

Tennessee Valley Authority

U.S. Fish and Wildlife Service

State Agencies/Committees

Tennessee Department of Environment and Conservation

Strategic Team

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SECTION 1 – INTRODUCTION AND BACKGROUND

1.1. PURPOSE

The purpose of the Tennessee Duck River Development Agency's (DRA) *Optimization of Normandy Reservoir Releases* (ONRR) is to review and discuss the factors impacting releases from Normandy Reservoir and assess whether modifications can be made to the reservoir releases to more precisely satisfy the flow targets at Shelbyville thereby preserving water in storage in Normandy Reservoir (Figure 1). This study addresses one of the five recommended water supply alternatives in the DRA's Comprehensive Regional Water Supply Plan (March 2011).

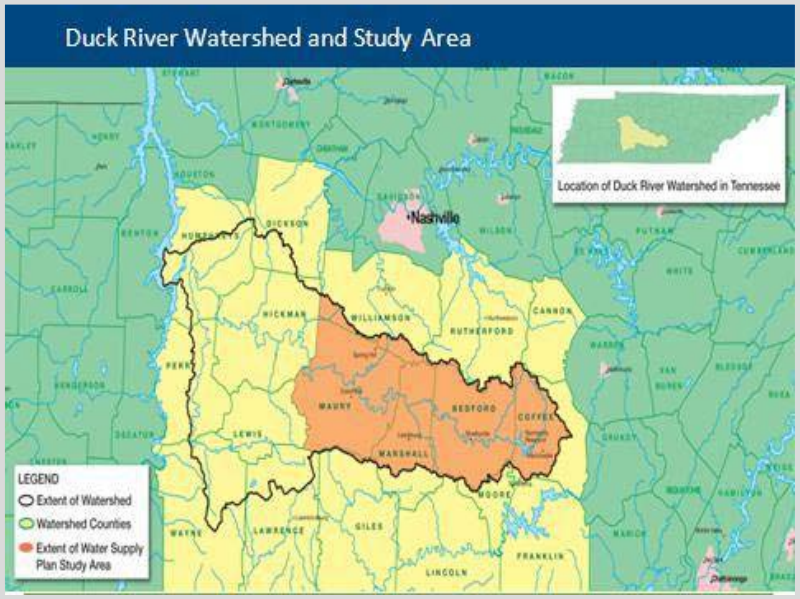

Figure 1. Duck River Watershed and Study Area

1.2. SCOPE OF SERVICES

In October 2011, O'Brien & Gere and DRA initiated the ONRR study based on the following Scope of Services:

- Conduct kickoff meeting/work session with regulators
- Meet with TVA to define characteristics of Normandy Reservoir release
- Evaluate stream gaging alternatives
- Meet with TDEC to discuss operating guidelines
- Formulate and review hydrologic modeling runs
- Evaluate alternatives
- Prepare letter report

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

1.3. TASK FORCE MEMBERS FOR OPTIMIZATION OF NORMANDY RESERVOIR RELEASES

At the outset of the DRA's ONRR study, DRA assembled an ONRR Task Force to assist with development of the plan (Table 1).

Table 1. Task Force Members for the Duck River Agency's Optimization of Normandy Reservoir Releases

Task Force Member	Entity	Email Address
Doug Murphy	Duck River Agency	doug@duckriveragency.org
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1.4. BACKGROUND FOR OPTIMIZATION OF NORMANDY RESERVOIR RELEASES

This study, *Optimization of Normandy Reservoir Releases*, is aimed at preserving water in storage in Normandy Reservoir so that water is available when it is most needed (i.e., severe drought events). 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. These alternatives were developed to meet a 2060 potential deficit of up to 32 mgd which equates to 1.4 BG at Columbia with a target of 3 BG if water is released upstream of Columbia for the 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 use 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 use 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 2:

- **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 water in 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 (i.e., 864 feet to 869 feet) without increasing the Summer/Fall pool elevation (i.e., 875 feet). This component increases water in storage during droughts, enhances flood protection while minimizing environmental impacts relative to other alternatives, and enhances the reliable yield available for all Duck River uses.

