City of Crossville
Drinking Water Facilities Plan
ARRA Raw Water Harvesting Project

May 28, 2009
Revised September 8, 2009

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SECTION 1. EXECUTIVE SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

1.1. Statement of the Problem

The City of Crossville has reached 75% to 80% capacity of their existing raw water supplies for the production of potable water. The configuration and supply network of the Cumberland County Region has changed significantly in the last five years with the City of Crossville, as always, remaining the primary supplier of water for the region. The droughts of 2006, 2007, and 2008 created shortages in the raw water supply which mandated the enforcement of water use restrictions throughout the region.

The City of Crossville must augment the currently available supply in order to maintain adequate water volumes to their customers in the region. The projected 20-year raw water demand is 7.54 million gallons per day. The City has no more than 6.0 million gallons per day available from the existing reservoirs.

1.2. Summary of the Alternative Solutions Considered

Four alternatives have been considered to provide additional raw water supply and storage to the City of Crossville. The four alternatives are

- No action alternative
- Water harvest from the Watts Bar Reservoir to Meadow Park Lake
- Water harvest from Lake Tansi to Meadow Park Lake
- Water harvest from the Caney Fork River to Meadow Park Lake

The following table summarizes the capital cost, capacity, electrical cost, advantages, and disadvantages of each of the alternatives:

Table 1 – Summary of Alternatives

	Watts Bar to Meadow Park Alternative	Lake Tansi to Meadow Park Lake	Caney Fork River to Meadow Park Lake
Capital Cost	$61.5 million	$5.0 million	$15.5 million
Capacity	3.5 MGD	3.5 MGD	3.5 MGD
Electrical Cost	$1,256,017 per year	$106,018 per year	$967,479 per year
Advantages	Highest level of expandability Highest increase in additional storage for raw water	Lowest power costs Lowest environmental effects High water quality Minimal or no additional sedimentation of Meadow Park Lake Provides additional storage for raw water	Some expandability

Table 1 – Summary of Alternatives

	Watts Bar to Meadow Park Alternative	Lake Tansi to Meadow Park Lake	Caney Fork River to Meadow Park Lake
Disadvantages	Highest power costs Highest environmental effects Increased sedimentation of Meadow Park Lake Poor water quality Subject to effects from TVA coal ash spill at Kingston	Minimal amount of expandability	High power costs Large environmental effects from power generation Increased sedimentation of Meadow Park Lake No additional storage for raw water

1.3. Recommended Solution

The selected alternative for this Project is to water harvest from Lake Tansi to the Meadow Park Lake and Treatment Plant. The Lake Tansi reservoir is a man made reservoir impounded by an earthen dam.

The reservoir has a surface area at normal pool of 404 acres and a drainage area of 4.48 square miles. The estimated storage volume in the top 8 feet of water on Lake Tansi is 919,697,404 million gallons or 2822 acre-feet. This storage would bring raw water storage for the City of Crossville to a total of 6575 acre-feet, a 75.2% increase in raw water storage. This increase in raw water storage would provide the City of Crossville with 284 days of storage at the 20-year design demand of 7.54 million gallons per day. This period of time is long enough to offset any extended dry periods usual to drought conditions on the Cumberland Plateau.

The Lake Tansi reservoir has a safe yield of approximately 3.5 million gallons per day. The proposed system includes an intake in Lake Tansi, a raw water pumping station adjacent to the lake at the intake, and construction of 2.1 miles of 36 inch pipeline to the Meadow Park Lake and Treatment Plant capable of drawing up to the safe yield of the Lake Tansi reservoir. The proposed intake is planned for a depth of 14 to 16 feet to provide capability of withdrawing the top 8 feet of storage.

Analyses of piping alternatives for the proposed system have been performed to determine the pipe size with the least amount of electrical input power. The cost difference of electrical power for different pipeline sizes were compared to the cost of pipe and installation for each of the sizes to provide a system with the lowest present value. This analysis has resulted in the selection of a 36 inch pipeline. A secondary benefit of minimizing the electrical cost for the system is the minimization of environmental effects from the generation of electrical power.

SECTION 2. PURPOSE AND NEED

2.1. Study Purpose

The purpose of this study is to apply for funds through the State of Tennessee Drinking Water State Revolving Fund and for American Recovery and Reinvestment Act (ARRA) funds available through the State Revolving Fund. The project purpose is to identify and construct a water harvesting system to augment raw water supplies for the City of Crossville Water System that is capable of providing an additional 3 to 3.5 million gallons per day of raw water on average through minimum system cost and protection of the environment through utilization of existing water resources, minimization of power requirements, and a long useful life.

2.2. Need for the Project

The City of Crossville is located on the upper portions of the Cumberland Plateau and sits astride the Tennessee Divide. The physical location of the City on the divide significantly limits the readily available supply of raw water from which to produce potable water. No major rivers are located within Cumberland County. The planning area is located on the Cumberland Plateau. The Cumberland Plateau is on average 35 miles wide and rises 1000 feet or more above the adjacent geological provinces. The narrow width and significant elevation difference results in any major rivers being off of the plateau. The ultimate effect is that any project that does not try to obtain water sources on the plateau is subject to significant costs and environmental effects associated with the pumping of water.

The City and Cumberland County has been actively seeking additional water supplies for over 12 years. The existing supplies were inadequate to maintain prior demand levels during the droughts of 2006, 2007, and 2008; requiring the region to implement water use restriction regulations. During these recent droughts, the Meadow Park reservoir reached a low elevation of 1811.79 feet during November 2007. This level was only 7.79 feet above the low intake leaving only 671 acre-feet of usable storage in the reservoir or approximately 40 to 50 days of water supply. If drought conditions had not mitigated somewhat during the winter of 2007 and 2008, the City would have been without adequate water supply.

The severity of the recent droughts has possibly been greater than any drought on record for the region, but a full analysis will not be available until the drought is known to be over and full analysis can be completed. Although, the City of Crossville obtains water from two reservoirs that prior studies indicated had a combined safe yield of approximately 9.6 million gallons per day, the recent droughts suggest that the safe yield of the two reservoirs may be significantly less than previous estimates. Current estimates place the safe yield of the two reservoirs at no more than 6.0 million gallons per day. During the droughts, both reservoirs experienced significant drawdown levels during the summer and fall months. However, reservoirs on the Cumberland Plateau tend to recover quickly once any the wetter winter months arrive. The shallow depth of native soils in their drainage basins over relatively impermeable sandstone bedrock result in quick soil profile saturation and large amounts of runoff. Consequently, storage volume is more critical to the safe yield of reservoirs than is the drainage area.

In addition, the City of Crossville's raw water supply infrastructure is aging. Primarily, the City must undertake repairs and modifications to the Meadow Park Lake Dam. The City will require an alternate source of water to meet system demand during the construction period for work on the Meadow Park Lake Dam. City personnel report that the system cannot operate more than about 7 to 10 days with only one plant operational without depleting the available storage within the water system. Neither treatment plant is capable of meeting the system demand peaks solely even with reservoir levels at normal water levels. The treatment capacity of each of the two treatment plants operated by the City of Crossville is inadequate to provide the peak system demand individually.

The raw water demand placed on the City of Crossville system has changed little over the period from 1988 to the present. The City has maintained the water system demand since approximately 1988 by the removal of large customers. The Crab Orchard Utility District's construction of a water plant in the mid-1990s has resulting in approximately 2.0 million gallons per day of demand being removed from the system. The West Cumberland Utility District ceased buying water from the City around 2005; further reducing the demand on the system. However, now the Crab Orchard Utility District is at or near withdrawal capacities from their water supply reservoir.

The following table summarizes the projected need for raw water for the City of Crossville Water System. Details of the population estimates, land use projections, and details associated with the development of the projected raw water demand can be found in Section 4 of this Plan.

Table 2 – City of Crossville Water System Projected Raw Water Demand

Year	Projected Demand (1000 gallons per day)
2010	4144.1
2015	4851.0
2020	5678.4
2025	6647.0
2029	7539.6
2030	7780.8
2035	9108.0
2040	10,661.6
2050	14,609.0

The above table may underestimate the projected demand on the system as the values from the reduced demand during the recent droughts were used in the projections. The effect of customers conserving water and the effect of water use restrictions have not been fully defined as data does not exist to quantify these values for the recent drought. An increase in raw water storage and supply will help alleviate the withdrawals and drawdown levels in each of the reservoirs used for raw water.

Furthermore, even a small percentage error in the population growth rates for the region can result in substantial differences in the projected raw water demand, particularly in fast growing communities such as the Cumberland County area. However, the above estimates agree closely within ranges projected by at least three other studies of the Cumberland County area.

Also, the City is adding potable water service to areas within the Catoosa Water Department that will further increase the demand on the system. The effect of these expansions is difficult to quantify without the completion of these projects. However, the Corps of Engineers has estimated the demand of the Cumberland Cove area to be approximately 250,000 gallons per day. Estimates of the demand in other areas of expansion are not readily available.

The City of Crossville is at 75% to 80% capacity of their existing raw water supply and it is time to plan and construct the necessary system expansions to augment available supply to provide potable water for the next twenty years and beyond.

SECTION 3. GENERAL INFORMATION

3.1. Existing Facilities and Area Served

The City of Crossville owns and operates two water treatment facilities, one on Lake Holiday and one on Meadow Park Lake. The City owns Meadow Park Lake in its entirety and all surrounding property. The City owns Lake Holiday Dam but does not own the lake itself. However, the City has all water rights to Lake Holiday. The details of the existing water sources, treatment plants, and distribution system can be found in this section below. The details of the City's distribution system storage tanks can be found in Section 4.4 of this Report.

All households with public water available within the county boundaries of Cumberland County are served by one of the four utility districts within the County or the City of Crossville. The four utility districts in the County, in order from largest to smallest based on number of customers served, are the Crab Orchard Utility District, the South Cumberland Utility District, the West Cumberland Utility District, and the Grandview Utility District. The City of Crossville has a larger customer base than any of the utility districts within the County.

The City of Crossville Water System serves the corporate boundaries of the City of Crossville, an area of Cumberland County surrounding the corporate boundaries, and the previous Catoosa Utility District boundary. The Catoosa Utility District was acquired by the City of Crossville and is now embodied within the Catoosa Utility Department of the City of Crossville.

The Catoosa Utility Department serves the north and northwestern areas of Cumberland County and a portion of the eastern parts of Putnam County. The Catoosa Utility Department is also capable of purchasing some limited amount of water from the Town of Monterey.

In addition, the City is contracted to sell water to the South Cumberland Utility District, the Grandview Utility District, West Cumberland Utility District, and the Fall Creek Falls Utility District. In addition, the City of Crossville and Crab Orchard Utility District have agreed to enter into a mutual aid agreement to buy and sell water from each other as needed and as available.

With the inclusion of the Utility Districts that have purchase agreements with the City of Crossville, the City of Crossville provides water to most of Cumberland County, portions of Putnam County, Rhea County, Bledsoe County, White County, and Van Buren County. Purchases from the West Cumberland Utility District have been light in recent years and mainly the result of emergency situations resulting in little transfer of water from the City of Crossville into White County in recent years.

Appendix I of this Report contains a map depicting the county boundaries as well as the utility boundaries in the region affected by the City of Crossville. The planning area map is shown over USGS topographic maps of the area; although the scale is too large due to page size limitations to make all of the topographic information readily readable.

3.2. Optimum Performance Available with the Existing Facilities / Operational Problems

The optimum performance of the existing system is limited most severely by the amount of raw water available for treatment. Recently, the droughts of 2007 and 2008 created the situation in which the City of Crossville along with its utility district customers and the Crab Orchard Utility District had to implement water restrictions. The vast majority of the region was under water restriction regulations for a significant portion of the drought.

The optimum performance available with rated capacities of the City of Crossville treatment works is approximately 7.5 million gallons per day of potable water. Obviously, the current optimum performance is more limited by storage capacity of the raw water systems than by the capacity of treatment plants.

No severe operational problems are known to exist within the City of Crossville system beyond the raw water systems. Operational problems or issues are primarily related to old piping or water loss within portions of the system.

3.3. Existing Distribution System

3.3.01. Water Sources

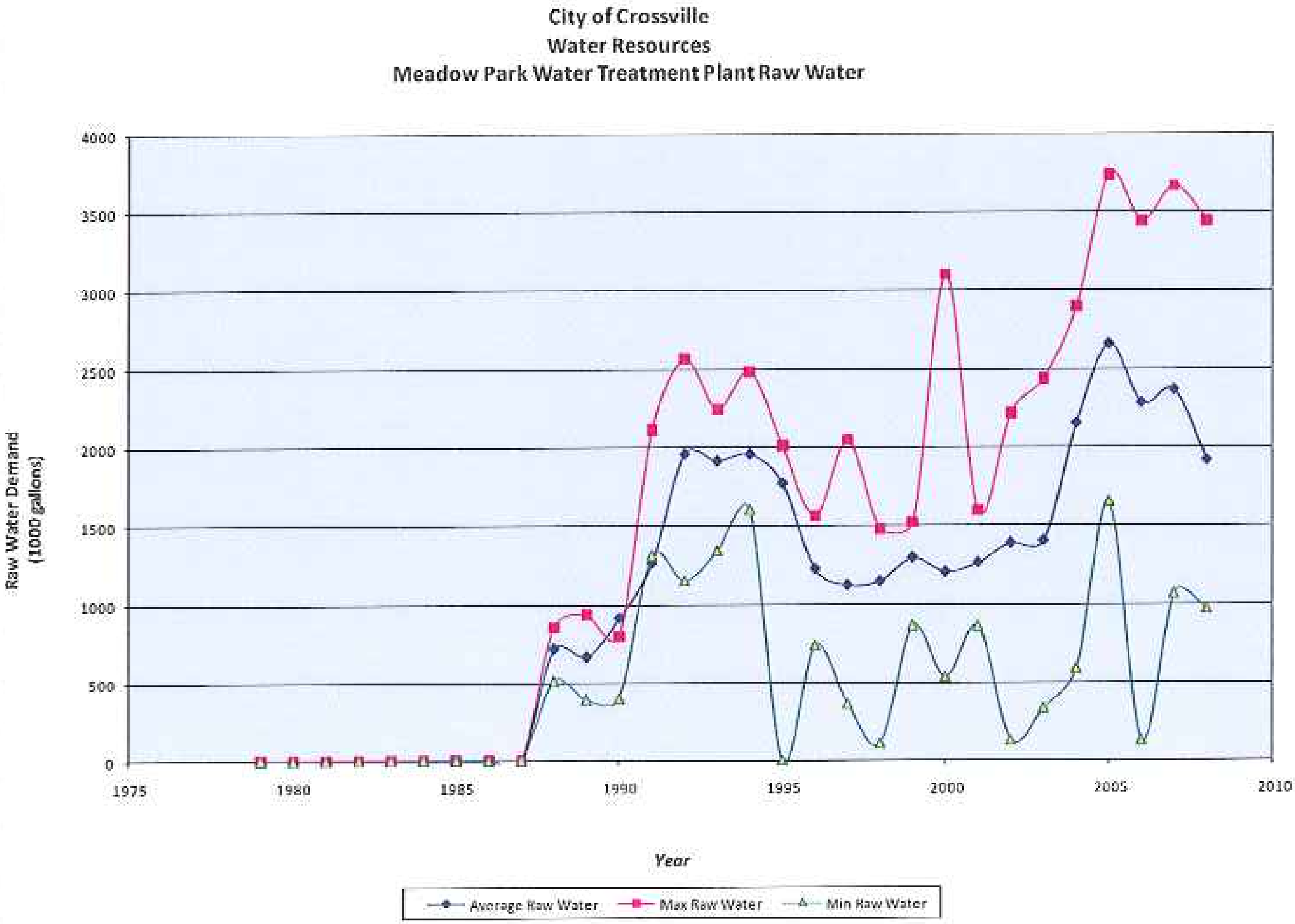
The City of Crossville currently uses two sources of water from which to produce potable water for its customers. The two sources are Meadow Park Lake and Lake Holiday.

Meadow Park Lake is an impoundment built in 1937 and completed in 1938 as a WPA project located south of the City of Crossville in a rural portion of Cumberland County. Previous studies have placed the safe yield of the Meadow Park Lake at approximately 3.6 million gallons per day. Detailed information on Meadow Park Lake and Meadow Park Dam is provided in the table below:

Table 3 - Meadow Park Lake and Meadow Park Dam Data

State Dam ID No.	18-7001	**Federal Dam ID No.**	TN 03501
Latitude	35 deg 54 min 09 sec N	**Longitude**	85deg 05 min 49 sec W
Year Completed	1938	**Engineer**	Freeland and Roberts
Type of Dam	Concrete Arch		
Downstream HPC	2	**Size Classification**	Intermediate
Structural Height	32 feet		
Hydraulic Height	28 feet		
Crest Length	274 feet	**Crest Width**	3.5 feet
Upstream Slope	Vertical	**Downstream Slope**	0.2:1
Normal Pool Area	274 Acres	**Maximum Pool Area**	390 Acres
Top of Dam El.	1821.5 ft (1823.62)	**Storage @ Top of Dam**	4397 Acre Feet
Normal Pool El.	1817.5 ft (1819.62)	**Storage @ Normal Pool**	3069 Acre Feet
Spillway Sizes	49 x 4 ft, right and 54 x 4 ft left		
Drainage Area	3317 acres or 5.183 square miles		
Ratio of Surface Area to Drainage Area		0.0826	
Storage Available for Water Treatment		2513 acre-feet at centerline of low intake 1967 acre-feet at 4 ft submergence of low intake	
Water Plant Intake Elevation	High Intake is 24" dia. at centerline el. 1813.00 (1815.12) Low Intake is 24" dia at centerline el. 1803.00 (1805.12) Intake pump well invert elevation is 1797.00 (1799.12) Intake pump floor elevation is 1832.00 (1834.12)		

The City has operated a water treatment plant at Meadow Park Lake since 1937 when it constructed the original Meadow Park Water Treatment Plant. The following graph shows the historic water demand that the Meadow Park Treatment Plant has placed on the Meadow Park Lake for the period of 1988 through 2008. In this period of the last twenty years, demand on the Meadow Park Lake has grown from an average of 0.7 million gallons per day to over 2.5 million gallons per day. With the



peak occurring in 2005. The City uses a management plan to control the withdrawal of water from the two reservoirs in an effort to balance the impacts on the reservoirs with the system demand.

The second raw water reservoir used by the City of Crossville, Lake Holiday, is an impoundment of the Obed River constructed between 1960 and 1962 as part of a residential development in the western portion of the City. The impoundment is located completely within the corporate boundaries of the City of Crossville. Previous studies have placed the safe yield of Lake Holiday at approximately 6.0 million gallons per day.

Environmental & Civil Engineering Services working for the City of Crossville undertook a major engineering project, constructed by Wright Brothers Construction Co., Inc., which increased the spillway capacity of the lake through widening of the spillway, construction of a new weir, and construction of a new bridge structure over the spillway for Lake Holiday Dam. The project was undertaken to remove the dam from violation status with the State of Tennessee, Safe Dams Section. The project also increased the amount of available water storage for use by the City of Crossville's treatment plant by an estimated 174 acre-feet or 56.7 million gallons. Construction of the project is near completion and will be completed within the current year of 2009.

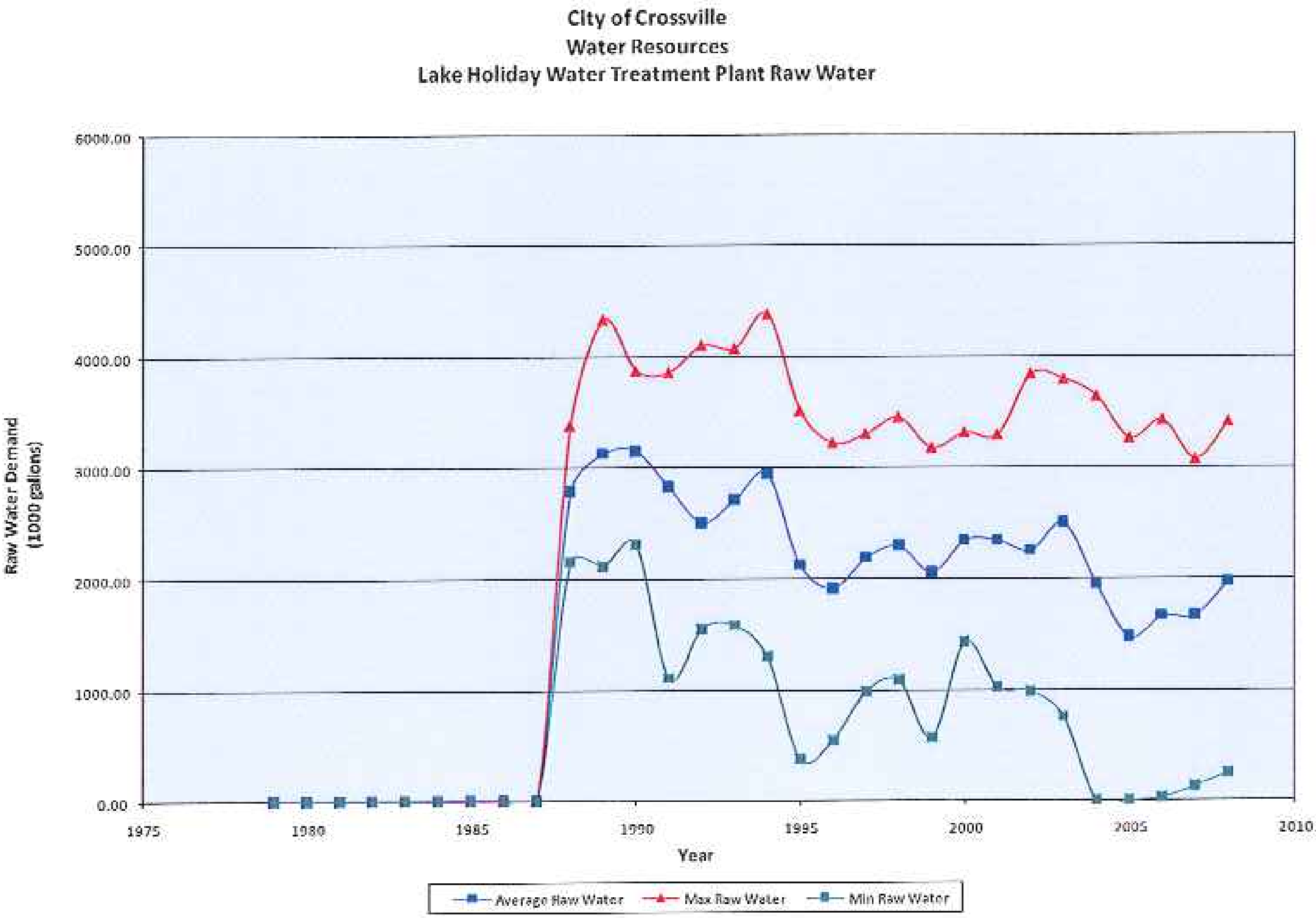
The area around Lake Holiday has become a highly developed residential area with houses surrounding the shoreline of the lake. Due to the extent of residential development around the lake itself, public opinion is strongly against the level of drawdown required to achieve the 6.0 million gallons per day withdrawal of previous safe yield estimates. The substantial development within the watershed and the size of the watershed of Lake Holiday produce significant volumes of runoff to the extent that storage is the limiting factor in the safe yield of Lake Holiday.

Detailed information on Lake Holiday and the Lake Holiday Dam is provided in the table below:

Table 4 – Lake Holiday and Lake Holiday Dam Data

State Dam ID No.	18-7022	**Federal Dam ID No.**	TN
Latitude	35 deg 57 min 20 sec N	**Longitude**	85deg 03 min 35 sec W
Year Completed	1963	**Engineer**	Freeland and Roberts
Type of Dam	Earth gravity		
Downstream HPC	2	**Size Classification**	Intermediate
Structural Height	47.4 feet		
Hydraulic Height	34.8 feet		
Crest Length	621 feet	**Crest Width**	40 feet
Upstream Slope	2:1	**Downstream Slope**	2:1
Normal Pool Area	232 acres	**Maximum Pool Area**	338 acres
Top of Dam El.	1781.00	**Storage @ Top of Dam**	7100 acre-feet
Normal Pool El.	1768.38	**Storage @ Normal Pool**	3573 acre-feet
Spillway Sizes	230 ft concrete weir		
Drainage Area	5446 acres or 8.51 square miles		
Ratio of Surface Area to Drainage Area		0.0426	
Storage Available for Water Treatment			
Water Plant Intake Elevation			

The following graph shows the historic raw water demand of the City of Crossville from Lake Holiday for the period of 1988 through 2008. In general, the demand placed on Lake Holiday over the past twenty years has been gradually reduced from an average over 3.0 million gallons per day to around



2.0 million gallons per day. The main driving force in this reduction is the public opposition to large drawdowns of the lake level. Although, the increases in withdrawal rates for 2006, 2007, and 2008 demonstrate that the City operates as necessary when water supplies are stretched despite the public opposition.

3.3.02. Treatment Plants

The City of Crossville currently operates two treatment plants as part of its water distribution system. The only other water treatment plant within Cumberland County is operated by the Crab Orchard Utility District. The Crab Orchard Utility District treatment plant is located on Stone Lake, an impoundment on Otter Creek and has a maximum withdrawal permit of 2.0 million gallons per day on average.

The City of Crossville operates a treatment plant on Lake Holiday. The Lake Holiday Plant is a conventional filtration water treatment plant that was placed into operation in 1968. The plant was expanded in 1975 to a capacity of 3.0 million gallons per day. The plant was further expanded in 2006 to its present capacity of 4.0 million gallons per day.

The City has operated a water treatment plant at Meadow Park Lake since 1937 when it constructed the original Meadow Park Water Treatment Plant with a design capacity of 220 gpm. The plant was expanded in 1952, 1961, and 1990. The facility was taken out of operation in 1968, renovated, and put back on line in 1974. The expansion in 1990 brought the plant to a design capacity of 2.0 million gallons per day. The City replaced the original Meadow Park Treatment Plant in 2001 as part of a State Revolving Fund Drinking Water Project with a new treatment facility. The new facility is a conventional filtration water treatment plant and has a treatment capacity of 3.5 million gallons per day and is expandable up to approximately 21 million gallons per day.

3.3.03. Distribution System

The City of Crossville operates a water distribution system which contains pipes of sizes ranging from two inches to sixteen inches in diameter. Pipe materials include galvanized iron, polyvinyl chloride (PVC), ductile iron (DIP), cast iron (CIP), and asbestos cement (AC). The vast majority of the piping is six inch diameter or larger.

Many of the older parts of the system contain galvanized and unlined cast iron piping. Installation of these materials was common at the time the areas were developed. After 10 to 20 years in service, many utilities have seen this pipe deteriorate and their level of service with it through internal corrosion. It is not uncommon for the corrosion to almost entirely block the flow of water through the pipe.

A description of the storage tanks present in the system can be found in the section of this report entitled Storage Capacities and Losses in the System.

3.4. Potential for Serving Additional Areas

The City of Crossville has the potential to serve additional areas provided that adequate raw water supply is available to the City. The City has recently begun the process of expanding their service area to include the Cumberland Cove Development as part of the City's acquisition of the Catoosa system. There are other areas, particularly within the Catoosa Utility Department to which service could be extended provided adequate raw water was available.

A recent investigation into the number of subdivision lots within the Catoosa Water Department that are already served with water utilities showed that 3545 subdivision lots exist within the Catoosa Water Department that do not have residences constructed on the lot currently. In addition, there are an estimated 5000 to 6000 undeveloped lots within the Lake Tansi Development that are served by the South Cumberland Utility District.

Adequate raw water supply is a limiting factor for growth of the system geographically and for development of properties that currently have water available.

SECTION 4. FUTURE CONDITIONS

4.1. Planning Period (20 years)

The City of Crossville developed a Master Plan in 1998 which projected water needs for the next 20 years and beyond. Also, the Corps of Engineers and Ogden Environmental and Energy Services did a study for Cumberland County in 1998, entitled Cumberland County Regional Water Supply Preliminary Engineering Report, which basically collaborated the projections of the City of Crossville Master Plan. Breedlove, Dennis, Young and Associates performed projections of average daily water consumption and average daily total water demand for Cumberland County in a study of 2002 entitled Cumberland County Water Supply Needs Assessment, May 2002. Additional forecasts were performed in 2008 by the Corps of Engineers and GKY & Associates, Inc. for the City of Crossville which have only been documented in a Memo related to the Water Needs Assessment for the Cumberland County Regional Water Supply Plan.

