Beaver Water District

Source Water Protection Plan

2018 UPDATE

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1 FORWARD

At the turn of the last century, water borne diseases killed thousands of Americans annually. The advent and implementation of water treatment contributed to the near elimination of water borne disease outbreaks in the U.S. over the last 100 years. Death rates from Typhoid fever have fallen from roughly 30 per 100,000 persons in 1900 to virtually none in 2000 (Christman, 2008). However, water borne diseases have not been totally eliminated. As recently as 2004, 30 water borne disease outbreaks were reported in the U.S. and were attributed to community drinking water systems (Center for Disease Control, 2006).

Responding to the need to continually improve water safety, the water industry has developed a multiple barrier approach. In this approach, protection and treatment of water from its source to the tap is emphasized. Source water protection is the first of the multiple barriers. Other barriers include drinking water standards, disinfection and treatment, distribution system control, and public awareness. Source water protection is the process of maintaining the quantity and the quality of raw water sources now and into the future.

The benefits of source water protection are clear. First, clean water is less expensive to treat than dirty water. Dearmont et al. (1998) determined that every 1% increase in raw water turbidity resulted in a 0.25% increase in treatment chemical costs in Texas. Additional benefits can be realized by avoidance of the cost of implementing new treatment facilities because of degraded water quality. For instance, if Cryptosporidium oocysts were found in Beaver Lake, then Beaver Water District (the District) would be forced to install additional removal technology to meet the regulation. If we can maintain our conventional treatment process, then we will avoid both added capital costs and treatment costs. A less obvious benefit of source water protection is improvement in the confidence that our customers and end users have in our product. Increased customer confidence helps the District to secure support for securing the resources necessary for state of the art water treatment.

In 2007, The American Water Works Association published Standard G300-07, “Source Water Protection.” The Source Water Protection standard established minimum elements of an effective source water protection program that should be implemented by a public utility providing potable water to the public. This plan outlines how the District intends to meet the requirements of that standard.

2 INTRODUCTION AND VISION

Purpose: The purpose of this plan is to define how the District will comply with AWWA’s standard G300-07, “Source Water Protection.”

Scope: This plan applies to efforts made by the District to maintain adequate quality and quantity of raw water to meet its mission of providing safe economically priced water to its customers in quantities sufficient for their needs.

Application: The source water protection plan will provide guidance to the District personnel in the development and implementation of all aspects of its Source Water Protection program as it applies to Beaver Lake.

Vision: Beaver Water District's mission is to serve our customers' needs by providing high quality drinking water that meets or exceeds all regulatory requirements and is economically priced consistent with our quality standards.

Providing high quality drinking water starts with protecting the source of that water, which is the first step in the multiple-barrier approach.

At the May 2006 meeting of the Beaver Water District Board, both a philosophy and position on source water protection were adopted (Appendices B and C). These board approved documents commit the District to providing leadership in protection of Beaver Lake, to taking the actions necessary to protect this resource, and to making resources available for source water protection activities, including conservation of land. The Board has been proactive in its commitment to the Source Water Protection Program. These two documents provide guidance to the development and implementation of the District's Source Water Protection Program. January 2012, the Board approved a vision statement for the Source Water Protection Program as follows:

> **Vision for Source Water Protection**: Beaver Water District will lead the citizens, businesses, and communities of Northwest Arkansas to cooperatively maintain the quality of Beaver Lake for all generations.

3 Source Water Characterization

3.1 Source of Water

The sole source of water for Beaver Water District is Beaver Lake (Figure 1). Beaver Lake is a large multiple use US Army Corps of Engineers Reservoir on the White River in Arkansas. Beaver is the most upstream of reservoirs on the river. Other projects on the main stem of the White are Table Rock Reservoir and Bull Shoals Reservoir. Beaver Lake was authorized by the Flood Control act of 1957 for flood control and hydroelectric power generation and other uses (USACOE 1998). Later, municipal and industrial (M&I) water supply was added to the authorized uses. Construction of Beaver Dam started in 1959 and was completed in 1966. The conservation pool was first filled in 1966 (USACOE 1998).

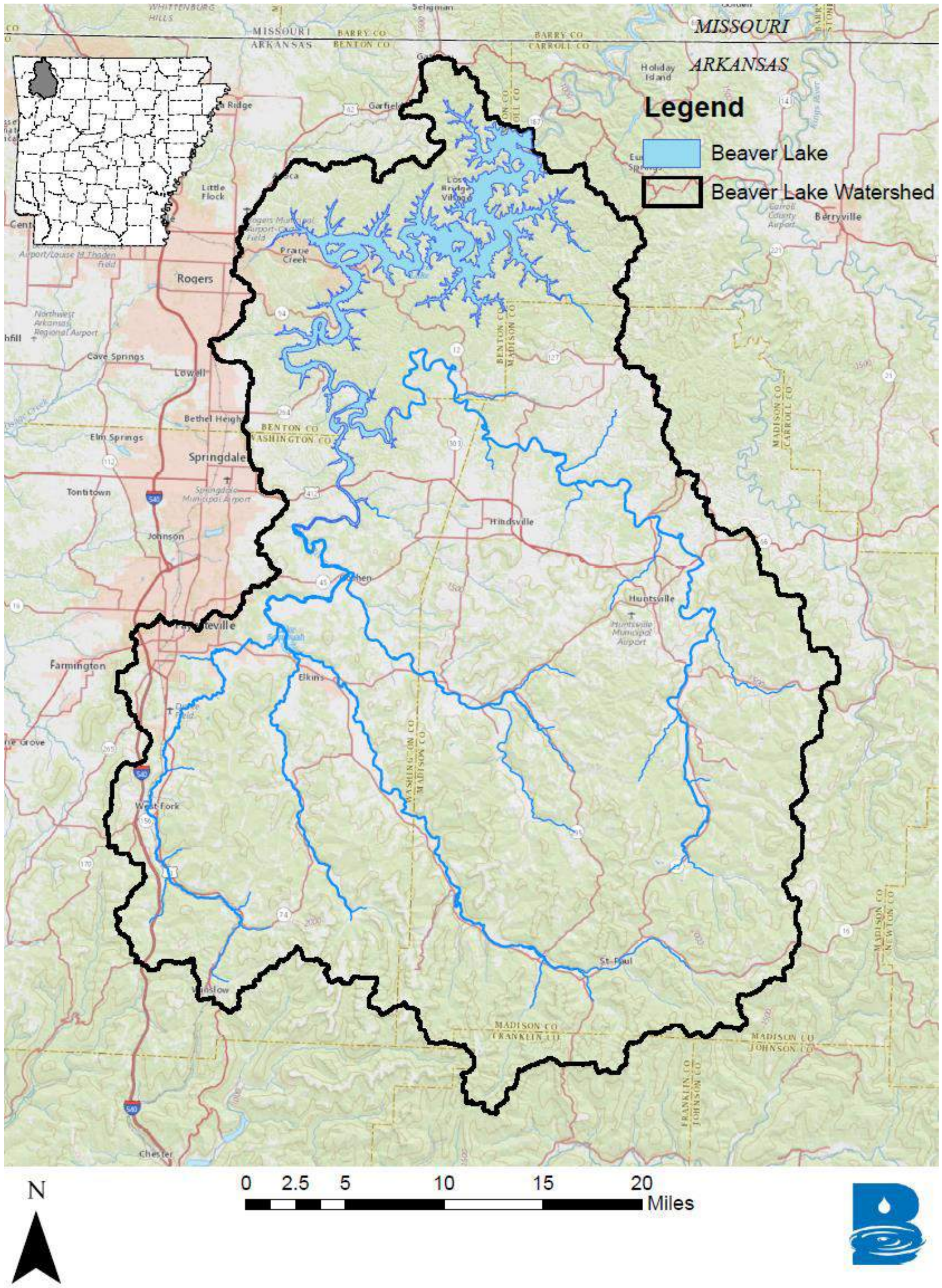

Figure 1. Beaver Lake and the HUC-8 watershed boundary.

Today, the lake is used for all three authorized purposes but also includes recreation and fish and wildlife management. Reservoir operation is managed for flood control, hydroelectric power, and water supply. There are currently four water suppliers using the lake as a source, which includes BWD, the Benton-Washington Regional Public Water Authority (Two-Ton), Carroll Boone Water district (CBWD), and Madison County Regional Water District (MCRWD).

At the top of the flood control pool (1130 ft MSL), Beaver Lake covers 31,700 acres. The total Corp of Engineers owned area is 37,763 acres. The lowest elevation within the reservoir is 914 ft MSL, 216 ft below the top of the flood pool (USACOE, 1998). The maximum depth of Beaver Reservoir is 73 m at the dam with a lake wide average of 18.3 m.

There are three distinct sections of the reservoir, the riverine where the reservoir behaves more like the original White and War Eagle Rivers, the transition zone, and the lacustrine where the reservoir behaves more like a lake. The trophic conditions of the reservoir change from eutrophic in the riverine zone to oligotrophic in the lacustrine zone (Haggard et al 1999). Beaver Reservoir is classified as a warm monomictic lake, one that typically does not freeze over, are thermally stratified once during the year, and fully mixed during the other part of the year. Thermally stratified lakes typically have a warm aerobic surface layer called the epilimnion, and transition zone often referred to as the thermocline or metalimnion, and a bottom layer that is cold and anoxic.

3.2 Source Water Area Delineation

In the initial source water assessment, performed by the Arkansas Department of Health (ADH) during 2000, the assessment area was defined as:

All lands within a 5-mile radius around the intake that are:

- Within 0.25 miles of the shoreline at the impoundment's high water level;
- Within 0.25 miles of either side of the centerline of all tributaries; and
- All lands within a 0.5 mile radius of the intake, regardless of watershed boundaries.

At the time, the District elected to expand the source water assessment to include the entire Beaver Lake Watershed (Figure 1). However, the watershed at 763,000 acres is extremely large. It is necessary to prioritize the areas within the watershed to most effectively use the District's resources and also to leverage the resources of other groups, such as the Beaver Watershed Alliance (BWA). Therefore, a time of travel study was conducted to find critical areas. Twenty-four (24) hour time of travel during storm conditions was selected as the priority area for source water protection, as it was believed that the District could react to any potential incident if 24-hour notice was provided.

To model time of travel to the District's intake on Beaver Lake, during 2008, District personnel created a computer model of the reservoir using the CE-QUAL-W2 hydrodynamic model developed by the United States Army Corps of Engineers, loosely coupled with the Environmental Protection Agency's Incident Command Tool for Protecting Drinking Water (ICWATER). CE-QUAL-W2 is a two-dimensional, laterally averaged, finite difference hydrodynamic and water quality model.

Because the model assumes lateral homogeneity, it is best suited for relatively long and narrow waterbodies exhibiting longitudinal and vertical water quality gradients. The model can be applied to rivers, lakes, reservoirs, and estuaries. Branched networks can be modeled. ICWATER utilizes real-time water gage data and weather to model system time of travel. The results from the District's study were compared to a time of travel study conducted by the United States Geological Survey (Galloway and Green, 2007). The results of the two models compared favorably, so the loosely coupled model was adopted.

Beaver Water District now utilizes a three-tier delineation of its source water protection area. Tier 1 (highest level of protection) is the area immediately adjacent to our raw water intake. Tier II is a priority area defined as roughly the area within 24 hours hydrologic travel time during a typical storm event. Tier III (lowest level of protection) is the total watershed tributary to Beaver Lake.

Tier I: Water Intake and Immediate Vicinity - Beaver Water District owns, in fee simple, all land within 2,000 feet of the raw water intake (Figure 2). In addition, lake access is excluded within 300 feet of the intake. Activity within this area is restricted to those actions necessary for proper operation of the intake. The Chief Executive Officer of the District must approve any other activity in advance.

Tier II: Priority source water protection area - The ability of Beaver Water District to prepare a response to a water contamination event, either accidental or intentional, is proportional to the time it has to respond. Therefore, it is necessary to provide increased protection to areas closer to the District's raw water intake. With 24 hours notice of an event, the District can mobilize an adequate response to most any event. With less than 24 hours notice, adequate mobilization of resources becomes more problematic. Therefore, areas within 24 hours of hydraulic travel time require a higher level of protection than Tier III areas. To delineate areas within 24 hours hydraulic travel time of Beaver Water District's intake (Figure 2), staff used a combination of a 2-dimensional lake hydrodynamic model, CE-QUAL-W2, and a 1-dimensional stream hydrologic model, ICWATER.

Tier III: Beaver Lake watershed - The Beaver Lake watershed is a portion of Hydrologic Unit Code 11010001, "Beaver Reservoir" watershed, as defined by the United States Geological Survey. Sub-watersheds 11010001001, "Headwaters White River;" 11010001002, "Lake Sequoyah-White River;" 11010001003, "Middle Fork-White River;" 11010001004, "West Fork-White River;" 11010001005, "Richland Creek;" 11010001006, "War Eagle Creek;" and 11010001007, "Beaver Lake-White River" are included in the watershed protection area (Figure 2).

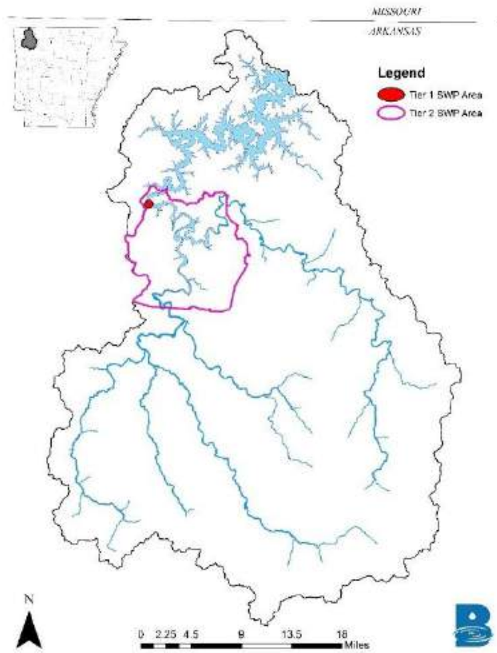

Figure 2. Beaver Water District Tier I Source Water Protection Area

3.3 Water Quantity

A great deal of data is available regarding both the quantity and quality of Beaver Water District's source water. These data are compiled by the District itself and in cooperation with several watershed partners including the United States Geological Survey (USGS) and the United States Army Corps of Engineers. Data regarding the volume of water in Beaver Lake are provided in Table 1. Beaver Water District holds contracts with the US Army Corps of Engineers for a total of 136,757 acre-feet of storage from the conservation pool of Beaver Lake. In addition to the municipal and industrial (M&I) storage allocated to Beaver Water District, the other three water suppliers using Beaver Lake as their source of raw water have a total of 48,681 acre-feet of current or pending allocations from the conservation pool. As of 2008, there is no additional allocation for space within the conservation pool of Beaver Lake. The US The safe yield for this reservoir, determined by USACE, is 120 million gallons per day (MGD) (USACOE 2001). This is the maximum quantity of water that can be considered reliably available in the reservoir. Included in this computation is credit for 40% return flow into the reservoir.

Pool elevation fluctuates throughout the year from a maximum flood storage high of around 1131 ft MSL to an average low of around 1115-1120 ft MSL (Figure 3). Periodically, pool elevation may go lower due to periods of drought as was seen in 2011, 2013, and 2017. Average pool elevation over the period from 2008-2018 was 1120.4 ft MSL. There are three pools defined by USACE, the flood pool, conservation pool, and the inactive pool (Table 1).

Table 1. Pertinent data regarding water quantity in Beaver Lake (USACOE 2001)

Pool	**Elevation, msl**	**Volume, acre- feet**
Flood Pool	1,130.00	1,951,500
Conservation Pool	1,120.43	1,664,200
In-active Pool	1,077.00	726,850

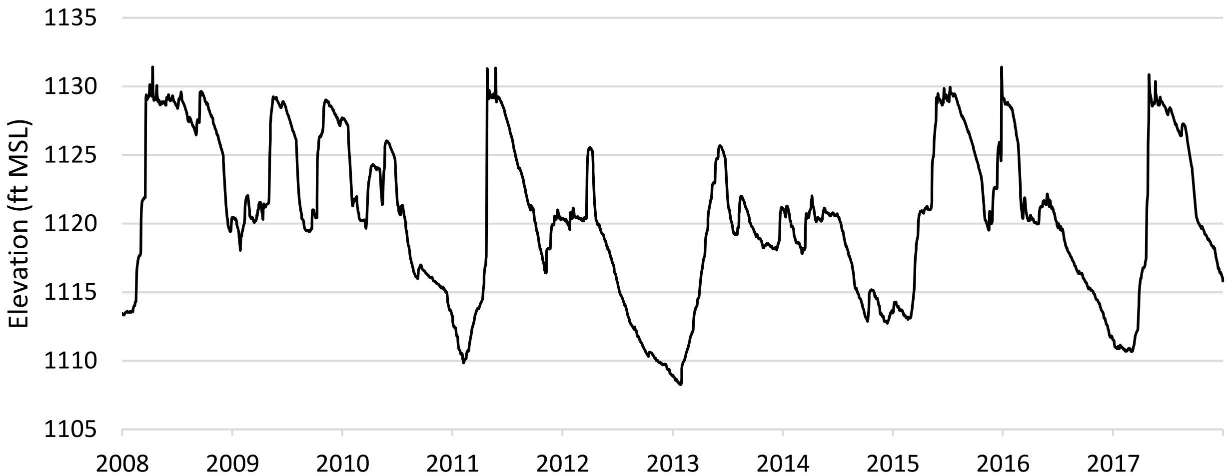

Figure 3. Daily pool elevation on Beaver Lake for the period of 2008 to 2018.

Data on inflow into Beaver Lake are collected at gages operated by the USGS on three major tributaries:

- 07048600 - White River near Fayetteville, AR,
- 07048800 - Richland Creek at Goshen, AR, and
- 07049000 - War Eagle Creek near Hindsville, AR.

These data are available in real time at http://waterdata.usgs.gov/ar/nwis. Daily data on discharge and withdrawal of water from Beaver Lake are maintained by the COE and are available at http://www.swl-wc.usace.army.mil/.

Beaver Water District completed a project with Carollo Engineers (901 East 104th Street, Kansas City, MO) in 2011 to study the feasibility of a western pipeline expansion to meet future city demand. This research project was called the Western Corridor. Within the western expansion study, future projections of water demand were updated from a 2006 study, also by Carollo. The results of the study indicate that the safe yield of our allocation from Beaver Lake is adequate to meet the average daily demand for water through the year 2050 (Figure 4). Water demand at the District is tracking right above the projected demand with our 2017 average daily production of around 50 MGD while predicted demand was 44 MGD.

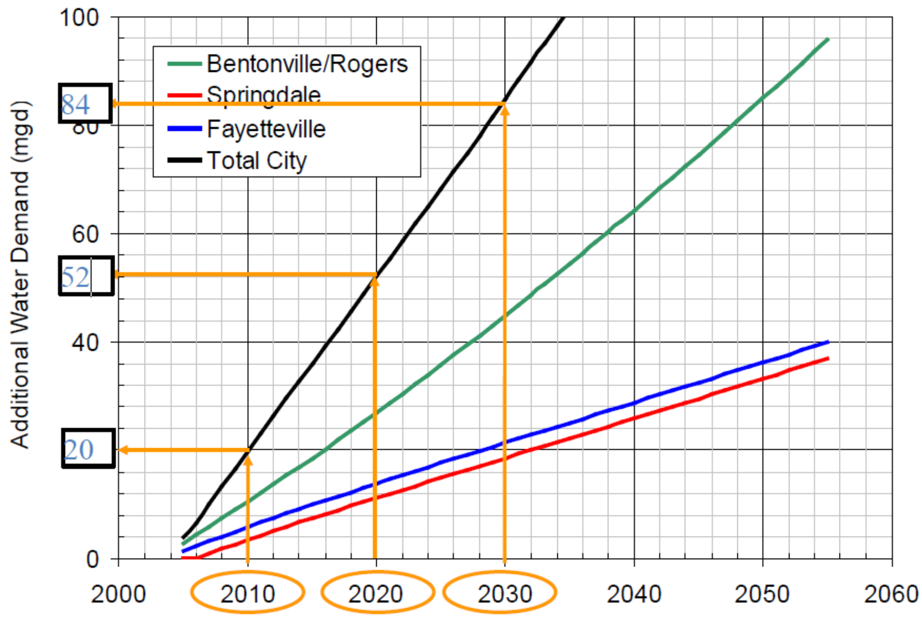

Figure 4. Projected water demand by Beaver Water District's customer cities

3.4 Water Quality

Beaver Water District participates in a variety of water quality monitoring efforts with multiple partners including the Arkansas Natural Resources Commission (ANRC), Arkansas Department of Environmental Quality (ADEQ), and the Arkansas Water Resources Center (AWRC). This monitoring is conducted to either provide information to plant operators necessary for the water treatment process, or it is conducted to compile data on source water quality for various purposes (Table 2). Water quality data is collected from sites on tributaries of Beaver Lake as well as within the lake itself (Figure 5).

Table 2: Routine water quality sampling conducted by Beaver Water District and its partners.

Program	Purpose	Frequency	Analyses
Daily Intake (1973 - present)	To inform plant operations	Daily	Iron, Manganese, Conductivity, Temp, Turbidity, Bacteria
Weekly Intake (1973-Present)	To inform plant operations	Weekly	Iron, Manganese, Conductivity, Nitrate, Nitrite, Ammonia, Silica, Orthophosphate, Copper, Color (True and Apparent), Turbidity, TSS, Chlorophyll, Alkalinity, Hardness, Calcium, Chloride, Sulfate, Temp, TDS, Fluoride, Bacteria
DT Profile (sonde data)	To inform plant operations and maintain data on health of the reservoir	Monthly during mixis, Weekly during stratification	Temp, DO, Conductivity, Turbidity, Chl-a, pH, TDS, ORP
DT Profile (grab samples- analysis performed varies at collection depth)	To inform plant operations and maintain data on health of the reservoir	Monthly during mixis, Weekly during stratification	Iron, Manganese, Sulfide, Ortho-phosphate, Total Phosphorous, TOC, TN, TDS, algae, In vivo Chlorophyll-a, Phycocyanin, Cyanotoxins
The Long Run (1993 - Present)	Long term trends in baseflow water quality for major watershed tributaries	Monthly	pH, Temp, DO, Conductivity, Turbidity, Alkalinity, Hardness, Ammonia, Chloride, Copper, Iron, Manganese, Nitrate, Nitrite, Ortho-P, Total P, Sulfate, TDS, TOC, TN, E. Coli
USGS Gage Sampling	Daily reservoir inflow	Continuous	Discharge
USGS Tributary Sampling (2001 - Present)	Annual pollutant load delivered to Beaver Lake and long term trends in major watershed tributaries	6 baseflow/4 storm event	Temp, DO, pH, Conductivity, Bacteria, Turbidity, Alkalinity, Dissolved NO2+NO3, NO2, NH4, Ortho-P, Total P, Total Ammonia plus Organic Nitrogen, Dissolved Magnesium, Sulfate, Calcium, Fluoride, Chloride, TDS, Iron, Manganese, TSS
USGS Lake Sampling (1977-1995, 2007-present)	Long term trends in lake water quality and inform lake management decisions	6 Total, 4 During Stratification	Temp, DO, pH, Conductivity, Bacteria, Turbidity, Alkalinity, Dissolved NO2+NO3, NO2, NH4, Ortho-P, Total P, Total Ammonia plus Organic Nitrogen, Dissolved Magnesium, Sulfate, Calcium, Fluoride, Chloride, TDS, Iron, Manganese, TSS, Secchi Depth, Phytoplankton, Chl-a
AWRC/ANRC 319(h) White River Monitoring (2004 - Present)	Computation of nutrient load into Beaver Lake from White River	2x Weekly Baseflow and Composite Storm Samples	NO3-N, NH4-N, Total N, Total P, SRP, Sulfate, Chloride, TSS
Secchi Day	Long term trends in lake water quality	Annually	Secchi Depth, Total P, Total N, Chl-a
Synoptic Watershed Surveys	Long term trends in watershed environmental condition		Rapid Bioassessment, Geomorphology, Water Chemistry, Benthic macroinvertebrates, Fish

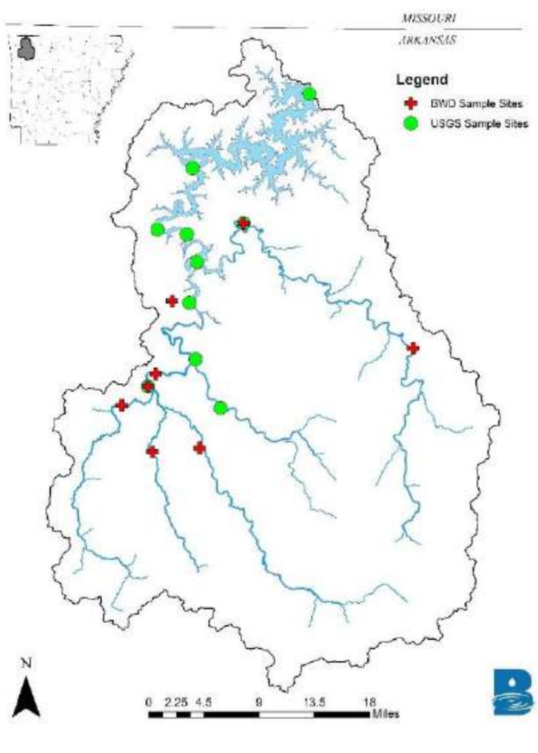

Figure 5. Beaver Water District's water quality sampling sites within Beaver Lake and on selected tributaries

In addition to the routine sampling, Beaver Water District occasionally conducts synoptic water quality surveys of the watershed. Such surveys may include rapid bio- assessments, geomorphologic surveys and water chemistry. The purpose of these synoptic surveys is to develop and maintain baseline conditions concerning tributaries of Beaver Lake. The latest synoptic survey was completed during 2017.

Water quality data prior to 1993 were collected by the plant operators and kept on the “Big Sheet,” a large paper spreadsheet. For data collected between 1993 and 1999, Lotus 123 files were compiled. Those data have been converted to Excel and are stored on the District’s server. Data compiled from 1999 till 2006 were stored on Excel spreadsheets and saved on the District’s server. Since 2006, data are maintained on the District’s Laboratory Information Management System (LIMS).

Water quality data collected by the USGS are maintained by the USGS and are available on the internet (http://waterdata.usgs.gov/ar/nwis). An exception to this rule is that the USGS pulls data from the web after 120 days and does not republish it for about a year. That leaves a small gap in the continuous data. The District maintains those data onsite until they are permanently published by the USGS.

Water quality issues faced by Beaver Water District include fecal bacteria, turbidity, increasing organic carbon resulting in formation of disinfection by-products, seasonal taste and odor issues related to the algae metabolite 2-methylisoborneol, or MIB, and occasional high concentrations of manganese. Following is a summary of water quality data that have been collected and analyzed.

3.4.1 Bacteria

The Arkansas Department of Health sets the coliform standard in source water through the “Rules and Regulations pertaining to Public Water Systems” (Arkansas State Board of Health, 2010). However, the standard is only applicable to new drinking water sources. The specific standards states that for new drinking water sources, Total Coliform Bacteria shall not exceed:

- 5,000 organisms/100 ml on the monthly arithmetical average;
- 20% of samples greater than 5,000 organisms/100 ml in any month; or
- 5% of samples greater than 20,000 organisms / 100 ml in any month.

Total coliform bacteria are measured daily at Beaver Water District’s intake by District staff. However, since Beaver Lake is already an established source of drinking water, the coliform limits set by the Arkansas Department of Health are not enforceable. Annual geometric mean for total coliforms ranges from around 200-500 Total Coliforms/100 ml (Figure 6). While a typical maximum is under 100,000 Total Coliforms/100 ml, maximum values approached 400,000 Total Coliforms/100 ml for a brief period in 2010. We have evaluated our source water using a simplified criteria, the number of daily samples that exceed 5000 organisms. Since January 2006, Total Coliform samples taken from BWD intake have exceeded 5000 organisms/100 ml 6% of the time, or roughly a total of 9 months out of 12 years.

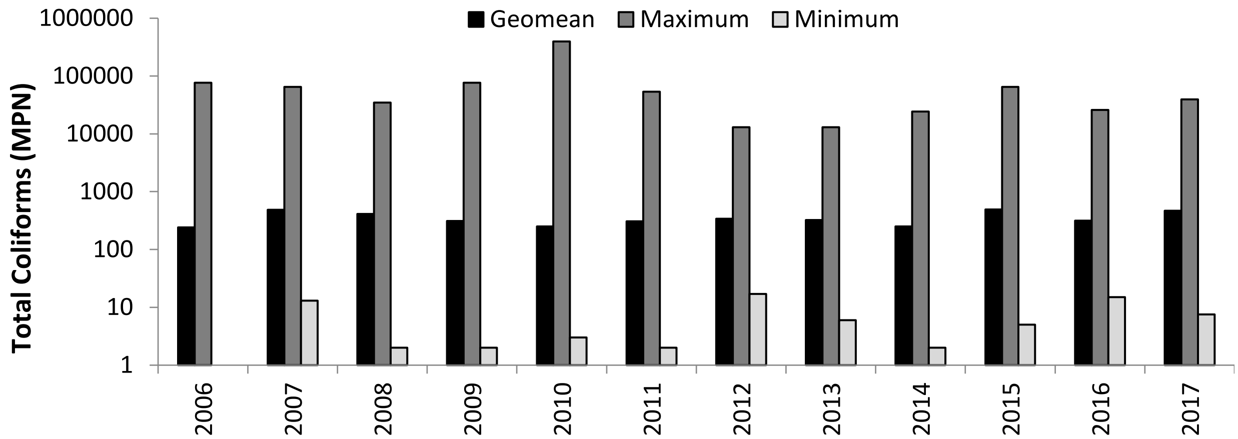

Figure 6. Annual geometric mean, maximum, and minimum counts for Total Coliforms/100 ml

In 2017, Gibson et al (2017) completed a study on bacteria in the lake and watershed looking for host specific markers in e. coli. The study found several things concerning e. coli: the predominant load of e coli originated in the White River portion of the watershed, both seasonal and locational factors are both important for fecal pollution in the lake, however, they were unable to determine a specific source of the e. coli.

In 2018, Williams et al. (2018) completed an investigation into onsite wastewater treatment systems (primarily septic) in the Source Water Protection Area. The data collected was digitized and incorporated into a risk assessment tool that takes into account, location, soils, slope, and many other factors to determine overall risk to the water body. A risk priority index was calculated and hot spots for systems with a high probability of failure were mapped. The septic risk tool can be used to locate areas of development around the lake to prioritize spending on septic system upgrades.

3.4.2 Turbidity

Turbidity is measured daily at Beaver Water District's intake using Standard Method 2130b. For the period of January 1977 through December 2017, the average daily turbidity was 14.1 NTUs (Std. Dev. 29.2 NTU). The minimum turbidity value of 0.63 NTU was measured in October of 1993, while the maximum of 660 NTU was measured in April of 2011. Wet season turbidity is related to inflow at the Wyman Bridge gauging station on the White River (FTN 2006). During most years, average turbidity was less than 15 NTU (Figure 7). Maximum turbidity has exceeded 300 NTU on four occasions, in 2004, 2008, 2011, and 2015. In most years, the maximum turbidity value was less than 200 NTU (Figure 8). Average annual rainfall does not appear to correlate well with average raw water turbidity, with some high rain years having low average and max turbidity (2013), and some average rain years having high average and max turbidity (2008, Figures 7, 8, and 9).

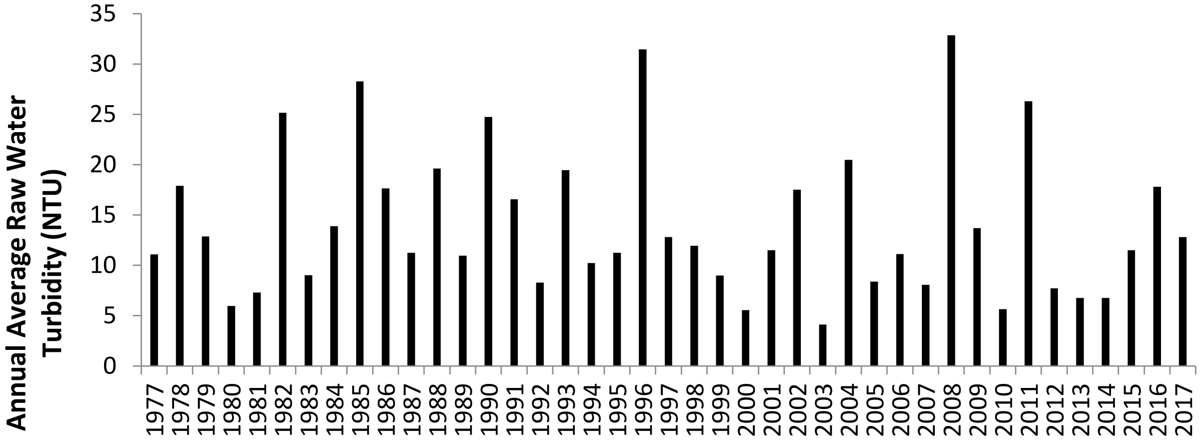

Figure 7. Annual average raw water intake turbidity at the Beaver Water District intake for the period from 1977 – 2017, NTU

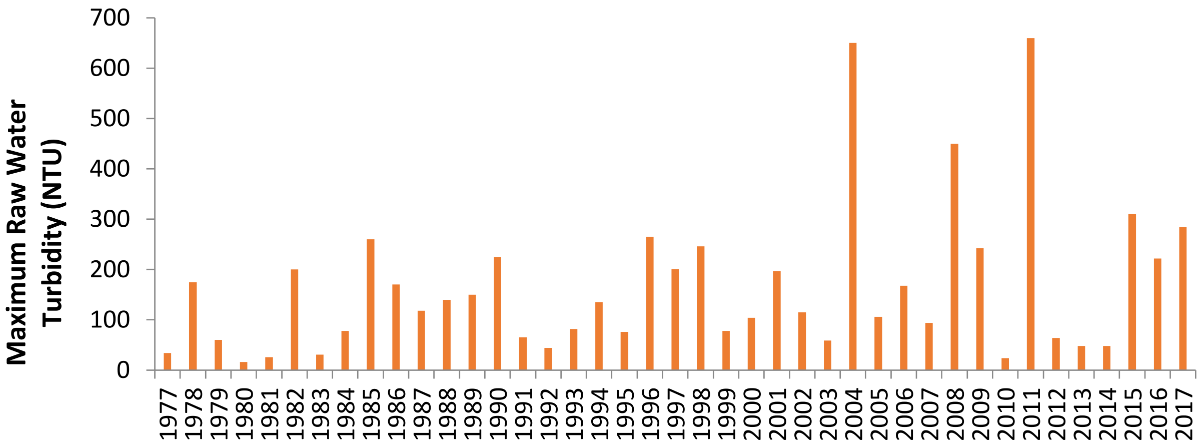

Figure 8. Annual maximum raw water intake turbidity at the Beaver Water District intake for the period from 1977 – 2017, NTU

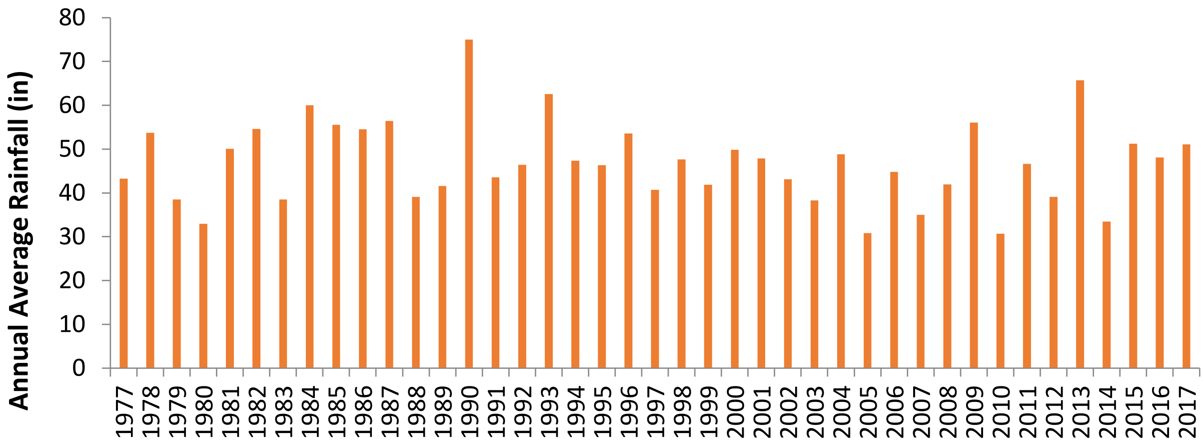

Figure 9. Annual average rainfall recorded at Drake Field for the period from 1977 – 2017, inches

3.4.3 Secchi Depth

Secchi depth is a measure of the transparency of a water body. The mean Secchi depth in Beaver Lake sampled near our intake by the USGS between 1998 and 2017, was 1.56 meters. The values at the intake ranged from 0.10 meters up to 3.5 meters (Figure 10). Secchi depth in Beaver Lake exhibits a strong longitudinal gradient from the headwaters to the dam (FTN 2008) with the lacustrine zone containing greater water clarity than the transition or riverine zones. Secchi depth is also the main parameter at our annual Secchi Day event held in August. Whole lake average values are presented in Figure 11 for the 12 years that we have held the event. The whole lake average for 2017 was 2.7 m.

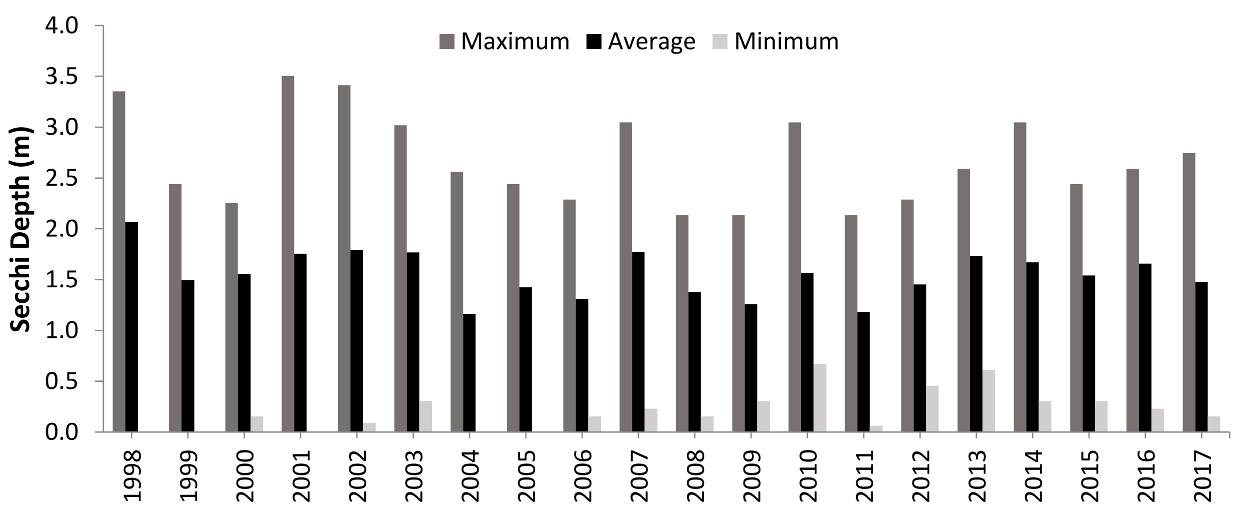

Figure 10. Secchi depth measured by the USGS at Beaver Water District's intake

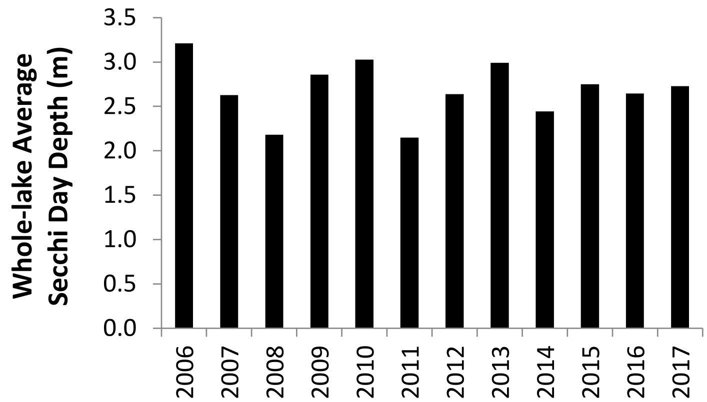

Figure 11. Whole-Lake average Secchi depth as taken on Secchi Day each year

In 2016, the EPA approved the ADEQ proposed Beaver Lake water quality standard that included chlorophyll-a (Chl-a) and secchi transparency (ST) quality indicators. The standard is assessed in the transition zone of the lake near the Hickory Creek Marina just up-lake from the drinking water intake. The standard states that ST should be greater than 1.1 m while Chl-a should be less than 8 µg l^{-1}, both on an annual average. The lake would be considered impaired if three out of five years or more were exceeded. Exceedance of this criteria would indicate that the lake is impaired for drinking water due to excess nutrients (Scott & Haggard 2015).

3.4.4 Chlorophyll-a

The growing season in Beaver Lake extends from May through October (FTN, 2008). From 2001 to 2017, the mean concentration of Chl-a measured in the profile at BWD's intake was 8.1 µg/L. Growing season (stratified) mean Chl-a in the profile ranged from 3.04 µg/L to 13.27 µg/L (Figure 12). Average values during mixis ranged from 2.5 to 13.5 µg/L, although most years were under 6 µg/L.

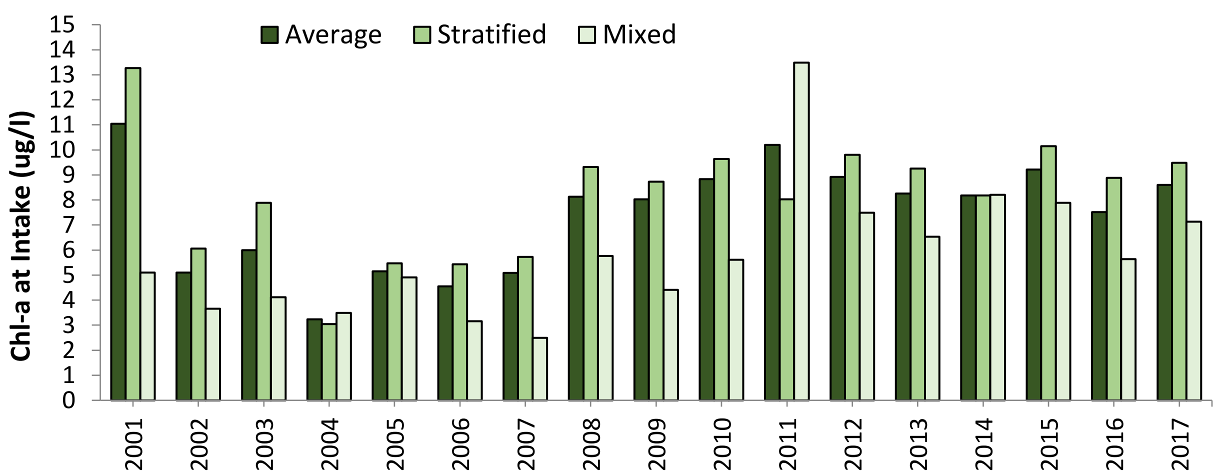

Figure 12. Mean epilimnetic chlorophyll-a on Beaver Lake near the intake broken down as annual average, average during stratification (typical of growing season), and average during mixis

3.4.5 Total Organic Carbon

Total Organic Carbon (TOC) is one of several water quality parameters related to the formation of disinfection byproducts (DBPs) (Singer, 1999). DBP potential was directly related to TOC concentration. TOC is collected at various lake elevations that correspond to the different intake valves with the dataset going back to 1989. Presented here is the combined data for the 1110 and 1114 ft MSL valves (Figure 13). The average for the period of record was 2.70 mg/l with a standard deviation of 0.80. The maximum for the period of record was 10.65 mg/l, however most years TOC stayed below 6 mg/l.

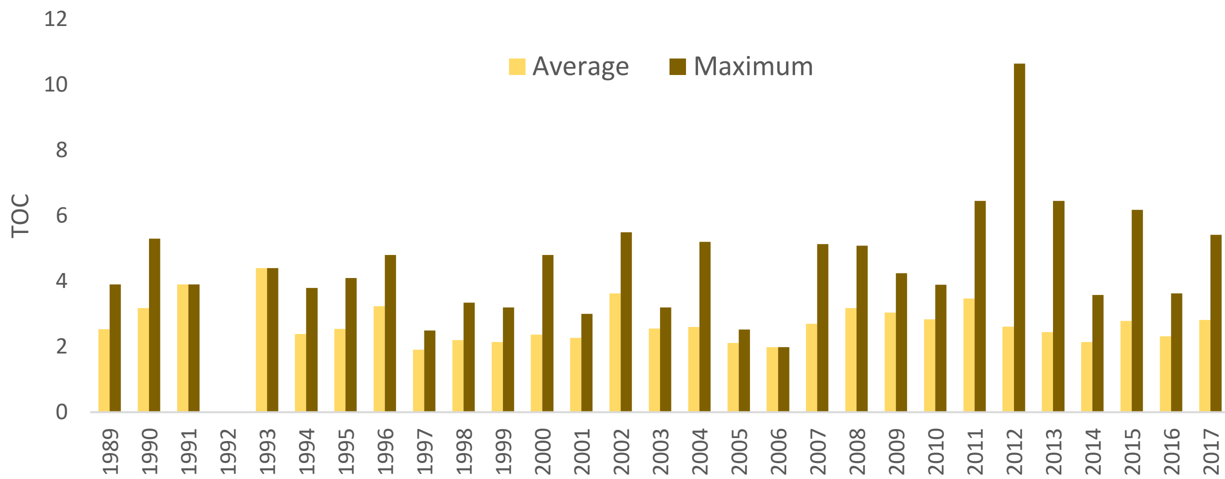

Figure 13. Mean concentration of Total Organic Carbon in Raw Water at Beaver Water District's intake

Haggard and Giovanetti (2006) studied TOC sources in the White River system under a contract from BWD during 2005 and 2006. Their findings indicate that tributary streams in general did not have elevated levels of TOC. Instead, TOC was related to the concentration of Chl-a, which in turn, was a function of primary productivity of the stream. Streams that separated into pools produced more Chl-a and, consequently, more TOC than permanently flowing streams. The one urban stream in the study did have significantly higher TOC concentration than the dominantly rural streams.

3.4.6 Taste and Odor

BWD experiences a periodic taste and odor event related to Methylisoborneal (MIB) and Geosmin. MIB and Geosmin are metabolites of cyanobacteria or potentially the soil bacteria Actinomycetes. Studies of MIB and Geosmin in Beaver Lake by Dr. Sonja Hausmann (personal communication) indicated that Actinomycetes, although present in the reservoir, did not act as the source of MIB, so the likely source is cyanobacteria or blue- green algae.

Geosmin is not a major concern for BWD as events with detectable levels are rare. MIB concentration at the BWD intake has a typical pattern of rising sharply around Labor Day and then tapering off over the next several weeks (Figure 14). Peak concentrations normally range from 50 to 100 ng/l (Figure 15). Since the year 2000, there are have been three years with concentrations over 100 ng/l, the highest of which in 2002 peaked at 240 ng/l. The threshold detection limit in which people can taste or smell it in their water is as low as 5 ng/l for sensitive people. Since 2000, the number of days each year with detectable MIB concentration has varied from 0 to 119 (Figure 16). The mean of days with detectable MIB concentration is 58.4 (St. Dev. 30.7 days).

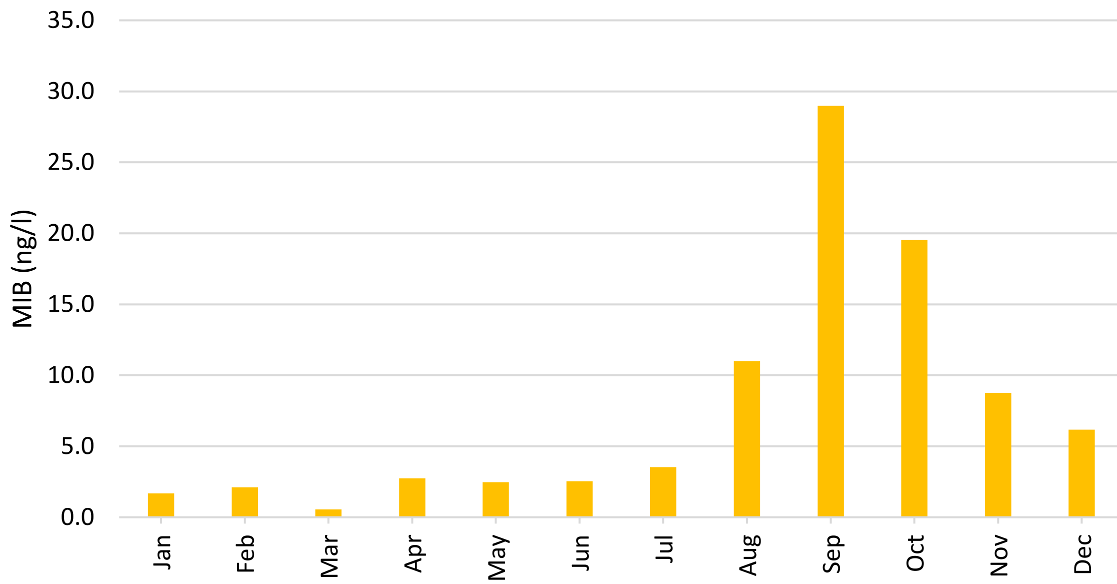

Figure 14. Average monthly MIB concentration.

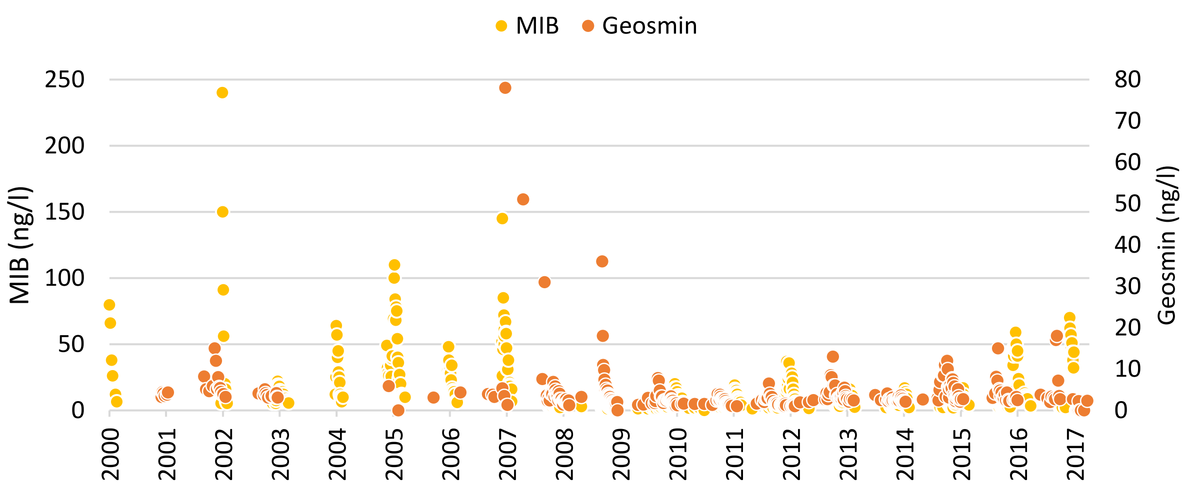

Figure 15. MIB (primary axis) and Geosmin (secondary axis) results for the years 2000-2018.

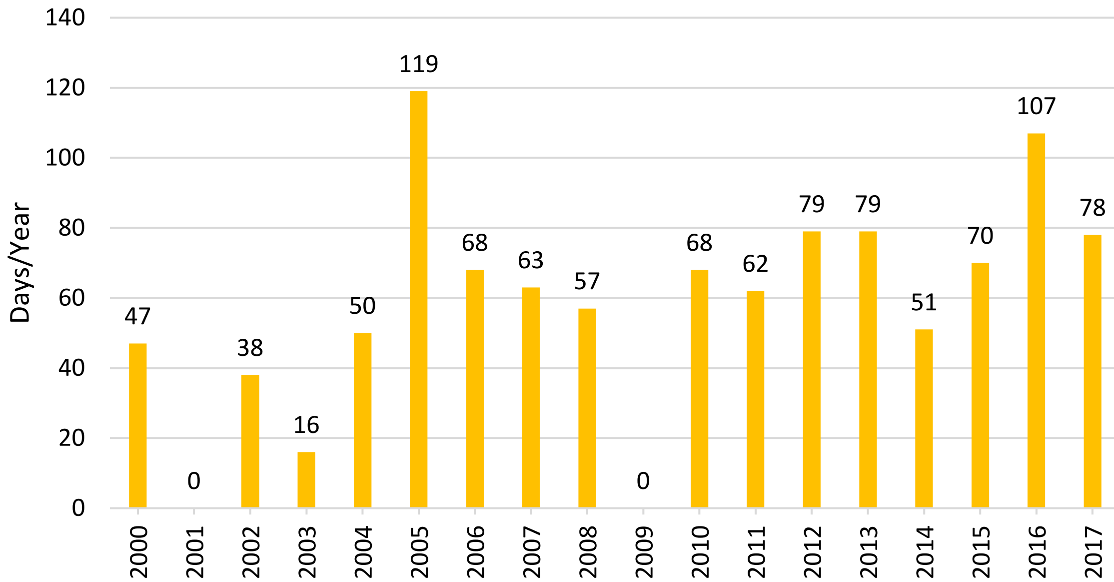

Figure 16. Number of days per year with detectable concentration of 2-Methylisoborneol in raw water at the Beaver Water District intake

3.4.7 Nutrients

Primary productivity, autochthonous growth of organic matter, is limited by many factors, but the importance of nitrogen and phosphorus has been long recognized (Wetzel, 2001). The limiting nutrient is the nutrient in least supply with respect to plant needs. Addition or deletion of the limiting nutrient will have a direct impact on primary productivity. Arkansas does not have numeric limits for nutrients in surface water. Narrative limits are used instead. The standard is, “Materials stimulating algal growth shall not be present in concentrations sufficient to cause objectionable algal densities or other nuisance aquatic vegetation or otherwise impair any designated use of the waterbody” (APCEC 2004). Because nutrient concentration is related to organic material growth, and organic material, especially algae, are responsible for DBP and Taste and Odor issues at BWD, it is prudent to manage nutrients in the reservoir.