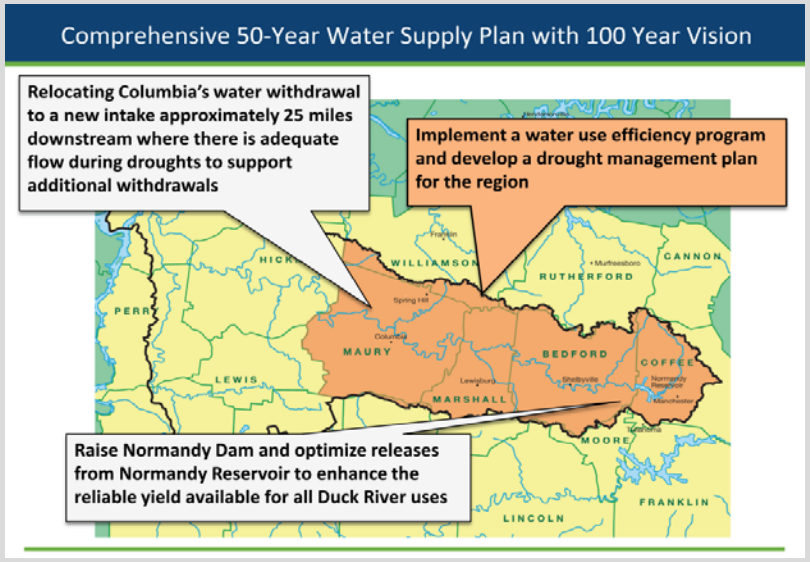

Figure 2. Recommended alternatives

» **New intake on the Duck River for Columbia Power and Water Systems** – Relocate water withdrawals for a portion of Maury County customers 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.

SECTION 2 – WATER SUPPLY CHARACTERISTICS

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.

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

- 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 (Figure 3) 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) based on a 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:

Figure 3. Normandy Reservoir

- 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.
- Volume of water in storage is roughly 36 billion gallons at a Summer/Fall (June-November) pool level of 875 feet and 25 billion gallons at a Winter/Spring (December-May) pool level of 864 feet.
- Drainage area is roughly 195 square miles.

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 4) 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

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 and the Duck River provide virtually all of the public water supply needs in the five county planning area.

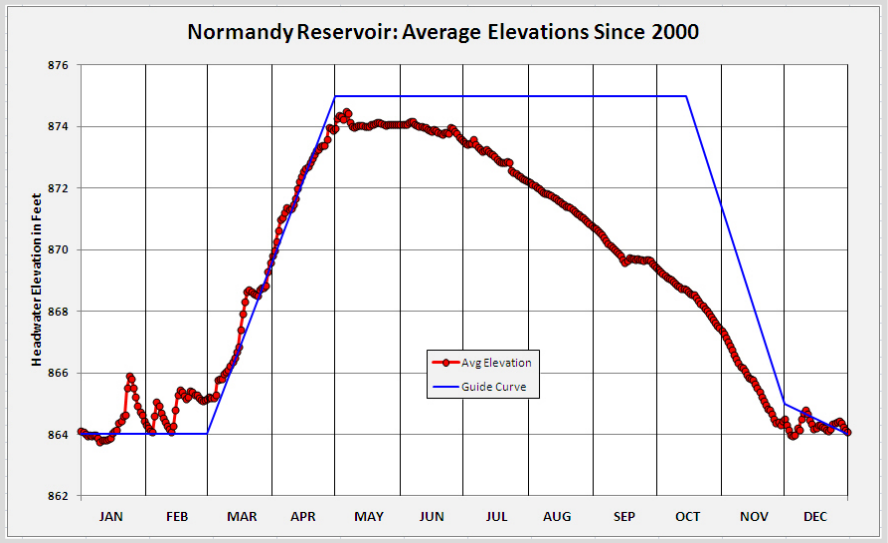

Figure 4. Normandy Reservoir operating rule curve

The following direct public water supply withdrawals occur along an 88 river mile segment of the Duck River between Shelbyville and 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.
- 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 5).

