RAW WATER STUDY

FOR THE

CITY OF CROSSVILLE, TENNESSEE

PROJECT NUMBER 4637

November 2017

WAUFORD
J. R. Wauford & Company, Consulting Engineers, Inc.

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Nashville, Tennessee 37214
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OFFICIALS

FOR THE

CITY OF CROSSVILLE, TENNESSEE

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James Mayberry

MAYOR PRO TEM
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CITY COUNCIL
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Danny Wyatt

CITY MANAGER
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CITY CLERK
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DIRECTOR OF ENGINEERING
Tim Begley

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RAW WATER STUDY
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1.0 EXECUTIVE SUMMARY

1.1 Purpose and Scope

The purpose of this Raw Water Study (Study) is to evaluate the existing high service water pumped, water sold, and growth and usage projections to determine timelines and alternatives related to the expansion of the available raw water capacity. This study is not intended to be a comprehensive alternatives analysis.

The scope of this Report includes the following items:

- Evaluation of the existing high service water pumped records and water sales records to determine the existing water system usage,
- Evaluation of available population projections and potential future industrial water usage predictions to determine estimated 20 year and 50 year raw water demands,
- Review of existing information produced by the United States Army Corps of Engineers and others related to the future water needs of the City,
- Review of available records of the Meadow Park Lake Dam and use agreement related to the transfer of Lake Tansi water to Meadow Park Lake, and
- Development of a plan of action including preliminary alternatives to meet the future raw water demands of the City for further review.

2.0 EXISTING FACILITIES

2.1 Raw Water Supply

The City of Crossville's raw water supply is stored in three existing reservoirs located to the south and west of the City – Holiday Hills Lake, Meadow Park Lake, and Lake Tansi. Holiday Hills Lake, the only reservoir

of the three located within the City limits, was created in the early 1960s and is owned by the City. Meadow Park Lake, which is also owned by the City, was constructed in 1938 and underwent a dam renovation in 2012 to address structural concerns. Lake Tansi, originally named Harrison Lake, was built in the mid-1950s and is owned by the Lake Tansi Village Property Owners Association. The City entered into a water-harvesting agreement with the Lake Tansi Village Property Owners Association in October 2009 to withdrawal water from the reservoir. The City is permitted to withdraw water from Lake Tansi between October 31 and April 15 with a restriction that the lake must not fall four inches below the normal operating pool elevation of 1861.71 feet. Water that is harvested from Lake Tansi can be pumped directly into Meadow Park Lake or to the Meadow Park Lake Water Treatment Plant. The transfer of water from Lake Tansi is also regulated by an inter-basin transfer permit issued by the Tennessee Department of Environment and Conservation (TDEC) limiting the daily transfer to 5.0 million gallons per day (MGD).

2.2 Water Treatment Plants

The City owns and operates two potable water treatment plants – the Holiday Hills Water Treatment Plant (WTP) located near Holliday Hills Lake Dam and the Meadow Park WTP located near Meadow Park Lake. Holiday Hills WTP was placed into operation as a conventional filtration plant in 1968 and has a current rated capacity of 4.0 million gallons per day (MGD). The original Meadow Park Lake WTP was constructed with the reservoir in 1938 and underwent expansions in 1952, 1961, and 1990. In 2001, the City built a new conventional filtration plant with a rated capacity of 3.5 MGD bringing the City's total treatment capacity to 7.5 MGD. The Meadow Park Lake WTP was designed to be expanded to 7.0 MGD.

3.0 PREVIOUS REPORTS AND FINDINGS

3.1 General

Engineering reports, memos, long-term plans, and agreements were obtained from the City for review. A list of these documents is shown below.