Since several of these studies were completed, the structure of the City of Crossville and utility districts within the Cumberland County region has changed significantly. The City of Crossville has remained the primary water supply for the region with the main change being the acquisition of the Catoosa Utility District by the City of Crossville. The prior Catoosa Utility District is now the Catoosa Water Department of the City of Crossville. The City of Crossville has also agreed to the sale of water to the Fall Creek Falls Utility District and continues to sell to the South Cumberland Utility District and the Grandview Utility District. In addition, the City of Crossville and the Crab Orchard Utility District have agreed to reinstate their relationship with water sales and agreed to enter into a mutual aid agreement to share water resources when either of the parties are in need.

The planning period for this Facilities Plan covers the twenty year period from 2009 to 2029. The projected raw water demand for the planning period and beyond is summarized in the following table:

Table 2 – City of Crossville Water System Projected Raw Water Demand

Year	Projected Demand (1000 gallons per day)
2010	4144.1
2015	4851.0
2020	5678.4
2025	6647.0
2029	7539.6
2030	7780.8
2035	9108.0
2040	10,661.6
2050	14,609.0

The City of Crossville currently serves 3649 inside residential customers, 2698 outside residential customers, 1220 inside commercial customers, 79 outside commercial customers, 35 inside industrial customers, and 2 outside industrial customers not including the five utility districts that it has as customers and the Catoosa Water Department customers. The following table summarizes the existing and projected facility conditions for the City of Crossville Water System:

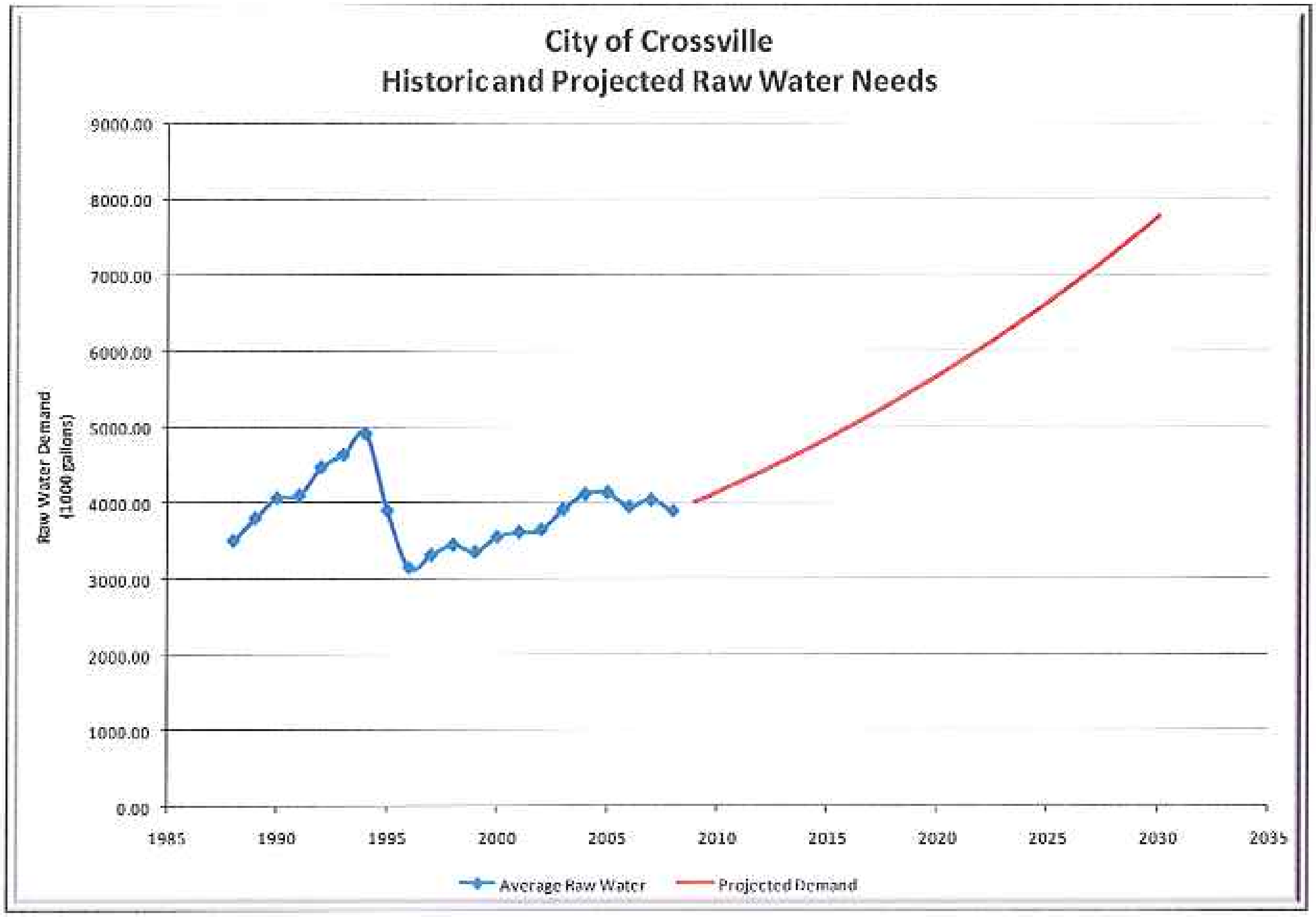
Table 5 – Existing and Proposed Facility Conditions

Population	Existing (2008)	Projected (2029)
City of Crossville	10,418	17,071
Percent Served	100%	100%
Service Area Excluding City of Crossville	44,582	76,929
Percent Served	74%	100%
Total Planning Area	55,000	94,000
Percent Served	79%	100%
Flows in gallons per day (gpd)	**Existing (2008)**	**Projected (2029)**
Residential	2.015 MGD	4.727 MGD
Commercial	0.488 MGD	1.146 MGD
Industrial	0.229 MGD	0.536 MGD
Loss	0.911 MGD	1.131 MGD
Total Flows	**3.643 MGD**	**7.540 MGD**

The values in the table above are revised slightly from the original issue of the Drinking Water Facilities Plan due to a miscalculation in the percent served in the total planning area. The table is based upon the raw water pumped from the reservoirs; therefore, the total flows include treatment loss or water that is used in the production of drinking water. The table provides an existing average of 42.60 gallons per capita per day for the total planning area and a projected 50.29 gallons per capita per day. The differences in the per capita consumptions are to bring the values more in line with expected figures during normal years since 2008 was a drought year. The system had slightly more than a 7% decline in raw water usage from 2007 to 2008 although, the number of customers increased. Exact figures on this require considerable time and effort, but we estimate the normal usage on a per capita basis to be 10 to 12% higher than the 2008 figures. A twelve percent increase in the per capita consumption in 2008 would be a 47.7 gallons per capita per day raw water demand.

The City of Crossville is hopeful that the conservation of water by customers of the system during the droughts of 2007 and 2008 has created long-term habits. The per capita numbers are very low when compared to national and state averages. An evaluation performed by the U.S. Army Corps of Engineers on the planning region for 2006 demonstrated that the annual average is 119.69 gpd per household. At the current density of 2.4 persons per household, this equates to 49.87 gpd per capita as compared to our projected value of 50.29 when the loss of treatment is including in the values.

The following graph depicts the projected raw water requirements through the planning period for the City of Crossville Water System.



4.2. Land Use Projections

Cumberland County and the City of Crossville have been part of a fast growing region since 1970. Cumberland County is defined in five main census tracts with five census places based on the 2000 Census. The five census places are Crossville, Fairfield Glade, Lake Tansi, Crab Orchard, and Pleasant Hill. The following table presents the population and population estimates according to the U.S. Census Bureau for Cumberland County.

Table 6 – U.S. Census Bureau Population and Population Estimates
Cumberland County, Tennessee

Date	Dataset	Total Population
1940	Census 1940	15,592
1950	Census 1950	18,877
1960	Census 1960	19,135
1970	Census 1970	20,733
1980	Census 1980	28,676
April 1, 1990	Census 1990	34,736
April 1, 2000	Census 2000	46,802
April 1, 2000	Estimates Base	46,801
July 1, 2000		47,024
July 1, 2001		47,693
July 1, 2002		48,598
July 1, 2003		49,092
July 1, 2004		49,894
July 1, 2005		50,870
July 1, 2006		51,984
July 1, 2007		52,932
July 1, 2008		53,590

Cumberland County and the City of Crossville are well known nationally as a second resort home and retirement area with numerous golf courses and other recreational attractions. Cumberland County was recently selected to be one of ten counties to participate in "Retire Tennessee," a pilot program of the Tennessee Department of Economic and Community Development designed to promote Tennessee as a great place for retirees to migrate to upon retirement.

The U.S. Army Corps of Engineers and GKY & Associates have compiled a Memo in regards to the land-use of Cumberland County in relation to their study of the Cumberland County Regional Water Supply. The data was compiled by the government agencies and utility districts within the County. The following table depicts the 2006 land use statistics for Cumberland County.

Table 7 – Cumberland County Land-Use Data

Land-Use Category	Number of Parcels	Total Area (acres)	Average Area (acres)	Average Improvement Value
Residential – Unimproved	35,797	32,523	0.91	
Residential - Improved	21,166	40,298	1.90	$80,814
County – Unimproved	358	510	1.42	
County – Improved	39	481	12.34	$1,692,469
City – Unimproved	101	3279	32.47	
City – Improved	107	532	4.97	$140,351
State – Unimproved	92	53,928	586.17	
State – Improved	7	2764	394.83	$36,629
Federal	14	1363	97.38	
Religious – Unimproved	173	245	1.41	
Religious – Improved	144	410	2.84	$378,275
Ed/Sci/Charitable – Unimproved	27	50	1.87	
Ed/Sci/Charitable – Improved	33	70	2.12	$163,082
Sap Utility – Unimproved	120	428	3.57	
Sap Utility – Improved	6	12	2.01	$138,400
Commercial – Unimproved	56	79	1.42	
Commercial – Improved	1206	5185	4.30	$229,743
Industrial	33	319	9.66	$699,718
Farm – Unimproved	1158	116,817	100.88	
Farm – Improved	1050	42,198	40.19	$134,469
Agricultural – Unimproved	383	31,674	82.70	
Agricultural – Improved	1089	78,366	71.96	$95,489
Forest – Unimproved	92	13,172	143.18	
Forest - Improved	40	2195	54.86	$138,218
Total or Average	63,291	426,898	68.97	$327,305

Review of the data shows only 37% of residential parcels are improved. There are significant numbers of unimproved residential lots available within the vicinity of the City of Crossville as well as the Fairfield Glade, Lake Tansi, Cumberland Cove, and Cumberland Lakes developments. The Corps of Engineers Memo suggests that the persons per household will continue to decline as a result of the County's continued effort to attract retirees to the area. Reductions in people per household will create more houses or improved residential properties but will not considerably increase water consumption.

Recently, Bowater, Inc. liquidated most all of their forest land in Cumberland County. Some of this property has remained in forest land, some has been converted to farm land, and some is being converted to residential development. In addition, with the amount of farm land, unimproved residential properties, and forest lands within the County, the County population for the next twenty years will not be limited by the availability of residential properties. Consider that the population of the county would have to increase by 85,912 people just to change all unimproved residential properties to improved residential properties at the current average household density of 2.4 persons per household.

Land use in the planning area is not expected to change significantly except for the continued construction of improvements on unimproved residential properties and the conversion of farm, agricultural, and forest lands to residential properties. Population in-migration and any increase in industrial property will drive water needs over the next twenty years much more than future land use changes within the County. Obviously, the amount of residential property available is not limiting the population growth of the County at the current time.

4.3. Population Forecast

The Tennessee Advisory Commission on Intergovernmental Relations (TACIR) in conjunction with the University of Tennessee Center for Business and Economic Research produced population projections for the State of Tennessee as well as for each county and city for the period of 2005 through 2025 in 5 year increments. The following table presents the TACIR projections for Cumberland County and the cities within Cumberland County.

Table 8 – Tennessee Advisory Commission on Intergovernmental Relations Population Projections for Tennessee, 2005 to 2025

County or City	2005	2010	2015	2020	2025
Cumberland County	50,082	54,059	58,045	61,922	66,119
Crab Orchard	881	946	1010	1077	1144
Crossville	9881	10,725	11,580	12,422	13,343
Pleasant Hill	586	632	685	731	780
Unincorporated	38,733	41,755	44,770	47,692	50,852

Obviously, the population estimates of the U.S. Census Bureau have already exceeded the population projections of the Tennessee Advisory Commission on Intergovernmental Relations for Cumberland County. The Tennessee Advisory Commission on Intergovernmental Relations population projections suggest that the majority of the growth in Cumberland County will occur in unincorporated areas first and the City of Crossville corporate boundaries second.

The U.S. Army Corps of Engineers along with GKY and Associates has produced a Memo on the land-use assumptions for the Cumberland County Regional Water Supply Study. The Memo summarizes that "all of the analysis described above ultimately show that the 'expected' growth scenario predicts that Cumberland County's population will grow at an annual average growth rate of about 1.78% over the next fifty years. The slow growth scenario predicts about 1.0% annual growth over 50 years."

The University of Tennessee Institute for Public Service and Institute of Agriculture produced a report entitled The Long-Term Impacts of Retiree In-Migration on Rural Areas: A Case Study of Cumberland County, Tennessee in September 2007. The report provides a detailed examination of the population trends of Cumberland County as compared to two other basis groups defined from Tennessee Counties comparable to Cumberland. The report shows the significant growth of Cumberland County as it has continued to outpace the other groups. The report shows that Cumberland County has had a sustained average growth rate of 2.63% on an annual average basis for the period of 1970 through 2004.

Numerous population forecasts have been performed on the Cumberland County area; although, all are based on numerous assumptions that may or may not prove to be valid assumptions. A sustained average annual growth rate of 2.63% over a 34 year period cannot be easily ignored in any population forecast made. Often times, once a city achieves a certain size, growth tends to occur faster than it did when the City was smaller. Furthermore, a small amount of error in the projected growth rates can result in serious errors in estimates of water demand, particularly for fast growing regions such as Cumberland County.

Population forecasts for this study have been based on a sustained average growth rate of 2.5%. Based on the information available and attempting to be somewhat conservative in forecasting, this report estimates that the growth rate for demand on the City of Crossville water system is a sustained average annual growth rate of 3.2%.

4.4. Storage Capacities and Losses in the System

The City of Crossville distribution system contains eleven finished water storage tanks or reservoirs with a total available storage capacity of 6.20 million gallons.

The storage tank reservoir at the Industrial Park has been demolished and removed from the system. The Industrial Park tank was previously used as a fire protection tank until distribution system improvements were made which provided the required fire flows without the storage tank.

In addition, the Water Tank Hill stand pipe and the Lantana Road 1 stand pipe have been taken out of service, demolished, and removed from the system due to age and construction features not meeting current codes.

The following table describes the storage tanks, historic and remaining, within the City of Crossville system.

Table 9 – City of Crossville Storage Tanks

Tank Location	Ground Elevation	Overflow Elevation	Capacity	Type
Dennison Carter	1894.13 ft	1958.13 ft	500,000 gal	Elevated Sphere
Industrial Park	1812.82 ft	1901.50 ft	400,000 gal	Elevated Sphere
Lantana Road 1	1937.77 ft	1986.91 ft	360,000 gal	Stand Pipe
Lantana Road 2	1934.00 ft	2060.00 ft	500,000 gal	Elevated Sphere
Penfield Road	1923.80 ft	1991.80 ft	1,000,000 gal	Elevated Sphere
Water Tank Hill	1897.89 ft	1986.18 ft	323,000 gal	Stand Pipe
Cook Road	1880.00 ft	1991.80 ft	1,000,000 gal	Elevated Sphere
Cotton Patch	1989.79 ft	1797.18 ft	1,000,000 gal	Elevated Composite
Homestead	2068.30 ft	1839.80 ft	1,000,000 gal	Elevated Composite
Plateau Road	2040 ft	2088 ft	300,000 gal	Stand Pipe
127 North Tank	1963 ft	2088 ft	200,000 gal	Elevated Sphere
I-40 Industrial Park	1796.5 ft	1958 ft	300,000 gal	Elevated Sphere
Genesis Road	1937 ft	2088 ft	200,000 gal	Elevated Sphere
Hwy 70N	2022 ft	2143 ft	200,000 gal	Elevated Sphere

The Tennessee Department of Environment and Conservation requires water suppliers to maintain a storage capacity in excess of the daily pumpage. The City of Crossville currently maintains storage of 6.2 million gallons or 1.6 days based on the current average daily pumpage.

The average raw water pumped into both of the City of Crossville water treatment plants was 4.074 million gallons per day in 2007 and 3.891 million gallons per day in 2008. The average daily pumpage from the treatment plants was 3.906 million gallons per day in 2007 and 3.643 million gallons per day in 2008. The difference is 168,000 gallons per day in 2007 and 248,000 gallons per day in 2008 and was process water used or rejected by the treatment plants. On average, 5.25% of the raw water pumped is process water used in the production of water at the treatment facilities. The process water at Meadow Park Lake is returned to the lake for later treatment, however, the process water at Lake Holiday is not returned to the lake and is no longer available for use.

The City of Crossville has a water loss within the distribution system calculated as 25% in 2006, 26% in 2007, and 21% in 2008. The water loss rates attribute loss as all water that is pumped from the treatment plants and not sold through a meter for consumption. Therefore, the values include all flushing losses, line break losses, leakage, meter inaccuracy, and related losses. In 2008, the City began a major reinvestment program to reduce the system's water loss. The program is examining losses due to flushing operations, unmetered water resulting from calibration of meters or age of meters, and losses due to piping materials such as galvanized pipe that were not suitable for the low pH soils of the Cumberland Plateau. The program will take three years to complete. Of the meter calibrations performed to date, the City has estimated that over 65% of the meters within the system are not within acceptable specifications. It is estimated that the water loss due to meter age and condition is from 8% to 10% of the total pumpage from the treatment plants. With the recent 25% total water loss within the distribution system and elimination of meter calibration issues, the City would be left with an estimated water loss of 15% to 17% due to piping conditions.

4.5. Fire Flow Requirements

The City of Crossville Fire Chief has indicated to the City Council that in the industrial areas of the City, lines should be designed for a minimum flow of 1000 gallons per minute from each hydrant. The City has upgraded most industrial areas to provide the necessary fire flow. Currently, the City has an ISO fire protection rating of Class 4. The City has maintained this rating for over 10 years and it is the intent of the City to continue to upgrade the water system and their fire protection components to maintain its current fire rating or a lower fire rating. The proposed project does not include any distribution piping for potable water and therefore, fire flows are not a design consideration for the Project but should be considered in overall planning.

SECTION 5. DEVELOPMENT OF ALTERNATIVES

5.1. Alternative #1: No Action Alternative

The no action alternative involves not undertaking any project to increase the raw water supply available to the City of Crossville Water System. The estimated capital cost of this alternative is understandably $0. The alternative, however, will bring a significant reduction to the socioeconomic systems in the area. A significant portion of the local economy is based upon construction and development of the area as a location for retirement and tourism. These sectors of the local economy as well as the industrial sectors are highly dependent upon the growth present in the county.

There are, of course, no environmental consequences to this alternative other than the detriment to the socioeconomic systems of the region. There could be secondary environmental consequences brought on by a reduction in socioeconomic activity.

However, this alternative is not feasible due to the fact that the existing system demand has already passed the point at which plans are required to address the expansion needs to meet system demand. The future water demand of the system will continue to grow and will outstrip available supply under this alternative.

5.2. Alternative #2: Water Harvesting from Watts Bar Reservoir

The second alternative investigated was water harvesting from the Watts Bar Reservoir of the Tennessee River. The Watts Bar Reservoir is controlled by the Tennessee Valley Authority. Appendix III contains a plan showing the projected pipeline routed and hydraulic calculations for this alternative.

The estimated capital cost of this alternative is $61.5 million. The cost estimate is based upon an intake structure at the Watts Bar Reservoir with a pumping station with two 5000 gpm pumps and approximately 32-miles of 36-inch pipeline to the Meadow Park Lake and Treatment Plant. The system would require two additional booster stations along the pipeline to prevent excessively high pressures in the pipeline. At each booster station, a ground storage tank would be necessary to minimize surges in the system and provide acceptable pump operation characteristics.

Item #	Description	Unit	Est. Qty	Unit Price	Item Total
1	Mobilization and General Conditions	LS	1	$350,000.00	$350,000
2	Erosion Control	LS	1	$375,000.00	$375,000
3	Raw Water Intake	LS	1	$275,000.00	$275,000
4	Raw Water Pumps	EA	6	$135,000.00	$810,000
5	Pump Station Electrical	LS	3	$165,000.00	$495,000
6	Water Tanks	EA	2	$350,000.00	$700,000
7	Trenching, Excavation, and Backfill	LF	166200	$75.00	$12,465,000
8	36" DIP PR350 Raw Water Main	LF	166200	$170.00	$28,254,000
9	60" Steel Casing; Open Cut	LF	400	$600.00	$240,000
10	60" Steel Casing; Bore & Jack or Tunnel	LF	1200	$850.00	$1,020,000
11	Asphalt Pavement Replacement	TON	2500	$120.00	$300,000
12	Crushed Stone for Backfill	TON	83100	$19.00	$1,578,900
13	Seeding w/ Mulch	UNIT	8000	$50.00	$400,000
	Total Estimated Construction Cost				**$47,262,900**
Non-Construction Costs					
	Project Contingency (specify percentage)	15%			$7,089,435
	Land and Easement Acquisition				$539,240
	Land and Easement Appraisals				$95,000

Legal Services	$75,000
Project Administration	$95,000
Environmental Studies	$150,000
Geotechnical Engineering	$85,000
Surveying	$120,000
Engineering Report	$30,000
Engineering Design	$4,076,425
Construction Admin & Inspection	$375,000
Environmental Permitting	$1,500,000
Plans Review Fees	$7,000
Total Estimated Project Cost	**$61,500,000**

The alternative is capable of supplying the 3.5 million gallons per day of projected demand required and provides additional storage of raw water. The system could be expanded beyond the 3.5 million gallons per day. However, the Watts Bar Nuclear Plant had to cease operation during the recent drought due to the reservoir water temperatures; so obviously, there is not an unlimited amount of water available in the Tennessee River.

The alternative would require an estimated power input of 18,389,109 kwh per year. The power generation necessary to supply the project would require additional inputs and have significant environmental consequences. The annual cost of the power at current rates would be an estimated $1,256,017 per year and have a present value of $30,334,362.44 for the twenty year planning period of this report.

All power generation plants require cooling water or water to operate the turbines in the case of hydroelectric plants. Power to any alternatives included in this report would be expected to be generated by the Tennessee Valley Authority. The Tennessee Valley Authority reports that 60% of their generation is fossil fuel based, 30% is generated by nuclear plants, and hydroelectric dams generate 10%.

Fossil fuel power plants burn fossil fuels such as coal, natural gas, or petroleum to produce electricity. For a 500 MW (e) plant, the makeup water amounts to 20 gallons/minute to offset losses in the system. This equates to a water usage of 0.0024 gallons/kWh. The condensate flow rate for the plant at full load is 6,000 gallons/minute which equates to a water usage of 0.72 gallons/kWh.

According to the United States Nuclear Regulatory Commission (U.S.NRC) the consumptive water loss normalized to 1,000 MW (e) is about 11,200 gallons/minute for nuclear plants in the United States. This equates to a total water usage of 0.672 gallons/kWh. With 30% generated for nuclear power, the water usage by nuclear plants for alternatives in this report is 0.2016 gallons/kWh of total power required. The U.S. NRC reports that TVA's Watts Bar Nuclear Plant has a condenser water flow rate of 410 thousand gallons/minute. Its cooling system consists of an environmentally friendly natural draft cooling tower.

Hydroelectric dams are the most reliable, efficient, and economical renewable power source. Tennessee Valley Authority's Watts Bar Dam generates 175,000 kW of electricity. With a height of 112 feet and assuming 80% efficiency, the flow rate of water would be 23,085.11 cubic feet per second. The total water usage would be 3552.68 gallons/kWh.

This alternative would require approximately 167,344 million gallons of water to implement for the twenty year planning period with only 36,500 million gallons or 22% being transferred to the treatment plant for use as potable water. The remaining water usage would be used in the generation of power for the Project.

Tennessee Valley Authority uses 14,000 tons of coal each day in the Kingston plant. The plant generates 10,906,079 MWh per year. This equates to a total of 0.000496 tons of coal/kWh. The alternative would require an estimated 109,500 tons of coal for the planning period of twenty years.

Coal fired power plants produce a numerous number of pollutants. The following table shows the pollutant generation from coal power on this alternative based upon emissions reports from the Tennessee Valley Authority.

Chemical	Air (lbs)	Water (lbs)	Land (lbs)	Offsite Disposal (lbs)	Amount Produced for Pipeline from Watts Bar to Meadow Park (lbs/yr)	Amount Produced over 20 yrs for Watts Bar to Meadow Park (lbs)
Hydrochloric Acid (aerosol)	3,380,056	0	0	0	5697.03	113940.59
Hydrogen Fluoride	453,626	0	0	0	764.58	15291.59
Sulfuric Acid (aerosol)	658,567	0	0	0	1110.00	22200.08
Ammonia	21,160	439	0	0	36.41	728.13
Arsenic Compounds	233	2,745	44,782	1	80.50	1609.97
Barium Compounds	2,456	43,530	1,400,666	16	2438.34	48766.71
Chromium Compounds	458	1,588	86,077	1	148.53	2970.60
Cobalt Compounds	117	0	36,400	0	61.55	1230.98
Copper Compounds	435	4,020	128,975	0	224.89	4497.88
Lead Compounds	288	0	49,716	1	84.28	1685.65
Manganese Compounds	676	0	142,790	0	241.81	4836.19
Mercury Compounds	481	0	235	0	1.21	24.14
Nickel Compounds	477	410	72,357	0	123.45	2469.03
Selenium Compounds	8,978	1,111	8,268	0	30.94	618.84
Vanadium Compounds	442	3,353	180,321	0	310.33	6206.52
Zinc Compounds	1529.22	4047.2	115190.79	0	203.55	4071.02
Benzo(g,h,i)perylene	0.16	0	0.28	0	0.00	0.01
Napthalene	65.998	0	0	0	0.11	2.22
Dioxin (grams)	2	0	0	0	0.00	0.07
Dioxin (lbs)	0	0	0	0	0.00	0.00
Polycyclic Aromatic Compounds	32	0	16	0	0.08	1.62
TOTALS	**4,530,077**	**61,244**	**2,265,794**	**19**	**11,557.59**	**231,151.73**

This alternative has the highest capital cost, environmental effects, and power requirement of the alternatives investigated.

The alternative would also increase the sediment load to the Meadow Park Lake which would be used to store a portion of the water pumped. The increased sediment load would reduce the useful life of the lake. Additional environmental consequences are present in the alternative due to the possible effects of the TVA coal ash spill at Kingston and the effects to streams along the pipeline route.

The water quality for treatment purposes from the Watts Bar Reservoir would be significantly lower than the existing water sources that the City of Crossville uses and possibly would require plant modifications in order to treat to the required standards.

This alternative could become unfeasible due to the negative public perception regarding drinking water from the Watts Bar Reservoir.

5.3. Alternative #3: Water Harvesting from Lake Tansi

The third alternative investigated was water harvesting from Lake Tansi within Cumberland County. The Lake Tansi reservoir is a man-made lake just across the Tennessee Divide from the Meadow Park Lake. Appendix IV contains a plan showing the projected pipeline routed and hydraulic calculations for this alternative.

The estimated capital cost of this alternative is $5.0 million. The cost estimate is based upon an intake structure at Lake Tansi with a pumping station with two 5000 gpm pumps and approximately 2.1-miles of 36-inch pipeline to the Meadow Park Lake and Treatment Plant.