From October 2008 through December 2017, total nitrogen (TN) and total phosphorus (TP) data collected by the USGS in Beaver Lake near Hickory Creek (Figure 17) averaged 0.76 mg/L TN and 0.03 mg/L TP (Std. Dev. 0.48 and 0.03 respectively). These data were collected six feet below the surface of the lake. One limitation of the data was that the detection limit for TN ranged from 0.24-0.37 mg/L throughout the sampling period. There were 19 non-detects when n=106. To determine the average and standard deviation, data below the detection limit were assumed to be one-half of the detection limit. The mean TN/TP ratio was 28. When the TN/TP ratio is greater than 23, phosphorus is considered the limiting nutrient. The TN/TP ratio exceeded 23 in 58 of the 106-discrete sampling occurrences.

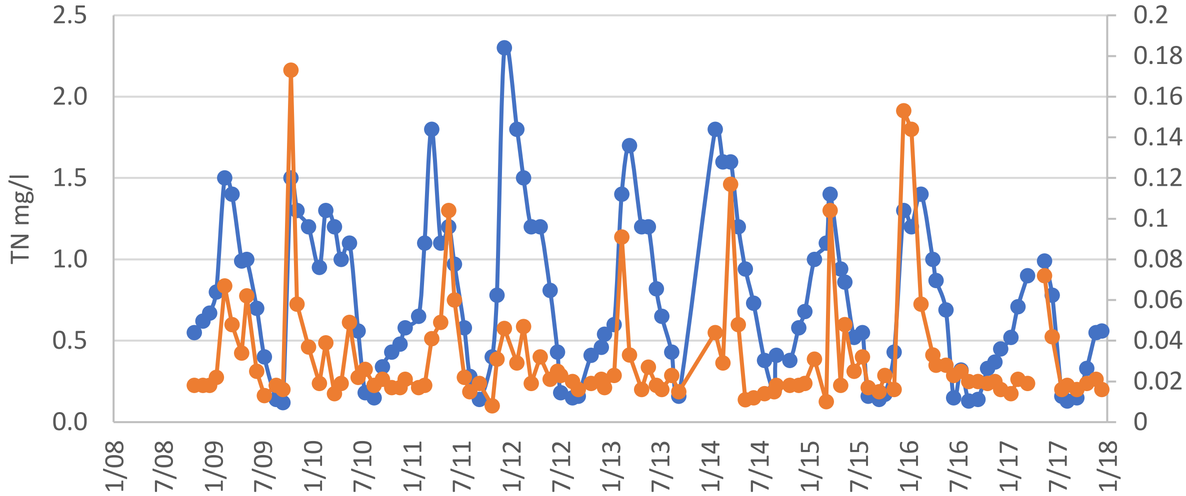

Figure 17. TN and TP data collected at the Beaver Water District drinking water intake

3.4.8 Alkalinity, Hardness, and Conductivity.

For the period of 2007 through 2018, alkalinity concentration at BWD's intake averaged 56.6 mg/L as CaCO3 (Std. Dev. 12.1 mg/L as CaCO3). The minimum recorded alkalinity was 20 mg/L as CaCO3 and the maximum was 84 mg/L as CaCO3 (Figure 18). Hardness concentration was similar, with an average of 62 mg/L as CaCO3 (Std. Dev. 10.7 mg/L as CaCO3), minimum 24 mg/L as CaCO3, and maximum 91 mg/L as CaCO3 (Figure 18). The daily average conductivity of raw water samples taken at BWD's intake for the period of 2007-2018 was 147.2 mS/cm (St. Dev. 24.6 mS/cm) with a range of 61 to 213 mS/cm (Figure 18). All three exhibited a similar trend with low points in spring to early summer and peaks in late fall to winter.

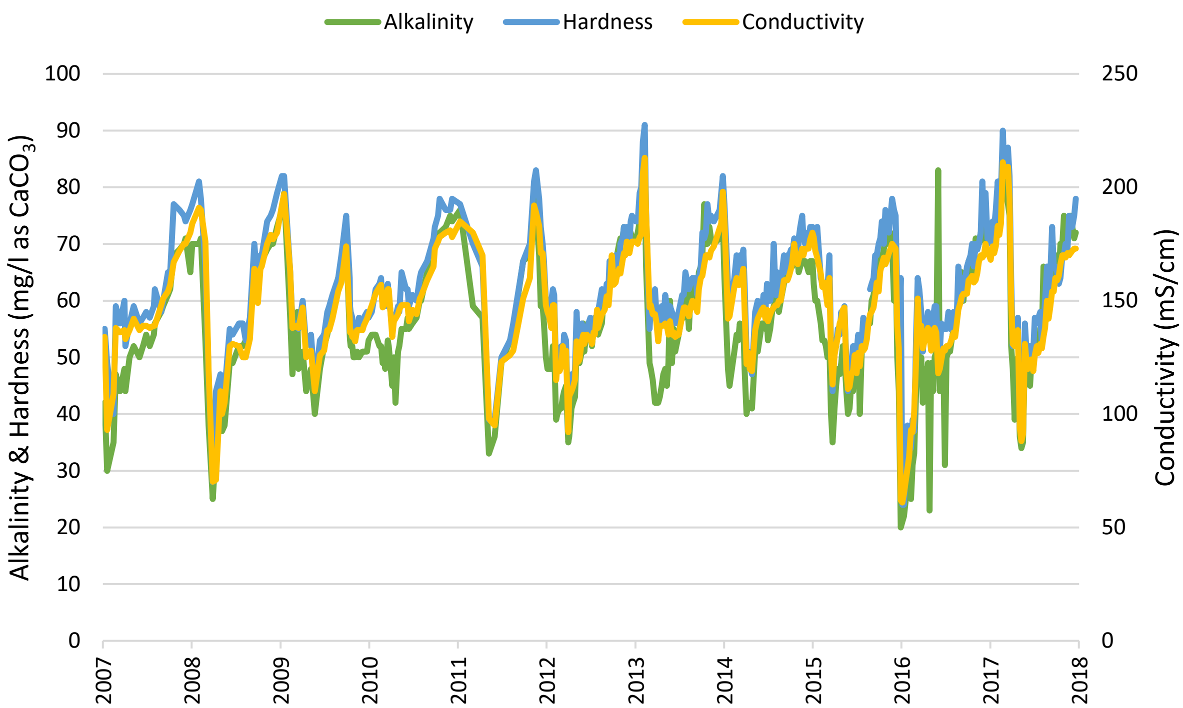

Figure 18. Conductivity, alkalinity, and hardness of samples taken at BWD's intake

3.4.9 Algae

Algae count data was available for 2010-2018 and was extremely variable. The concentration of total algae varied from practically none to over 27,000 cells/100 ml. The pattern of algae growth has not been totally clear (Figure 19). Concentration are low in the winter months, and then increase over the spring and summer. During some years, there were bi-modal peaks in algae concentration, with one peak during the spring and a second peak close to Labor Day. However, in other years, the bi-modal pattern did not appear.

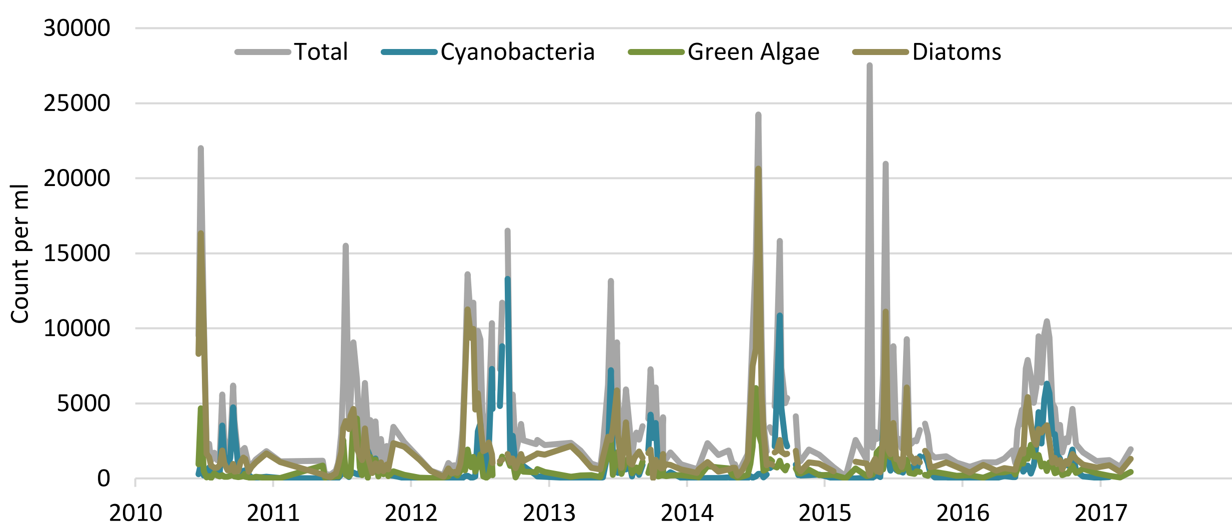

Figure 19. Total algae at various depths near the BWD intake

3.4.10 Trophic Status

A frequently used index of water quality for a reservoir is its trophic status. Trophic status is a way of measuring the organic content of a waterbody and is related to our water quality issues of increasing organic carbon and taste and odor. There have been four major studies of the trophic status of Beaver Lake since it was first filled in 1966. Bennett (1970) sampled six sites within the reservoir from 1968 through 1969. This period was near to the initial filling of the reservoir and there was still considerable pre-impoundment organic matter in the reservoir. Bennett's finding was that the reservoir exhibited eutrophic characteristics based on oxygen depletion and plankton production but that nutrient loading did not support that classification. However, reservoirs often exhibit bell shaped trophic curves throughout their lifespan. Their most productive times occur right after the reservoir is filled and all the organic matter from the river valley is inundated. This organic material forms the base of the trophic system. As this material is consumed, the reservoir becomes more oligotrophic.

The next major study was the National Eutrophication Survey (NES) that was conducted in 1974 (EPA 1977). The NES data for Beaver Lake indicates a mesotrophic to eutrophic lake, at that time, at the Beaver Water District Intake. In 1974, water quality at the dam site indicated a mesotrophic lake. There was a strong gradient in trophic status from upstream to downstream with the upstream being more eutrophic. In 1992, a Clean Lakes Study was conducted on the reservoir (Arkansas Department of Pollution Control and Ecology, 1992). The Clean Lakes Study found little change in trophic status from 1974 to 1992. At Beaver Water District's Intake, the status was mesotrophic and, at the dam, the status was oligotrophic to mesotrophic. Once again, the longitudinal gradient was exhibited. The final trophic study of the reservoir was by Haggard et al. (1999). Haggard et al. monitored over a two-year period. They found conditions to vary considerably from year to year. However, the overall finding was mesotrophic to eutrophic conditions in the upper end of the reservoir and oligotrophic conditions in the lower end.

3.4.11 Hypolimnetic Anoxia

Hypolimnetic anoxia (the absence of dissolved oxygen in the water column below the theromocline) is another indication of organic content of a reservoir. Studies as far back as 1968 (Bennett, 1970) have documented degradation of dissolved oxygen in the hypolimnion of the reservoir during summer months. In 2005, FTN reviewed data that Beaver Water District had collected from the hypolimnion in the reservoir and concluded that the period of anoxia was occurring earlier over time and lasted longer into the fall (FTN 2006).

3.5 Contaminant Source Inventory

Source water inventory includes identification of potential sources of contamination (PSOCs), characterization of land use/land cover in the watershed and the associated water quality impacts, and identification of significant point sources of contamination.

3.5.1 Potential Sources of Contamination

The Arkansas Department of Health has completed its source water assessment for Beaver Water District (ADH 2000). The ADH assessment considered various susceptibility zones that started with the first zone extending from 0 – 1 mile from the intake. Each successive zone covered and area one additional mile from the intake up to zone six, which was up to six miles away from the intake. A total of 1492 potential PSOCs were found within study area. The vast majority (1390) of the PSOCs identified were individual household waste water systems or septic tanks. County road bridges were the next most prevalent PSOC at 33, followed by chicken houses at 20. These data are maintained on file at BWD as “AHD Source Water Protection” in Administration’s central files.

The ADH assessment ranked the susceptibility of the source water to contamination. This susceptibility rating was not an absolute measurement, nor did it mean that contamination was or was not present. The susceptibility rating for Beaver Lake was low.

In addition to the AHD assessment, Beaver Water District contracted with the University of Arkansas’ Center for Advanced Spatial Technology to assess the entire Beaver Lake watershed for potential sources of contamination. 15,900 PSOCs were identified, as a result of the assessment, including 915 businesses, 1,827 poultry houses, 13,038 rural residences, 102 hog houses, and 18 non-residential septic systems. These data are maintained in GIS format in the Beaver Water District’s Water Quality Department laboratory.

3.5.1.1 PSOC Database 2008

During 2008, the District updated the PSOC database for that area within the Tier I and II SWP protection areas. All business PSOC’s were found by phonebook and internet searches. Trailer parks, apartment/motel, cemeteries, chicken houses, picnic grounds, sawmills, camps, boat ramps, and boat docks were obtained from the AR Highway and Transportation Department – All Cultural GIS layer from GeoStor. Septic tank data is from the rural buildings GIS layer from the AHTD. It was assumed all rural buildings had a septic tank. Septic tanks were only mapped in the SWP area. Storage tank data were obtained from Arkansas Department of Environmental Quality (ADEQ) storage tank database. All bridges and their locations were found by driving the SWP area.

All business PSOC’s and bridges within the SWP area were verified by ground checking. Most other PSOC’s in the SWP area were verified either by ground checking or from aerial photos. Some PSOC’s (i.e. rural structures, chicken houses, cemeteries, etc.) were mapped based on the assumption that the GIS layers were correct. Each PSOC in the SWP area was assigned a rank that took into account the relative public health significance and the likelihood for a release of contaminants to affect the source. There are ten categories with Category 1 considered the most significant and Category 10 being the least significant. The rank was assigned based on information provided by ADH (ADH 2000). Table 3 shows the breakdown of PSOCs by rank in the SWP area. The PSOCs outside of the SWP area were located using addresses and aerial photos.

Table 3. Hazard ranking of PSOCs within Beaver Water District's Tier II source water protection area.

PSOC Health Risk	Total Number
1	1
2	4
3	0
4	17
5	52
6	233
7	1
8	6
9	3017
10	33
TOTAL:	3364

3.5.1.1.1 Land use

Land use/land cover data were compiled by BWD using the National Land Cover Database from the USGS (citation) for the Beaver Reservoir watershed (outlet at the Dam, Table 4). The percentage of urban land use increased by 1% from 2001 to 2011 while forest decreased by 1%. Forest still remains the dominant land use within the watershed. Distribution of land use is not uniform over the watershed (Figure 20). The area immediately around Beaver Lake is primarily single family residences currently. Further out from the lake, land use becomes dominantly pasture with urban areas along the western boundary. To the south, as the topography becomes steeper, the pasture gives way to dominant hardwood forest.

Table 4. Land use/land cover in the Beaver Lake watershed from 2001 through 2011. Data are from the Arkansas GIS Gateway and processed in ArcGIS.

Year	Urban	Forest	Pasture	Other
2001	5%	61%	27%	6%
2006	6%	61%	27%	6%
2011	6%	60%	27%	7%

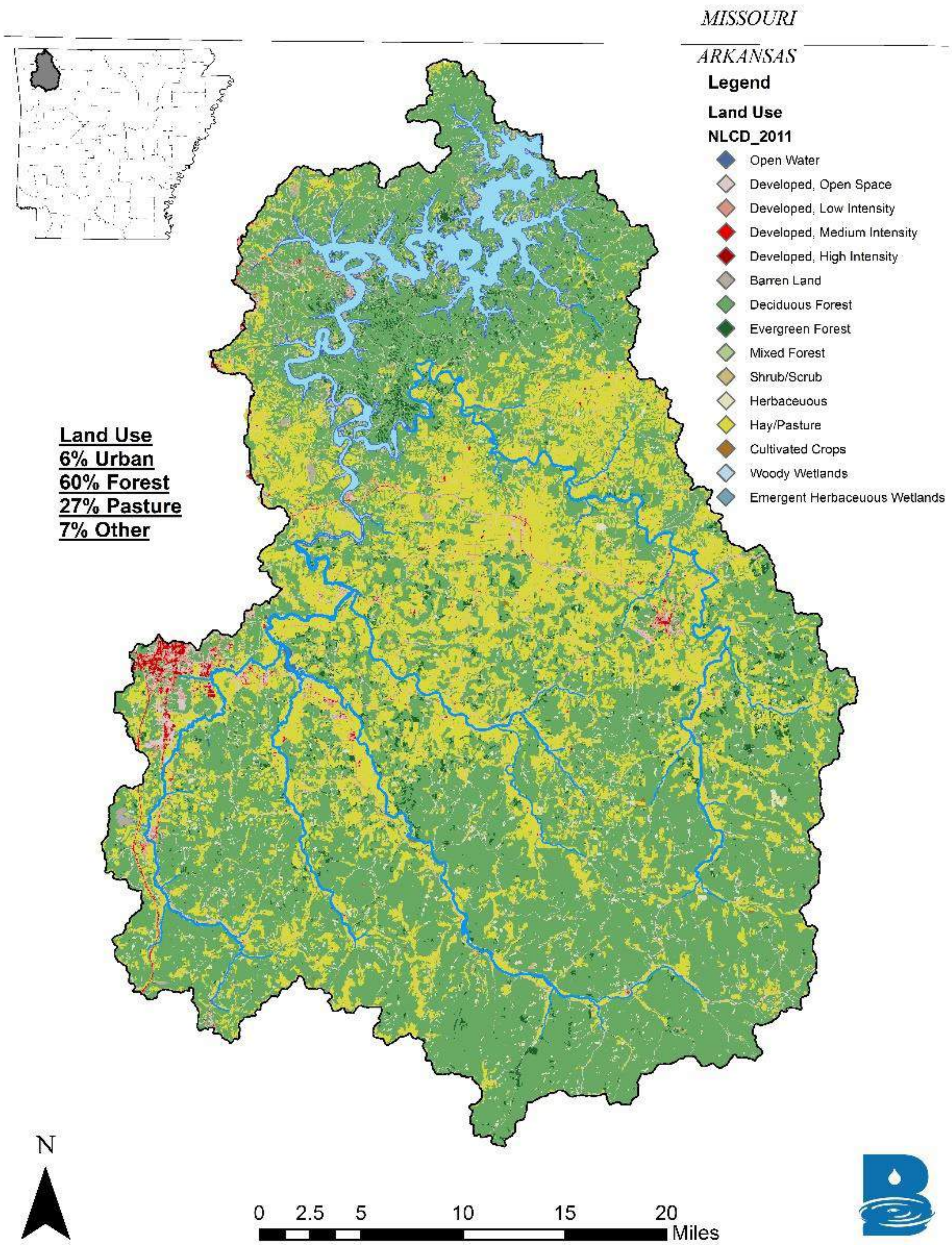

Figure 20. Distribution of land use over the Beaver Lake Watershed. Data are from the Arkansas GIS Gateway, 30 m coverage.

Two specific land uses have been shown to be problematic for the Beaver Lake Watershed, commercial poultry operations and cattle grazing. Feed and nutrients are imported to the region for the commercial production of poultry which has benefited cattle production through the enrichment of pasture using poultry manure. Over the decades, the regions pastures have become overloaded with phosphorus from the poultry manure, creating a nutrient surplus area. Pasture operations most influential on stream chemistry include those that are within the riparian zone of streams. The most highly concentrated areas of riparian pasture land use are contained within the central areas of the watershed (Figure 21). The concentration of poultry operations in the watershed (Figure 22) also overlap with many of these critical riparian pasture land uses. This creates zones where nutrient availability and transport conditions to the stream are optimized. It is not a coincidence that the areas of highest density in Figures 21 and 22 (orange to red) also see some of the highest concentrations of in-stream nutrients.

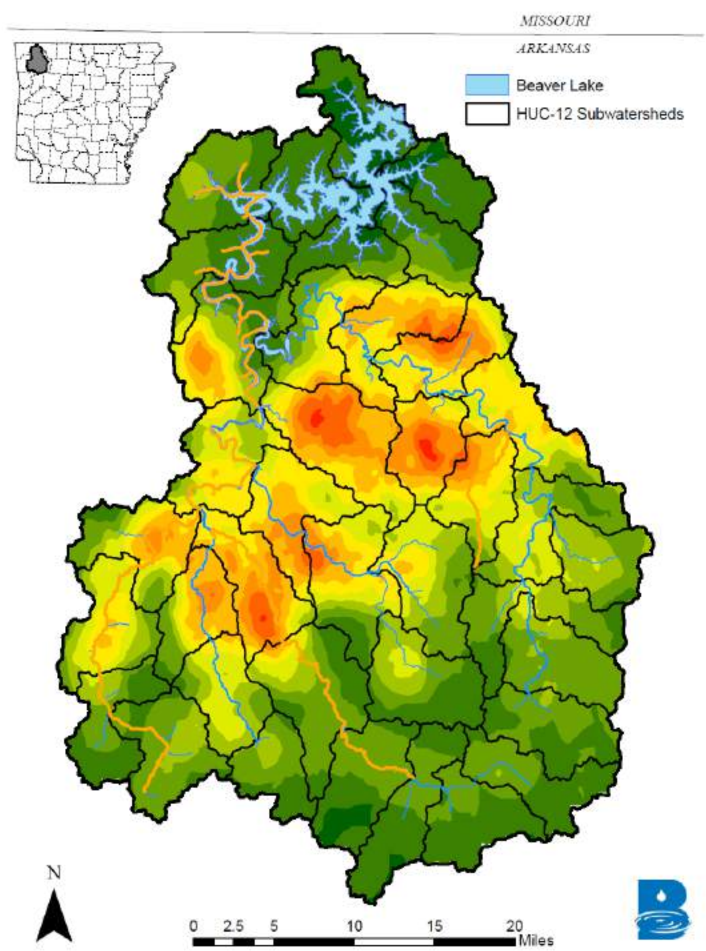

Figure 21. Map depicting areas with the high concentration of riparian areas dominated by pasture. Scale is green to red = low to high density.

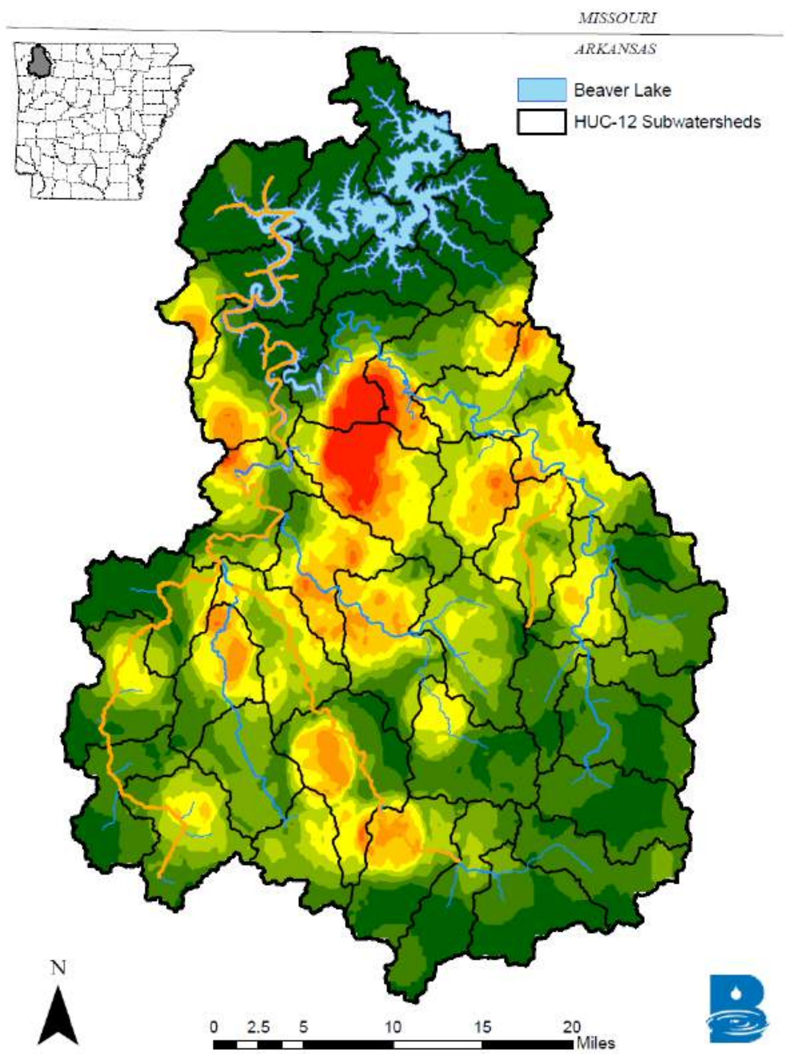

Figure 22. Map depicting areas with the high concentration of poultry production. Scale is green to red = low to high density.

The majority of land ownership is private (Figure 23). Public land is held by the US Army Corps of Engineers within the lake's takeline and by the National Forest Service in the extreme headwaters of the watershed. The State of Arkansas owns land in the Hobbs Wildlife Management Area, Beaver Lake State Park, and Withrow Springs State Park. Other public lands are small parcels held by the local municipalities.

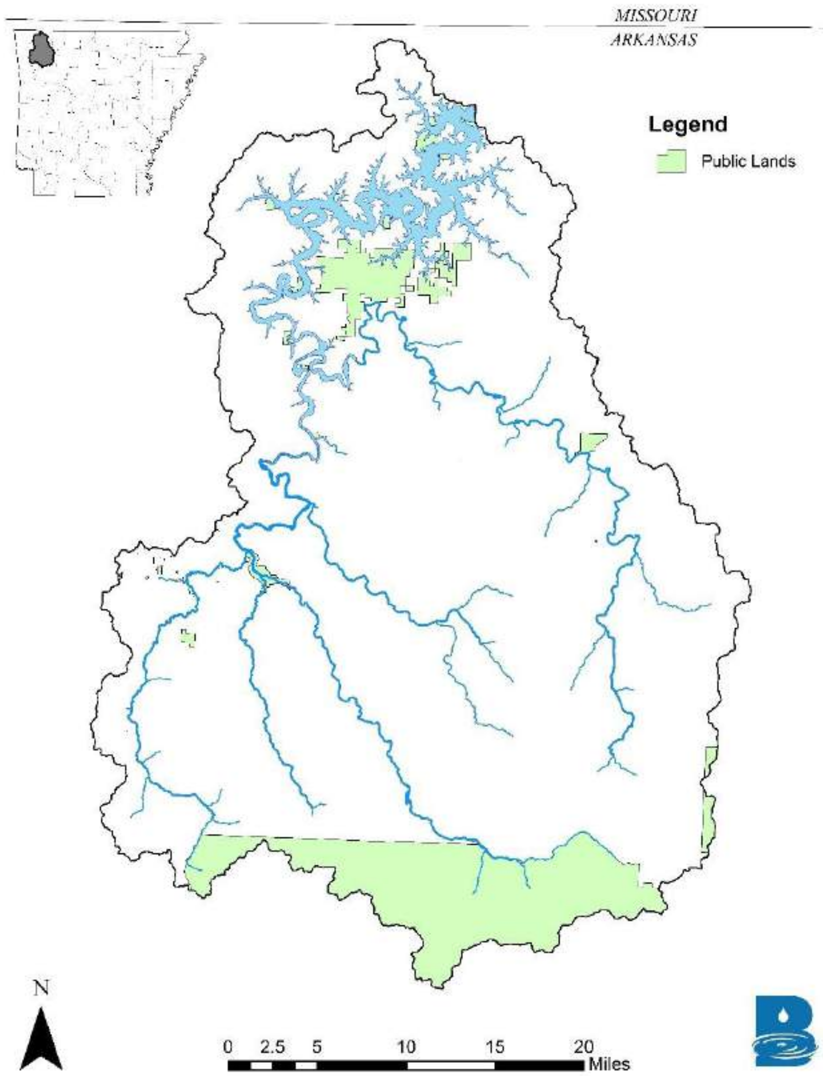

Figure 23. Public land ownership in the Beaver Lake watershed. Public land is shown in green.

3.5.1.1.2 Trends

A gradual conversion of forest to developed land is apparent in Table 4. The Carrollo Engineering Regional Growth Study (2005) confirms this trend of increasing development. Along with the conversion to developed land, it can be projected that the number of rural residences and county road crossings will increase accordingly. The majority of development within the watershed is anticipated to be along the western shoreline of Beaver Lake and within Washington County (Figure 1).

One apparent trend in rural development within the watershed is the use of decentralized wastewater systems in place of traditional septic tanks. If this trend is real, then higher density development can be expected within the more desirable areas. Higher density carries with it the potential for more nonpoint source pollution from lawns, streets, and parking lots and more severe consequence in the event of a system failure.

3.6 Existing Management Activities

Analysis of existing management activities was completed in 2009 by TetraTech and reported in the Watershed Protection Strategy (TetraTech, 2009). The conclusion was that, with existing management and the projected growth trend, Beaver Lake would see a 21% increase in sediment load and a 14% increase in phosphorus load over the next 40-year period.

Areas of concern in the TetraTech report were:

- strengthen the stormwater and erosion/sediment control programs of local jurisdictions and the AHTD (especially improved inspection and enforcement);
- improved oversight of on-site wastewater disposal; and
- lowering point source discharge limits.

Poultry nutrient regulations were thought to be adequate for the time being, but public review was needed. In addition, the report indicated that the region's stormwater education program was strong. The 2009 report also indicated that there was a need to increase the amount of land that is protected for conservation purposes, and to conduct a major stream and riparian zone restoration effort.

3.7 Regulatory Requirements

Beaver Lake and its watershed are subject to regulation from a wide array of jurisdictions including the Federal Government, State Government, County Governments, and Municipal Governments. Arkansas has received delegation of authority from the United States Environmental Protection Agency for implementation of both the Clean Water Act and the Safe Drinking Water Act. Lead agencies for the delegation of the Clean Water Act and the Safe Drinking Water Act are the Arkansas Department of Environmental Quality and the Arkansas Department of Health, respectively. This section reviews regulations pertinent to Beaver Water District's source water protection plan, starting at the federal level and working down through smaller units of government.

3.7.1 Federal Regulations

Federal agencies with authority relevant to the source water protection program are the United States Environmental Protection Agency (EPA), the United States Army Corps of Engineers (COE), the Department of Agriculture including the United States Forest Service (USFS), and the Natural Resources Conservation Service (NRCS).

3.7.1.1 United States Environmental Protection Agency

The EPA has the responsibility for promulgating drinking water regulations and standards at the federal level. The Safe Drinking Water Act is the primary federal law pertaining to provision of potable water for the public. Regulations promulgated by the EPA under the Safe Drinking Water Act that are pertinent to the source water protection program are:

- National Primary and Secondary Drinking Water Regulations (40 CFR sec. 141, 142, 143);

- Long Term 2 Enhanced Surface Water Treatment Rule;
- Stage 2 Disinfectants and Disinfection Byproducts Rule; and
- Underground Injection Control Program (40 CFR sections 144 - 147).

The EPA also has primary responsibility for implementation of the Clean Water Act and the Safe Drinking Water Act. Both laws are pertinent to the source water protection program. The Clean Water Act pertains to protection of surface and ground waters of the United States. The specific objective of the act is to protect the physical, chemical, and biological integrity of the nation's waters. Pertinent sections to the source water protection program are:

- Section 301 establishing effluent limitations;
- Section 302 establishing water quality related effluent limitations;
- Section 303 requiring States to develop ambient water quality standards, Section 305 requiring States to conduct biennial water quality inventories, Section 307 requiring toxic and pretreatment effluent standards;
- Section 312 establishing standards for marine sanitation devices, Section 313 setting standards for pollution control at federal facilities, Section 314, the clean lakes program;
- Section 319, nonpoint source pollution management;
- Section 402, the National Pollution Discharge Elimination System Program; and
- Section 404 (enforced by COE), Permits for dredged or fill material.

3.7.1.2 United States Army Corps of Engineers

The COE has primary responsibility for the operation and maintenance of Beaver Lake. The lake is operated in accordance with operating rules established by the United States Congress. Those operating rules are coordinated by the State Water Plan that is overseen by the Arkansas Natural Resources Commission (ANRC). In addition, the COE enforces provisions of the following sections of the US Code pertinent to the source water protection program:

- Title 36 of the US Code, Chapter 111, Part 327, Rules and Regulations governing public use of Corps of Engineers water resources development projects;
- Title 33 of U.S. Code, Chapter 1344 (Section 404 of the Clean Water Act): requiring permits for dredge and fill operations into non-tidal waters of the US; and
- Title 33 of the U.S. Code, Chapter 403 (Section 10 of the Rivers and Harbors Act of 1899) prohibiting obstruction or alteration of navigable waters of the US without a Department of Army permit.

3.7.1.3 Department of Agriculture; National Forest Service

The Ozark National Forest is a significant landowner, approximately 11%, in the Beaver Lake watershed. All national forests are managed in accordance with a forest plan. Forest Plans are required by the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA), as amended by the National Forest Management Act of 1976 (NFMA). The 1982 national forest planning process is described at Title 36, Part 219, Code of Federal Regulations (CFR). New regulations, NFMA 2004, were recently approved, but the Ozark-St. Francis National Forests 2005 plan revision was completed under the 1982 regulations. Forest plans are developed for 15-year periods, so the next revision will be for 2020.

3.7.1.4 Department of Agriculture; National Resources Conservation Service

The NRCS is responsible for providing technical assistance to local soil and water conservation districts, and for implementing provisions of the Federal Farm Bill. NRCS and its sister agency, the Farm Services Agency (FSA), implement conservation programs on individual farms in accordance with funding provided by the federal government through the current farm bill.

3.7.2 State regulations

State agencies with authority relevant to the source water protection program include the Arkansas Department of Environmental Quality, Arkansas Department of Health, Arkansas Department of Parks and Tourism, Arkansas Department of Emergency Management, the Arkansas Highways and Transportation Department, the Arkansas Natural Resources Commission, the Arkansas Game and Fish Commission, the Arkansas Livestock and Poultry Commission.

3.7.2.1 Arkansas Department of Environmental Quality (ADEQ)

According to their website, www.adeq.state.ar.us, the ADEQ strives to protect Arkansas' priceless natural resources - its air, water and land - from the threat of pollution. They do this through a combination of regulatory programs, proactive programs and educational activities. ADEQ is the designated agency in the State for implementation of the State's water quality management plan and the National Pollution Discharge Elimination System (NPDES) program. ADEQ enforces regulations established by the Arkansas Pollution Control and Ecology Commission. Regulations of the Department relevant to BWD's source water protection program are:

- Regulation # 1, Regulation for the Prevention of Pollution by Salt Water and Other Oil Field Wastes Produced by Wells in All Fields or Pools, effective March, 16, 1993;
- Regulation # 2, Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas as revised, effective November 25, 2007;
- Regulation # 4, Regulation to Require a Disposal Permit for Real Estate Subdivisions in Proximity to Lakes and Streams, effective July 7, 1973;
- Regulation # 5, Liquid Animal Waste Management Systems as revised, effective April 26, 2008;
- Regulation # 6, Regulations for State Administration of the National Pollutant Discharge Elimination System (NPDES), effective January 17, 2008;
- Regulation # 8, Administrative Procedures as revised, effective June 12, 2000, Regulation # 9, Permit Fee Regulations as revised, effective March 15, 2008;
- Regulation #12 (PDF File) - Storage Tank Regulations as revised, effective October 15, 2007; and
- Regulation #15 (PDF File) - The Arkansas Open-Cut Mining and Land Reclamation Code as revised, effective May 28, 2006;
- Regulation #17 (PDF File) - Arkansas Underground Injection Control Code, effective February 14, 2005;
- Regulation #22 (PDF File) - Solid Waste Management Rules, effective April 26, 2008, Regulation #23 (PDF File 3.5mb) - Hazardous Waste Management as revised, effective May 26, 2008;
- Regulation #29 (PDF File) - Brownfields Redevelopment as revised, effective March 3, 2006;
- Regulation #30 (PDF File) - Arkansas Remedial Action Trust Fund Hazardous Substances Site Priority List, effective December 16, 2005; and

- Regulation #34 (PDF File) – State Water Permit Regulation, effective August 26, 2011.

3.7.2.2 Arkansas Department of Parks and Tourism (ADPT)

The ADPT manages property in the Hobbs State Park jointly with the Arkansas Game and Fish Commission and the Withrow Springs State Park. Both properties lie completely within the Beaver Lake watershed. Withrow Springs State Park is completely within the Tier III Source Water Protection area as defined above. The Hobbs State Park has property that falls within the Tier III SWP area and a very small area within the Tier II area, but most of the property is several miles downstream of BWD's Intake.

3.7.2.3 Arkansas Department of Health (ADH)

The ADH is the state agency that is responsible for implementation of the Safe Drinking Water Act within the state. In addition, the ADH has certain other authorities related to plumbing and sanitation practices. The following list gives pertinent rules and regulations related to the source water protection program:

- Rules and Regulations Pertaining to Public Water Systems, Effective January 11, 2007 (http://www.healthyarkansas.com/eng/pdf/pwsregsfinal.pdf);
- Rules and Regulations Pertaining to Onsite Wastewater Systems, Designated Representatives and Installers, Effective December 16, 2006 (http://www.sosweb.state.ar.us/elections/elections_pdfs/register/nov-dec_06/016.24.06-009.pdf);
- Rules and Regulations Pertaining to Mobile Home and Recreational Vehicle Parks, Effective April 1, 2008 (http://www.healthyarkansas.com/rules_regs/mobile_home_parks.pdf); and
- Rules and Regulations Pertaining to General Sanitation, Effective November 1, 2000 (http://www.healthyarkansas.com/rules_regs/general_sanitation.pdf).

3.7.2.4 Arkansas Game and Fish Commission (AGFC)

Regulations of the Arkansas Game and Fish Commission do not directly apply to BWD's source water protection program. However, the AGFC has joint responsibility for management of the Hobbs State Conservation Area within the Beaver Lake watershed. AGFC also manages the Beaver Lake Nursery Pond that is adjacent to Beaver Lake, but downstream from the BWD Intake.

3.7.2.5 Arkansas Department of Emergency Management (ADEM)

(Arkansas Code Annotated (ACA) 1275101 et al) directs the Arkansas Department of Emergency Management to maintain a management system that effectively and efficiently provides mitigation of and recovery from the effects of natural and man caused disasters. This goal is accomplished through a series of programs designed to identify all disasters threatening the State; assist state agencies, local governments, volunteer and other organizations in determining the means to mitigate disaster effects; develop procedures for fast and efficient deployment of identified resources to effectuate mitigation and recovery; continually exercise all plans, evaluate results and make modifications to ensure procedures are effective; and, coordinate the efforts of all organizations responding to disasters.

3.7.2.6 Arkansas Highway and Transportation Department (AHTD)

The AHTD maintains standards for State Highway construction, including erosion and sediment control, spill prevention, and site stabilization practices.

3.7.2.7 Arkansas Livestock and Poultry Commission (ALPC)

The mission of the ALPC is, "to safeguard human and animal health, assure food safety and quality, and promote Arkansas livestock and poultry industries for the benefit of our citizens." ALPC is not a primary environmental agency. However, they regulate disposal of on-farm mortality that may become a water quality issue if not properly managed.

3.7.2.8 Arkansas Natural Resources Commission (ANRC)

The mission of the ANRC is, "To manage and protect our water and land resources for the health, safety and economic benefit of the State of Arkansas." In fulfillment of this mission, the ANRC has a number of regulations relevant to the source water protection program including:

- Regulation # 3, Rules for Utilization of Surface Water;
- Regulation # 5, Administrative Rules and Regulations for Financial Assistance;
- Regulation # 6, Rules for Water Development Project Compliance with the Arkansas Water Plan;
- Regulation # 8, Rules Governing Water Rights Investigations;
- Regulation # 9, Rules and Procedures for Claiming Tax Credit;
- Regulation #10, Rules Governing the Arkansas Water Resource Cost-Share Program;
- Regulation # 11, Rules Governing the Surplus Poultry Litter Removal Incentives Cost-Share Program;
- Regulation # 12, Rules Governing the Arkansas Wetlands Mitigation Bank Program;
- Regulation # 13, Rules Governing the Tax Credit Program for the Creation and Restoration of Private Wetland and Riparian Zones;
- Regulation # 14, Rules Implementing the Water Resource Conservation and Development Incentives Act;
- Regulation # 15, Rules Governing Loans from the Safe Drinking Water Fund;
- Regulation # 16, Rules Governing the Arkansas Clean Water Revolving Loan Fund Program;
- Regulation # 17, Rules Governing Water Authorities;
- Regulation # 22, Nutrient and Poultry Litter Application and Management Program; and
- Regulation # 23, Rules Governing Water and Wastewater Project Funding through the Arkansas Community and Economic Development Program.

3.7.2.9 Local County and Municipal Regulations

In Arkansas, land use and development regulations rest at the county and municipal level. An inventory of local regulations is attached as Appendix D to this report. Regulations change rapidly, so this inventory is only correct as of the date of its completion.

A summary of rules and regulations in effect as of 2009 was compiled and included in the Beaver Lake Watershed Protection Strategy (TetraTech, 2009). Beaver Water District's Environmental Attorney monitors state and federal regulation updates. The Water Quality Department monitors agenda for municipal planning commissions and county planning boards to stay abreast of changes to local land use regulations.

3.8 Source Water Stakeholders

The Beaver Watershed Alliance (BWA) was formed in March 2011, after roughly two years of meetings to develop a watershed management strategy and to generate by- laws for the group. The Alliance represents stakeholders from agriculture, government, education, business, utilities, conservation, development, and technical communities. The purpose of the Alliance is to implement voluntary components of the Watershed Protection Strategy that was completed as a project of the Northwest Arkansas Council in 2009. The BWA is the primary stakeholder coalition within the Beaver Lake Watershed.

The oldest stakeholder group in the Beaver Lake watershed is the Association for Beaver Lake Environment (ABLE) that has existed since 1980. ABLE has played an important role in developing both the Beaver Lake Watershed Protection Strategy and this Source Water Protection plan. ABLE's mission is:

"To do any and all things necessary and convenient to promote the general welfare, development and environment of the areas surrounding Beaver Lake; and specifically to work with local, state and federal planning commissions, and regulatory agencies to assure that land development in the Beaver Lake area does not result in a deterioration of Beaver Lake water quality and/or living conditions in the area surrounding Beaver Lake."

Beaver Water District also considers those institutions that have a direct involvement in provision of safe drinking water to Northwest Arkansas as stakeholders in its source water protection effort. These institutions include state and federal agencies, our customer cities, three sister utilities that use Beaver as their source water, local research institutions, and other program collaborators.

State and federal agencies with responsibility for resource management were listed in the preceding section, Regulatory Requirements. BWD maintains working relationships with personnel in each of these agencies.

BWD's customer cities include Bentonville, Fayetteville, Rogers, and Springdale, Arkansas. BWD's administration meets periodically with representatives of the water utility from these cities. The purpose of these meetings is to discuss issues related to delivery of water to their customers, including source water protection.

In addition to BWD, the Benton and Washington County Water Authority (Two-Ton), Carroll Boone Regional Water District, and Madison County Regional Water District use Beaver Lake as the source for their raw water. BWD administration meets quarterly with personnel from Two-Ton and Carroll Boone Regional Water Districts. In these meetings, issues related to water supply and treatment are discussed. Source water protection is a frequent topic for discussion at the meetings. Currently, Madison County Rural Water District has elected to not attend these meetings.

The primary research institutions in the Beaver Lake region are the University of Arkansas and the United States Geological Survey (USGS). BWD maintains an ongoing cooperative research program with the University of Arkansas through the Arkansas Water Resource Center. Meetings are held annually to discuss research needs for Beaver Lake and potential funding sources for that research. BWD also executes an annual joint funding agreement with the USGS for monitoring and modeling of water quality in Beaver and its tributaries.

Within the four county area encompassing the Beaver Lake watershed are several additional organizations with missions complementary to BWD's Source Water Protection vision. BWD maintains active relationships with these partners and conducts cooperative projects wherever possible. These organizations include:

- Upper White River Basin Foundation (Ozark Water Watch or OWW);
- West Fork Environmental Protection Association;
- Illinois River Watershed Partners (IRWP);
- The Multi-Basin Watershed Authority;
- Audubon Arkansas;
- The Watershed Conservation Resource Center (WCRC);
- Fayetteville Natural Heritage Association (FNHA);
- Local Soil and Water Conservation Districts;
- Local Farm Bureaus; and
- Other ad hoc committees.

In addition to these stakeholder organizations, individual businesses or industries may have interest in the quality and quantity of water available from Beaver Water District. These businesses and industries include agriculture, recreation, food processing industries, high water use industries, medical care facilities, real estate developers, and construction.

3.9 Security Planning

The District contracted with MWH, Inc. in 2003 to conduct a vulnerability analysis of the District's facilities. This document is on file with the United States Environmental Protection Agency and is classified. The District, also in 2009, evaluated potential natural and man-caused disasters and appropriate response. The results of the analysis are included in our "No-regrets Source Water Plan" (Appendix E).

3.10 Vulnerability Assessment

During 2000, the Arkansas Department of Health (ADH 2000) completed a vulnerability assessment of Beaver Lake as a portion of BWD's Source Water Assessment. The vulnerability assessment considered factors including land use/land cover, soils, channel slope, reservoir volume, water withdrawal rate, and history of contaminant events. The overall rating in the susceptibility analysis was "Low" (Appendix F). With revision of the source water protection area in 2009, BWD updated that analysis. The susceptibility rating remains at "low."

3.11 Emergency Response

Beaver Water District's Emergency Response Plan was completed by AssureCo (Three Financial Center, Little Rock, AR), October 10, 2003. Each department supervisor has been given a copy of this plan. The emergency response plan was developed in accordance with the Public Health Security and Bioterrorism Preparedness and Response Act of 2002. This plan describes the actions facility personnel must take in response to fires, explosions, or any unplanned, sudden, or non-sudden release of hazardous materials or hazardous materials constituents to air, soil, or surface water at the facility. Any chemical spill that occurs within 2000 feet of the District's source water is covered by this plan and is treated as a level IV emergency. In level IV events, the emergency response coordinator (ERC) will be either the District's Chief Executive Officer or the Chief Operating Officer.

Off-site incidents are significantly different to on-site. Of primary importance is that the emergency response coordinator (ERC) will most likely be non-District personnel either from the County Sheriff's department, local municipal police department, the Arkansas Department of Environmental Quality, or the Arkansas Emergency Management. BWD's role in off-site emergencies will be to offer technical assistance to the ERC and to inform plant operators if a danger to the water supply exists.

BWD has, in its water quality laboratory, a Hach DR850 portable spectrophotometer that includes over 50 methods for water quality analysis. When deemed necessary, District personnel will secure permission from the site ERC to sample water and will submit results to plant operators. Safety protocol will be followed at all times as outlined in the District's "Emergency Water Sample Collection Plan" (Appendix H).

A listing of off-site contacts that may be required during an emergency is provided on page 12 of the Emergency Response Action Plan.

After each significant water quality event, the Manager of Environmental Quality and the Environmental Technicians will meet to evaluate the District's response. A report on the event will be prepared and submitted to the COO. This report will include at a minimum:

- The date of the event
- Location of the event
- How the District was notified of the event
- Evaluation of the event including
    - Material or materials spilled
    - Quantity
    - Location
    - How the spill occurred,
    - Responsible party
- Summary of BWD actions taken

Event reports will be kept on file at Beaver Water District in accordance with the District's document retention policy.

3.12 Health and Safety

Procedures for protection of District personnel during emergency sampling events, as well as during routine water quality sampling, are included in our “Emergency Water Sample Collection Plan” (Appendix H), our “Chemical Hygiene & Laboratory Safety Plan” (Appendix G) prepared in 2009, and our “Sampling Standard Operating Procedures” (SOP) that are on file in the water quality laboratory and which are updated annually. These SOP’s include protocols for sampling of tributary sites and lake sites, including samples taken from the shoreline, from the District’s sampling boat, wading, and on the highway. Procedures also include the proper handling and storage of chemical reagents.

BWD also requires the use of proper personal protective equipment (PPE) at all times. PPE for field sampling situations is outlined in the health and safety manual. PPE is provided by the District for each person engaged in field sampling. It is the responsibility of field personnel to inform the laboratory supervisor when PPE must be replaced or repaired.

3.13 Periodic Update

This is the third review and update of the source water assessment. Updates of the source water assessment will be made as more current land use/land cover data become available from the State.

4 Program Goals

4.1 Water Quality Goals

In keeping with the vision of this program, the water quality goal is to maintain water quality in Beaver Lake such that conventional water treatment will adequately meet all state and federal requirements. To meet this goal, BWD must assure that:

- Chlorphyll-a concentration in Beaver meets or exceeds the proposed ADEQ criteria of less than 8 ppb from samples taken over the thalwag of the reservoir at Hickory Creek recreation area. This concentration is to be measured as the geometric mean of samples taken 1 meter below the surface, during the growing season of May through October (FTN Associates, Ltd, 2008);
- Secchi transparency measured at Hickory Creek shall have an annual average of more than 1.1 meters (FTN Associates, Ltd, 2008);
- Coliform organisms in raw water at the Intake, based on the monthly arithmetical average, shall not exceed 5,000 per 100 ml. in any month; nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per 100 ml. in more than 5 percent of such samples (ADH 2010 Rules & Regulations Pertaining to Public Water Systems); and
- Total Organic Carbon concentration in raw water at BWD’s intake shall not exceed 4 mg/l (ADH, Arkansas Public Water Compliance Summary).

4.2 Programmatic Goals and Strategies

Programmatic goals and strategies for BWD's source water protection program were set by the District's Water Quality Department in consultation with our stakeholders, the District administration, and the District's Board of Directors (Table 5). Many of these strategies are directly taken from the Beaver Lake Watershed Protection Strategy (TetraTech, 2009). That strategy has been adopted by the Beaver Watershed Alliance as its guidance document. The remainder of the strategies were developed to meet the District's responsibility for providing safe and sufficient drinking water for our customer cities.

The District's Board of Directors reviewed and approved these goals and objectives during its April 2012 meeting.

Table 5: Programmatic Goals and Strategies of Beaver Water District's Source Water Quality Program, as approved by the Beaver Water District's Board of Directors, April 2012.

Source Water Protection at Beaver Water District		
Vision Beaver Water District will lead the citizens, businesses and communities of Northwest Arkansas to cooperatively maintain the quality of Beaver Lake for all generations.		
Goal 1 Protect Public Health Strategies • In-lake monitoring • Emergency response • Coliform management • Disinfection Byproduct management • Research	Goal 2 Maintain Water Quality Strategies • Tributary monitoring • Watershed protection strategy • Regulatory compliance • Watershed Protection Advocacy • Research	Goal 2 Community Leadership Strategies • Stakeholder involvement • Public awareness • Tech. and Financial Assistance • Planning • Adaptive Management

5 Action Plan

The Action Plan consists of two elements; actions to be initiated by personnel at the Beaver Water District (included in this Source Water Protection Plan), and actions to be initiated by our partners and stakeholders and included in the Beaver Lake Watershed Protection Strategy (Available at: http://www.beaverwatershedalliance.org) (TetraTech 2009). Short and intermediate-term action items (Table 6) for initiation by Beaver Water District were developed by District personnel after consultation with stakeholders and District leadership. These items are for implementation during the period of 2013 through 2018. At the April, 2012 meeting of the Beaver Water District Board of Directors, the Board reviewed and approved the plan for implementation.

Every five years, the District will review and update the District's Source Water Protection Action Plan. Longer term action items include review and update of the Beaver Lake Watershed Protection strategy during the 2018-2023, period and securing additional allocation for water supply out of Beaver Lake during the 2030-2050 time period. The full action plan is included in appendix A.

6 Implementation

Beaver Water District has an effective delivery system for its source water protection program. As of 2018, the program has been staffed with seven full-time equivalents with an annual budget of approximately $350,000. The District also has a source water protection fund, which allocates 0.04 cents per every thousand gallons sold toward source water protection activities. The fund was passed in 2016 with the full support of the BWD board.

In addition to the water quality department, support to the program is provided by the Staff Attorney and the Director of Public Affairs. BWD has full capability in the areas of watershed and reservoir monitoring, hydrologic and watershed modeling, GIS, laboratory analysis, public awareness/education, and policy analysis.

6.1 Watershed Management Planning

Beaver Water District was one of several partners funding development of the Northwest Arkansas Council's Beaver Lake Watershed Protection Strategy (Appendix I, TetraTech, 2009). Water Quality Department personnel provided technical expertise and data to the Council's consultant to assist in development of a scientifically based management policy. The Watershed Protection Strategy was adopted by the Beaver Watershed Alliance as its action plan at the May 2012 meeting of the BWA Board. The Watershed Protection Strategy has been submitted to the Arkansas Natural Resources Commission as a nine-element watershed protection plan for nonpoint source pollution project implementation. When approved, the strategy will be the first approved watershed management plan in Arkansas.

6.2 Public Awareness

The Water Quality and Public Affairs Departments cooperate with local organizations including the Beaver Watershed Alliance, Watershed Conservation Resource Center, Arkansas Water Resources Center, Northwest Arkansas Land Trust, Hobbs State Park, the University of Arkansas Cooperative Extension Service, and several regional non-profits to promote public awareness about Source Water Protection within the Beaver Lake Watershed and BWD's service area.

6.2.1 Secchi Day on Beaver Lake

A citizen science event and water science festival co-sponsored by BWD, Beaver Watershed Alliance, the U.S. Army Corps of Engineers and a host of other partners. This event involves over 30 water quality monitoring teams measuring Secchi depths and collecting water samples, and also provides public awareness activities for the general public. Attendance typically ranges from 550-700 people.