- *"Engineering Report for Cumberland County Water Supply"*, May 1988, Barge, Waggoner, Sumner and Cannon
- *"Cumberland County Rural Water Improvement Plan"*, November 1997, Cumberland County Regional Planning Commission
- *"Cumberland County Regional Water Supply Study"*, December 1998, United States Army Corps of Engineers Nashville District
- *"Securing Watts-Bar Reservoir Water for Crossville"*, November 1999, Lamar Dunn & Associates, Inc.
- *"Investigating the Feasibility of Constructing Raw Water Impoundments Downstream of Meadow Park Lake"*, December 2001, Lamar Dunn & Associates, Inc.
- *"Report on the Expansion of Meadow Park Dam and Lake for the City of Crossville"*, April 2003, Environmental & Civil Engineering Services
- *"Land-Use Assumption for Phase II of the Cumberland County Regional Water Supply Study"*, December 2006, GKY & Associates, Inc.
- *"Crossville City Council Meeting Minutes"* (excerpt), May 2007, City of Crossville
- *"Water Supply Assessment letter to Jerry Kerley"*, November 2007, Environmental & Civil Engineering Services
- *"Lake Tansi Water Harvesting Project – Preliminary"*, January 2008, Environmental & Civil Engineering Services
- *"Tansi Water Analysis"*, February 2008, Field's Engineering Consultant Services
- *"Cumberland County Drought Identification - Standardized Precipitation Index Analysis of Monthly Rainfall"*, September 2008, GKY & Associates, Inc.
- *"Water Conservation Plan for the Cumberland County Regional Water Supply Study"*, September 2008, GKY & Associates, Inc.
- *"Water Needs Assessment for the Cumberland County Regional Water Supply Study"*, September 2008, GKY & Associates, Inc.

- *"Water Needs Assessment and Water Conservation Plan - Final Report"*, March 2009, GKY & Associates, Inc.
- *"Drinking Water Facilities Plan - ARRA Raw Water Harvesting Project"*, September 2009, Environmental & Civil Engineering Services
- *"Cumberland County Regional Water Supply Plan – Assumptions"*, July 2012, GKY & Associates
- "*Cumberland County Regional Water Supply - Task 1 Technical Memorandum*", October 2012, GKY & Associates
- *"Meadow Park Lake Usable Storage - Yield Curve"*, Unknown, Unknown
- *"Fox Creek Lake Usable Storage - Yield Curve"*, Unknown, Unknown
- *"Crossville Utility Service Area Map"*, February 2013, City of Crossville
- *"Annual Utility Rate Survey"*, 2014, East Tennessee Development District
- *"Cumberland County Regional Water Supply Plan Scope of Work"*, August 2014, United States Army Corps of Engineers
- *"Cumberland County Regional Water Supply - Task 3: Water Needs Summary Memo"*, September 2015, GKY & Associates
- *"Cumberland County Regional Water Supply Plan – Presentation"*, October 2015
- *"Aquatic Resources Alteration Permit (ARAP) Application - Daddys Creek Raw Water Intake"*, May 2017, Field's Engineering Consultant Services, LLC

Each of these documents, beginning with the oldest report from May 1988, is related to Cumberland County's raw water supply and possible alternatives to increase raw water storage or to reduce potable water pumping rates. These alternatives include the following: transfer of water from Watts-Bar Reservoir, transfer of water from the Caney Fork River, construction of new impoundments for storing water, and raising existing dams to provide for higher reservoir capacity.

Some of the previous documents examined methods to reduce the potable water (high service) pumping rate from the Water Treatment Plants, thereby increasing available capacity. These primary methods consist of reducing

system leakage and the use of conservation techniques such as new plumbing fixtures and increasing the purchase price for increased usage rates. Although these methods can achieve some level of success, they do not provide the certainty of an increased raw water supply. The City's current unaccounted for water rate is less than 25 percent which is probably below average for similar systems. There may be opportunities to further reduce the unaccounted for water rate, but it is likely that a series of leaks will occur in the future that the City may not be able to locate immediately. If this occurs in conjunction with a spike in usage, regardless of pricing structures, the City could find itself depleting its raw water capacity. An increased raw water capacity will give the City the flexibility to overcome uncertain events similar to those described herein.