Item #	Description	Unit	Est. Qty	Unit Price	Item Total
1	Mobilization and General Conditions	LS	1	$120,000.00	$120,000
2	Erosion Control	LS	1	$25,000.00	$25,000
3	Lake Tansi Raw Water Intake	LS	1	$275,000.00	$275,000
4	Lake Tansi Raw Water Pumps	EA	2	$135,000.00	$270,000
5	Lake Tansi Raw Water Intake Electrical	LS	1	$85,000.00	$85,000
6	Trenching, Excavation, and Backfill	LF	11110	$74.00	$822,140
7	36" DIP PR350 Raw Water Main	LF	11110	$150.00	$1,666,500
8	60" Steel Casing; Open Cut	LF	60	$600.00	$36,000
9	60" Steel Casing; Bore & Jack or Tunnel	LF	100	$850.00	$85,000
10	Asphalt Pavement Replacement	TON	300	$120.00	$36,000
11	Crushed Stone for Backfill	TON	7818	$19.00	$148,545
12	Seeding w/ Mulch	UNIT	470	$50.00	$23,500
	Total Estimated Construction Cost				**$3,592,685**
Non-Construction Costs					
	Project Contingency (specify percentage)				$539,419
	Land and Easement Acquisition				$650,000
	Land and Easement Appraisals				$30,150
	Legal Services				$70,000
	Project Administration				$45,000
	Environmental Studies				$65,000
	Geotechnical Engineering				$25,000
	Surveying				$35,000
	Engineering Report				$30,000
	Engineering Design				$296,396
	Construction Admin & Inspection				$225,000
	Environmental Permitting				$75,000
	Plans Review Fees				$1,500
	Total Estimated Project Cost				**$5,680,150**

The alternative is capable of supplying the 3.5 million gallons per day of projected demand required and provides additional storage of raw water. The system could be expanded somewhat beyond the 3.5 million gallons per day, however, not to the extent that the Watts Bar Reservoir Alternative could be expanded.

The alternative would require an estimated power input of 1,455,693 kwh per year. The power generation necessary to supply the project would require additional inputs and have some environmental consequences. The annual cost of the power at current rates would be an estimated $106,018 per year and have a present value of $2,560,465 for the twenty year planning period of this report.

This alternative would require approximately 46,862 million gallons of water to implement for the twenty year planning period with 36,500 million gallons or 78% being transferred to the treatment plant for use as potable water. The remaining water usage would be used in the generation of power for the Project. The alternative would require an estimated 8665 tons of coal for the planning period of twenty years.

The following table shows the pollutant generation from coal power on this alternative based upon emissions reports from the Tennessee Valley Authority. This alternative has the lowest capital cost, environmental effects, and power requirement of the alternatives investigated.

Chemical	Air (lbs)	Water (lbs)	Land (lbs)	Offsite Disposal (lbs)	Amount Produced for Pipeline from Lake Tansi to Meadow Park (lbs/yr)	Amount Produced over 20 yrs for Lake Tansi to Meadow Park (lbs)
Hydrochloric Acid (aerosol)	3,380,056	0	0	0	451.15	9023.08
Hydrogen Fluoride	453,626	0	0	0	60.55	1210.96
Sulfuric Acid (aerosol)	658,567	0	0	0	87.90	1758.05
Ammonia	21,160	439	0	0	2.88	57.66
Arsenic Compounds	233	2,745	44,782	1	6.37	127.50
Barium Compounds	2,456	43,530	1,400,666	16	193.09	3861.89
Chromium Compounds	458	1,588	86,077	1	11.76	235.25
Cobalt Compounds	117	0	36,400	0	4.87	97.48
Copper Compounds	435	4,020	128,975	0	17.81	356.19
Lead Compounds	288	0	49,716	1	6.67	133.49
Manganese Compounds	676	0	142,790	0	19.15	382.98
Mercury Compounds	481	0	235	0	0.10	1.91
Nickel Compounds	477	410	72,357	0	9.78	195.53
Selenium Compounds	8,978	1,111	8,268	0	2.45	49.01
Vanadium Compounds	442	3,353	180,321	0	24.58	491.50
Zinc Compounds	1529.22	4047.2	115190.79	0	16.12	322.39
Benzo(g,h,i)perylene	0.16	0	0.28	0	0.00	0.00
Napthalene	65.998	0	0	0	0.01	0.18
Dioxin (grams)	2	0	0	0	0.00	0.01
Dioxin (lbs)	0	0	0	0	0.00	0.00
Polycyclic Aromatic Compounds	32	0	16	0	0.01	0.13
TOTALS	**4,530,077**	**61,244**	**2,265,794**	**19**	**915.26**	**18305.17**

The alternative would have no appreciable change in the sediment load to the Meadow Park Lake which would be used to store a portion of the water pumped. The water quality for treatment purposes from the Lake Tansi is not significantly different than the water quality found in Meadow Park Lake and would not require plant modifications in order to treat.

5.4. Alternative #4: Water Harvesting from Caney Fork River

The fourth alternative investigated was water harvesting from the Caney Fork River within Cumberland County. The location for water harvesting is assumed to be in the western part of the County near Clifty. Appendix V contains a plan showing the projected pipeline route and hydraulic calculations for this alternative.

The estimated capital cost of this alternative is $15.5 million. The cost estimate is based upon an intake structure on the Caney Fork River with a pumping station with two 30,000 gpm pumps and approximately 7.0-miles of 48-inch pipeline to the Meadow Park Lake and Treatment Plant.

Item #	Description	Unit	Est. Qty	Unit Price	Item Total
1	Mobilization and General Conditions	LS	1	$175,000.00	$175,000
2	Erosion Control	LS	1	$95,000.00	$95,000
3	Raw Water Intake	LS	1	$385,000.00	$385,000
4	Raw Water Pumps	EA	2	$250,000.00	$500,000
5	Raw Water Intake Electrical	LS	1	$205,000.00	$205,000
6	Trenching, Excavation, and Backfill	LF	36800	$75.00	$2,760,000
7	48" DIP PR350 Raw Water Main	LF	36800	$170.00	$6,256,000
8	72" Steel Casing; Open Cut	LF	60	$2,500.00	$150,000
9	72" Steel Casing; Bore & Jack or Tunnel	LF	100	$6,000.00	$600,000
10	Asphalt Pavement Replacement	TON	800	$120.00	$96,000
11	Crushed Stone for Backfill	TON	18400	$19.00	$349,600
12	Seeding w/ Mulch	UNIT	3000	$50.00	$150,000
	Total Estimated Construction Cost				**$11,721,600**
Non-Construction Costs					
	Project Contingency (specify percentage)	15%			$1,758,240
	Land and Easement Acquisition				$186,172
	Land and Easement Appraisals				$45,000
	Legal Services				$75,000
	Project Administration				$65,000
	Environmental Studies				$150,000
	Geotechnical Engineering				$30,000
	Surveying				$60,000
	Engineering Report				$20,000
	Engineering Design				$1,010,988
	Construction Admin & Inspection				$225,000
	Environmental Permitting				$150,000
	Plans Review Fees				$3,000
	Total Estimated Project Cost				**$15,500,000**

The alternative is capable of supplying the 3.5 million gallons per day of projected demand required but provides no additional storage of raw water. The capital cost of the system would have to be increased to include construction of a detention basin at the intake site in order to provide any additional storage of raw water. The system could be expanded somewhat beyond the 3.5 million gallons per day, however, not to the extent that the Watts Bar Reservoir Alternative could be.

The alternative would require an estimated power input of 4,460,059 kwh per year. The power generation necessary to supply the project would require additional inputs and have some environmental consequences. The annual cost of the power at current rates would be an estimated $967,479 per year and have a present value of $23,365,807 for the twenty year planning period of this report.

This alternative would require approximately 68,247 million gallons of water to implement for the twenty year planning period with 36,500 million gallons or 54% being transferred to the treatment plant for use as potable water. The remaining water usage would be used in the generation of power for the Project. The alternative would require an estimated 26,547 tons of coal for the planning period of twenty years.

The following table shows the pollutant generation from coal power on this alternative based upon emissions reports from the Tennessee Valley Authority.

Chemical	Air (lbs)	Water (lbs)	Land (lbs)	Offsite Disposal (lbs)	Amount Produced for Pipeline from Caney Fork River to Meadow Park (lbs/yr)	Amount Produced over 20 yrs for Caney Fork River to Meadow Park (lbs)
Hydrochloric Acid (aerosol)	3,380,056	0	0	0	1382.28	27645.59
Hydrogen Fluoride	453,626	0	0	0	185.51	3710.22
Sulfuric Acid (aerosol)	658,567	0	0	0	269.32	5386.44
Ammonia	21,160	439	0	0	8.83	176.67
Arsenic Compounds	233	2,745	44,782	1	19.53	390.63
Barium Compounds	2,456	43,530	1,400,666	16	591.62	11832.34
Chromium Compounds	458	1,588	86,077	1	36.04	720.76
Cobalt Compounds	117	0	36,400	0	14.93	298.67
Copper Compounds	435	4,020	128,975	0	54.57	1091.33
Lead Compounds	288	0	49,716	1	20.45	408.99
Manganese Compounds	676	0	142,790	0	58.67	1173.41
Mercury Compounds	481	0	235	0	0.29	5.86
Nickel Compounds	477	410	72,357	0	29.95	599.07
Selenium Compounds	8,978	1,111	8,268	0	7.51	150.15
Vanadium Compounds	442	3,353	180,321	0	75.29	1505.90
Zinc Compounds	1529.22	4047.2	115190.79	0	49.39	987.76
Benzo(g,h,i)perylene	0.16	0	0.28	0	0.00	0.00
Napthalene	65.998	0	0	0	0.03	0.54
Dioxin (grams)	2	0	0	0	0.00	0.02
Dioxin (lbs)	0	0	0	0	0.00	0.00
Polycyclic Aromatic Compounds	32	0	16	0	0.02	0.39
TOTALS	**4,530,077**	**61,244**	**2,265,794**	**19**	**2804.24**	**56084.71**

This alternative has a moderate level of capital cost, environmental effects, and power requirements of the alternatives investigated.

The alternative would significantly increase the sediment load to the Meadow Park Lake which would be used to store a portion of the water pumped. Primarily, since pumping would have to be performed during high water flows on the Caney Fork River, the pumping rate had to be increased in order to provide adequate capacity to meet the required demand and sediment loads would be higher from the flooding. The water quality for treatment purposes from the Caney Fork River would be anticipated to be less desirable than the water quality found in Meadow Park Lake. However, the Meadow Park Treatment Plant would not require plant modifications in order to treat if adequate sedimentation time was implemented in Meadow Park Lake.

5.5. Chosen Alternative

The selected alternative for this Project is to water harvest from Lake Tansi to the Meadow Park Lake and Treatment Plant as described in Alternative #3. The Lake Tansi reservoir is a man made reservoir impounded by an earthen dam.

The reservoir has a surface area at normal pool of 404 acres and a drainage area of 4.48 square miles. The estimated storage volume in the top 8 feet of water on Lake Tansi is an estimated 919,697,404 million gallons or 2822 acre-feet. This storage would bring raw water storage for the City of Crossville to a total of 6575 acre-feet, a 75.2% increase in raw water storage. This increase in raw water storage would provide the City of Crossville with 284 days of storage at the 20-year design demand of 7.54 million gallons per day. This period of time is long enough to offset any extended dry periods usual to drought conditions on the Cumberland Plateau.

The Lake Tansi reservoir has a safe yield of approximately 3.5 million gallons per day. The proposed system includes an intake in Lake Tansi, a raw water pumping station adjacent to the lake at the intake, and construction of 2.1 miles of 36 inch pipeline to the Meadow Park Lake and Treatment Plant capable of drawing up to the safe yield of the Lake Tansi reservoir. The proposed intake is planned for a depth of 14 to 16 feet to provide capability of withdrawing the top 8 feet of storage.

Piping alternatives for the pipeline have been evaluated to provide a system with the least amount of electrical input power. The cost difference of electrical power for different pipeline sizes were compared to the cost of pipe and installation for each of the sizes to provide a system with the lowest present value. This analysis has resulted in the selection of a 36 inch pipeline. A secondary benefit of minimizing the electrical cost for the system is the minimization of environmental effects from the generation of electrical power.

The proposed pipeline has an elevation high point at Lantana Road (State Route 101) that is approximately 118 feet above the Lake Tansi reservoir. The Meadow Park Lake is actually lower than the Lake Tansi reservoir, hydraulically. However, pumping is required to cross the Tennessee Divide as the lakes are on the two sides of the divide.

Detailed hydraulic calculations can be found in Appendix III of this Plan.

The proposed project schedule is outlined as follows:

Submit complete plans and specifications	On or before September 1, 2009
Receive bids	On or before November 30, 2009
Start Construction	On or before December 15, 2009
Complete Construction	On or before December 15, 2010
Initiate Operation	On or before December 31, 2010
Complete Start Up Services	On or before February 15, 2011

SECTION 6. SELECTED PLAN DESCRIPTION

6.1. Proposed Treatment Process

The proposed treatment process for the selected alternative would not vary from the existing treatment process at the Meadow Park Treatment Plant.

6.1.01. Treatment Capacities

No difference from existing capacities.

6.1.02. Treatment Retention Times

No difference from existing.

6.1.03. Treatment Loading Rates

No difference from existing.

6.1.04. Treatment Filter Area

No difference from existing.

6.1.05. Treatment Filtration Rate

No difference from existing.

6.1.06. Treatment Backwash Rate

No difference from existing.

6.2. Water Source and Demand Requirements

The proposed project does not increase the demand on the City of Crossville Water System but only supplies additional water source for treatment. Details of the selected alternative can be found in Section 5 of this Plan.

6.2.01. Stream Flow Data

No stream flow data has been located for gauges close to the spillway of the Lake Tansi Reservoir. A regression analysis has been performed between the nearest downstream gauge and the drainage area of Lake Tansi. The results are valid for estimates but have limited use..

6.2.02. Existing or Potential Ground Water Sources

The development of a ground water source could be done with extraction wells or springs as an additional alternative to those investigated in this study. However, the National Ground Water Atlas of the U. S. Geological Survey reports that the geologic structure of the Cumberland Plateau has a subsurface ground water system that is reliant upon crevices and voids in the sandstone bedrock structure in order for the transmission of usable quantities of water. The sandstone naturally does not conduct enough water volume to be usable by residences in many situations nevertheless as a public water supply. The feasibility of constructing a system of extraction wells is based upon effectively locating crevices and voids in the bedrock structure that are carrying appreciable amounts of water. No reliable means exist to do this without extensive geologic investigation to map faulting and subsurface conditions. Although the extraction wells option is feasible, however, costs are unpredictable and can be very high. The use of springs is very unreliable on the Cumberland Plateau and is considered to be unfeasible.

The environmental impact of sustained pumping of the aquifers underlying a region are well established by the documented effects of salt or brackish water intrusion, the effects of subsurface oil removal, and the long term reduction as has occurred in the Ogalala Aquifer. The sustained pumping of the aquifer particularly if at a rate higher than the recharge rate can lead to a reduced elevation of the top of the water surface resulting in the reduction of baseline stream flows. This effect is a long term effect in comparison to the overwithdrawal of water from a surface water source as it may take the aquifer years to recover depending upon the recharge rate. In addition, the effect to baseline stream flows is not a short term effect and could result in permanent alteration of the stream ecology at the surface. Brackish water intrusion is a real possibility on the Cumberland Plateau and water quality could deteriorate rather quickly depending upon influences from oil deposits, shale, and coal beds. Based on these issues, the use of extraction wells is considered to have an environmental impact that is greater than using an existing impoundment or water harvesting. However, it could have less environmental impact than the construction of a new impoundment that is not associated with water harvesting.

The financial aspects of using extraction wells is based primarily upon four factors, the first being the cost to drill and explore to locate the fissures and crevices within the bedrock structure; second, the amount of water based upon safe yields that could be extracted from each well, third, the depth required to reach usable quantities of water; and fourth, the time that the well could be used prior to degradation of the water quality.

Based on published data and interviews of well drillers, the average producing well would be expected to produce approximately 35 gallons per minute in the region. Other reports have investigated the alternative to obtain groundwater wells to supply the region. However, feasible well fields are expected to be off of the Cumberland Plateau and would have similar power requirements and environmental impacts similar to the option of pumping from the Watts Bar Reservoir.

Because of the geologic structure, springs are not common on the Cumberland Plateau and at best are small and unreliable when they do occur. It is not uncommon for small springs to supply water to surface streams or impoundments within the Cumberland Plateau. However, again these are small and unreliable to use as a sole source for public water. Therefore, consequently this option is not feasible as a solution to the needs of region.

In summary, groundwater sources could be obtained to augment the surface water supply should they become necessary. At the current time, there remains a lot of unknown factors that would affect the construction and permitting costs to undertake any of these options.

6.3. Effects to or from any Wastewater Treatment Facility

The proposed project has no direct effect on any wastewater treatment facility. The increase in water consumption due to increased industrial activity and population growth in the planning area may have impacts to the City of Crossville's wastewater treatment facility.

6.4. Site Selection (sites considered and the chosen site)

The site selection process is limited to the selection of sites for the intake structure, pumping station, and the pipeline route.

To the extent possible, the pipeline route is planned to be on property already owned by the City of Crossville. The project planning map included in the Appendices of this plan includes three possible route alternatives for the pipeline that have been considered identified as Route A, B, and C. Route C has been eliminated from consideration as it does not meet the project design requirement to be able to be piped directly to the Meadow Park Water Treatment Plant. Route A is longer than Route B and affects more private property owners; although it avoids one stream crossing. Therefore, Route B is the preferred pipeline route even if the stream crossings require a boring method of crossing in lieu of open cut trenches. Route B has been optimized to include placing the maximum amount of pipeline on the City of Crossville property for Meadow Park Lake, minimize impacts to traffic and traffic disruption, and has been located to avoid any known wetlands as well as not requiring relocation of any residents.

The site selection process for the intake structure and pumping station have been based on the reduction of cost associated with length of transmission line, the location of adequate water depth in the lake at an accessible location, reduction of impacts associated with navigation and water recreation, and such that relocation of residents are not required. Five properties have been identified and are under evaluation as the site for the pumping station. The final site selection will be based upon a number of factors including:

- Access to adequate depth of water for intake structure
- Willingness of owner to sell property
- Access to pipeline meeting constraints imposed on pipeline

6.5. Soil Conditions (for water line placement and foundations)

The project area like the vast majority of the Cumberland Plateau is generally described as having 1 to 2.5 feet of soil over the underlying sandstone bedrock. The soil tends to be a sandy loam in general. The soil conditions expected within the project area will require trenching into the bedrock for pipelines and excavation of pump station foundations into the bedrock at the site of the pumping station. A copy of the soils report from the U.S. Department of Agriculture for the project area can be found in Appendix VII of this Plan.

6.6. Public Involvement Public Meeting

The Owner advertised and held a public meeting on Tuesday, May 26, 2009 at 6:00 p.m. local time in the Council Chambers of the Crossville City Hall. Appendix VI of this Plan contains a copy of the advertisement of the meeting, a copy of the sign-in sheet from the meeting, and a copy of the agenda for the meeting. All questions asked by the public during the meeting were answered during the meeting to the satisfaction of the party asking the question. Additional documentation regarding the public involvement public meeting will be sent under separate cover.

SECTION 7. PROJECT COSTS

7.1. Estimated Construction Costs and Overall Project Costs

The estimated construction costs and overall project costs are $5.68 million and are detailed in the Section of this Plan entitled Development of Alternatives. The details of life cycle costs for the project are included in the following table presented in annual costs and present values.

Project Life Cycle Costs

Cost Component	Annual Cost or First Year Cost	Present Value
Loan Capital	$110,291	$3,000,000
Loan Interest	$93,600	$1,077,237
Depreciation	$108,250	
Electrical Power	$106,018	$2,560,465
Pump & Pipeline Maintenance	$20,000	$297,550
Storage Maintenance Fee	$50,000	$743,874
Total	**$488,159**	**$7,679,126**

Note: Land and easement acquisition and appraisal costs of $680,150 are not included in the cost analysis above. These costs are ineligible for ARRA funding and are not depreciable.

The depreciation is calculated based on 50 year life for the system with the exception of pumps which are calculated based on a 20 year life. The present value of all cost components assumes that the inflation rate is 3.0%. The present value of depreciation is not included in the total present value for the system.

7.2. Proposed Financing

The project is proposed to be financed by the State Revolving Fund Loan Program for Drinking Water in conjunction with the American Recovery and Reinvestment Act Funds disbursed to the State Revolving Fund Loan Program. The inclusion of ARRA funds results in a program in which 40% of the initial debt will be forgiven by State Revolving Fund. Therefore, the anticipated loan amount is $3,000,000 for the Project.

The estimated interest rate on the financing is expected to be 3.12% based on the ability to pay index (ATPI) of 80%. The calculated principal and interest payment on $3,000,000 for a 20-year term at 3.12% is $203,890.04.

7.3. Projected Operating Costs and Water Rate Structure

The projected operating costs for the proposed project include an annual cost of $106,018 for power, $20,000 per year for pump and pipeline maintenance, and an estimated $50,000 for storage maintenance fees for the use of Lake Tansi.

The City of Crossville present rate structure for water is $3.69 per 1000 gallons inside the City limits with a minimum of 2000 gallons billed if usage is below 2000 gallons. The rates outside of the City limits is 150% of the inside rate. The City's wholesale rate to Utility Districts is currently $2.67 per 1000 gallons. The City of Crossville City Council has passed a rate resolution to increase the water rates by 20% in 4 equal increments over the next four years. At the end of the four years, the rate structure will be $4.43 per 1000 gallons inside the City limits.

The rate increase when fully implemented will provide an estimated revenue increase of $1,159,493 per year, a level well above the projected annual costs of $488,159 for the project..

SECTION 8. ENVIRONMENTAL IMPACTS

8.1. Planning Area and Project Area

The planning area for the City of Crossville Water System covers the vast majority of Cumberland County along with portions of Putnam and Rhea Counties and to a lesser extent portions of White, Bledsoe and Van Buren Counties. Appendix I contains a map depicting the location of the planning area.

The project area for the ARRA Water Harvesting Project is depicted on a USGS Topographic Quadrangle Map found in Appendix II of this Report.

8.2. Project Specific Impacts

The proposed project has some project specific impacts as detailed below. However, none of the impacts are considered negative and significant based upon evaluations conducted to date.

8.2.01. Impacts on Transportation Resources

The proposed project is not expected to have any impacts on transportation resources either positive or negative. The project requires a few road crossings for utility line installation. The most significant crossing is planned to be crossed by boring methods and will not disrupt traffic. The minor crossings are planned as open cut but will only disrupt the low traffic volumes on these roads for a period of 2 to 3 days. The disruption of traffic through the construction period will not translate to any level of service loss in transportation systems.

8.2.02. Impacts on Socioeconomic Resources

The proposed project is not expected to have any negative impacts on socioeconomic resources. The project will allow the socioeconomic systems that have been present in Cumberland County, Tennessee to continue growing and developing as they have over the past thirty years. The proposed project does not take any

8.2.03. Impacts on Air Quality Resources

The proposed project has two potential impacts to air quality resources.

The first impact would be from the dust generation of rock removal for excavating trenches to construct the project. This impact would not be present after the completion of construction. Any impact from construction activity will be mitigated by the use of dust suppression methods used in the construction such as dust collectors on drills and wetting of materials to prevent dust from becoming airborne.

The second impact to air quality resources would be secondary effects created by the generation of power to operate the project. Power generation is assumed to be performed by the Tennessee Valley Authority. Estimates of the pollutants to introduced into the atmosphere by TVA power generation can be found in Section 5 of this Plan.

8.2.04. Impacts related to Noise

The proposed project has two potential noise related impacts.

First, noise levels will be fairly high during the construction process due to the excavation activities associated with rock removal and the general use of construction equipment. This is a short-term impact and can be somewhat mitigated with the use of proper exhaust systems on equipment.

Second, the pumps at the intake will generate noise when they are operating. The proposed plan includes constructing the pump house in such a manner as to isolate the noise from the residential area in which it is located. Insulation and construction methods will be used to prevent ambient noise levels from exceeding current values.

8.2.05. Impacts on Cultural / Paleontological Resources

The proposed project is not expected to have any impacts on cultural or paleontological resources. No known cultural or paleontological sites are within the project area. The project area has been strip mined in portions of it, had significant development activities in other portions, and has been logged in the remaining portions. Therefore, no cultural or paleontological resources are expected to be present in the project area.

8.2.06. Impacts on Visual Resources

The proposed project is not expected to have any impacts on visual resources. The majority of the proposed system will be underground and out of sight.

8.2.07. Impacts on Land Use

The proposed project is not expected to have any impacts on land use.

8.2.08. Impacts related to Electrical Power Resources

The proposed project will have an impact on electrical power resources although this impact has been minimized through the selection of the alternative and in the design parameters of the selected alternative to the extent that is possible. Details of the impacts to electrical power resources are detailed in Section 5 of this Plan.

8.2.09. Impacts on Geology and Soils

The proposed project is on the Cumberland Plateau in Cumberland County. The Cumberland Plateau is the southern portion of the Appalachian Plateau Physiographic Province and extends through portions of Pennsylvania, Kentucky, West Virginia, Tennessee, Alabama, and Georgia. The Cumberland Plateau is a deeply dissected plateau, with topographic relief of around four hundred feet with frequent sandstone outcroppings and bluffs. The plateau is described as a relatively flat-topped table land, rising 1000 feet above the adjacent provinces. It is on average 35 miles wide and extends the entire width of Tennessee from Kentucky to Alabama. The central portion of the plateau in which the site is located, is a rolling topography with generally low hills and a few deeply incised stream valleys.

The surface geology to a depth of approximately 600 feet of the Cumberland Plateau within Cumberland County is primarily comprised of Pennsylvanian age sedimentary rocks, a mixture of sandstones, conglomerates, shales, coals, and minor limestones. The sedimentary rocks are composed of near shore sediments washed westward from the old Appalachian Mountains and some rock layers were laid down in shallow coastal waters including bituminous coal seams that were laid onshore in swampy environments. These are interlaced with delta formations of cross-bedded sandstones and are occasionally conglomeratic. Numerous discontinuities exist in the rock beds where they have been raised high enough to be eroded, then lowered to have more sediments deposited on top.

Much of the plateau contains nearly horizontally bedded rocks with a very simple geologic structure. However, the Meadow Park Lake and Lake Tansi area is very near the Cumberland Plateau Overthrust created during the Allegheny Orogeny, 300-280 million years ago. The Cumberland Plateau Overthrust is a major thrust fault that displaced rock both horizontally and vertically.

Locally, the area between the two lakes is known for the hard characteristics of the shallow surface sandstone. The proposed project will have no impacts on the geology of the area with the exception of the trenches cut into the upper layers of the sandstone bedrock.

Prime farmland is a designation assigned by the U.S. Department of Agriculture and is land that has the best combination of physical and chemical characteristics for producing food, forage, fiber, and oilseed crops and is available for these uses. Prime farmland has the soil quality, growing season, and moisture supply needed to produce economically sustained high yields of crops when treated and managed according to acceptable farming methods, including water management. In general, prime farmland has an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, an acceptable level of acidity or alkalinity, an acceptable content of salt or sodium, and few or no rocks. Its soils are permeable to water and air. Prime farmland is not excessively eroded or saturated with water for long periods of time, and it either does not flood frequently during the growing season or is protected from flooding.

The proposed project is not expected to have any significant impacts on geological resources or prime farmland.

8.2.10. Impacts on Water Resources

The proposed project will have a positive impact on water resources used for the production of potable water for the region by increasing the amount of raw water storage for the system and providing additional raw water.

The proposed project will require an estimated three stream crossings in order to complete the pipeline as well as work in Lake Tansi and on the banks of Meadow Park Lake. Construction activities will provide a potential for erosion of sediments into waterways. The Tennessee Erosion and Sediment Control Manual and the Tennessee General NPDES Permit for Stormwater Associated with Construction Activity will be used to prevent any impacts to water resources related to the construction activities. The stream crossings will be performed in accordance with Tennessee Aquatic Resource Alteration General Permit for stream crossings with utility lines in order to minimize any impact.