6.2.2 Watershed Educational Materials

BWD produces an informative, educational map depicting Beaver Lake Watershed, source water streams and sub-watersheds, Beaver Dam and Lake history, a timeline of Northwest Arkansas Public Water Supply Development, Bioindicators of Water Quality, and Watershed Characteristics and Best Management Practices, as well as points of interest (for example: Beaver Dam, Devil's Eyebrow, Hobbs and Withrow Springs State Parks, Kessler Mountain Reserve and Outdoor Education Classroom, and U.S. Army Corps of Engineers Lakeside Recreational areas). A Low Impact Development Guide and bi-lingual (English-Spanish, English-Marshallese) materials, such as Beaver Lake Watershed Passports and Water Fun Facts Coloring Books, are also available in our Water Education Center and for distribution at schools and public outreach settings. The Water Education Center houses a dedicated Watershed Learning kiosk, as well as a wall-sized Beaver Lake Watershed Map.

6.2.3 Beaver Lake Watershed Events, Activities, and Programs

BWD cooperates with the Beaver Watershed Alliance and other entities in a variety of events, activities, and programs that raise awareness of the importance of water and maintaining natural places throughout the Beaver Lake Watershed. Best Management Practices (BMP) activities entail lake and stream cleanups, removing and replacing non-native invasive plants with native plants that improve habitat and contribute to source water protection, rain garden installation and maintenance, and the Beaver LakeSmart Program – all of which provide public education and outreach to both youth and adults at local outdoor venues and partner organizations' facilities. Events include, but are not limited to, War Eagle Appreciation Day at Withrow Springs State Park, Hobbs State Park Cleanup in conjunction with Lakes Appreciation Month, Hobbs State Park and Ozark Natural Science Center Youth Education, U.S. Army Corps of Engineers Beaver Lake Cleanup, the Annual Kessler Trail Run, and Sub-Watershed Cleanups.

6.2.4 BWD Website and Social Media

The District website (www.bwdh2o.org) contains topical webpages dedicated to Beaver Lake Water Quality and Source Water Protection, as well as links to other organizations with water quality information. Social media, such as Facebook, Twitter, and Linked In, work in tandem with the website to expand reach in cross-promoting source water protection awareness, education, and events.

6.2.5 Public Relations Education and Marketing Campaigns

The Public Relations and Water Quality Departments partner to facilitate public awareness campaigns related to Beaver Water District's Source Water Protection Plan and efforts. Public service announcements and related collateral are brought to the general public and targeted audiences via broadcast, digital, and print media. Past examples include Lake Minutes and the Bacteria Awareness Education Campaign (a.k.a. "Quack Campaign").

6.2.6 Speaker's Bureau

Water Quality Department and other District personnel make presentations to interested local groups regarding water quality and Beaver Lake. Presentations are often scheduled through the Public Affairs Department and presented at the earliest opportunity considering ongoing department duties.

6.3 Information and Education

The BWD Water Education Center and Water Education Program provide a variety of field trip opportunities and lesson guides that meet K-12 Common Core and Next Generation Science Standards. The Water Education Program is designed to help citizens of all ages develop functional knowledge pertaining to the Science, Technology, Engineering, Art, and Math (STEAM) of water cycle, watershed hydrology and geomorphology, source water protection, and drinking water treatment. Beaver Lake serves as an immediately recognizable local reference for teaching universally relevant and applicable Watershed Dynamics & Water Quality concepts. BWD Water Education includes Water Education Center tours for the general public and students, activities, flyers, puppets, videos, maps of local watersheds that feed into Beaver Lake, working watershed models, “Where’s the Water” board games, water treatment career opportunities, videos, and much more. Water Treatment Plant tours are available to individuals 18 and older.

6.4 Technology Transfer

To improve water quality management in Northwest Arkansas, it is necessary to demonstrate appropriate technology to those that make policy and those that implement practices within the watershed. Beaver Water District utilizes demonstration projects to transfer appropriate technology to these persons. Current demonstration projects include rain gardens, riparian restoration, native plant restoration, and rain barrels. Fact sheets are developed and distributed from each demonstration project. Water Quality Department personnel developed a hands-on rain barrel construction workshop and delivered it to residents of the service area and watershed. Recently, the NW Arkansas Master Gardeners have taken over this program. We are seeking opportunities to expand the demonstration program to include agricultural and urban Best Management Practices.

In 2009, BWD occupied a new LEED certified Administration Center. The Administration Center includes numerous Best Management Practices such as, pervious pavement, bio-retention cells, rain water capture, water reuse, and native plantings. The interior of the Administration Center has watershed exhibits designed to improve knowledge of Beaver Lake’s source water.

6.5 Regulatory Compliance

Beaver Water District’s enabling legislation does not provide any regulatory authority to the District. Beaver Water District’s Staff Attorney regularly reviews proposed rules and regulations from both state agencies and local municipalities. The District works closely with local and state agencies to assure full implementation of rules and regulations that may help to protect Beaver Lake. Of particular interest at present (2018) is the third-party rulemaking process to establish a nutrient trading credit regulation. This regulation has the potential to offset point source discharges of nutrients with nonpoint source best management practices.

6.6 Contaminant Source Management

Beaver Water District’s Staff Attorney and Manager of Environmental Quality constantly monitor for notices of intent and applications for permits to discharge within the Beaver Lake watershed. When appropriate, comments are made regarding the potential source of contamination. BWD also monitor’s the planning commission agendas for the cities of Springdale and Fayetteville and Washington County for developments that might potentially impact Beaver Lake. Comments to the respective planning director are made when potential impact is noted.

Beaver Water District also strives to be proactive in protection of Beaver Lake. In 2018, the District continued its support for an innovative agreement with the City of Fayetteville whereby the City will continue to look for ways to mitigate nonpoint source nutrient loading to the lake in lieu of more restrictive nutrient limits on their NPDES permit. The agreement between the City and the District was included as a condition of the NPDES permit. The District also will work directly with developers, when requested, to help plan developments with the least potential impact to water quality.

Beaver Water District has an ongoing contract with the Watershed Conservation Resource Center (WCRC) to develop a streambank restoration bank in the White River watershed. This bank will provide funding for ongoing restoration of priority degraded banks. In addition, we have partnered with the WCRC to restore 1,600 feet of eroding stream bank along the West Fork of the White River. Eroding stream banks are the major source of sediment to Beaver Lake. This project has reduced the load of sediment to the Lake by hundreds of tons per year. BWD provided technical and financial assistance to the WCRC to enable completion of this project.

6.7 Conservation Priorities

Beaver Water District owns approximately 300 acres immediately surrounding the District's raw water intake. This area is maintained mostly in native forest. Approximately one-quarter mile from each side of the intake is protected by this land. Beaver Water District also supports the Northwest Arkansas Land Trust and the Ozark Regional Land Trust to conserve properties of environmental significance within the watershed. In this program, BWD provides funding to the land trusts for perpetual stewardship of conservation easements. Emphasis is placed on acquiring lands within riparian areas. Contributions to the stewardship funds are scaled according to the priority we place on them. The most funds go towards lands within our designated SWP area and within riparian areas.

In 2018, a subsequent priority map was developed by McCarty et al. (2018) that was based on land uses and their relationship to water quality. Land use indicators of water quality have been studied extensively in Beaver and other watersheds (Giovannetti et al. 2013, Haggard et al. 2007, Jones et al. 2001, Strayer et al. 2003). McCarty et al. (2018) paired average baseflow concentrations of NO_3-N, TN, SRP, and TP with catchment land use across five Arkansas watersheds. Beaver Lake was one of the watersheds used in the study. Four land uses were found to be most influential on water chemistry, forest, riparian forest, stream density, and poultry house density. Based on these findings, a priority map of HUC-12 subwatersheds is presented in Figure 24.

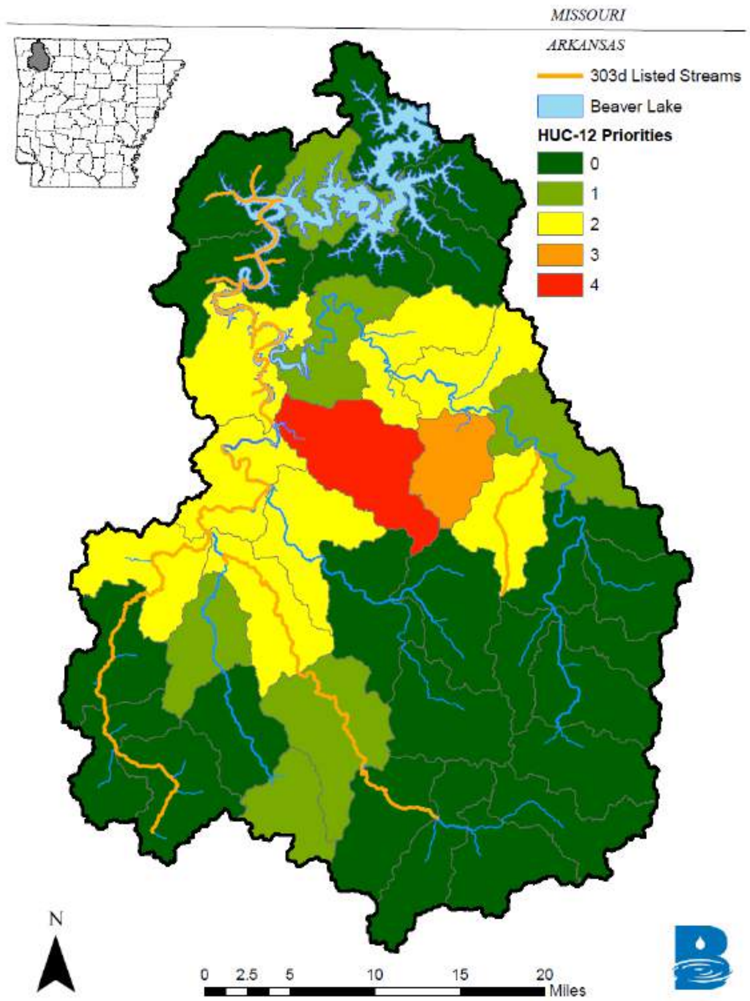

Figure 24. Priority areas for increased nonpoint source stream nutrient concentrations identified by McCarty et al. (2018).

6.8 RESEARCH

The Environmental Quality Department has a technically competent staff that can conduct various lake and water quality research. The goal of the department is to be self-sufficient in generating research with the result being that when we have specific question concerning the lake or watershed, we have the capability to address it. When we have limited capacity or technical experience, we use one of several partners including AWRC and the USGS. A research plan is included as part of the SWP plan in Appendix J. The plan outlines our research priorities for the next five years. It includes three main priorities, research concerning external loads of sediment and nutrients, internal loads of nutrients, and algae production and its treatment impacts.

7 EVALUATION AND REVISION

Each fiscal year, the Water Quality Department will make a report to the Board regarding progress in implementation of the Source Water Protection Plan. The Director of the Beaver Watershed Alliance will also make a similar report to the Board regarding the Alliance's activities and success. Each calendar year, the Water Quality Department will make a report to the Board and the public regarding water quality in Beaver Lake. Those reports provide basis for evaluation of the plan. Short-term modifications of the plan may be made at each funding cycle for the District. Long-term revision of the Source Water Protection Plan will be conducted roughly once per five years or when new land use/land cover datasets become available.

In the annual plan, specified reports to management are recommended. It is the responsibility of the Manager of Environmental Quality to submit these reports to BWD's administration. The annual strategic plan is used in preparation of the Department's budget, which is subsequently approved by the District's Board of Directors.

7.1 VERIFICATION

7.1.1 Document Retention

Beaver Water District has instituted a document retention policy for all departments. Critical documents regarding the source water protection program are maintained in the District's central filing system. These documents include minutes of board meetings, contracts and memoranda of agreement, summaries of stakeholder and focus group meetings, and regulatory compliance documents. The District's executive assistant is responsible for maintaining these files.

7.1.2 Technical Studies

Because of the proximity of Beaver Lake to the University of Arkansas, numerous technical studies are conducted on the lake each year. In addition, the District conducts studies of the reservoir as necessary for its planning purposes and federal agencies occasional study the reservoir. The Manager of Environmental Quality maintains a current bibliography of studies relevant to management of water quality in Beaver Lake.

7.1.3 Water Quality Data

Water quality data on Beaver Lake are available from the USGS, ADEQ, and Beaver Water District. USGS data are available on-line at: http://waterdata.usgs.gov/ar/nwis. ADEQ data are available on-line through EPA's STORET database. BWD's water quality data is maintained in its Laboratory Inventory Management System (LIMS) software. The LIMS software is a Microsoft Access application which allows retrieval of data through preprogrammed or custom queries. Data compiled by the District prior to acquisition of LIMS is maintained on the District's server in Microsoft Excel spreadsheets.

7.1.4 Water Quality Budget

The current budget for the Water Quality Department at Beaver Water District, exclusive of personnel, is $689,510 (2013). BWD's budget is developed by the staff and approved by the Board each August.

BWD's accounting system is audited by an external auditor annually. Copies of the audit may be obtained from the Chief Financial Officer.

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Appendix A: Source Water Protection Action Plan

Protect Public Health

Strategy: In-Lake Monitoring and Assessment

Strategic Objective: To maintain awareness of water quality and trends, to inform management programs, to alert staff to changing conditions

Measurable Indicator: Percentage of samples collected and passing QA/QC

Action	Objective	Measurable Indicator	Contract/Support	Status/ Start Date	FTE/Yr.	Funding Source	Estimated Annual Budget
Continue in-lake monitoring	To detect long-term trends in lake water quality and to inform lake management decisions	Completion of proposed sampling schedule	USGS	Ongoing	0.17	O&M	$145,000.00
Monitor for Algal Toxins	To provide advance warning to operations if algal toxins become an issue	Completion of quarterly sampling. Toxins discovered in lake before in finished water		Ongoing	0.07	O&M	$900.00
Monitor for Contaminants of Emerging Concern	To provide advance warning to operations if emerging contaminants become an issue	Completion of quarterly sampling. Contaminants discovered in lake before in finished water.	Eurofins	Ongoing		O&M	$3,000.00
Monitor Algal Population	To monitor for seasonal trends in algal populations and for conditions impacting nuisance growth	Identification of hotspots for algae growth	BSA Env.	Ongoing	0.23	O&M	$1,980.00
Algal Community Composition	To properly identify the algae community at multiple locations in the lake	Completion of report on seasonal fluctuation of algal species	Baylor	Ongoing	0.23	O&M	$1,980.00
Volunteer Monitoring Programs (Secchi Day and LakeSmart)	To track the long-term trend in transparency and quality within Beaver Lake	Collection of samples from all proposed sites each year	OWW	Ongoing	0.3	SWP	$11,250.00
In-Lake Water Quality Model (CE-Qual-W2 and IC-WATER)	To assess the impact of changing tributary load on in-lake water quality and to advice management in event of an emergency	Models can be updated and results compiled within 24 hours of request during time of emergency		2018 Scenario Update	0.29	O&M	
Annual Pollutant Load Report	To determine trends in the annual load to Beaver Lake of pollutants of concern	Load Reports are complete by Dec. 31 of each year	USGS	Ongoing	0.02	O&M	
Annual Water Quality Report	To review conditions in the lake, to evaluate trends, and to inform the public	The water quality report is completed by March 31 of each year		Ongoing	0.06	O&M	

Protect Public Health

Strategy: Emergency Response
Strategic Objective: To prevent and/or ameliorate the impact of inadvertent or intentional pollutant discharges.
Measurable Indicator: Percentage of incidents investigated

Action	Objective	Measurable Indicator	Contract/Support	Status/ Start Date	FTE/Yr.	Funding Source	Estimated Annual Budget
Re-evaluate No Regrets Plan	Ensure preparedness for emergency scenarios	Evaluate existing and potential new scenarios and update the Critical Priority Risk Index		Complete	0.03	O&M	
Event Response	To minimize the impact of an environmental event on delivery of potable water	Completion of after incident reports		Ongoing	0.03	O&M	
Table Top Exercises	To maintain staff preparedness	Completion and evaluation of annual table top exercise		Ongoing	0.01	O&M	
Update PSOC File	To maintain an accurate list of PSOC	Review existing, add new, and remove non PSOCs from the PSOC file	ADH	Complete	0.09	O&M	
Lake Spill Emergency Exercise	To equip emergency managers with the appropriate training for how to manage a lake spill or other emergency lake event, to maintain readiness, and to improve inter-agency emergency response	Completion of an emergency event response exercise	Benton Co. Emergency Management	2019	0.03	O&M	

Protect Public Health

Strategy: Coliform Management
Strategic Objective: To reduce violations of ADH criteria for bacteria concentration.
Measurable Indicator: Months exceeding ADH criteria for coliform bacteria at the Intake

Action	Objective	Measurable Indicator	Contract/Support	Status/ Start Date	FTE/Yr.	Funding Source	Estimated Annual Budget
Assess NPS Studies (Source Tracking, Septic, Optical Brighteners)	To determine the effectiveness of past efforts in helping to identify potential coliform sources	Report on their effectiveness and finding as they relate to coliform sources		2017	0.17	SWP	

Protect Public Health							
Strategy: Disinfection Byproduct Precursor Management							
Strategic Objective: To reduce organic content of Beaver Lake and prevent violation of ADH Disinfection Byproduct standards.							
Measurable Indicator: In-lake concentration of Total Organic Carbon							
Action	**Objective**	**Measurable Indicator**	**Contract/Support**	**Status/ Start Date**	**FTE/Yr.**	**Funding Source**	**Estimated Annual Budget**
Implement the Watershed Protection Strategy	To reduce the quantity of disinfection byproduct precursors in Beaver Lake water	See goal, "Maintain Water Quality"	BWA, ANRC	Ongoing	0.03	SWP	

Protect Public Health							
Strategy: Support Relevant Research							
Strategic Objective: To develop knowledge of basic processes affecting water quality in Beaver Lake and to develop management strategies							
Measurable Indicator: Peer reviewed papers published resulting from supported research							
Action	**Objective**	**Measurable Indicator**	**Contract/Support**	**Status/ Start Date**	**FTE/Yr.**	**Funding Source**	**Estimated Annual Budget**
Littoral P and Alum Study	Quantify internal loading from littoral zone	Three peer reviewed papers	USGS	2017-2018	0.38	SWP	$12,000.00
Cyanotoxin SPATT Resin Study	Characterize the amount of cyantoxins and their spatial variability in Beaver Lake	Peer reviewed paper documenting the objectives		2019	0.16	SWP	

Maintain Water Quality							
Strategy: Tributary Monitoring and Assessment **Strategic Objective: To maintain awareness of water quality and trends, to inform management programs, to alert staff to changing conditions, to maintain awareness pollutants entering Beaver Lake, to assess trends in water quality, and to inform decision making regarding watershed management.** **Measurable Indicator: Agreeable trends in water quality parameters measured at tributary sites**							
Action	**Objective**	**Measurable Indicator**	**Contract/ Support**	**Status/ Start Date**	**FTE/Yr.**	**Funding Source**	**Estimated Annual Budget**
Monitoring Program Evaluation	Assess the need for new/additional sites, usefulness of existing sites	Add new and remove old sites from sampling program		Complete	0.02	O&M	
New Gage Evaluation	Assess the need for new gauges	If new gages needed, implement plan to bring them online		Complete	0.01	O&M	
New Gage Installation and Support	Provide support to USGS for the installation of two new gages	Successful installation, rating curve, and calibrated streamflow, constituent, and rainfall data	USGS	Complete	0.01	O&M	$29,000.00
Support state funding of stream gaging and water quality monitoring (election years).	To reduce the direct cost to BWD for maintaining tributary gages	Amount of state and federal funding toward Beaver Lake tributary stations	BWD	Ongoing	0.01	O&M	
Maintain tributary gages and water quality stations	To maintain a system of stream gages sufficient to assess the quality and quantity of water flowing into Beaver at any time	Gages are sufficient to capture 70% of inflow into Beaver Lake and to estimate annual load	USGS	Ongoing	0.01	O&M	$30,000.00
StreamSmart volunteer monitoring	To evaluate the baseline condition of a wide-spread network of streams tributary to Beaver Lake	Number of stream sites successfully monitored by volunteer teams	OWW	Ongoing	0.03	SWP	$22,500.00
Regional High Resolution Aerial Photos	To assist with update of PSOC file and maintain current land uses inventory	Photos compiled biennially	NWARPC	Ongoing	0.01	O&M	$2,500.00
Targeted water quality monitoring (the long run)	Compile background data on base flow conditions in 7 tributary streams and to provide warning of changing conditions	Percentage of samples collected and passing QA compared to the potential number of samples	BWD	Ongoing	0.27	O&M	
Synoptic watershed surveys	Evaluation of current biological and physical condition of streams tributary to Beaver Lake	Collection of samples and completion of analysis	BWD, ADEQ	Ongoing, 2019 Rest Year	0.26	O&M	$5,000.00

Maintain Water Quality

Strategy: Implement the Watershed Protection Strategy
Strategic Objective: To maintain water quality in Beaver Lake and to restore all designated uses to stream reaches identified by ADEQ as "impaired".
Measurable Indicator: Number of Watershed Protection Strategy programs initiated

Action	Objective	Measurable Indicator	Contract/Support	Status/ Start Date	FTE/Yr.	Funding Source	Estimated Annual Budget
BWD Property Forest Management Program	A plan for effective forest management in BWD properties	Completion of forest plan	AR Forestry Commission	2017	0.01	SWP	
Support for BWA and BWA/BWD Cooperative program	Maintain or restore designated uses of streams tributary to Beaver Lake	Number of management practices implemented, Annual report to Board	BWA	Ongoing	0.15	SWP	$386,000.00
Farmland and forest conservation easements	To reduce the load of sediment and nutrients into Beaver Lake from the watershed	Acres of conservation easement acquitted by all parties	ORLT, NWARLT	Ongoing	0.03	SWP	$15,000.00
Landwise Program	Acquire land in SWP area for conservation easements	500 ac per year in conservation easements	NWARLT	Ongoing	0.04	SWP	$20,000.00
RCPP Planning and Design	Plan for the implementation of RCPP objectives	Complete enrollment to utilize all funds and design work complete	WCRC	2018	0.07	SWP	$100,000.00
Implement Forest Management Plan	Demonstrate the effectiveness of a forest management plan	Change in water quality for receiving streams	AR Forestry Commission	2019	0.03	SWP	$20,000.00
RCPP Streambank restoration and protection	To reduce the load of sediment and nutrients into Beaver Lake from eroding stream banks and streambeds	Lineal feet of streambank restoration completed	WCRC	2019-2022	0.31	SWP	$100,000.00

Maintain Water Quality							
Strategy: Regulatory Compliance							
Strategic Objective: To assure that existing regulations are adequately and fairly enforced.							
Measurable Indicator: Percentage of identified relevant violations processed by the appropriate authority.							
Action	**Objective**	**Measurable Indicator**	**Contract/Support**	**Status/ Start Date**	**FTE/Yr.**	**Funding Source**	**Estimated Annual Budget**
Construction BMP Training Pilot	Determine knowledge gaps in construction training	Report detailing the findings of the construction management survey	UAEX	Complete	0.01	SWP	$2,000.00
Construction BMP Training Implementation	Training program to improve construction BMP utilization	Some number of training sessions help per year	UAEX	Complete	0.01	SWP	$13,800.00
SWP Area surveys (Windshield Survey and LiDAR Imagery Analysis)	To reduce the number of violations of water quality regulations in the SWP Tier II area	Number of violations reported and resolved by the appropriate agency		Ongoing	0.06	OPM	
Support for increase enforcement staff at state/local agencies (even years)	To increase the capacity of enforcement agencies to find and correct regulatory violations	Number of inspectors in the four county area		Ongoing	0.01	SWP	

Maintain Water Quality							
Strategy: In-Lake Monitoring and Assessment **Strategic Objective: To increase our knowledge of watershed processes so that informed decisions on watershed management can be made by the appropriate officials** **Measurable Indicator: Number of peer reviewed publications produced.**							
Action	**Objective**	**Measurable Indicator**	**Contract/Support**	**Status/ Start Date**	**FTE/Yr.**	**Funding Source**	**Estimated Annual Budget**
Subwatershed Prioritization	Select priority subwatersheds for management and utilization of resources	Peer reviewed paper documenting the selection process		2017	0.2	SWP	
Subwatershed Prioritization Validation Study	Collect WQ data to validate the prioritization model	A successful validation of the model and selection or priority subwatersheds		2018	0.11	SWP	
AWRC Technical Advisory Committee	To have input into the AWRC's priorities for water research	Number of AWRC research projects relevant to Beaver Lake	AWRC	Ongoing	0.02	SWP	

Community Leadership

Strategy: Stakeholder Involvement

Strategic Objective: To gather input and support from a wide range of interests regarding source water protection

Measurable Indicator: Number of persons involved in various stakeholder groups

Action	Objective	Measurable Indicator	Contract/Support	Status/ Start Date	FTE/Yr.	Funding Source	Estimated Annual Budget
Participate in local and regional watershed partnerships	To generate synergy in local efforts and to assure consistent message	Number of joining projects implemented		Ongoing	0.03	O&M	
Customer City Meetings	To generate support in the customer cities for SWP programs and to communicate our SWP goals and objectives	Completion of annual SWP update and Q&A		Ongoing	0.01	O&M	
Sister Utility Forums	To generate support from our sister utilities for SWP programs and to communicate our SWP goals and objectives	Completion of annual SWP update and Q&A		Ongoing	0.01	O&M	
NWARLT Win/Win Workshop participation	To reach key stakeholders for participation and support of the SWP program	Number of attendees at focus group meetings, number of suggestions for program improvements	NWARLT	Ongoing	0.02	SWP	
Beaver Technical Advisory Group	Develop research agenda for the lake and watershed	Quarterly meetings to develop a multi-year research agenda		Ongoing	0.05	SWP	

Community Leadership

Strategy: Public Awareness/Education

Strategic Objective: To increase the knowledge base of the general public regarding our water resource and how to protect that resource

Measurable Indicator: Score of the general public on periodic knowledge gap assessments

Action	Objective	Measurable Indicator	Contract/Support	Status/ Start Date	FTE/Yr.	Funding Source	Estimated Annual Budget
Provide technical support for BWD's education program	To assure that the BWD K-12 education program is providing accurate and timely information regarding SWP	Number of materials reviewed and the number of students participating in the program		Ongoing	0.01	SWP	
Provide technical support BWD's public information/education program	To assure that the BWD public info/ed program is providing accurate and timely information regarding SWP	Number of materials produced and reviewed, number of persons attending education programs		Ongoing	0.01	SWP	
Provide technical support for delivery of BWD's public awareness/education programs	To assure that accurate scientifically based information on SWP in Beaver Lake is delivered to the public	Number of public awareness messages delivered by media. Number of persons receiving message		Ongoing	0.01	SWP	
Speaker's Bureau	To increase awareness of interest groups regarding BWD source Water Protection efforts	Number of events, type, and number in attendance		Ongoing	0.01	SWP	
Support partners in priority watershed and awareness events	To increase awareness of water resources in NW Arkansas	Number of participants in watershed events		Ongoing	0.02	SWP	
LakeSmart/StreamSmart Program	To increase use of best practices by near lake residents	Number of participants in the program and number of practices planned		Ongoing	0.03	SWP	$11,250.00
Participate in State, Regional, And National Technical Committees	To generate ideas for implementation in BWD's SWP program and to have input into State, Regional and National Policy regarding SWP	Committee meetings attended, number of documents reviewed, edited, or produced		Ongoing	0.06	OPM	

Community Leadership

Strategy: Technical and Financial Assistance
Strategic Objective: To increase the number or water quality management practices implemented in the watershed
Measurable Indicator: Grants secured, practices implemented

Action	Objective	Measurable Indicator	Contract/Support	Status/ Start Date	FTE/Yr.	Funding Source	Estimated Annual Budget
Assist local NGOs and other partners to secure grants relevant to the SWP program	To improve the capacity of local NGOs to participate in our SWP program	Number of grant applications submitted		Ongoing	0.02	SWP	
Provide in-kind match for RCPP implementing projects relevant to the SWP program	To leverage our personnel and other resources for implementation of management practices in the watershed	Number of projects approved and implemented		Ongoing	0.02	SWP	
Provide financial support to watershed demonstration projects	To provide local demonstrations of SWP management practices and increase implementation of those practices	Number of projects approved and implemented		Ongoing	0.02	SWP	

Community Leadership

Strategy: Planning
Strategic Objective: To represent the interest of water quality in planning decisions
Measurable Indicator: Favorable policy decisions implemented

Action	Objective	Measurable Indicator	Contract/Support	Status/ Start Date	FTE/Yr.	Funding Source	Estimated Annual Budget
Support Implementation of Green Space plan by RCPP	To identify critical natural resources for protection during the planning process	Implementing green infrastructure elements in WFWR	WCRC	2018	0.01	O&M	
Support county land use planning	To have input in county planning policy	Numbers of recommendations made to planning boards compared to the number of relevant policies adopted	County Planning Commission	Ongoing	0.01	O&M	

Community Leadership

Strategy: Adaptive Management
Strategic Objective: To make corrections to the SWP plan with respect to changing conditions and new information on the effectiveness of current practices
Measurable Indicator: Completion of evaluations and recommendations made.

Action	Objective	Measurable Indicator	Contract/ Support	Status/ Start Date	FTE/Yr.	Funding Source	Estimated Annual Budget
Annual review of measureable indicators and recommendations for revisions	To evaluate the effectiveness of the SWP program and make needed corrections	Completion of the review		Ongoing	0.03		
Report to Board	To keep the Board engaged in the program and secure financial support	Approval of proposed budgets		Ongoing	0.03		
Four-year update of the SWP Plan	To evaluate our long term effectiveness in meeting the water quality goals	Completion of needed revision to the SWP program		2018	0.09		

Appendix B: Beaver Water District's Philosophy of Source Water Protection

Beaver Water District's Philosophy of Source Water Protection
Adopted, May 2006

Long term thinking by area leaders such as Joe Steele and Hardy Croxton in the 1950s ensured that Northwest Arkansas now has an ample supply of fresh clean water. That water is consumed every day not only by the people who live here, but also by the industries that rely on an uninterrupted supply of affordable water for food processing and other manufacturing and production purposes.

Today, Beaver Lake is an outstanding resource, with water quality meeting all Arkansas Department of Environmental Quality standards. But we cannot expect it to stay that way if we are not proactive in protecting our resource.

It is our responsibility as citizens and leaders of the Northwest Arkansas community to continue the tradition of long-term thinking and protect the resource that past visionary leaders provided for us. It is that resource that has raised our standard of living and improved countless lives, making possible a sustained economic prosperity unlike any in the United States.

The Lake is a reflection of its watershed. That is, the quality of the water in the reservoir is dependent upon what is being done in its tributary area. If land use is thoughtful, we will enjoy the Lake and its blessings for generations to come. If our use of land in the watershed is careless, then the quality of the water in the Lake will suffer and become degraded.

Beaver Lake's watershed is rapidly changing. Economic forecasters predict that more than 800,000 people will populate Benton and Washington counties by the year 2025, and as many as 1.2 million people will be living in Northwest Arkansas by 2050. With growth comes increased pressure on the watershed and the lake. Forests are cleared to make way for development. Roads are built to accommodate new subdivisions. More waste water is produced. Storm water runoff increases as does non-point source pollution.

We know from current research that the upper third of Beaver Lake has an overabundance of algae. Because of algae, Beaver Water District experiences episodic taste and odor events in the drinking water. We know that we are experiencing an increase in disinfection byproducts precursors. When chlorinated, these precursors form potentially carcinogenic disinfection byproducts. We know also that during certain seasons, the bottom layers of the lake are depleted of oxygen. We know that the lake becomes extremely turbid after storm events. And we know from monitoring that the nutrient supply to the reservoir far exceeds the lake's needs. Our lake cannot take care of itself.

Beaver Water District is committed to taking a leadership role in protecting Beaver Lake. But we want to make it clear that taking care of Beaver Lake is a community effort. All of us are part of the problem and all of us must be a part of the solution. It will take the combined efforts of children, adults, teachers, developers, engineers, accountants, farmers, politicians and all citizens to accomplish this vital task. That is, to maintain the quality of Beaver Lake.

Source water protection is not about telling people what to do. It's about everyone doing what is right for our common good. If we work together, we can find a way to make it happen.

Beaver Water District, along with other stakeholders in the watershed, is dedicated to the long-term protection of the watershed. We are working daily through our public education programs, media contacts, speaking engagements, and our website to educate the public, children, business people, and policy makers about how the lake can be protected. Beaver Water District also sponsors monitoring and research on water quality in the watershed and on the lake. We have committed funds to securing conservation easements on critical properties in the watershed. And, we will take whatever actions are necessary to help watershed residents protect our common resource.

This is not just about drinking water. This is about our legacy; this is about the kind of Beaver Lake we want to leave for our sons and daughters, our grandchildren and their grandchildren and their grandchildren's grandchildren. It is about swimming and boating and fishing, or just sitting and enjoying the water. It's about leaving a clean environment for future generations. As our Board President John Lewis said, "It's about building something sustainable where water can always be taken out of the lake for drinking." (The late John Lewis served on the Beaver Water District board of directors from 1975 to 2007.)

Appendix C: Beaver Water District's Position on Source Water Protection

Beaver Water District

Position Paper on Source Water Protection

copyright 2006

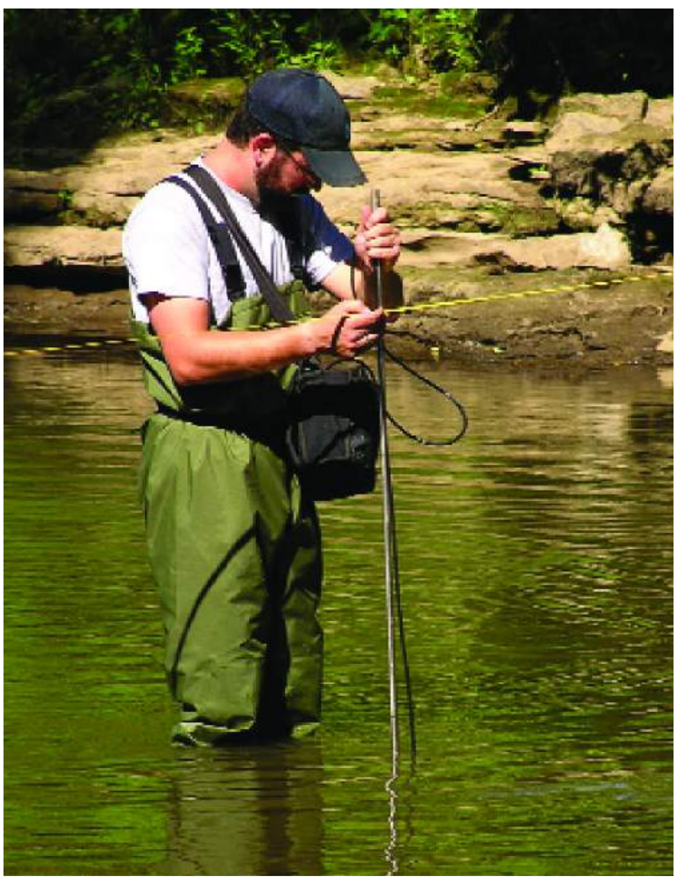
Summer 2006

Mission Statement

Beaver Water District is a public entity whose mission is to provide our customers in Benton & Washington counties with high quality drinking water that meets or exceeds all federal and state regulatory requirements, in plentiful quantities, at an economical price. To accomplish this, the District must act as environmental stewards of Beaver Lake and its vital watershed.

Introduction

Beaver Lake is Northwest Arkansas' only source of potable water. Currently water in the reservoir is of good quality to serve as this source. Even so, there are significant issues related to taste and odor, bacteriological contamination, and increasing organics that indicate degradation of our source water. Our mission requires us to take proactive actions to assure that our source water maintains its high quality for the future. Existing and developing land uses within the Beaver Lake watershed create the potential for degradation of the quality of the water in the reservoir. The following paper outlines Beaver Water District's position regarding source water protection.



Monitoring and Assessment

Description: Collection of physical, chemical, and biological data on Beaver Lake, its tributaries and its watershed related to the sustainability of Beaver Lake as a source of potable water and the utilization of those data to assess the current condition and trends in water quality of the reservoir and to identify emerging threats to that water quality.

Scientifically valid data are the foundation for decisions regarding appropriate watershed and reservoir manage - ment strategies.

Position: Scientifically valid data are the foundation for decisions regarding appropriate watershed and reservoir management strategies. Beaver Water District will work with its local, state and federal partners to collect adequate data to characterize the reservoir, its tributaries, and its watershed. All data shall be collected in accordance with quality assurance/quality control standards and with identified data quality objectives.

Water Quality

Description: Reservoir water quality is often measured by its trophic status, which is the amount of organic matter in the water. Oligotrophic lakes are very clear with little organic matter. Eutrophic lakes are more turbid with an overabundance of organic matter. Mesotrophic lakes are intermediate between the other two states. Beaver reservoir exhibits a longitudinal gradient of trophic status from eutrophic in the headwaters to oligotrophic at the dam[1]. In the vicinity of Beaver Water District's intake, the reservoir varies between meso and eutrophic conditions. Nutrient (nitrogen and phosphorus) concentration is the primary driver of trophic status in freshwater reservoirs. *Continued on page 2*

[1] *Haggard, Brian E. Et al. 1999. Trophic Conditions and Gradients of the Headwater Reaches of Beaver Lake, Arkansas. Proceedings of the Oklahoma Academy of Natural Sciences*

Bacteriological contamination, disinfection byproduct precursors, and sedimentation are other issues related to water quality.

Position: The cost of treating water from Beaver Lake is directly related to reservoir water quality. While the water quality of Beaver is generally good, the trophic status indicates potential water quality problems. Current water quality problems experienced by the District are episodic taste and odor events related to blue-green algae in the reservoir and spikes of high turbidity caused by inflow of organic and inorganic particles following storm events. A statistically significant trend of increasing total organic carbon has been found in data taken from Beaver Water District's raw water[2]. With increasing organic carbon, the potential for formation of disinfection byproducts also increases. Some of the nutrients, organics and sediment causing water quality problems are natural. However, most are from anthropogenic (man made) sources. Beaver Water District's position is that anthropogenic sources of pollutants should be managed at the source and that the reservoir should be maintained at or below its current trophic status. Beaver Water District supports the Arkansas Department of Environmental Quality in its effort to develop specific nutrient water quality criteria for Beaver Lake that will be protective of the water supply designated use. Beaver Water District also supports research on emerging water quality pollutants so that we are aware of issues as they arise.

Watershed Management

Description: According to the North American Lake Management Society[3], a lake is a reflection of its watershed. Lakes receive water, dissolved materials, and particulates from their watershed. As land use within the watershed changes, so does the quality of water in the reservoir. Therefore, to manage the quality of water in the lake, it is necessary to manage the inputs by these factors beyond the reservoir. Watershed management seeks to identify the cause of water quality problems, relate them to their source in the watershed, and find suitable management practices for each source. The Arkansas Department of Environmental Quality has determined that the War Eagle Creek tributary of Beaver Lake no longer supports its designated use of drinking water supply and that the White River tributary does not support the designated use of agricultural and industrial water supply[4].

According to the North American Lake Management Society, a lake is a reflection of its watershed. Rapid expansion of developed areas within the Beaver Lake watershed and along its shoreline is creating a potential for degradation of water in the reservoir.

Position: Rapid expansion of developed areas within the Beaver Lake watershed and along its shoreline is creating a potential for degradation of water in the reservoir. Beaver Water District's position is that anthropogenic sources of water pollution and pollutants should be eliminated or managed at the source. We will work along with our local, state and federal partners to reduce the mass loading of pollutants into Beaver Lake from both point sources (such as industrial or municipal discharges) and nonpoint sources (such as polluted runoff from urban and/or agricultural areas, septic tanks etc.). Point sources can be managed through the National Pollution Discharge Elimination System (NPDES) program administered by the Arkansas Department of Environmental Quality. Nonpoint sources of pollution originate in both rural and urban settings. All sources must be managed to maintain the current high quality of our source water. Through collaborative stakeholder processes, effective management measures can be developed that are both protective of water quality and also attractive to the property owner. Beaver Water District will utilize such processes in development of a watershed management plan for the Beaver Lake watershed.

[2] *FTN. 2006. Analysis of Water Quality Trends in Beaver Lake near the Beaver Water District Intake. FTN Associates, Ltd. Little Rock Arkansas*
[3] *North American Lake Management Society. 2001. Managing Lakes and Reservoirs. pp 13*
[4] *Arkansas Department of Environmental Quality. 2004. Arkansas'2004 List of Impaired WaterBodies. Available at: http://www.adeq.state.ar.us/water/branch_planning/pdfs/303d_list_public_notice.pdf*

Source water protection should be a factor in decisions regarding local and regional land use planning. Beaver Water District supports local and state agencies in full implementation of their rules and regulations regarding water quality protection and in development of new, appropriate rules and regulations. Beaver Water District also supports the implementation of incentive based conservation programs within the watershed and information/education programs that increase the awareness of local residents concerning their responsibility to manage pollutants at their source. Some industries and businesses by their nature have a high risk of contributing pollutants to nearby water courses. These industries and businesses should not be located within the source water protection area of any water intake on the reservoir.

Through collaborative stakeholder processes, effective management measures can be developed that are both protective of water quality and also attractive to the property owner.

Riparian zone buffers (vegetated streamside areas) provide many functions along streams including trapping and removing sediment and nutrients[5] as well as ecological and aesthetic benefits. Beaver Water District will work along with our partners to secure conservation easements along critical waterways in the watershed.

Reservoir Management

Description: Reservoirs, as opposed to natural lakes, are created by man made structures. As a result, reservoirs are artificial ecosystems. The way that a reservoir is operated can have a significant impact on both the quantity and quality of the water within the reservoir. Management of Beaver Lake is the responsibility of the U.S. Army Corps of Engineers, Little Rock District.

Position: Beaver Water District encourages research into the impact of reservoir operation on water quantity and quality in Beaver Lake. Such research should include the development of calibrated and validated hydrologic and ecological models of the reservoir and analysis of potential management scenarios. Beaver Water District encourages the Corps of Engineers to consider water quality in its reservoir operation plan.

Public Awareness/Education

Description: Increasing the knowledge of the public and specific stakeholder groups concerning the impact of Beaver Lake on their lives and how their activities may impact the reservoir.

Position: While there is a general awareness by the public that water quality is important to their lifestyle and economy, there is much less awareness by the public about what

Continued on page 4

Photograph courtesy of Clifton Eoff.

[5] *Wenger and Fowler. 2000. Protecting Stream and River Corridors. Carl Vinson Institute of Government, The University of Georgia*

Continued from page 3

affects the quality of Beaver Lake and how the public can be directly responsible for some of the impacts. Beaver Water District will work to increase the public's knowledge of water quality both directly through its website, publications, and presentations, and indirectly through cooperation with our local, state, federal, institutional, and non-governmental partners. Public awareness activities will be directed toward all age and ethnic groups, and toward specific interest groups and trade associations.

HOW TO REACH US

Amy Wilson
Director of Public Affairs
awilson@bwdh2o.org
www.bwdh2o.org
479-756-3651

Research

Description: While there are many data available on Beaver Lake, there is also much that is not known with respect to the processes at work in the system. Environmental research on the reservoir will help to understand water quality issues and to identify what conditions create those issues.

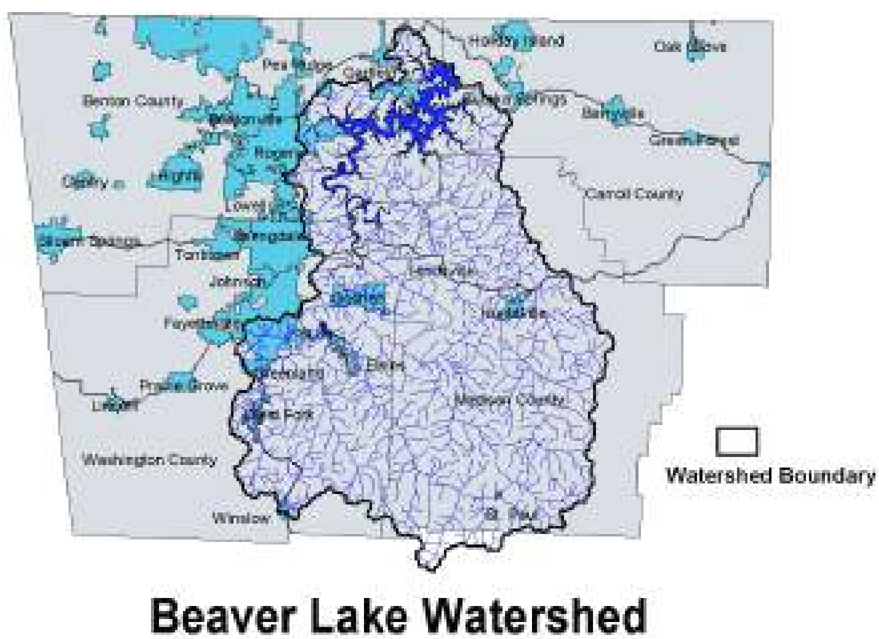
Position: Beaver Water District supports research by qualified scientists into the ecological and physical processes at operation in Beaver Lake. We will, when appropriate, participate in such research through assistance with collection of data, analysis of data, and participation in project review teams. It is also our position that scientific research is not complete until it is published in a peer reviewed scientific journal. Through the peer review process we are assured that sound science is utilized in our sponsored projects.

Beaver Water District supports research by qualified scientists into the ecological and physical processes at operation in Beaver Lake.

Evaluation

Description: Periodic review of the status of water quality in the reservoir and progress in achieving our goal of a sustainable water supply.

Position: Beaver Water District will periodically meet with our stakeholders to review the current status of the reservoir and the effectiveness of our management activities. Through this review, we will continually improve our management of the resource.



Appendix D: Inventory of Local Laws and Regulations

Related to Water Quality Protection for the Beaver Lake Watershed, Fall 2007

A. Benton County

Entity	Citation	Web Address	Description
Benton County	Code of Ordinances of Benton County, Arkansas, Bluebook, Chapt. 1-9	**www.municode.com/Resources/OnlineLibrary.asp** **www.co.benton.ar.us/planning/Development.html**	The County regulates subdivisions, commercial/industrial Large Scale Developments, and mobile homes. Building permits are required. No zoning in the unincorporated areas of the county. A floodplain management ordinance and Flood Damage Prevention Code are under consideration. Working on a land use plan. Sedimentation and erosion control requirements appear to be minimal. See Code, Chapt. 38 (Floods), Chapt. 54 (Planning), and Chapt. 66 (Subdivisions). See also Bluebook, Chapt. 1-9
Avoca			
Garfield			No fees or permits for building
Gateway			Has zoning
Lost Bridge Village			

Lowell	Code of Ordinances of the City of Lowell, Arkansas	**www.municode.com/Resources/OnlineLibrary.asp**	See Code, Chapt.8 (Land Development Code) and Chapt. 16 (Water, Sewers and Sewage Disposal)
Rogers	Code of Ordinances, City of Rogers, Arkansas	**www.rogersarkansas.com/clerk/mainordinance.asp**	See Code, Chapt. 42 (Environment), Chapt.50 (Floods), Chapt. 94 (Planning), Chapt. 110 (Subdivisions), Chapt. 111 (Design Criteria), Chapt. 122 (Vegetation), and Chapt. 130 (Zoning)
Springdale	Code of Ordinances of the City of Springdale, Arkansas Comprehensive Land Use Plan	**www.springdaleark.org/coo/index.htm** **www.springdaleark.org/depts/planning/index.htm**	See Code, Chapt. 42 (Environment), Chapt.50 (Floods), Chapt. 56 (Landscape and Buffers), Chapt. 90 (Planning), Chapt. 106 (Stormwater Drainage), Chapt.107 (Stormwater Pollution), Chapt. 112 (Subdivisions), and Chapt. 130 (Zoning Ordinance)

B. Carroll County

Entity	Citation	Web Address	Description
Carroll County			No zoning in the unincorporated areas of the county. No incorporated cities in the Beaver Lake watershed.

C. Madison County

Entity	Citation	Web Address	Description
Madison County	Code of Madison County, Title XV, Land Use	**www.amlegal.com/library/ar/madisonco.html** (As of 10.10.07, the Code is current through 02.02.07)	No zoning in the unincorporated areas of the county. There is not a Planning Board, but there is a nine member Land Use Committee. See Chapters 150 (Flood Damage), 153 (Land Use), and 154 (Subdivisions).
Hindsville	None	None	No regulations, permits, or fees
Huntsville	Huntsville Municipal Code	**www.Huntsvillear.org/pdfs/Huntsville_City_Ordinances.pdf**	Online, see: Title 13, Planning; Title 14, Zoning; Title 15, Subdivision Regulations Title 14 incorporates by reference the hard copy of the zoning regulations and map that are in the City Clerk's office. Reportedly, the regulations would have to be copied page by page and the map is out-of-date. Title 15 says "Reserved", but reportedly there are minimal subdivision regulations.
St. Paul	None	None	No regulations, permits, or fees

D. Washington County

Entity	Citation	Web Address	Description
Washington County	Washington County Code	**www.municode.com/Resources/OnlineLibrary.asp** (Code can also be accessed at) **www.co.benton.ar.us/planning/Development.html**	Zoning in the unincorporated areas of the county in areas extending two miles from the corporate boundaries of cities of the first class and one mile from the boundaries of cities of the second class (zoned agricultural and single family residential with 1 acre minimum lot size (except 2 acre minimum for Goshen)). Has Land Use Plan. Regulates subdivisions, large scale developments, mobile homes, floodplain development, septic and wastewater disposal systems. Has Stormwater Management Plan. See Code, Chapt. 11 (Planning and Development) and Chapt. 17 (Water and Sewers)
Elkins			
Fayetteville	Code of Fayetteville, Title XV, Unified Development Code, Chapters 150-175	**www.accessfayetteville.org/government/city_clerk/city_code/index.html**	See Code: Chapter 161 - Zoning Regulations Chapter 162 - Use Units Chapter 163 - Use Conditions Chapter 164 - Supplementary District Regulations

			Chapter 165 - Airport Zone Chapter 166 - Development Chapter 167 - Tree Preservation & Protection Chapter 168 - Flood Damage Prevention Code Chapter 169 - Physical Alteration of Land Chapter 170 - Stormwater Mgt., Drainage, & Erosion
Goshen	Ordinances not codified	Regulations not yet available on the internet (working on it). City website: cityofgoshen.net has Building Dept. guidelines	Has zoning, subdivision, and floodplain ordinances. Two- acre minimum lot size (except for “conservation easement subdivisions)
Greenland			
Springdale	See Citation under Benton County	See Web Address under Benton County	See Description under Benton County
West Fork			
Winslow			No zoning

Appendix E: No Regrets Source Water Plan

No Regrets Source Water Plan

Beaver Water District

February, 2012

Ray Avery and Bob Morgan

Table of Contents

Introduction

The goal of the No-Regrets Sourcewater plan is to provide a framework for coordination of activities in response to high impact events that may negatively affect our source water quality. Specific planning objectives are to: 1) Identify, describe, and characterize events to which Beaver Lake is susceptible, 2) Rank events in terms of warning time, probability of occurrence, magnitude of event, and severity of consequence. 3) Examine feasible monitoring and response activities for each identified event, 4) Provide resources to aid decision making, and 5) Isolate key contacts for each event. This framework should be used for responding to specific events that may negatively impact sourcewater quality in addition to the Beaver Water District Sourcewater Protection Program documentation (1).

Event Characterization

We identified several events that, because they pose a significant risk to sourcewater quality for Beaver Water District (BWD), warranted a complete profile in this plan. These events were identified through an extensive process that utilized input from several departments at BWD. Events were ranked based on their impact on sourcewater quality using a critical priority risk index (CPRI) (2) where;

Probability: Likely (3), Possible (2), or Unlikely (1), chance of occurrence relative to other areas of the US

Magnitude: Critical (3), Limited (2), or Negligible (1), potential extent of an event's size

Severity: Critical (3), Limited (2), or Negligible (1), impact relative to other events in the area

Warning time: 6 to 12 hours (3), 12 to 24 hours (2), or 24+ hours (1), time between event and impact

CPRI = Probability (0.45*P) + Magnitude (0.15*M) + Severity (0.25*S) + Warning Time (0.15*W).

Table 1: Calculation of the Critical Priority Risk Index (CPRI)

Event	Probability	Magnitude	Severity	Warning Time	CPRI
Tornado	2	3	3	3	2.55
Winter Storm	3	2	2	1	2.3
Wildfire	2	2	3	2	2.25
Marina Fire	2	2	2	3	2.15
Intentional Contamination	1	3	3	3	2.1
Earthquake	1	3	3	3	2.1
Drought	3	2	1	1	2.05
Dam Failure	2	3	1	3	2.05
100 Year Flood	2	2	2	2	2
Train Wreck	1	2	3	3	1.95
HAZMAT Spill	1	3	3	2	1.95
Fish Kill	2	2	1	3	1.9
Airplane Crash	1	1	3	3	1.8

Forest Fire

Event Description

Forest fires alter the vegetation and soils in watersheds and affect hydrologic cycle processes including interception, infiltration, evapotranspiration, soil moisture storage, and overland flow. Fire may reduce interception by destroying the forest canopy and organic litter on the soil surface which could lead to increased runoff and erosion. Infiltration may be reduced as a result of fire where soil pores are clogged with ash which also leads to increased runoff. Increased streamflow may also follow fires as a result of vegetation loss and the subsequent reduction in transpiration losses (3).

The hydrologic response of a watershed to fire is dependent on the interaction of fire characteristics with watershed characteristics. Fire characteristics include frequency, severity, duration, and spatial extent. Watershed characteristics include weather, slope, soil type, geology, land use, and the proportion of vegetation burned. This interaction between fire and watershed is highly variable which leads to increased uncertainty when predicting the impact on water quality. Despite these variances, fires have been shown to increase runoff and erosion rates by one or more orders of magnitude (4).

Wildfires are generally more severe than prescribed fires and elicit a greater impact on water quality (4) (5). Fuel accumulation in nearby forests has increased recently due to damage from fire exclusion, ice storms and insects (Red Oak Borer, Gypsy Moth, etc.) (6). The most effective means of reducing watershed damage by high severity wildfires is to reduce the accumulation of fuels (e.g. forest thinning, timber harvesting, or prescribed burning) (3).

Within our high priority SWP area there are approximately 28000 acres of forest. This forest is classified as oak-hickory/ shortleaf pine with a composition of approximately 90% hardwood and 10% pine. The largest contiguous forest block (~15,000 Acres) is located on the east side of the lake and includes private land near War Eagle Creek and portions of Hobbs State Park-Conservation Area.