The United States Army Corps of Engineers (COE) has the authority to regulate the creation or modification of dams and their reservoirs in Tennessee. In 2006, the COE initiated the Cumberland County Water Supply project and contracted with GKY & Associates (GKY) of Chantilly, Virginia to find a regional water solution that would meet the County's need for water over a fifty-year planning period. In March 2009, GKY submitted a final report titled "*Water Needs Assessment and Water Conservation Plan*" addressing the potential for reducing demand only and not increasing raw water supply. In 2009, Crossville acquired the rights to harvest water from Lake Tansi, located about two miles from the Meadow Park WTP. The pipeline and pumping station from Lake Tansi to Meadow Park Lake were completed in October 2011. The COE 404 Permit given to Crossville for the harvesting of Lake Tansi water only allows water to be pumped from October 31 to April 15 with a restriction that the City may draw down the lake only four inches from the normal pool elevation. Furthermore, an Inter-basin Transfer Permit from the Tennessee Department of Environment and Conservation (TDEC) restricts the amount of water harvested from Lake Tansi to 5 MGD. In 2015, GKY presented a timetable depicting their

envisioned sequence of infrastructure upgrades which including expanding the existing WTP capacities, reducing institutional constraints, expanding the Holiday Hills WTP service area, removing pipe constraints, and lastly, raising Meadow Park Lake Dam.

Since 1988, little advancement has been made toward securing Crossville an increased supply of raw water.

4.0 FUTURE WATER DEMAND

4.1 General

Two methods have been used to forecast future high service flows and raw water demand for Cumberland County. These methods are (1) finished water pumping and water sales records and (2) population projections.

4.2 Finished Water Pumping and Water Sales Records

Crossville currently provides potable water to a large area of Cumberland County. The City's zone of direct service includes the area within the city limits as well as the former service area of the Catoosa Utility District which merged with the City in October 2005. The City sells wholesale water to the South Cumberland Utility District, which serves the Lake Tansi community, and the Grandview Utility District located to the southeast. The approximate service zones of the water providers in Cumberland County are depicted at Exhibit No. 2 in the Appendix.

Finished water pumping data provided by Crossville from 1998 to 2017 were used to perform a linear regression which is shown in Exhibit No. 1 - Historical and Projected Water Usage Data in the Appendix. In addition to the finished water pumped, the water sold for the same period for each month from 1998 to 2016 are also shown in Exhibit No. 1. The yearly average finished, sold, and unaccounted water flows from 1998 to 2016 are depicted in Table No. 4-1.

TABLE NO. 4-1
EXISTING WATER USAGE
CROSSVILLE, TENNESSEE

Year	Total Water Pumped (MGD)	Total Water Sold (MGD)	Unaccounted Water (MGD)
1998	2.937	2.398	0.539
1999	2.946	2.546	0.400
2000	2.914	2.638	0.276
2001	2.939	2.652	0.287
2002	3.334	2.725	0.609
2003	3.481	2.587	0.894
2004	3.548	2.511	1.037
2005	3.676	2.894	0.782
2006	3.644	2.744	0.900
2007	3.881	2.886	0.996
2008	3.645	2.863	0.782
2009	3.751	2.805	0.946
2010	3.974	2.895	1.079
2011	3.656	2.880	0.776
2012	3.675	2.904	0.770
2013	3.934	2.825	1.109
2014	3.834	2.937	0.897
2015	3.761	2.965	0.796
2016	3.774	2.995	0.779

Crossville's total water sold has risen an average of 0.60 MGD from 1998 to 2016. This represents an increase of 24.9 percent over 18 years which can be adjusted to 27.7 percent growth rate over a 20-year design period and a 69.1 percent growth rate over a 50-year design period for this study. This rate indicates that Crossville has had a steady increase in total water sold for almost two decades. Additionally, the City's unaccounted water (leakage, flushing, testing, *etc*.) averages between 20 and 25 percent. Generally, a leakage rate of 20 percent is considered acceptable and operators find it difficult to substantially reduce leakage below 20 percent long term.

4.3 Population Projections

The second method by which the projected water demand can be determined is through population projections. Using this method, the actual historical and projected population data is used to project future water usage. Population data was obtained from the United States Census Bureau and the University of Tennessee Center for Business and Economic Research. Since the City also serves a significant population in Cumberland County through line extensions and selling water to other utility districts, population projections for Cumberland County were used. The historical and projected population of Cumberland County is shown in Table No. 4-2.

TABLE NO. 4-2
POPULATION DATA
CUMBERLAND COUNTY, TENNESSEE

Year	Cumberland County Population
2000 census	46,802
2010 census	56,053
2017 estimate	58,655
2027 projection	66,546
2037 projection	74,437
2047 projection	82,328
2057 projection	90,218
2067 projection	98,110

The projected growth of Cumberland County from 58,655 persons in the year 2017 to 98,110 persons in the year 2067 results in a 67.3 percent increase, or 1.35 percent per year for the 50 year design period.