The project minimizes any impact to water resources as a result of water withdrawal for the use in production of potable water by utilizing existing resources. It provides another beneficial use for the Lake Tansi reservoir.

8.2.11. Impacts on Fisheries Resources

The proposed project is not expected to have any impacts on fisheries resources.

8.2.12. Impacts on Vegetation Resources

The proposed project will require the clearing of some timber in order to complete construction of the pipeline. There are no old growth forests within the project area and any impact to vegetation resources is minimal.

8.2.13. Impacts on Wetland Resources

The proposed project will not have any impacts on wetland resources. The National Wetland Inventory does not show any wetland areas within the project area. However, previous studies conducted by Environmental & Civil Engineering Services have delineated wetlands within the general vicinity of the proposed project. The pipeline route has been selected in order to avoid all wetlands known to exist and will be modified if necessary to avoid any wetlands discovered during the process of engineering and construction of the project.

8.2.14. Impacts on Wildlife Resources

The proposed project is not expected to have any impacts on wildlife resources unless there are unknown impacts associated with power generation.

8.2.15. Impacts on Biodiversity

The proposed project is not expected to have any impacts on biodiversity.

8.2.16. Impacts on Recreational Resources

The proposed project can have a negative impact on recreational resources since Lake Tansi has been used solely for recreation up to this point of time since its construction. Any impacts to recreational resources will be mitigated to the extent possible through an effective management plan for the resource. However, drinking water is considered by the City of Crossville to be a higher priority than recreational activities. The City of Crossville spends a significant amount of their budget to provide recreational activities and opportunities. The City is not unaware of the quality of life issues associated with recreational resources and will strive to maintain the recreational uses on Lake Tansi to the extent possible.

SECTION 9. ENVIRONMENTAL JUSTICE CONCERNS

9.1. Identification of Minority and Low-Income Populations in Project Area

A review of the 2000 census for Cumberland County reveals no delineation of minority populations within the County. The relatively small minority population appears to be fairly evenly distributed throughout the County.

The Project Area is relatively small, rural, and does not include a significant population. The Project Area is closest to the Lake Tansi CDP in the 2000 census. Comparisons of the Lake Tansi CDP to the Cumberland County census data provide the following information regarding minority and low-income populations. The minority population of Cumberland County as a whole is 1.9% with the majority of the minorities being Hispanic while the minority population of the Lake Tansi CDP is 1.6% with half of the minorities being Hispanic. The percent of families living below the poverty level in Cumberland County as a whole is 11.1% while the value for the Lake Tansi CDP is 12.6%. The project area does not include a significant portion of the Lake Tansi CDP which is primarily a retirement community where household incomes would be expected to be lower than working families in the county.

Therefore, no minority or low-income populations have been identifiable or identified to be more affected by this Project.

9.2. Evaluation of Disproportionate Risks to Identified EJ Populations

No disproportionate risks to identified Environmental Justice populations have been evaluated as there are no identified Environmental Justice populations within the Project Area.

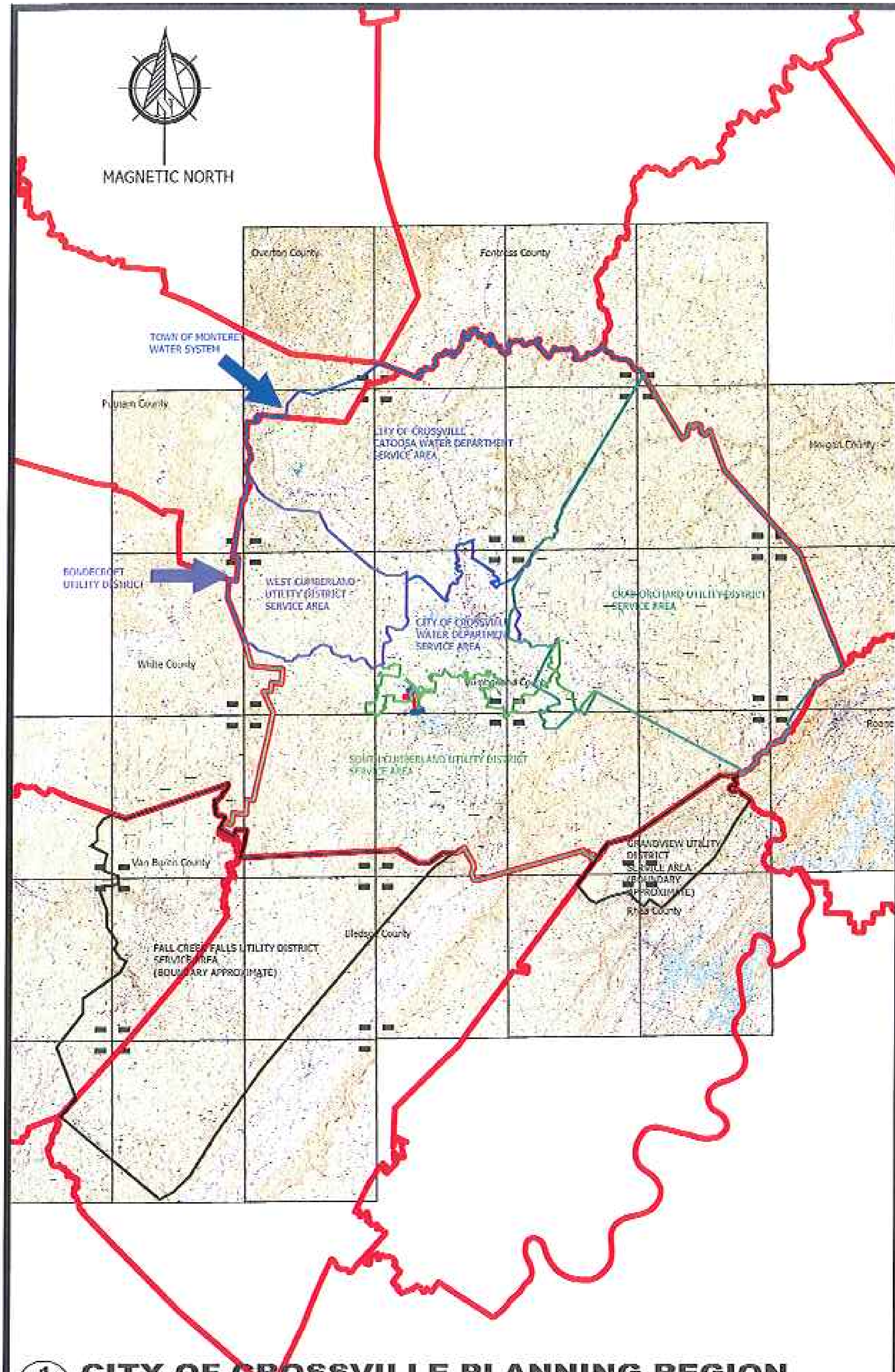
9.3. Identification of Public Participation Opportunities for Identified EJ Populations

No special public participation opportunities have been arranged for Environmental Justice populations in addition to the opportunities made available to the public in its entirety as no identified Environmental Justice populations have been identified within the Project Area.

9.4. Evaluation of Environmental / Health Risks among Identified EJ Populations that may be Exacerbated by Proper Construction and Operation of the Selected Alternative

No evaluation of environmental or health risks among Environmental Justice populations has been made as there is no identified Environmental Justice populations within the Project Area.

Appendix I
City of Crossville Planning Area Map



1/1 **CITY OF CROSSVILLE PLANNING REGION**

SCALE: 1"=50,000'

CHK BY: S.J.C.
DESIGN BY: S.J.C.
DWN BY: S.J.C.
MAY 5, 2009
PROJECT #7035
DWG #
REVISION #: 0
SCALE: 1 in = 40,000 ft
SHEET 1 OF 1

FIGURE 1 - CITY OF CROSSVILLE PLANNING REGION

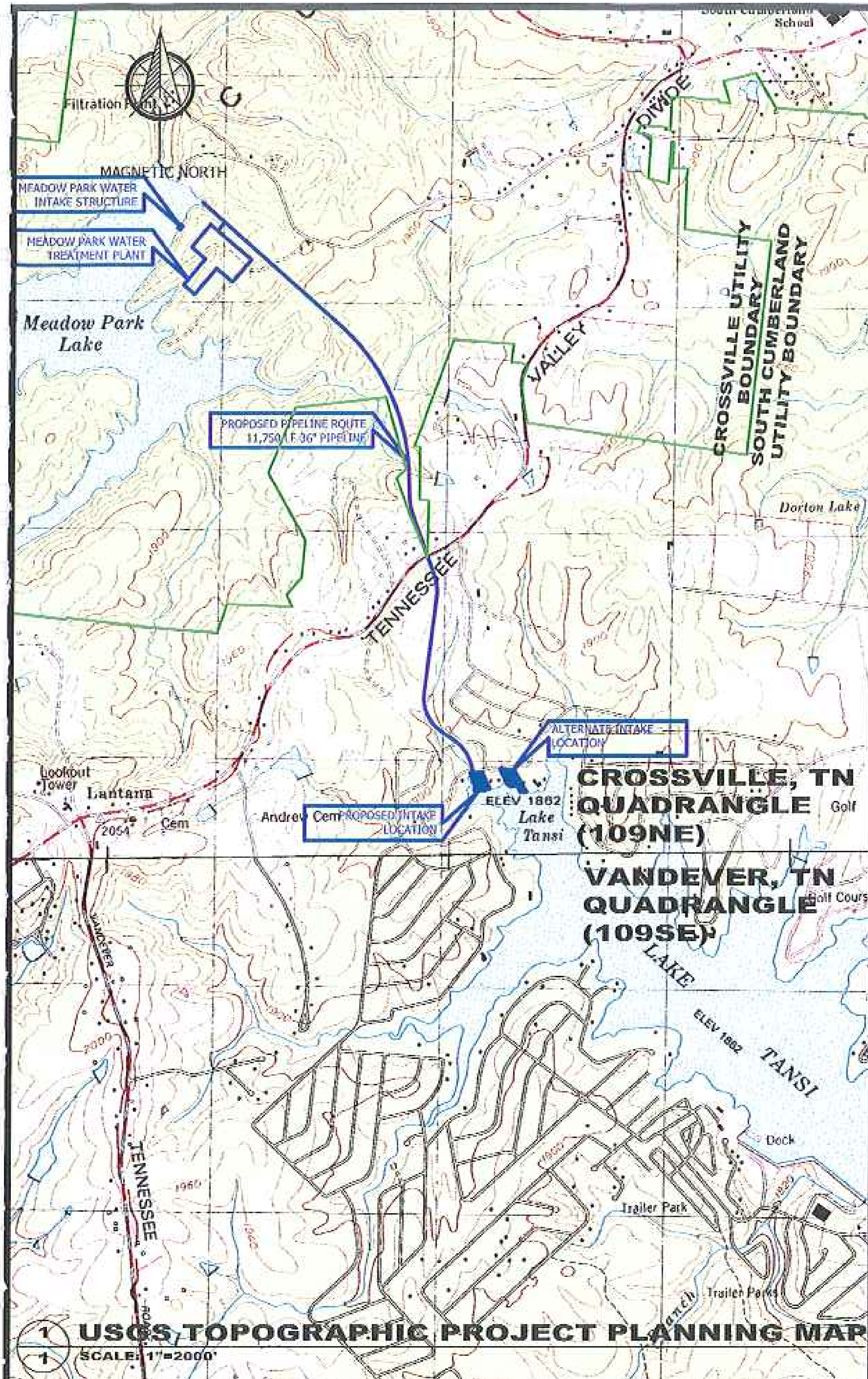
CITY OF CROSSVILLE
STATE REVOLVING FUND AND AMERICAN RECOVERY AND REINVESTMENT ACT
WATER HARVESTING PROJECT
CUMBERLAND COUNTY, TENNESSEE

ece SERVICES
ENVIRONMENTAL & CIVIL ENGINEERING SERVICES

702 Old Jamestown Hwy
Crossville, TN 38555
Telephobne: 931.484.9321
Fax: 931.484.9322
www.eceservices.com

* ENGINEERING * GEOTECHNICAL
* QA/QC TESTING

Appendix II
Project Area Map



CHK BY: S.J.C.	
DESIGN BY: S.J.C.	
DWN BY: S.J.C.	
MAY 5, 2009	
PROJECT #7035	
DWG #	
REVISION #: 0	
SCALE: 1 in = 2000 ft	
SHEET 1 OF 1	

FIGURE 2 - USGS TOPOGRAPHIC PROJECT PLANNING MAP

CITY OF CROSSVILLE
STATE REVOLVING FUND AND AMERICAN RECOVERY AND REINVESTMENT ACT
WATER HARVESTING PROJECT
CUMBERLAND COUNTY, TENNESSEE

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ENVIRONMENTAL & CIVIL ENGINEERING SERVICES

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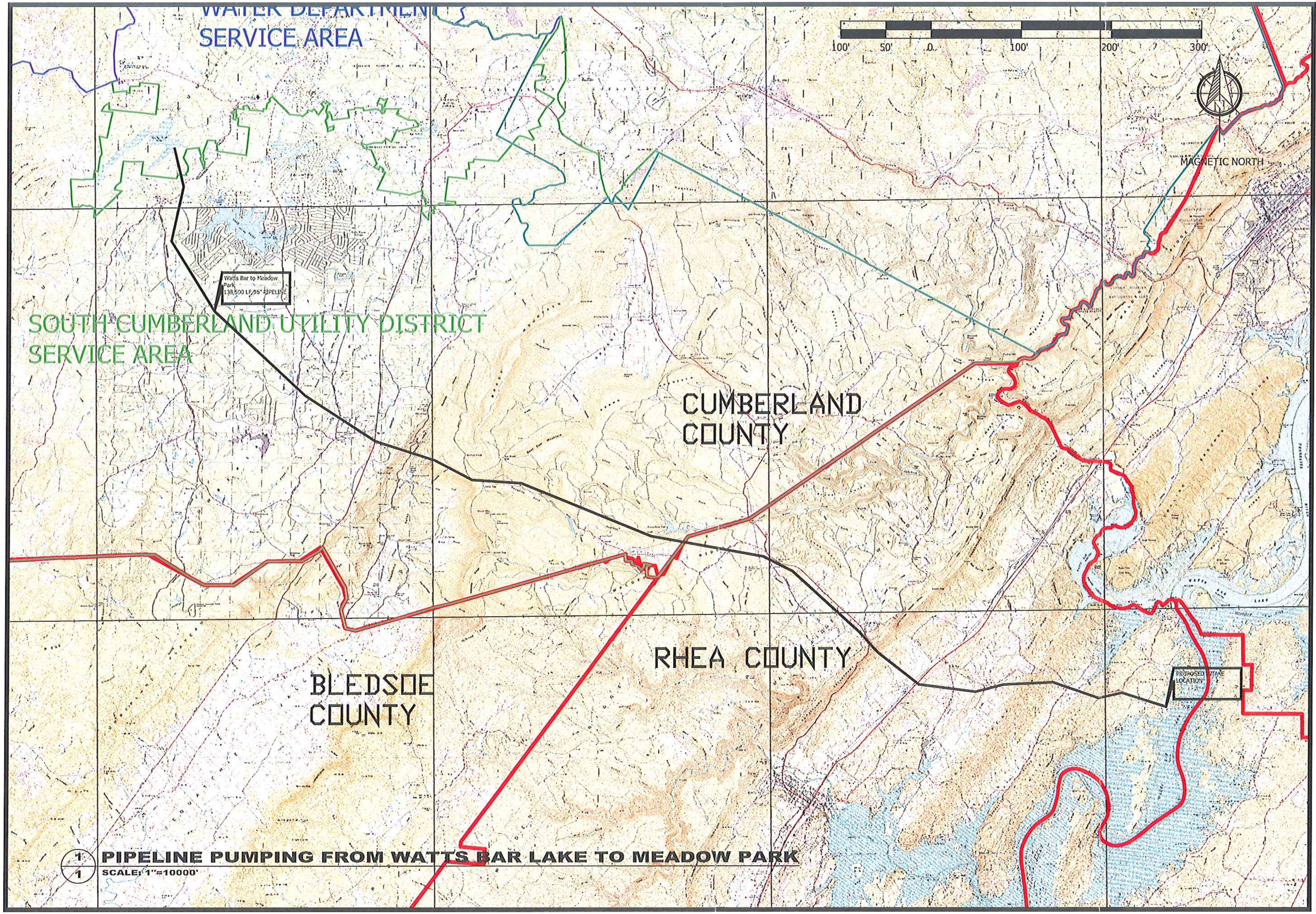
Appendix III

Alternative 2 Location Map and Hydraulic Calculations

Watts Bar Reservoir to Meadow Park Lake



NO.	DATE	REVISIONS DESCRIPTION	CHK

WATTS BAR LAKE TO MEADOW PARK ALTERNATIVE

CITY OF CROSSVILLE
ARRA WATER HARVESTING PROJECT
CUMBERLAND COUNTY, TENNESSEE

ece SERVICES
ENVIRONMENTAL & CIVIL ENGINEERING SERVICES

702 Old Jamestown Hwy
Crossville, TN 38555
Telephone: 931.484.9321
Fax: 931.484.9322
www.eceservices.com

* ENGINEERING * GEOTECHNICAL * QA/QC TESTING

CHK BY: SJC
DESIGN BY: SJC
DWN BY: MBJ
MAY 22, 2009
PROJECT # 7035
DWG #
REVISION #: 0
SCALE: 1 in = 10000 ft

SHEET 1 OF 1

DESIGN OF WATER HARVESTING PUMP SYSTEMS

Project No.: 7035
Project Title: ARRA Water Harvesting Project - City of Crossville
System: Watts Bar Lake to Meadow Park

SITUATION:

Design a pumping system capable of pulling from one reservoir to a second reservoir. Design intent is for a water harvesting system capable of supplying an annual volume of water. Calculate the theoretical horsepower, design horsepower, pump conditions, and related information.

Assumptions:

1. Using Hazen-Williams equation, the flow is assumed to be turbulent and the liquid should have a kinematic viscosity around 1.2 x 10^-5 square feet per second which corresponds to the viscosity of 60 degrees Fahrenheit water. The velocity is assumed to be no greater than 6 ft/sec.
2. In calculating the total dynamic head, minor losses due to friction were assumed negligible.
3. The power factor was also assumed to be 0.80.
4. Pump run time is assumed to be averaged over 12 months per year for the purposes of calculating the average monthly electrical cost.

References:

1.

Defined Units:

$$gpm := \frac{gal}{min}$$

$$MG := 1000000 \cdot gal$$

$$psi := \frac{lbf}{in^2}$$

$$hp := 550 \cdot \frac{ft \cdot lbf}{sec}$$

$$kwh := kW \cdot hr$$

$kva := 0.80kW$ Power factor is assumed to be 0.80

Input Variables:

$HGL_1 := 740.00 \cdot ft$	Input hydraulic grade line of reservoir #1 or the reservoir being pumped from
$HGL_2 := 1819.62 \cdot ft$	Input hydraulic grade line of reservoir #2 or the reservoir being pumped to
$Q_{design} := 4000 \cdot gpm$	Input design pumping rate
$VOL := 1825 \cdot MG$	Input desired annual volume of water to be pumped
$d := 36 \cdot in$	Input the design pipeline diameter
$L := 138500 \cdot ft$	Input the length of pipeline
$C := 120$	Input the Hazen-Williams C Factor for pipeline material
$EL_{pump} := 740 \cdot ft$	Input pump elevation
$EL_{low} := 740 \cdot ft$	Input the low elevation in pipeline
$L_{low} := 5 \cdot ft$	Input the distance along pipeline to low elevation in pipeline from pumping station
$EL_{high} := 2240.00 \cdot ft$	Input the high elevation in pipeline
$L_{high} := 80000 \cdot ft$	Input the distance along pipeline to high elevation in pipeline from pumping station
$SG := 1$	Input specific gravity of fluid
$\eta_{pump} := 0.70$	Input pump efficiency
$\eta_{motor} := 0.85$	Input motor efficiency

Calculate pipeline velocity:

$A_{pipe} := \pi \cdot \frac{d^2}{4}$ $\qquad A_{pipe} = 7.1ft^2$ $\qquad A_{pipe} = 1017.876in^2$

$v := \frac{Q_{design}}{A_{pipe}}$ $\qquad v = 1.3ftsec^{-1}$

Calculate detention time in piping system:

$t_d := \frac{A_{pipe} \cdot L}{Q_{design}}$ $\qquad t_d = 30.5hr$ $\qquad$ Detention time in pipeline with pumps running

Calculate pump head - operating conditions:

$H_{elev} := EL_{high} - HGL_1$ $\qquad H_{elev} = 1500ft$ $\qquad$ Elevation Head

$$H_L := 3.02 \cdot \frac{L}{ft} \cdot \left(\frac{d}{12 \cdot in}\right)^{-1.167} \cdot \left(\frac{\frac{\frac{Q_{design}}{7.48 \cdot 60 \cdot gpm}}{\frac{A_{pipe}}{ft^2}}}{C}\right)^{1.85} \cdot ft$$

Calculate friction head in piping system using Hazen-Williams headloss formula

$H_L = 25.4ft$

Calculate total dynamic head:

$TDH := H_L + H_{elev}$

$TDH = 1525.4ft$

Calculate pressure at pump discharge:

$$P_{pump} := TDH \cdot \frac{0.433 \cdot psi}{ft} \qquad P_{pump} = 660.5psi$$

Calculate pressure at low point in pipeline:

$$P_{low} := P_{pump} + \left[\left(EL_{pump} - EL_{low} \right) - \frac{H_L}{L} \cdot L_{low} \right] \cdot \frac{0.433 \cdot psi}{ft} \qquad P_{low} = 660.5psi$$

Calculate pressure at high point in pipeline:

$$P_{high} := P_{pump} + \left[\left(EL_{pump} - EL_{high} \right) - \frac{H_L}{L} \cdot L_{high} \right] \cdot \frac{0.433 \cdot psi}{ft} \qquad P_{high} = 4.6psi$$

Calculate annual & monthly run times:

$$t_{run} := \frac{VOL}{Q_{design}} \qquad t_{run} = 7604hr$$

$$t_{monthly} := \frac{t_{run}}{12} \qquad t_{monthly} = 633.7hr$$

Calculate theoretical horsepower or hydraulic horsepower:

$$hp_{hyd} := TDH \cdot Q_{design} \cdot SG \cdot 62.43 \cdot \frac{lbf}{ft^3} \qquad hp_{hyd} = 1543.1hp$$

Calculate estimated brake horsepower required:

$$hp_{pump} := \frac{hp_{hyd}}{\eta_{pump}} \qquad hp_{pump} = 2204.4hp$$

$$bhp := \frac{hp_{pump}}{\eta_{motor}} \qquad bhp = 2593.4hp \qquad bhp = 1933.9kW \qquad bhp = 2417.4kva$$

Calculate input power required:

$$Power_{reqd} := \frac{bhp \cdot t_{run}}{0.8} \qquad Power_{reqd} = 18382019.132 kwh$$

Calculate the average monthly electrical cost:

$$index := \begin{cases} 1 \text{ if } \frac{bhp}{0.8} < 50 \cdot kW \\ 2 \text{ if } \frac{bhp}{0.8} < 1000 \cdot kW \\ 3 \text{ if } \frac{bhp}{0.8} > 1000 \cdot kW \end{cases}$$

$$index = 3$$

$$cost_1 := 14 + \frac{Power_{reqd}}{12} \cdot \frac{0.08902}{kwh} \qquad cost_1 = 136377.95$$

$$cost_2 := \begin{cases} 25 + \left(\frac{bhp}{0.8} - 50 \cdot kW\right) \cdot \frac{13.08}{kW} + 15000 \cdot 0.08902 + \left(\frac{Power_{reqd}}{12} - 15000 \cdot kwh\right) \cdot \frac{0.04702}{kwh} \text{ if } \frac{Power}{12} \\ 25 + \left(\frac{bhp}{0.8} - 50 \cdot kW\right) \cdot 13.08 + \frac{Power_{reqd}}{12} \cdot \frac{0.08902}{kwh} \text{ otherwise} \end{cases}$$

$$cost_2 = 103646.97$$

$$cost_3 := \begin{cases} 150 + 1000 \cdot 13.60 + 1500 \cdot 14.42 + \left(\frac{bhp}{0.8} - 2500 \cdot kW\right) \cdot \frac{14.82}{kW} + \frac{Power_{reqd}}{12} \cdot \frac{0.04601}{kwh} \text{ if } \frac{bhp}{0.8} > \\ \left[150 + 1000 \cdot 13.60 + \left(\frac{bhp}{0.8} - 1000 \cdot kW\right) \cdot \frac{14.42}{kW} + \frac{Power_{reqd}}{12} \cdot \frac{0.04601}{kwh}\right] \text{ otherwise} \end{cases}$$

$$cost_3 = 104668.08$$

$cost_{index} = 104668.08$ Estimated monthly electrical cost

$cost_{index} \cdot 12 = 1256016.92$ Estimated annual electrical cost

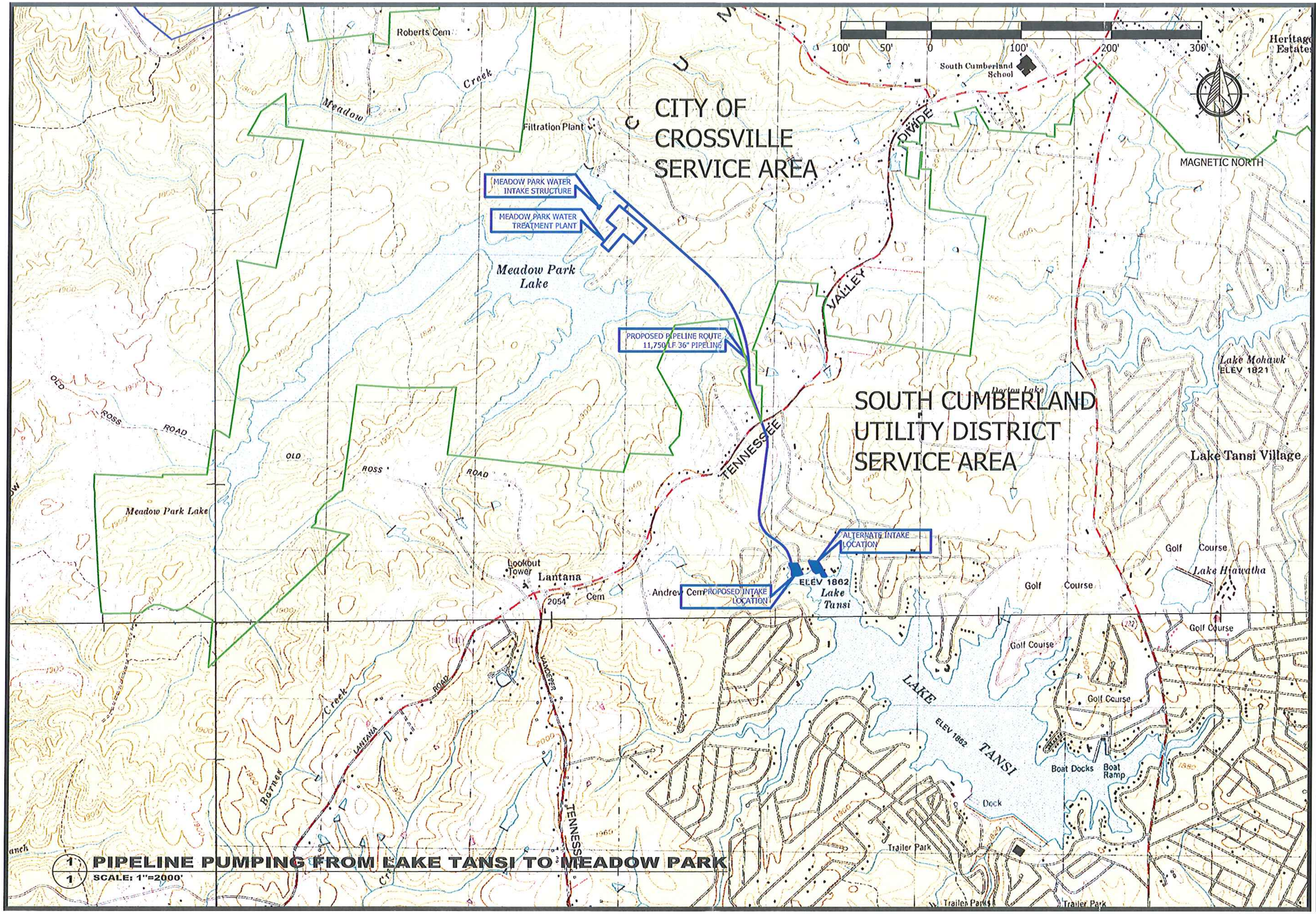
$\frac{{}^{\prime}\mathrm{reqd}}{!} \geq 15000 \cdot kwh$

2500kW

Appendix IV

Alternative 3 Location Map and Hydraulic Calculations

Lake Tansi Reservoir to Meadow Park Lake



PIPELINE PUMPING FROM LAKE TANSI TO MEADOW PARK

SCALE: 1"=2000'

REVISIONS			
NO.	DATE	DESCRIPTION	CHK

LAKE TANSI TO MEADOW PARK ALTERNATIVE

CITY OF CROSSVILLE
ARRA WATER HARVESTING PROJECT
CUMBERLAND COUNTY, TENNESSEE

ece SERVICES
ENVIRONMENTAL & CIVIL ENGINEERING SERVICES

702 Old Jamestown Hwy
Crossville, TN 38555
Telephobne: 931.484.9321
Fax: 931.484.9322
www.eceservices.com

* ENGINEERING * GEOTECHNICAL * QA/QC TESTING

CHK BY: SJC
DESIGN BY: SJC
DWN BY: MBJ
MAY 22, 2009
PROJECT # 7035
DWG #
REVISION #: 0
SCALE: 1 in = 2000 ft

SHEET 1 OF 1

DESIGN OF WATER HARVESTING PUMP SYSTEMS

Project No.: 7035
Project Title: ARRA Water Harvesting Project - City of Crossville
System: Lake Tansi to Meadow Park

SITUATION:

Design a pumping system capable of pulling from one reservoir to a second reservoir. Design intent is for a water harvesting system capable of supplying an annual volume of water. Calculate the theoretical horsepower, design horsepower, pump conditions, and related information.