The most probable effect of fire on our sourcewater quality includes increases in sediment, turbidity, nutrients, and organic carbon. Changes in pH and alkalinity are also likely but would be less pronounced at the intake. Algal blooms and increased taste and odor compounds are also possible (7) (8) (9) (5).

Potential Impacts

- Immediate
  - Increased turbidity and suspended solids will likely necessitate significant changes in coagulant dosing, filter run times, and solids handling.
- Short term
  - Increased DOC loading will increase chlorine demand and may increase DBP formation.
- Long term
  - Increased nutrient loading may cause algae blooms which could decrease filter run times or increase the probability of taste and odor events.

Monitoring Plan

Sample collection should begin before the first precipitation following the fire and continue following each precipitation event for several months. Long term monitoring may be needed for up to three years. At the time of sample collection in-situ measurements of water quality should be collected for the following parameters:

- Turbidity
- pH
- Alkalinity
- Temperature
- Dissolved Oxygen, DO
- Oxidation-Reduction potential, ORP
- Chlorophyll-a
- Specific Conductivity

Water quality samples should be returned to the lab and analyzed for the following parameters:

- Nitrate, NO_3-N
- Nitrite, NO_2-N
- Phosphate, PO_4-P
- Total Phosphorus, TP
- UV254
- Algae Identification
- Total Dissolved Solids, TDS
- Total Suspended Solids, TSS
- Dissolved Organic Carbon, DOC
- Total Organic Carbon, TOC

Reporting

Contact the responsible agency or incident commander to determine the magnitude and extent of the fire. Potential impacts and further refinement of the monitoring plan should be discussed with the plant manager, operations supervisor, and the chief operating officer during and following a wildfire.

Resources

USA Wildland Fire Potential.
http://www.arcgis.com/home/webmap/viewer.html?services=fc0ccb504be142b59eb16a7ef44669a3

USGS Fire Danger Forecast. **http://firedanger.cr.usgs.gov/viewer/viewer.htm**

Wildland Fire Support. **http://www.geomac.gov/index.shtml**

USGS LANDFIRE Data Distribution Site. **http://landfire.cr.usgs.gov/viewer/viewer.html**

A Forest Water Quality Literature Review.
http://www.dof.virginia.gov/wq/resources/lit-review-2006_austin.pdf

Southern Area Coordination Center
http://gacc.nifc.gov/sacc/predictive/intelligence/intelligence.htm

Agency Contacts

US Forest Service, Boston Mountain RD,
Arkansas Forestry Commission, District 7 Forester, Eric Curl,
US Army Corps of Engineers, Chief Park Ranger, Beaver Lake Office, Jared Trammell,
Hobbs State Park-Conservation Area

Tornado

Event Description

Tornadoes occur all over the world. The highest concentrations of tornadoes occur in the United States and are most common in the central plains east of the Rocky Mountains and West of the Appalachian Mountains. Around 1000 tornadoes hit the US every year and are particularly likely to occur in the area known as Tornado Alley. Arkansas is not usually included in maps of Tornado Alley but the state has experienced devastating losses due to tornadic activity in the past (10) (11). Our watershed is located in an area with a high likelihood of significant tornadic activity (F2 or greater) (Figure 1) (12). Since 1950 there have been 20 reported tornado touchdowns in the Beaver Lake Watershed and 1 was in our high priority SWP area (Figure 2).

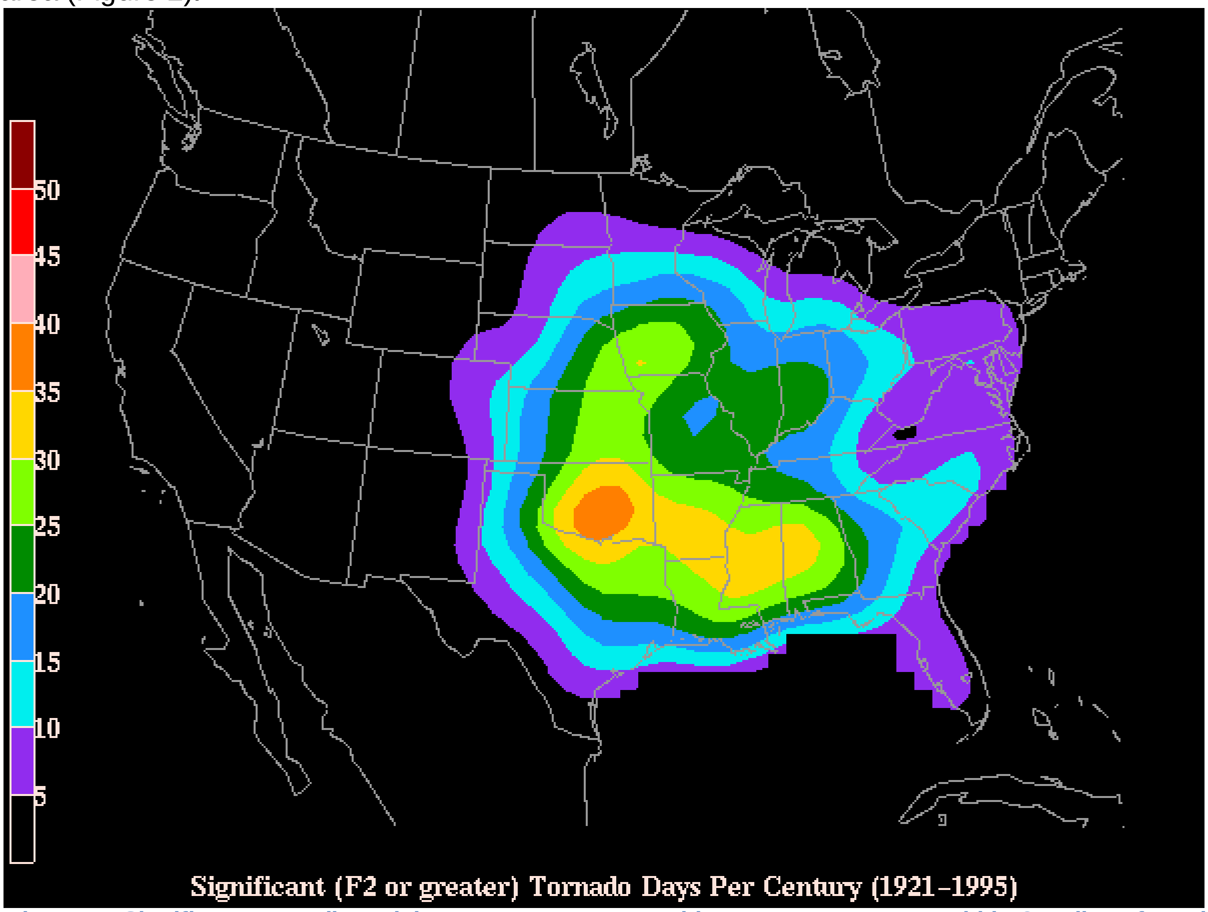


Figure 1: Significant Tornadic activity. Days per century with one or more events within 25 miles of a point.

Tornadoes and Tracks 1950-2010

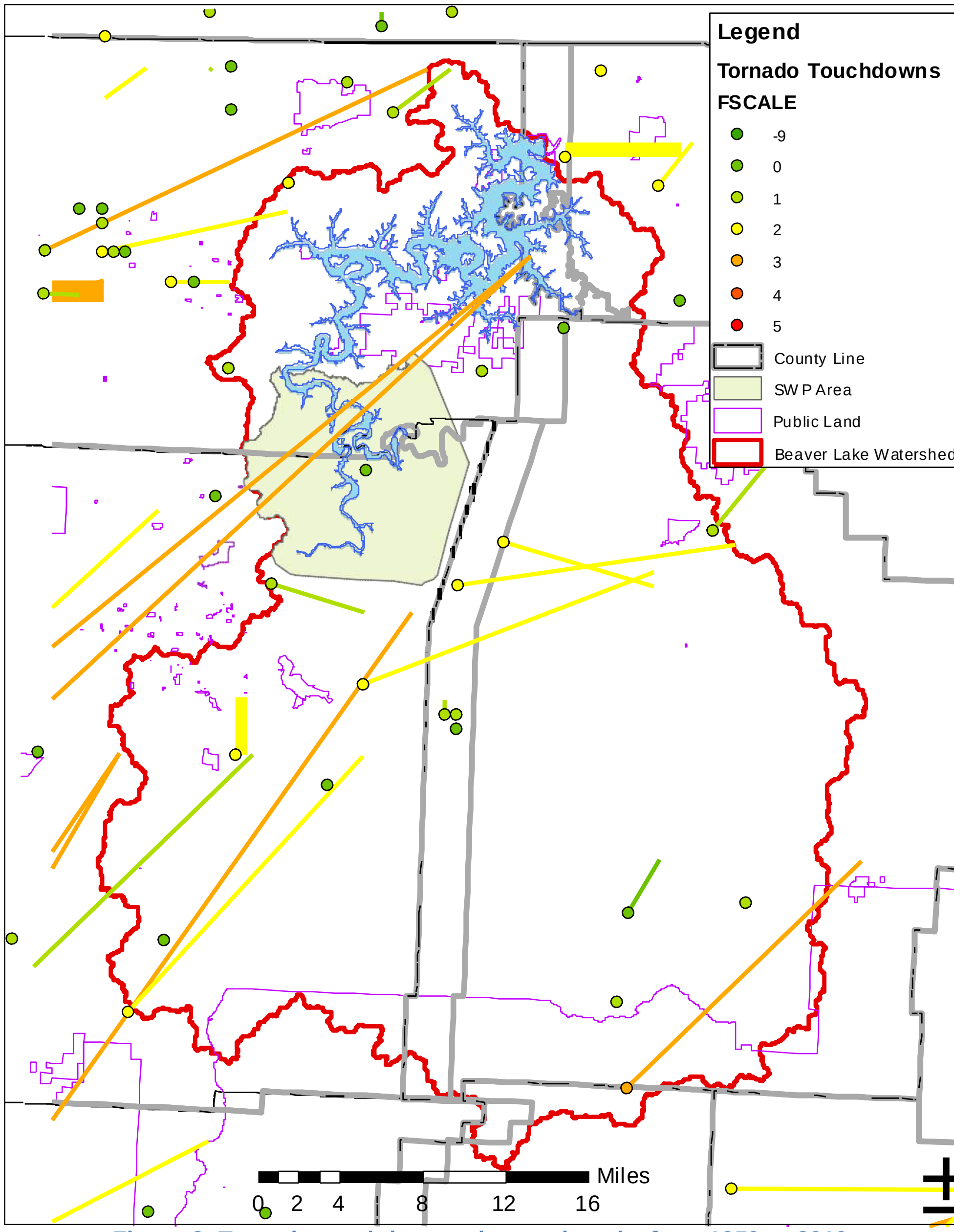


Figure 2: Tornado touchdown points and tracks from 1950 to 2010

On May 10, 2010 a F4 tornado touched down near Lake Thunderbird State Park, OK and damaged or destroyed 270 boats at the Little River Marina. Fuel and other contaminants were spilled into the lake though significant impacts to water quality were not reported (Figure 3). Debris from nearby homes and business were thrown into the lake and power was also knocked out to the Lake Stanley water treatment plant for two weeks (13).

Figure 3: (AP Photo/The Noman Transcript, Kyle Phillips)

Figure 4: (AP Photo/Charlie Riedel)

On May 22, 2011 a F5 tornado hit Joplin, MO and damaged 8000 structures and destroyed 2000 homes and 100 businesses while killing 146 people (Figure 4). This storm produced the deadliest tornado in the United States since 1947. Power was lost to their water treatment plant and distribution system for around 24 hours (14).

On April 30, 2010 a F1 tornado occurred near the town of Willow Springs, MO and completely disabled their wastewater treatment plant. This severe damage caused an overall 75% decrease from normal capacity. However, no sanitary sewer overflows were reported to arise directly from this event (15).

Figure 5: Wastewater treatment plant at Willow Springs. Photo/KY3 Springfield News

Potential Impacts

- Immediate
    - Fuel and other contaminants may necessitate deploying absorbent booms or pads around the intake facility. Larger debris may be kept away from the intake using hard (containment) booms.
- Short term
    - Water production may be temporarily halted as a precautionary measure.
- Long term
    - No significant impact expected.

Monitoring Plan

Sample collection should begin immediately following the tornado. Short term monitoring may be needed for weeks as the cleanup progresses. At the time of sample collection in-situ measurements of water quality should be collected for the following parameters:

- Turbidity
- pH
- Alkalinity
- Temperature
- Dissolved Oxygen, DO
- Oxidation-Reduction potential, ORP
- Chlorophyll-a
- Specific Conductivity

Water quality samples should be returned to the lab and analyzed for the following parameters:

- Dissolved Organic Carbon, DOC
- Total Organic Carbon, TOC
- Total Coliforms
- TSS
- E. coli
- BOD
- VOC + SVOC + PAH + TPH Gas/ Oil (Special sample handling required)

Reporting

Contact the responsible agency or incident commander to determine the magnitude and extent of the damage. Potential impacts and further refinement of the monitoring plan should be discussed with the plant manager, operations supervisor, and the chief operating officer during and following a tornado.

Resources

Real Time Hazard Maps
http://www.nesec.org/hazards/hazard_maps.cfm

National Weather Hazards
http://www.weather.gov/largemap.php

Agency Contacts

Hickory Creek Marina
War Eagle Marina
Washington County Emergency Management
Benton County Emergency Services
Paul R. Noland WastewaterTreatment Plant
University of Arkansas, Facilities Management

Winter Storm

Event Description

Severe winter storms, which may include heavy snowfall, ice storms, winter storms, and/or strong winds, affect every state in the continental United States. Areas where such weather is uncommon, such as Arkansas, are typically disrupted more severely by severe winter storms than are regions that experience this weather more frequently. In addition, winter storms may spawn other hazards such as flooding, severe thunderstorms, tornadoes and extreme winds. To make travel on roads safer, deicers composed of rock salt and calcium magnesium acetate (CMA) or potassium acetate (KA), are commonly used. Runoff events may occur if warmer weather quickly moves back into the area.

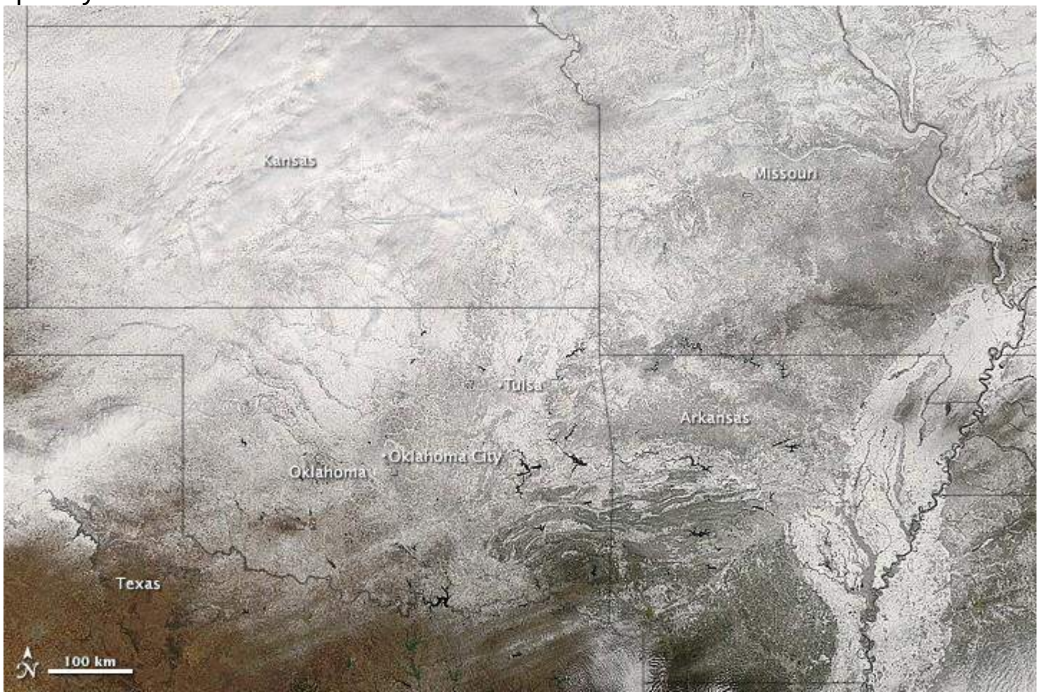


Figure 6: Snowfall topped 20 inches in parts of Oklahoma, Kansas, and Arkansas, just one week after a Groundhog Day storm coated the region with several inches. Source: NASA Earth Observatory, MODIS/AQUA acquired February 10, 2011 (16).

Potential Impacts

- Immediate
    - Slick roads will increase the probability of vehicle collisions and subsequently increase the probability of spills resulting from collisions. See HAZMAT spills
- Short term
    - Increased use of deicing chemicals may runoff.
- Long term
    - No significant impact expected.

Monitoring Plan

Sample collection should begin when the temperature begins to warm and continue until the runoff from the melt subsides.. At the time of sample collection in-situ measurements of water quality should be collected for the following parameters:

- Turbidity
- pH
- Alkalinity
- Temperature
- Dissolved Oxygen, DO
- Oxidation-Reduction potential, ORP
- Chlorophyll-a
- Specific Conductivity

Water quality samples should be returned to the lab and analyzed for the following parameters:

- Hardness
- Total Dissolved Solids, TDS
- Total Suspended Solids, TSS
- Chloride, Cl
- Dissolved Organic Carbon, DOC
- Alkalinity

Reporting

Contact the responsible agency or incident commander to determine the magnitude and extent of the winter storm. Potential impacts and further refinement of the monitoring plan should be discussed with the plant manager, operations supervisor, and the chief operating officer during and following a winter storm.

Resources

NCDC Storm Event Database,
http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms

AHTD Arkansas Road Conditions,
http://www.arkansashighways.com/roads/roads.aspx

Agency Contacts

Washington County Emergency Management
Benton County Emergency Services

Drought

Event Description

Drought is a normal part of virtually all climatic regimes, including areas with high and low average rainfall. Drought differs from normal aridity, which occurs in low-rainfall regions and is a permanent characteristic of the climate. Drought is the consequence of a natural reduction in the amount of precipitation expected over an extended period of time, usually a season or more in length.

Other climatic factors, such as high temperatures, prolonged high winds, and low relative humidity, can aggravate the severity of a drought. Severity depends not only on duration, intensity, and geographic extent of a specific drought event, but also on the demands made by human activities and vegetation on regional water supplies.

When drought begins, the agricultural sector is usually the first to be affected because of its heavy dependence on stored soil water. Soil water can be rapidly depleted during extended dry periods. If precipitation deficiencies continue, then people dependent on other sources of water will begin to feel the effects of the shortage. Those who rely on surface water (i.e., reservoirs and lakes) and subsurface water (i.e., ground water), for example, are usually the last to be affected. A short-term drought that persists for 3 to 6 months may have little impact on these sectors, depending on the characteristics of the hydrologic system and water use requirements (Figure 7) (17).

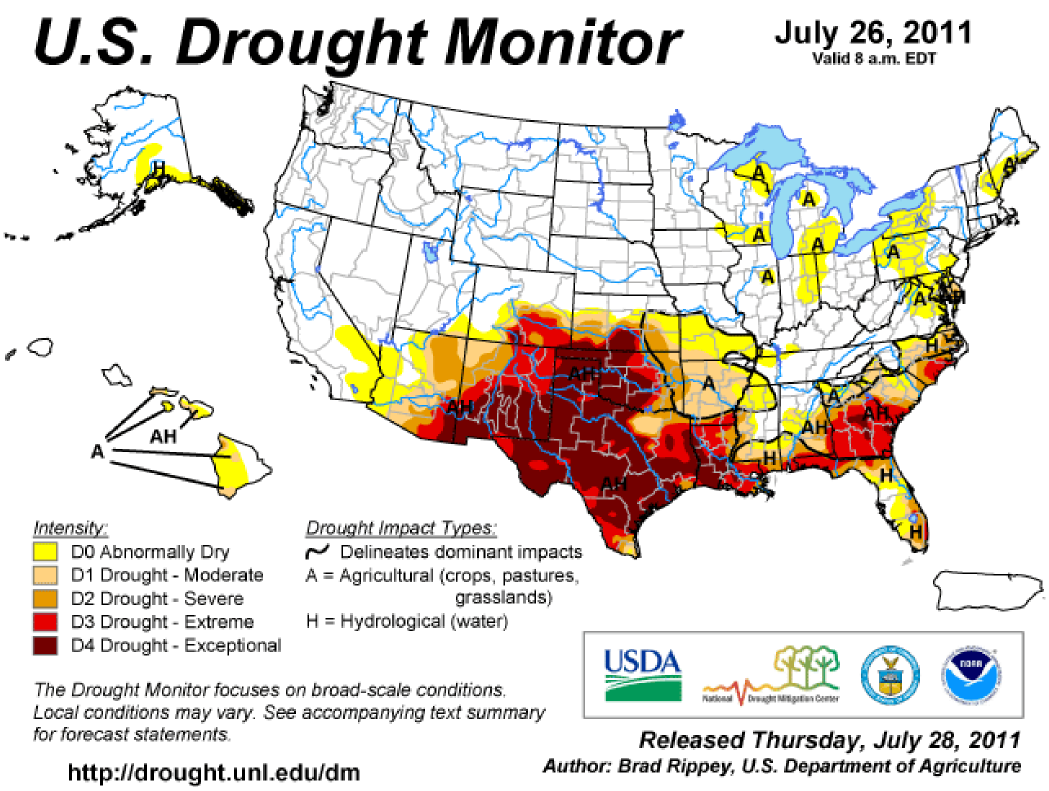


Figure 7: Moderate drought impacting only agriculture in Northwest Arkansas.

The long term average annual (July-June) precipitation for Northwest Arkansas is 45.7 inches and shows an increasing trend 1.9 inches/century (Figure 8) (18). Long term average annual (July-June) temperature for Northwest Arkansas is 57.4°F and shows a decreasing trend of 0.4°F/century (Figure 9)

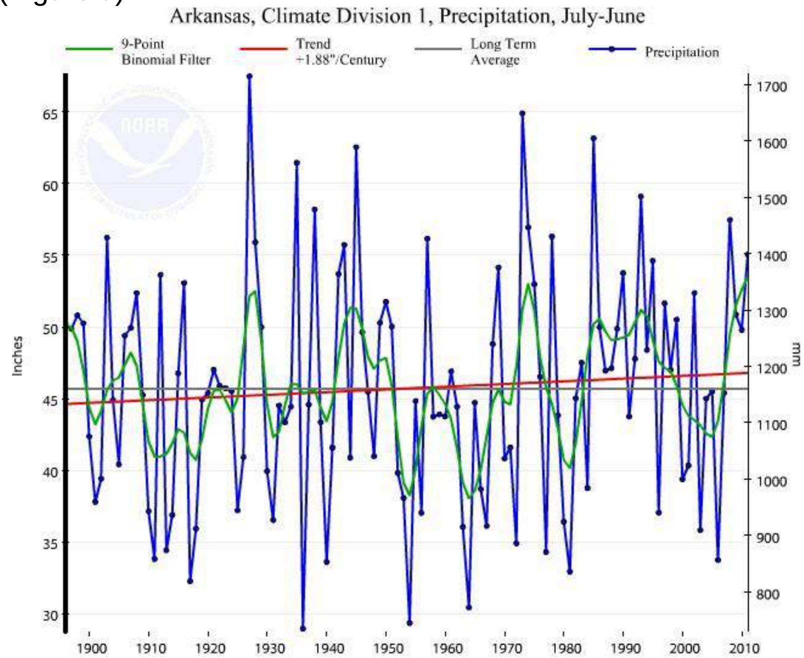


Figure 8: Northwest Arkansas average annual precipitation.

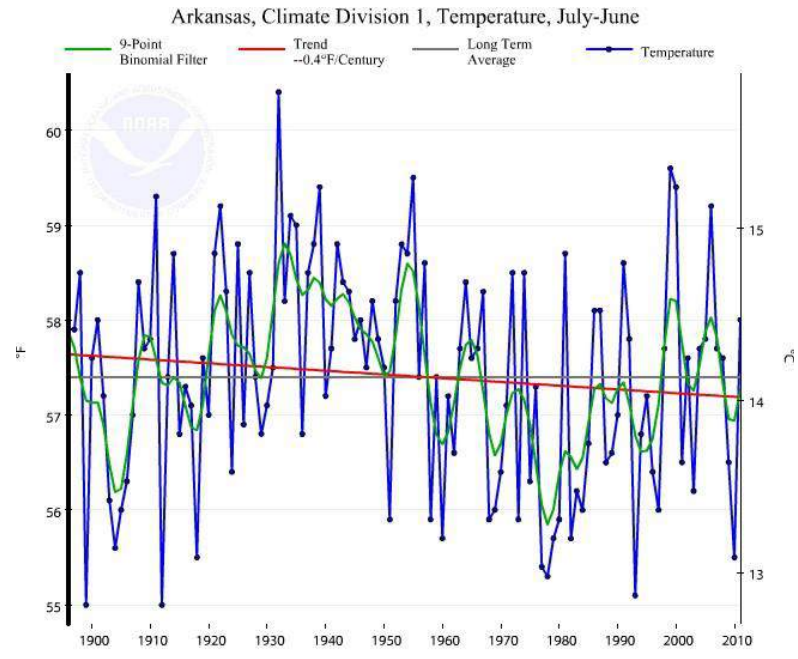


Figure 9: Northwest Arkansas average annual temperature.

Potential Impacts

- Immediate
  - Severe drought may cause a very high fire risk. See Forest Fire section.
- Short term

- Warm still water may lead to nuisance algae blooms and extremely dry years have been shown to coincide with T/O events in Beaver Lake (19).
- Long term
  - No significant impact expected.

Monitoring Plan

Water surface elevation data is necessary for determining the impact of a drought. Additional monitoring of algae and T/O compounds as a result of drought may also be warranted.

Reporting

Potential impacts and further refinement of the monitoring plan should be discussed with the plant manager, operations supervisor, and the chief operating officer during drought conditions.

Resources

US Drought Monitor **http://droughtmonitor.unl.edu/**

Drought Events for Arkansas
http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Agency Contacts

Not Applicable

Flooding

Event Description

Flooding causes more deaths and property damage in the USA than any other severe weather related event. Flooding can occur in all 50 states and is a potential threat in all months of the year. Moreover, flooding is responsible for more fatalities than any other severe weather related phenomena. The average annual deaths attributable to flooding exceed those from lightning or tornadoes. For the 20 year period 1984-2004, floods on average were responsible for $4.6 billion in damage and more than 100 deaths

A variety of factors affect the type and severity of flooding within the Beaver Lake Watershed, including topography, geology, urban development and infrastructure. Serious flooding in the mountainous areas is unusual because streams tend to be faster flowing and flood waters drain quickly. Flash floods are most common in this area due to this area exhibiting high to moderate relief, steep to moderate slopes, and bedrock with low permeability. All factors facilitate rapid runoff and the consequent potential for flash floods. Urban development exacerbates the flash flooding problem. Intense rainfall events, often accompanying the large thunderstorms that occur in the watershed several times a year, may result in water flowing rapidly from higher elevations into valleys and sometimes overtopping the banks.

Flood events in the recent past (2008 and 2011) have negatively impacted water quality in Beaver Lake. Large runoff events increase the suspended sediment concentration and reduce the alkalinity of the sourcewater which disrupts Alum coagulation. If sufficient alkalinity is not present, soluble aluminum is formed, which can result in postflocculation in downstream processes. In this case, supplemental alkalinity must be added before the Alum in order to avoid postflocculation (20).

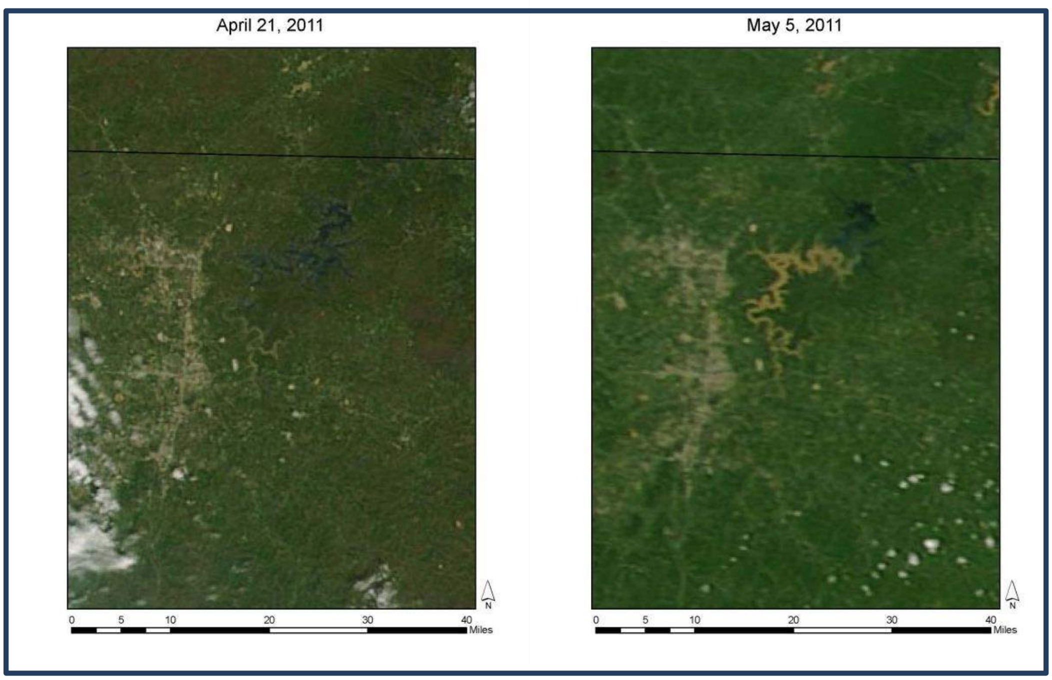


Figure 10: Imagery from MODIS Terra Sattellite before and after opening the floodgates (35) (36).

- Immediate
  - Increased runoff and erosion may lead to disruptions in the treatment process.
- Short term

  - Increased nutrient loading may lead to nuisance algae blooms.
- Long term
  - None expected

Monitoring Plan

Sample collection should begin immediately following large runoff events and continue until normal treatment operations have been restored. Bridges in the watershed should be utilized for sample collection. If in-lake monitoring is desired, samples should be collected in both the White River and War Eagle Creek arms. Long term monitoring will not be necessary. At the time of sample collection in-situ measurements of water quality should be collected for the following parameters:

- Turbidity
- pH
- Temperature
- Dissolved Oxygen, DO
- Oxidation-Reduction potential, ORP
- Chlorophyll-a
- Specific Conductivity

Water quality samples should be returned to the lab and analyzed for the following parameters:

- Nitrate, NO_3-N
- Nitrite, NO_2-N
- Phosphate, PO_4-P
- Total Phosphorus, TP
- UV254
- Alkalinity
- E. coli
- Total Coliforms
- Chloride
- Hardness
- Total Dissolved Solids, TDS
- Total Suspended Solids, TSS
- Dissolved Organic Carbon, DOC
- Total Organic Carbon, TOC

Reporting

Contact the responsible agency or incident commander to determine the magnitude and extent of the flooding. Potential impacts and further refinement of the monitoring plan should be discussed with the plant manager, operations supervisor, and the chief operating officer during and following a flood.

Resources

NASA / GSFC, Rapid Response, **http://lance.nasa.gov/imagery/rapid-response/**

Agency Contacts

Washington County Emergency ManagementBenton County Emergency Services

Fish Kill

Event Description

A fish kill is defined as the localized die-off of a fish population. Such events are characterized by large numbers of aquatic animals dying over a short period of time. Fish kills occur all over the world as a result of stress, starvation, oxygen depletion, disease, parasites, toxins, rapid temperature change, etc. The most common cause of fish kills is hypoxia, or lack of oxygen (21). Localized hypoxia may result from algae blooms, drought, reservoir mixis, or increased BOD loading (22).

On December 29, 2010 a fish kill, estimated at 83,000 freshwater drum and 1,000 other fish, occurred on a 20 mile stretch of the Arkansas River between Clarksville and Ozark, AR. The Arkansas Game and Fish Commission (AGFC) reported that they had ruled out bacterial infection, viral infection, and parasites but the cause remains unknown (23). On March 17, 2011 the AGFC reported that after conducting experiments regarding the operation of spillway gates the kill was likely caused by Gas Bubble Trauma (24)

Figure 11: Fish kill on the Arkansas River

Potential Impacts

- Immediate
  - Potential toxicity of the sourcewater.
- Short term
  - Increased BOD due to decaying fish.
- Long term
  - None expected

Monitoring Plan

Sample collection should begin immediately following a fish kill and continue until the cause has been determined. Samples should also be collected both upstream and downstream of the affected area. Special procedures should be followed when collecting whole or tissue samples from fish (25) (26).

At the time of sample collection in-situ measurements of water quality should be collected for the following parameters:

- Turbidity
- pH
- Temperature
- Dissolved Oxygen, DO
- Oxidation-Reduction potential, ORP
- Chlorophyll-a
- Specific Conductivity

Water quality samples should be returned to the lab and analyzed for the following parameters:

- Nitrate, NO_3-N
- Nitrite, NO_2-N
- Phosphate, PO_4-P
- Iron, Fe
- Manganese, Mn
- BOD
- Alkalinity
- E. coli
- Total Coliforms
- Chloride, Cl
- Sulfate, SO_4
- Calcium, Ca
- Turbidity
- Hardness
- Total Dissolved Solids, TDS
- Total Suspended Solids, TSS
- Pesticides
- Dissolved Organic Carbon, DOC
- Total Organic Carbon, TOC

Reporting

Contact the responsible agency or incident commander to determine the magnitude and extent of the fish kill. Potential impacts and further refinement of the monitoring plan should be discussed with the plant manager, operations supervisor, and the chief operating officer following a fish kill.

Resources

Field Manual for the Investigation of Fish Kills. (26)
Southern Regional Aquaculture Center. (27)

Agency Contacts

Arkansas Game and Fish Commission, Bureau of Fisheries
Arkansas Department of Environmental Quality
Arkansas Department of Health
University of Arkansas at Pine Bluff

HAZMAT Spill

Event Description

Hazardous materials are defined by the Occupational Safety and Health Administration (OSHA) as any chemical which is a physical or health hazard. OSHA has published a list of hazardous, toxic, and reactive materials in the Code of Federal Regulations (28). Spills can originate from pipelines, boats, motor vehicles, railroads, or fixed containers and consist of liquid, solid or gaseous materials (29). An inventory of hazardous materials located in the Beaver Water District Sourcewater Protection Area is periodically updated in the Potential Sources of Contamination (PSOC) database (30). If the substance enters a waterway before containment then a downstream trace should be performed using the Beaver Lake Aquatic Spill Tool (BLAST). BLAST is a loosely coupled watershed and reservoir water quality model for quickly tracing contaminants (31). An example of an upstream trace when the flood gates are open during very high inflows to the lake is shown in Figure 13.

On August 11, 2011 a tanker truck carrying diesel fuel overturned at the intersection of Arkansas 12 and Dream Valley Road in Rogers, AR. Fire departments and hazardous materials teams responded from surrounding cities. Temporary dams were built in the road ditch to prevent the diesel from flowing into the lake (Figure 12). (32)

Figure 12: Diesel fuel leaking from an overturned tanker. (NWAonline Photo / Flip Putthoff)

Potential Impacts

- Immediate
  - Adjustments to the intake or temporary shutdown may be necessary. Potential fish kills.
- Short term
  - Increased BOD due to decaying fish.
- Long term
  - None expected

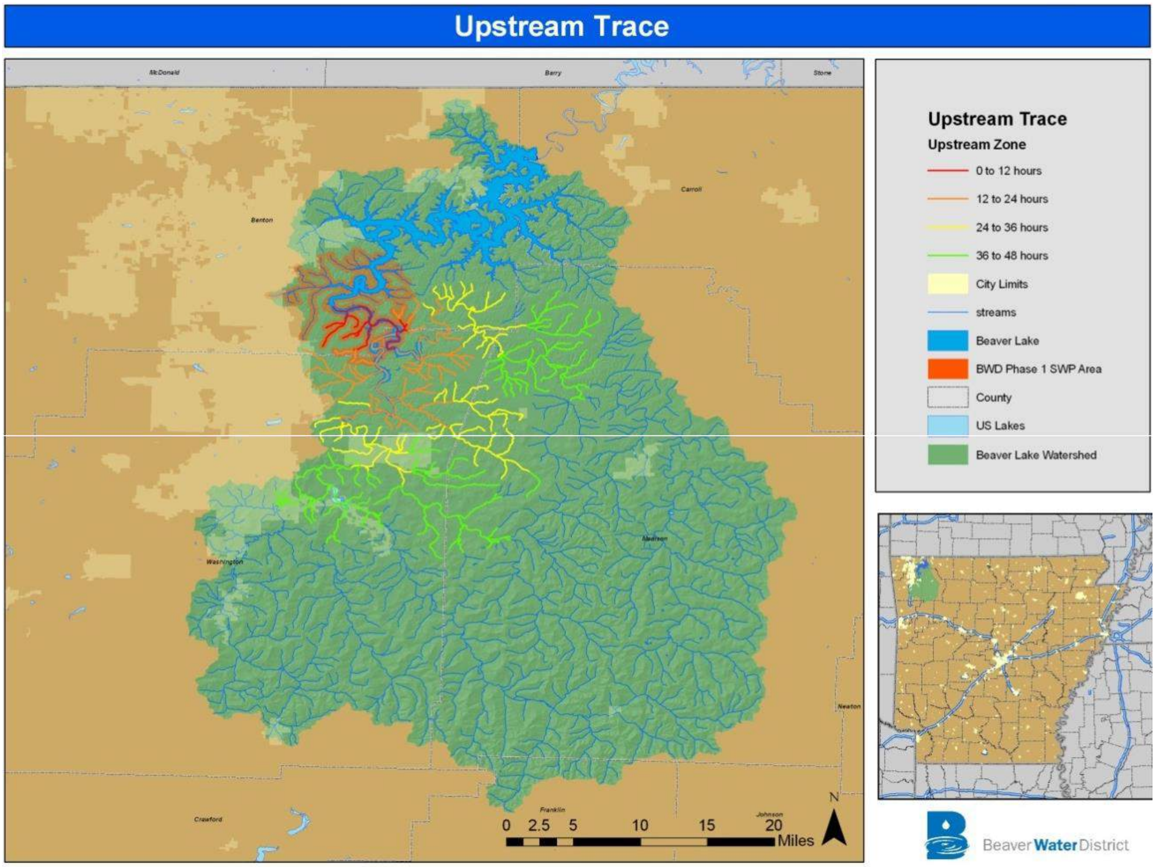


Figure 13 Upstream trace from intake during very high inflow to the lake.

Monitoring Plan

Sample collection should begin immediately following a spill. Special procedures should be followed when collecting samples that may contain hazardous materials. These procedures are found in the BWD Emergency Water Sample Collection Guide (33). Samples should be collected both upstream and downstream of the affected area. Decontamination procedures should be carefully considered before any equipment or instruments are exposed to the contaminated water.

At the time of sample collection in-situ measurements of water quality may be collected for the following parameters:

- Turbidity
- pH
- Temperature
- Dissolved Oxygen, DO
- Oxidation-Reduction potential, ORP
- Specific Conductivity

Water quality samples may be returned to the lab and analyzed for the spilled material or sent to a contract lab for priority pollutant screening (34).

Reporting

Contact the responsible agency or incident commander to determine the magnitude and extent of the spill. Potential impacts and further refinement of the monitoring plan should be discussed with the plant manager, operations supervisor, and the chief operating officer following a HAZMAT spill.

Resources

WaterISAC, **https://portal.waterisac.org/web/**

EPA Lab Compendium**, https://cfext.epa.gov/cetl/lblogin.cfm**

EPA Emergency / Incident Planning,
http://water.epa.gov/infrastructure/watersecurity/emerplan/index.cfm

Agency Contacts

Washington County Emergency Management
Benton County Emergency Services, Matt Garrity
Hickory Creek Fire and Rescue, Marc Trollinger

Airplane Crash

See HAZMAT Spill

Train Wreck

See HAZMAT Spill

Fire at Hickory Creek Marina

See HAZMAT Spill

Intentional Contamination

See HAZMAT Spill

Dam Failure

For Dam Failure upstream see Flooding

For Dam Failure downstream see Drought

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Appendix F: ADH Vulnerability Assessment and Susceptibility Analysis

SOURCE WATER ASSESSMENT

Beaver Water District - PWS ID - 038

Completed by
Arkansas Department of Health
Engineering Section
February 15, 2018

Contents

1. Introduction

A Vulnerability Assessment was recently completed for the source water(s) utilized by Beaver Water District. This report provides information about the assessment and its results. Also contained in this report is information related to the benefits of this Vulnerability Assessment for your public water system (PWS) and its customers.

The completion of this Vulnerability Assessment fulfils the source water assessment requirements of the Safe Drinking Water Act (SDWA) Amendments of 1996. Under Section 1453 of the SDWA Amendments, each State shall develop, "a source water assessment program within the State's boundaries." This is to be done "for the protection and benefit of public water systems and for the support of monitoring flexibility."

This assessment provides another means to enhance the Arkansas Department of Health's (ADH's) continuing efforts to protect public drinking water supply sources under the State's Source Water Protection Program (SWPP). Under the SWPP education and technical assistance are used as an integrated approach to source water protection. The ADH was assisted in this project by the U.S. Geological Survey's Lower Mississippi-Gulf Water Science Center, the University of Arkansas' Center for Advanced Spatial Technology, and Arkansas Water Resources Center.

2. Vulnerability Assessment

(The following is a general description of the assessment process. If more detailed information is needed, it can be found in the Source Water Assessment Plan on the Internet `http://www.healthyarkansas.com/eng/swp/swp.htm` or by contacting the ADH.)

Arkansas Source Water Assessment Plan (SWAP) established a methodology to perform Vulnerability Assessments in an effort to provide information or data to water systems and their customers. A susceptibility analysis of each source was conducted, and this information was combined with an inventory of Potential Sources of Contamination (PSOCs) in the assessment area to complete the Vulnerability Assessment. This report is a summary of all data, maps, and the susceptibility analysis for your water system.

2.1 Source Location and Assessment Area Delineation

The first steps in the Vulnerability Assessment were location of the water sources and the delineation of assessment areas. Well delineation methods were those approved for the Arkansas Well Head Protection Program (AWHPP) or other delineation methods approved to meet specific assessment conditions. This approach will enable systems to establish protection programs specific to their source, customer needs, or other concerns.

2 source(s) of water were identified for Beaver Water District: Beaver Lake - 038101 and Beaver Lake - 038201. Assessment area delineation was completed using the following method(s): arbitrary fixed buffer and arbitrary fixed buffer respectively. A detailed description of this delineation method can be found in the SWAP.

2.2 Susceptibility Analysis

The susceptibility analysis evaluated how easily each of the PWSs sources of drinking water could be affected by a contaminant at concentrations that may pose a public health concern. To complete the susceptibility analysis, the intrinsic sensitivity of each source of drinking water was determined. The natural characteristics of the delineated assessment area for each source were analyzed to measure intrinsic sensitivity. Potential barriers to contaminant transport were evaluated. A designation of high, medium or low susceptibility was assigned to each source of the PWS. The designation means the drinking water source has a high/medium/low susceptibility to contamination, if or when contaminants are present. **Please note that this rating is not an absolute measurement.** The rating of high susceptibility for a source does not mean contamination is assured, nor does a low rating mean contamination will not occur. A source with a high susceptibility ranking has been determined to have a higher sensitivity to contaminant transport than a source with a low or medium ranking.

Table 1 shows a summary of the susceptibility findings. Data used in the susceptibility analysis are given in Appendix B. Beaver Water District was found to have 2 source(s): Beaver Lake - 038101 with a Low susceptibility rating; and Beaver Lake - 038201 with a Low susceptibility rating.

2.3 PSOC Identification and Categorization

Within a delineated assessment area, PSOCs were identified and assigned to a health risk category. The health risk category takes into account the relative public health significance. PSOCs were ranked by health risk categories 1 through 10, (1 representing the highest risk). PSOCs located outside the delineated assessment area may be considered in the overall Vulnerability Assessment report at the discretion of ADH.

Section 3.2 containes table(s) that lists the number of PSOCs in the assessment area relative to their distance from the source. Appendix C contains a list of all the PSOCs.

If a large number of PSOCs are present in the assessment area of a source, a protection plan focused on reducing PSOC impact on the source should be considered to reduce the potential for source water contamination.

3. Maps and Tables

3.1 Maps

One (1) map per water source or two (2) maps per surface water source with a basin are attached at the end of this report. One (1) map will show the well or intake location, assessment area, and PSOCs excluding individual sewage disposal systems and domestic or agricultural water wells. A second map for surface water sources will show the intake location, assessment area, and basin.

The health risk category group for each PSOC is indicated by the symbol on the maps. The health risk category takes into account the relative public health significance. There are 10 categories with 1 being the most significant and 10 the least significant.

3.2 Tables

Table 1 summarizes the susceptibility of the Beaver Water District drinking water source(s) to contamination. The susceptibility analysis designates each source as high, medium, or low. Please note these ratings are not absolute measurements. The designation means the drinking water source has a high/medium/low susceptibility to contamination, if or when contaminants are present in the assessment area.

Table 1: Susceptibility Analysis:

Beaver Water District PWS ID - 038

PWS Source	High	Medium	Low
Beaver Lake - 038101			X
Beaver Lake - 038201			X

Table 2 lists the number of PSOCs identified within the assessment area of Beaver Lake relative to the distance from the source. The potential risk posed by the PSOC is ranked by Health Risk Categories 1 through 10, ("1" representing the highest risk). PSOCs appearing in the upper left corner pose the greatest potential risk to Beaver Lake. PSOCs appearing in the lower right corner pose the lowest potential risk. Appendix C lists each PSOC by zone.

Table 2: Vulnerability Assessment:

Beaver Water District - Beaver Lake - 038101

	Beaver Lake					
PSOC Health Risk Category[1]	0-1mi	1-2mi	2-3mi	3-4mi	4-5mi	Total
1			1	1		2
2		2	30	6		38
3			10	8	5	23
4			3	4	1	8
5		6	22	11	5	44
6		1		1		2
7				1		1
8			2	2	1	5
9	46	362	523	445	424	1800
10		1	3	1	4	9
Total	46	372	594	480	440	1932

[1] For more information about what types of PSOCs are included in each health risk category, see the "Contaminant Inventory Methods" section of the SWAP on the Internet at: http://www.healthy.arkansas.gov/programsServices/environmentalHealth/Engineering/sourceWaterProtection/Pages/TableofContents.aspx.

Table 3 lists the number of PSOCs identified within the assessment area of Beaver Lake relative to the distance from the source. The potential risk posed by the PSOC is ranked by Health Risk Categories 1 through 10, ("1" representing the highest risk). PSOCs appearing in the upper left corner pose the greatest potential risk to Beaver Lake. PSOCs appearing in the lower right corner pose the lowest potential risk. Appendix C lists each PSOC by zone.

Table 3: Vulnerability Assessment:

Beaver Water District - Beaver Lake - 038201

	Beaver Lake					
PSOC Health Risk Category[1]	0-1mi	1-2mi	2-3mi	3-4mi	4-5mi	Total
1			1	1		2
2		5	28	5		38
3			10	2	11	23
4			3	2	3	8
5		5	24	9	6	44
6		1		1		2
7				1		1
8			2	2	1	5
9	46	370	519	436	444	1815
10		1	3	1	4	9
Total	46	382	590	460	469	1947

[1] For more information about what types of PSOCs are included in each health risk category, see the "Contaminant Inventory Methods" section of the SWAP on the Internet at: http://www.healthy.arkansas.gov/programsServices/environmentalHealth/Engineering/sourceWaterProtection/Pages/TableofContents.aspx.

4. How Assessment Results Can Be Beneficial

4.1 PWS and Public Information

This document can be used as a management tool by public water systems to enhance the protection of their sources of drinking water. Providing public water systems and their customers with information concerning their drinking water supply enables them to develop and implement protection activities. Such activities can help to assure a continued safe drinking water supply and, in some cases, limit capital expenditures for treatment.

After receipt of the Source Water Assessment Report, the PWS should send its customers a Notice of Report Availability. An example is given in Appendix D. Amendments to the SDWA in 1996 require a notice of completion, the corresponding date of completion, and a brief summary of a system's Source Water Assessment to be included in the water system's next Consumer Confidence Report to its customers.

4.2 Source Water Protection Plan

This Vulnerability Assessment can be used as a basis to develop a source water protection plan. The ADH will provide technical assistance to the public water systems in developing their local source protection program. This assistance will be available upon request.

The involvement and cooperation of the local community is of primary importance. Each local plan may be customized to the particular area and the hazards, both actual and potential, contained therein. Such a plan may be enacted at the local level or by local Source Water Protection Teams. These teams can assist in gathering information, public education, the development of contingency and emergency plans, as well as other local options for reducing the threat of drinking water source contamination.

5. How To Obtain Additional Source Water Assessment Information

The ADH utilized many different data sources to complete the source water assessments. Some of these data can be useful for completion of source water protection plans. Below is a list of ADH Source Water Protection Program staff that can provide assessment data and technical assistance for protection plan development.

Table 4: ADH Source Water Protection Program Staff

Name	*Phone Number*	*Email*
Lyle Godfrey, P.E.	501-661-2623	lyle.godfrey@arkansas.gov
Darcia Routh, P.G.	501-661-2856	darcia.routh@arkansas.gov
Benjamin Gilley, GIS Supervisor	501-661-2623	benjamin.gilley@arkansas.gov
Evelyn Kort, P.G.	501-661-2890	evelyn.kort@arkansas.gov
Richard Norwood, Env. Health Specialist	501-661-2067	richard.norwood@arkansas.gov
Tyler Couch, Env. Health Specialist	501-280-4428	tyler.couch@arkansas.gov

Information about your public water system is also available from the local operator. A complete list of contacts for each system in the state is available at http://www.healthy.arkansas.gov/eng/autoupdates/pwslist0.htm or by calling the ADH.

Appendices

A. Definitions and Acronyms

Assessment Area: A delineated area around the intake or wellhead of a public water system that establishes the general boundary for the Vulnerability Assessment. Determined by AWHPP methods or other approved site specific methods.

AWHPP: Arkansas Well Head Protection Program. A state program developed to help protect and manage the states groundwater resources. Four methods are approved to be used to delineate the Well Head Protection Area (WHPA) under the AWHPP: 1. Arbitrary Fixed Radius - an area of arbitrary radius around a well, usually 0.25-mile, unless otherwise determined by hydrogeologic data. 2. Volumetric - a modified formula of the volume of a cylinder based on well discharge, time of travel, and aquifer characteristics. 3. Mathematical Flow Equation - the Theis Non-Equilibrium Equation or other applicable flow equation used to determine the WHPA. 4. Hydrogeologic Mapping and Hydrologic Budget - the drainage basin determined by the hydrologic budget, topographic maps, and geologic maps.

Ground Water: Naturally occurring water occupying the zone of saturation in the ground below the surface of the earth.

GWUDI: Ground Water Under the Direct Influence of Surface Water. Water beneath the surface of the ground with one of the following characteristics: 1. Significant occurrences of insects or other macro-organisms, including algae and large diameter pathogens such as Giardia-lamblia. 2. Significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions.

Health Risk Category: Ranking of identified potential sources of contamination that takes into account the relative public health significance. Each potential source of contamination is ranked by Health Risk Categories 1 through 10, (1 representing the highest risk).

Intrinsic Sensitivity: A measure of the potential barriers to contaminant transport including land use/land cover, hydrologic, and geologic/hydrogeologic conditions. Well construction will also be considered where applicable.

PSOC: Potential Sources of Contamination. Sources of contaminants that have the potential to adversely affect the quality of a drinking water supply.

PWS: Public Water System. A system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals.

SWPP: Source Water Protection Program. The State's mechanism to implement the Safe Drinking Water Act, and integrate education and technical assistance for public water supplies. The Arkansas Department of Healths Division of Engineering is primarily responsible for the implementation of the SWPP, and all rules and regulations promulgated by EPA that deals with drinking water.

Source Water: The body of water, either surface water or ground water that a PWS utilizes as a raw water supply for drinking water. Examples include impoundments, rivers, and underground aquifers.

Surface Water: Water that flows over or rests upon the surface of the earth. The term surface water includes rivers, lakes, impoundments, reservoirs, and springs in addition to other man-made and naturally occurring bodies of water on the surface of the earth.

Susceptibility Analysis: A determination of how easily each of the PWSs sources of drinking water can be affected by contaminants. It is calculated from the intrinsic sensitivity and historic water quality data to give each source a low, medium, or high rating.

Vulnerability Assessment: A multi-step process to summarize the potential for contamination of individual sources of waters at public water systems. This assessment consists of source location, delineation of source water assessment areas, identification of potential sources of contamination, and a susceptibility analysis.