4.4 Growth Outside Crossville Service Area

There are four water providers that serve the citizens of Cumberland County: City of Crossville, West Cumberland Utility District (WCUD), South

Cumberland Utility District (SCUD), and Crab Orchard Utility District (COUD). Crossville, the largest of the four, sells water to the SCUD which subsequently sells water to other smaller utility districts outside Cumberland County. WCUD purchases all of its water (approximately 0.35 MGD) from BonDeCroft Utility District located in White County, although future considerations should be made for WCUD to purchase water from Crossville due to proximity.

COUD serves the eastern part of Cumberland County including the Fairfield Glade Community Club. In 1995, COUD constructed a dam on Otter Creek creating a 137 acre reservoir and constructed a 2.0 MGD water treatment plant. This plant has been expanded to treat 4.0 MGD although Otter Creek Lake can reportedly only produce a safe yield of approximately 3.0 MGD. COUD serves approximately 8,000 active customers. Using 2010 census data of 2.35 persons per household in Cumberland County, it is estimated that COUD serves 18,800 residents – approximately 32 percent of the county's total population. COUD currently averages between 2.0 to 2.5 MGD of daily water pumped and has applied for an Aquatic Resources Alteration Permit for a raw water intake on Daddys Creek and accompanying dam and reservoir on a nearby unnamed tributary for additional raw water supply. If unsuccessful, COUD may be forced to purchase water from Crossville above the 3.0 MGD limit that Otter Creek Lake can provide as growth occurs.

4.5 Conclusion

The two methods used to forecast future high service flows and water sales are (1) finished water pumping and water sales records and (2) population projections. The respective year 2017 to year 2037 (20 year) and year 2017 to year 2067 (50 year) growth rates for each forecast method are shown in Table No. 4-3.

TABLE NO. 4-3
GROWTH FORECAST METHOD COMPARISONS
CROSSVILLE, TENNESSEE

Forecast Method	20 Year Growth Rate	50 Year Growth Rate
Finished Water and Water Sales	27.7 percent	69.1 percent
Population Projection	26.9 percent	67.3 percent

Since 1998, the daily finished water sold by the City has increased by 24.9 percent, or 1.38 percent annually. Additionally, the projected population increase for Cumberland County to the design year of 2067 is 67.3% - 1.35 percent annually. These numbers suggest that a finished water 20-year growth factor of 30% and a finished water 50-year growth factor of 80% are adequate. The Year 2017 and Year 2067 projected raw water demands are depicted at Table No. 4-4.

TABLE NO. 4-4
YEAR 2037 (20 YEAR) AND YEAR 2067 (50 YEAR)
RAW WATER USAGE FORECAST
MODERATE GROWTH FORECAST
(30% IN 20 YEARS AND 80% IN 50 YEARS)
CROSSVILLE, TENNESSEE

Usage Entity	Year 2037 Flows	Year 2067 Flows
City of Crossville	3.89 MGD	5.39 MGD
West Cumberland Utility District	0.46 MGD	0.63 MGD
Crab Orchard Utility District Growth	0.44 MGD	1.17 MGD
Industrial Growth Allotment	2.00 MGD	2.00 MGD
Unaccounted Water Estimate	1.27 MGD	1.71 MGD
Total Raw Water Demand	8.06 MGD	10.98 MGD

For comparison, a high growth rate projection of future water demands was prepared using a 20-year growth rate of 50% and a 50-year growth rate of 100%. These projections are depicted at Table No. 4-5.

TABLE NO. 4-5
YEAR 2037 (20 YEAR) AND YEAR 2067 (50 YEAR)
RAW WATER USAGE FORECAST
HIGH GROWTH FORECAST
(50% IN 20 YEARS AND 100% IN 50 YEARS)
CROSSVILLE, TENNESSEE

Usage Entity	Year 2037 Flows	Year 2067 Flows
City of Crossville	4.49 MGD	5.99 MGD
West Cumberland Utility District	0.53 MGD	0.70 MGD
Crab Orchard Utility District Growth	0.73 MGD	1.47 MGD
Industrial Growth Allotment	2.00 MGD	2.00 MGD
Unaccounted Water Estimate	1.44 MGD	1.89 MGD
Total Raw Water Demand	9.19 MGD	12.05 MGD

Table Nos. 4-4 and 4-5 depict projected water usage rates for “moderate” and “high” growth scenarios. No projection for a “low growth” scenario is included due to the critical nature of adequate raw water capacity.