Assumptions:

1. Using Hazen-Williams equation, the flow is assumed to be turbulent and the liquid should have a kinematic viscosity around 1.2 x 10^-5 square feet per second which corresponds to the viscosity of 60 degrees Fahrenheit water. The velocity is assumed to be no greater than 6 ft/sec.
2. In calculating the total dynamic head, minor losses due to friction were assumed negligible.
3. The power factor was also assumed to be 0.80.
4. Pump run time is assumed to be averaged over 12 months per year for the purposes of calculating the average monthly electrical cost.

References:

1.

Defined Units:

$$gpm := \frac{gal}{min}$$

$$MG := 1000000 \cdot gal$$

$$psi := \frac{lbf}{in^2}$$

$$hp := 550 \cdot \frac{ft \cdot lbf}{sec}$$

$$kwh := kW \cdot hr$$

$kva := 0.80kW$ Power factor is assumed to be 0.80

Input Variables:

$HGL_1 := 1852.00 \cdot ft$	Input hydraulic grade line of reservoir #1 or the reservoir being pumped from
$HGL_2 := 1819.62 \cdot ft$	Input hydraulic grade line of reservoir #2 or the reservoir being pumped to
$Q_{design} := 5000 \cdot gpm$	Input design pumping rate
$VOL := 1825 \cdot MG$	Input desired annual volume of water to be pumped
$d := 36 \cdot in$	Input the design pipeline diameter
$L := 10100 \cdot ft$	Input the length of pipeline
$C := 120$	Input the Hazen-Williams C Factor for pipeline material
$EL_{pump} := 1862 \cdot ft$	Input pump elevation
$EL_{low} := 1820 \cdot ft$	Input the low elevation in pipeline
$L_{low} := 10100 \cdot ft$	Input the distance along pipeline to low elevation in pipeline from pumping station
$EL_{high} := 1970 \cdot ft$	Input the high elevation in pipeline
$L_{high} := 3500 \cdot ft$	Input the distance along pipeline to high elevation in pipeline from pumping station
$SG := 1$	Input specific gravity of fluid
$\eta_{pump} := 0.70$	Input pump efficiency
$\eta_{motor} := 0.85$	Input motor efficiency

Calculate pipeline velocity:

$A_{pipe} := \pi \cdot \frac{d^2}{4}$ $\quad A_{pipe} = 7.069\,ft^2$ $\quad A_{pipe} = 1017.876\,in^2$

$v := \frac{Q_{design}}{A_{pipe}}$ $\quad v = 1.576\,ft\,sec^{-1}$

Calculate detention time in piping system:

$t_d := \frac{A_{pipe} \cdot L}{Q_{design}}$ $\quad t_d = 1.78\,hr$ Detention time in pipeline with pumps running

Calculate pump head - operating conditions:

$H_{elev} := EL_{high} - HGL_1$ $\quad H_{elev} = 118\,ft$ Elevation Head

$$H_L := 3.02 \cdot \frac{L}{ft} \cdot \left(\frac{d}{12 \cdot in}\right)^{-1.167} \cdot \left(\frac{\dfrac{\dfrac{Q_{design}}{7.48 \cdot 60 \cdot gpm}}{\dfrac{A_{pipe}}{ft^2}}}{C}\right)^{1.85} \cdot ft$$

Calculate friction head in piping system using Hazen-Williams headloss formula

$H_L = 2.796\,ft$

Calculate total dynamic head:

$TDH := H_L + H_{elev}$

$TDH = 120.796\,ft$

Calculate pressure at pump discharge:

$$P_{pump} := TDH \cdot \frac{0.433 \cdot psi}{ft} \qquad P_{pump} = 52.305\,psi$$

Calculate pressure at low point in pipeline:

$$P_{low} := P_{pump} + \left[\left(EL_{pump} - EL_{low} \right) - \frac{H_L}{L} \cdot L_{low} \right] \cdot \frac{0.433 \cdot psi}{ft} \qquad P_{low} = 69.28\,psi$$

Calculate pressure at high point in pipeline:

$$P_{high} := P_{pump} + \left[\left(EL_{pump} - EL_{high} \right) - \frac{H_L}{L} \cdot L_{high} \right] \cdot \frac{0.433 \cdot psi}{ft} \qquad P_{high} = 5.121\,psi$$

Calculate annual & monthly run times:

$$t_{run} := \frac{VOL}{Q_{design}} \qquad t_{run} = 6083.333\,hr$$

$$t_{monthly} := \frac{t_{run}}{12} \qquad t_{monthly} = 506.944\,hr$$

Calculate theoretical horsepower or hydraulic horsepower:

$$hp_{hyd} := TDH \cdot Q_{design} \cdot SG \cdot 62.43 \cdot \frac{lbf}{ft^3} \qquad hp_{hyd} = 152.746\,hp$$

Calculate estimated brake horsepower required:

$$hp_{pump} := \frac{hp_{hyd}}{\eta_{pump}} \qquad hp_{pump} = 218.209\,hp$$

$$bhp := \frac{hp_{pump}}{\eta_{motor}} \qquad bhp = 256.717\,hp \qquad bhp = 191.434\,kW \qquad bhp = 239.292\,kva$$

Calculate input power required:

$$Power_{reqd} := \frac{bhp \cdot t_{run}}{0.8} \qquad Power_{reqd} = 1455692.969\,kwh$$

Calculate the average monthly electrical cost:

$$index := \begin{cases} 1 & \text{if } \frac{bhp}{0.8} < 50 \cdot kW \\ 2 & \text{if } \frac{bhp}{0.8} < 1000 \cdot kW \\ 3 & \text{if } \frac{bhp}{0.8} > 1000 \cdot kW \end{cases}$$

$$index = 2$$

$$cost_1 := 14 + \frac{Power_{reqd}}{12} \cdot \frac{0.08902}{kwh} \qquad cost_1 = 10812.82$$

$$cost_2 := \begin{cases} 25 + \left(\frac{bhp}{0.8} - 50 \cdot kW\right) \cdot \frac{13.08}{kW} + 15000 \cdot 0.08902 + \left(\frac{Power_{reqd}}{12} - 15000 \cdot kwh\right) \cdot \frac{0.04702}{kwh} & \text{if } \frac{Power_{r\ldots}}{12} \\ 25 + \left(\frac{bhp}{0.8} - 50 \cdot kW\right) \cdot 13.08 + \frac{Power_{reqd}}{12} \cdot \frac{0.08902}{kwh} & \text{otherwise} \end{cases}$$

$$cost_2 = 8834.83$$

$$cost_3 := \begin{cases} 150 + 1000 \cdot 13.60 + 1500 \cdot 14.42 + \left(\frac{bhp}{0.8} - 2500 \cdot kW\right) \cdot \frac{14.82}{kW} + \frac{Power_{reqd}}{12} \cdot \frac{0.04601}{kwh} & \text{if } \frac{bhp}{0.8} > 25\ldots \\ \left[150 + 1000 \cdot 13.60 + \left(\frac{bhp}{0.8} - 1000 \cdot kW\right) \cdot \frac{14.42}{kW} + \frac{Power_{reqd}}{12} \cdot \frac{0.04601}{kwh}\right] & \text{otherwise} \end{cases}$$

$$cost_3 = 8361.96$$

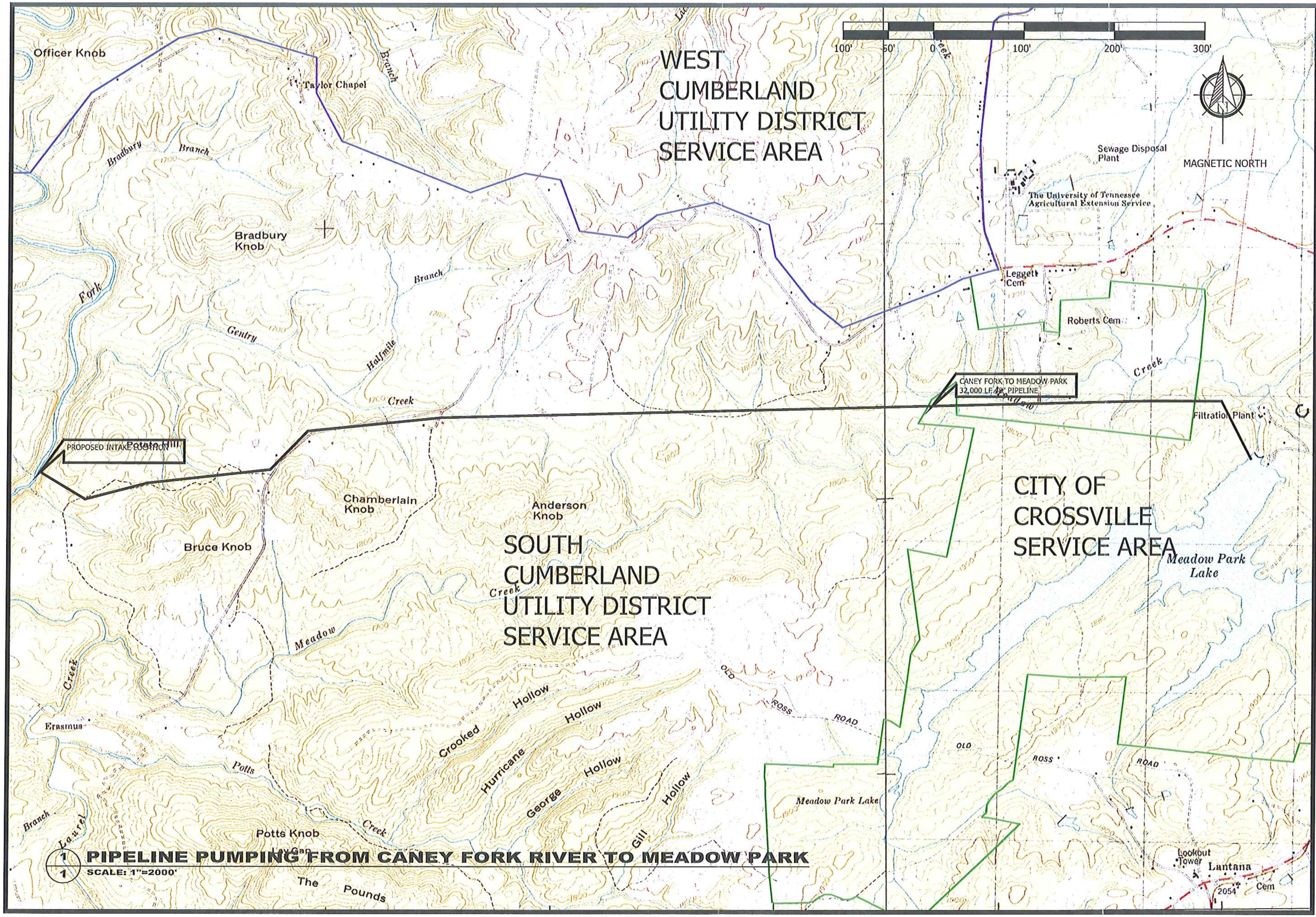
$cost_{index} = 8834.83$ Estimated monthly electrical cost

$cost_{index} \cdot 12 = 106017.95$ Estimated annual electrical cost

$\frac{\text{:qd}}{} \geq 15000 \bullet \text{kwh}$

)0kW

Appendix V
Alternative 4 Location Map and Hydraulic Calculations
Caney Fork River to Meadow Park Lake



NO.	DATE	DESCRIPTION	CHK

REVISIONS

CANEY FORK RIVER TO MEADOW PARK ALTERNATIVE

CITY OF CROSSVILLE
ARRA WATER HARVESTING PROJECT
CUMBERLAND COUNTY, TENNESSEE

ece SERVICES
ENVIRONMENTAL & CIVIL ENGINEERING SERVICES
702 Old Jamestown Hwy
Crossville, TN 38555
Telephobne: 931.484.9321
Fax: 931.484.9322
www.eceservices.com

* ENGINEERING * GEOTECHNICAL * QA/QC TESTING

CHK BY: SJC
DESIGN BY: SJC
DWN BY: MBJ
MAY 22, 2009
PROJECT # 7035
DWG #
REVISION #: 0
SCALE: 1 in = 2000 ft

SHEET 1 OF 1

DESIGN OF WATER HARVESTING PUMP SYSTEMS

Project No.: 7035
Project Title: ARRA Water Harvesting Project - City of Crossville
System: Caney Fork to Meadow Park

SITUATION:

Design a pumping system capable of pulling from one reservoir to a second reservoir. Design intent is for a water harvesting system capable of supplying an annual volume of water. Calculate the theoretical horsepower, design horsepower, pump conditions, and related information.

Assumptions:

1. Using Hazen-Williams equation, the flow is assumed to be turbulent and the liquid should have a kinematic viscosity around 1.2 x 10^-5 square feet per second which corresponds to the viscosity of 60 degrees Fahrenheit water. The velocity is assumed to be no greater than 6 ft/sec.
2. In calculating the total dynamic head, minor losses due to friction were assumed negligible.
3. The power factor was also assumed to be 0.80.
4. Pump run time is assumed to be averaged over 12 months per year for the purposes of calculating the average monthly electrical cost.

References:

1.

Defined Units:

$$gpm := \frac{gal}{min}$$

$$MG := 1000000 \cdot gal$$

$$psi := \frac{lbf}{in^2}$$

$$hp := 550 \cdot \frac{ft \cdot lbf}{sec}$$

$$kwh := kW \cdot hr$$

$kva := 0.80kW$ Power factor is assumed to be 0.80

Input Variables:

$HGL_1 := 1550.00 \cdot ft$	Input hydraulic grade line of reservoir #1 or the reservoir being pumped from
$HGL_2 := 1819.62 \cdot ft$	Input hydraulic grade line of reservoir #2 or the reservoir being pumped to
$Q_{design} := 30000 \cdot gpm$	Input design pumping rate
$VOL := 1825 \cdot MG$	Input desired annual volume of water to be pumped
$d := 48 \cdot in$	Input the design pipeline diameter
$L := 32000 \cdot ft$	Input the length of pipeline
$C := 120$	Input the Hazen-Williams C Factor for pipeline material
$EL_{pump} := 1550 \cdot ft$	Input pump elevation
$EL_{low} := 1550 \cdot ft$	Input the low elevation in pipeline
$L_{low} := 5 \cdot ft$	Input the distance along pipeline to low elevation in pipeline from pumping station
$EL_{high} := 1860.00 \cdot ft$	Input the high elevation in pipeline
$L_{high} := 31000 \cdot ft$	Input the distance along pipeline to high elevation in pipeline from pumping station
$SG := 1$	Input specific gravity of fluid
$\eta_{pump} := 0.70$	Input pump efficiency
$\eta_{motor} := 0.85$	Input motor efficiency

Calculate pipeline velocity:

$A_{pipe} := \pi \cdot \frac{d^2}{4}$ $A_{pipe} = 12.6ft^2$ $A_{pipe} = 1809.557in^2$

$v := \frac{Q_{design}}{A_{pipe}}$ $v = 5.3ftsec^{-1}$

Calculate detention time in piping system:

$t_d := \frac{A_{pipe} \cdot L}{Q_{design}}$ $t_d = 1.7hr$ Detention time in pipeline with pumps running

Calculate pump head - operating conditions:

$H_{elev} := EL_{high} - HGL_1$ $H_{elev} = 310ft$ Elevation Head

$$H_L := 3.02 \cdot \frac{L}{ft} \cdot \left(\frac{d}{12 \cdot in}\right)^{-1.167} \cdot \left(\frac{\frac{\frac{Q_{design}}{7.48 \cdot 60 \cdot gpm}}{\frac{A_{pipe}}{ft^2}}}{C}\right)^{1.85} \cdot ft$$

Calculate friction head in piping system using Hazen-Williams headloss formula

$H_L = 60.1ft$

Calculate total dynamic head:

$TDH := H_L + H_{elev}$

$TDH = 370.1ft$

Calculate pressure at pump discharge:

$P_{pump} := TDH \cdot \frac{0.433 \cdot psi}{ft}$ $\qquad P_{pump} = 160.3psi$

Calculate pressure at low point in pipeline:

$P_{low} := P_{pump} + \left[\left(EL_{pump} - EL_{low}\right) - \frac{H_L}{L} \cdot L_{low}\right] \cdot \frac{0.433 \cdot psi}{ft}$ $\qquad P_{low} = 160.3psi$

Calculate pressure at high point in pipeline:

$P_{high} := P_{pump} + \left[\left(EL_{pump} - EL_{high}\right) - \frac{H_L}{L} \cdot L_{high}\right] \cdot \frac{0.433 \cdot psi}{ft}$ $\qquad P_{high} = 0.8psi$

Calculate annual & monthly run times:

$t_{run} := \frac{VOL}{Q_{design}}$ $\qquad t_{run} = 1014hr$

$t_{monthly} := \frac{t_{run}}{12}$ $\qquad t_{monthly} = 84.5hr$

Calculate theoretical horsepower or hydraulic horsepower:

$hp_{hyd} := TDH \cdot Q_{design} \cdot SG \cdot 62.43 \cdot \frac{lbf}{ft^3}$ $\qquad hp_{hyd} = 2808hp$

Calculate estimated brake horsepower required:

$hp_{pump} := \frac{hp_{hyd}}{\eta_{pump}}$ $\qquad hp_{pump} = 4011.4hp$

$bhp := \frac{hp_{pump}}{\eta_{motor}}$ $\qquad bhp = 4719.3hp \qquad bhp = 3519.2kW \qquad bhp = 4399kva$

Calculate input power required:

$$Power_{reqd} := \frac{bhp \cdot t_{run}}{0.8} \qquad Power_{reqd} = 4460058.562kwh$$

Calculate the average monthly electrical cost:

$$index := \begin{vmatrix} 1 \text{ if } \frac{bhp}{0.8} < 50 \cdot kW \\ 2 \text{ if } \frac{bhp}{0.8} < 1000 \cdot kW \\ 3 \text{ if } \frac{bhp}{0.8} > 1000 \cdot kW \end{vmatrix}$$

$$index = 3$$

$$cost_1 := 14 + \frac{Power_{reqd}}{12} \cdot \frac{0.08902}{kwh} \qquad cost_1 = 33100.2$$

$$cost_2 := \begin{vmatrix} 25 + \left(\frac{bhp}{0.8} - 50 \cdot kW\right) \cdot \frac{13.08}{kW} + 15000 \cdot 0.08902 + \left(\frac{Power_{reqd}}{12} - 15000 \cdot kwh\right) \cdot \frac{0.04702}{kwh} \text{ if } \frac{Power}{12} \\ 25 + \left(\frac{bhp}{0.8} - 50 \cdot kW\right) \cdot 13.08 + \frac{Power_{reqd}}{12} \cdot \frac{0.08902}{kwh} \text{ otherwise} \end{vmatrix}$$

$$cost_2 = 75015.42$$

$$cost_3 := \begin{vmatrix} 150 + 1000 \cdot 13.60 + 1500 \cdot 14.42 + \left(\frac{bhp}{0.8} - 2500 \cdot kW\right) \cdot \frac{14.82}{kW} + \frac{Power_{reqd}}{12} \cdot \frac{0.04601}{kwh} \text{ if } \frac{bhp}{0.8} > \\ \left[150 + 1000 \cdot 13.60 + \left(\frac{bhp}{0.8} - 1000 \cdot kW\right) \cdot \frac{14.42}{kW} + \frac{Power_{reqd}}{12} \cdot \frac{0.04601}{kwh}\right] \text{ otherwise} \end{vmatrix}$$

$$cost_3 = 80623.22$$

$cost_{index} = 80623.22$ Estimated monthly electrical cost

$cost_{index} \cdot 12 = 967478.67$ Estimated annual electrical cost

$\frac{\text{reqd}}{} \geq 15000 \cdot \text{kwh}$

?500kW

Appendix VI
Public Involvement Public Meeting Documentation

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filed for record in the Register's Office of Cumberland County, Tennessee, with all the rights, powers and privileges of the original Trustee named in said Deed of Trust; and

NOW, THEREFORE, notice is hereby given that the entire indebtedness has been declared due and payable as provided in said Deed of Trust by the Owner and Holder, and that the undersigned, Nationwide Trustee Services, Inc., Substitute Trustee, or his duly appointed attorneys or agents, by virtue of the power and authority vested in him, will on Thursday, June 18, 2009, commencing at 12:00 PM at the Main entrance of the Cumberland County Courthouse, Crossville, Tennessee, proceed to sell at public outcry to the highest and best bidder for cash, the following described property situated in Cumberland County, Tennessee, to wit:

acre off of the original tract conveyed by O.D.Gunnels and wife, Minnie Gunnels, to Dora Bell Morgan dated December 28, 1951, which is of record in Deed Book No. 43, Pages 238-239, Register's Office, Cumberland, County.

SECOND TRACT:
In the Fourth Civil District of Cumberland County, Tennessee, bounded and described as follows: BEGINNING at a stone at the Northeast corner of Dora Bell Morgan's tract and Detour Road; thence North 69-1/2 degrees East 613 feet to the Southeast corner of Bailey Lock's tract and Detour Road; thence North 34-1/4 degrees West 227 feet to Bailey Locke's Southwest corner; thence South 69-1/2 degrees West and parallel with the first line 613 feet to a stone; thence South 34/14" East 227 feet to the BEGINNING and containing three (3) acres, more or less.

fixture filing; and any matter that an accurate survey of the premises might disclose.

SUBORDINATE LIENHOLDERS: Citifinancial, Inc.; Volunteer Electric Cooperative

OTHER INTERESTED PARTIES: N/A

All right and equity of redemption, statutory or otherwise, homestead, and dower are expressly waived in said Deed of Trust, and the title is believed to be good, but the undersigned will sell and convey only as Substitute Trustee.

The right is reserved to adjourn the day of the sale to another day, time, and place certain without further publication, upon announcement at the time and place for the sale set forth above.

THIS IS AN ATTEMPT TO COLLECT A DEBT. ANY INFORMATION OBTAINED WILL BE USED FOR THAT PURPOSE.

Nationwide Trustee Services, Inc., Substitute Trustee
c/o ron key
Nationwide Trustee Services, Inc.
1587 Northeast Expressway
Atlanta, Ga 30329
(770) 234-9181 (ext.)
File No.: 416.0617177TN
Web Site: www.msplaw.com
Insertion Dates: 05/20/09, 05/27/09, 06/03/09

Tennessee, will be sold to highest call bidder subject to unpaid taxes, prior liens encumbrances of record:
Described property located the Third (3rd) Civil District Cumberland County, Tenness to wit: TRACT NUMBER MAP 149D-D-027.00, Number 128, Section Num Comanche I of Lake Ta Village, Inc., as shown on pla same of record in Plat Book Page 19, Register's Offi Cumberland County, Tenness to which plat reference is here made for a more compl metes and bounds descripti TRACT NUMBER 2: M. 149D-D-028.00, Lot Numb 129, Section Number Comanc I of Lake Tansi Village, Inc., shown on plat of same of rec In Plat Book 7, Page 1 Register's Office, Cumberla County, Tennessee, to which p reference is hereby made for more complete metes a bounds description.
Street Address: 4038 Deso Drive (Lot 129), 4036 Deso Drive (Lot 128/Vacan Crossville, TN 38572
Current Owner(s) of Propert Cynthia M. Barnett and Richar Barnett, husband and wife
Other interested partie Caterpillar Financial Service Corporation c/o Eric W. Smith
The street address of the abov described property is believed t be 4038 Desoto Drive (Lot 129), 4036 Desoto Drive (Lc 128/Vacant), Crossville, Tl 38572, but such address is no part of the legal description o

TICE OF PUBLIC HEARING

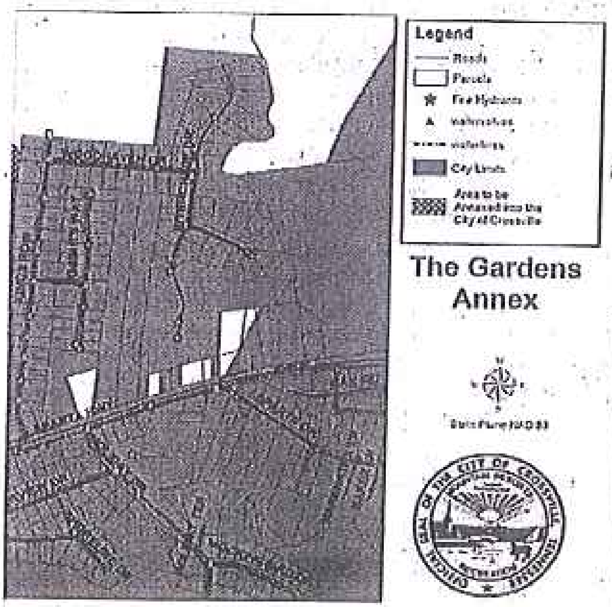
of the City of Crossville, Tennessee, will hold a Public Hearing 2009, at 5:45 p.m. in the Crossville City Hall located at 99 pose of the hearing is as follows:

from the public regarding the proposed annexation and plan of f Sparta Highway and adjacent to The Gardens Subdivision. ation Plan of Service can be reviewed in the City Clerk's Office ue, Cumberland County Mayor's Office at the Cumberland d the office of Looney & Looney at 156 Rector Avenue during perty owners in the affected area, as well as interested citizens, l make comments regarding this report.

gress Report: Spruce Loop (Wibel) - 2.8 acres
lopted October 14, 2008. All services of the City have been d/or requested by the property owner/developer.

affected areas, as well as interested citizens, are invited to ents regarding this report.

Sally Oglesby, MMC
City Clerk



PUBLIC NOTICE

The City of Crossville intends to file an application for financial assistance with the USDA Rural Development funding for three projects. The specific elements of the proposed projects include:

1) Meadow Park Lake Dam Renovation & Expansion
2) Highway 70N Waterline Upgrade
3) Construction of a Fire Station

A public information meeting for all interested parties will be held as follows:

DATE: May 26, 2009
TIME: 6:00 p.m.
PLACE: Crossville City Hall

The purpose of the meeting will be to give the public an opportunity to become acquainted with the proposed projects and to comment on economic and environmental impacts, service areas, alternatives and other issues. Representatives of the City of Crossville will be available to explain the proposals and to answer questions.