B. Selected Data for Drinking Water Sources

Beaver Water District - BEAVER LAKE - 038101

Surface Water Data

Maximum Pumping Capacity - Intake (gallons/minute)	64200.0
Impoundment Volume (acre-feet)	1652000.0
Controlled Discharge	Yes

Assessment area data

Main Channel Average Slope (%)	<0.10
Main Channel Slope Weight	1.0
Average Annual Precipitation (inches/year)	47-53
Historical Water Quality	Exceedance of Giardia Lamblia or Cryptosporidium action level
Percentage with Forested Land Use	58.83
Percentage with Pasture/Grassland Land Use	14.5
Percentage with Cropland Land Use	0.05
Percentage with Residential Land Use	6.49
Percentage with Commercial/Industrial Land Use	0.31
Percentage with Water/Bare Earth Land Use	19.83

Beaver Water District - BEAVER LAKE - 038201

Surface Water Data

Maximum Pumping Capacity - Intake (gallons/minute)	48611.0
Impoundment Volume (acre-feet)	1652000.0
Controlled Discharge	Yes

Assessment area data

Main Channel Average Slope (%)	<0.10
Main Channel Slope Weight	1.0
Average Annual Precipitation (inches/year)	47-53
Historical Water Quality	Exceedance of Giardia Lamblia or Cryptosporidium action level
Percentage with Forested Land Use	58.83
Percentage with Pasture/Grassland Land Use	14.5
Percentage with Cropland Land Use	0.05
Percentage with Residential Land Use	6.49
Percentage with Commercial/Industrial Land Use	0.31
Percentage with Water/Bare Earth Land Use	19.83

C. List of PSOCs in each Zone by Source

The following is a list of the PSOCs in the assessment area of the Beaver Water District. For each PSOC the health risk category is given along with a brief description, the approximate distance of the PSOC from the source, and a reference number. The list is displayed for each distance zone from the source. The list begins with a description of PSOCs in zone 1, the closest zone to the source. Lists for each successive distant zone follows the list for zone 1. For a list of contaminants that may be found at particular PSOCs, see Appendix C "Sources of Contaminants Commonly Found in Watersheds or Recharge Zones" in the SWAP on the Internet at: http://www.healthyarknasas.com/eng/swapappC.htm

LIST OF PSOCS BY ZONE

Beaver Water District
Beaver Lake - 038101

Susceptibility Rating - Low

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
1	ADEQ Leaking Storage Tank of Unknown Type	2.51	04001674

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
1	Bridge: Railroad	3.74	6-124

Beaver Lake Zone 2			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
2	Poultry House	1.15	22-2048
2	Poultry House	1.07	22-2049

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
2	Bridge: State Highway	2.68	3-165
2	Bridge: State Highway	2.52	3-4487
2	Bridge: State Highway	2.48	3-4488
2	Bridge: State Highway	2.42	3-4524

2	Poultry House	2.05	22-880
2	Poultry House	2.07	22-881
2	Poultry House	2.1	22-882
2	Poultry House	2.12	22-883
2	Poultry House	2.1	22-884
2	Poultry House	2.08	22-885
2	Poultry House	2.39	22-899
2	Poultry House	2.95	22-1283
2	Poultry House	2.94	22-1284
2	Poultry House	2.94	22-1285
2	Poultry House	2.93	22-1286
2	Poultry House	2.93	22-1287
2	Poultry House	2.92	22-1288
2	Poultry House	2.28	22-1293
2	Poultry House	2.28	22-1294
2	Poultry House	2.27	22-1295
2	Poultry House	2.27	22-1296
2	Poultry House	2.26	22-1297
2	Poultry House	2.44	22-1548
2	Poultry House	2.47	22-1549
2	Poultry House	2.52	22-2068
2	Poultry House	2.54	22-2069
2	Poultry House	2.56	22-2070
2	Poultry House	2.61	22-2071
2	Poultry House	2.39	22-2072
2	Poultry House	2.42	22-2073

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
2	Bridge: US Highway	3.76	4-1858
2	Industrial Site: Meat Packing	3.8	70-3647
2	Poultry House	3.61	22-1279
2	Poultry House	3.59	22-1280
2	Poultry House	3.04	22-1282
2	Poultry House	3.1	22-2044

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number

3	ADEQ Underground Storage Tank: In Use	2.51	04001674
3	ADEQ Underground Storage Tank: In Use	2.51	04001674
3	ADEQ Underground Storage Tank: In Use	2.51	04001674
3	ADEQ Aboveground Storage Tank: In Use	2.17	04001670
3	ADEQ Aboveground Storage Tank: In Use	2.17	04001670
3	ADEQ Aboveground Storage Tank: In Use	2.5	04001754
3	Industrial Site: Asphalt Paving Mixture and Block Manufacturer	2.14	70-327
3	Industrial Site: Trucking	2.26	70-3648
3	ADEQ Mining Permit: Non-Coal, Limestone	2.41	0454-MN-A5
3	ADEQ Mining Permit: Non-Coal, Bauxite	2.78	0629-MN-A1

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
3	ADEQ Underground Storage Tank: In Use	3.95	72001678
3	ADEQ Underground Storage Tank: In Use	3.95	72001678
3	ADEQ Underground Storage Tank: In Use	3.95	72001678

3	ADEQ Underground Storage Tank: In Use	3.95	72001678
3	ADEQ Aboveground Storage Tank: In Use	3.48	04000140
3	ADEQ Aboveground Storage Tank: In Use	3.97	72001821
3	ADEQ Aboveground Storage Tank: In Use	3.97	72001821
3	Landing Strip	3.1	52-43

Beaver Lake Zone 5			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
3	ADEQ Aboveground Storage Tank: In Use	4.27	72001820
3	ADEQ Aboveground Storage Tank: In Use	4.27	72001820
3	ADEQ Aboveground Storage Tank: In Use	4.27	72001820
3	ADEQ Aboveground Storage Tank: In Use	4.27	72001820
3	ADEQ Aboveground Storage Tank: In Use	4.27	72001820

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
4	ADEQ Underground Storage Tank: Permanently Out of Use	2.51	04001674
4	Business: Electronics and Electronic Equipment	2.96	53-4660
4	Electric Substation	2.76	32-271

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
4	ADEQ Underground Storage Tank: Permanently Out of Use	3.97	72001821
4	ADEQ Underground Storage Tank: Permanently Out of Use	3.97	72001821
4	ADEQ Underground Storage Tank: Permanently Out of Use	3.48	04000140
4	ADEQ Underground Storage Tank: Permanently Out of Use	3.48	04000140

Beaver Lake Zone 5			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
4	Industrial Site: Metal Fabricator	4.72	70-3651

Beaver Lake Zone 2			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
5	Bridge: County Road	1.88	1-331
5	Bridge: County Road	1.54	1-358
5	Bridge: County Road	1.01	1-4559
5	Bridge: County Road	1.83	1-4892
5	Bridge: County Road	1.86	1-4893
5	Bridge: County Road	1.9	1-4898

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number

5	Bridge: County Road	2.59	1-4544
5	Bridge: County Road	2.69	1-4545
5	Bridge: County Road	2.67	1-4546
5	Bridge: County Road	2.47	1-4549
5	Bridge: County Road	2.61	1-4550
5	Bridge: County Road	2.22	1-4551
5	Bridge: County Road	2.14	1-4552
5	Bridge: County Road	2.55	1-4553
5	Bridge: County Road	2.6	1-4554
5	Bridge: County Road	2.79	1-4555
5	Bridge: County Road	2.85	1-4556
5	Bridge: County Road	2.78	1-4557
5	Bridge: County Road	2.38	1-4890
5	Bridge: County Road	2.35	1-4891
5	Bridge: County Road	2.4	1-4894
5	Bridge: County Road	2.34	1-4895
5	Bridge: County Road	2.52	1-4896
5	Bridge: County Road	2.78	1-4897
5	Boat Docks or Piers	2.38	43-401
5	Boat Docks or Piers	2.43	43-402
5	Boat Ramp	2.41	43-525
5	Boat Ramp	2.48	43-534

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number

5	Bridge: County Road	3.42	1-357
5	Bridge: County Road	3.73	1-4531
5	Bridge: County Road	3.48	1-4532
5	Bridge: County Road	3.33	1-4547
5	Bridge: County Road	3.41	1-4548
5	Bridge: County Road	3.39	1-4558
5	Bridge: County Road	3.02	1-4560
5	Business: Auto Alternators and Generators	3.49	53-4659
5	Boat Docks or Piers	3.95	43-400
5	Boat Ramp	3.9	43-524
5	Boat Ramp	3.47	43-533

Beaver Lake Zone 5			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
5	Bridge: County Road	4.75	1-4889
5	Bridge: County Road	4.13	1-10880
5	Bridge: County Road	4.13	1-10881
5	Boat Ramp	4.93	43-531
5	Boat Ramp	4.89	43-532

Beaver Lake Zone 2			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
6	ADEQ NPDES Permit Outfall: Individual Domestic	1.98	AR0037320

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
6	Park/Public Use Area	3.85	49-913

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
7	School	3.96	58-155

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
8	ADEQ NPDES Permit Outfall: Stormwater	2.9	ARR00A069
8	ADEQ NPDES Permit Outfall: Stormwater	2.19	ARR000173

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
8	ADEQ NPDES Permit Outfall: Stormwater	3.71	ARR000503
8	ADEQ NPDES Permit Outfall: Stormwater	3.68	ARR000503

Beaver Lake Zone 5			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
8	ADEQ NPDES Permit Outfall: Stormwater	4.3	ARR000360

Beaver Lake Zone 1			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
9	Individual Sewage Disposal System	0.62	90-360707
9	Individual Sewage Disposal System	0.38	90-360708
9	Individual Sewage Disposal System	0.49	90-360709
9	Individual Sewage Disposal System	0.46	90-360711
9	Individual Sewage Disposal System	0.68	90-360712

9	Individual Sewage Disposal System	0.7	90-360713
9	Individual Sewage Disposal System	0.75	90-360714
9	Individual Sewage Disposal System	0.92	90-360715
9	Individual Sewage Disposal System	0.57	90-360729
9	Individual Sewage Disposal System	0.86	90-360731
9	Individual Sewage Disposal System	0.73	90-360732
9	Individual Sewage Disposal System	0.79	90-360733
9	Individual Sewage Disposal System	0.83	90-360734
9	Individual Sewage Disposal System	0.91	90-360735
9	Individual Sewage Disposal System	0.88	90-361318
9	Individual Sewage Disposal System	0.85	90-362584
9	Individual Sewage Disposal System	0.62	90-362585
9	Individual Sewage Disposal System	0.9	90-362586
9	Individual Sewage Disposal System	0.99	90-362587
9	Individual Sewage Disposal System	0.59	90-362589
9	Individual Sewage Disposal System	0.58	90-362590
9	Individual Sewage Disposal System	0.56	90-362591
9	Individual Sewage Disposal System	0.54	90-362592
9	Individual Sewage Disposal System	0.72	90-362593
9	Individual Sewage Disposal System	0.67	90-362596
9	Individual Sewage Disposal System	0.46	90-362601
9	Individual Sewage Disposal System	0.49	90-362602

9	Individual Sewage Disposal System	0.49	90-362603
9	Individual Sewage Disposal System	0.48	90-362604
9	Individual Sewage Disposal System	0.48	90-362605
9	Individual Sewage Disposal System	0.48	90-362606
9	Individual Sewage Disposal System	0.49	90-362607
9	Individual Sewage Disposal System	0.33	90-362620
9	Individual Sewage Disposal System	0.89	90-362659
9	Individual Sewage Disposal System	0.77	90-362660
9	Individual Sewage Disposal System	0.46	90-365770
9	Individual Sewage Disposal System	0.72	90-365771
9	Individual Sewage Disposal System	0.7	90-365772
9	Individual Sewage Disposal System	0.78	90-365773
9	Individual Sewage Disposal System	0.96	90-365774
9	Individual Sewage Disposal System	0.98	90-365775
9	Individual Sewage Disposal System	0.47	90-367381
9	Individual Sewage Disposal System	0.44	90-367382
9	Individual Sewage Disposal System	0.81	90-413426
9	Individual Sewage Disposal System	0.78	90-413427
9	Individual Sewage Disposal System	0.73	90-413428

Beaver Lake Zone 2			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
9	Individual Sewage Disposal System	1.03	90-344638

9	Individual Sewage Disposal System	1.14	90-344639
9	Individual Sewage Disposal System	1.28	90-344640
9	Individual Sewage Disposal System	1.77	90-358947
9	Individual Sewage Disposal System	1.9	90-358948
9	Individual Sewage Disposal System	1.87	90-358949
9	Individual Sewage Disposal System	1.97	90-358967
9	Individual Sewage Disposal System	1.88	90-360388
9	Individual Sewage Disposal System	1.54	90-360389
9	Individual Sewage Disposal System	1.85	90-360392
9	Individual Sewage Disposal System	1.44	90-360393
9	Individual Sewage Disposal System	1.5	90-360394
9	Individual Sewage Disposal System	1.59	90-360395
9	Individual Sewage Disposal System	1.98	90-360411
9	Individual Sewage Disposal System	1.92	90-360699
9	Individual Sewage Disposal System	1.81	90-360702
9	Individual Sewage Disposal System	1.49	90-360703
9	Individual Sewage Disposal System	1.38	90-360704
9	Individual Sewage Disposal System	1.41	90-360705
9	Individual Sewage Disposal System	1.2	90-360706
9	Individual Sewage Disposal System	1.02	90-360716
9	Individual Sewage Disposal System	1.04	90-360717
9	Individual Sewage Disposal System	1.2	90-360718

9	Individual Sewage Disposal System	1.23	90-360719
9	Individual Sewage Disposal System	1.19	90-360720
9	Individual Sewage Disposal System	1.15	90-360721
9	Individual Sewage Disposal System	1.15	90-360722
9	Individual Sewage Disposal System	1.19	90-360723
9	Individual Sewage Disposal System	1.19	90-360724
9	Individual Sewage Disposal System	1.13	90-360725
9	Individual Sewage Disposal System	1.21	90-360726
9	Individual Sewage Disposal System	1.15	90-360727
9	Individual Sewage Disposal System	1.33	90-360728
9	Individual Sewage Disposal System	1.85	90-361239
9	Individual Sewage Disposal System	1.87	90-361240
9	Individual Sewage Disposal System	1.88	90-361241
9	Individual Sewage Disposal System	1.86	90-361242
9	Individual Sewage Disposal System	1.84	90-361243
9	Individual Sewage Disposal System	1.83	90-361244
9	Individual Sewage Disposal System	1.8	90-361245
9	Individual Sewage Disposal System	1.83	90-361246
9	Individual Sewage Disposal System	1.81	90-361247
9	Individual Sewage Disposal System	1.78	90-361248
9	Individual Sewage Disposal System	1.75	90-361249
9	Individual Sewage Disposal System	1.75	90-361250

9	Individual Sewage Disposal System	1.77	90-361251
9	Individual Sewage Disposal System	1.84	90-361252
9	Individual Sewage Disposal System	1.86	90-361253
9	Individual Sewage Disposal System	1.94	90-361254
9	Individual Sewage Disposal System	1.95	90-361255
9	Individual Sewage Disposal System	1.91	90-361256
9	Individual Sewage Disposal System	1.98	90-361273
9	Individual Sewage Disposal System	1.98	90-361274
9	Individual Sewage Disposal System	1.92	90-361275
9	Individual Sewage Disposal System	1.93	90-361276
9	Individual Sewage Disposal System	1.86	90-361277
9	Individual Sewage Disposal System	1.85	90-361278
9	Individual Sewage Disposal System	1.8	90-361279
9	Individual Sewage Disposal System	1.83	90-361280
9	Individual Sewage Disposal System	1.72	90-361281
9	Individual Sewage Disposal System	1.8	90-361282
9	Individual Sewage Disposal System	1.8	90-361283
9	Individual Sewage Disposal System	1.73	90-361284
9	Individual Sewage Disposal System	1.71	90-361285
9	Individual Sewage Disposal System	1.69	90-361286
9	Individual Sewage Disposal System	1.71	90-361287
9	Individual Sewage Disposal System	1.73	90-361288

9	Individual Sewage Disposal System	1.75	90-361289
9	Individual Sewage Disposal System	1.8	90-361290
9	Individual Sewage Disposal System	1.64	90-361291
9	Individual Sewage Disposal System	1.5	90-361292
9	Individual Sewage Disposal System	1.51	90-361293
9	Individual Sewage Disposal System	1.52	90-361294
9	Individual Sewage Disposal System	1.56	90-361295
9	Individual Sewage Disposal System	1.16	90-361296
9	Individual Sewage Disposal System	1.27	90-361297
9	Individual Sewage Disposal System	1.29	90-361298
9	Individual Sewage Disposal System	1.27	90-361299
9	Individual Sewage Disposal System	1.34	90-361300
9	Individual Sewage Disposal System	1.38	90-361301
9	Individual Sewage Disposal System	1.39	90-361303
9	Individual Sewage Disposal System	1.33	90-361304
9	Individual Sewage Disposal System	1.29	90-361305
9	Individual Sewage Disposal System	1.22	90-361306
9	Individual Sewage Disposal System	1.19	90-361307
9	Individual Sewage Disposal System	1.19	90-361308
9	Individual Sewage Disposal System	1.23	90-361309
9	Individual Sewage Disposal System	1.31	90-361310
9	Individual Sewage Disposal System	1.35	90-361311

9	Individual Sewage Disposal System	1.28	90-361312
9	Individual Sewage Disposal System	1.3	90-361313
9	Individual Sewage Disposal System	1.84	90-361314
9	Individual Sewage Disposal System	1.99	90-362094
9	Individual Sewage Disposal System	2.0	90-362146
9	Individual Sewage Disposal System	1.71	90-362149
9	Individual Sewage Disposal System	1.73	90-362150
9	Individual Sewage Disposal System	1.73	90-362151
9	Individual Sewage Disposal System	1.27	90-362153
9	Individual Sewage Disposal System	1.41	90-362154
9	Individual Sewage Disposal System	1.22	90-362155
9	Individual Sewage Disposal System	1.19	90-362156
9	Individual Sewage Disposal System	1.45	90-362157
9	Individual Sewage Disposal System	1.33	90-362555
9	Individual Sewage Disposal System	1.45	90-362556
9	Individual Sewage Disposal System	1.47	90-362557
9	Individual Sewage Disposal System	1.48	90-362558
9	Individual Sewage Disposal System	1.42	90-362559
9	Individual Sewage Disposal System	1.42	90-362560
9	Individual Sewage Disposal System	1.39	90-362561
9	Individual Sewage Disposal System	1.35	90-362562
9	Individual Sewage Disposal System	1.33	90-362563

9	Individual Sewage Disposal System	1.37	90-362564
9	Individual Sewage Disposal System	1.41	90-362565
9	Individual Sewage Disposal System	1.44	90-362566
9	Individual Sewage Disposal System	1.51	90-362567
9	Individual Sewage Disposal System	1.62	90-362568
9	Individual Sewage Disposal System	1.64	90-362569
9	Individual Sewage Disposal System	1.7	90-362570
9	Individual Sewage Disposal System	1.76	90-362571
9	Individual Sewage Disposal System	1.69	90-362572
9	Individual Sewage Disposal System	1.65	90-362573
9	Individual Sewage Disposal System	1.61	90-362574
9	Individual Sewage Disposal System	1.49	90-362579
9	Individual Sewage Disposal System	1.27	90-362580
9	Individual Sewage Disposal System	1.1	90-362588
9	Individual Sewage Disposal System	1.8	90-362621
9	Individual Sewage Disposal System	1.6	90-362631
9	Individual Sewage Disposal System	1.46	90-362632
9	Individual Sewage Disposal System	1.45	90-362633
9	Individual Sewage Disposal System	1.5	90-362634
9	Individual Sewage Disposal System	1.37	90-362635
9	Individual Sewage Disposal System	1.41	90-362636
9	Individual Sewage Disposal System	1.51	90-362637

9	Individual Sewage Disposal System	1.5	90-362638
9	Individual Sewage Disposal System	1.68	90-362639
9	Individual Sewage Disposal System	1.67	90-362640
9	Individual Sewage Disposal System	1.64	90-362641
9	Individual Sewage Disposal System	1.64	90-362642
9	Individual Sewage Disposal System	1.54	90-362643
9	Individual Sewage Disposal System	1.49	90-362644
9	Individual Sewage Disposal System	1.28	90-362645
9	Individual Sewage Disposal System	1.27	90-362646
9	Individual Sewage Disposal System	1.34	90-362647
9	Individual Sewage Disposal System	1.25	90-362648
9	Individual Sewage Disposal System	1.83	90-362649
9	Individual Sewage Disposal System	1.82	90-362650
9	Individual Sewage Disposal System	1.81	90-362651
9	Individual Sewage Disposal System	1.89	90-362676
9	Individual Sewage Disposal System	1.82	90-362677
9	Individual Sewage Disposal System	1.85	90-362678
9	Individual Sewage Disposal System	2.0	90-362679
9	Individual Sewage Disposal System	1.91	90-364244
9	Individual Sewage Disposal System	1.9	90-364249
9	Individual Sewage Disposal System	1.8	90-364250
9	Individual Sewage Disposal System	1.79	90-364251

9	Individual Sewage Disposal System	1.77	90-364252
9	Individual Sewage Disposal System	1.73	90-364253
9	Individual Sewage Disposal System	1.99	90-364264
9	Individual Sewage Disposal System	1.44	90-364271
9	Individual Sewage Disposal System	1.55	90-364272
9	Individual Sewage Disposal System	1.72	90-364273
9	Individual Sewage Disposal System	1.68	90-364284
9	Individual Sewage Disposal System	1.67	90-364285
9	Individual Sewage Disposal System	1.47	90-364286
9	Individual Sewage Disposal System	1.44	90-364287
9	Individual Sewage Disposal System	1.46	90-364288
9	Individual Sewage Disposal System	1.56	90-364289
9	Individual Sewage Disposal System	1.57	90-364290
9	Individual Sewage Disposal System	1.29	90-364291
9	Individual Sewage Disposal System	1.34	90-364292
9	Individual Sewage Disposal System	1.83	90-364293
9	Individual Sewage Disposal System	1.78	90-364294
9	Individual Sewage Disposal System	1.92	90-364296
9	Individual Sewage Disposal System	1.96	90-364297
9	Individual Sewage Disposal System	2.0	90-365374
9	Individual Sewage Disposal System	1.98	90-365375
9	Individual Sewage Disposal System	1.95	90-365741

9	Individual Sewage Disposal System	1.99	90-365742
9	Individual Sewage Disposal System	1.98	90-365743
9	Individual Sewage Disposal System	1.57	90-365745
9	Individual Sewage Disposal System	1.59	90-365746
9	Individual Sewage Disposal System	1.62	90-365747
9	Individual Sewage Disposal System	1.67	90-365748
9	Individual Sewage Disposal System	1.65	90-365749
9	Individual Sewage Disposal System	1.6	90-365750
9	Individual Sewage Disposal System	1.59	90-365751
9	Individual Sewage Disposal System	1.28	90-365752
9	Individual Sewage Disposal System	1.15	90-365753
9	Individual Sewage Disposal System	1.22	90-365754
9	Individual Sewage Disposal System	1.46	90-365755
9	Individual Sewage Disposal System	1.48	90-365756
9	Individual Sewage Disposal System	1.5	90-365757
9	Individual Sewage Disposal System	1.57	90-365758
9	Individual Sewage Disposal System	1.57	90-365759
9	Individual Sewage Disposal System	1.53	90-365760
9	Individual Sewage Disposal System	1.61	90-365761
9	Individual Sewage Disposal System	1.65	90-365762
9	Individual Sewage Disposal System	1.7	90-365763
9	Individual Sewage Disposal System	1.58	90-365764

9	Individual Sewage Disposal System	1.61	90-365765
9	Individual Sewage Disposal System	1.58	90-365766
9	Individual Sewage Disposal System	1.66	90-365767
9	Individual Sewage Disposal System	1.7	90-365768
9	Individual Sewage Disposal System	1.75	90-365769
9	Individual Sewage Disposal System	1.06	90-365776
9	Individual Sewage Disposal System	1.38	90-365777
9	Individual Sewage Disposal System	1.28	90-365778
9	Individual Sewage Disposal System	1.32	90-365779
9	Individual Sewage Disposal System	1.36	90-365780
9	Individual Sewage Disposal System	1.19	90-365781
9	Individual Sewage Disposal System	1.84	90-366683
9	Individual Sewage Disposal System	1.87	90-366684
9	Individual Sewage Disposal System	1.75	90-366687
9	Individual Sewage Disposal System	1.75	90-366688
9	Individual Sewage Disposal System	1.76	90-366689
9	Individual Sewage Disposal System	1.74	90-366690
9	Individual Sewage Disposal System	1.76	90-367251
9	Individual Sewage Disposal System	1.79	90-367252
9	Individual Sewage Disposal System	1.8	90-367253
9	Individual Sewage Disposal System	1.79	90-367254
9	Individual Sewage Disposal System	1.78	90-367255

9	Individual Sewage Disposal System	1.79	90-367256
9	Individual Sewage Disposal System	1.78	90-367257
9	Individual Sewage Disposal System	1.81	90-367258
9	Individual Sewage Disposal System	1.84	90-367259
9	Individual Sewage Disposal System	1.86	90-367260
9	Individual Sewage Disposal System	1.88	90-367263
9	Individual Sewage Disposal System	1.9	90-367264
9	Individual Sewage Disposal System	1.91	90-367275
9	Individual Sewage Disposal System	1.84	90-367279
9	Individual Sewage Disposal System	1.78	90-367280
9	Individual Sewage Disposal System	1.83	90-367281
9	Individual Sewage Disposal System	1.79	90-367282
9	Individual Sewage Disposal System	1.84	90-367283
9	Individual Sewage Disposal System	1.81	90-367284
9	Individual Sewage Disposal System	1.78	90-367285
9	Individual Sewage Disposal System	1.85	90-367286
9	Individual Sewage Disposal System	1.88	90-367287
9	Individual Sewage Disposal System	1.82	90-367288
9	Individual Sewage Disposal System	1.92	90-367289
9	Individual Sewage Disposal System	1.9	90-367290
9	Individual Sewage Disposal System	1.72	90-367291
9	Individual Sewage Disposal System	1.96	90-367296

9	Individual Sewage Disposal System	1.96	90-367297
9	Individual Sewage Disposal System	1.94	90-367298
9	Individual Sewage Disposal System	1.93	90-367299
9	Individual Sewage Disposal System	1.94	90-367300
9	Individual Sewage Disposal System	1.96	90-367301
9	Individual Sewage Disposal System	1.91	90-367302
9	Individual Sewage Disposal System	1.92	90-367303
9	Individual Sewage Disposal System	1.92	90-367304
9	Individual Sewage Disposal System	1.92	90-367305
9	Individual Sewage Disposal System	1.96	90-367306
9	Individual Sewage Disposal System	1.93	90-367318
9	Individual Sewage Disposal System	1.91	90-367319
9	Individual Sewage Disposal System	1.92	90-367320
9	Individual Sewage Disposal System	1.9	90-367321
9	Individual Sewage Disposal System	1.89	90-367322
9	Individual Sewage Disposal System	1.9	90-367323
9	Individual Sewage Disposal System	1.89	90-367324
9	Individual Sewage Disposal System	1.87	90-367325
9	Individual Sewage Disposal System	1.88	90-367326
9	Individual Sewage Disposal System	1.81	90-367327
9	Individual Sewage Disposal System	1.79	90-367328
9	Individual Sewage Disposal System	1.8	90-367329

9	Individual Sewage Disposal System	1.84	90-367330
9	Individual Sewage Disposal System	1.84	90-367331
9	Individual Sewage Disposal System	1.86	90-367332
9	Individual Sewage Disposal System	1.78	90-367333
9	Individual Sewage Disposal System	1.79	90-367334
9	Individual Sewage Disposal System	1.81	90-367335
9	Individual Sewage Disposal System	1.82	90-367336
9	Individual Sewage Disposal System	1.86	90-367337
9	Individual Sewage Disposal System	1.83	90-367338
9	Individual Sewage Disposal System	1.79	90-367339
9	Individual Sewage Disposal System	1.79	90-367340
9	Individual Sewage Disposal System	1.79	90-367341
9	Individual Sewage Disposal System	1.78	90-367342
9	Individual Sewage Disposal System	1.79	90-367343
9	Individual Sewage Disposal System	1.8	90-367344
9	Individual Sewage Disposal System	1.8	90-367345
9	Individual Sewage Disposal System	1.59	90-367346
9	Individual Sewage Disposal System	1.57	90-367347
9	Individual Sewage Disposal System	1.95	90-367351
9	Individual Sewage Disposal System	1.91	90-367352
9	Individual Sewage Disposal System	1.87	90-367353
9	Individual Sewage Disposal System	1.85	90-367354

9	Individual Sewage Disposal System	1.86	90-367355
9	Individual Sewage Disposal System	1.85	90-367356
9	Individual Sewage Disposal System	1.91	90-367357
9	Individual Sewage Disposal System	1.95	90-367358
9	Individual Sewage Disposal System	1.91	90-367359
9	Individual Sewage Disposal System	1.93	90-367360
9	Individual Sewage Disposal System	1.9	90-367361
9	Individual Sewage Disposal System	1.93	90-367367
9	Individual Sewage Disposal System	1.15	90-367369
9	Individual Sewage Disposal System	1.19	90-368173
9	Individual Sewage Disposal System	1.24	90-368174
9	Individual Sewage Disposal System	1.42	90-368176
9	Individual Sewage Disposal System	1.45	90-368177
9	Individual Sewage Disposal System	1.92	90-368610
9	Individual Sewage Disposal System	1.89	90-368611
9	Individual Sewage Disposal System	1.87	90-368612
9	Individual Sewage Disposal System	1.83	90-368613
9	Individual Sewage Disposal System	1.91	90-368614
9	Individual Sewage Disposal System	1.68	90-368615
9	Individual Sewage Disposal System	1.72	90-368620
9	Individual Sewage Disposal System	1.48	90-368621
9	Individual Sewage Disposal System	1.5	90-368622

9	Individual Sewage Disposal System	1.46	90-368623
9	Individual Sewage Disposal System	1.49	90-368624
9	Individual Sewage Disposal System	1.51	90-368625
9	Individual Sewage Disposal System	1.34	90-368626
9	Individual Sewage Disposal System	1.35	90-368627
9	Individual Sewage Disposal System	1.16	90-368628
9	Individual Sewage Disposal System	1.2	90-368629
9	Individual Sewage Disposal System	1.85	90-368641
9	Individual Sewage Disposal System	1.91	90-368642
9	Individual Sewage Disposal System	1.94	90-368643
9	Individual Sewage Disposal System	1.97	90-368644
9	Individual Sewage Disposal System	1.09	90-368649
9	Individual Sewage Disposal System	1.36	90-368650
9	Individual Sewage Disposal System	1.38	90-368651
9	Individual Sewage Disposal System	1.35	90-368652
9	Individual Sewage Disposal System	1.27	90-368653
9	Individual Sewage Disposal System	1.31	90-368654
9	Individual Sewage Disposal System	1.42	90-368655
9	Individual Sewage Disposal System	1.44	90-368656
9	Individual Sewage Disposal System	1.48	90-368659
9	Individual Sewage Disposal System	1.46	90-368660
9	Individual Sewage Disposal System	1.78	90-368675

9	Individual Sewage Disposal System	1.77	90-368676
9	Individual Sewage Disposal System	1.77	90-368677
9	Individual Sewage Disposal System	1.79	90-368678
9	Individual Sewage Disposal System	1.86	90-368679
9	Individual Sewage Disposal System	1.81	90-368680
9	Individual Sewage Disposal System	1.63	90-368681
9	Individual Sewage Disposal System	1.94	90-368682
9	Individual Sewage Disposal System	1.73	90-413423
9	Individual Sewage Disposal System	1.61	90-413424
9	Individual Sewage Disposal System	1.04	90-413425
9	Individual Sewage Disposal System	1.56	90-413429
9	Individual Sewage Disposal System	1.7	90-413430
9	Individual Sewage Disposal System	1.9	90-413431
9	Individual Sewage Disposal System	1.85	90-413439
9	Individual Sewage Disposal System	1.86	90-413440
9	Individual Sewage Disposal System	1.87	90-413441
9	Individual Sewage Disposal System	1.89	90-413442
9	Individual Sewage Disposal System	1.81	90-413443
9	Individual Sewage Disposal System	1.79	90-413444
9	Individual Sewage Disposal System	1.77	90-413445
9	Individual Sewage Disposal System	1.75	90-413446
9	Individual Sewage Disposal System	1.73	90-413447

9	Individual Sewage Disposal System	1.35	90-413454
9	Individual Sewage Disposal System	1.35	90-413454
9	Individual Sewage Disposal System	1.35	90-413455
9	Individual Sewage Disposal System	1.28	90-413456
9	Individual Sewage Disposal System	1.25	90-413457
9	Individual Sewage Disposal System	1.34	90-413458
9	Individual Sewage Disposal System	1.37	90-413459
9	Individual Sewage Disposal System	1.38	90-413459
9	Individual Sewage Disposal System	1.43	90-413459

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
9	Individual Sewage Disposal System	2.31	90-344678
9	Individual Sewage Disposal System	2.34	90-344679
9	Individual Sewage Disposal System	2.38	90-344680
9	Individual Sewage Disposal System	2.43	90-344681
9	Individual Sewage Disposal System	2.45	90-344682
9	Individual Sewage Disposal System	2.45	90-344683
9	Individual Sewage Disposal System	2.48	90-344684
9	Individual Sewage Disposal System	2.52	90-344685
9	Individual Sewage Disposal System	2.53	90-344686
9	Individual Sewage Disposal System	2.6	90-344687
9	Individual Sewage Disposal System	2.57	90-344688

9	Individual Sewage Disposal System	2.53	90-344689
9	Individual Sewage Disposal System	2.51	90-344690
9	Individual Sewage Disposal System	2.49	90-344691
9	Individual Sewage Disposal System	2.55	90-344692
9	Individual Sewage Disposal System	2.62	90-344693
9	Individual Sewage Disposal System	2.61	90-344694
9	Individual Sewage Disposal System	2.63	90-344695
9	Individual Sewage Disposal System	2.7	90-344696
9	Individual Sewage Disposal System	2.95	90-349882
9	Individual Sewage Disposal System	2.93	90-349883
9	Individual Sewage Disposal System	2.92	90-349884
9	Individual Sewage Disposal System	2.83	90-349885
9	Individual Sewage Disposal System	2.82	90-349886
9	Individual Sewage Disposal System	2.81	90-349887
9	Individual Sewage Disposal System	2.84	90-349888
9	Individual Sewage Disposal System	2.85	90-349889
9	Individual Sewage Disposal System	2.86	90-349890
9	Individual Sewage Disposal System	2.86	90-349891
9	Individual Sewage Disposal System	2.84	90-349892
9	Individual Sewage Disposal System	2.87	90-349893
9	Individual Sewage Disposal System	2.88	90-349894
9	Individual Sewage Disposal System	2.9	90-349895

9	Individual Sewage Disposal System	2.93	90-357339
9	Individual Sewage Disposal System	2.34	90-358873
9	Individual Sewage Disposal System	2.37	90-358874
9	Individual Sewage Disposal System	2.32	90-358875
9	Individual Sewage Disposal System	2.29	90-358876
9	Individual Sewage Disposal System	2.21	90-358877
9	Individual Sewage Disposal System	2.19	90-358878
9	Individual Sewage Disposal System	2.24	90-358879
9	Individual Sewage Disposal System	2.15	90-358880
9	Individual Sewage Disposal System	2.08	90-358881
9	Individual Sewage Disposal System	2.07	90-358882
9	Individual Sewage Disposal System	2.2	90-358883
9	Individual Sewage Disposal System	2.25	90-358884
9	Individual Sewage Disposal System	2.29	90-358885
9	Individual Sewage Disposal System	2.31	90-358886
9	Individual Sewage Disposal System	2.3	90-358887
9	Individual Sewage Disposal System	2.38	90-358888
9	Individual Sewage Disposal System	2.47	90-358889
9	Individual Sewage Disposal System	2.56	90-358890
9	Individual Sewage Disposal System	2.63	90-358891
9	Individual Sewage Disposal System	2.05	90-358906
9	Individual Sewage Disposal System	2.09	90-358907

9	Individual Sewage Disposal System	2.16	90-358913
9	Individual Sewage Disposal System	2.19	90-358914
9	Individual Sewage Disposal System	2.27	90-358922
9	Individual Sewage Disposal System	2.3	90-358923
9	Individual Sewage Disposal System	2.26	90-358924
9	Individual Sewage Disposal System	2.32	90-358925
9	Individual Sewage Disposal System	2.34	90-358926
9	Individual Sewage Disposal System	2.36	90-358927
9	Individual Sewage Disposal System	2.37	90-358928
9	Individual Sewage Disposal System	2.34	90-358929
9	Individual Sewage Disposal System	2.36	90-358930
9	Individual Sewage Disposal System	2.42	90-358931
9	Individual Sewage Disposal System	2.36	90-358932
9	Individual Sewage Disposal System	2.37	90-358933
9	Individual Sewage Disposal System	2.38	90-358934
9	Individual Sewage Disposal System	2.45	90-358935
9	Individual Sewage Disposal System	2.51	90-358936
9	Individual Sewage Disposal System	2.5	90-358940
9	Individual Sewage Disposal System	2.35	90-358950
9	Individual Sewage Disposal System	2.37	90-358951
9	Individual Sewage Disposal System	2.91	90-358997
9	Individual Sewage Disposal System	2.92	90-358998

9	Individual Sewage Disposal System	2.95	90-358999
9	Individual Sewage Disposal System	2.95	90-359000
9	Individual Sewage Disposal System	2.96	90-359001
9	Individual Sewage Disposal System	2.93	90-359002
9	Individual Sewage Disposal System	2.93	90-359003
9	Individual Sewage Disposal System	2.94	90-359004
9	Individual Sewage Disposal System	2.25	90-360386
9	Individual Sewage Disposal System	2.15	90-360387
9	Individual Sewage Disposal System	2.05	90-360399
9	Individual Sewage Disposal System	2.14	90-360400
9	Individual Sewage Disposal System	2.13	90-360401
9	Individual Sewage Disposal System	2.06	90-360402
9	Individual Sewage Disposal System	2.04	90-360403
9	Individual Sewage Disposal System	2.03	90-360404
9	Individual Sewage Disposal System	2.07	90-360405
9	Individual Sewage Disposal System	2.12	90-360406
9	Individual Sewage Disposal System	2.12	90-360407
9	Individual Sewage Disposal System	2.09	90-360408
9	Individual Sewage Disposal System	2.06	90-360409
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9	Individual Sewage Disposal System	2.03	90-360412
9	Individual Sewage Disposal System	2.07	90-360413

9	Individual Sewage Disposal System	2.99	90-360747
9	Individual Sewage Disposal System	2.97	90-360756
9	Individual Sewage Disposal System	2.89	90-360757
9	Individual Sewage Disposal System	2.87	90-360758
9	Individual Sewage Disposal System	2.81	90-360759
9	Individual Sewage Disposal System	2.8	90-360760
9	Individual Sewage Disposal System	2.85	90-360761
9	Individual Sewage Disposal System	2.83	90-360762
9	Individual Sewage Disposal System	2.92	90-360763
9	Individual Sewage Disposal System	2.99	90-360769
9	Individual Sewage Disposal System	2.92	90-360770
9	Individual Sewage Disposal System	2.92	90-360771
9	Individual Sewage Disposal System	2.85	90-360772
9	Individual Sewage Disposal System	2.84	90-360773
9	Individual Sewage Disposal System	2.85	90-360774
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9	Individual Sewage Disposal System	2.89	90-360776
9	Individual Sewage Disposal System	2.7	90-360777
9	Individual Sewage Disposal System	2.61	90-360778
9	Individual Sewage Disposal System	2.55	90-360779
9	Individual Sewage Disposal System	2.67	90-361129
9	Individual Sewage Disposal System	2.65	90-361130

9	Individual Sewage Disposal System	2.63	90-361131
9	Individual Sewage Disposal System	2.71	90-361132
9	Individual Sewage Disposal System	2.74	90-361133
9	Individual Sewage Disposal System	2.74	90-361134
9	Individual Sewage Disposal System	2.76	90-361135
9	Individual Sewage Disposal System	2.81	90-361136
9	Individual Sewage Disposal System	2.79	90-361137
9	Individual Sewage Disposal System	2.82	90-361138
9	Individual Sewage Disposal System	2.85	90-361139
9	Individual Sewage Disposal System	2.86	90-361140
9	Individual Sewage Disposal System	2.84	90-361141
9	Individual Sewage Disposal System	2.86	90-361142
9	Individual Sewage Disposal System	2.88	90-361143
9	Individual Sewage Disposal System	2.9	90-361144
9	Individual Sewage Disposal System	2.91	90-361145
9	Individual Sewage Disposal System	2.99	90-361147
9	Individual Sewage Disposal System	3.0	90-361154
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9	Individual Sewage Disposal System	2.71	90-361164
9	Individual Sewage Disposal System	2.63	90-361165
9	Individual Sewage Disposal System	2.75	90-361168
9	Individual Sewage Disposal System	2.74	90-361173

9	Individual Sewage Disposal System	2.28	90-361174
9	Individual Sewage Disposal System	2.12	90-361236
9	Individual Sewage Disposal System	2.01	90-361257
9	Individual Sewage Disposal System	2.01	90-361258
9	Individual Sewage Disposal System	2.01	90-361259
9	Individual Sewage Disposal System	2.01	90-361260
9	Individual Sewage Disposal System	2.02	90-361261
9	Individual Sewage Disposal System	2.01	90-361262
9	Individual Sewage Disposal System	2.02	90-361263
9	Individual Sewage Disposal System	2.02	90-361264
9	Individual Sewage Disposal System	2.02	90-361265
9	Individual Sewage Disposal System	2.06	90-361266
9	Individual Sewage Disposal System	2.07	90-361267
9	Individual Sewage Disposal System	2.08	90-361268
9	Individual Sewage Disposal System	2.05	90-361269
9	Individual Sewage Disposal System	2.05	90-361270
9	Individual Sewage Disposal System	2.03	90-361271
9	Individual Sewage Disposal System	2.03	90-361272
9	Individual Sewage Disposal System	2.93	90-361433
9	Individual Sewage Disposal System	2.7	90-361434
9	Individual Sewage Disposal System	2.16	90-361443
9	Individual Sewage Disposal System	2.17	90-361444

9	Individual Sewage Disposal System	2.15	90-361452
9	Individual Sewage Disposal System	2.01	90-361453
9	Individual Sewage Disposal System	2.22	90-361454
9	Individual Sewage Disposal System	2.74	90-361462
9	Individual Sewage Disposal System	2.68	90-362031
9	Individual Sewage Disposal System	2.61	90-362088
9	Individual Sewage Disposal System	2.57	90-362089
9	Individual Sewage Disposal System	2.45	90-362090
9	Individual Sewage Disposal System	2.4	90-362091
9	Individual Sewage Disposal System	2.34	90-362092
9	Individual Sewage Disposal System	2.7	90-362114
9	Individual Sewage Disposal System	2.74	90-362115
9	Individual Sewage Disposal System	2.76	90-362116
9	Individual Sewage Disposal System	2.78	90-362117
9	Individual Sewage Disposal System	2.8	90-362118
9	Individual Sewage Disposal System	2.77	90-362119
9	Individual Sewage Disposal System	2.66	90-362120
9	Individual Sewage Disposal System	2.77	90-362121
9	Individual Sewage Disposal System	2.26	90-362135
9	Individual Sewage Disposal System	2.23	90-362136
9	Individual Sewage Disposal System	2.22	90-362137
9	Individual Sewage Disposal System	2.46	90-362138

9	Individual Sewage Disposal System	2.44	90-362139
9	Individual Sewage Disposal System	2.39	90-362140
9	Individual Sewage Disposal System	2.27	90-362141
9	Individual Sewage Disposal System	2.34	90-362142
9	Individual Sewage Disposal System	2.12	90-362145
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9	Individual Sewage Disposal System	2.01	90-362148
9	Individual Sewage Disposal System	2.66	90-362663
9	Individual Sewage Disposal System	2.92	90-362664
9	Individual Sewage Disposal System	2.83	90-362665
9	Individual Sewage Disposal System	2.87	90-362667
9	Individual Sewage Disposal System	2.77	90-362668
9	Individual Sewage Disposal System	2.74	90-362669
9	Individual Sewage Disposal System	2.67	90-362670
9	Individual Sewage Disposal System	2.15	90-362671
9	Individual Sewage Disposal System	2.1	90-362672
9	Individual Sewage Disposal System	2.07	90-362680
9	Individual Sewage Disposal System	2.19	90-362681
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9	Individual Sewage Disposal System	2.33	90-362684
9	Individual Sewage Disposal System	2.29	90-362898

9	Individual Sewage Disposal System	2.35	90-362899
9	Individual Sewage Disposal System	2.65	90-362900
9	Individual Sewage Disposal System	2.58	90-362901
9	Individual Sewage Disposal System	2.5	90-362902
9	Individual Sewage Disposal System	2.53	90-362903
9	Individual Sewage Disposal System	2.62	90-362904
9	Individual Sewage Disposal System	2.7	90-362905
9	Individual Sewage Disposal System	2.72	90-362906
9	Individual Sewage Disposal System	2.72	90-362910
9	Individual Sewage Disposal System	2.61	90-362911
9	Individual Sewage Disposal System	2.57	90-362912
9	Individual Sewage Disposal System	2.53	90-362913
9	Individual Sewage Disposal System	2.47	90-362914
9	Individual Sewage Disposal System	2.4	90-362915
9	Individual Sewage Disposal System	2.32	90-362916
9	Individual Sewage Disposal System	2.79	90-362944
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9	Individual Sewage Disposal System	2.87	90-364238
9	Individual Sewage Disposal System	2.83	90-364239
9	Individual Sewage Disposal System	2.32	90-364240
9	Individual Sewage Disposal System	2.34	90-364241

9	Individual Sewage Disposal System	2.14	90-364242
9	Individual Sewage Disposal System	2.16	90-364243
9	Individual Sewage Disposal System	2.03	90-364245
9	Individual Sewage Disposal System	2.05	90-364265
9	Individual Sewage Disposal System	2.15	90-364267
9	Individual Sewage Disposal System	2.09	90-364268
9	Individual Sewage Disposal System	2.07	90-364269
9	Individual Sewage Disposal System	2.1	90-364270
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9	Individual Sewage Disposal System	2.19	90-364279
9	Individual Sewage Disposal System	2.14	90-364280
9	Individual Sewage Disposal System	2.15	90-364281
9	Individual Sewage Disposal System	2.25	90-364282
9	Individual Sewage Disposal System	2.17	90-364283
9	Individual Sewage Disposal System	2.08	90-364298
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9	Individual Sewage Disposal System	2.06	90-364300
9	Individual Sewage Disposal System	2.07	90-364301
9	Individual Sewage Disposal System	2.2	90-364302
9	Individual Sewage Disposal System	2.23	90-364303
9	Individual Sewage Disposal System	2.33	90-364304

9	Individual Sewage Disposal System	2.18	90-364305
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9	Individual Sewage Disposal System	2.26	90-364307
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9	Individual Sewage Disposal System	2.55	90-364311
9	Individual Sewage Disposal System	2.46	90-364312
9	Individual Sewage Disposal System	2.46	90-364313
9	Individual Sewage Disposal System	2.5	90-364314
9	Individual Sewage Disposal System	2.49	90-364315
9	Individual Sewage Disposal System	2.62	90-364316
9	Individual Sewage Disposal System	2.64	90-364317
9	Individual Sewage Disposal System	2.68	90-364318
9	Individual Sewage Disposal System	2.81	90-364319
9	Individual Sewage Disposal System	2.8	90-364322
9	Individual Sewage Disposal System	2.73	90-364323
9	Individual Sewage Disposal System	2.97	90-364324
9	Individual Sewage Disposal System	2.99	90-365338
9	Individual Sewage Disposal System	2.09	90-365367
9	Individual Sewage Disposal System	2.05	90-365368
9	Individual Sewage Disposal System	2.09	90-365369

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9	Individual Sewage Disposal System	2.04	90-365371
9	Individual Sewage Disposal System	2.08	90-365372
9	Individual Sewage Disposal System	2.08	90-365373
9	Individual Sewage Disposal System	2.07	90-365376
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9	Individual Sewage Disposal System	2.05	90-365791
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9	Individual Sewage Disposal System	2.04	90-365797
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9	Individual Sewage Disposal System	2.1	90-365822
9	Individual Sewage Disposal System	2.04	90-365823
9	Individual Sewage Disposal System	2.23	90-365824
9	Individual Sewage Disposal System	2.29	90-365825
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9	Individual Sewage Disposal System	2.11	90-365828
9	Individual Sewage Disposal System	2.13	90-365829
9	Individual Sewage Disposal System	2.18	90-365830
9	Individual Sewage Disposal System	2.47	90-365831
9	Individual Sewage Disposal System	2.46	90-365832
9	Individual Sewage Disposal System	2.44	90-365833
9	Individual Sewage Disposal System	2.44	90-365834
9	Individual Sewage Disposal System	2.42	90-365835
9	Individual Sewage Disposal System	2.34	90-365836
9	Individual Sewage Disposal System	2.35	90-365837
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9	Individual Sewage Disposal System	2.37	90-365839
9	Individual Sewage Disposal System	2.38	90-365840
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9	Individual Sewage Disposal System	2.14	90-365845
9	Individual Sewage Disposal System	2.09	90-365846
9	Individual Sewage Disposal System	2.1	90-365847
9	Individual Sewage Disposal System	2.19	90-365848

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9	Individual Sewage Disposal System	2.32	90-365850
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9	Individual Sewage Disposal System	2.38	90-365855
9	Individual Sewage Disposal System	2.42	90-365856
9	Individual Sewage Disposal System	2.85	90-366584
9	Individual Sewage Disposal System	2.91	90-366585
9	Individual Sewage Disposal System	2.78	90-366586
9	Individual Sewage Disposal System	2.79	90-366587
9	Individual Sewage Disposal System	2.76	90-366588
9	Individual Sewage Disposal System	2.74	90-366589
9	Individual Sewage Disposal System	2.7	90-366590
9	Individual Sewage Disposal System	2.72	90-366591
9	Individual Sewage Disposal System	2.69	90-366592
9	Individual Sewage Disposal System	2.66	90-366593
9	Individual Sewage Disposal System	2.71	90-366594
9	Individual Sewage Disposal System	2.74	90-366595
9	Individual Sewage Disposal System	2.76	90-366596
9	Individual Sewage Disposal System	2.8	90-366597

9	Individual Sewage Disposal System	2.74	90-366598
9	Individual Sewage Disposal System	2.72	90-366599
9	Individual Sewage Disposal System	2.71	90-366600
9	Individual Sewage Disposal System	2.78	90-366601
9	Individual Sewage Disposal System	2.81	90-366602
9	Individual Sewage Disposal System	2.83	90-366603
9	Individual Sewage Disposal System	2.66	90-366604
9	Individual Sewage Disposal System	2.63	90-366605
9	Individual Sewage Disposal System	2.61	90-366606
9	Individual Sewage Disposal System	2.74	90-366607
9	Individual Sewage Disposal System	2.81	90-366608
9	Individual Sewage Disposal System	3.0	90-366610
9	Individual Sewage Disposal System	2.64	90-366611
9	Individual Sewage Disposal System	2.78	90-366612
9	Individual Sewage Disposal System	2.76	90-366613
9	Individual Sewage Disposal System	2.8	90-366614
9	Individual Sewage Disposal System	2.84	90-366615
9	Individual Sewage Disposal System	2.8	90-366616
9	Individual Sewage Disposal System	2.78	90-366617
9	Individual Sewage Disposal System	2.77	90-366618
9	Individual Sewage Disposal System	2.75	90-366619
9	Individual Sewage Disposal System	2.75	90-366620

9	Individual Sewage Disposal System	2.73	90-366621
9	Individual Sewage Disposal System	2.72	90-366622
9	Individual Sewage Disposal System	2.7	90-366623
9	Individual Sewage Disposal System	2.69	90-366624
9	Individual Sewage Disposal System	2.71	90-366625
9	Individual Sewage Disposal System	2.73	90-366626
9	Individual Sewage Disposal System	2.72	90-366627
9	Individual Sewage Disposal System	2.7	90-366628
9	Individual Sewage Disposal System	2.71	90-366629
9	Individual Sewage Disposal System	2.74	90-366630
9	Individual Sewage Disposal System	2.7	90-366631
9	Individual Sewage Disposal System	2.67	90-366632
9	Individual Sewage Disposal System	2.68	90-366633
9	Individual Sewage Disposal System	2.64	90-366634
9	Individual Sewage Disposal System	2.76	90-366635
9	Individual Sewage Disposal System	2.76	90-366636
9	Individual Sewage Disposal System	2.75	90-366637
9	Individual Sewage Disposal System	2.74	90-366638
9	Individual Sewage Disposal System	2.75	90-366639
9	Individual Sewage Disposal System	2.76	90-366640
9	Individual Sewage Disposal System	2.6	90-366641
9	Individual Sewage Disposal System	2.58	90-366642

9	Individual Sewage Disposal System	2.58	90-366643
9	Individual Sewage Disposal System	2.58	90-366644
9	Individual Sewage Disposal System	2.57	90-366645
9	Individual Sewage Disposal System	2.44	90-366670
9	Individual Sewage Disposal System	2.44	90-366671
9	Individual Sewage Disposal System	2.42	90-366672
9	Individual Sewage Disposal System	2.4	90-366673
9	Individual Sewage Disposal System	2.47	90-366674
9	Individual Sewage Disposal System	2.48	90-366675
9	Individual Sewage Disposal System	2.49	90-366676
9	Individual Sewage Disposal System	2.5	90-366677
9	Individual Sewage Disposal System	2.51	90-366678
9	Individual Sewage Disposal System	2.48	90-366679
9	Individual Sewage Disposal System	2.6	90-366680
9	Individual Sewage Disposal System	2.57	90-366681
9	Individual Sewage Disposal System	2.61	90-366682
9	Individual Sewage Disposal System	2.1	90-366828
9	Individual Sewage Disposal System	2.12	90-366829
9	Individual Sewage Disposal System	2.17	90-366830
9	Individual Sewage Disposal System	2.14	90-366831
9	Individual Sewage Disposal System	2.16	90-366832
9	Individual Sewage Disposal System	2.16	90-366833

9	Individual Sewage Disposal System	2.16	90-366834
9	Individual Sewage Disposal System	2.15	90-366835
9	Individual Sewage Disposal System	2.11	90-366836
9	Individual Sewage Disposal System	2.1	90-366837
9	Individual Sewage Disposal System	2.08	90-366838
9	Individual Sewage Disposal System	2.07	90-366839
9	Individual Sewage Disposal System	2.07	90-366840
9	Individual Sewage Disposal System	2.08	90-366841
9	Individual Sewage Disposal System	2.11	90-366842
9	Individual Sewage Disposal System	2.12	90-366843
9	Individual Sewage Disposal System	2.14	90-366844
9	Individual Sewage Disposal System	2.16	90-366845
9	Individual Sewage Disposal System	2.03	90-367317
9	Individual Sewage Disposal System	2.0	90-367350
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9	Individual Sewage Disposal System	2.43	90-368183
9	Individual Sewage Disposal System	2.43	90-368184
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9	Individual Sewage Disposal System	3.0	90-368211
9	Individual Sewage Disposal System	2.97	90-368212
9	Individual Sewage Disposal System	2.9	90-368213
9	Individual Sewage Disposal System	2.87	90-368225