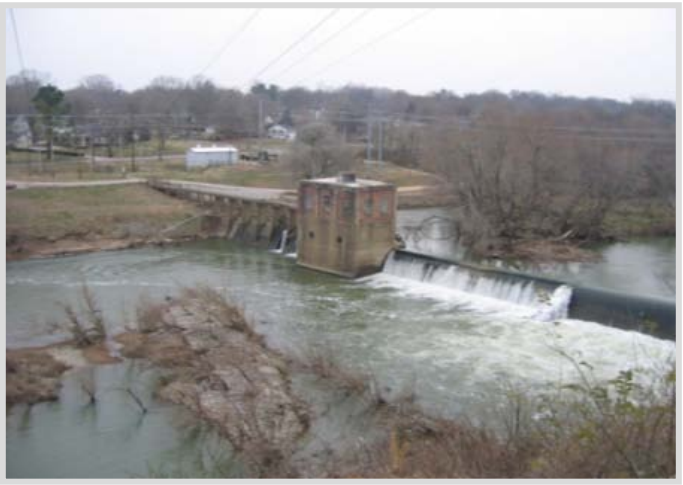

Figure 5. Columbia Dam

2.2. POTENTIAL SOURCES OF UNCERTAINTY FOR WATER SUPPLY

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. The precision of the valving used for the Normandy Reservoir release is capable of meeting a flow target at Shelbyville with a tolerance of approximately 5 cfs (i.e., 125 cfs for the 120 cfs flow target and 160 cfs for the 155 cfs flow target). The OASIS hydrologic model used in the Comprehensive Regional Water Supply Plan includes an additional 5 cfs release 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 in the Duck River above the target levels at Shelbyville. Localized drought conditions downstream of the dam can also impact 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 flow targets 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. However, the date of occurrence, magnitude, and duration of this future event are not known.
- 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 known 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 available water used for 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.

SECTION 3 – ALTERNATIVES ANALYSIS

3.1. IDENTIFICATION AND DISCUSSION OF ALTERNATIVES

In October 2011, the DRA formed an ONRR Task Force and held an initial work session with the Task Force to address the following topics related to Normandy Reservoir releases:

- Confirm existing information related to releases from Normandy Reservoir and discuss possible approaches for optimizing releases
- Identify which aspects of the Normandy Reservoir release are "open for discussion" and which cannot be modified
- Identify what information the Task Force and regulatory agencies need to make decisions

As a result of this initial work session, the Task Force identified that the following aspects of the Normandy Reservoir release and Shelbyville flow target are not open for discussion or modification:

- Any change in 40 cfs release immediately downstream of Normandy Reservoir
- Any change that could potentially compromise the safety of the dam for Normandy Reservoir
- Any change in location or quantity of flow established for the 120 cfs and 155 cfs flow targets at Shelbyville

It is noted that the Task Force recognized that changing the operation of Normandy Reservoir (i.e., change in operating rule curve) or the flow targets for the Duck River at Shelbyville was not unprecedented:

- In 1987, the Winter/Spring pool level for Normandy Reservoir was increased five feet (i.e., 859 feet to 864 feet) to facilitate refilling of the reservoir to the Summer/Fall pool level of 875 feet
- During the drought of 1980-1981, a continuous year-round release of 155 cfs was reduced to 80 cfs in the Winter/Spring months (December through May) to make more water storage available in Normandy Reservoir for water supply, recreation and fish and aquatic life
- In 1991, the Winter/Spring flow was increased from 80 cfs to 120 cfs to address wasteload assimilation needs at Shelbyville
- During the severe drought of 2007/2008 (i.e., driest on record in 118 years), 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 "temporarily" reduce the flow constraints at Shelbyville in order to reduce releases (i.e., preserve water in storage) from Normandy Reservoir

The Task Force agreed that the following three alternatives are worthy of investigation as part of this study:

- Extending December through May Shelbyville Flow Target. Discuss possibility of extending the period of the December through May release of 120 cfs at Shelbyville (i.e., thereby reducing the reservoir release period for 155 cfs) to facilitate refilling Normandy Reservoir to the Summer/Fall pool level of 875 feet
- Relocate or Add USGS Gaging Stations. Evaluate the possibility of relocating existing stream gages or adding new stream gages on the Duck River tributaries between Normandy Reservoir and the flow target at Shelbyville in order to improve efficiency of reservoir releases
- Revise Instantaneous Measurement of Flow Target at Shelbyville. Evaluate the possibility of changing the flow target at Shelbyville from an "instantaneous" measurement of the flow target to a 3-day or 7-day rolling average or some other measure

A summary of the three alternatives identified by the ONRR Task Force follows.

3.1.1. Extension of December through May Shelbyville Flow Target

This alternative involves extending the December through May flow target of 120 cfs at Shelbyville for a period of time (defined by reservoir water levels) to facilitate refill of Normandy Reservoir to the Summer/Fall pool level of 875 feet. Based on discussions with the ONRR Task Force, it was concluded that if water levels in Normandy Reservoir were low, the triggers established in DRA's Regional Drought Management Plan (DMP) and tied to water levels in Normandy Reservoir would be activated and the flow target at Shelbyville would be reduced as outlined in DRA's DMP. Consequently, the benefits and actions associated with this alternative are described in DRA's Regional DMP. However, at this time, it is unclear whether the actions outlined in the DRA's Regional DMP will be implemented. Consequently, it is recommended that DRA retain for future consideration this alternative which involves extending the December through May flow target of 120 cfs at Shelbyville for a period of time to facilitate refill of Normandy Reservoir to the Summer/Fall pool level of 875 feet.

3.1.2. Relocate or Add USGS Gaging Stations

This alternative involves relocating existing USGS gages or adding new gages to the tributaries feeding the Duck River between Normandy Reservoir and Shelbyville in order to better account for flows from localized thunderstorms on tributary watersheds and to allow TVA to more precisely satisfy the flow target at Shelbyville. As of January 2011, the USGS provided information on the location and data collected for the current streamflow gages in the Duck River basin (Figures 6 and 7). As part of this study, DRA worked closely with USGS to identify possible sites on the Duck River and its tributaries near Normandy Reservoir that would be suitable for installation of stream gages. As a result of these discussions and investigations, DRA and the USGS identified that a stream gauge on the Duck River, immediately below the confluence with Garrison Fork, may be beneficial for TVA to monitor or adjust releases from Normandy Reservoir during low flow periods. For this study, DRA recognizes the uncertainties associated with obtaining stream gage data under low flow conditions and the difficulty in interpreting and using this information to make adjustments to the releases from Normandy Reservoir. Consequently, DRA did not attempt to quantify the potential benefits associated with the reduction in releases from Normandy Reservoir resulting from the installation of stream gages. However, this alternative is recommended for further consideration and DRA will continue to work with USGS to identify suitable locations for new stream gages on this reach of the Duck River. (Note that in support of the need to monitor the critical habitat on the Duck River downstream of Shelbyville, DRA and the USGS identified that relocating the existing Garrison Fork stream gauge above the L&N Railroad at Wartrace (#03597210) to the Duck River at Sowell Mill Pike Bridge (DR mile 156.2) was beneficial. A gauge previously existed at this location could be used for collecting critical flow data and monitoring aquatic habitat needs, especially during low flow conditions.)