J. H. Graham, III
Mayor
City of Crossville

May 14, 2009
Crossville, Tennessee

CALL FOR SPECIAL MEETING

TO: Councilman Earl Dean
Councilman Carl Duer
Councilman Jesse Kerley
Councilman Boyd Wyatt, Sr.

Councilmen of the City of Crossville, you and each of you are hereby notified to meet in special session on Tuesday, May 26, 2009 at 5:45 p.m. at the Crossville City Hall for the following purposes:

1) Consent Agenda
   a) 2nd Reading of revised Floodplain Ordinance
   b) 2nd Reading of Ordinance adopting a budget for FY09-10 (in title only)
   c) 2nd Reading of Ordinance adopting a tax rate for FY09-10 (in title only)
   d) 2nd Reading of Ordinance authorizing payments for contracts with James + Associates for engineering and design services beyond the current budget year
   e) 2nd Reading of Ordinance authorizing payments for contracts with EG&G for engineering and design services beyond the current budget year
   f) 2nd Reading of Ordinance authorizing payments for contracts with GRW Engineers for engineering and design services beyond the current budget year
   g) 2nd Reading of Ordinance authorizing payments for contracts with Community Development Partners for administration services beyond the current budget year
   h) 2nd Reading of Ordinance authorizing payments for contracts with Hart Freeland Roberts for engineering and design services beyond the current budget year
   i) 2nd Reading of Ordinance authorizing payments for contracts with PBS&J for engineering and design services beyond the current budget year
   j) 2nd Reading of Ordinance authorizing payments for contracts with ECE Services for engineering and design services beyond the current budget year
   k) 2nd Reading of Ordinance authorizing payments for contracts with Stigall Engineering Associates for engineering and design services beyond the current budget year
   l) 2nd Reading of Ordinance authorizing payments for contracts with Freitag Construction for construction services beyond the current budget year
   m) 2nd Reading of Ordinance authorizing payments for contracts with Ironwood Construction for construction services beyond the current budget year
   n) 2nd Reading of Ordinance authorizing payments for contracts with

meet in special session on Tuesday, May 26, 2009 at 5:45 p.m. at the Crossville City Hall for the following purposes:

1) Consent Agenda
   a) 2nd Reading of revised Floodplain Ordinance
   b) 2nd Reading of Ordinance adopting a budget for FY09-10 (in title only)
   c) 2nd Reading of Ordinance adopting a tax rate for FY09-10 (in title only)
   d) 2nd Reading of Ordinance authorizing payments for contracts with James + Associates for engineering and design services beyond the current budget year
   e) 2nd Reading of Ordinance authorizing payments for contracts with EG&G for engineering and design services beyond the current budget year
   f) 2nd Reading of Ordinance authorizing payments for contracts with GRW Engineers for engineering and design services beyond the current budget year
   g) 2nd Reading of Ordinance authorizing payments for contracts with Community Development Partners for administration services beyond the current budget year
   h) 2nd Reading of Ordinance authorizing payments for contracts with Hart Freeland Roberts for engineering and design services beyond the current budget year
   i) 2nd Reading of Ordinance authorizing payments for contracts with PBS&J for engineering and design services beyond the current budget year
   j) 2nd Reading of Ordinance authorizing payments for contracts with ECE Services for engineering and design services beyond the current budget year
   k) 2nd Reading of Ordinance authorizing payments for contracts with Stigall Engineering Associates for engineering and design services beyond the current budget year
   l) 2nd Reading of Ordinance authorizing payments for contracts with Freitag Construction for construction services beyond the current budget year
   m) 2nd Reading of Ordinance authorizing payments for contracts with Ironwood Construction for construction services beyond the current budget year
   n) 2nd Reading of Ordinance authorizing payments for contracts with Veolia/PSG for management services beyond the current budget year
   o) 2nd Reading of Ordinance annexing 6.33 acres off Sparta Hwy (adjacent to the Gardens Subdivision)
   p) 2nd Reading of Ordinance amending the FY08-09 budget in the amount of $50,000 for the Art Circle Library project
   q) 3rd Reading of Ordinance amending the FY08-09 budget in the amount of $260,000 for the North Cumberland Elementary sewer project
   r) 3rd Reading of Ordinance amending the FY08-09 budget in the amount of $150,000 for the Genesis Road property purchase

2) Matters relative to purchase of caboose

3) Matters relative to purchase of water meters

4) Award of FY09/10 annual price contracts
   a) Bulk Coarse Salt – North American Salt
   b) Uniforms (all departments, except Fire and Police) – Unifirst for 3-year contract

BEER BOARD---5:55 p.m.

1) An application submitted by the William Edward LeGraff, Jr. dba Just One More Sports Bar & Grill located at 750 Hwy. 70E, Ste. 107

PUBLIC HEARING---6:00 p.m.

1) Clean Water State Revolving Fund Loan in the amount of $5,000,000 to make improvements to the existing Crossville Wastewater Treatment Plant
2) Drinking Water State Revolving Fund Loan in the amount of $5,000,000 for a raw water harvesting project
3) USDA Rural Development funding for Meadow Park Lake Dam Renovation & Expansion
4) USDA Rural Development funding for Highway 70N waterline upgrade
5) USDA Rural Development funding for construction of a fire station
6) Dooley Street sewer and drainage project

J. H. Graham III

Mayor

CONSENT TO MEETING

We, the undersigned Councilmen of the City of Crossville, hereby accept and acknowledge service in the foregoing call, waive any and all irregularities in such call and agree to meet at the time and place therein mentioned for the purpose therein stated.

Earl Darr

Councilman

Boyd Wyatt Sr

Councilman

[signature]

Councilman

Carl T Dixon

Councilman

Copy to City Manager
Copy to City Attorney

[illegible] Special Called Council Meeting

1. Fred Houston
2. Mary Beth Jones
3. Eric Brady
4. Andy Vaughn
5. [illegible signature]
6. C. Coyne
7. Ron Alt
8. Evan Snyders
9. Bill [illegible]
10. Jim Hillegas [illegible]
11. Darrell [illegible]
12. [illegible signature]
13. [illegible signature]
14. Tim Begley
15. [illegible signature]
16. Carolyn Jozwiak
17. [illegible signature]
18. Kenneth [illegible]
19. Mike Ferry
20. [illegible signature]
21. Corey [illegible]
22. Mark Rosser
23. [illegible signature]
24. Margie [illegible]
25. [illegible signature]
26. Jerry Harrison
27. [illegible signature]
28.
29.

Appendix VII
U.S. Department of Agriculture
Soils Report for Project Area

USDA United States Department of Agriculture

NRCS Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Cumberland County, Tennessee

Lake Tansi to Meadow Park

May 29, 2009

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://soils.usda.gov/sqi/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://soils.usda.gov/contact/state_offices/).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Soil Data Mart Web site or the NRCS Web Soil Survey. The Soil Data Mart is the data storage site for the official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

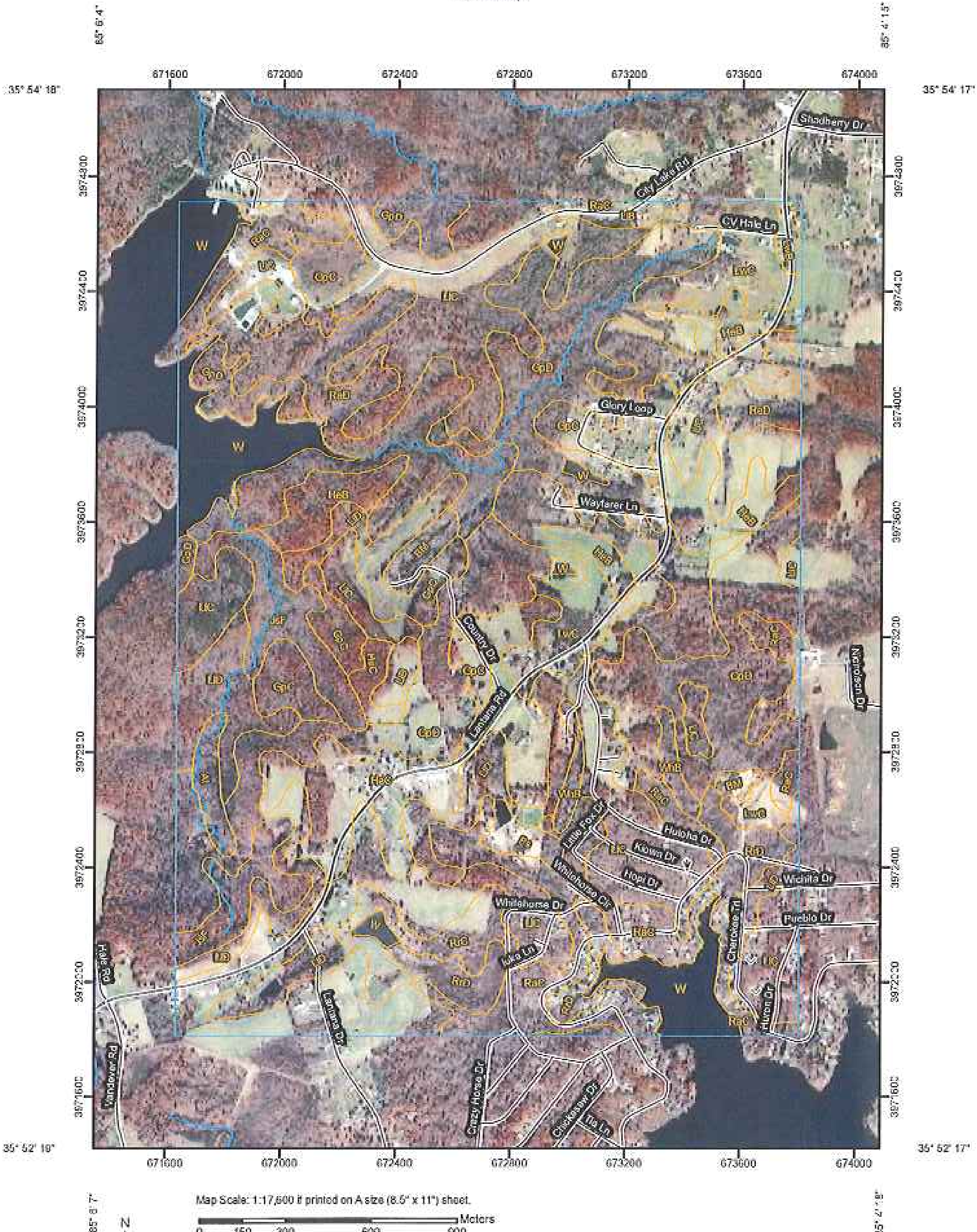
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features
- Gully
- Short Steep Slope
- Other

Political Features
- Cities

Water Features
- Oceans
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:17,600 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 16N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cumberland County, Tennessee
Survey Area Data: Version 10, Nov 15, 2006

Date(s) aerial images were photographed: 11/4/2006

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Cumberland County, Tennessee (TN035)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
At	Atkins loam, frequently flooded	9.7	0.6%
BM	Bethesda-Mine pits complex, 10 to 80 percent slopes	11.5	0.7%
GpC	Gilpin loam, 5 to 12 percent slopes	98.6	6.3%
GpD	Gilpin loam, 12 to 20 percent slopes	293.1	18.8%
HeB	Hendon silt loam, 2 to 5 percent slopes	60.0	3.8%
HeC	Hendon silt loam, 5 to 12 percent slopes	81.7	5.2%
JsF	Jefferson-Shelocta complex, 20 to 45 percent slopes	50.6	3.2%
LlB	Lily loam, 2 to 5 percent slopes	13.7	0.9%
LlC	Lily loam, 5 to 12 percent slopes	384.5	24.7%
LlD	Lily loam, 12 to 20 percent slopes	79.7	5.1%
LwB	Lonewood loam, 2 to 5 percent slopes	4.4	0.3%
LwC	Lonewood loam, 5 to 12 percent slopes	83.2	5.3%
Ps	Pits, sandstone quarrys	8.1	0.5%
RaC	Ramsey loam, 5 to 12 percent slopes	115.7	7.4%
RaD	Ramsey loam, 12 to 20 percent slopes	111.9	7.2%
RrC	Ramsey-Rock outcrop complex, 5 to 12 percent slopes	24.1	1.5%
RrD	Ramsey-Rock outcrop complex, 12 to 20 percent slopes	38.0	2.4%
W	Water	79.7	5.1%
WhB	Whitwell loam, 2 to 5 percent slopes	11.3	0.7%
Totals for Area of Interest		**1,559.4**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Cumberland County, Tennessee

At—Atkins loam, frequently flooded

Map Unit Setting

Mean annual precipitation: 48 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 190 to 205 days

Map Unit Composition

Atkins and similar soils: 100 percent

Description of Atkins

Setting

Landform: Flood plains
Landform position (three-dimensional): Tread
Parent material: Loamy alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 2.00 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water capacity: High (about 9.5 inches)

Interpretive groups

Land capability (nonirrigated): 4w

Typical profile

0 to 10 inches: Loam
10 to 52 inches: Clay loam
52 to 60 inches: Sandy loam

BM—Bethesda-Mine pits complex, 10 to 80 percent slopes

Map Unit Setting

Elevation: 600 to 1,350 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 120 to 190 days

Map Unit Composition

Bethesda and similar soils: 80 percent
Mine pits: 20 percent

Description of Bethesda

Setting

Landform: Hillslopes
Landform position (three-dimensional): Side slope
Parent material: Coal extraction mine spoil derived from interbedded sedimentary rock

Properties and qualities

Slope: 10 to 80 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 5.6 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 23 inches: Channery loam
23 to 45 inches: Very channery clay loam
45 to 60 inches: Cobbly loam

Description of Mine Pits

Setting

Landform: Hillslopes

GpC—Gilpin loam, 5 to 12 percent slopes

Map Unit Setting

Mean annual precipitation: 48 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 190 to 205 days

Map Unit Composition

Gilpin and similar soils: 100 percent

Description of Gilpin

Setting

Landform: Hillslopes
Landform position (three-dimensional): Side slope
Parent material: Loamy residuum weathered from interbedded sedimentary rock

Properties and qualities

Slope: 5 to 12 percent

Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 4.8 inches)

Interpretive groups
Land capability (nonirrigated): 3e

Typical profile
0 to 8 inches: Loam
8 to 26 inches: Silty clay loam
26 to 37 inches: Clay
37 to 50 inches: Unweathered bedrock

GpD—Gilpin loam, 12 to 20 percent slopes

Map Unit Setting
Mean annual precipitation: 48 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 190 to 205 days

Map Unit Composition
Gilpin and similar soils: 100 percent

Description of Gilpin

Setting
Landform: Hillslopes
Landform position (three-dimensional): Side slope
Parent material: Loamy residuum weathered from interbedded sedimentary rock

Properties and qualities
Slope: 12 to 20 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 4.8 inches)

Interpretive groups
Land capability (nonirrigated): 4e

Typical profile
0 to 8 inches: Loam
8 to 26 inches: Silty clay loam
26 to 37 inches: Clay

37 to 50 inches: Unweathered bedrock

HeB—Hendon silt loam, 2 to 5 percent slopes

Map Unit Setting

Mean annual precipitation: 48 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 190 to 205 days

Map Unit Composition

Hendon and similar soils: 100 percent

Description of Hendon

Setting

Landform: Ridges
Landform position (three-dimensional): Crest
Parent material: Loess over loamy residuum weathered from sandstone and shale

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: High (about 9.7 inches)

Interpretive groups

Land capability (nonirrigated): 2e

Typical profile

0 to 6 inches: Silt loam
6 to 23 inches: Silt loam
23 to 29 inches: Silt loam
29 to 61 inches: Clay loam

HeC—Hendon silt loam, 5 to 12 percent slopes

Map Unit Setting

Mean annual precipitation: 48 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 190 to 205 days

Map Unit Composition

Hendon and similar soils: 100 percent

Description of Hendon

Setting

Landform: Ridges
Landform position (three-dimensional): Crest
Parent material: Loess over loamy residuum weathered from sandstone and shale

Properties and qualities

Slope: 5 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: High (about 9.7 inches)

Interpretive groups

Land capability (nonirrigated): 3e

Typical profile

0 to 6 inches: Silt loam
6 to 23 inches: Silt loam
23 to 29 inches: Silt loam
29 to 61 inches: Clay loam

JsF—Jefferson-Shelocta complex, 20 to 45 percent slopes

Map Unit Setting

Elevation: 550 to 3,500 feet
Mean annual precipitation: 42 to 54 inches
Mean annual air temperature: 48 to 59 degrees F
Frost-free period: 169 to 185 days

Map Unit Composition

Jefferson and similar soils: 50 percent
Shelocta and similar soils: 40 percent
Minor components: 10 percent

Description of Jefferson

Setting

Landform: Hillslopes
Landform position (three-dimensional): Side slope
Parent material: Loamy colluvium derived from interbedded sedimentary rock

Properties and qualities

Slope: 20 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Moderate (about 7.7 inches)

Interpretive groups

Land capability (nonirrigated): 7s

Typical profile

0 to 7 inches: Cobbly loam
7 to 56 inches: Cobbly loam
56 to 60 inches: Very gravelly sandy loam

Description of Shelocta

Setting

Landform: Hillslopes
Landform position (three-dimensional): Side slope
Parent material: Loamy colluvium derived from sandstone and shale

Properties and qualities

Slope: 20 to 45 percent
Depth to restrictive feature: 48 to 60 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Moderate (about 7.6 inches)

Interpretive groups

Land capability (nonirrigated): 7s

Typical profile

0 to 3 inches: Loam
3 to 50 inches: Silty clay loam
50 to 60 inches: Weathered bedrock

Minor Components

Minor component

Percent of map unit: 10 percent

LIB—Lily loam, 2 to 5 percent slopes

Map Unit Setting

Elevation: 700 to 950 feet
Mean annual precipitation: 40 to 49 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 170 to 200 days

Map Unit Composition

Lily and similar soils: 100 percent

Description of Lily

Setting

Landform: Ridges
Landform position (three-dimensional): Crest
Parent material: Loamy residuum weathered from sandstone

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 5.2 inches)

Interpretive groups

Land capability (nonirrigated): 2e

Typical profile

0 to 2 inches: Loam
2 to 31 inches: Loam
31 to 35 inches: Cobbly sandy loam
35 to 40 inches: Unweathered bedrock

LlC—Lily loam, 5 to 12 percent slopes

Map Unit Setting

Elevation: 700 to 950 feet
Mean annual precipitation: 40 to 49 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 170 to 200 days

Map Unit Composition

Lily and similar soils: 100 percent

Description of Lily

Setting

Landform: Ridges
Landform position (three-dimensional): Side slope
Parent material: Loamy residuum weathered from sandstone

Properties and qualities

Slope: 5 to 12 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 5.2 inches)

Interpretive groups
Land capability (nonirrigated): 3e

Typical profile
0 to 2 inches: Loam
2 to 31 inches: Loam
31 to 35 inches: Cobbly sandy loam
35 to 40 inches: Unweathered bedrock

LID—Lily loam, 12 to 20 percent slopes

Map Unit Setting
Elevation: 700 to 950 feet
Mean annual precipitation: 40 to 49 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 170 to 200 days

Map Unit Composition
Lily and similar soils: 100 percent

Description of Lily

Setting
Landform: Hillslopes
Landform position (three-dimensional): Side slope
Parent material: Loamy residuum weathered from sandstone

Properties and qualities
Slope: 12 to 20 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 5.2 inches)

Interpretive groups
Land capability (nonirrigated): 4e

Typical profile
0 to 2 inches: Loam
2 to 31 inches: Loam
31 to 35 inches: Cobbly sandy loam
35 to 40 inches: Unweathered bedrock

LwB—Lonewood loam, 2 to 5 percent slopes

Map Unit Setting

Elevation: 1,740 to 2,300 feet
Mean annual precipitation: 54 to 62 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 170 to 190 days

Map Unit Composition

Lonewood and similar soils: 100 percent

Description of Lonewood

Setting

Landform: Ridges
Landform position (three-dimensional): Crest
Parent material: Loamy residuum weathered from sandstone

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: 40 to 80 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: High (about 9.8 inches)

Interpretive groups

Land capability (nonirrigated): 2e

Typical profile

0 to 10 inches: Loam
10 to 37 inches: Clay loam
37 to 55 inches: Silty clay loam
55 to 72 inches: Clay loam
72 to 80 inches: Weathered bedrock

LwC—Lonewood loam, 5 to 12 percent slopes

Map Unit Setting

Elevation: 1,740 to 2,300 feet
Mean annual precipitation: 54 to 62 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 170 to 190 days

Map Unit Composition

Lonewood and similar soils: 100 percent

Description of Lonewood

Setting

Landform: Ridges
Landform position (three-dimensional): Side slope
Parent material: Loamy residuum weathered from sandstone

Properties and qualities

Slope: 5 to 12 percent
Depth to restrictive feature: 40 to 80 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: High (about 9.8 inches)

Interpretive groups

Land capability (nonirrigated): 3e

Typical profile

0 to 10 inches: Loam
10 to 37 inches: Clay loam
37 to 55 inches: Silty clay loam
55 to 72 inches: Clay loam
72 to 80 inches: Weathered bedrock

Ps—Pits, sandstone quarrys

Map Unit Composition

Pits: 100 percent

Description of Pits

Properties and qualities

Slope: 0 to 200 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Available water capacity: Very low (about 0.0 inches)

Typical profile

0 to 60 inches: Unweathered bedrock

RaC—Ramsey loam, 5 to 12 percent slopes

Map Unit Setting

Mean annual precipitation: 48 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 190 to 205 days

Map Unit Composition

Ramsey and similar soils: 100 percent

Description of Ramsey

Setting

Landform: Ridges
Landform position (three-dimensional): Crest
Parent material: Loamy residuum weathered from sandstone

Properties and qualities

Slope: 5 to 12 percent
Depth to restrictive feature: 7 to 20 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 2.0 inches)

Interpretive groups

Land capability (nonirrigated): 6e

Typical profile

0 to 2 inches: Loam
2 to 18 inches: Loam
18 to 25 inches: Unweathered bedrock

RaD—Ramsey loam, 12 to 20 percent slopes

Map Unit Setting

Mean annual precipitation: 48 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 190 to 205 days

Map Unit Composition

Ramsey and similar soils: 100 percent

Description of Ramsey

Setting

Landform: Hillslopes
Landform position (three-dimensional): Side slope
Parent material: Loamy residuum weathered from sandstone

Properties and qualities

Slope: 12 to 20 percent
Depth to restrictive feature: 7 to 20 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 2.0 inches)

Interpretive groups

Land capability (nonirrigated): 6e

Typical profile

0 to 2 inches: Loam
2 to 18 inches: Loam
18 to 25 inches: Unweathered bedrock

RrC—Ramsey-Rock outcrop complex, 5 to 12 percent slopes

Map Unit Setting

Elevation: 650 to 4,000 feet
Mean annual precipitation: 8 to 55 inches
Mean annual air temperature: 45 to 61 degrees F
Frost-free period: 110 to 205 days

Map Unit Composition

Ramsey and similar soils: 70 percent
Rock outcrop: 20 percent
Minor components: 10 percent

Description of Ramsey

Setting

Landform: Ridges
Landform position (three-dimensional): Crest
Parent material: Loamy residuum weathered from sandstone

Properties and qualities

Slope: 5 to 12 percent
Depth to restrictive feature: 7 to 20 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 2.0 inches)

Interpretive groups
Land capability (nonirrigated): 6s

Typical profile
0 to 2 inches: Loam
2 to 18 inches: Loam
18 to 25 inches: Unweathered bedrock

Description of Rock Outcrop

Setting
Landform: Hillslopes

Properties and qualities
Slope: 5 to 12 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)

Interpretive groups
Land capability (nonirrigated): 8

Typical profile
0 to 60 inches: Unweathered bedrock

Minor Components

Minor component
Percent of map unit: 10 percent

RrD—Ramsey-Rock outcrop complex, 12 to 20 percent slopes

Map Unit Setting
Elevation: 650 to 4,000 feet
Mean annual precipitation: 8 to 55 inches
Mean annual air temperature: 45 to 61 degrees F
Frost-free period: 110 to 205 days

Map Unit Composition
Ramsey and similar soils: 70 percent
Rock outcrop: 20 percent
Minor components: 10 percent

Description of Ramsey

Setting
Landform: Hillslopes

Landform position (three-dimensional): Side slope
Parent material: Loamy residuum weathered from sandstone

Properties and qualities

Slope: 12 to 20 percent
Depth to restrictive feature: 7 to 20 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 2.0 inches)

Interpretive groups

Land capability (nonirrigated): 7s

Typical profile

0 to 2 inches: Loam
2 to 18 inches: Loam
18 to 25 inches: Unweathered bedrock

Description of Rock Outcrop

Setting

Landform: Hillslopes

Properties and qualities

Slope: 12 to 20 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)

Interpretive groups

Land capability (nonirrigated): 8

Typical profile

0 to 60 inches: Unweathered bedrock

Minor Components

Minor component

Percent of map unit: 10 percent

W—Water

Map Unit Setting

Elevation: 590 to 1,050 feet
Mean annual precipitation: 46 to 63 inches
Mean annual air temperature: 46 to 70 degrees F
Frost-free period: 189 to 213 days

Map Unit Composition

Water: 100 percent

WhB—Whitwell loam, 2 to 5 percent slopes

Map Unit Setting

Mean annual precipitation: 48 to 55 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 190 to 205 days

Map Unit Composition

Whitwell and similar soils: 100 percent

Description of Whitwell

Setting

Landform: Stream terraces
Landform position (three-dimensional): Tread
Parent material: Loamy alluvium derived from interbedded sedimentary rock

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 24 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: High (about 10.2 inches)

Interpretive groups

Land capability (nonirrigated): 2e

Typical profile

0 to 7 inches: Loam
7 to 60 inches: Clay loam

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Land Classifications

This folder contains a collection of tabular reports that present a variety of soil groupings. The reports (tables) include all selected map units and components for each map unit. Land classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Hydric Soils

This table lists the map unit components that are rated as hydric soils in the survey area. This list can help in planning land uses; however, onsite investigation is recommended to determine the hydric soils on a specific site (National Research Council, 1995; Hurt and others, 2002).

The three essential characteristics of wetlands are hydrophytic vegetation, hydric soils, and wetland hydrology (Cowardin and others, 1979; U.S. Army Corps of Engineers, 1987; National Research Council, 1995; Tiner, 1985). Criteria for all of the characteristics must be met for areas to be identified as wetlands. Undrained hydric soils that have natural vegetation should support a dominant population of ecological wetland plant species. Hydric soils that have been converted to other uses should be capable of being restored to wetlands.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part

(Federal Register, 1994). These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in "Soil Taxonomy" (Soil Survey Staff, 1999) and "Keys to Soil Taxonomy" (Soil Survey Staff, 2006) and in the "Soil Survey Manual" (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in "Field Indicators of Hydric Soils in the United States" (Hurt and Vasilas, 2006).

Hydric soils are identified by examining and describing the soil to a depth of about 20 inches. This depth may be greater if determination of an appropriate indicator so requires. It is always recommended that soils be excavated and described to the depth necessary for an understanding of the redoximorphic processes. Then, using the completed soil descriptions, soil scientists can compare the soil features required by each indicator and specify which indicators have been matched with the conditions observed in the soil. The soil can be identified as a hydric soil if at least one of the approved indicators is present.

Map units that are dominantly made up of hydric soils may have small areas, or inclusions, of nonhydric soils in the higher positions on the landform, and map units dominantly made up of nonhydric soils may have inclusions of hydric soils in the lower positions on the landform.

The criteria for hydric soils are represented by codes in the table (for example, 2B3). Definitions for the codes are as follows:

1. All Histels except for Folistels, and Histosols except for Folists.
2. Soils in Aquic suborders, great groups, or subgroups, Albolls suborder, Historthels great group, Histoturbels great group, Pachic subgroups, or Cumulic subgroups that:
   A. are somewhat poorly drained and have a water table at the surface (0.0 feet) during the growing season, or
   B. are poorly drained or very poorly drained and have either:
      i. a water table at the surface (0.0 feet) during the growing season if textures are coarse sand, sand, or fine sand in all layers within a depth of 20 inches, or
      ii. a water table at a depth of 0.5 foot or less during the growing season if saturated hydraulic conductivity (Ksat) is equal to or greater than 6.0 in/hr in all layers within a depth of 20 inches, or
      iii. a water table at a depth of 1.0 foot or less during the growing season if saturated hydraulic conductivity (Ksat) is less than 6.0 in/hr in any layer within a depth of 20 inches.
3. Soils that are frequently ponded for long or very long duration during the growing season.