9	Individual Sewage Disposal System	2.84	90-368233
9	Individual Sewage Disposal System	2.82	90-368234
9	Individual Sewage Disposal System	2.8	90-368235
9	Individual Sewage Disposal System	2.82	90-368236
9	Individual Sewage Disposal System	2.8	90-368237
9	Individual Sewage Disposal System	2.78	90-368238
9	Individual Sewage Disposal System	2.75	90-368239
9	Individual Sewage Disposal System	2.72	90-368240
9	Individual Sewage Disposal System	2.71	90-368241
9	Individual Sewage Disposal System	2.74	90-368242
9	Individual Sewage Disposal System	2.76	90-368243
9	Individual Sewage Disposal System	2.54	90-368253
9	Individual Sewage Disposal System	2.48	90-368260
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9	Individual Sewage Disposal System	2.43	90-368262
9	Individual Sewage Disposal System	2.54	90-368263
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9	Individual Sewage Disposal System	2.43	90-368270
9	Individual Sewage Disposal System	2.11	90-368274
9	Individual Sewage Disposal System	2.57	90-368275
9	Individual Sewage Disposal System	2.59	90-368276

9	Individual Sewage Disposal System	2.63	90-368277
9	Individual Sewage Disposal System	2.09	90-368456
9	Individual Sewage Disposal System	2.1	90-368457
9	Individual Sewage Disposal System	2.08	90-368458
9	Individual Sewage Disposal System	2.09	90-368459
9	Individual Sewage Disposal System	2.07	90-368472
9	Individual Sewage Disposal System	2.02	90-368630
9	Individual Sewage Disposal System	2.27	90-368686
9	Individual Sewage Disposal System	2.23	90-368687
9	Individual Sewage Disposal System	2.14	90-368688
9	Individual Sewage Disposal System	2.18	90-368689
9	Individual Sewage Disposal System	2.18	90-368690
9	Individual Sewage Disposal System	2.14	90-368691
9	Individual Sewage Disposal System	2.23	90-368692
9	Individual Sewage Disposal System	2.75	90-368907
9	Individual Sewage Disposal System	2.82	90-368908
9	Individual Sewage Disposal System	2.93	90-368914
9	Individual Sewage Disposal System	2.97	90-368915
9	Individual Sewage Disposal System	2.89	90-368928
9	Individual Sewage Disposal System	2.9	90-368929
9	Individual Sewage Disposal System	2.88	90-368930
9	Individual Sewage Disposal System	2.84	90-368931

9	Individual Sewage Disposal System	2.77	90-368985
9	Individual Sewage Disposal System	2.8	90-368986
9	Individual Sewage Disposal System	2.79	90-368987
9	Individual Sewage Disposal System	2.94	90-369322
9	Individual Sewage Disposal System	2.88	90-369323
9	Individual Sewage Disposal System	2.82	90-369325
9	Individual Sewage Disposal System	2.82	90-369326
9	Individual Sewage Disposal System	2.74	90-369328
9	Individual Sewage Disposal System	2.91	90-369330
9	Individual Sewage Disposal System	2.52	90-369336
9	Individual Sewage Disposal System	2.76	90-369337
9	Individual Sewage Disposal System	2.12	90-369338
9	Individual Sewage Disposal System	2.42	90-369343
9	Individual Sewage Disposal System	2.45	90-369344
9	Individual Sewage Disposal System	2.41	90-369345
9	Individual Sewage Disposal System	2.51	90-369347
9	Individual Sewage Disposal System	2.82	90-369841
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9	Individual Sewage Disposal System	2.95	90-413393
9	Individual Sewage Disposal System	2.92	90-413394
9	Individual Sewage Disposal System	2.98	90-413417
9	Individual Sewage Disposal System	2.94	90-413418

9	Individual Sewage Disposal System	2.99	90-413419
9	Individual Sewage Disposal System	2.01	90-413432
9	Individual Sewage Disposal System	2.19	90-413433
9	Individual Sewage Disposal System	2.1	90-413451
9	Individual Sewage Disposal System	2.15	90-413453
9	Individual Sewage Disposal System	2.09	90-413452

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
9	Individual Sewage Disposal System	3.77	90-301477
9	Individual Sewage Disposal System	3.79	90-301478
9	Individual Sewage Disposal System	3.79	90-301479
9	Individual Sewage Disposal System	3.87	90-301480
9	Individual Sewage Disposal System	3.94	90-301484
9	Individual Sewage Disposal System	3.98	90-301485
9	Individual Sewage Disposal System	4.0	90-301489
9	Individual Sewage Disposal System	3.92	90-302002
9	Individual Sewage Disposal System	3.91	90-302003
9	Individual Sewage Disposal System	3.88	90-302004
9	Individual Sewage Disposal System	3.84	90-302005
9	Individual Sewage Disposal System	3.83	90-302006
9	Individual Sewage Disposal System	3.86	90-302007
9	Individual Sewage Disposal System	3.91	90-302008

9	Individual Sewage Disposal System	3.96	90-302009
9	Individual Sewage Disposal System	3.86	90-302032
9	Individual Sewage Disposal System	3.83	90-302033
9	Individual Sewage Disposal System	3.87	90-302034
9	Individual Sewage Disposal System	3.78	90-302035
9	Individual Sewage Disposal System	3.74	90-302036
9	Individual Sewage Disposal System	3.71	90-302037
9	Individual Sewage Disposal System	3.74	90-302038
9	Individual Sewage Disposal System	3.77	90-302039
9	Individual Sewage Disposal System	3.8	90-302040
9	Individual Sewage Disposal System	3.75	90-302044
9	Individual Sewage Disposal System	3.76	90-302456
9	Individual Sewage Disposal System	3.78	90-302457
9	Individual Sewage Disposal System	3.86	90-302462
9	Individual Sewage Disposal System	3.92	90-302463
9	Individual Sewage Disposal System	3.95	90-302464
9	Individual Sewage Disposal System	3.97	90-302465
9	Individual Sewage Disposal System	3.5	90-302490
9	Individual Sewage Disposal System	3.53	90-302492
9	Individual Sewage Disposal System	3.55	90-302493
9	Individual Sewage Disposal System	3.56	90-302494
9	Individual Sewage Disposal System	3.57	90-302495

9	Individual Sewage Disposal System	3.61	90-302496
9	Individual Sewage Disposal System	3.92	90-309965
9	Individual Sewage Disposal System	3.86	90-309966
9	Individual Sewage Disposal System	3.78	90-309974
9	Individual Sewage Disposal System	3.73	90-309975
9	Individual Sewage Disposal System	3.75	90-309976
9	Individual Sewage Disposal System	3.75	90-309977
9	Individual Sewage Disposal System	3.8	90-309979
9	Individual Sewage Disposal System	3.25	90-349857
9	Individual Sewage Disposal System	3.23	90-349858
9	Individual Sewage Disposal System	3.19	90-349859
9	Individual Sewage Disposal System	3.16	90-349860
9	Individual Sewage Disposal System	3.14	90-349861
9	Individual Sewage Disposal System	3.13	90-349862
9	Individual Sewage Disposal System	3.17	90-349863
9	Individual Sewage Disposal System	3.19	90-349864
9	Individual Sewage Disposal System	3.22	90-349865
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9	Individual Sewage Disposal System	3.15	90-349867
9	Individual Sewage Disposal System	3.11	90-349868
9	Individual Sewage Disposal System	3.07	90-349869
9	Individual Sewage Disposal System	3.18	90-349870

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9	Individual Sewage Disposal System	3.03	90-349872
9	Individual Sewage Disposal System	3.04	90-349873
9	Individual Sewage Disposal System	3.05	90-349874
9	Individual Sewage Disposal System	3.06	90-349875
9	Individual Sewage Disposal System	3.08	90-349876
9	Individual Sewage Disposal System	3.09	90-349877
9	Individual Sewage Disposal System	3.08	90-349878
9	Individual Sewage Disposal System	3.04	90-349879
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9	Individual Sewage Disposal System	3.0	90-349881
9	Individual Sewage Disposal System	3.54	90-357301
9	Individual Sewage Disposal System	3.65	90-357302
9	Individual Sewage Disposal System	3.64	90-357303
9	Individual Sewage Disposal System	3.6	90-357304
9	Individual Sewage Disposal System	3.0	90-357340
9	Individual Sewage Disposal System	3.0	90-357341
9	Individual Sewage Disposal System	3.06	90-357342
9	Individual Sewage Disposal System	3.12	90-357343
9	Individual Sewage Disposal System	3.57	90-357344
9	Individual Sewage Disposal System	3.38	90-357345
9	Individual Sewage Disposal System	3.27	90-357346

9	Individual Sewage Disposal System	3.15	90-357347
9	Individual Sewage Disposal System	3.18	90-357348
9	Individual Sewage Disposal System	3.21	90-357349
9	Individual Sewage Disposal System	3.42	90-357350
9	Individual Sewage Disposal System	3.5	90-357351
9	Individual Sewage Disposal System	3.39	90-358591
9	Individual Sewage Disposal System	3.27	90-358893
9	Individual Sewage Disposal System	3.45	90-358894
9	Individual Sewage Disposal System	3.66	90-358895
9	Individual Sewage Disposal System	3.68	90-358896
9	Individual Sewage Disposal System	3.75	90-358897
9	Individual Sewage Disposal System	3.76	90-358898
9	Individual Sewage Disposal System	3.8	90-358899
9	Individual Sewage Disposal System	3.27	90-358990
9	Individual Sewage Disposal System	3.01	90-359005
9	Individual Sewage Disposal System	3.0	90-359006
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9	Individual Sewage Disposal System	3.85	90-360132
9	Individual Sewage Disposal System	3.76	90-360134
9	Individual Sewage Disposal System	3.78	90-360135
9	Individual Sewage Disposal System	3.65	90-360136

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9	Individual Sewage Disposal System	3.76	90-360303
9	Individual Sewage Disposal System	3.92	90-360304
9	Individual Sewage Disposal System	3.89	90-360310
9	Individual Sewage Disposal System	3.72	90-360316
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9	Individual Sewage Disposal System	3.97	90-360368
9	Individual Sewage Disposal System	3.94	90-360369
9	Individual Sewage Disposal System	3.99	90-360370
9	Individual Sewage Disposal System	3.94	90-360371
9	Individual Sewage Disposal System	3.97	90-360379
9	Individual Sewage Disposal System	3.67	90-360380
9	Individual Sewage Disposal System	3.87	90-360381
9	Individual Sewage Disposal System	3.43	90-360383
9	Individual Sewage Disposal System	3.38	90-360384
9	Individual Sewage Disposal System	3.88	90-360736
9	Individual Sewage Disposal System	3.77	90-360737
9	Individual Sewage Disposal System	3.77	90-360738
9	Individual Sewage Disposal System	3.68	90-360739
9	Individual Sewage Disposal System	3.6	90-360740
9	Individual Sewage Disposal System	3.13	90-360741
9	Individual Sewage Disposal System	3.22	90-360742

9	Individual Sewage Disposal System	3.11	90-360743
9	Individual Sewage Disposal System	3.05	90-360744
9	Individual Sewage Disposal System	3.03	90-360745
9	Individual Sewage Disposal System	3.06	90-360746
9	Individual Sewage Disposal System	3.17	90-360748
9	Individual Sewage Disposal System	3.29	90-360749
9	Individual Sewage Disposal System	3.74	90-360750
9	Individual Sewage Disposal System	3.75	90-360751
9	Individual Sewage Disposal System	3.66	90-360752
9	Individual Sewage Disposal System	3.25	90-360753
9	Individual Sewage Disposal System	3.17	90-360754
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9	Individual Sewage Disposal System	3.39	90-360782
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9	Individual Sewage Disposal System	3.25	90-360784
9	Individual Sewage Disposal System	3.18	90-360785
9	Individual Sewage Disposal System	3.16	90-360786
9	Individual Sewage Disposal System	3.31	90-360787

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9	Individual Sewage Disposal System	3.32	90-360789
9	Individual Sewage Disposal System	3.35	90-360790
9	Individual Sewage Disposal System	3.51	90-360791
9	Individual Sewage Disposal System	3.31	90-360792
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9	Individual Sewage Disposal System	3.01	90-360813
9	Individual Sewage Disposal System	3.01	90-360814
9	Individual Sewage Disposal System	3.02	90-360815
9	Individual Sewage Disposal System	3.25	90-360816

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9	Individual Sewage Disposal System	3.46	90-360818
9	Individual Sewage Disposal System	3.45	90-360819
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9	Individual Sewage Disposal System	3.45	90-360830
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9	Individual Sewage Disposal System	3.94	90-361205
9	Individual Sewage Disposal System	3.92	90-361206
9	Individual Sewage Disposal System	3.95	90-361207
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9	Individual Sewage Disposal System	3.22	90-361331
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9	Individual Sewage Disposal System	3.21	90-361335
9	Individual Sewage Disposal System	3.19	90-361336

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9	Individual Sewage Disposal System	3.95	90-361357
9	Individual Sewage Disposal System	3.9	90-361358
9	Individual Sewage Disposal System	3.83	90-361359
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9	Individual Sewage Disposal System	3.79	90-361361
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9	Individual Sewage Disposal System	3.79	90-361363
9	Individual Sewage Disposal System	3.83	90-361364
9	Individual Sewage Disposal System	3.84	90-361365
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9	Individual Sewage Disposal System	3.65	90-361370
9	Individual Sewage Disposal System	3.62	90-361371
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9	Individual Sewage Disposal System	3.43	90-361382
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9	Individual Sewage Disposal System	3.58	90-361389
9	Individual Sewage Disposal System	3.52	90-361390
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9	Individual Sewage Disposal System	3.45	90-361392
9	Individual Sewage Disposal System	3.62	90-361393
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9	Individual Sewage Disposal System	3.24	90-361405
9	Individual Sewage Disposal System	3.2	90-361406
9	Individual Sewage Disposal System	3.19	90-361407
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9	Individual Sewage Disposal System	3.07	90-364006
9	Individual Sewage Disposal System	3.69	90-364216
9	Individual Sewage Disposal System	3.65	90-364217
9	Individual Sewage Disposal System	3.43	90-364218
9	Individual Sewage Disposal System	3.42	90-364219
9	Individual Sewage Disposal System	3.98	90-364220
9	Individual Sewage Disposal System	3.95	90-364222
9	Individual Sewage Disposal System	3.91	90-364223
9	Individual Sewage Disposal System	3.89	90-364224

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9	Individual Sewage Disposal System	3.86	90-364226
9	Individual Sewage Disposal System	3.8	90-364227
9	Individual Sewage Disposal System	3.33	90-364228
9	Individual Sewage Disposal System	3.05	90-364229
9	Individual Sewage Disposal System	3.12	90-364230
9	Individual Sewage Disposal System	3.16	90-364231
9	Individual Sewage Disposal System	3.32	90-364232
9	Individual Sewage Disposal System	3.43	90-364233
9	Individual Sewage Disposal System	3.46	90-364234
9	Individual Sewage Disposal System	3.31	90-364235
9	Individual Sewage Disposal System	3.28	90-364236
9	Individual Sewage Disposal System	3.11	90-364325
9	Individual Sewage Disposal System	3.23	90-364333
9	Individual Sewage Disposal System	3.83	90-364341
9	Individual Sewage Disposal System	3.23	90-364731
9	Individual Sewage Disposal System	3.75	90-364732
9	Individual Sewage Disposal System	3.94	90-365322
9	Individual Sewage Disposal System	3.64	90-365323
9	Individual Sewage Disposal System	3.65	90-365324
9	Individual Sewage Disposal System	3.61	90-365325
9	Individual Sewage Disposal System	3.3	90-365339

9	Individual Sewage Disposal System	3.39	90-365340
9	Individual Sewage Disposal System	3.24	90-365341
9	Individual Sewage Disposal System	3.25	90-365342
9	Individual Sewage Disposal System	3.26	90-365343
9	Individual Sewage Disposal System	3.31	90-365344
9	Individual Sewage Disposal System	3.42	90-365345
9	Individual Sewage Disposal System	3.36	90-365346
9	Individual Sewage Disposal System	3.38	90-365347
9	Individual Sewage Disposal System	3.52	90-365348
9	Individual Sewage Disposal System	3.52	90-365349
9	Individual Sewage Disposal System	3.44	90-365393
9	Individual Sewage Disposal System	3.2	90-365799
9	Individual Sewage Disposal System	3.21	90-365800
9	Individual Sewage Disposal System	3.27	90-365801
9	Individual Sewage Disposal System	3.48	90-365802
9	Individual Sewage Disposal System	3.42	90-365803
9	Individual Sewage Disposal System	3.33	90-365804
9	Individual Sewage Disposal System	3.27	90-365805
9	Individual Sewage Disposal System	3.42	90-365809
9	Individual Sewage Disposal System	3.83	90-366570
9	Individual Sewage Disposal System	3.91	90-366573
9	Individual Sewage Disposal System	3.22	90-366578

9	Individual Sewage Disposal System	3.03	90-366579
9	Individual Sewage Disposal System	3.04	90-366580
9	Individual Sewage Disposal System	3.08	90-366581
9	Individual Sewage Disposal System	3.09	90-366582
9	Individual Sewage Disposal System	3.23	90-366583
9	Individual Sewage Disposal System	3.92	90-368127
9	Individual Sewage Disposal System	3.89	90-368128
9	Individual Sewage Disposal System	3.85	90-368132
9	Individual Sewage Disposal System	3.57	90-368248
9	Individual Sewage Disposal System	3.66	90-368889
9	Individual Sewage Disposal System	3.59	90-368890
9	Individual Sewage Disposal System	3.59	90-368891
9	Individual Sewage Disposal System	3.47	90-368892
9	Individual Sewage Disposal System	3.43	90-368894
9	Individual Sewage Disposal System	3.46	90-368895
9	Individual Sewage Disposal System	3.46	90-368896
9	Individual Sewage Disposal System	3.53	90-368897
9	Individual Sewage Disposal System	3.49	90-368898
9	Individual Sewage Disposal System	3.22	90-368899
9	Individual Sewage Disposal System	3.21	90-368900
9	Individual Sewage Disposal System	3.21	90-368901
9	Individual Sewage Disposal System	3.33	90-368905

9	Individual Sewage Disposal System	3.44	90-368906
9	Individual Sewage Disposal System	3.37	90-368911
9	Individual Sewage Disposal System	3.25	90-368912
9	Individual Sewage Disposal System	3.2	90-368913
9	Individual Sewage Disposal System	3.61	90-368933
9	Individual Sewage Disposal System	3.61	90-368934
9	Individual Sewage Disposal System	3.6	90-368935
9	Individual Sewage Disposal System	3.65	90-368936
9	Individual Sewage Disposal System	3.74	90-368937
9	Individual Sewage Disposal System	3.75	90-368938
9	Individual Sewage Disposal System	3.72	90-368939
9	Individual Sewage Disposal System	3.72	90-368940
9	Individual Sewage Disposal System	3.78	90-368941
9	Individual Sewage Disposal System	3.82	90-368942
9	Individual Sewage Disposal System	3.94	90-368943
9	Individual Sewage Disposal System	3.91	90-368944
9	Individual Sewage Disposal System	3.93	90-368945
9	Individual Sewage Disposal System	3.91	90-368946
9	Individual Sewage Disposal System	3.91	90-368947
9	Individual Sewage Disposal System	3.9	90-368948
9	Individual Sewage Disposal System	3.91	90-368949
9	Individual Sewage Disposal System	4.0	90-368955

9	Individual Sewage Disposal System	3.75	90-368956
9	Individual Sewage Disposal System	3.87	90-368957
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9	Individual Sewage Disposal System	3.44	90-368959
9	Individual Sewage Disposal System	3.39	90-368960
9	Individual Sewage Disposal System	3.94	90-368964
9	Individual Sewage Disposal System	3.8	90-369293
9	Individual Sewage Disposal System	3.78	90-369294
9	Individual Sewage Disposal System	3.8	90-369295
9	Individual Sewage Disposal System	3.82	90-369296
9	Individual Sewage Disposal System	3.84	90-369297
9	Individual Sewage Disposal System	3.77	90-369298
9	Individual Sewage Disposal System	3.75	90-369299
9	Individual Sewage Disposal System	3.76	90-369300
9	Individual Sewage Disposal System	3.8	90-369301
9	Individual Sewage Disposal System	3.77	90-369302
9	Individual Sewage Disposal System	3.77	90-369303
9	Individual Sewage Disposal System	3.74	90-369304
9	Individual Sewage Disposal System	3.6	90-369305
9	Individual Sewage Disposal System	3.52	90-369306
9	Individual Sewage Disposal System	3.53	90-369307
9	Individual Sewage Disposal System	3.35	90-369308

9	Individual Sewage Disposal System	3.64	90-369309
9	Individual Sewage Disposal System	3.56	90-369310
9	Individual Sewage Disposal System	3.45	90-369311
9	Individual Sewage Disposal System	3.5	90-369312
9	Individual Sewage Disposal System	3.13	90-369319
9	Individual Sewage Disposal System	3.1	90-369839
9	Individual Sewage Disposal System	3.11	90-369840
9	Individual Sewage Disposal System	3.67	90-413371
9	Individual Sewage Disposal System	3.62	90-413372
9	Individual Sewage Disposal System	3.59	90-413374
9	Individual Sewage Disposal System	3.61	90-413373
9	Individual Sewage Disposal System	3.6	90-413375
9	Individual Sewage Disposal System	3.57	90-413376
9	Individual Sewage Disposal System	3.58	90-413377
9	Individual Sewage Disposal System	3.62	90-413378
9	Individual Sewage Disposal System	3.57	90-413379
9	Individual Sewage Disposal System	3.59	90-413380
9	Individual Sewage Disposal System	3.56	90-413381
9	Individual Sewage Disposal System	3.57	90-413382
9	Individual Sewage Disposal System	3.53	90-413383
9	Individual Sewage Disposal System	3.51	90-413384
9	Individual Sewage Disposal System	3.49	90-413385

9	Individual Sewage Disposal System	3.5	90-413386
9	Individual Sewage Disposal System	3.46	90-413387
9	Individual Sewage Disposal System	3.36	90-413388
9	Individual Sewage Disposal System	3.45	90-413389
9	Individual Sewage Disposal System	3.06	90-413391
9	Individual Sewage Disposal System	3.07	90-413390
9	Individual Sewage Disposal System	3.05	90-413391
9	Individual Sewage Disposal System	3.41	90-413395
9	Individual Sewage Disposal System	3.45	90-413396
9	Individual Sewage Disposal System	3.39	90-413397
9	Individual Sewage Disposal System	3.45	90-413398
9	Individual Sewage Disposal System	3.55	90-413399
9	Individual Sewage Disposal System	3.59	90-413400
9	Individual Sewage Disposal System	3.62	90-413401
9	Individual Sewage Disposal System	3.53	90-413402
9	Individual Sewage Disposal System	3.71	90-413403
9	Individual Sewage Disposal System	3.71	90-413404
9	Individual Sewage Disposal System	3.58	90-413405
9	Individual Sewage Disposal System	3.31	90-413406
9	Individual Sewage Disposal System	3.23	90-413407
9	Individual Sewage Disposal System	3.21	90-413409
9	Individual Sewage Disposal System	3.13	90-413415

9	Individual Sewage Disposal System	3.02	90-413420
9	Individual Sewage Disposal System	3.01	90-413421
9	Individual Sewage Disposal System	3.0	90-413422
9	Individual Sewage Disposal System	3.85	90-413435
9	Individual Sewage Disposal System	3.81	90-413436
9	Individual Sewage Disposal System	3.75	90-413437
9	Individual Sewage Disposal System	3.69	90-413438
9	Individual Sewage Disposal System	3.09	90-413460
9	Individual Sewage Disposal System	3.06	90-413461
9	Individual Sewage Disposal System	3.04	90-413462
9	Individual Sewage Disposal System	3.07	90-413463
9	Individual Sewage Disposal System	3.04	90-413464
9	Individual Sewage Disposal System	3.02	90-413465

Beaver Lake Zone 5			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
9	Individual Sewage Disposal System	4.8	90-300977
9	Individual Sewage Disposal System	4.8	90-300981
9	Individual Sewage Disposal System	4.1	90-301481
9	Individual Sewage Disposal System	4.07	90-301482
9	Individual Sewage Disposal System	4.09	90-301483
9	Individual Sewage Disposal System	4.08	90-301486
9	Individual Sewage Disposal System	4.1	90-301487

9	Individual Sewage Disposal System	4.02	90-301488
9	Individual Sewage Disposal System	4.01	90-301490
9	Individual Sewage Disposal System	4.12	90-301491
9	Individual Sewage Disposal System	4.13	90-301492
9	Individual Sewage Disposal System	4.07	90-301493
9	Individual Sewage Disposal System	4.17	90-301494
9	Individual Sewage Disposal System	4.13	90-301495
9	Individual Sewage Disposal System	4.15	90-301496
9	Individual Sewage Disposal System	4.18	90-301908
9	Individual Sewage Disposal System	4.23	90-301909
9	Individual Sewage Disposal System	4.23	90-301910
9	Individual Sewage Disposal System	4.26	90-301911
9	Individual Sewage Disposal System	4.3	90-301912
9	Individual Sewage Disposal System	4.33	90-301913
9	Individual Sewage Disposal System	4.34	90-301914
9	Individual Sewage Disposal System	4.38	90-301915
9	Individual Sewage Disposal System	4.38	90-301916
9	Individual Sewage Disposal System	4.35	90-301917
9	Individual Sewage Disposal System	4.33	90-301918
9	Individual Sewage Disposal System	4.23	90-301919
9	Individual Sewage Disposal System	4.23	90-301920
9	Individual Sewage Disposal System	4.2	90-301921

9	Individual Sewage Disposal System	4.19	90-301922
9	Individual Sewage Disposal System	4.13	90-301923
9	Individual Sewage Disposal System	4.15	90-301924
9	Individual Sewage Disposal System	4.25	90-301925
9	Individual Sewage Disposal System	4.47	90-301926
9	Individual Sewage Disposal System	4.5	90-301927
9	Individual Sewage Disposal System	4.54	90-301928
9	Individual Sewage Disposal System	4.66	90-301929
9	Individual Sewage Disposal System	4.88	90-301930
9	Individual Sewage Disposal System	4.92	90-301931
9	Individual Sewage Disposal System	4.98	90-301937
9	Individual Sewage Disposal System	4.96	90-301938
9	Individual Sewage Disposal System	4.85	90-301939
9	Individual Sewage Disposal System	4.86	90-301940
9	Individual Sewage Disposal System	4.88	90-301941
9	Individual Sewage Disposal System	4.88	90-301942
9	Individual Sewage Disposal System	4.9	90-301943
9	Individual Sewage Disposal System	4.91	90-301944
9	Individual Sewage Disposal System	4.93	90-301945
9	Individual Sewage Disposal System	4.96	90-301950
9	Individual Sewage Disposal System	4.96	90-301951
9	Individual Sewage Disposal System	4.88	90-301952

9	Individual Sewage Disposal System	4.86	90-301953
9	Individual Sewage Disposal System	4.87	90-301954
9	Individual Sewage Disposal System	4.88	90-301955
9	Individual Sewage Disposal System	4.89	90-301956
9	Individual Sewage Disposal System	4.92	90-301957
9	Individual Sewage Disposal System	4.92	90-301958
9	Individual Sewage Disposal System	4.96	90-301959
9	Individual Sewage Disposal System	4.97	90-301960
9	Individual Sewage Disposal System	4.95	90-301961
9	Individual Sewage Disposal System	4.82	90-301970
9	Individual Sewage Disposal System	4.0	90-302010
9	Individual Sewage Disposal System	4.0	90-302011
9	Individual Sewage Disposal System	4.02	90-302012
9	Individual Sewage Disposal System	4.04	90-302013
9	Individual Sewage Disposal System	4.01	90-302014
9	Individual Sewage Disposal System	4.04	90-302015
9	Individual Sewage Disposal System	4.1	90-302016
9	Individual Sewage Disposal System	4.13	90-302017
9	Individual Sewage Disposal System	4.17	90-302018
9	Individual Sewage Disposal System	4.25	90-302019
9	Individual Sewage Disposal System	4.32	90-302020
9	Individual Sewage Disposal System	4.33	90-302021

9	Individual Sewage Disposal System	4.24	90-302023
9	Individual Sewage Disposal System	4.18	90-302024
9	Individual Sewage Disposal System	4.16	90-302025
9	Individual Sewage Disposal System	4.14	90-302026
9	Individual Sewage Disposal System	4.11	90-302027
9	Individual Sewage Disposal System	4.1	90-302028
9	Individual Sewage Disposal System	4.07	90-302029
9	Individual Sewage Disposal System	4.06	90-302030
9	Individual Sewage Disposal System	4.01	90-302031
9	Individual Sewage Disposal System	4.01	90-302466
9	Individual Sewage Disposal System	4.2	90-302467
9	Individual Sewage Disposal System	4.21	90-302468
9	Individual Sewage Disposal System	4.17	90-302469
9	Individual Sewage Disposal System	4.17	90-302470
9	Individual Sewage Disposal System	4.12	90-302471
9	Individual Sewage Disposal System	4.02	90-302472
9	Individual Sewage Disposal System	4.68	90-307632
9	Individual Sewage Disposal System	4.03	90-309905
9	Individual Sewage Disposal System	4.01	90-309906
9	Individual Sewage Disposal System	4.08	90-309907
9	Individual Sewage Disposal System	4.47	90-309908
9	Individual Sewage Disposal System	4.46	90-309909

9	Individual Sewage Disposal System	4.45	90-309910
9	Individual Sewage Disposal System	4.54	90-309911
9	Individual Sewage Disposal System	4.87	90-309914
9	Individual Sewage Disposal System	4.87	90-309915
9	Individual Sewage Disposal System	4.03	90-309980
9	Individual Sewage Disposal System	4.05	90-309981
9	Individual Sewage Disposal System	4.55	90-313311
9	Individual Sewage Disposal System	4.54	90-313312
9	Individual Sewage Disposal System	4.83	90-313313
9	Individual Sewage Disposal System	4.76	90-313314
9	Individual Sewage Disposal System	4.21	90-344625
9	Individual Sewage Disposal System	4.25	90-344626
9	Individual Sewage Disposal System	4.22	90-344627
9	Individual Sewage Disposal System	4.12	90-344628
9	Individual Sewage Disposal System	4.07	90-344629
9	Individual Sewage Disposal System	4.01	90-344630
9	Individual Sewage Disposal System	4.1	90-344631
9	Individual Sewage Disposal System	4.09	90-344632
9	Individual Sewage Disposal System	4.58	90-345310
9	Individual Sewage Disposal System	4.57	90-345311
9	Individual Sewage Disposal System	4.54	90-345312
9	Individual Sewage Disposal System	4.52	90-345313

9	Individual Sewage Disposal System	4.52	90-345314
9	Individual Sewage Disposal System	4.48	90-345315
9	Individual Sewage Disposal System	4.48	90-345316
9	Individual Sewage Disposal System	4.53	90-345317
9	Individual Sewage Disposal System	4.83	90-345323
9	Individual Sewage Disposal System	4.76	90-345324
9	Individual Sewage Disposal System	4.71	90-345325
9	Individual Sewage Disposal System	4.64	90-345326
9	Individual Sewage Disposal System	4.62	90-345327
9	Individual Sewage Disposal System	4.6	90-345328
9	Individual Sewage Disposal System	4.64	90-345329
9	Individual Sewage Disposal System	4.6	90-345330
9	Individual Sewage Disposal System	4.58	90-345331
9	Individual Sewage Disposal System	4.54	90-345332
9	Individual Sewage Disposal System	4.54	90-345333
9	Individual Sewage Disposal System	4.73	90-345334
9	Individual Sewage Disposal System	4.7	90-345335
9	Individual Sewage Disposal System	4.62	90-345336
9	Individual Sewage Disposal System	4.63	90-345337
9	Individual Sewage Disposal System	4.65	90-345338
9	Individual Sewage Disposal System	4.25	90-345340
9	Individual Sewage Disposal System	4.3	90-345342

9	Individual Sewage Disposal System	4.75	90-348393
9	Individual Sewage Disposal System	4.66	90-348402
9	Individual Sewage Disposal System	4.64	90-348403
9	Individual Sewage Disposal System	4.91	90-353114
9	Individual Sewage Disposal System	4.82	90-353115
9	Individual Sewage Disposal System	4.93	90-353116
9	Individual Sewage Disposal System	4.86	90-353117
9	Individual Sewage Disposal System	4.89	90-353123
9	Individual Sewage Disposal System	4.84	90-353124
9	Individual Sewage Disposal System	4.58	90-353134
9	Individual Sewage Disposal System	4.51	90-353138
9	Individual Sewage Disposal System	4.37	90-353139
9	Individual Sewage Disposal System	4.5	90-353140
9	Individual Sewage Disposal System	4.18	90-353142
9	Individual Sewage Disposal System	4.09	90-353143
9	Individual Sewage Disposal System	4.85	90-357584
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9	Individual Sewage Disposal System	4.71	90-358588
9	Individual Sewage Disposal System	4.81	90-358589
9	Individual Sewage Disposal System	4.85	90-358590
9	Individual Sewage Disposal System	4.64	90-358648

9	Individual Sewage Disposal System	4.68	90-358649
9	Individual Sewage Disposal System	4.68	90-358650
9	Individual Sewage Disposal System	4.67	90-358651
9	Individual Sewage Disposal System	4.66	90-358652
9	Individual Sewage Disposal System	4.65	90-358653
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9	Individual Sewage Disposal System	4.72	90-358659
9	Individual Sewage Disposal System	4.69	90-358660
9	Individual Sewage Disposal System	4.69	90-358661
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9	Individual Sewage Disposal System	4.68	90-358663
9	Individual Sewage Disposal System	4.67	90-358664
9	Individual Sewage Disposal System	4.67	90-358665
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9	Individual Sewage Disposal System	4.71	90-358667
9	Individual Sewage Disposal System	4.72	90-358668
9	Individual Sewage Disposal System	4.72	90-358669
9	Individual Sewage Disposal System	4.77	90-358671

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9	Individual Sewage Disposal System	4.78	90-358673
9	Individual Sewage Disposal System	4.78	90-358674
9	Individual Sewage Disposal System	4.79	90-358675
9	Individual Sewage Disposal System	4.79	90-358676
9	Individual Sewage Disposal System	4.79	90-358677
9	Individual Sewage Disposal System	4.8	90-358678
9	Individual Sewage Disposal System	4.83	90-358679
9	Individual Sewage Disposal System	4.94	90-359451
9	Individual Sewage Disposal System	4.97	90-359452
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9	Individual Sewage Disposal System	4.97	90-360018
9	Individual Sewage Disposal System	4.94	90-360019
9	Individual Sewage Disposal System	4.94	90-360020
9	Individual Sewage Disposal System	4.96	90-360021
9	Individual Sewage Disposal System	4.96	90-360022
9	Individual Sewage Disposal System	4.96	90-360023
9	Individual Sewage Disposal System	4.97	90-360024

9	Individual Sewage Disposal System	4.97	90-360025
9	Individual Sewage Disposal System	4.97	90-360026
9	Individual Sewage Disposal System	4.82	90-360053
9	Individual Sewage Disposal System	4.81	90-360054
9	Individual Sewage Disposal System	4.81	90-360055
9	Individual Sewage Disposal System	4.81	90-360056
9	Individual Sewage Disposal System	4.8	90-360057
9	Individual Sewage Disposal System	4.8	90-360058
9	Individual Sewage Disposal System	4.8	90-360060
9	Individual Sewage Disposal System	4.79	90-360061
9	Individual Sewage Disposal System	4.83	90-360062
9	Individual Sewage Disposal System	4.84	90-360063
9	Individual Sewage Disposal System	4.81	90-360064
9	Individual Sewage Disposal System	4.85	90-360065
9	Individual Sewage Disposal System	4.83	90-360066
9	Individual Sewage Disposal System	4.84	90-360067
9	Individual Sewage Disposal System	4.82	90-360068
9	Individual Sewage Disposal System	4.8	90-360069
9	Individual Sewage Disposal System	4.78	90-360070
9	Individual Sewage Disposal System	4.88	90-360095
9	Individual Sewage Disposal System	4.55	90-360112
9	Individual Sewage Disposal System	4.64	90-360113

9	Individual Sewage Disposal System	4.55	90-360127
9	Individual Sewage Disposal System	4.45	90-360128
9	Individual Sewage Disposal System	4.25	90-360284
9	Individual Sewage Disposal System	4.26	90-360285
9	Individual Sewage Disposal System	4.08	90-360290
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9	Individual Sewage Disposal System	4.09	90-360292
9	Individual Sewage Disposal System	4.2	90-360293
9	Individual Sewage Disposal System	4.2	90-360294
9	Individual Sewage Disposal System	4.19	90-360295
9	Individual Sewage Disposal System	4.16	90-360296
9	Individual Sewage Disposal System	4.14	90-360297
9	Individual Sewage Disposal System	4.12	90-360308
9	Individual Sewage Disposal System	4.09	90-360309
9	Individual Sewage Disposal System	4.15	90-360317
9	Individual Sewage Disposal System	4.18	90-360318
9	Individual Sewage Disposal System	4.23	90-360319
9	Individual Sewage Disposal System	4.67	90-360348
9	Individual Sewage Disposal System	4.53	90-360349
9	Individual Sewage Disposal System	4.59	90-360350
9	Individual Sewage Disposal System	4.57	90-360351
9	Individual Sewage Disposal System	4.67	90-360352

9	Individual Sewage Disposal System	4.72	90-360353
9	Individual Sewage Disposal System	4.38	90-360354
9	Individual Sewage Disposal System	4.37	90-360355
9	Individual Sewage Disposal System	4.42	90-360356
9	Individual Sewage Disposal System	4.55	90-360357
9	Individual Sewage Disposal System	4.44	90-360358
9	Individual Sewage Disposal System	4.24	90-360359
9	Individual Sewage Disposal System	4.19	90-360360
9	Individual Sewage Disposal System	4.18	90-360361
9	Individual Sewage Disposal System	4.21	90-360362
9	Individual Sewage Disposal System	4.05	90-360363
9	Individual Sewage Disposal System	4.02	90-360364
9	Individual Sewage Disposal System	4.02	90-360365
9	Individual Sewage Disposal System	4.03	90-360366
9	Individual Sewage Disposal System	4.11	90-360367
9	Individual Sewage Disposal System	4.04	90-360372
9	Individual Sewage Disposal System	4.16	90-360373
9	Individual Sewage Disposal System	4.13	90-360374
9	Individual Sewage Disposal System	4.16	90-360377
9	Individual Sewage Disposal System	4.04	90-360378
9	Individual Sewage Disposal System	4.0	90-361201
9	Individual Sewage Disposal System	4.05	90-361202

9	Individual Sewage Disposal System	4.41	90-361226
9	Individual Sewage Disposal System	4.43	90-361227
9	Individual Sewage Disposal System	4.44	90-361228
9	Individual Sewage Disposal System	4.32	90-361229
9	Individual Sewage Disposal System	4.19	90-361230
9	Individual Sewage Disposal System	4.15	90-361231
9	Individual Sewage Disposal System	4.21	90-361232
9	Individual Sewage Disposal System	4.14	90-361233
9	Individual Sewage Disposal System	4.03	90-364221
9	Individual Sewage Disposal System	4.79	90-364717
9	Individual Sewage Disposal System	4.73	90-364718
9	Individual Sewage Disposal System	4.8	90-364719
9	Individual Sewage Disposal System	4.82	90-364720
9	Individual Sewage Disposal System	4.66	90-364721
9	Individual Sewage Disposal System	4.58	90-364722
9	Individual Sewage Disposal System	4.46	90-364723
9	Individual Sewage Disposal System	4.23	90-364724
9	Individual Sewage Disposal System	4.31	90-364725
9	Individual Sewage Disposal System	4.25	90-364726
9	Individual Sewage Disposal System	4.32	90-364727
9	Individual Sewage Disposal System	4.48	90-364728
9	Individual Sewage Disposal System	4.31	90-364729

9	Individual Sewage Disposal System	4.17	90-364730
9	Individual Sewage Disposal System	4.98	90-365269
9	Individual Sewage Disposal System	4.97	90-365285
9	Individual Sewage Disposal System	4.99	90-365286
9	Individual Sewage Disposal System	4.98	90-365291
9	Individual Sewage Disposal System	4.96	90-365292
9	Individual Sewage Disposal System	4.79	90-365316
9	Individual Sewage Disposal System	4.82	90-365317
9	Individual Sewage Disposal System	4.79	90-365318
9	Individual Sewage Disposal System	4.82	90-365319
9	Individual Sewage Disposal System	4.81	90-365320
9	Individual Sewage Disposal System	4.07	90-365321
9	Individual Sewage Disposal System	4.68	90-365327
9	Individual Sewage Disposal System	4.67	90-365328
9	Individual Sewage Disposal System	4.69	90-365329
9	Individual Sewage Disposal System	4.7	90-365330
9	Individual Sewage Disposal System	4.71	90-365732
9	Individual Sewage Disposal System	4.69	90-365733
9	Individual Sewage Disposal System	4.68	90-365734
9	Individual Sewage Disposal System	4.65	90-365735
9	Individual Sewage Disposal System	4.67	90-365736
9	Individual Sewage Disposal System	4.69	90-365737

9	Individual Sewage Disposal System	4.72	90-365738
9	Individual Sewage Disposal System	4.18	90-366560
9	Individual Sewage Disposal System	4.18	90-366561
9	Individual Sewage Disposal System	4.27	90-366562
9	Individual Sewage Disposal System	4.24	90-366565
9	Individual Sewage Disposal System	4.06	90-366566
9	Individual Sewage Disposal System	4.02	90-366567
9	Individual Sewage Disposal System	4.14	90-366568
9	Individual Sewage Disposal System	4.7	90-366869
9	Individual Sewage Disposal System	4.66	90-366870
9	Individual Sewage Disposal System	4.65	90-366871
9	Individual Sewage Disposal System	4.63	90-366872
9	Individual Sewage Disposal System	4.61	90-366873
9	Individual Sewage Disposal System	4.59	90-366874
9	Individual Sewage Disposal System	4.63	90-366875
9	Individual Sewage Disposal System	4.67	90-366876
9	Individual Sewage Disposal System	4.65	90-366877
9	Individual Sewage Disposal System	4.67	90-366878
9	Individual Sewage Disposal System	4.62	90-366879
9	Individual Sewage Disposal System	4.6	90-366880
9	Individual Sewage Disposal System	4.9	90-367735
9	Individual Sewage Disposal System	4.53	90-367737

9	Individual Sewage Disposal System	4.86	90-367739
9	Individual Sewage Disposal System	4.85	90-367740
9	Individual Sewage Disposal System	4.32	90-367745
9	Individual Sewage Disposal System	4.33	90-367746
9	Individual Sewage Disposal System	4.44	90-367747
9	Individual Sewage Disposal System	4.41	90-367748
9	Individual Sewage Disposal System	4.39	90-367749
9	Individual Sewage Disposal System	4.45	90-367750
9	Individual Sewage Disposal System	4.55	90-367752
9	Individual Sewage Disposal System	4.39	90-367755
9	Individual Sewage Disposal System	4.15	90-368115
9	Individual Sewage Disposal System	4.15	90-368116
9	Individual Sewage Disposal System	4.69	90-368118
9	Individual Sewage Disposal System	4.67	90-368119
9	Individual Sewage Disposal System	4.47	90-368120
9	Individual Sewage Disposal System	4.18	90-368121
9	Individual Sewage Disposal System	4.17	90-368122
9	Individual Sewage Disposal System	4.2	90-368123
9	Individual Sewage Disposal System	4.19	90-368125
9	Individual Sewage Disposal System	4.1	90-368126
9	Individual Sewage Disposal System	4.02	90-368130
9	Individual Sewage Disposal System	4.66	90-368562

9	Individual Sewage Disposal System	4.75	90-368563
9	Individual Sewage Disposal System	4.71	90-368564
9	Individual Sewage Disposal System	4.69	90-368565
9	Individual Sewage Disposal System	4.65	90-368566
9	Individual Sewage Disposal System	4.72	90-368567
9	Individual Sewage Disposal System	4.71	90-368568
9	Individual Sewage Disposal System	4.72	90-368569
9	Individual Sewage Disposal System	4.73	90-368570
9	Individual Sewage Disposal System	4.75	90-368571
9	Individual Sewage Disposal System	4.78	90-368572
9	Individual Sewage Disposal System	4.82	90-368573
9	Individual Sewage Disposal System	4.8	90-368574
9	Individual Sewage Disposal System	4.81	90-368575
9	Individual Sewage Disposal System	4.8	90-368576
9	Individual Sewage Disposal System	4.78	90-368577
9	Individual Sewage Disposal System	4.48	90-368578
9	Individual Sewage Disposal System	4.47	90-368579
9	Individual Sewage Disposal System	4.45	90-368580
9	Individual Sewage Disposal System	4.48	90-368581
9	Individual Sewage Disposal System	4.46	90-368582
9	Individual Sewage Disposal System	4.45	90-368583
9	Individual Sewage Disposal System	4.44	90-368584

9	Individual Sewage Disposal System	4.43	90-368585
9	Individual Sewage Disposal System	4.4	90-368586
9	Individual Sewage Disposal System	4.34	90-368587
9	Individual Sewage Disposal System	4.29	90-368588
9	Individual Sewage Disposal System	4.32	90-368589
9	Individual Sewage Disposal System	4.38	90-368590
9	Individual Sewage Disposal System	4.4	90-368591
9	Individual Sewage Disposal System	4.36	90-368592
9	Individual Sewage Disposal System	4.35	90-368593
9	Individual Sewage Disposal System	4.38	90-368594
9	Individual Sewage Disposal System	4.45	90-368595
9	Individual Sewage Disposal System	4.48	90-368596
9	Individual Sewage Disposal System	4.49	90-368597
9	Individual Sewage Disposal System	4.47	90-368598
9	Individual Sewage Disposal System	4.49	90-368599
9	Individual Sewage Disposal System	4.5	90-368600
9	Individual Sewage Disposal System	4.43	90-368601
9	Individual Sewage Disposal System	4.44	90-368602
9	Individual Sewage Disposal System	4.43	90-368603
9	Individual Sewage Disposal System	4.46	90-368604
9	Individual Sewage Disposal System	4.45	90-368605
9	Individual Sewage Disposal System	4.48	90-368606

9	Individual Sewage Disposal System	4.48	90-368607
9	Individual Sewage Disposal System	4.57	90-368608
9	Individual Sewage Disposal System	4.51	90-368609
9	Individual Sewage Disposal System	4.51	90-368884
9	Individual Sewage Disposal System	4.51	90-368885
9	Individual Sewage Disposal System	4.52	90-368886
9	Individual Sewage Disposal System	4.54	90-368887
9	Individual Sewage Disposal System	4.58	90-368888
9	Individual Sewage Disposal System	4.14	90-368893
9	Individual Sewage Disposal System	4.04	90-368904
9	Individual Sewage Disposal System	4.03	90-368950
9	Individual Sewage Disposal System	4.04	90-368951
9	Individual Sewage Disposal System	4.1	90-368952
9	Individual Sewage Disposal System	4.09	90-368953
9	Individual Sewage Disposal System	4.07	90-368954
9	Individual Sewage Disposal System	4.25	90-368961
9	Individual Sewage Disposal System	4.19	90-368962
9	Individual Sewage Disposal System	4.14	90-368963
9	Individual Sewage Disposal System	4.2	90-368965
9	Individual Sewage Disposal System	4.65	90-371017
9	Individual Sewage Disposal System	4.39	90-413434

Beaver Lake Zone 2

Health Risk Category	PSOC Description	Distance from Intake	Reference Number
10	Cemetery	1.37	38-4836

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
10	Cemetery	2.71	38-4835
10	Cemetery	2.87	38-4850
10	Cemetery	2.09	38-4851

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
10	Cemetery	3.78	38-4833

Beaver Lake Zone 5			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
10	Cemetery	4.69	38-4831
10	Cemetery	4.34	38-4832
10	Cemetery	4.67	38-4990
10	Cemetery	4.59	38-5012

LIST OF PSOCS BY ZONE

Beaver Water District
Beaver Lake - 038201

Susceptibility Rating - Low

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
1	ADEQ Leaking Storage Tank of Unknown Type	2.41	04001674

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
1	Bridge: Railroad	3.69	6-124

Beaver Lake Zone 2			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
2	Poultry House	1.97	22-880
2	Poultry House	1.99	22-881
2	Poultry House	1.99	22-885
2	Poultry House	1.25	22-2048
2	Poultry House	1.17	22-2049

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
2	Bridge: State Highway	2.58	3-165
2	Bridge: State Highway	2.41	3-4487
2	Bridge: State Highway	2.38	3-4488
2	Bridge: State Highway	2.52	3-4524
2	Poultry House	2.02	22-882
2	Poultry House	2.03	22-883
2	Poultry House	2.01	22-884
2	Poultry House	2.45	22-899
2	Poultry House	2.94	22-1282
2	Poultry House	2.9	22-1283
2	Poultry House	2.89	22-1284
2	Poultry House	2.89	22-1285

2	Poultry House	2.88	22-1286
2	Poultry House	2.88	22-1287
2	Poultry House	2.87	22-1288
2	Poultry House	2.23	22-1293
2	Poultry House	2.23	22-1294
2	Poultry House	2.22	22-1295
2	Poultry House	2.23	22-1296
2	Poultry House	2.22	22-1297
2	Poultry House	2.5	22-1548
2	Poultry House	2.53	22-1549
2	Poultry House	2.57	22-2068
2	Poultry House	2.6	22-2069
2	Poultry House	2.62	22-2070
2	Poultry House	2.67	22-2071
2	Poultry House	2.45	22-2072
2	Poultry House	2.48	22-2073

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
2	Bridge: US Highway	3.72	4-1858
2	Industrial Site: Meat Packing	3.76	70-3647
2	Poultry House	3.52	22-1279
2	Poultry House	3.5	22-1280
2	Poultry House	3.19	22-2044

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
3	ADEQ Underground Storage Tank: In Use	2.41	04001674
3	ADEQ Underground Storage Tank: In Use	2.41	04001674
3	ADEQ Underground Storage Tank: In Use	2.41	04001674
3	ADEQ Aboveground Storage Tank: In Use	2.25	04001670

3	ADEQ Above-ground Storage Tank: In Use	2.25	04001670
3	ADEQ Above-ground Storage Tank: In Use	2.59	04001754
3	Industrial Site: Asphalt Paving Mixture and Block Manufacturer	2.24	70-327
3	Industrial Site: Trucking	2.36	70-3648
3	ADEQ Mining Permit: Non-Coal, Limestone	2.51	0454-MN-A5
3	ADEQ Mining Permit: Non-Coal, Bauxite	2.72	0629-MN-A1

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
3	ADEQ Above-ground Storage Tank: In Use	3.43	04000140
3	Landing Strip	3.19	52-43

Beaver Lake Zone 5			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
3	ADEQ Under-ground Storage Tank: In Use	4.04	72001678
3	ADEQ Under-ground Storage Tank: In Use	4.04	72001678
3	ADEQ Under-ground Storage Tank: In Use	4.04	72001678
3	ADEQ Under-ground Storage Tank: In Use	4.04	72001678
3	ADEQ Above-ground Storage Tank: In Use	4.37	72001820

3	ADEQ Above-ground Storage Tank: In Use	4.37	72001820
3	ADEQ Above-ground Storage Tank: In Use	4.37	72001820
3	ADEQ Above-ground Storage Tank: In Use	4.37	72001820
3	ADEQ Above-ground Storage Tank: In Use	4.37	72001820
3	ADEQ Above-ground Storage Tank: In Use	4.06	72001821
3	ADEQ Above-ground Storage Tank: In Use	4.06	72001821

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
4	ADEQ Under-ground Storage Tank: Permanently Out of Use	2.41	04001674
4	Business: Electronics and Electronic Equipment	2.89	53-4660
4	Electric Substation	2.72	32-271

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
4	ADEQ Under-ground Storage Tank: Permanently Out of Use	3.43	04000140
4	ADEQ Under-ground Storage Tank: Permanently Out of Use	3.43	04000140

Beaver Lake Zone 5

Health Risk Category	PSOC Description	Distance from Intake	Reference Number
4	ADEQ Underground Storage Tank: Permanently Out of Use	4.06	72001821
4	ADEQ Underground Storage Tank: Permanently Out of Use	4.06	72001821
4	Industrial Site: Metal Fabricator	4.63	70-3651

Beaver Lake Zone 2			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
5	Bridge: County Road	1.78	1-331
5	Bridge: County Road	1.45	1-358
5	Bridge: County Road	1.0	1-4559
5	Bridge: County Road	1.9	1-4892
5	Bridge: County Road	1.93	1-4893

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
5	Bridge: County Road	2.49	1-4544
5	Bridge: County Road	2.59	1-4545
5	Bridge: County Road	2.57	1-4546
5	Bridge: County Road	2.36	1-4549
5	Bridge: County Road	2.51	1-4550
5	Bridge: County Road	2.11	1-4551
5	Bridge: County Road	2.04	1-4552
5	Bridge: County Road	2.44	1-4553

5	Bridge: County Road	2.49	1-4554
5	Bridge: County Road	2.72	1-4555
5	Bridge: County Road	2.79	1-4556
5	Bridge: County Road	2.72	1-4557
5	Bridge: County Road	2.91	1-4560
5	Bridge: County Road	2.47	1-4890
5	Bridge: County Road	2.44	1-4891
5	Bridge: County Road	2.49	1-4894
5	Bridge: County Road	2.44	1-4895
5	Bridge: County Road	2.59	1-4896
5	Bridge: County Road	2.85	1-4897
5	Bridge: County Road	2.01	1-4898
5	Boat Docks or Piers	2.45	43-401
5	Boat Docks or Piers	2.5	43-402
5	Boat Ramp	2.48	43-525
5	Boat Ramp	2.56	43-534

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
5	Bridge: County Road	3.51	1-357
5	Bridge: County Road	3.63	1-4531
5	Bridge: County Road	3.38	1-4532
5	Bridge: County Road	3.22	1-4547
5	Bridge: County Road	3.31	1-4548
5	Bridge: County Road	3.29	1-4558

5	Business: Auto Alternators and Generators	3.39	53-4659
5	Boat Ramp	3.99	43-524
5	Boat Ramp	3.43	43-533

Beaver Lake Zone 5			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
5	Bridge: County Road	4.79	1-4889
5	Bridge: County Road	4.23	1-10880
5	Bridge: County Road	4.24	1-10881
5	Boat Docks or Piers	4.04	43-400
5	Boat Ramp	4.86	43-531
5	Boat Ramp	4.83	43-532