USGS Gaging Stations in the Duck River Watershed – January 2011

Map Number	STATION NUMBER	STATION NAME	Lat	Long	Gage Type	Funding Agencies
1	03601990	DUCK RIVER AT HWY 100 AT CENTERVILLE	35.784234	-87.460014	Discharge & Precip	TDOT-USGS
2	03602500	PINEY RIVER AT VERNON	35.871263	-87.501404	Discharge	TDEC-USGS
3	03599500	DUCK RIVER AT COLUMBIA	35.618055	-87.032347	Discharge & Precip	DRA - USGS
4	03599450	FOUNTAIN CREEK NEAR FOUNTAIN HEIGHTS	35.51824	-86.94207	Discharge	DRA - USGS
5	03599240	DUCK RIVER ABOVE MILLTOWN	35.57636	-86.778585	Discharge	DRA - USGS
6	03599100	BIG ROCK CR AT DOUBLE BRIDGES	35.530605	-86.768652	Discharge	DRA - USGS
7	03598000	DUCK RIVER NEAR SHELBYVILLE	35.48035	-86.499161	Discharge	USGS-NSIP
8	03597860	DUCK RIVER AT SHELBYVILLE	35.4829	-86.462597	Discharge, Precip, QW	DRA-USGS
9	03597590	WARTRACE CREEK BELOW COUNTY ROAD AT WARTRACE	35.527295	-86.340271	Discharge	Wartrace - USGS
10	03597210	GARRISON FORK ABOVE L&N RAILROAD AT WARTRACE	35.51174	-86.323882	Discharge	DRA - USGS
11	03596000	DUCK RIVER BELOW MANCHESTER	35.47091	-86.121656	Discharge	TVA
12	03596075	SINKING POND AT AEDC	35.410078	-86.069709	Stage	AEDC
13	03601630	LOCKE BRANCH NEAR BENDING CHESTNUT	35.87201	-87.103895	Sediment Load	TDOT-USGS