The Tennessee Department of Environment and Conservation Rule 0400-45-01-.05(10) requires that a utility begin plans for expansion of water treatment plant when the average daily usage reaches 80 percent of the plant capacity. Crossville currently has a combined water treatment plant capacity of 7.5 MGD with an 80 percent treatment capacity of 6.0 MGD.

5.0 ALTERNATIVES TO INCREASE RAW WATER SUPPLY

5.1 General

There are numerous possible alternatives for increasing the raw water capacity for the City of Crossville. The following alternatives were developed based on the review of previous studies and documents described herein. Alternatives such as development of groundwater sources and reducing system leakage to below 20 percent are not included either due to their remote chance of success or due to their lack of reliability. In other words, the City cannot guarantee their leakage will remain below

20 percent in perpetuity, meaning they will need additional raw water until the system can be repaired.

5.2 Alternative No. 1 – Raise Meadow Park Lake Dam and continue to harvest water from Lake Tansi

Alternative No. 1 consists of raising the elevation of Meadow Park Lake Dam to a sufficient elevation to provide raw water storage to meet the Year 2067 (50 year) forecast demands. The increased dam height will increase the storage volume of Meadow Park Lake, allowing additional transfer of Lake Tansi water during the winter months, although the daily maximum rate of transfer is not proposed to increase. The evaluation of this alternative will include a water mass balance and net storage model to determine the required dam height and if sufficient water can be transferred from Lake Tansi. The permits required for this alternative include but are not limited to a TDEC Aquatic Resource Alternation Permit and a COE Section 404 permit.

5.3 Alternative No. 2 – Raise Meadow Park Lake Dam, continue to harvest water from Lake Tansi and harvest Caney Fork River water

Alternative No. 2 is similar to Alternative No. 1 but includes the construction of a raw water transfer pumping station on the Caney Fork River to transport peak river flows to Meadow Park Lake for storage. The increased height of Meadow Park Lake Dam will allow for additional storage of peak flow transported from the Caney Fork River and Lake Tansi. The daily maximum transfer rate from Lake Tansi is not proposed to increase. The evaluation of this alternative will include a water mass balance and net storage model to determine the required dam height and resulting required transfer volume from Lake Tansi and the Caney Fork River. The permits required for this alternative include but are not limited to a TDEC Aquatic Resource Alternation Permit and a COE Section 404 permit.

5.4 Alternative No. 3 – Raise Meadow Park Lake Dam, continue to harvest water from Lake Tansi and harvest water from Holiday Hills Lake

Alternative No. 3 is similar to Alternative No. 1 but includes the construction of a pipeline from the Holiday Hills Lake raw water intake to Meadow Park Lake to transport peak flows to Meadow Park Lake for storage. The increased height of Meadow Park Lake Dam will allow for additional storage of peak flows transported from Holiday Hills Lake and Lake Tansi. The daily maximum rate of transfer from Lake Tansi is not proposed to increase. The evaluation of this alternative will include a water mass balance and net storage model to determine the required dam height and resulting required transfer volumes from Lake Tansi and Holiday Hills Lake. The permits required for this alternative include but are not limited to a TDEC Aquatic Resource Alternation Permit and a COE Section 404 permit. It is believed that the National Park Service will have commenting and review authority related to this alternative.

5.5 Alternative No. 4 – Harvest water from Watts Bar Lake

Alternative No. 4 consists of the construction of a raw water intake on Watts Bar Lake and raw water pipeline from Watts Bar Lake to Meadow Park Lake. Due to the virtually limitless supply of Watts Bar Lake, there will be no need to raise Meadow Park Lake Dam, nor will there be a need to prepare a water mass balance. The permits required for this alternative include but are not limited to a TDEC Aquatic Resource Alternation Permit and a COE Section 404 permit.