Beaver Lake Zone 2			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
6	ADEQ NPDES Permit Outfall: Individual Domestic	1.89	AR0037320

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
6	Park/Public Use Area	3.94	49-913

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
7	School	3.92	58-155

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
8	ADEQ NPDES Permit Outfall: Stormwater	2.83	ARR00A069

8	ADEQ NPDES Permit Outfall: Stormwater	2.29	ARR000173

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
8	ADEQ NPDES Permit Outfall: Stormwater	3.82	ARR000503
8	ADEQ NPDES Permit Outfall: Stormwater	3.78	ARR000503

Beaver Lake Zone 5			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
8	ADEQ NPDES Permit Outfall: Stormwater	4.41	ARR000360

Beaver Lake Zone 1			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
9	Individual Sewage Disposal System	0.53	90-360707
9	Individual Sewage Disposal System	0.32	90-360708
9	Individual Sewage Disposal System	0.46	90-360709
9	Individual Sewage Disposal System	0.48	90-360711
9	Individual Sewage Disposal System	0.7	90-360712
9	Individual Sewage Disposal System	0.73	90-360713
9	Individual Sewage Disposal System	0.77	90-360714
9	Individual Sewage Disposal System	0.95	90-360715
9	Individual Sewage Disposal System	0.66	90-360729
9	Individual Sewage Disposal System	0.95	90-360731

9	Individual Sewage Disposal System	0.82	90-360732
9	Individual Sewage Disposal System	0.87	90-360733
9	Individual Sewage Disposal System	0.91	90-360734
9	Individual Sewage Disposal System	0.99	90-360735
9	Individual Sewage Disposal System	0.99	90-361318
9	Individual Sewage Disposal System	0.74	90-362584
9	Individual Sewage Disposal System	0.52	90-362585
9	Individual Sewage Disposal System	0.79	90-362586
9	Individual Sewage Disposal System	0.89	90-362587
9	Individual Sewage Disposal System	0.99	90-362588
9	Individual Sewage Disposal System	0.49	90-362589
9	Individual Sewage Disposal System	0.47	90-362590
9	Individual Sewage Disposal System	0.46	90-362591
9	Individual Sewage Disposal System	0.44	90-362592
9	Individual Sewage Disposal System	0.64	90-362593
9	Individual Sewage Disposal System	0.61	90-362596
9	Individual Sewage Disposal System	0.39	90-362601
9	Individual Sewage Disposal System	0.43	90-362602
9	Individual Sewage Disposal System	0.43	90-362603
9	Individual Sewage Disposal System	0.43	90-362604
9	Individual Sewage Disposal System	0.44	90-362605
9	Individual Sewage Disposal System	0.44	90-362606

9	Individual Sewage Disposal System	0.46	90-362607
9	Individual Sewage Disposal System	0.24	90-362620
9	Individual Sewage Disposal System	0.88	90-362659
9	Individual Sewage Disposal System	0.76	90-362660
9	Individual Sewage Disposal System	0.39	90-365770
9	Individual Sewage Disposal System	0.8	90-365771
9	Individual Sewage Disposal System	0.78	90-365772
9	Individual Sewage Disposal System	0.87	90-365773
9	Individual Sewage Disposal System	0.43	90-367381
9	Individual Sewage Disposal System	0.41	90-367382
9	Individual Sewage Disposal System	1.0	90-413425
9	Individual Sewage Disposal System	0.75	90-413426
9	Individual Sewage Disposal System	0.71	90-413427
9	Individual Sewage Disposal System	0.65	90-413428

Beaver Lake Zone 2			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
9	Individual Sewage Disposal System	1.12	90-344638
9	Individual Sewage Disposal System	1.23	90-344639
9	Individual Sewage Disposal System	1.39	90-344640
9	Individual Sewage Disposal System	1.88	90-358947
9	Individual Sewage Disposal System	2.0	90-358948
9	Individual Sewage Disposal System	1.97	90-358949

9	Individual Sewage Disposal System	1.85	90-360388
9	Individual Sewage Disposal System	1.52	90-360389
9	Individual Sewage Disposal System	1.86	90-360392
9	Individual Sewage Disposal System	1.44	90-360393
9	Individual Sewage Disposal System	1.56	90-360394
9	Individual Sewage Disposal System	1.65	90-360395
9	Individual Sewage Disposal System	1.96	90-360699
9	Individual Sewage Disposal System	1.85	90-360702
9	Individual Sewage Disposal System	1.46	90-360703
9	Individual Sewage Disposal System	1.34	90-360704
9	Individual Sewage Disposal System	1.39	90-360705
9	Individual Sewage Disposal System	1.17	90-360706
9	Individual Sewage Disposal System	1.04	90-360716
9	Individual Sewage Disposal System	1.05	90-360717
9	Individual Sewage Disposal System	1.21	90-360718
9	Individual Sewage Disposal System	1.28	90-360719
9	Individual Sewage Disposal System	1.23	90-360720
9	Individual Sewage Disposal System	1.2	90-360721
9	Individual Sewage Disposal System	1.2	90-360722
9	Individual Sewage Disposal System	1.24	90-360723
9	Individual Sewage Disposal System	1.24	90-360724
9	Individual Sewage Disposal System	1.19	90-360725

9	Individual Sewage Disposal System	1.27	90-360726
9	Individual Sewage Disposal System	1.21	90-360727
9	Individual Sewage Disposal System	1.39	90-360728
9	Individual Sewage Disposal System	1.92	90-361239
9	Individual Sewage Disposal System	1.93	90-361240
9	Individual Sewage Disposal System	1.95	90-361241
9	Individual Sewage Disposal System	1.92	90-361242
9	Individual Sewage Disposal System	1.91	90-361243
9	Individual Sewage Disposal System	1.89	90-361244
9	Individual Sewage Disposal System	1.87	90-361245
9	Individual Sewage Disposal System	1.9	90-361246
9	Individual Sewage Disposal System	1.87	90-361247
9	Individual Sewage Disposal System	1.85	90-361248
9	Individual Sewage Disposal System	1.82	90-361249
9	Individual Sewage Disposal System	1.81	90-361250
9	Individual Sewage Disposal System	1.83	90-361251
9	Individual Sewage Disposal System	1.91	90-361252
9	Individual Sewage Disposal System	1.93	90-361253
9	Individual Sewage Disposal System	1.98	90-361256
9	Individual Sewage Disposal System	1.95	90-361277
9	Individual Sewage Disposal System	1.93	90-361278
9	Individual Sewage Disposal System	1.89	90-361279

9	Individual Sewage Disposal System	1.92	90-361280
9	Individual Sewage Disposal System	1.81	90-361281
9	Individual Sewage Disposal System	1.88	90-361282
9	Individual Sewage Disposal System	1.88	90-361283
9	Individual Sewage Disposal System	1.81	90-361284
9	Individual Sewage Disposal System	1.78	90-361285
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9	Individual Sewage Disposal System	1.79	90-361287
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9	Individual Sewage Disposal System	1.83	90-361289
9	Individual Sewage Disposal System	1.87	90-361290
9	Individual Sewage Disposal System	1.72	90-361291
9	Individual Sewage Disposal System	1.57	90-361292
9	Individual Sewage Disposal System	1.59	90-361293
9	Individual Sewage Disposal System	1.6	90-361294
9	Individual Sewage Disposal System	1.64	90-361295
9	Individual Sewage Disposal System	1.24	90-361296
9	Individual Sewage Disposal System	1.34	90-361297
9	Individual Sewage Disposal System	1.36	90-361298
9	Individual Sewage Disposal System	1.34	90-361299
9	Individual Sewage Disposal System	1.41	90-361300
9	Individual Sewage Disposal System	1.45	90-361301

9	Individual Sewage Disposal System	1.47	90-361303
9	Individual Sewage Disposal System	1.41	90-361304
9	Individual Sewage Disposal System	1.38	90-361305
9	Individual Sewage Disposal System	1.3	90-361306
9	Individual Sewage Disposal System	1.28	90-361307
9	Individual Sewage Disposal System	1.27	90-361308
9	Individual Sewage Disposal System	1.32	90-361309
9	Individual Sewage Disposal System	1.4	90-361310
9	Individual Sewage Disposal System	1.44	90-361311
9	Individual Sewage Disposal System	1.37	90-361312
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9	Individual Sewage Disposal System	1.93	90-361314
9	Individual Sewage Disposal System	1.92	90-361453
9	Individual Sewage Disposal System	1.91	90-362146
9	Individual Sewage Disposal System	1.96	90-362147
9	Individual Sewage Disposal System	1.93	90-362148
9	Individual Sewage Disposal System	1.62	90-362149
9	Individual Sewage Disposal System	1.64	90-362150
9	Individual Sewage Disposal System	1.65	90-362151
9	Individual Sewage Disposal System	1.18	90-362153
9	Individual Sewage Disposal System	1.32	90-362154
9	Individual Sewage Disposal System	1.14	90-362155

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9	Individual Sewage Disposal System	1.4	90-362557
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9	Individual Sewage Disposal System	1.35	90-362559
9	Individual Sewage Disposal System	1.35	90-362560
9	Individual Sewage Disposal System	1.33	90-362561
9	Individual Sewage Disposal System	1.29	90-362562
9	Individual Sewage Disposal System	1.27	90-362563
9	Individual Sewage Disposal System	1.31	90-362564
9	Individual Sewage Disposal System	1.34	90-362565
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9	Individual Sewage Disposal System	1.58	90-362569
9	Individual Sewage Disposal System	1.63	90-362570
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9	Individual Sewage Disposal System	1.7	90-362621
9	Individual Sewage Disposal System	1.53	90-362631
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9	Individual Sewage Disposal System	1.56	90-362641
9	Individual Sewage Disposal System	1.55	90-362642
9	Individual Sewage Disposal System	1.45	90-362643
9	Individual Sewage Disposal System	1.41	90-362644
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9	Individual Sewage Disposal System	1.26	90-362647
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9	Individual Sewage Disposal System	1.76	90-362651
9	Individual Sewage Disposal System	1.84	90-362676
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9	Individual Sewage Disposal System	1.54	90-364286
9	Individual Sewage Disposal System	1.52	90-364287
9	Individual Sewage Disposal System	1.53	90-364288
9	Individual Sewage Disposal System	1.62	90-364289
9	Individual Sewage Disposal System	1.64	90-364290

9	Individual Sewage Disposal System	1.36	90-364291
9	Individual Sewage Disposal System	1.41	90-364292
9	Individual Sewage Disposal System	1.91	90-364293
9	Individual Sewage Disposal System	1.87	90-364294
9	Individual Sewage Disposal System	1.99	90-365367
9	Individual Sewage Disposal System	1.96	90-365368
9	Individual Sewage Disposal System	1.99	90-365369
9	Individual Sewage Disposal System	1.93	90-365370
9	Individual Sewage Disposal System	1.95	90-365371
9	Individual Sewage Disposal System	1.98	90-365372
9	Individual Sewage Disposal System	1.98	90-365373
9	Individual Sewage Disposal System	1.91	90-365374
9	Individual Sewage Disposal System	1.9	90-365375
9	Individual Sewage Disposal System	1.92	90-365739
9	Individual Sewage Disposal System	1.96	90-365740
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9	Individual Sewage Disposal System	1.89	90-365742
9	Individual Sewage Disposal System	1.88	90-365743
9	Individual Sewage Disposal System	1.99	90-365744
9	Individual Sewage Disposal System	1.47	90-365745
9	Individual Sewage Disposal System	1.49	90-365746
9	Individual Sewage Disposal System	1.53	90-365747

9	Individual Sewage Disposal System	1.58	90-365748
9	Individual Sewage Disposal System	1.56	90-365749
9	Individual Sewage Disposal System	1.51	90-365750
9	Individual Sewage Disposal System	1.51	90-365751
9	Individual Sewage Disposal System	1.19	90-365752
9	Individual Sewage Disposal System	1.07	90-365753
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9	Individual Sewage Disposal System	1.42	90-365756
9	Individual Sewage Disposal System	1.44	90-365757
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9	Individual Sewage Disposal System	1.51	90-365759
9	Individual Sewage Disposal System	1.47	90-365760
9	Individual Sewage Disposal System	1.56	90-365761
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9	Individual Sewage Disposal System	1.51	90-365766
9	Individual Sewage Disposal System	1.6	90-365767
9	Individual Sewage Disposal System	1.64	90-365768
9	Individual Sewage Disposal System	1.69	90-365769

9	Individual Sewage Disposal System	1.03	90-365774
9	Individual Sewage Disposal System	1.06	90-365775
9	Individual Sewage Disposal System	1.15	90-365776
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9	Individual Sewage Disposal System	1.43	90-365780
9	Individual Sewage Disposal System	1.27	90-365781
9	Individual Sewage Disposal System	1.99	90-365822
9	Individual Sewage Disposal System	1.93	90-365823
9	Individual Sewage Disposal System	1.91	90-365827
9	Individual Sewage Disposal System	1.99	90-365846
9	Individual Sewage Disposal System	1.73	90-366683
9	Individual Sewage Disposal System	1.76	90-366684
9	Individual Sewage Disposal System	1.64	90-366687
9	Individual Sewage Disposal System	1.64	90-366688
9	Individual Sewage Disposal System	1.65	90-366689
9	Individual Sewage Disposal System	1.64	90-366690
9	Individual Sewage Disposal System	1.65	90-367251
9	Individual Sewage Disposal System	1.68	90-367252
9	Individual Sewage Disposal System	1.69	90-367253
9	Individual Sewage Disposal System	1.68	90-367254

9	Individual Sewage Disposal System	1.68	90-367255
9	Individual Sewage Disposal System	1.68	90-367256
9	Individual Sewage Disposal System	1.67	90-367257
9	Individual Sewage Disposal System	1.71	90-367258
9	Individual Sewage Disposal System	1.73	90-367259
9	Individual Sewage Disposal System	1.76	90-367260
9	Individual Sewage Disposal System	1.78	90-367263
9	Individual Sewage Disposal System	1.8	90-367264
9	Individual Sewage Disposal System	1.8	90-367275
9	Individual Sewage Disposal System	1.74	90-367279
9	Individual Sewage Disposal System	1.68	90-367280
9	Individual Sewage Disposal System	1.73	90-367281
9	Individual Sewage Disposal System	1.69	90-367282
9	Individual Sewage Disposal System	1.74	90-367283
9	Individual Sewage Disposal System	1.7	90-367284
9	Individual Sewage Disposal System	1.67	90-367285
9	Individual Sewage Disposal System	1.75	90-367286
9	Individual Sewage Disposal System	1.78	90-367287
9	Individual Sewage Disposal System	1.71	90-367288
9	Individual Sewage Disposal System	1.82	90-367289
9	Individual Sewage Disposal System	1.8	90-367290
9	Individual Sewage Disposal System	1.62	90-367291

9	Individual Sewage Disposal System	1.86	90-367296
9	Individual Sewage Disposal System	1.85	90-367297
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9	Individual Sewage Disposal System	1.92	90-367317
9	Individual Sewage Disposal System	1.82	90-367318
9	Individual Sewage Disposal System	1.8	90-367319
9	Individual Sewage Disposal System	1.81	90-367320
9	Individual Sewage Disposal System	1.8	90-367321
9	Individual Sewage Disposal System	1.79	90-367322
9	Individual Sewage Disposal System	1.79	90-367323
9	Individual Sewage Disposal System	1.79	90-367324
9	Individual Sewage Disposal System	1.76	90-367325
9	Individual Sewage Disposal System	1.78	90-367326
9	Individual Sewage Disposal System	1.7	90-367327

9	Individual Sewage Disposal System	1.68	90-367328
9	Individual Sewage Disposal System	1.69	90-367329
9	Individual Sewage Disposal System	1.73	90-367330
9	Individual Sewage Disposal System	1.74	90-367331
9	Individual Sewage Disposal System	1.76	90-367332
9	Individual Sewage Disposal System	1.67	90-367333
9	Individual Sewage Disposal System	1.68	90-367334
9	Individual Sewage Disposal System	1.71	90-367335
9	Individual Sewage Disposal System	1.72	90-367336
9	Individual Sewage Disposal System	1.76	90-367337
9	Individual Sewage Disposal System	1.73	90-367338
9	Individual Sewage Disposal System	1.69	90-367339
9	Individual Sewage Disposal System	1.69	90-367340
9	Individual Sewage Disposal System	1.69	90-367341
9	Individual Sewage Disposal System	1.68	90-367342
9	Individual Sewage Disposal System	1.69	90-367343
9	Individual Sewage Disposal System	1.69	90-367344
9	Individual Sewage Disposal System	1.69	90-367345
9	Individual Sewage Disposal System	1.48	90-367346
9	Individual Sewage Disposal System	1.47	90-367347
9	Individual Sewage Disposal System	1.9	90-367350
9	Individual Sewage Disposal System	1.85	90-367351

9	Individual Sewage Disposal System	1.81	90-367352
9	Individual Sewage Disposal System	1.77	90-367353
9	Individual Sewage Disposal System	1.75	90-367354
9	Individual Sewage Disposal System	1.76	90-367355
9	Individual Sewage Disposal System	1.75	90-367356
9	Individual Sewage Disposal System	1.8	90-367357
9	Individual Sewage Disposal System	1.85	90-367358
9	Individual Sewage Disposal System	1.82	90-367359
9	Individual Sewage Disposal System	1.83	90-367360
9	Individual Sewage Disposal System	1.8	90-367361
9	Individual Sewage Disposal System	1.83	90-367367
9	Individual Sewage Disposal System	1.05	90-367369
9	Individual Sewage Disposal System	1.29	90-368173
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9	Individual Sewage Disposal System	1.82	90-368610
9	Individual Sewage Disposal System	1.79	90-368611
9	Individual Sewage Disposal System	1.77	90-368612
9	Individual Sewage Disposal System	1.73	90-368613
9	Individual Sewage Disposal System	1.81	90-368614
9	Individual Sewage Disposal System	1.58	90-368615

9	Individual Sewage Disposal System	1.64	90-368620
9	Individual Sewage Disposal System	1.4	90-368621
9	Individual Sewage Disposal System	1.42	90-368622
9	Individual Sewage Disposal System	1.39	90-368623
9	Individual Sewage Disposal System	1.42	90-368624
9	Individual Sewage Disposal System	1.44	90-368625
9	Individual Sewage Disposal System	1.27	90-368626
9	Individual Sewage Disposal System	1.28	90-368627
9	Individual Sewage Disposal System	1.09	90-368628
9	Individual Sewage Disposal System	1.13	90-368629
9	Individual Sewage Disposal System	1.97	90-368630
9	Individual Sewage Disposal System	1.81	90-368641
9	Individual Sewage Disposal System	1.87	90-368642
9	Individual Sewage Disposal System	1.9	90-368643
9	Individual Sewage Disposal System	1.92	90-368644
9	Individual Sewage Disposal System	1.1	90-368649
9	Individual Sewage Disposal System	1.38	90-368650
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9	Individual Sewage Disposal System	1.29	90-368653
9	Individual Sewage Disposal System	1.32	90-368654
9	Individual Sewage Disposal System	1.44	90-368655

9	Individual Sewage Disposal System	1.46	90-368656
9	Individual Sewage Disposal System	1.51	90-368659
9	Individual Sewage Disposal System	1.48	90-368660
9	Individual Sewage Disposal System	1.83	90-368675
9	Individual Sewage Disposal System	1.81	90-368676
9	Individual Sewage Disposal System	1.8	90-368677
9	Individual Sewage Disposal System	1.83	90-368678
9	Individual Sewage Disposal System	1.91	90-368679
9	Individual Sewage Disposal System	1.85	90-368680
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9	Individual Sewage Disposal System	1.7	90-413423
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9	Individual Sewage Disposal System	1.57	90-413429
9	Individual Sewage Disposal System	1.71	90-413430
9	Individual Sewage Disposal System	1.9	90-413431
9	Individual Sewage Disposal System	1.93	90-413439
9	Individual Sewage Disposal System	1.95	90-413440
9	Individual Sewage Disposal System	1.96	90-413441
9	Individual Sewage Disposal System	1.97	90-413442
9	Individual Sewage Disposal System	1.9	90-413443
9	Individual Sewage Disposal System	1.88	90-413444

9	Individual Sewage Disposal System	1.86	90-413445
9	Individual Sewage Disposal System	1.83	90-413446
9	Individual Sewage Disposal System	1.82	90-413447
9	Individual Sewage Disposal System	1.45	90-413454
9	Individual Sewage Disposal System	1.45	90-413454
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9	Individual Sewage Disposal System	1.39	90-413456
9	Individual Sewage Disposal System	1.35	90-413457
9	Individual Sewage Disposal System	1.45	90-413458
9	Individual Sewage Disposal System	1.47	90-413459
9	Individual Sewage Disposal System	1.48	90-413459
9	Individual Sewage Disposal System	1.53	90-413459

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
9	Individual Sewage Disposal System	2.39	90-344678
9	Individual Sewage Disposal System	2.43	90-344679
9	Individual Sewage Disposal System	2.47	90-344680
9	Individual Sewage Disposal System	2.52	90-344681
9	Individual Sewage Disposal System	2.54	90-344682
9	Individual Sewage Disposal System	2.54	90-344683
9	Individual Sewage Disposal System	2.57	90-344684
9	Individual Sewage Disposal System	2.61	90-344685

9	Individual Sewage Disposal System	2.62	90-344686
9	Individual Sewage Disposal System	2.69	90-344687
9	Individual Sewage Disposal System	2.65	90-344688
9	Individual Sewage Disposal System	2.62	90-344689
9	Individual Sewage Disposal System	2.59	90-344690
9	Individual Sewage Disposal System	2.57	90-344691
9	Individual Sewage Disposal System	2.63	90-344692
9	Individual Sewage Disposal System	2.7	90-344693
9	Individual Sewage Disposal System	2.69	90-344694
9	Individual Sewage Disposal System	2.72	90-344695
9	Individual Sewage Disposal System	2.78	90-344696
9	Individual Sewage Disposal System	2.99	90-349884
9	Individual Sewage Disposal System	2.91	90-349885
9	Individual Sewage Disposal System	2.89	90-349886
9	Individual Sewage Disposal System	2.89	90-349887
9	Individual Sewage Disposal System	2.91	90-349888
9	Individual Sewage Disposal System	2.93	90-349889
9	Individual Sewage Disposal System	2.94	90-349890
9	Individual Sewage Disposal System	2.94	90-349891
9	Individual Sewage Disposal System	2.92	90-349892
9	Individual Sewage Disposal System	2.94	90-349893
9	Individual Sewage Disposal System	2.96	90-349894

9	Individual Sewage Disposal System	2.98	90-349895
9	Individual Sewage Disposal System	2.43	90-358873
9	Individual Sewage Disposal System	2.47	90-358874
9	Individual Sewage Disposal System	2.41	90-358875
9	Individual Sewage Disposal System	2.38	90-358876
9	Individual Sewage Disposal System	2.31	90-358877
9	Individual Sewage Disposal System	2.28	90-358878
9	Individual Sewage Disposal System	2.33	90-358879
9	Individual Sewage Disposal System	2.24	90-358880
9	Individual Sewage Disposal System	2.18	90-358881
9	Individual Sewage Disposal System	2.17	90-358882
9	Individual Sewage Disposal System	2.3	90-358883
9	Individual Sewage Disposal System	2.35	90-358884
9	Individual Sewage Disposal System	2.39	90-358885
9	Individual Sewage Disposal System	2.4	90-358886
9	Individual Sewage Disposal System	2.39	90-358887
9	Individual Sewage Disposal System	2.47	90-358888
9	Individual Sewage Disposal System	2.56	90-358889
9	Individual Sewage Disposal System	2.65	90-358890
9	Individual Sewage Disposal System	2.72	90-358891
9	Individual Sewage Disposal System	2.15	90-358906
9	Individual Sewage Disposal System	2.19	90-358907

9	Individual Sewage Disposal System	2.26	90-358913
9	Individual Sewage Disposal System	2.3	90-358914
9	Individual Sewage Disposal System	2.37	90-358922
9	Individual Sewage Disposal System	2.41	90-358923
9	Individual Sewage Disposal System	2.37	90-358924
9	Individual Sewage Disposal System	2.43	90-358925
9	Individual Sewage Disposal System	2.44	90-358926
9	Individual Sewage Disposal System	2.47	90-358927
9	Individual Sewage Disposal System	2.47	90-358928
9	Individual Sewage Disposal System	2.45	90-358929
9	Individual Sewage Disposal System	2.46	90-358930
9	Individual Sewage Disposal System	2.52	90-358931
9	Individual Sewage Disposal System	2.47	90-358932
9	Individual Sewage Disposal System	2.47	90-358933
9	Individual Sewage Disposal System	2.48	90-358934
9	Individual Sewage Disposal System	2.55	90-358935
9	Individual Sewage Disposal System	2.61	90-358936
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9	Individual Sewage Disposal System	2.45	90-358950
9	Individual Sewage Disposal System	2.46	90-358951
9	Individual Sewage Disposal System	2.07	90-358967
9	Individual Sewage Disposal System	2.22	90-360386

9	Individual Sewage Disposal System	2.11	90-360387
9	Individual Sewage Disposal System	2.1	90-360399
9	Individual Sewage Disposal System	2.19	90-360400
9	Individual Sewage Disposal System	2.17	90-360401
9	Individual Sewage Disposal System	2.11	90-360402
9	Individual Sewage Disposal System	2.09	90-360403
9	Individual Sewage Disposal System	2.07	90-360404
9	Individual Sewage Disposal System	2.11	90-360405
9	Individual Sewage Disposal System	2.17	90-360406
9	Individual Sewage Disposal System	2.17	90-360407
9	Individual Sewage Disposal System	2.14	90-360408
9	Individual Sewage Disposal System	2.1	90-360409
9	Individual Sewage Disposal System	2.08	90-360410
9	Individual Sewage Disposal System	2.02	90-360411
9	Individual Sewage Disposal System	2.07	90-360412
9	Individual Sewage Disposal System	2.11	90-360413
9	Individual Sewage Disposal System	2.98	90-360744
9	Individual Sewage Disposal System	2.96	90-360745
9	Individual Sewage Disposal System	2.98	90-360746
9	Individual Sewage Disposal System	2.92	90-360747
9	Individual Sewage Disposal System	2.92	90-360756
9	Individual Sewage Disposal System	2.83	90-360757

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9	Individual Sewage Disposal System	2.02	90-413432
9	Individual Sewage Disposal System	2.25	90-413433
9	Individual Sewage Disposal System	2.2	90-413451
9	Individual Sewage Disposal System	2.25	90-413453
9	Individual Sewage Disposal System	2.2	90-413452

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
9	Individual Sewage Disposal System	3.84	90-301477
9	Individual Sewage Disposal System	3.86	90-301478
9	Individual Sewage Disposal System	3.86	90-301479
9	Individual Sewage Disposal System	3.93	90-301480
9	Individual Sewage Disposal System	3.98	90-302004
9	Individual Sewage Disposal System	3.94	90-302005
9	Individual Sewage Disposal System	3.93	90-302006
9	Individual Sewage Disposal System	3.96	90-302007
9	Individual Sewage Disposal System	3.97	90-302032
9	Individual Sewage Disposal System	3.94	90-302033
9	Individual Sewage Disposal System	3.97	90-302034
9	Individual Sewage Disposal System	3.89	90-302035
9	Individual Sewage Disposal System	3.85	90-302036
9	Individual Sewage Disposal System	3.82	90-302037
9	Individual Sewage Disposal System	3.84	90-302038

9	Individual Sewage Disposal System	3.88	90-302039
9	Individual Sewage Disposal System	3.9	90-302040
9	Individual Sewage Disposal System	3.86	90-302044
9	Individual Sewage Disposal System	3.87	90-302456
9	Individual Sewage Disposal System	3.88	90-302457
9	Individual Sewage Disposal System	3.96	90-302462
9	Individual Sewage Disposal System	3.6	90-302490
9	Individual Sewage Disposal System	3.64	90-302492
9	Individual Sewage Disposal System	3.65	90-302493
9	Individual Sewage Disposal System	3.67	90-302494
9	Individual Sewage Disposal System	3.68	90-302495
9	Individual Sewage Disposal System	3.72	90-302496
9	Individual Sewage Disposal System	3.96	90-309966
9	Individual Sewage Disposal System	3.89	90-309974
9	Individual Sewage Disposal System	3.84	90-309975
9	Individual Sewage Disposal System	3.85	90-309976
9	Individual Sewage Disposal System	3.85	90-309977
9	Individual Sewage Disposal System	3.91	90-309979
9	Individual Sewage Disposal System	4.0	90-344629
9	Individual Sewage Disposal System	3.93	90-344630
9	Individual Sewage Disposal System	3.31	90-349857
9	Individual Sewage Disposal System	3.29	90-349858

9	Individual Sewage Disposal System	3.25	90-349859
9	Individual Sewage Disposal System	3.21	90-349860
9	Individual Sewage Disposal System	3.2	90-349861
9	Individual Sewage Disposal System	3.19	90-349862
9	Individual Sewage Disposal System	3.23	90-349863
9	Individual Sewage Disposal System	3.25	90-349864
9	Individual Sewage Disposal System	3.28	90-349865
9	Individual Sewage Disposal System	3.22	90-349866
9	Individual Sewage Disposal System	3.22	90-349867
9	Individual Sewage Disposal System	3.17	90-349868
9	Individual Sewage Disposal System	3.14	90-349869
9	Individual Sewage Disposal System	3.25	90-349870
9	Individual Sewage Disposal System	3.09	90-349871
9	Individual Sewage Disposal System	3.1	90-349872
9	Individual Sewage Disposal System	3.11	90-349873
9	Individual Sewage Disposal System	3.12	90-349874
9	Individual Sewage Disposal System	3.13	90-349875
9	Individual Sewage Disposal System	3.15	90-349876
9	Individual Sewage Disposal System	3.16	90-349877
9	Individual Sewage Disposal System	3.15	90-349878
9	Individual Sewage Disposal System	3.11	90-349879
9	Individual Sewage Disposal System	3.09	90-349880

9	Individual Sewage Disposal System	3.07	90-349881
9	Individual Sewage Disposal System	3.02	90-349882
9	Individual Sewage Disposal System	3.0	90-349883
9	Individual Sewage Disposal System	3.61	90-357301
9	Individual Sewage Disposal System	3.73	90-357302
9	Individual Sewage Disposal System	3.71	90-357303
9	Individual Sewage Disposal System	3.67	90-357304
9	Individual Sewage Disposal System	3.01	90-357339
9	Individual Sewage Disposal System	3.08	90-357340
9	Individual Sewage Disposal System	3.08	90-357341
9	Individual Sewage Disposal System	3.15	90-357342
9	Individual Sewage Disposal System	3.2	90-357343
9	Individual Sewage Disposal System	3.65	90-357344
9	Individual Sewage Disposal System	3.46	90-357345
9	Individual Sewage Disposal System	3.35	90-357346
9	Individual Sewage Disposal System	3.24	90-357347
9	Individual Sewage Disposal System	3.27	90-357348
9	Individual Sewage Disposal System	3.3	90-357349
9	Individual Sewage Disposal System	3.51	90-357350
9	Individual Sewage Disposal System	3.59	90-357351
9	Individual Sewage Disposal System	3.45	90-358591
9	Individual Sewage Disposal System	3.36	90-358893

9	Individual Sewage Disposal System	3.55	90-358894
9	Individual Sewage Disposal System	3.76	90-358895
9	Individual Sewage Disposal System	3.78	90-358896
9	Individual Sewage Disposal System	3.85	90-358897
9	Individual Sewage Disposal System	3.87	90-358898
9	Individual Sewage Disposal System	3.9	90-358899
9	Individual Sewage Disposal System	3.37	90-358990
9	Individual Sewage Disposal System	3.01	90-358997
9	Individual Sewage Disposal System	3.02	90-358998
9	Individual Sewage Disposal System	3.04	90-358999
9	Individual Sewage Disposal System	3.05	90-359000
9	Individual Sewage Disposal System	3.06	90-359001
9	Individual Sewage Disposal System	3.03	90-359002
9	Individual Sewage Disposal System	3.02	90-359003
9	Individual Sewage Disposal System	3.04	90-359004
9	Individual Sewage Disposal System	3.1	90-359005
9	Individual Sewage Disposal System	3.1	90-359006
9	Individual Sewage Disposal System	3.87	90-360130
9	Individual Sewage Disposal System	3.83	90-360131
9	Individual Sewage Disposal System	3.75	90-360132
9	Individual Sewage Disposal System	3.66	90-360134
9	Individual Sewage Disposal System	3.69	90-360135

9	Individual Sewage Disposal System	3.56	90-360136
9	Individual Sewage Disposal System	3.81	90-360137
9	Individual Sewage Disposal System	3.97	90-360290
9	Individual Sewage Disposal System	3.97	90-360291
9	Individual Sewage Disposal System	3.98	90-360292
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9	Individual Sewage Disposal System	3.99	90-360366
9	Individual Sewage Disposal System	3.93	90-360368
9	Individual Sewage Disposal System	3.9	90-360369
9	Individual Sewage Disposal System	3.96	90-360370
9	Individual Sewage Disposal System	3.91	90-360371
9	Individual Sewage Disposal System	3.94	90-360379
9	Individual Sewage Disposal System	3.64	90-360380
9	Individual Sewage Disposal System	3.85	90-360381
9	Individual Sewage Disposal System	3.42	90-360383

9	Individual Sewage Disposal System	3.37	90-360384
9	Individual Sewage Disposal System	3.81	90-360736
9	Individual Sewage Disposal System	3.7	90-360737
9	Individual Sewage Disposal System	3.69	90-360738
9	Individual Sewage Disposal System	3.6	90-360739
9	Individual Sewage Disposal System	3.52	90-360740
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9	Individual Sewage Disposal System	3.68	90-360751
9	Individual Sewage Disposal System	3.59	90-360752
9	Individual Sewage Disposal System	3.2	90-360753
9	Individual Sewage Disposal System	3.12	90-360754
9	Individual Sewage Disposal System	3.11	90-360755
9	Individual Sewage Disposal System	3.0	90-360767
9	Individual Sewage Disposal System	3.35	90-360780
9	Individual Sewage Disposal System	3.27	90-360781
9	Individual Sewage Disposal System	3.3	90-360782
9	Individual Sewage Disposal System	3.11	90-360783

9	Individual Sewage Disposal System	3.16	90-360784
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9	Individual Sewage Disposal System	3.06	90-360786
9	Individual Sewage Disposal System	3.22	90-360787
9	Individual Sewage Disposal System	3.2	90-360788
9	Individual Sewage Disposal System	3.24	90-360789
9	Individual Sewage Disposal System	3.26	90-360790
9	Individual Sewage Disposal System	3.41	90-360791
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9	Individual Sewage Disposal System	3.38	90-360809
9	Individual Sewage Disposal System	3.06	90-360810
9	Individual Sewage Disposal System	3.14	90-360816
9	Individual Sewage Disposal System	3.26	90-360817

9	Individual Sewage Disposal System	3.36	90-360818
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9	Individual Sewage Disposal System	3.28	90-360820
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9	Individual Sewage Disposal System	3.1	90-361156
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9	Individual Sewage Disposal System	3.24	90-361161
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9	Individual Sewage Disposal System	3.83	90-361211

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9	Individual Sewage Disposal System	3.81	90-361213
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9	Individual Sewage Disposal System	3.81	90-361216
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9	Individual Sewage Disposal System	3.77	90-361219
9	Individual Sewage Disposal System	3.75	90-361220
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9	Individual Sewage Disposal System	3.72	90-361222
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9	Individual Sewage Disposal System	3.89	90-361224
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9	Individual Sewage Disposal System	3.17	90-361332
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9	Individual Sewage Disposal System	3.11	90-361335
9	Individual Sewage Disposal System	3.08	90-361336
9	Individual Sewage Disposal System	3.02	90-361342
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9	Individual Sewage Disposal System	3.73	90-361359
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9	Individual Sewage Disposal System	3.63	90-361368
9	Individual Sewage Disposal System	3.58	90-361369
9	Individual Sewage Disposal System	3.55	90-361370
9	Individual Sewage Disposal System	3.52	90-361371
9	Individual Sewage Disposal System	3.56	90-361372
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9	Individual Sewage Disposal System	3.43	90-361374
9	Individual Sewage Disposal System	3.44	90-361375
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9	Individual Sewage Disposal System	3.38	90-361377

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9	Individual Sewage Disposal System	3.34	90-361380
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9	Individual Sewage Disposal System	3.33	90-361382
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9	Individual Sewage Disposal System	3.48	90-361389
9	Individual Sewage Disposal System	3.42	90-361390
9	Individual Sewage Disposal System	3.38	90-361391
9	Individual Sewage Disposal System	3.35	90-361392
9	Individual Sewage Disposal System	3.52	90-361393
9	Individual Sewage Disposal System	3.51	90-361394
9	Individual Sewage Disposal System	3.54	90-361395
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9	Individual Sewage Disposal System	3.41	90-361400
9	Individual Sewage Disposal System	3.34	90-361401
9	Individual Sewage Disposal System	3.29	90-361402

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9	Individual Sewage Disposal System	3.1	90-361406
9	Individual Sewage Disposal System	3.09	90-361407
9	Individual Sewage Disposal System	3.08	90-361408
9	Individual Sewage Disposal System	3.0	90-361409
9	Individual Sewage Disposal System	3.19	90-362666
9	Individual Sewage Disposal System	3.72	90-363999
9	Individual Sewage Disposal System	3.66	90-364000
9	Individual Sewage Disposal System	3.61	90-364216
9	Individual Sewage Disposal System	3.57	90-364217
9	Individual Sewage Disposal System	3.35	90-364218
9	Individual Sewage Disposal System	3.34	90-364219
9	Individual Sewage Disposal System	3.89	90-364220
9	Individual Sewage Disposal System	3.96	90-364221
9	Individual Sewage Disposal System	3.87	90-364222
9	Individual Sewage Disposal System	3.84	90-364223
9	Individual Sewage Disposal System	3.82	90-364224
9	Individual Sewage Disposal System	3.93	90-364225
9	Individual Sewage Disposal System	3.79	90-364226
9	Individual Sewage Disposal System	3.72	90-364227

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9	Individual Sewage Disposal System	3.05	90-364230
9	Individual Sewage Disposal System	3.09	90-364231
9	Individual Sewage Disposal System	3.26	90-364232
9	Individual Sewage Disposal System	3.36	90-364233
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9	Individual Sewage Disposal System	3.25	90-364235
9	Individual Sewage Disposal System	3.22	90-364236
9	Individual Sewage Disposal System	3.06	90-364324
9	Individual Sewage Disposal System	3.2	90-364325
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9	Individual Sewage Disposal System	3.14	90-364731
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9	Individual Sewage Disposal System	3.15	90-365341

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9	Individual Sewage Disposal System	3.16	90-365343
9	Individual Sewage Disposal System	3.21	90-365344
9	Individual Sewage Disposal System	3.32	90-365345
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9	Individual Sewage Disposal System	3.1	90-365799
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9	Individual Sewage Disposal System	3.17	90-365801
9	Individual Sewage Disposal System	3.38	90-365802
9	Individual Sewage Disposal System	3.32	90-365803
9	Individual Sewage Disposal System	3.23	90-365804
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9	Individual Sewage Disposal System	3.96	90-366566
9	Individual Sewage Disposal System	3.92	90-366567
9	Individual Sewage Disposal System	3.73	90-366570
9	Individual Sewage Disposal System	3.81	90-366573
9	Individual Sewage Disposal System	3.12	90-366578

9	Individual Sewage Disposal System	3.13	90-366583
9	Individual Sewage Disposal System	3.88	90-368127
9	Individual Sewage Disposal System	3.86	90-368128
9	Individual Sewage Disposal System	3.99	90-368130
9	Individual Sewage Disposal System	3.83	90-368132
9	Individual Sewage Disposal System	3.1	90-368211
9	Individual Sewage Disposal System	3.07	90-368212
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9	Individual Sewage Disposal System	3.48	90-368897
9	Individual Sewage Disposal System	3.43	90-368898
9	Individual Sewage Disposal System	3.17	90-368899
9	Individual Sewage Disposal System	3.16	90-368900
9	Individual Sewage Disposal System	3.16	90-368901
9	Individual Sewage Disposal System	3.31	90-368905
9	Individual Sewage Disposal System	3.43	90-368906

9	Individual Sewage Disposal System	3.42	90-368911
9	Individual Sewage Disposal System	3.31	90-368912
9	Individual Sewage Disposal System	3.26	90-368913
9	Individual Sewage Disposal System	3.04	90-368915
9	Individual Sewage Disposal System	3.7	90-368933
9	Individual Sewage Disposal System	3.7	90-368934
9	Individual Sewage Disposal System	3.69	90-368935
9	Individual Sewage Disposal System	3.73	90-368936
9	Individual Sewage Disposal System	3.83	90-368937
9	Individual Sewage Disposal System	3.84	90-368938
9	Individual Sewage Disposal System	3.8	90-368939
9	Individual Sewage Disposal System	3.81	90-368940
9	Individual Sewage Disposal System	3.87	90-368941
9	Individual Sewage Disposal System	3.91	90-368942
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9	Individual Sewage Disposal System	4.0	90-368946
9	Individual Sewage Disposal System	3.99	90-368947
9	Individual Sewage Disposal System	3.99	90-368948
9	Individual Sewage Disposal System	3.99	90-368949
9	Individual Sewage Disposal System	3.84	90-368956
9	Individual Sewage Disposal System	3.96	90-368957
9	Individual Sewage Disposal System	3.93	90-368958

9	Individual Sewage Disposal System	3.54	90-368959
9	Individual Sewage Disposal System	3.48	90-368960
9	Individual Sewage Disposal System	3.7	90-369293
9	Individual Sewage Disposal System	3.68	90-369294
9	Individual Sewage Disposal System	3.7	90-369295
9	Individual Sewage Disposal System	3.72	90-369296
9	Individual Sewage Disposal System	3.74	90-369297
9	Individual Sewage Disposal System	3.68	90-369298
9	Individual Sewage Disposal System	3.65	90-369299
9	Individual Sewage Disposal System	3.66	90-369300
9	Individual Sewage Disposal System	3.7	90-369301
9	Individual Sewage Disposal System	3.68	90-369302
9	Individual Sewage Disposal System	3.67	90-369303
9	Individual Sewage Disposal System	3.64	90-369304
9	Individual Sewage Disposal System	3.5	90-369305
9	Individual Sewage Disposal System	3.42	90-369306
9	Individual Sewage Disposal System	3.43	90-369307
9	Individual Sewage Disposal System	3.25	90-369308
9	Individual Sewage Disposal System	3.55	90-369309
9	Individual Sewage Disposal System	3.46	90-369310
9	Individual Sewage Disposal System	3.35	90-369311
9	Individual Sewage Disposal System	3.41	90-369312

9	Individual Sewage Disposal System	3.04	90-369319
9	Individual Sewage Disposal System	3.03	90-369839
9	Individual Sewage Disposal System	3.04	90-369840
9	Individual Sewage Disposal System	3.59	90-413371
9	Individual Sewage Disposal System	3.54	90-413372
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9	Individual Sewage Disposal System	3.51	90-413375
9	Individual Sewage Disposal System	3.48	90-413376
9	Individual Sewage Disposal System	3.5	90-413377
9	Individual Sewage Disposal System	3.54	90-413378
9	Individual Sewage Disposal System	3.49	90-413379
9	Individual Sewage Disposal System	3.51	90-413380
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9	Individual Sewage Disposal System	3.42	90-413386
9	Individual Sewage Disposal System	3.38	90-413387
9	Individual Sewage Disposal System	3.28	90-413388
9	Individual Sewage Disposal System	3.36	90-413389

9	Individual Sewage Disposal System	3.34	90-413395
9	Individual Sewage Disposal System	3.38	90-413396
9	Individual Sewage Disposal System	3.32	90-413397
9	Individual Sewage Disposal System	3.37	90-413398
9	Individual Sewage Disposal System	3.48	90-413399
9	Individual Sewage Disposal System	3.51	90-413400
9	Individual Sewage Disposal System	3.54	90-413401
9	Individual Sewage Disposal System	3.46	90-413402
9	Individual Sewage Disposal System	3.64	90-413403
9	Individual Sewage Disposal System	3.64	90-413404
9	Individual Sewage Disposal System	3.52	90-413405
9	Individual Sewage Disposal System	3.26	90-413406
9	Individual Sewage Disposal System	3.18	90-413407
9	Individual Sewage Disposal System	3.16	90-413409
9	Individual Sewage Disposal System	3.08	90-413415
9	Individual Sewage Disposal System	3.95	90-413435
9	Individual Sewage Disposal System	3.91	90-413436
9	Individual Sewage Disposal System	3.85	90-413437
9	Individual Sewage Disposal System	3.79	90-413438
9	Individual Sewage Disposal System	3.19	90-413460
9	Individual Sewage Disposal System	3.16	90-413461
9	Individual Sewage Disposal System	3.14	90-413462

9	Individual Sewage Disposal System	3.16	90-413463
9	Individual Sewage Disposal System	3.14	90-413464
9	Individual Sewage Disposal System	3.11	90-413465

Beaver Lake Zone 5			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
9	Individual Sewage Disposal System	4.86	90-300977
9	Individual Sewage Disposal System	4.88	90-300981
9	Individual Sewage Disposal System	4.18	90-301481
9	Individual Sewage Disposal System	4.16	90-301482
9	Individual Sewage Disposal System	4.17	90-301483
9	Individual Sewage Disposal System	4.02	90-301484
9	Individual Sewage Disposal System	4.06	90-301485
9	Individual Sewage Disposal System	4.16	90-301486
9	Individual Sewage Disposal System	4.17	90-301487
9	Individual Sewage Disposal System	4.1	90-301488
9	Individual Sewage Disposal System	4.08	90-301489
9	Individual Sewage Disposal System	4.09	90-301490
9	Individual Sewage Disposal System	4.2	90-301491
9	Individual Sewage Disposal System	4.21	90-301492
9	Individual Sewage Disposal System	4.15	90-301493
9	Individual Sewage Disposal System	4.24	90-301494
9	Individual Sewage Disposal System	4.21	90-301495

9	Individual Sewage Disposal System	4.22	90-301496
9	Individual Sewage Disposal System	4.25	90-301908
9	Individual Sewage Disposal System	4.31	90-301909
9	Individual Sewage Disposal System	4.31	90-301910
9	Individual Sewage Disposal System	4.33	90-301911
9	Individual Sewage Disposal System	4.38	90-301912
9	Individual Sewage Disposal System	4.4	90-301913
9	Individual Sewage Disposal System	4.41	90-301914
9	Individual Sewage Disposal System	4.45	90-301915
9	Individual Sewage Disposal System	4.45	90-301916
9	Individual Sewage Disposal System	4.42	90-301917
9	Individual Sewage Disposal System	4.41	90-301918
9	Individual Sewage Disposal System	4.31	90-301919
9	Individual Sewage Disposal System	4.3	90-301920
9	Individual Sewage Disposal System	4.28	90-301921
9	Individual Sewage Disposal System	4.26	90-301922
9	Individual Sewage Disposal System	4.21	90-301923
9	Individual Sewage Disposal System	4.23	90-301924
9	Individual Sewage Disposal System	4.33	90-301925
9	Individual Sewage Disposal System	4.56	90-301926
9	Individual Sewage Disposal System	4.59	90-301927
9	Individual Sewage Disposal System	4.63	90-301928

9	Individual Sewage Disposal System	4.75	90-301929
9	Individual Sewage Disposal System	4.96	90-301930
9	Individual Sewage Disposal System	4.93	90-301939
9	Individual Sewage Disposal System	4.94	90-301940
9	Individual Sewage Disposal System	4.96	90-301941
9	Individual Sewage Disposal System	4.96	90-301942
9	Individual Sewage Disposal System	4.99	90-301943
9	Individual Sewage Disposal System	5.0	90-301944
9	Individual Sewage Disposal System	4.98	90-301952
9	Individual Sewage Disposal System	4.96	90-301953
9	Individual Sewage Disposal System	4.97	90-301954
9	Individual Sewage Disposal System	4.98	90-301955
9	Individual Sewage Disposal System	4.99	90-301956
9	Individual Sewage Disposal System	4.92	90-301970
9	Individual Sewage Disposal System	4.02	90-302002
9	Individual Sewage Disposal System	4.01	90-302003
9	Individual Sewage Disposal System	4.02	90-302008
9	Individual Sewage Disposal System	4.06	90-302009
9	Individual Sewage Disposal System	4.11	90-302010
9	Individual Sewage Disposal System	4.11	90-302011
9	Individual Sewage Disposal System	4.12	90-302012
9	Individual Sewage Disposal System	4.14	90-302013

9	Individual Sewage Disposal System	4.11	90-302014
9	Individual Sewage Disposal System	4.14	90-302015
9	Individual Sewage Disposal System	4.2	90-302016
9	Individual Sewage Disposal System	4.24	90-302017
9	Individual Sewage Disposal System	4.28	90-302018
9	Individual Sewage Disposal System	4.36	90-302019
9	Individual Sewage Disposal System	4.42	90-302020
9	Individual Sewage Disposal System	4.43	90-302021
9	Individual Sewage Disposal System	4.34	90-302023
9	Individual Sewage Disposal System	4.29	90-302024
9	Individual Sewage Disposal System	4.27	90-302025
9	Individual Sewage Disposal System	4.25	90-302026
9	Individual Sewage Disposal System	4.21	90-302027
9	Individual Sewage Disposal System	4.21	90-302028
9	Individual Sewage Disposal System	4.17	90-302029
9	Individual Sewage Disposal System	4.16	90-302030
9	Individual Sewage Disposal System	4.12	90-302031
9	Individual Sewage Disposal System	4.03	90-302463
9	Individual Sewage Disposal System	4.06	90-302464
9	Individual Sewage Disposal System	4.07	90-302465
9	Individual Sewage Disposal System	4.11	90-302466
9	Individual Sewage Disposal System	4.31	90-302467

9	Individual Sewage Disposal System	4.32	90-302468
9	Individual Sewage Disposal System	4.28	90-302469
9	Individual Sewage Disposal System	4.28	90-302470
9	Individual Sewage Disposal System	4.22	90-302471
9	Individual Sewage Disposal System	4.13	90-302472
9	Individual Sewage Disposal System	4.76	90-307632
9	Individual Sewage Disposal System	4.11	90-309905
9	Individual Sewage Disposal System	4.09	90-309906
9	Individual Sewage Disposal System	4.16	90-309907
9	Individual Sewage Disposal System	4.56	90-309908
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9	Individual Sewage Disposal System	4.62	90-313311
9	Individual Sewage Disposal System	4.6	90-313312
9	Individual Sewage Disposal System	4.91	90-313313
9	Individual Sewage Disposal System	4.84	90-313314

9	Individual Sewage Disposal System	4.13	90-344625
9	Individual Sewage Disposal System	4.17	90-344626
9	Individual Sewage Disposal System	4.15	90-344627
9	Individual Sewage Disposal System	4.04	90-344628
9	Individual Sewage Disposal System	4.03	90-344631
9	Individual Sewage Disposal System	4.02	90-344632
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9	Individual Sewage Disposal System	4.74	90-345323
9	Individual Sewage Disposal System	4.68	90-345324
9	Individual Sewage Disposal System	4.62	90-345325
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9	Individual Sewage Disposal System	4.54	90-345327
9	Individual Sewage Disposal System	4.52	90-345328
9	Individual Sewage Disposal System	4.56	90-345329
9	Individual Sewage Disposal System	4.51	90-345330

9	Individual Sewage Disposal System	4.5	90-345331
9	Individual Sewage Disposal System	4.45	90-345332
9	Individual Sewage Disposal System	4.46	90-345333
9	Individual Sewage Disposal System	4.64	90-345334
9	Individual Sewage Disposal System	4.61	90-345335
9	Individual Sewage Disposal System	4.53	90-345336
9	Individual Sewage Disposal System	4.54	90-345337
9	Individual Sewage Disposal System	4.56	90-345338
9	Individual Sewage Disposal System	4.16	90-345340
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9	Individual Sewage Disposal System	4.9	90-353114
9	Individual Sewage Disposal System	4.81	90-353115
9	Individual Sewage Disposal System	4.92	90-353116
9	Individual Sewage Disposal System	4.86	90-353117
9	Individual Sewage Disposal System	4.9	90-353123
9	Individual Sewage Disposal System	4.83	90-353124
9	Individual Sewage Disposal System	4.6	90-353134
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9	Individual Sewage Disposal System	4.2	90-353142
9	Individual Sewage Disposal System	4.11	90-353143
9	Individual Sewage Disposal System	4.8	90-357584
9	Individual Sewage Disposal System	4.39	90-358586
9	Individual Sewage Disposal System	4.84	90-358587
9	Individual Sewage Disposal System	4.75	90-358588
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9	Individual Sewage Disposal System	4.98	90-358637
9	Individual Sewage Disposal System	4.57	90-358648
9	Individual Sewage Disposal System	4.61	90-358649
9	Individual Sewage Disposal System	4.61	90-358650
9	Individual Sewage Disposal System	4.6	90-358651
9	Individual Sewage Disposal System	4.59	90-358652
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9	Individual Sewage Disposal System	4.57	90-358654
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9	Individual Sewage Disposal System	4.55	90-358656
9	Individual Sewage Disposal System	4.6	90-358657

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9	Individual Sewage Disposal System	4.65	90-358659
9	Individual Sewage Disposal System	4.62	90-358660
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9	Individual Sewage Disposal System	4.72	90-358677
9	Individual Sewage Disposal System	4.73	90-358678
9	Individual Sewage Disposal System	4.76	90-358679
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9	Individual Sewage Disposal System	4.95	90-359457
9	Individual Sewage Disposal System	4.99	90-359478
9	Individual Sewage Disposal System	4.95	90-359479
9	Individual Sewage Disposal System	4.93	90-359480
9	Individual Sewage Disposal System	4.9	90-359481
9	Individual Sewage Disposal System	4.9	90-359482
9	Individual Sewage Disposal System	4.92	90-359483
9	Individual Sewage Disposal System	4.92	90-359484
9	Individual Sewage Disposal System	4.94	90-359485
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9	Individual Sewage Disposal System	4.96	90-359487
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9	Individual Sewage Disposal System	4.93	90-360017
9	Individual Sewage Disposal System	4.9	90-360018
9	Individual Sewage Disposal System	4.87	90-360019
9	Individual Sewage Disposal System	4.87	90-360020
9	Individual Sewage Disposal System	4.89	90-360021
9	Individual Sewage Disposal System	4.89	90-360022
9	Individual Sewage Disposal System	4.9	90-360023
9	Individual Sewage Disposal System	4.9	90-360024