Figure 6. USGS Gage Data

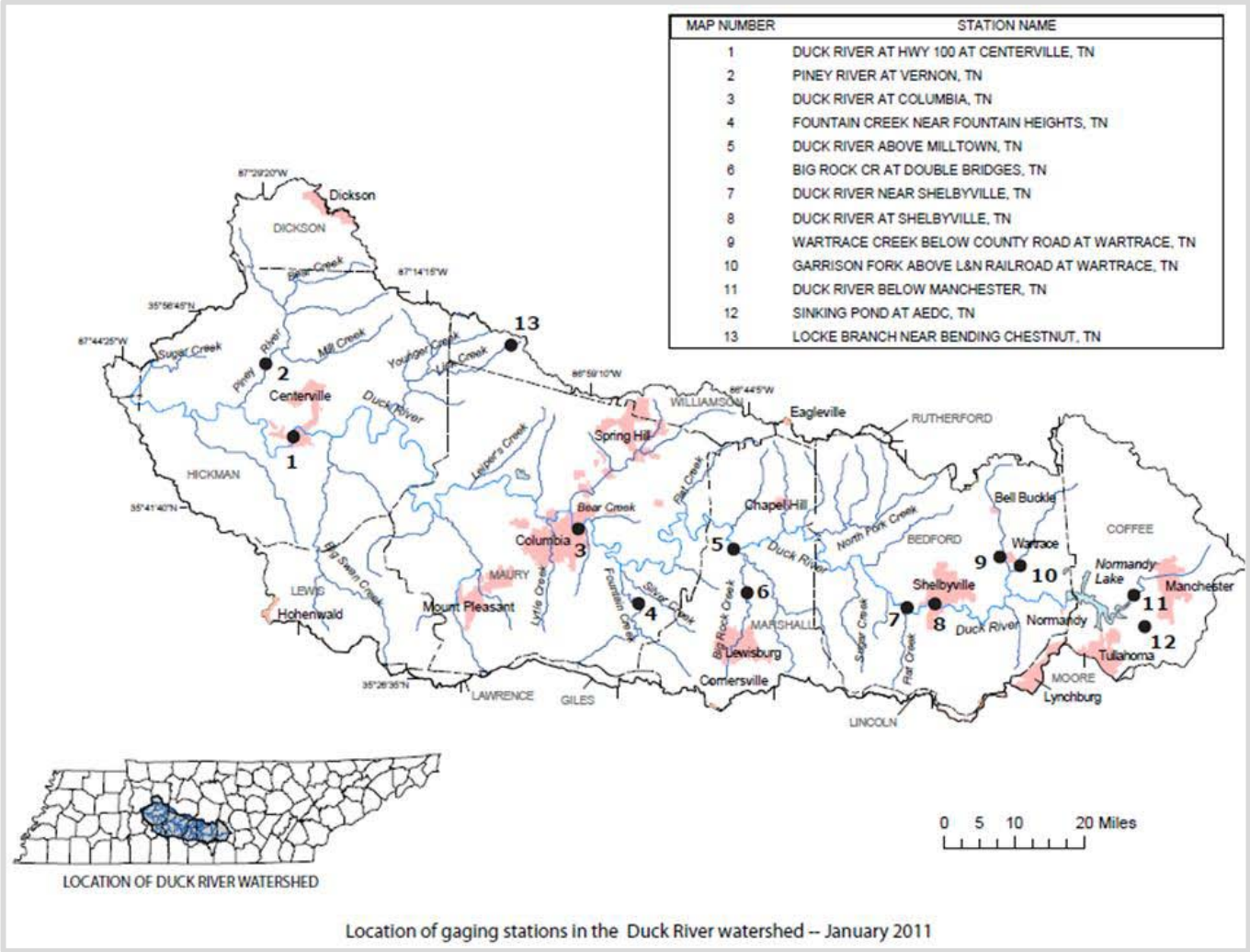

Figure 7. USGS Gage Station Map

3.1.3. Revise "Instantaneous" Flow Target at Shelbyville

The current flow targets at Shelbyville include flow measurements based on minimum "instantaneous" flow requirements as outlined in the following statements:

- 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.

Currently, TVA releases what could be considered to be "excess" water from Normandy Reservoir to ensure that flows in the Duck River at Shelbyville never drop below the target flows of 120 cfs or 155 cfs on an instantaneous basis. This alternative addresses the possibility of changing the "instantaneous" flow requirement included in the Shelbyville flow target to an alternative measure (i.e., weekly average, flow tolerance with minimum threshold, etc.) that would allow TVA to more precisely satisfy the flow target at Shelbyville.

In November 2011, several members of the Task Force met with TDEC to discuss the connection between the NPDES permits at Shelbyville and the flow targets (i.e., Normandy Reservoir releases). A summary of the meeting follows:

- TDEC provided a chronology of events associated with establishment and modification of the flow targets downstream of the dam as well as at Shelbyville and Columbia.
- TDEC has conducted modeling of the Duck River at Shelbyville to assess the impacts of the recent and significant improvements at the wastewater treatment facilities and outfall diffusers at Shelbyville. 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. The Task Force members therefore agreed that the location and quantity of flow associated with the Shelbyville flow targets would not be permanently altered. The Task Force did propose the possibility of extending the period of the December through May flow target of 120 cfs at Shelbyville in order to preserve water in storage in Normandy Reservoir.
- The Task Force identified several alternatives to the instantaneous requirement for the flow target at Shelbyville including a 3-day or 7-day rolling average or a 5 or 10 cfs "buffer" with a minimum threshold flow.
- Hydrologic modeling using the OASIS model was recommended to assess the water storage benefits associated with changing the instantaneous flow to an alternative measure.

Following the TDEC meeting, several versions of the Duck River flow constraint at Shelbyville (DRM 221.4) were generated, reviewed, and evaluated by the ONRR Task Force members. The following represents the proposed wording for the revised flow target on the Duck River at Shelbyville:

- *Weekly average flow of 120 cfs measured at midnight on Sunday for the period of December 1 through May 31 with a minimum instantaneous flow of not less than 100 cfs*
- *Weekly average flow of 155 cfs measured at midnight on Sunday for the period of June 1 through November 30 with a minimum instantaneous flow of not less than 135 cfs*
- *Any partial weeks resulting from the change in target average flows at midnight on June 1 and at midnight on December 1 shall be treated as full weeks with respect to compliance with the required weekly average flow targets*