4. Soils that are frequently flooded for long or very long duration during the growing season.

References:
Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.
Federal Register. September 18, 2002. Hydric soils of the United States.
Federal Register. July 13, 1994. Changes in hydric soils of the United States.
Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.
National Research Council. 1995. Wetlands: Characteristics and boundaries.
Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18.
Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service.
Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.
Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.
United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

Report—Hydric Soils

Hydric Soils-- Cumberland County, Tennessee				
Map symbol and map unit name	Component	Percent of map unit	Landform	Hydric criteria
At—Atkins loam, frequently flooded				
	Atkins	100	Flood plains	2B3

Prime and other Important Farmlands

This table lists the map units in the survey area that are considered important farmlands. Important farmlands consist of prime farmland, unique farmland, and farmland of statewide or local importance. This list does not constitute a recommendation for a particular land use.

In an effort to identify the extent and location of important farmlands, the Natural Resources Conservation Service, in cooperation with other interested Federal, State, and local government organizations, has inventoried land that can be used for the production of the Nation's food supply.

Prime farmland is of major importance in meeting the Nation's short- and long-range needs for food and fiber. Because the supply of high-quality farmland is limited, the U.S. Department of Agriculture recognizes that responsible levels of government, as well as individuals, should encourage and facilitate the wise use of our Nation's prime farmland.

Prime farmland, as defined by the U.S. Department of Agriculture, is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. It could be cultivated land, pastureland, forestland, or other land, but it is not urban or built-up land or water areas. The soil quality, growing season, and moisture supply are those needed for the soil to economically produce sustained high yields of crops when proper management, including water management, and acceptable farming methods are applied. In general, prime farmland has an adequate and dependable supply of moisture from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, an acceptable salt and sodium content, and few or no rocks. The water supply is dependable and of adequate quality. Prime farmland is permeable to water and air. It is not excessively erodible or saturated with water for long periods, and it either is not frequently flooded during the growing season or is protected from flooding. Slope ranges mainly from 0 to 6 percent. More detailed information about the criteria for prime farmland is available at the local office of the Natural Resources Conservation Service.

For some of the soils identified in the table as prime farmland, measures that overcome a hazard or limitation, such as flooding, wetness, and droughtiness, are needed. Onsite evaluation is needed to determine whether or not the hazard or limitation has been overcome by corrective measures.

A recent trend in land use in some areas has been the loss of some prime farmland to industrial and urban uses. The loss of prime farmland to other uses puts pressure on marginal lands, which generally are more erodible, droughty, and less productive and cannot be easily cultivated.

Unique farmland is land other than prime farmland that is used for the production of specific high-value food and fiber crops, such as citrus, tree nuts, olives, cranberries, and other fruits and vegetables. It has the special combination of soil quality, growing season, moisture supply, temperature, humidity, air drainage, elevation, and aspect needed for the soil to economically produce sustainable high yields of these crops when properly managed. The water supply is dependable and of adequate quality. Nearness to markets is an additional consideration. Unique farmland is not based on national criteria. It commonly is in areas where there is a special microclimate, such as the wine country in California.

In some areas, land that does not meet the criteria for prime or unique farmland is considered to be *farmland of statewide importance* for the production of food, feed, fiber, forage, and oilseed crops. The criteria for defining and delineating farmland of statewide importance are determined by the appropriate State agencies. Generally, this land includes areas of soils that nearly meet the requirements for prime farmland and that economically produce high yields of crops when treated and managed according to acceptable farming methods. Some areas may produce as high a yield as prime farmland if conditions are favorable. Farmland of statewide importance may include tracts of land that have been designated for agriculture by State law.

In some areas that are not identified as having national or statewide importance, land is considered to be *farmland of local importance* for the production of food, feed, fiber, forage, and oilseed crops. This farmland is identified by the appropriate local agencies. Farmland of local importance may include tracts of land that have been designated for agriculture by local ordinance.

Report—Prime and other Important Farmlands

Prime and other Important Farmlands– Cumberland County, Tennessee		
Map Symbol	Map Unit Name	Farmland Classification
At	Atkins loam, frequently flooded	Not prime farmland
BM	Bethesda-Mine pits complex, 10 to 80 percent slopes	Not prime farmland
GpC	Gilpin loam, 5 to 12 percent slopes	Not prime farmland
GpD	Gilpin loam, 12 to 20 percent slopes	Not prime farmland
HeB	Hendon silt loam, 2 to 5 percent slopes	All areas are prime farmland
HeC	Hendon silt loam, 5 to 12 percent slopes	Not prime farmland
JsF	Jefferson-Shelocta complex, 20 to 45 percent slopes	Not prime farmland
LlB	Lily loam, 2 to 5 percent slopes	All areas are prime farmland
LlC	Lily loam, 5 to 12 percent slopes	Not prime farmland
LlD	Lily loam, 12 to 20 percent slopes	Not prime farmland
LwB	Lonewood loam, 2 to 5 percent slopes	All areas are prime farmland
LwC	Lonewood loam, 5 to 12 percent slopes	Not prime farmland
Ps	Pits, sandstone quarrys	Not prime farmland
RaC	Ramsey loam, 5 to 12 percent slopes	Not prime farmland
RaD	Ramsey loam, 12 to 20 percent slopes	Not prime farmland
RrC	Ramsey-Rock outcrop complex, 5 to 12 percent slopes	Not prime farmland
RrD	Ramsey-Rock outcrop complex, 12 to 20 percent slopes	Not prime farmland
W	Water	Not prime farmland
WhB	Whitwell loam, 2 to 5 percent slopes	All areas are prime farmland

Soil Erosion

This folder contains a collection of tabular reports that present soil erosion factors and groupings. The reports (tables) include all selected map units and components for each map unit. Soil erosion factors are soil properties and interpretations used in evaluating the soil for potential erosion. Example soil erosion factors can include K factor for the whole soil or on a rock free basis, T factor, wind erodibility group and wind erodibility index.

RUSLE2 Related Attributes

This report summarizes those soil attributes used by the Revised Universal Soil Loss Equation Version 2 (RUSLE2) for the map units in the selected area. The report includes the map unit symbol, the component name, and the percent of the component in the map unit. Soil property data for each map unit component include the hydrologic soil group, erosion factors Kf for the surface horizon, erosion factor T, and the representative percentage of sand, silt, and clay in the surface horizon.

Report—RUSLE2 Related Attributes

RUSLE2 Related Attributes– Cumberland County, Tennessee							
Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value		
					% Sand	% Silt	% Clay
At—Atkins loam, frequently flooded							
Atkins	100	D	.28	5	42.1	37.9	20.0
BM—Bethesda-Mine pits complex, 10 to 80 percent slopes							
Bethesda	80	C	.49	5	39.8	37.7	22.5
Mine pits	20	—	—	—	—	—	—
GpC—Gilpin loam, 5 to 12 percent slopes							
Gilpin	100	C	.32	3	41.6	37.4	21.0
GpD—Gilpin loam, 12 to 20 percent slopes							
Gilpin	100	C	.32	3	41.6	37.4	21.0
HeB—Hendon silt loam, 2 to 5 percent slopes							
Hendon	100	C	.37	5	27.0	54.0	19.0
HeC—Hendon silt loam, 5 to 12 percent slopes							
Hendon	100	C	.37	5	27.0	54.0	19.0
JsF—Jefferson-Shelocta complex, 20 to 45 percent slopes							
Jefferson	50	B	.28	5	43.2	38.8	18.0
Shelocta	40	B	.32	4	43.0	39.5	17.5
LlB—Lily loam, 2 to 5 percent slopes							
Lily	100	B	.37	2	43.3	39.7	17.0
LlC—Lily loam, 5 to 12 percent slopes							
Lily	100	B	.37	2	43.3	39.7	17.0
LlD—Lily loam, 12 to 20 percent slopes							
Lily	100	B	.37	2	43.3	39.7	17.0
LwB—Lonewood loam, 2 to 5 percent slopes							
Lonewood	100	B	.37	4	42.1	37.9	20.0
LwC—Lonewood loam, 5 to 12 percent slopes							
Lonewood	100	B	.37	4	42.1	37.9	20.0
Ps—Pits, sandstone quarrys							
Pits	100	—	—	—	—	—	0.0
RaC—Ramsey loam, 5 to 12 percent slopes							
Ramsey	100	D	.20	1	43.8	40.2	16.0

RUSLE2 Related Attributes– Cumberland County, Tennessee							
Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value		
					% Sand	% Silt	% Clay
RaD—Ramsey loam, 12 to 20 percent slopes							
Ramsey	100	D	.20	1	43.8	40.2	16.0
RrC—Ramsey-Rock outcrop complex, 5 to 12 percent slopes							
Ramsey	70	D	.20	1	43.8	40.2	16.0
Rock outcrop	20	D	—	—	—	—	—
RrD—Ramsey-Rock outcrop complex, 12 to 20 percent slopes							
Ramsey	70	D	.20	1	43.8	40.2	16.0
Rock outcrop	20	D	—	—	—	—	—
W—Water							
Water	100	—	—	—	—	—	—
WhB—Whitwell loam, 2 to 5 percent slopes							
Whitwell	100	C	.32	5	43.2	38.8	18.0

RUSLE2 Related Attributes

This report summarizes those soil attributes used by the Revised Universal Soil Loss Equation Version 2 (RUSLE2) for the map units in the selected area. The report includes the map unit symbol, the component name, and the percent of the component in the map unit. Soil property data for each map unit component include the hydrologic soil group, erosion factors Kf for the surface horizon, erosion factor T, and the representative percentage of sand, silt, and clay in the surface horizon.

Report—RUSLE2 Related Attributes

RUSLE2 Related Attributes– Cumberland County, Tennessee							
Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value		
					% Sand	% Silt	% Clay
At—Atkins loam, frequently flooded							
Atkins	100	D	.28	5	42.1	37.9	20.0
BM—Bethesda-Mine pits complex, 10 to 80 percent slopes							
Bethesda	80	C	.49	5	39.8	37.7	22.5
Mine pits	20	—	—	—	—	—	—
GpC—Gilpin loam, 5 to 12 percent slopes							
Gilpin	100	C	.32	3	41.6	37.4	21.0

RUSLE2 Related Attributes– Cumberland County, Tennessee							
Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value		
					% Sand	% Silt	% Clay
GpD—Gilpin loam, 12 to 20 percent slopes							
Gilpin	100	C	.32	3	41.6	37.4	21.0
HeB—Hendon silt loam, 2 to 5 percent slopes							
Hendon	100	C	.37	5	27.0	54.0	19.0
HeC—Hendon silt loam, 5 to 12 percent slopes							
Hendon	100	C	.37	5	27.0	54.0	19.0
JsF—Jefferson-Shelocta complex, 20 to 45 percent slopes							
Jefferson	50	B	.28	5	43.2	38.8	18.0
Shelocta	40	B	.32	4	43.0	39.5	17.5
LlB—Lily loam, 2 to 5 percent slopes							
Lily	100	B	.37	2	43.3	39.7	17.0
LlC—Lily loam, 5 to 12 percent slopes							
Lily	100	B	.37	2	43.3	39.7	17.0
LlD—Lily loam, 12 to 20 percent slopes							
Lily	100	B	.37	2	43.3	39.7	17.0
LwB—Lonewood loam, 2 to 5 percent slopes							
Lonewood	100	B	.37	4	42.1	37.9	20.0
LwC—Lonewood loam, 5 to 12 percent slopes							
Lonewood	100	B	.37	4	42.1	37.9	20.0
Ps—Pits, sandstone quarrys							
Pits	100	—	—	—	—	—	0.0
RaC—Ramsey loam, 5 to 12 percent slopes							
Ramsey	100	D	.20	1	43.8	40.2	16.0
RaD—Ramsey loam, 12 to 20 percent slopes							
Ramsey	100	D	.20	1	43.8	40.2	16.0
RrC—Ramsey-Rock outcrop complex, 5 to 12 percent slopes							
Ramsey	70	D	.20	1	43.8	40.2	16.0
Rock outcrop	20	D	—	—	—	—	—

RUSLE2 Related Attributes– Cumberland County, Tennessee							
Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value		
					% Sand	% Silt	% Clay
RrD—Ramsey-Rock outcrop complex, 12 to 20 percent slopes							
Ramsey	70	D	.20	1	43.8	40.2	16.0
Rock outcrop	20	D	—	—	—	—	—
W—Water							
Water	100	—	—	—	—	—	—
WhB—Whitwell loam, 2 to 5 percent slopes							
Whitwell	100	C	.32	5	43.2	38.8	18.0

Windbreaks and Environmental Plantings

Windbreaks protect livestock, buildings, yards, fruit trees, gardens, and cropland from wind and snow; help to keep snow on fields; and provide food and cover for wildlife. Field windbreaks are narrow plantings made at right angles to the prevailing wind and at specific intervals across the field. The interval depends on the erodibility of the soil.

Environmental plantings help to beautify and screen houses and other buildings and to abate noise. The plants, mostly evergreen shrubs and trees, are closely spaced. To ensure plant survival, a healthy planting stock of suitable species should be planted properly on a well prepared site and maintained in good condition.

This table shows the height that locally grown trees and shrubs are expected to reach in 20 years on soils in the survey area. The estimates are based on measurements and observation of established plantings that have been given adequate care. They can be used as a guide in planning windbreaks and screens. Additional information on planning windbreaks and screens and planting and caring for trees and shrubs can be obtained from the local office of the Natural Resources Conservation Service or of the Cooperative Extension Service or from a commercial nursery.

Report—Windbreaks and Environmental Plantings

Windbreaks and Environmental Plantings– Cumberland County, Tennessee					
Map symbol and soil name	Trees having predicted 20-year average height of—				
	8 feet or less	>8 to 15 feet	>15 to 25 feet	>25 to 35 feet	>35 feet
At—Atkins loam, frequently flooded					
Atkins	—	—	—	—	—

Windbreaks and Environmental Plantings– Cumberland County, Tennessee					
Map symbol and soil name	Trees having predicted 20-year average height of—				
	8 feet or less	>8 to 15 feet	>15 to 25 feet	>25 to 35 feet	>35 feet
BM—Bethesda-Mine pits complex, 10 to 80 percent slopes					
Bethesda	Siberian peashrub Silky dogwood Gray dogwood Manyflower cotoneaster	Amur maple Common lilac American cranberrybush	Eastern redcedar	Jack pine Red pine	Norway spruce Eastern white pine
Mine pits	—	—	—	—	—
GpC—Gilpin loam, 5 to 12 percent slopes					
Gilpin	Siberian peashrub Amur honeysuckle Tatarian honeysuckle Common lilac	Washington hawthorn Autumn olive Eastern redcedar Flowering crabapple	Jack pine Austrian pine Red pine Eastern white pine	—	—
GpD—Gilpin loam, 12 to 20 percent slopes					
Gilpin	Siberian peashrub Amur honeysuckle Tatarian honeysuckle Common lilac	Washington hawthorn Autumn olive Eastern redcedar Flowering crabapple	Jack pine Austrian pine Red pine Eastern white pine	—	—
HeB—Hendon silt loam, 2 to 5 percent slopes					
Hendon	—	—	—	—	—
HeC—Hendon silt loam, 5 to 12 percent slopes					
Hendon	—	—	—	—	—
JsF—Jefferson-Shelocta complex, 20 to 45 percent slopes					
Jefferson	—	—	—	—	—
Shelocta	Silky dogwood	Amur honeysuckle American cranberrybush	White fir Washington hawthorn Amur privet Blue spruce Eastern arborvitae	Norway spruce Austrian pine	Eastern white pine Pin oak

Windbreaks and Environmental Plantings– Cumberland County, Tennessee					
Map symbol and soil name	Trees having predicted 20-year average height of—				
	8 feet or less	>8 to 15 feet	>15 to 25 feet	>25 to 35 feet	>35 feet
LlB—Lily loam, 2 to 5 percent slopes					
Lily	Amur honeysuckle Fragrant sumac Common lilac	Autumn olive	Common hackberry Russian olive Green ash Honeylocust Eastern redcedar Austrian pine Bur oak	Siberian elm	—
LlC—Lily loam, 5 to 12 percent slopes					
Lily	Amur honeysuckle Fragrant sumac Common lilac	Autumn olive	Common hackberry Russian olive Green ash Honeylocust Eastern redcedar Austrian pine Bur oak	Siberian elm	—
LlD—Lily loam, 12 to 20 percent slopes					
Lily	Amur honeysuckle Fragrant sumac Common lilac	Autumn olive	Common hackberry Russian olive Green ash Honeylocust Eastern redcedar Austrian pine Bur oak	Siberian elm	—
LwB—Lonewood loam, 2 to 5 percent slopes					
Lonewood	—	—	—	—	—
LwC—Lonewood loam, 5 to 12 percent slopes					
Lonewood	—	—	—	—	—
Ps—Pits, sandstone quarrys					
Pits	—	—	—	—	—
RaC—Ramsey loam, 5 to 12 percent slopes					
Ramsey	—	—	—	—	—
RaD—Ramsey loam, 12 to 20 percent slopes					
Ramsey	—	—	—	—	—

Windbreaks and Environmental Plantings– Cumberland County, Tennessee					
Map symbol and soil name	Trees having predicted 20-year average height of—				
	8 feet or less	>8 to 15 feet	>15 to 25 feet	>25 to 35 feet	>35 feet
RrC—Ramsey-Rock outcrop complex, 5 to 12 percent slopes					
Ramsey	—	—	—	—	—
Rock outcrop	—	—	—	—	—
RrD—Ramsey-Rock outcrop complex, 12 to 20 percent slopes					
Ramsey	—	—	—	—	—
Rock outcrop	—	—	—	—	—
W—Water					
Water	—	—	—	—	—
WhB—Whitwell loam, 2 to 5 percent slopes					
Whitwell	—	—	—	—	—

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Engineering Properties

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

References:

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Absence of an entry indicates that the data were not estimated. The asterisk '*' denotes the representative texture; other possible textures follow the dash.

Engineering Properties– Cumberland County, Tennessee

Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				Pct	Pct					Pct	
At—Atkins loam, frequently flooded												
Atkins	0-10	*Loam	CL, ML, SC, SM	A-4, A-6	0	0-5	90-100	80-100	60-95	45-75	20-35	1-15
	10-52	*Clay loam, Silty clay loam, silt loam	CL, ML, SC, SM	A-4, A-6	0	0-5	90-100	85-100	65-100	45-85	20-40	3-20
	52-60	*Sandy loam	CL, GM, ML, SM	A-2, A-4, A-6	0	0-15	90-100	85-100	50-95	30-85	20-40	1-15
BM—Bethesda-Mine pits complex, 10 to 80 percent slopes												
Bethesda	0-23	*Channery loam	CL-ML, GC-GM, GM, ML	A-4, A-6	0-20	0-15	65-90	55-80	50-80	35-75	25-40	4-14
	23-45	*Very channery clay loam, Very channery silty clay loam, channery clay loam	CL, GC-GM, GM, ML	A-2, A-4, A-6, A-7	0-20	10-30	45-80	25-65	25-65	20-60	24-50	3-23
	45-60	*Cobbly loam, Very channery silty clay loam, channery clay loam	CL, GC-GM, GM, ML	A-2, A-4, A-6, A-7	10-20	10-30	45-80	25-65	25-65	20-60	24-50	3-23
Mine pits	—	—	—	—	—	—	—	—	—	—	—	—

Engineering Properties– Cumberland County, Tennessee

Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				Pct	Pct					Pct	
GpC—Gilpin loam, 5 to 12 percent slopes												
Gilpin	0-8	*Loam	CL, CL-ML	A-4, A-6	0	0	80-100	75-95	70-85	65-80	20-40	4-15
	8-26	*Silty clay loam, Channery loam, channery silt loam, channery silty clay loam	CL, CL-ML, GC, SC	A-2, A-4, A-6	0	0	80-100	75-95	35-85	30-80	20-40	4-15
	26-37	*Clay, Clay, silty clay loam	GC, GC-GM	A-1, A-2, A-4, A-6	0	0	80-100	75-95	15-45	15-40	20-40	4-15
	37-50	*Unweathered bedrock	—	—	—	—	—	—	—	—	—	—
GpD—Gilpin loam, 12 to 20 percent slopes												
Gilpin	0-8	*Loam	CL, CL-ML	A-4, A-6	0	0	80-100	75-95	70-85	65-80	20-40	4-15
	8-26	*Silty clay loam, Channery loam, channery silt loam	CL, CL-ML, GC, SC	A-2, A-4, A-6	0	0	80-100	75-95	35-85	30-80	20-40	4-15
	26-37	*Clay, Silty clay loam, clay	GC, GC-GM	A-1, A-2, A-4, A-6	0	0	80-100	75-95	15-45	15-40	20-40	4-15
	37-50	*Unweathered bedrock	—	—	—	—	—	—	—	—	—	—
HeB—Hendon silt loam, 2 to 5 percent slopes												
Hendon	0-6	*Silt loam	CL, CL-ML, ML	A-4	0	0	100	90-100	85-100	75-90	18-30	1-9
	6-23	*Silt loam, Loam, clay loam	CL, CL-ML, ML	A-4, A-6	0	0	100	90-100	80-100	65-85	20-35	3-12
	23-29	*Silt loam, Loam, clay loam	CL	A-4, A-6	0	0	95-100	85-100	75-100	60-85	25-38	7-15
	29-61	*Clay loam, Loam	CL	A-4, A-6	0	0	95-100	85-100	75-100	60-85	25-40	7-16

Engineering Properties– Cumberland County, Tennessee													
Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
HeC—Hendon silt loam, 5 to 12 percent slopes												
Hendon	0-6	*Silt loam	CL, CL-ML, ML	A-4	0	0	100	90-100	85-100	75-90	18-30	1-9
	6-23	*Silt loam, Loam, clay loam	CL, CL-ML, ML	A-4, A-6	0	0	100	90-100	80-100	55-85	20-35	3-12
	23-29	*Silt loam, Loam, clay loam	CL	A-4, A-6	0	0	95-100	85-100	75-100	60-85	25-38	7-15
	29-61	*Clay loam, Loam	CL	A-4, A-6	0	0	95-100	85-100	75-100	60-85	25-40	7-16
JsF—Jefferson-Shelocta complex, 20 to 45 percent slopes												
Jefferson	0-7	*Cobbly loam	CL, GM, ML, SM	A-2, A-4	0	10-35	65-90	60-90	50-80	30-60	20-35	2-10
	7-56	*Cobbly loam, Cobbly clay loam, gravelly sandy clay loam	CL, ML, SC, SM	A-2, A-4, A-6	0	10-35	75-90	70-90	50-80	30-70	20-40	2-15
	56-60	*Very gravelly sandy loam, Cobbly loam, cobbly clay loam	GC-GM, GM, ML, SM	A-1, A-2, A-4	0	10-35	55-75	50-75	35-70	20-60	20-35	2-10
Shelocta	0-3	*Loam	CL-ML, ML	A-4	0-2	0-5	80-95	75-95	60-95	55-90	0-35	NP-10
	3-50	*Silty clay loam, Silt loam, channery silty clay loam	CL, CL-ML, GC, SC	A-4, A-6	0-5	0-10	55-95	50-95	45-95	40-90	25-40	4-15
	50-60	*Weathered bedrock	—	—	—	—	—	—	—	—	—	—
Minor component	—	—	—	—	—	—	—	—	—	—	—	—

Engineering Properties– Cumberland County, Tennessee												
Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				Pct	Pct					Pct	
LIB—Lily loam, 2 to 5 percent slopes												
Lily	0-2	*Loam	CL-ML, ML	A-4	0	0-5	90-100	85-100	70-95	55-80	0-35	NP-10
	2-31	*Loam, Clay loam, sandy clay loam	CL, ML, SC, SM	A-4, A-6	0	0-5	90-100	85-100	75-100	40-80	0-35	3-15
	31-35	*Cobbly sandy loam, Sandy clay loam, clay loam	CL, ML, SC, SM	A-1-b, A-2, A-4, A-6	0	0-10	65-100	50-100	40-95	20-75	0-35	3-15
	35-40	*Unweathered bedrock	—	—	—	—	—	—	—	—	—	—
LIC—Lily loam, 5 to 12 percent slopes												
Lily	0-2	*Loam	CL-ML, ML	A-4	0	0-5	90-100	85-100	70-95	55-80	0-35	NP-10
	2-31	*Loam, Clay loam, sandy clay loam	CL, ML, SC, SM	A-4, A-6	0	0-5	90-100	85-100	75-100	40-80	0-35	3-15
	31-35	*Cobbly sandy loam, Sandy clay loam, clay loam	ML, SC, SM, CL	A-1-b, A-2, A-4, A-6	0	0-10	65-100	50-100	40-95	20-75	0-35	3-15
	35-40	*Unweathered bedrock	—	—	—	—	—	—	—	—	—	—

Engineering Properties– Cumberland County, Tennessee													
Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				Pct	Pct					Pct	
LlD—Lily loam, 12 to 20 percent slopes												
Lily	0-2	*Loam	CL-ML, ML	A-4	0	0-5	90-100	85-100	70-95	55-80	0-35	NP-10
	2-31	*Loam, Clay loam, sandy clay loam	CL, ML, SC, SM	A-4, A-6	0	0-5	90-100	85-100	75-100	40-80	0-35	3-15
	31-35	*Cobbly sandy loam, Sandy clay loam, clay loam	ML, SC, SM, CL	A-1-b, A-2, A-4, A-6	0	0-10	65-100	50-100	40-95	20-75	0-35	3-15
	35-40	*Unweathered bedrock	—	—	—	—	—	—	—	—	—	—
LwB—Lonewood loam, 2 to 5 percent slopes												
Lonewood	0-10	*Loam	CL, CL-ML, ML	A-4	0	0	100	90-100	85-100	75-90	18-26	3-9
	10-37	*Clay loam, Silt loam, silty clay loam	CL	A-4, A-6	0	0	100	90-100	85-95	70-90	25-39	9-18
	37-55	*Silty clay loam, Clay loam, loam	CL	A-6, A-7	0	0	95-100	85-100	75-90	65-85	29-48	10-23
	55-72	*Clay loam, Channery clay loam, channery silty clay loam	CL, GC, SC	A-2, A-4, A-6, A-7	0-5	5-25	45-90	25-85	25-80	25-75	25-48	9-23
	72-80	*Weathered bedrock	—	—	—	—	—	—	—	—	—	—

Engineering Properties– Cumberland County, Tennessee

Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
LwC—Lonewood loam, 5 to 12 percent slopes												
Lonewood	0-10	*Loam	CL, CL-ML, ML	A-4	0	0	100	90-100	85-100	75-90	18-26	3-9
	10-37	*Clay loam, Silt loam, silty clay loam	CL	A-4, A-6	0	0	100	90-100	85-95	70-90	25-39	9-18
	37-55	*Silty clay loam, Clay loam, loam	CL	A-6, A-7	0	0	95-100	85-100	75-90	65-85	29-48	10-23
	55-72	*Clay loam, Channery clay loam, channery silty clay loam	CL, GC, SC	A-2, A-4, A-6, A-7	0-5	5-25	45-90	25-85	25-80	25-75	25-48	9-23
	72-80	*Weathered bedrock	—	—	—	—	—	—	—	—	—	—
Ps—Pits, sandstone quarrys												
Pits	0-60	*Unweathered bedrock	—	—	—	—	—	—	—	—	0-14	—
RaC—Ramsey loam, 5 to 12 percent slopes												
Ramsey	0-2	*Loam	CL-ML, ML, SC-SM, SM	A-2, A-4	0	0-10	85-100	75-95	60-75	30-70	0-25	NP-7
	2-18	*Loam, Sandy loam, fine sandy loam	CL-ML, ML, SC-SM, SM	A-2, A-4	0	0-10	85-100	75-95	60-77	30-70	0-25	NP-7
	18-25	*Unweathered bedrock	—	—	—	—	—	—	—	—	—	—