6.0 ALTERNATIVES ANALYSIS CONSIDERATIONS AND TIMELINES

Due to the size, complexity and permitting requirements of the alternatives proposed herein, a lengthy project implementation should be anticipated. Table No. 6-1 below depicts project milestones and estimated project schedule. Since

multiple agencies will be involved in the project approval process, it is likely that delays will be encountered.

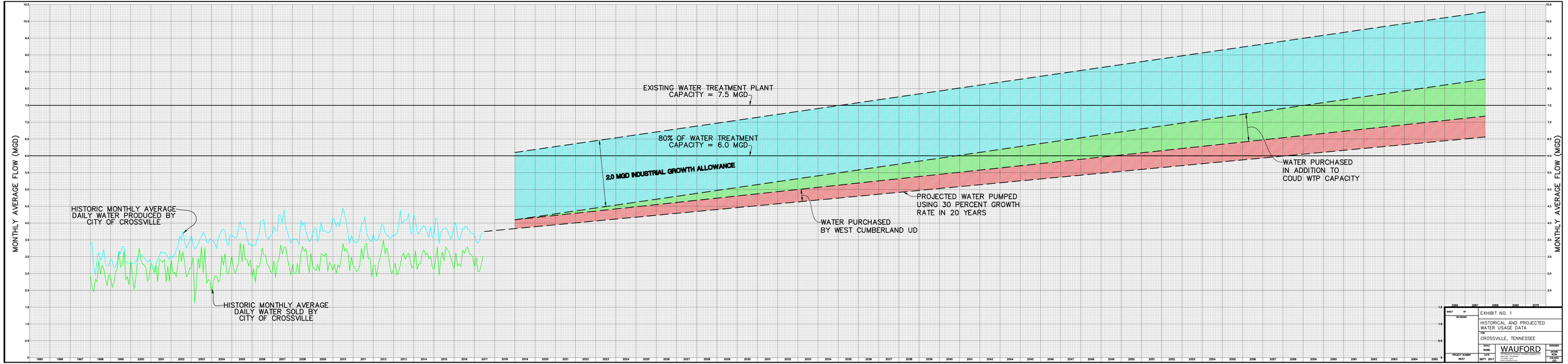
TABLE NO. 6-1
PROJECT IMPLEMENTATION SCHEDULE
CROSSVILLE, TENNESSEE

Task No.	Description	Scheduled Date
1	Deliver Final Preliminary Report to Crossville	November 2017
2	Meet with Representatives of the COE and TDEC about Crossville plans	January 2018
3	Prepare Detailed Alternative Analysis and Deliver to Crossville	January 2019
4	Prepare and Submit Permit Applications to Regulatory Agencies	April 2019
5	Receive Final Permits from Regulatory Agencies	April 2020
6	Prepare Plans and Specifications and Submit to Regulatory Agencies	January 2021
7	Accept Bids for Construction	May 2021
8	Complete Construction and Place in Service	May 2023

The aforementioned schedule should be considered reasonable to implement but will be extended if unforeseen permitting issues arise.