In February 2012, hydrologic modeling was performed using the OASIS model to identify the impacts of modifying reservoir releases by moving from an instantaneous flow target at Shelbyville to the weekly average flow conditions identified in the revised flow target. A 5 cfs change in flow was used in the model to test the sensitivity of the flow target at Shelbyville under instantaneous and weekly average flows. As shown in Figure 8, a 5 cfs change in the flow target at Shelbyville yields an increase in water in storage of approximately 700 MG during worst drought of record (roughly 1 ft increase in reservoir pool level which equates to roughly 2 mgd for one year or 30 percent of the projected water demand for Manchester and Tullahoma in 2020). In addition, this operational strategy should provide TVA with some additional flexibility in terms of monitoring and meeting the flow targets at Shelbyville.

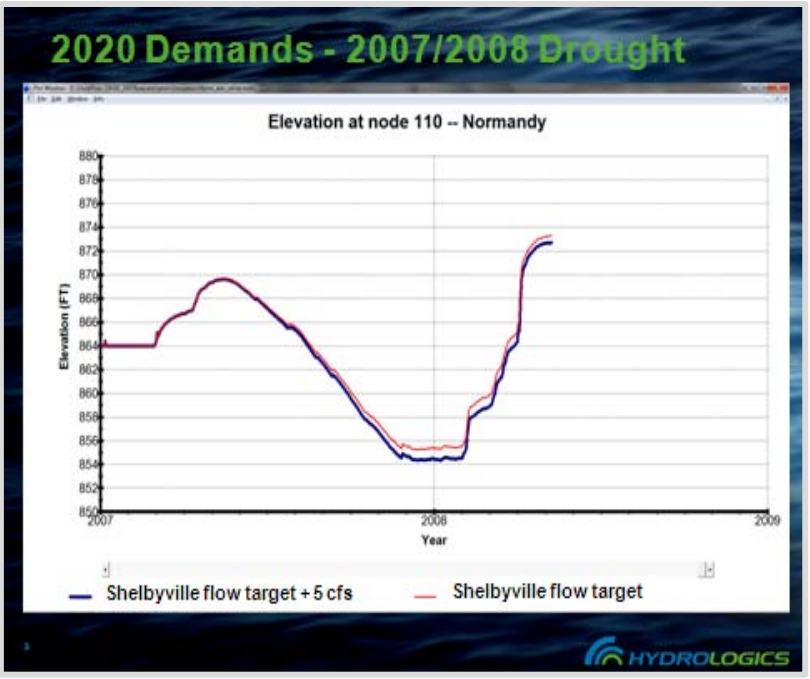

Figure 8. Impact of 5 cfs change in Shelbyville flow target on Normandy Reservoir water level

3.2. SUMMARY AND RECOMMENDATIONS

The purpose of the Tennessee Duck River Development Agency's (DRA) *Optimization of Normandy Reservoir Releases* (ONRR) is to review and discuss the factors impacting releases from Normandy Reservoir and assess whether modifications can be made to the reservoir releases to more precisely satisfy the flow targets at Shelbyville thereby preserving water in storage in Normandy Reservoir. The study discussed the following three alternatives:

- Extending December through May Shelbyville Flow Target. Discuss possibility of extending the period of the December through May release of 120 cfs at Shelbyville (i.e., thereby reducing the reservoir release period for 155 cfs) to facilitate refilling Normandy Reservoir to the Summer/Fall pool level of 875 feet
- Relocate or Add USGS Gaging Stations. Evaluate the possibility of relocating existing stream gages or adding new stream gages on the Duck River tributaries between Normandy Reservoir and the flow target at Shelbyville in order to improve efficiency of reservoir releases
- Revise Instantaneous Measurement of Flow Target at Shelbyville. Evaluate the possibility of changing the flow target at Shelbyville from an "instantaneous" measurement of the flow target to a 3-day or 7-day rolling average or some other measure

It is recommended that DRA carry each of the three alternatives forward for implementation.