Engineering Properties– Cumberland County, Tennessee												
Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				Pct	Pct					Pct	
RaD—Ramsey loam, 12 to 20 percent slopes												
Ramsey	0-2	*Loam	CL-ML, ML, SC-SM, SM	A-2, A-4	0	0-10	85-100	75-95	60-75	30-70	0-25	NP-7
	2-18	*Loam, Sandy loam, fine sandy loam	CL-ML, ML, SC-SM, SM	A-2, A-4	0	0-10	85-100	75-95	60-77	30-70	0-25	NP-7
	18-25	*Unweathered bedrock	—	—	—	—	—	—	—	—	—	—
RrC—Ramsey-Rock outcrop complex, 5 to 12 percent slopes												
Ramsey	0-2	*Loam	CL-ML, ML, SC-SM, SM	A-2, A-4	0	0-10	85-100	75-95	60-75	30-70	0-25	NP-7
	2-18	*Loam, Sandy loam, fine sandy loam	CL-ML, ML, SC-SM, SM	A-2, A-4	0	0-10	85-100	75-95	60-77	30-70	0-25	NP-7
	18-25	*Unweathered bedrock	—	—	—	—	—	—	—	—	—	—
Rock outcrop	0-60	*Unweathered bedrock	—	—	—	—	—	—	—	—	—	—
Minor component	—	—	—	—	—	—	—	—	—	—	—	—

Engineering Properties– Cumberland County, Tennessee													
Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
RrD—Ramsey-Rock outcrop complex, 12 to 20 percent slopes												
Ramsey	0-2	*Loam	CL-ML, ML, SC-SM, SM	A-2, A-4	0	0-10	85-100	75-95	60-75	30-70	0-25	NP-7
	2-18	*Loam, Sandy loam, fine sandy loam	CL-ML, ML, SC-SM, SM	A-2, A-4	0	0-10	85-100	75-95	60-77	30-70	0-25	NP-7
	18-25	*Unweathered bedrock	—	—	—	—	—	—	—	—	—	—
Rock outcrop	0-60	*Unweathered bedrock	—	—	—	—	—	—	—	—	—	—
Minor component	—	—	—	—	—	—	—	—	—	—	—	—
W—Water												
Water	—	—	—	—	—	—	—	—	—	—	—	—
WhB—Whitwell loam, 2 to 5 percent slopes												
Whitwell	0-7	*Loam	CL, CL-ML, ML	A-4	0	0-3	80-100	75-100	70-100	55-95	18-28	3-10
	7-60	*Clay loam, Loam, silt loam	CL, CL-ML, ML, SC	A-4, A-6	0	0-3	80-100	75-100	60-90	40-80	18-35	3-15

Engineering Properties (TN)

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

References:

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.
American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Engineering Properties (TN)– Cumberland County, Tennessee													
Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				Pct	Pct					Pct	
At—Atkins loam, frequently flooded												
Atkins	— — —	—	—	—	0	0-15 0-5	90-100	85-100 80-100	50-95 65-95 60-95	30-85 45-75	20-40 20-35	1-15 3-20
BM—Bethesda-Mine pits complex, 10 to 80 percent slopes												
Bethesda	— — —	—	—	—	0-20 10-20	10-30 0-15	45-80 65-90	25-65 55-80	25-65 50-80	20-60 35-75	24-50 25-40	3-23 4-14
GpC—Gilpin loam, 5 to 12 percent slopes												
Gilpin	— — — —	—	—	—	0 —	0 —	80-100 —	75-95 —	15-45 — 70-45 35-45	15-40 — 65-40 30-40	20-40 —	4-15 —
GpD—Gilpin loam, 12 to 20 percent slopes												
Gilpin	— — — —	—	—	—	0 —	0 —	80-100 —	75-95 —	15-45 — 70-45 35-45	15-40 — 65-40 30-40	20-40 —	4-15 —
HeB—Hendon silt loam, 2 to 5 percent slopes												
Hendon	— — — —	—	—	—	0	0	95-100 100	85-100 90-100	75-100 85-100 80-100	60-85 75-85 65-85	25-38 25-40 25-30 25-35	7-15 7-16 7-9 7-12

Engineering Properties (TN)– Cumberland County, Tennessee

Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				Pct	Pct					Pct	
HeC—Hendon silt loam, 5 to 12 percent slopes												
Hendon	— — — —	—	—	—	0	0	95-100 100	85-100 90-100	75-100 85-100 80-100	60-85 75-85 65-85	25-38 25-40 25-30 25-35	7-15 7-16 7-9 7-12
JsF—Jefferson-Shelocta complex, 20 to 45 percent slopes												
Shelocta Jefferson	— — — — —	—	—	—	— — — —	— — — —	— — — — —	— — — — —	— — — — —	— — — — —	— — — —	— — — —
LIB—Lily loam, 2 to 5 percent slopes												
Lily	— — — —	—	—	—	0 —	0-10 — 0-5	65-100 — 90-100	50-100 — 85-100	40-95 — 70-95 75-95	20-75 — 55-75 40-75	0-35 —	3-15 — NP-10
LIC—Lily loam, 5 to 12 percent slopes												
Lily	— — — —	—	—	—	0 —	0-10 — 0-5	65-100 — 90-100	50-100 — 85-100	40-95 — 70-95 75-95	20-75 — 55-75 40-75	0-35 —	3-15 — NP-10
LID—Lily loam, 12 to 20 percent slopes												
Lily	— — — —	—	—	—	0 —	0-10 — 0-5	65-100 — 90-100	50-100 — 85-100	40-95 — 70-95 75-95	20-75 — 55-75 40-75	0-35 —	3-15 — NP-10

Engineering Properties (TN)– Cumberland County, Tennessee												
Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
LwB—Lonewood loam, 2 to 5 percent slopes												
Lonewood	— — — — —	—	—	—	0-5 — 0	5-25 — 0	45-90 — 95-90 100-90	25-85 — 85 90-85	25-80 — 25-90 25-100 25-95	25-75 — 65-75 75 70-75	25-48 — 29-26 18-39	9-23 — 10-9 3-18
LwC—Lonewood loam, 5 to 12 percent slopes												
Lonewood	— — — — —	—	—	—	0-5 — 0	5-25 — 0	45-90 — 95-90 100-90	25-85 — 85 90-85	25-80 — 25-90 25-100 25-95	25-75 — 65-75 75 70-75	25-48 — 29-26 18-39	9-23 — 10-9 3-18
Ps—Pits, sandstone quarrys												
Pits	—	—	—	—	—	—	—	—	—	—	0-14	—
RaC—Ramsey loam, 5 to 12 percent slopes												
Ramsey	— — —	—	—	—	— 0	— 0-10	— 85-100	— 75-95	— — —	— 30-70	— 0-25	— NP-7
RaD—Ramsey loam, 12 to 20 percent slopes												
Ramsey	— — —	—	—	—	— 0	— 0-10	— 85-100	— 75-95	— — —	— 30-70	— 0-25	— NP-7

Engineering Properties (TN)– Cumberland County, Tennessee

Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
			Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
RrC—Ramsey-Rock outcrop complex, 5 to 12 percent slopes												
Ramsey Rock outcrop	— — — —	—	—	—	— 0	— 0-10	— 85-100	— 75-95	— — —	— 30-70	— 0-25	— NP-7
RrD—Ramsey-Rock outcrop complex, 12 to 20 percent slopes												
Ramsey Rock outcrop	— — — —	—	—	—	— 0	— 0-10	— 85-100	— 75-95	— — —	— 30-70	— 0-25	— NP-7
WhB—Whitwell loam, 2 to 5 percent slopes												
Whitwell	— —	—	—	—	0	0-3	80-100	75-100	60-90 70-100	40-80 55-95	18-35 18-28	3-15 3-10

Particle Size and Coarse Fragments

This table shows estimates of particle size distribution and coarse fragment content of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Total fragments is the content of fragments of rock and other materials larger than 2 millimeters in diameter on volumetric basis of the whole soil.

Fragments 2-74 mm refers to the content of coarse fragments in the 2 to 74 millimeter size fraction.

Fragments 75-249 mm refers to the content of coarse fragments in teh 75 to 249 millimeter size fraction.

Fragments 250-599 mm refers to the content of coarse fragments in the 250 to 599 millimeter size fraction.

Fragments >=600 mm refers to the content of coarse fragments in the greater than or equal to 600 millimeter size fraction.

Reference:

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Particle Size and Coarse Fragments– Cumberland County, Tennessee										
Map symbol and soil name	Horizon	Depth	Sand	Silt	Clay	Total fragments	Fragments 2-74 mm	Fragments 75-249 mm	Fragments 250-599 mm	Fragments >=600 mm
At—Atkins loam, frequently flooded										
Atkins	H1	0-10	—	—	15-20 -25	11	9	2	—	—
	H2	10-52	—	—	18-29 -35	10	8	2	—	—
	H3	52-60	—	—	10-18 -35	5	5	0	—	—
BM—Bethesda-Mine pits complex, 10 to 80 percent slopes										
Bethesda	H1	0-23	—	—	18-23 -27	28	23	5	—	—
	H2	23-45	—	—	18-29 -35	44	32	12	—	—
	H3	45-60	—	—	18-22 -35	25	15	10	—	—
Mine pits	—	—	—	—	—	—	—	—	—	—
GpC—Gilpin loam, 5 to 12 percent slopes										
Gilpin	H1	0-8	—	—	15-21 -27	3	3	0	—	—
	H2	8-26	—	—	18-32 -35	5	5	0	—	—
	H3	26-37	—	—	18-50 -50	4	4	0	—	—
	H4	37-50	—	—	—	—	—	—	—	—
GpD—Gilpin loam, 12 to 20 percent slopes										
Gilpin	H1	0-8	—	—	15-21 -27	3	3	0	—	—
	H2	8-26	—	—	18-32 -35	5	5	0	—	—
	H3	26-37	—	—	18-50 -50	4	4	0	—	—
	H4	37-50	—	—	—	—	—	—	—	—

/ n | P ct | P ct | P ct | R V P ct | R V P ct | R V P ct | R V P ct | R V P ct

Particle Size and Coarse Fragments– Cumberland County, Tennessee										
Map symbol and soil name	Horizon	Depth	Sand	Silt	Clay	Total fragments	Fragments 2-74 mm	Fragments 75-249 mm	Fragments 250-599 mm	Fragments >=600 mm
HeB—Hendon silt loam, 2 to 5 percent slopes										
Hendon	H1	0-6	—	—	12-19 -25	3	3	—	—	—
	H2	6-23	—	—	18-25 -32	3	3	—	—	—
	H3	23-29	—	—	18-26 -35	7	7	—	—	—
	H4	29-61	—	—	20-30 -35	7	7	—	—	—
HeC—Hendon silt loam, 5 to 12 percent slopes										
Hendon	H1	0-6	—	—	12-19 -25	3	3	—	—	—
	H2	6-23	—	—	18-25 -32	3	3	—	—	—
	H3	23-29	—	—	18-26 -35	7	7	—	—	—
	H4	29-61	—	—	20-30 -35	7	7	—	—	—
JsF—Jefferson-Shelocta complex, 20 to 45 percent slopes										
Jefferson	H1	0-7	—	—	10-18 -25	20	7	13	—	—
	H2	7-56	—	—	18-26 -34	30	14	16	—	—
	H3	56-60	—	—	15-18 -30	50	30	20	—	—
Shelocta	H1	0-3	—	—	10-18 -25	10	10	0	—	0
	H2	3-50	—	—	18-30 -34	14	14	0	—	0
	H3	50-60	—	—	—	—	—	—	—	—

	I n	P ct	P ct	P ct	R V P ct	R V P ct	R V P ct	R V P ct	R V P ct

Particle Size and Coarse Fragments– Cumberland County, Tennessee										
Map symbol and soil name	Horizon	Depth	Sand	Silt	Clay	Total fragments	Fragments 2-74 mm	Fragments 75-249 mm	Fragments 250-599 mm	Fragments >=600 mm
LIB—Lily loam, 2 to 5 percent slopes										
Lily	H1	0-2	—	—	7-17 -27	10	8	2	—	—
	H2	2-31	—	—	18-23 -35	10	8	2	—	—
	H3	31-35	—	—	16-18 -35	30	24	6	—	—
	H4	35-40	—	—	—	—	—	—	—	—
LIC—Lily loam, 5 to 12 percent slopes										
Lily	H1	0-2	—	—	7-17 -27	10	8	2	—	—
	H2	2-31	—	—	18-23 -35	10	8	2	—	—
	H3	31-35	—	—	16-18 -35	30	24	6	—	—
	H4	35-40	—	—	—	—	—	—	—	—
LID—Lily loam, 12 to 20 percent slopes										
Lily	H1	0-2	—	—	7-17 -27	10	8	2	—	—
	H2	2-31	—	—	18-23 -35	10	8	2	—	—
	H3	31-35	—	—	16-18 -35	30	24	6	—	—
	H4	35-40	—	—	—	—	—	—	—	—

/ n	P ct	P ct	P ct	R V P ct	R V P ct	R V P ct	R V P ct	R V P ct

Particle Size and Coarse Fragments– Cumberland County, Tennessee										
Map symbol and soil name	Horizon	Depth	Sand	Silt	Clay	Total fragments	Fragments 2-74 mm	Fragments 75-249 mm	Fragments 250-599 mm	Fragments >=600 mm
LwB—Lonewood loam, 2 to 5 percent slopes										
Lonewood	H1	0-10	—	—	15-20 -25	3	3	—	—	—
	H2	10-37	—	—	20-30 -39	3	3	—	—	—
	H3	37-55	—	—	25-35 -45	7	7	—	—	—
	H4	55-72	—	—	25-35 -45	10	10	0	—	0
	H5	72-80	—	—	—	—	—	—	—	—
LwC—Lonewood loam, 5 to 12 percent slopes										
Lonewood	H1	0-10	—	—	15-20 -25	3	3	—	—	—
	H2	10-37	—	—	20-30 -39	3	3	—	—	—
	H3	37-55	—	—	25-35 -45	7	7	—	—	—
	H4	55-72	—	—	25-35 -45	10	10	0	—	0
	H5	72-80	—	—	—	—	—	—	—	—
Ps—Pits, sandstone quarrys										
Pits	H1	0-60	—	—	0	—	—	—	—	—
RaC—Ramsey loam, 5 to 12 percent slopes										
Ramsey	H1	0-2	—	—	8-16 -25	7	7	0	—	—
	H2	2-18	—	—	8-17 -25	7	7	0	—	—
	H3	18-25	—	—	—	—	—	—	—	—

/ n	P ct	P ct	P ct	R V P ct	R V P ct	R V P ct	R V P ct	R V P ct	

Particle Size and Coarse Fragments– Cumberland County, Tennessee											
Map symbol and soil name	Horizon	Depth	Sand	Silt	Clay	Total fragments	Fragments 2-74 mm	Fragments 75-249 mm	Fragments 250-599 mm	Fragments >=600 mm
RaD—Ramsey loam, 12 to 20 percent slopes										
Ramsey	H1	0-2	—	—	8-16 -25	7	7	0	—	—
	H2	2-18	—	—	8-17 -25	7	7	0	—	—
	H3	18-25	—	—	—	—	—	—	—	—
RrC—Ramsey-Rock outcrop complex, 5 to 12 percent slopes										
Ramsey	H1	0-2	—	—	8-16 -25	7	7	0	—	—
	H2	2-18	—	—	8-17 -25	7	7	0	—	—
	H3	18-25	—	—	—	—	—	—	—	—
Rock outcrop	H1	0-60	—	—	—	—	—	—	—	—
RrD—Ramsey-Rock outcrop complex, 12 to 20 percent slopes										
Ramsey	H1	0-2	—	—	8-16 -25	7	7	0	—	—
	H2	2-18	—	—	8-17 -25	7	7	0	—	—
	H3	18-25	—	—	—	—	—	—	—	—
Rock outcrop	H1	0-60	—	—	—	—	—	—	—	—
W—Water										
Water	—	—	—	—	—	—	—	—	—	—

	I n	P ct	P ct	P ct	R V P ct	R V P ct	R V P ct	R V P ct	R V P ct

Particle Size and Coarse Fragments– Cumberland County, Tennessee																				
Map symbol and soil name	Horizon	Depth	Sand	Silt	Clay	Total fragments	Fragments 2-74 mm	Fragments 75-249 mm	Fragments 250-599 mm	Fragments >=600 mm	I n	P ct	P ct	P ct	R V P ct	R V P ct	R V P ct	R V P ct	R V P ct
WhB—Whitwell loam, 2 to 5 percent slopes																			
Whitwell	H1	0-7	—	—	10-18 -25	14	13	1	—	—									
	H2	7-60	—	—	18-30 -32	14	13	1	—	—									

Physical Soil Properties

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion.

There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Physical Soil Properties– Cumberland County, Tennessee														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
At—Atkins loam, frequently flooded														
Atkins	0-10	-42-	-38-	15-20- 25	1.20-1.40	4.23-14.11	0.14-0.22	0.0-2.9	2.0-4.0	.28	.28	5		
	10-52	-34-	-37-	18-29- 35	1.20-1.50	0.42-14.11	0.14-0.18	0.0-2.9	0.3-0.8	.32	.32			
	52-60	-67-	-15-	10-18- 35	1.20-1.50	1.41-42.34	0.08-0.18	0.0-2.9	0.0-0.5	.28	.32			
BM—Bethesda-Mine pits complex, 10 to 80 percent slopes														
Bethesda	0-23	-40-	-38-	18-23- 27	1.40-1.55	4.23-14.11	0.10-0.16	0.0-2.9	0.0-0.5	.28	.49	5		
	23-45	-38-	-36-	18-29- 35	1.60-1.90	1.41-4.23	0.04-0.10	0.0-2.9	0.0-0.3	.32	.64			
	45-60	-41-	-37-	18-22- 35	1.60-1.90	1.41-4.23	0.04-0.10	0.0-2.9	0.0-0.3	.32	.64			
Mine pits	—	—	—	—	—	—	—	—	—					
GpC—Gilpin loam, 5 to 12 percent slopes														
Gilpin	0-8	-42-	-37-	15-21- 27	1.20-1.40	4.23-14.11	0.12-0.18	0.0-2.9	0.5-4.0	.32	.32	3		
	8-26	-19-	-49-	18-32- 35	1.20-1.50	4.23-14.11	0.12-0.16	0.0-2.9	0.0-0.5	.24	.28			
	26-37	-30-	-20-	18-50- 50	1.20-1.50	4.23-14.11	0.08-0.12	0.0-2.9	0.0-0.5	.24	.32			
	37-60	—	—	—	—	1.41-14.11	—	—	—					

Physical Soil Properties– Cumberland County, Tennessee

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
GpD—Gilpin loam, 12 to 20 percent slopes														
Gilpin	0-8	-42-	-37-	15-21- 27	1.20-1.40	4.23-14.11	0.12-0.18	0.0-2.9	0.5-4.0	.32	.32	3		
	8-26	-19-	-49-	18-32- 35	1.20-1.50	4.23-14.11	0.12-0.16	0.0-2.9	0.0-0.5	.24	.28			
	26-37	-30-	-20-	18-50- 50	1.20-1.50	4.23-14.11	0.08-0.12	0.0-2.9	0.0-0.5	.24	.32			
	37-50	—	—	—	—	1.41-14.11	—	—	—					
HeB—Hendon silt loam, 2 to 5 percent slopes														
Hendon	0-6	-27-	-54-	12-19- 25	1.30-1.45	4.23-14.11	0.17-0.21	0.0-2.9	1.0-3.0	.37	.37	5		
	6-23	-24-	-51-	18-25- 32	1.35-1.45	4.23-14.11	0.16-0.20	0.0-2.9	0.0-0.5	.37	.37			
	23-29	-24-	-50-	18-26- 35	1.45-1.60	1.41-4.23	0.13-0.17	0.0-2.9	0.0-0.5	.32	.32			
	29-61	-34-	-37-	20-30- 35	1.45-1.55	4.23-14.11	0.13-0.17	0.0-2.9	0.0-0.5	.32	.32			
HeC—Hendon silt loam, 5 to 12 percent slopes														
Hendon	0-6	-27-	-54-	12-19- 25	1.30-1.45	4.23-14.11	0.17-0.21	0.0-2.9	1.0-3.0	.37	.37	5		
	6-23	-24-	-51-	18-25- 32	1.35-1.45	4.23-14.11	0.16-0.20	0.0-2.9	0.0-0.5	.37	.37			
	23-29	-24-	-50-	18-26- 35	1.45-1.60	1.41-4.23	0.13-0.17	0.0-2.9	0.0-0.5	.32	.32			
	29-61	-34-	-37-	20-30- 35	1.45-1.55	4.23-14.11	0.13-0.17	0.0-2.9	0.0-0.5	.32	.32			

Physical Soil Properties– Cumberland County, Tennessee

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
JsF—Jefferson-Shelocta complex, 20 to 45 percent slopes														
Jefferson	0-7	-43-	-39-	10-18- 25	1.30-1.50	14.11-42.34	0.10-0.16	0.0-2.9	0.5-5.0	.17	.28	5		
	7-56	-38-	-36-	18-26- 34	1.30-1.65	14.11-42.34	0.10-0.16	0.0-2.9	0.0-0.5	.17	.24			
	56-60	-67-	-15-	15-18- 30	1.30-1.65	14.11-42.34	0.08-0.14	0.0-2.9	0.0-0.5	.17	.24			
Shelocta	0-3	-43-	-40-	10-18- 25	1.15-1.30	4.23-14.11	0.16-0.22	0.0-2.9	0.5-5.0	.32	.32	4		
	3-50	-20-	-50-	18-30- 34	1.30-1.55	4.23-14.11	0.10-0.20	0.0-2.9	0.0-0.5	.28	.32			
	50-60	—	—	—	—	—	—	—	—					
LlB—Lily loam, 2 to 5 percent slopes														
Lily	0-2	-43-	-40-	7-17- 27	1.20-1.40	4.23-42.34	0.13-0.18	0.0-2.9	0.5-4.0	.28	.37	2		
	2-31	-38-	-39-	18-23- 35	1.25-1.35	14.11-42.34	0.12-0.18	0.0-2.9	0.1-0.5	.28	.28			
	31-35	-65-	-17-	16-18- 35	1.25-1.35	14.11-42.34	0.08-0.17	0.0-2.9	0.0-0.5	.17	.24			
	35-40	—	—	—	—	0.00-1.41	—	—	—					
LlC—Lily loam, 5 to 12 percent slopes														
Lily	0-2	-43-	-40-	7-17- 27	1.20-1.40	4.23-42.34	0.13-0.18	0.0-2.9	0.5-4.0	.28	.37	2		
	2-31	-38-	-39-	18-23- 35	1.25-1.35	14.11-42.34	0.12-0.18	0.0-2.9	0.1-0.5	.28	.28			
	31-35	-65-	-17-	16-18- 35	1.25-1.35	14.11-42.34	0.08-0.17	0.0-2.9	0.0-0.5	.17	.24			
	35-40	—	—	—	—	0.00-1.41	—	—	—					

Physical Soil Properties– Cumberland County, Tennessee

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
LID—Lily loam, 12 to 20 percent slopes														
Lily	0-2	-43-	-40-	7-17- 27	1.20-1.40	4.23-42.34	0.13-0.18	0.0-2.9	0.5-4.0	.28	.37	2		
	2-31	-38-	-39-	18-23- 35	1.25-1.35	14.11-42.34	0.12-0.18	0.0-2.9	0.1-0.5	.28	.28			
	31-35	-65-	-17-	16-18- 35	1.25-1.35	14.11-42.34	0.08-0.17	0.0-2.9	0.0-0.5	.17	.24			
	35-40	—	—	—	—	0.00-1.41	—	—	—					
LwB—Lonewood loam, 2 to 5 percent slopes														
Lonewood	0-10	-42-	-38-	15-20- 25	1.30-1.40	4.23-14.11	0.18-0.20	0.0-2.9	1.0-3.0	.37	.37	4		
	10-37	-34-	-37-	20-30- 39	1.30-1.45	4.23-14.11	0.16-0.18	0.0-2.9	0.0-0.5	.37	.37			
	37-55	-17-	-48-	25-35- 45	1.40-1.55	4.23-14.11	0.14-0.17	0.0-2.9	0.0-0.5	.32	.32			
	55-72	-33-	-32-	25-35- 45	1.40-1.55	4.23-14.11	0.05-0.11	0.0-2.9	0.0-0.5	.32	.32			
	72-80	—	—	—	—	0.00-1.41	—	—	—					
LwC—Lonewood loam, 5 to 12 percent slopes														
Lonewood	0-10	-42-	-38-	15-20- 25	1.30-1.40	4.23-14.11	0.18-0.20	0.0-2.9	1.0-3.0	.37	.37	4		
	10-37	-34-	-37-	20-30- 39	1.30-1.45	4.23-14.11	0.16-0.18	0.0-2.9	0.0-0.5	.37	.37			
	37-55	-17-	-48-	25-35- 45	1.40-1.55	4.23-14.11	0.14-0.17	0.0-2.9	0.0-0.5	.32	.32			
	55-72	-33-	-32-	25-35- 45	1.40-1.55	4.23-14.11	0.05-0.11	0.0-2.9	0.0-0.5	.32	.32			
	72-80	—	—	—	—	0.00-1.41	—	—	—					

Physical Soil Properties– Cumberland County, Tennessee

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
Ps—Pits, sandstone quarrys														
Pits	0-60	—	—	0- 0- 0	—	—	0.00	—	—					
RaC—Ramsey loam, 5 to 12 percent slopes														
Ramsey	0-2	-44-	-40-	8-16- 25	1.25-1.50	42.34-141.14	0.09-0.12	0.0-2.9	0.5-2.0	.20	.20	1		
	2-18	-43-	-40-	8-17- 25	1.20-1.40	42.34-141.14	0.09-0.12	0.0-2.9	0.0-0.5	.17	.20			
	18-25	—	—	—	—	0.00-1.41	—	—	—					
RaD—Ramsey loam, 12 to 20 percent slopes														
Ramsey	0-2	-44-	-40-	8-16- 25	1.25-1.50	42.34-141.14	0.09-0.12	0.0-2.9	0.5-2.0	.20	.20	1		
	2-18	-43-	-40-	8-17- 25	1.20-1.40	42.34-141.14	0.09-0.12	0.0-2.9	0.0-0.5	.17	.20			
	18-25	—	—	—	—	0.00-1.41	—	—	—					
RrC—Ramsey-Rock outcrop complex, 5 to 12 percent slopes														
Ramsey	0-2	-44-	-40-	8-16- 25	1.25-1.50	42.34-141.14	0.09-0.12	0.0-2.9	0.5-2.0	.20	.20	1		
	2-18	-43-	-40-	8-17- 25	1.20-1.40	42.34-141.14	0.09-0.12	0.0-2.9	0.0-0.5	.17	.20			
	18-25	—	—	—	—	0.00-1.41	—	—	—					
Rock outcrop	0-60	—	—	—	—	0.42-42.34	—	—	—					

Physical Soil Properties– Cumberland County, Tennessee														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct					
RrD—Ramsey-Rock outcrop complex, 12 to 20 percent slopes														
Ramsey	0-2	-44-	-40-	8-16- 25	1.25-1.50	42.34-141.14	0.09-0.12	0.0-2.9	0.5-2.0	.20	.20	1		
	2-18	-43-	-40-	8-17- 25	1.20-1.40	42.34-141.14	0.09-0.12	0.0-2.9	0.0-0.5	.17	.20			
	18-25	—	—	—	—	0.00-1.41	—	—	—					
Rock outcrop	0-60	—	—	—	—	0.42-42.34	—	—	—					
W—Water														
Water	—	—	—	—	—	—	—	—	—					
WhB—Whitwell loam, 2 to 5 percent slopes														
Whitwell	0-7	-43-	-39-	10-18- 25	1.35-1.55	4.23-14.11	0.15-0.20	0.0-2.9	1.0-3.0	.32	.32	5		
	7-60	-34-	-37-	18-30- 32	1.40-1.70	4.23-14.11	0.14-0.20	0.0-2.9	0.0-0.5	.32	.32			

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