APPENDIX

Exhibits


MONTHLY AVERAGE FLOW (MGD)
EXISTING WATER TREATMENT PLANT
CAPACITY = 7.5 MGD
80% OF WATER TREATMENT
CAPACITY = 6.0 MGD
2.0 MGD INDUSTRIAL GROWTH ALLOWANCE
HISTORIC MONTHLY AVERAGE
DAILY WATER PRODUCED BY
CITY OF CROSSVILLE
HISTORIC MONTHLY AVERAGE
DAILY WATER SOLD BY
CITY OF CROSSVILLE
WATER PURCHASED
BY WEST CUMBERLAND UD
PROJECTED WATER PUMPED
USING 30 PERCENT GROWTH
RATE IN 20 YEARS
WATER PURCHASED
IN ADDITION TO
COUD WTP CAPACITY
SHEET
OF
EXHIBIT NO. 1
REVISIONS
HISTORICAL AND PROJECTED
WATER USAGE DATA
TITLE
CROSSVILLE, TENNESSEE
SCALE
NONE
DESIGNED
WAUFORD
PROJECT NUMBER
4637
DATE
SEPT. 2017
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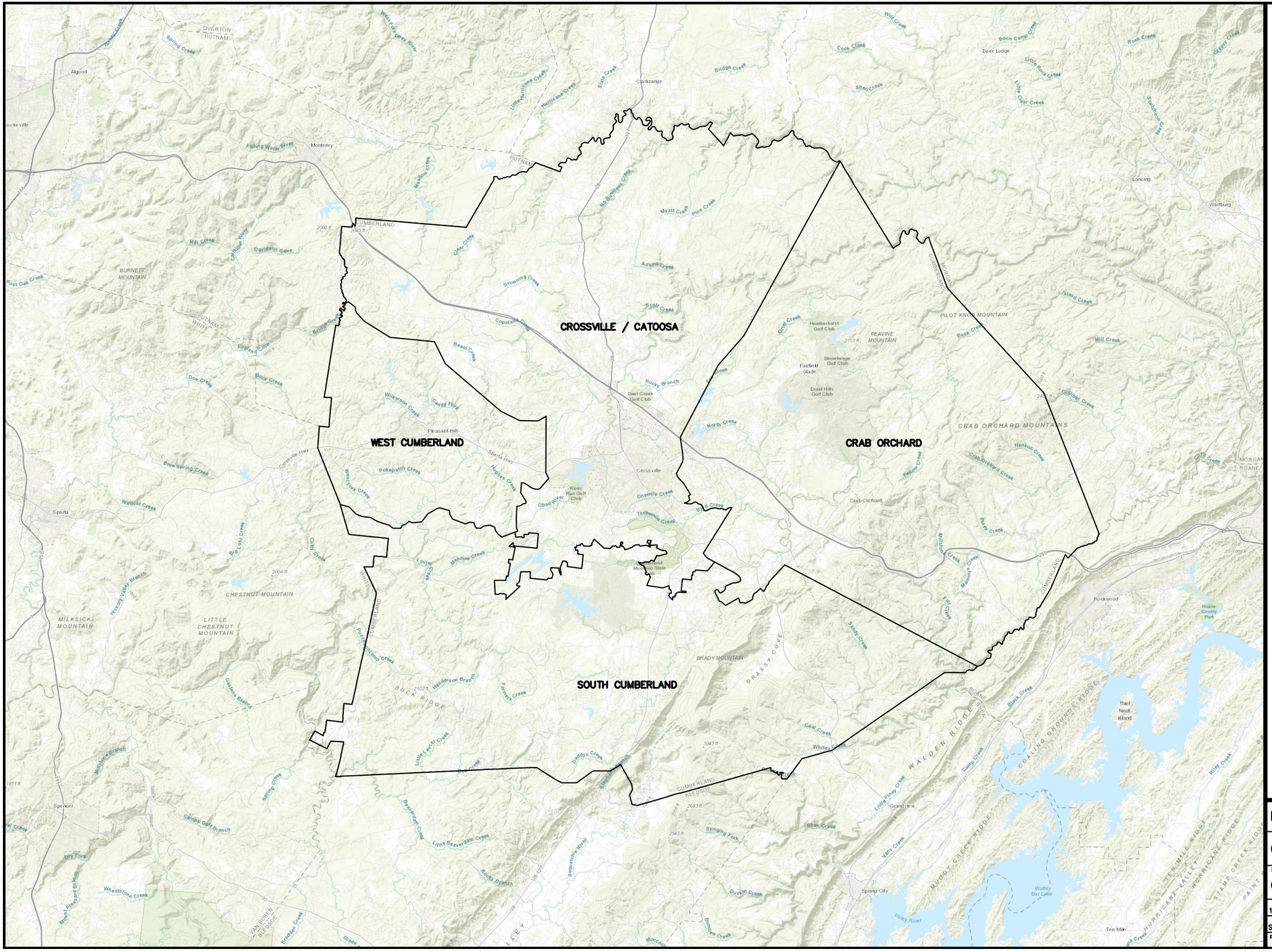

EXHIBIT NO. 2

CUMBERLAND COUNTY UTILITY DISTRICT MAP

FOR

CROSSVILLE, TENNESSEE

SCALE 1"=20,000'	WAUFORD	DESIGNED –
DATE SEPT. 2017	J. R. Wauford & Company, Consulting Engineers, Inc. Nashville, Tennessee (615)883-3243 www.jrwauford.com	DRAWN WZM
PROJECT NO. 4637		CHECKED –