9	Individual Sewage Disposal System	4.9	90-360025
9	Individual Sewage Disposal System	4.9	90-360026
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9	Individual Sewage Disposal System	4.97	90-360036
9	Individual Sewage Disposal System	4.95	90-360037
9	Individual Sewage Disposal System	4.75	90-360053
9	Individual Sewage Disposal System	4.74	90-360054
9	Individual Sewage Disposal System	4.74	90-360055
9	Individual Sewage Disposal System	4.74	90-360056
9	Individual Sewage Disposal System	4.73	90-360057
9	Individual Sewage Disposal System	4.72	90-360058
9	Individual Sewage Disposal System	4.73	90-360060
9	Individual Sewage Disposal System	4.72	90-360061
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9	Individual Sewage Disposal System	4.77	90-360063
9	Individual Sewage Disposal System	4.74	90-360064
9	Individual Sewage Disposal System	4.78	90-360065

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9	Individual Sewage Disposal System	4.77	90-360067
9	Individual Sewage Disposal System	4.75	90-360068
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9	Individual Sewage Disposal System	4.1	90-360293
9	Individual Sewage Disposal System	4.1	90-360294
9	Individual Sewage Disposal System	4.09	90-360295
9	Individual Sewage Disposal System	4.06	90-360296
9	Individual Sewage Disposal System	4.04	90-360297
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9	Individual Sewage Disposal System	4.27	90-360318
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9	Individual Sewage Disposal System	4.63	90-360352
9	Individual Sewage Disposal System	4.68	90-360353
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9	Individual Sewage Disposal System	4.33	90-360355
9	Individual Sewage Disposal System	4.38	90-360356
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9	Individual Sewage Disposal System	4.19	90-360359
9	Individual Sewage Disposal System	4.14	90-360360
9	Individual Sewage Disposal System	4.13	90-360361
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9	Individual Sewage Disposal System	4.1	90-360374
9	Individual Sewage Disposal System	4.12	90-360377
9	Individual Sewage Disposal System	4.01	90-360378
9	Individual Sewage Disposal System	4.09	90-361201

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9	Individual Sewage Disposal System	4.04	90-361204
9	Individual Sewage Disposal System	4.02	90-361205
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9	Individual Sewage Disposal System	4.23	90-364725

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9	Individual Sewage Disposal System	4.9	90-365285
9	Individual Sewage Disposal System	4.92	90-365286
9	Individual Sewage Disposal System	4.91	90-365291
9	Individual Sewage Disposal System	4.89	90-365292
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9	Individual Sewage Disposal System	4.58	90-365327
9	Individual Sewage Disposal System	4.58	90-365328

9	Individual Sewage Disposal System	4.6	90-365329
9	Individual Sewage Disposal System	4.61	90-365330
9	Individual Sewage Disposal System	4.64	90-365732
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9	Individual Sewage Disposal System	4.6	90-365734
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9	Individual Sewage Disposal System	4.64	90-365738
9	Individual Sewage Disposal System	4.07	90-366560
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9	Individual Sewage Disposal System	4.16	90-366562
9	Individual Sewage Disposal System	4.14	90-366565
9	Individual Sewage Disposal System	4.03	90-366568
9	Individual Sewage Disposal System	4.79	90-366869
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9	Individual Sewage Disposal System	4.74	90-366871
9	Individual Sewage Disposal System	4.72	90-366872
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9	Individual Sewage Disposal System	4.68	90-366874
9	Individual Sewage Disposal System	4.72	90-366875
9	Individual Sewage Disposal System	4.76	90-366876

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9	Individual Sewage Disposal System	4.76	90-366878
9	Individual Sewage Disposal System	4.71	90-366879
9	Individual Sewage Disposal System	4.69	90-366880
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9	Individual Sewage Disposal System	4.87	90-367739
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9	Individual Sewage Disposal System	4.47	90-367747
9	Individual Sewage Disposal System	4.43	90-367748
9	Individual Sewage Disposal System	4.41	90-367749
9	Individual Sewage Disposal System	4.47	90-367750
9	Individual Sewage Disposal System	4.57	90-367752
9	Individual Sewage Disposal System	4.42	90-367755
9	Individual Sewage Disposal System	4.18	90-368115
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9	Individual Sewage Disposal System	4.42	90-368120
9	Individual Sewage Disposal System	4.14	90-368121

9	Individual Sewage Disposal System	4.12	90-368122
9	Individual Sewage Disposal System	4.16	90-368123
9	Individual Sewage Disposal System	4.16	90-368125
9	Individual Sewage Disposal System	4.06	90-368126
9	Individual Sewage Disposal System	4.98	90-368560
9	Individual Sewage Disposal System	4.59	90-368562
9	Individual Sewage Disposal System	4.68	90-368563
9	Individual Sewage Disposal System	4.64	90-368564
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9	Individual Sewage Disposal System	4.68	90-368571
9	Individual Sewage Disposal System	4.71	90-368572
9	Individual Sewage Disposal System	4.75	90-368573
9	Individual Sewage Disposal System	4.73	90-368574
9	Individual Sewage Disposal System	4.74	90-368575
9	Individual Sewage Disposal System	4.73	90-368576
9	Individual Sewage Disposal System	4.71	90-368577
9	Individual Sewage Disposal System	4.41	90-368578

9	Individual Sewage Disposal System	4.4	90-368579
9	Individual Sewage Disposal System	4.38	90-368580
9	Individual Sewage Disposal System	4.41	90-368581
9	Individual Sewage Disposal System	4.38	90-368582
9	Individual Sewage Disposal System	4.37	90-368583
9	Individual Sewage Disposal System	4.37	90-368584
9	Individual Sewage Disposal System	4.36	90-368585
9	Individual Sewage Disposal System	4.33	90-368586
9	Individual Sewage Disposal System	4.27	90-368587
9	Individual Sewage Disposal System	4.22	90-368588
9	Individual Sewage Disposal System	4.25	90-368589
9	Individual Sewage Disposal System	4.31	90-368590
9	Individual Sewage Disposal System	4.33	90-368591
9	Individual Sewage Disposal System	4.29	90-368592
9	Individual Sewage Disposal System	4.28	90-368593
9	Individual Sewage Disposal System	4.3	90-368594
9	Individual Sewage Disposal System	4.38	90-368595
9	Individual Sewage Disposal System	4.41	90-368596
9	Individual Sewage Disposal System	4.42	90-368597
9	Individual Sewage Disposal System	4.4	90-368598
9	Individual Sewage Disposal System	4.42	90-368599
9	Individual Sewage Disposal System	4.43	90-368600

9	Individual Sewage Disposal System	4.36	90-368601
9	Individual Sewage Disposal System	4.37	90-368602
9	Individual Sewage Disposal System	4.36	90-368603
9	Individual Sewage Disposal System	4.38	90-368604
9	Individual Sewage Disposal System	4.37	90-368605
9	Individual Sewage Disposal System	4.41	90-368606
9	Individual Sewage Disposal System	4.41	90-368607
9	Individual Sewage Disposal System	4.5	90-368608
9	Individual Sewage Disposal System	4.43	90-368609
9	Individual Sewage Disposal System	4.44	90-368884
9	Individual Sewage Disposal System	4.44	90-368885
9	Individual Sewage Disposal System	4.45	90-368886
9	Individual Sewage Disposal System	4.46	90-368887
9	Individual Sewage Disposal System	4.5	90-368888
9	Individual Sewage Disposal System	4.09	90-368893
9	Individual Sewage Disposal System	4.0	90-368904
9	Individual Sewage Disposal System	4.02	90-368943
9	Individual Sewage Disposal System	4.01	90-368945
9	Individual Sewage Disposal System	4.11	90-368950
9	Individual Sewage Disposal System	4.12	90-368951
9	Individual Sewage Disposal System	4.18	90-368952
9	Individual Sewage Disposal System	4.18	90-368953

9	Individual Sewage Disposal System	4.15	90-368954
9	Individual Sewage Disposal System	4.08	90-368955
9	Individual Sewage Disposal System	4.33	90-368961
9	Individual Sewage Disposal System	4.27	90-368962
9	Individual Sewage Disposal System	4.23	90-368963
9	Individual Sewage Disposal System	4.04	90-368964
9	Individual Sewage Disposal System	4.3	90-368965
9	Individual Sewage Disposal System	4.56	90-371017
9	Individual Sewage Disposal System	4.49	90-413434

Beaver Lake Zone 2			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
10	Cemetery	1.41	38-4836

Beaver Lake Zone 3			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
10	Cemetery	2.67	38-4835
10	Cemetery	2.96	38-4850
10	Cemetery	2.14	38-4851

Beaver Lake Zone 4			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
10	Cemetery	3.84	38-4833

Beaver Lake Zone 5			
Health Risk Category	PSOC Description	Distance from Intake	Reference Number
10	Cemetery	4.6	38-4831
10	Cemetery	4.44	38-4832
10	Cemetery	4.76	38-4990
10	Cemetery	4.67	38-5012

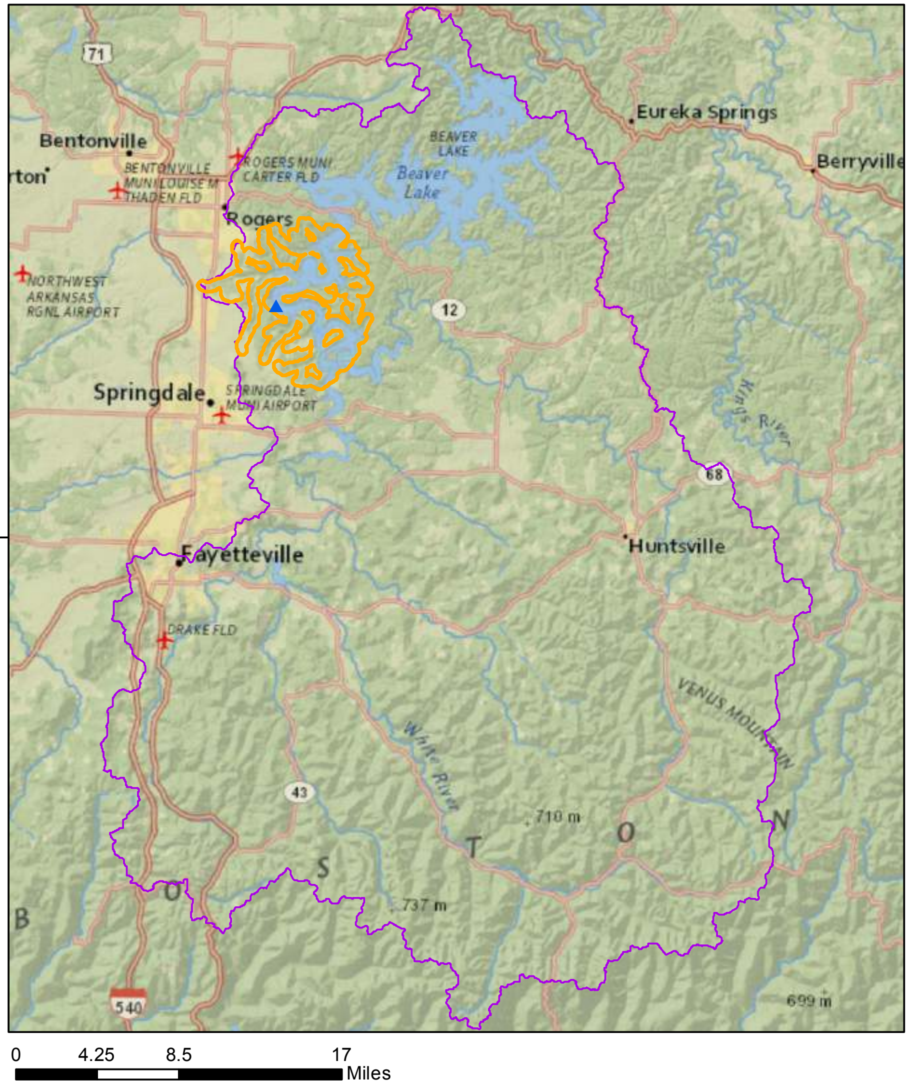
D. Example of Notice of Report Availability for Customers

The Arkansas Department of Health completed a source water Vulnerability Assessment for Beaver Water District in February 2018. This assessment summarizes the potential for contamination of our source of drinking water and can be used as a basis for developing a source water protection plan. A report explaining the assessment process and results can be obtained from the Beaver Water District office, or accessed through the Arkansas Department of Healths SWAP website at: `http://www.healthy.arkansas.gov/eng/swp/swp.htm`.

E. Maps of Source and Assessment Area

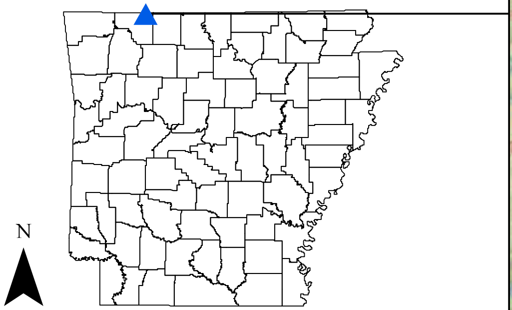
For each water source a map is included showing their location, respective assessment area and related PSOCs.

Beaver Water District
Overview Map of Beaver Lake - 038101
PWS ID = 038



Explanation

- Source Intake
- Assessment Area
- Drainage Basin



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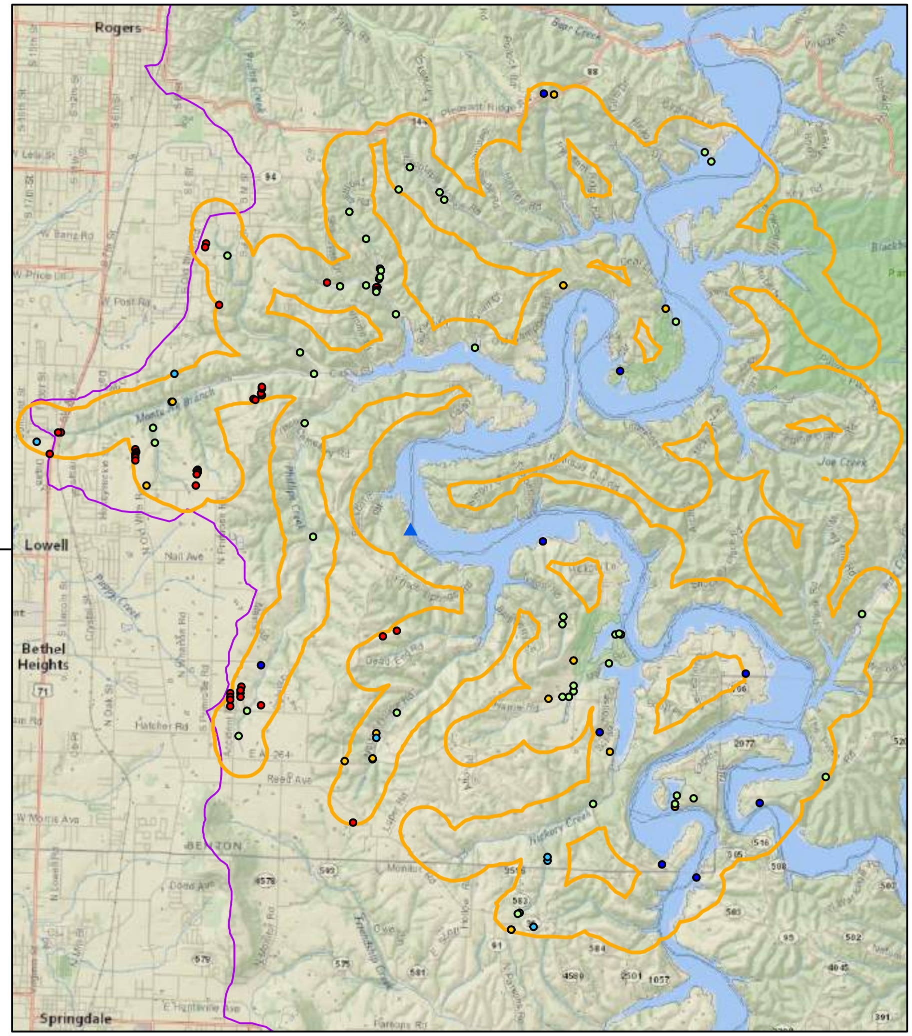
Beaver Water District
Beaver Lake - 038101
PWS ID = 038

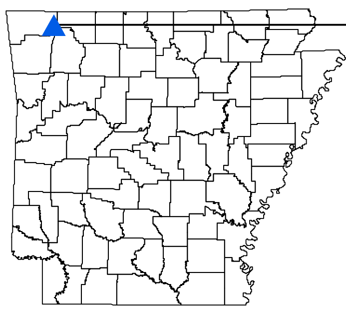
Explanation

Source Intake

PSOCs and their Health Risk Codes

- 1 and 2 (Highest Risk)
- 3 and 4
- 5 and 6 (Moderate Risk)
- 7 and 8
- 9 and 10 (Lowest Risk)
- Assessment Area
- Drainage Basin
- Waterbody





N

Arkansas Department of Health
Keeping Your Hometown Healthy

0 0.75 1.5 3 Miles

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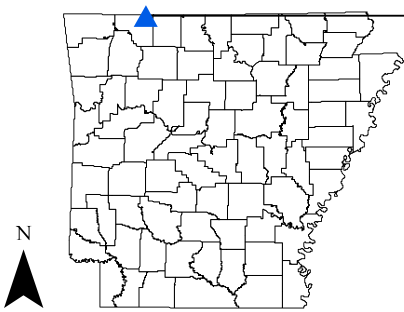
Beaver Water District
Overview Map of Beaver Lake - 038201
PWS ID = 038

Explanation

- ▲ Source Intake
- Assessment Area
- Drainage Basin



Arkansas Department of Health
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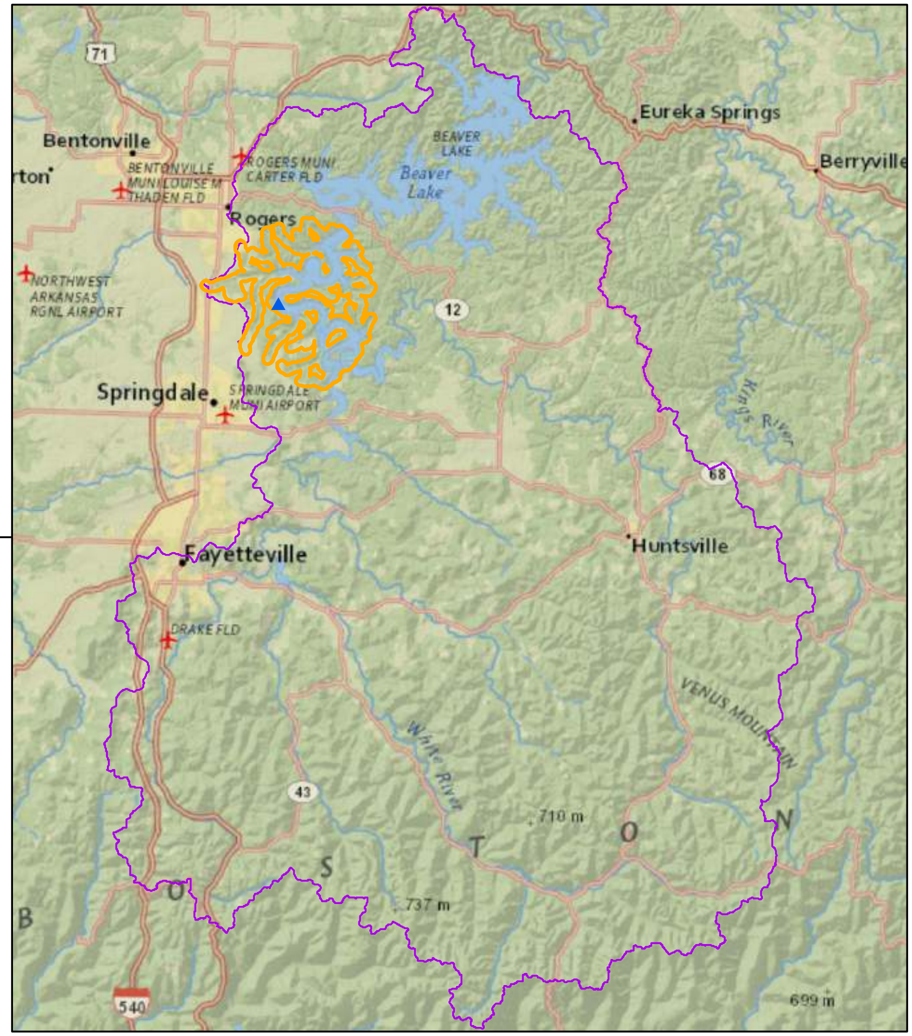


0 4.25 8.5 17
Miles

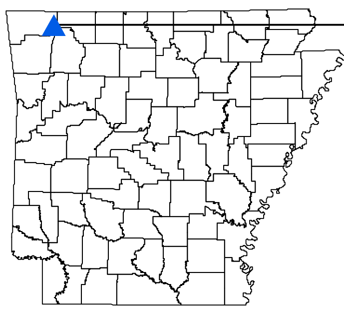
Beaver Water District
Beaver Lake - 038201
PWS ID = 038

Explanation

- ▲ Source Intake

PSOCs and their Health Risk Codes

- 1 and 2 (Highest Risk)
- 3 and 4
- 5 and 6 (Moderate Risk)
- 7 and 8
- 9 and 10 (Lowest Risk)
- Assessment Area
- Drainage Basin
- Waterbody



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Arkansas Department of Health
Keeping Your Hometown Healthy

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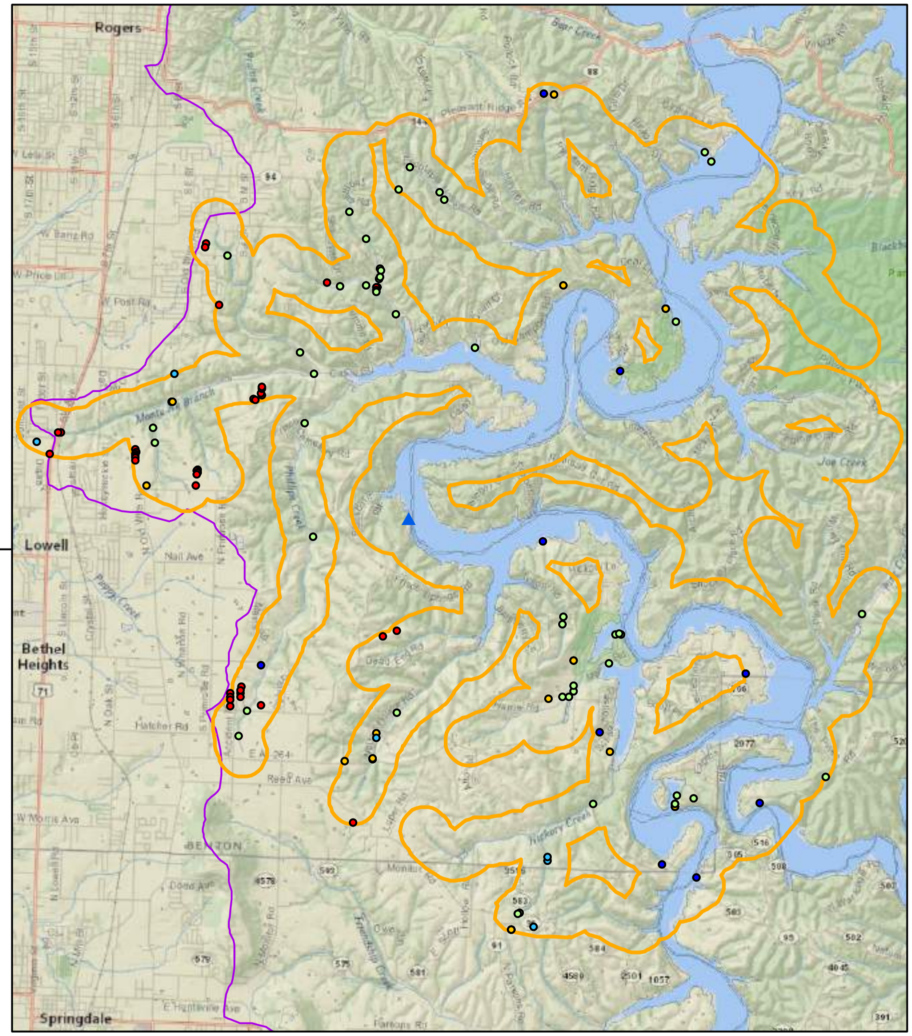


0 0.75 1.5 3 Miles

Appendix G: Beaver Water District: Chemical Hygiene and Laboratory Safety Plan

Beaver Water District

Chemical Hygiene and Laboratory Safety Plan

Effective Date: August 1, 2011

Table of Contents

Overview

This Chemical Hygiene & Laboratory Safety Plan was developed to outline protocols to safeguard the employees working in the BWD Laboratory. This plan complies with the Occupational Safety & Health Administration's (OSHA), Title 29 Code of Federal Regulations (CFR), Part 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories." The OSHA laboratory rule apply to all who engage in the laboratory use of hazardous chemicals. The purpose of the rule is to assure that all laboratory worker exposure to hazardous chemicals is below certain Permissible Exposure Limits (PELs) for substances specified in 29 CFR Part 1910, Subpart Z.

1.0 Standard Operating Procedures

1.1 General Safety Principles

The following guidelines have been established to minimize hazards and to maintain basic safety in the laboratory.

1. Be familiar with the location of emergency equipment – fire extinguishers, emergency eye wash and safety shower stations, and know the appropriate evacuation routes.
2. Be familiar with the known hazards associated with the materials/chemicals being used. Review the Material Safety Data Sheet (MSDS) for special handling information.
3. Avoid distracting or startling other workers when they are handling hazardous chemicals.
4. Wear the appropriate Personal Protective Equipment (PPE)
5. Be alert to any unsafe conditions and report them immediately for corrective action.

1.2 Health and Hygiene

The following practices have been established to protect laboratory employees from health risks when working with hazardous chemicals.

1. Always wear the appropriate PPE as listed in the Table in section III.
2. No open toed shoes are allowed while working in the laboratory.
3. Do not pipette by mouth.
4. Wash hands thoroughly with soap and water after handling chemicals, before leaving the laboratory, and before eating or drinking.

5. No food, drinks, or tobacco products are allowed in the laboratory. They should be contained in the office areas; not past the file cabinets entering into the front and back areas of the lab.

1.3 General Housekeeping

Use the following guidelines to maintain an orderly laboratory:

1. Keep work area clean and uncluttered. Clean area up at the end of the task or at the end of the day.
2. Dispose of all broken glass and empty glass chemical bottles that have been rinsed in the “Glassware Box” located in the washroom.
3. Keep all exit areas cleared and do not use as storage areas.

1.4 Chemical Handling and Storage

1. Material Safety Data Sheets should be made available to all laboratory employees prior to the use of a chemical. The MSDS books are located on the book shelf in the Main Laboratory and a copy of them is kept in the Administration Department.
2. Chemical containers with missing or defaced labels should not be accepted.
3. The laboratory’s ventilation system must support the chemicals that are used in the laboratory.
4. Chemicals should not be stored on high shelves.
5. Chemicals must be stored by compatibility. All acids are stored in the cabinet under the hood in the chemical storage room and bases are stored under the cabinet across from the dry chemical storage cabinet. Solvents are stored under the hood in the sample prep area.
6. Any chemical mixture shall be assumed to be as toxic as its most toxic component and any unknown substances shall be assumed to be toxic.

1.5 Chemical Waste Disposal

There is a 55 gallon drum for inorganic, non-solvent chemical waste located in the storage closet outside of the laboratory on the East side of the building. Waste in this barrel is mainly from our chloride analysis and contains mercury. Waste from expired chemicals, buffers, and electrode storage solutions can also be disposed of in this barrel. Any broken thermometers that contain mercury and any mercury that was cleaned up is stored in the south cabinet of the chemical storage room in an enclosed jar and/or bag and clearly labeled “Contains Mercury”. All chemical wastes will be held until the next time we schedule a chemical waste pickup by Mid-America Environmental Solutions.

1.6 Chemical Spills

The chemical spill kits are located in the south cabinet in the chemical storage room. Gloves and safety glasses (at a minimum) should be worn when cleaning up a chemical spill. Chemical spills do not have to be large spills in order to use the appropriate spill kits. Do not just wipe up a spill with paper towels and discard.

Choose the proper kit for the spill cleanup:

Spill X-S – for Solvent spills
Spill X-A – for neutralizing acids
Spill X-C – for neutralizing caustics
Mercury spill kit – for containing and picking up mercury

How to Use:
Pour the agent around the spill to encircle and dike its perimeter. Use the scraper to carefully mix the agent into the spill for a complete reaction. If spill was corrosive, any neutralization reaction will subside after a few minutes leaving a paste-like residue.
Test the pH: should be 2.0 – 12.5 before disposal
Put about 10 cc of spill residue into a beaker. Add DI water until volume reaches about 100 ml. Stir for 3 minutes. Measure the pH by using pH strips or electrode.
If pH is acceptable, scoop up all spill reagent and place in a plastic bag. Depending on what the spill was, will determine how we dispose of it. Place the plastic bag into a sealed 5 gallon bucket.

Mercury spill kit:
Mercury sponges

1) Wet sponges to activate the Hg Absorb coating
2) Wipe contaminated surface with coated side of sponge
3) Place sponge in disposal bag

What **<u>NOT</u>** to do in the event of a mercury spill:

1) Don't walk around an area contaminated with mercury
2) Don't use an ordinary vacuum cleaner to clean up mercury
3) Don't use a broom to clean up mercury
4) Don't wash mercury contaminated items in a washing machine

Spill response procedure:

1) Alert people in immediate area of spill
2) Wear appropriate PPE – gloves (rubber or nitrile), goggles, lab coat
3) Avoid breathing vapors from the spill
4) Confine spill to small area & absorb with spill agent
5) Clean spill area with soap and water

6) Collect all contaminated absorbent, gloves, & residue in plastic bag lined garbage can
7) Label and dispose of properly

2.0 Reducing exposure to hazardous chemicals

The laboratory design includes 3 fume hoods that are designed to handle the chemicals that are used in the lab and are spread out in different locations of the lab. There are also multiple exits from the laboratory in the case of an emergency. Exit doors to the outside are located on the East and West ends of the lab while the South door leads to the remainder of the Technical Services Building.

Standard Operating Procedures (SOPs) are in place for each method. The SOPs contain any specific concerns related to chemicals being used in the method as well as any special disposal procedures.

Personal Protective Equipment (PPE) is supplied and the minimum PPE required for various tasks is listed in section III. PPE should be used as the last line of defense against chemical exposure and Beaver Water District will take necessary measures to reduce employee exposure by reviewing administrative and engineering controls of the facility first if a potential problem is suspected.

3.0 Fume hoods and other protective equipment

The fume hoods are checked periodically by laboratory staff to ensure that they are working properly. An outside company (Tech-scan) also comes and performs the face velocity and sash level testing on the hoods every 3-5 years. There are 3 hoods in the laboratory: one in the main wet chemistry area, one in the chemical storage room, and one in the East end of the lab where the sample bottles are prepped.

Safety showers and eye wash stations are located at the East and West ends of the laboratory. These stations are flushed monthly to ensure that they are working properly and that the water lines are flushed. Records of the flushing are posted at each station.

Fire extinguishers are mounted in cabinets on the wall at the East and West ends of the lab. The Maintenance department checks them monthly and replaces them if they are out of date.

The First Aid Cabinet is located in the washroom in the laboratory. It is stocked with general first aid supplies and bandages, medicines, and CPR face shields and masks. Smaller first aid kits are also located in each laboratory vehicle.

Personal Protective Equipment (PPE) is available for all lab employees and has been identified for specific tasks listed in the table below.

Personal Protective Equipment

Task	Required Equipment	Optional Equipment
Wetchemistry Analysis (Ex. Daily/Weekly Chems)	Latex or Nitrile gloves	Lab coat, safety glasses
Bacti samples	Latex or Nitrile gloves	Lab coat, safety glasses
Microbiological QC Cultures	Latex or Nitrile gloves	Lab coat, safety glasses
Preparing acids and/or bases	Latex or Nitrile gloves, safety glasses	Lab coat
Preparation of chemicals and standards	Latex or Nitrile gloves	Lab coat
Working with Solvents	Nitrile gloves, safety glasses, fume hood	Lab coat
Making Agar	Latex or Nitrile gloves, fume hood	Lab coat
pH adjustment with Ammonium Hydroxide	Nitrile gloves, safety glasses, fume hood	Lab coat

4.0 Employee information and training

A monthly safety training meeting has been implemented for laboratory employees. In addition to attending the meetings, each staff member will be required to lead at least one of the meetings each year. Topics may vary from explaining how to use MSDS, PPE, weather related issues, CPR and first aid, signs and symbols, chemical labeling etc.

5.0 Prior approval from employer

There are no extremely hazardous chemicals in the lab that requires approval prior to use.

6.0 Provisions for medical consultations and examinations

Medical consultation and examination will be provided to any employee under the following conditions:

1. "Whenever an employee develops signs or symptoms associated with a hazardous chemical."
2. "Where exposure monitoring reveals an exposure level routinely above the action level."
3. "Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure."

The medical examination should be performed by or under the direct supervision of a licensed physician, within a reasonable time frame, and at a reasonable place. The examination will be provided at no cost to the employee, including no loss in pay.

The employer should provide any information including MSDS on the hazardous chemical that the employee was exposed to, the conditions under which the exposure occurred, and signs and symptoms that the employee is experiencing.

The employer can obtain a letter from the physician with any information regarding any recommendations for follow-up, the results of the examination and any associated tests. The opinion cannot reveal any specific findings unrelated to the occupational exposure.

7.0 Designation of personnel responsible

The Laboratory Supervisor is responsible for implementing the Chemical Hygiene Plan and for completing annual revisions to the plan. Management will provide input and review the plan.

8.0 Provisions for additional employee protection for work with particularly hazardous substances

There are not any chemicals in the BWD laboratory that are considered particularly hazardous substances according to the list from the International Agency for Research on Cancer (IARC).

Appendix H: Emergency Water Sample Collection Plan

Beaver Water District
Emergency Water Sample Collection Plan

Prepared by:
Ray Avery
Environmental Technician
April 1, 2009

Table of Contents

Emergency Water Sample Collection Plan

Site Characterization Plan

THREAT WARNING INFORMATION

INVESTIGATION SITE

Site Name: ______________________________

Type of facility:

- -- Source water
- -- Ground storage tank
- -- Distribution main
- -- Other ___________
- -- Treatment plant
- -- Elevated storage tank
- -- Hydrant
- -- Pump station
- -- Finished water
- -- Service connection

Address: ______________________________

____

Additional Site Information: ______________________________

____

INITIAL HAZARD ASSESSMENT

Are there any indicators of an explosive hazard? -- Yes -- No

If "Yes," notify law enforcement and do not send a team to the site.

Initial hazard categorization

- -- Low hazard
- -- Radiological hazard
- -- Chemical hazard
- -- Biological hazard

If anything other than Low Hazard is checked above then only teams trained to deal with such hazards should be sent to the site.

SITE CHARACTERIZATION TEAM

Name & Affiliation of Site Characterization Team Leader:

____

Drinking water utility staff:

- -- Environmental Name: ______________________
- -- Maintenance Name: ______________________
- -- Operator Name: ______________________
- -- Other ______________ Name: ______________________

Representatives from other agencies:

- -- Local law enforcement
- -- US EPA
- -- Fire department
- -- FBI
- -- HazMat
- -- Other

COMMUNICATION PROCEDURES

Mode of communication:

- Phone
- Facsimile
- 2-way radio
- Other ______________________________
- Digital

Reporting events:

- Upon arrival at site
- After site evaluation
- Other ______________________________
- During approach
- After field testing
- Site entry
- Site exit

FIELD SCREENING CHECKLIST

U	Parameter[1]	Screen[2]	Meter/Kit ID[3]	Check Date[4]	Reference Value[5]
	Chlorine residual	Water			
	pH / conductivity	Water			

1. List the parameters that will be evaluated as part of field screening.
2. Screening may be conducted for safety, rapid water testing, or both.
3. Report the unique identifier for the meter or kit used during screening.
4. Report date of calibration, expiration date, or date of last equipment check as appropriate.
5. List any reference value that would trigger a particular action, such as exiting the site.

EQUIPMENT CHECKLIST

- Completed Site Characterization Plan
- Emergency Water Sampling Kit
- Reagents (if stored separately)
- Hach DR/850 and Hanna Sonde
- Special equipment for the specific site
- Other ______________________________
- Additional documentation
- Field Testing Kit
- Bags of ice or freezer packs
- Deionized Rinse water (10 liters)
- Camera

SAMPLING CHECKLIST

U	Analyte[1]	No. Samples	Sample Preservation[2]
	Standard VOCs		
	Semi-volatiles		
	Cyanide		
	Metals/elements		
	Organometallic compounds		
	Radionuclides		
	Non-target VOCs		
	Non-target organic compounds		
	Non-target inorganic compounds		
	Immunoassays		
	Pathogens – culture		
	Pathogens – PCR		
	Water quality – bacteria		
	Water quality – chemistry		

1. Parameters that will be sampled during site characterization.
2. Preservatives and dechlorinating agents and indicate if they are to be added in the field.

SAMPLE HANDLING INSTRUCTIONS

Sample delivery:

- Return samples to water utility
- Ship samples to specified location
- Deliver samples to specified recipient (e.g., laboratory, law enforcement)

Name of recipient: ______________________________

Phone No.: ______________ Fax No.: ______________

Delivery address: ______________________________

____

Sample storage and security:

Describe any special precautions or instructions related to sample storage and security:

____

SIGNOFF

Supervisor: Print name ______________

Signature ______________________ Date/Time: __________

Site Characterization Team Leader: Print name ______________

Signature ______________________ Date/Time: __________

Site Characterization Report Form

GENERAL INFORMATION

Date: ______________ **Time arrived investigation at site:** __________

Name of Site Characterization Team Leader: ________________________________

Phone No.: ____________________ **Fax No.:** ____________________

LOCATION OF INVESTIGATION SITE

Site Name: ____

Type of facility:

- -- Source water
- -- Treatment plant
- -- Pump station
- -- Ground storage tank
- -- Elevated storage tank
- -- Finished water
- -- Distribution main
- -- Hydrant
- -- Service connection
- -- Other ____

Address: ____

____

Weather Conditions at Site: ____

Additional Site Information: ____

____

APPROACH TO SITE

Time of Approach to Site: ______________

Initial Field Safety Screening

- -- None
- -- Radiation
- -- Volatile chemicals
- -- HAZCAT
- -- Chemical weapons
- -- Biological agents
- -- Other _____

Report results of field safety screening in "Field Testing Results Form."
If any field safety screening result is above the corresponding reference value, immediately notify supervisor and do not proceed further into the site.

Initial Observation and Assessment of Immediate Hazards

- -- Unauthorized individuals present at the site
- -- Fire or other obvious hazard
- -- Signs of a potential explosive hazard (e.g., devices with exposed wires)
- -- Signs of a potential chemical hazard (e.g., dead animals, unusual fogs, unusual odors)
- -- Unusual and unexplained equipment at the site
- -- Other signs of immediate hazard ________________________________

SITE INVESTIGATION

Time of Entry to Site: ____________

Repeat Field Safety Screening

- None
- Radiation
- Volatile chemicals
- HAZCAT
- Chemical weapons
- Biological agents
- Other _____

If any field safety screening result is above the corresponding reference value, immediately notify supervisor and do not proceed further into the site.

Signs of Hazard:

- None
- Unexplained dead animals
- Unexplained dead or stressed vegetation
- Unexplained clouds or vapors
- Unexplained liquids
- Other ____________________

Describe signs of hazard: ____

____

Unexplained or Unusual Odors:

- None
- Pungent
- Irritating
- Sulfur
- Skunky
- Bitter almond
- Sweet/Fruity
- New mown hay
- Other ____________

Describe unusual odor: ____

____

Unusual Vehicles Found at the Site:

- Car/sedan
- SUV
- Pickup truck
- Flatbed truck
- Construction vehicle
- None
- Other ____

Describe vehicles (including make/model/year/color, license plate #, and logos or markings): ____

____

Signs of Tampering:

- None
- Cut locks/fences
- Open/damaged gates, doors, or windows
- Open/damaged access hatches
- Missing/damaged equipment
- Facility in disarray
- Other ____

Signs of sequential intrusion (e.g., locks removed from a gate and hatch)?

- Yes
- No

Describe signs of tampering: ____

____

Unusual Equipment:

- None
- Discarded PPE (e.g., gloves, masks)

- Tools (e.g., wrenches, bolt cutters)
- Hardware (e.g., valves, pipe)
- Lab equipment (e.g., beakers, tubing)
- Pumping equipment
- Other ______

Describe equipment: ______

Unusual Containers:

Type of container:

- None
- Drum/Barrel
- Bottle/Jar
- Plastic bag
- Box/Bin
- Pressurized cylinder
- Test Tube
- Bulk container
- Other ______

Condition of container:

- Opened
- New
- Damaged/leaking
- Unopened
- Old
- Intact/dry

Size of container: ______

Describe labeling on container: ______

Describe visible contents of container: ______

Rapid Field Testing of the Water

- None
- Residual disinfectant
- pH / conductivity
- Cyanide
- Radiation
- VOCs and SVOCs
- Pesticides
- Biotoxins
- General toxicity
- Other ______

If any field test result is above the corresponding reference value, immediately notify supervisor and wait for instruction regarding how to proceed.

Time Sampling was Initiated / Completed: ______________/________________

Implement Sampling Procedures Appropriate for the Hazard Conditions at the Site:

- Low hazard
- Chemical hazard
- Radiological hazard
- Biological hazard

Safety Checklist:

- **Do not** eat, drink, or smoke at the site.
- **Do not** taste or smell the water samples.
- **Do** use the general PPE included in the emergency water sampling kit.
- **Avoid** all contact with the water, and rinse with clean water in the case of contact.
- **Slowly fill** sample bottles to avoid volatilization and aerosolization.
- **Minimize** the time that personnel are on site and collecting samples.

General Sampling Guidelines:

- Properly label each sample bottle.
- Carefully flush sample taps prior to sample collection, if applicable.
- Collect samples according to method requirements.
- Add preservatives or dechlorinating agents as specified.
- Carefully close sample containers and verify that they don't leak.
- Wipe the outside of sample containers if there was any spillage.
- Place sample containers into a sealable plastic bag.
- Place samples into an appropriate, rigid shipping container.
- Pack container with frozen ice packs.
- Complete "Sample Documentation Form".
- Complete "Chain of Custody Form".
- Secure shipping container with custody tape.

EXITING THE SITE

Time of Site Exit: _______________

Site Exit Checklist

- Record contact information for representatives from other agencies.
- Verify that hatches, locks, etc. are properly secured.
- Remove all samples, equipment, and materials from the site.
- Verify that all samples are in the cooler and properly seal the cooler.
- Remove all PPE at site perimeter and place in trash bag.
- Verify that the perimeter has been properly secured before leaving the site.
- Ensure that all documentation has been completed before leaving the site perimeter.
- Comply with any site control measures required by participating agencies.
- Contact supervisor and inform them that the team is leaving the site.

SIGNOFF

Site Characterization Team Leader: Print name -

____

Signature ________________________ Date/Time: ______________________

Contact Information for Representatives from Other Agencies

Date/Time:	Site Name:	Name:	Phone No.
Agency	**Name**	**Phone Number**	**Other**

BWD Field Testing Results Form

Date of Field Testing:		Site Name:			Field Tester:	Phone No.	
Parameter	**Units**	**Screen[1]**	**Meter/Kit ID[2]**	**Testing Location[3]**	**Testing Time[4]**	**Results[5]**	**Ref. Value[6]**
pH	Unit	Water					
Conductivity	µS/cm	Water					

1: Screening may be conducted for safety, rapid water testing, or both.
2: Report the unique identifier for the meter or kit used during screening.
3: Report the specific location where the field testing was conducted.
4: Report the specific time at which the test was performed.
5: Results of field testing should include replicate analysis where appropriate.
6. Results should be compared with a reference value, if available, to determine whether or not the levels detected pose a hazard.

BWD Chain of Custody Form

Site Name:		**Sampler:**								
Sampler Phone No.:		**Signature:**								
Sample ID	**Collection Date/Time**	**No. Bottles**	**Analysis**	**Preservatives**				**Additives**		
				H_2SO_4	HNO_3	HCl	$NaOH$	$Na_2S_2O_3$	$C_6H_8O_6$	Na_2SO_3

Relinquished by:	**Received by:**	**Date/time:**
Relinquished by:	**Received by:**	**Date/time:**
Relinquished by:	**Received by:**	**Date/time:**

Dispatched by:	**Date/time:**	**Received at Laboratory by:**	**Date/time:**
Method of Sample Transport:			

Shipper: **Phone No.:** **Tracking No.:**

Emergency Contact / Notification System

The following list provides names and telephone numbers for emergency contact personnel. In the event of a medical emergency, personnel will take direction from their supervisor and notify the appropriate emergency organization. Local hospitals and emergency medical facilities and maps are presented in the next section. In the event of a fire or chemical spill, the site supervisor will notify the appropriate local, state, and federal agencies.

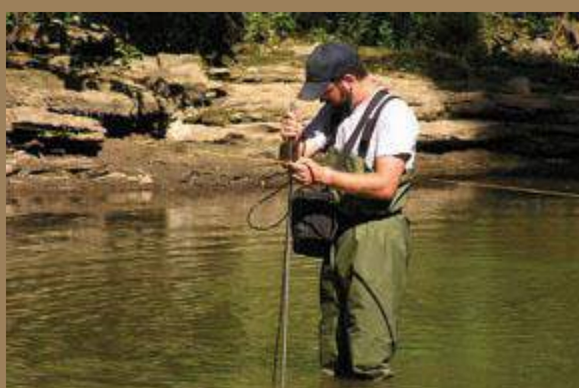
Organization	Telephone
Beaver Water District	(479) 756-3651
Emergency/Police/Fire/Ambulance	911
Hospitals/Emergency Care Facilities:	
Washington Regional - Fayetteville	(479) 713-1000
Northwest Medical Center - Springdale	(479) 751-5711
Mercy Medical Center - Rogers	(479) 338-8000
Poison Control Center (National)	(800) 222-1222
National Response Center (Spills)	(800) 424-8802

Job hazard Analysis

Vehicle Operations	Vehicle vs. vehicle collisions, vehicle vs. fixed object collisions	Do not use cell phones when driving. Do not use paper or electronic maps when driving. The passenger should act as the navigator and read off the directions to the driver. The driver's only task is driving the vehicle in a safe and courteous manner. Follow posted speed limits. Decrease speed in limited sight and rain conditions. Follow one vehicle length per 10 miles of speed. Move to the left lane when vehicles are stopped or workers are present on the right shoulder. Always use turn signals and make sure all lamps are in working order before each trip. Always wear seat belts. All vehicles must be equipped with a first aid kit
	Vehicle accidents	All vehicles must be equipped with a working fire extinguisher.
	Vehicle fire	Never park a warm engine vehicle in tall grass. Avoid engine fuel spills.
Assess site conditions	Sever weather conditions	If weather has changed since leaving the office or previous site, ensure that proper precautions are taken before beginning site work. Monitor lightning detectors and stop work when alarm alerts closer than 20 miles.
	Wind borne contaminants	Obtain wind direction information and identify upwind
	Physical contact hazards	When necessary wear steel toed safety shoes, safety glasses, and hard hats.
	Fire hazards	Be alert of fire conditions. Do not enter uncontrolled burning areas. Minimize flammables in and near vehicle and work area.
Ensure vehicle/equipment/ security on site	Passing Traffic	Be alert, secure area from through traffic with safety cones, traffic warning signs, use amber colored strobe lights, and wear site/activity appropriate PPE. Pull over at least 4 feet on shoulder from white line. Use parking brake
	Theft, vandalism	Always lock vehicle, do not leave valuables in vehicle, cover/keep from view equipment left in vehicle.
	Contact with fixed or movable objects	Conduct a full walk-around of vehicle and place orange marker cones behind and/or in front of the vehicle if parked in a high traffic area.
Conduct visual inspection of facility/site layout	Irritated site owner/neighbors	Be courteous and diplomatic. Identify yourself immediately. Always wear identification.
	Dangerous surroundings	Do not enter site unless accompanied by another employee or site personnel. When necessary wear safety shoes, protective eyewear, hearing protection, and hard hat.
	Animals (dogs), snakes, stinging insects, ticks	Identify areas where biological hazards may be present; wear insect repellant on all exposed skin surfaces; wear long sleeve shirt and full length pants; avoid high grass areas if possible; do not put hand/arm into/under an area that you can not see into/under clearly; do not touch any suspected contaminant without appropriate hand PPE; wash hands as soon as possible upon completion of task.
Collecting samples	Irritation from contaminates in water	Always wear gloves and never drink non-potable water.
	Electrocution hazard	Always use grounded equipment and keep water from electric power items. Identify any electrical hazards before commencing work. Halt all work if unsafe conditions exist. Always check wires (when de-energized) for chaffing and exposed conductors.
Lifting heavy objects (covers, pumps, sampling equipment, coolers, etc.)	Muscle strain	Use proper ergonomics when lifting heavy objects; use appropriate mechanical assistance and tools when possible.

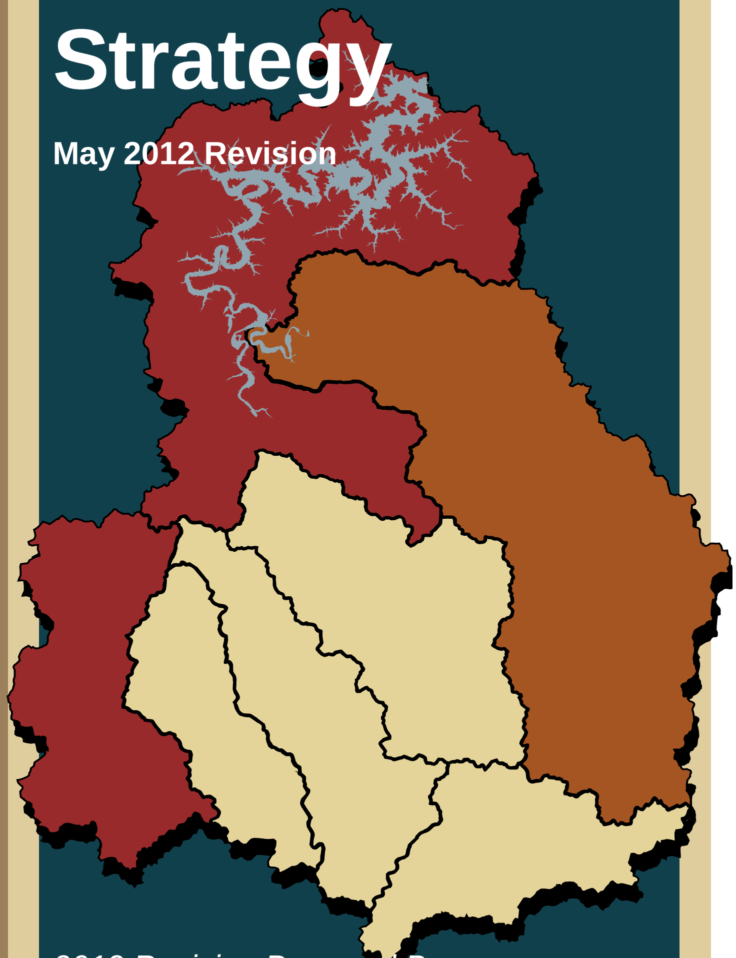
Water sampling (Lakes, Streams, Wells, Springs, etc)	Contaminated media Eye/skin contact with biological agents and chemicals Inhalation of chemical vapors Dangerous animals and vegetation Trailblazing with machete/cuts Heat exhaustion & sun exposure Hypothermia/cold water exposure Stinging insects Slip/trip hazards Muscle and soft tissue injury	Review and understand MSDS for all chemicals being handled. Be careful when handling acids and caustic substances. Wear adequate PPE and wash hands after completion of task. MSDS must be in vehicle at all times Position body in order to minimize downwind exposure. Be aware of your surroundings. Learn to identify, and avoid, toxic plants such as poison ivy. Watch for dangerous animals, such as aggressive dogs, raccoons, snakes and harmful insects. Be aware of sharp edges and angle of cuts. Be aware of briars. Drink lots of water, wear hats, sunglasses and sunscreen. Wear layers of clothing. Stay dry. watch for biting insects BE ALERT; position pumps and other sampling equipment in an orderly and safe fashion. Use proper ergonomics when positioning and lifting equipment
Wearing waders	Drowning	Work in pairs, wear life jacket (PFD) at all times when in water deeper than 4 feet.
Working in isolated areas	Victim of crime	Use the buddy system and carry a cellular phone. Always be alert. Never leave partner alone.
Vessel Operations	Boating accidents	Complete USCG approved training. All BWD employees must wear life vests while underway. Maintain vessel and proper safety equipment. Carry cell phone or radio. File a float plan and work in pairs. See BWD boating policy at \\Fileserver\d\Laboratory\Boat\boating policy.doc
Sampling from bridges	Struck by vehicles slips/trips/falls/noise	Wear a safety vest, use buddy system. Use traffic cones and a lookout when traffic is high. Attempt to sample away from the bridge if possible.
Icing (re-icing) sample coolers, transporting coolers and other equipment back to laboratory	Slip hazard Muscle and back Injury	Use due care when draining water from coolers, use proper ergonomics when lifting and moving coolers and other equipment.
Site exit	Contaminated vehicle Exotic plants	Wash hands promptly. Contaminated PPE should be disposed of on site if possible. Clean vehicles thoroughly. Never transport vegetation from water body.
Acid preservation	Acid burns	Always wear PPE including safety glasses and gloves. Provide proper ventilation. Have a buddy present at all times.
Operating all terrain equipment	Physical injury	Operate equipment at safe speeds. Complete ATV training.

Appendix I: Watershed Protection Strategy



Beaver Lake Watershed Protection Strategy

May 2012 Revision



2012 Revision Prepared By:
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Cover Page Photographs

Photograph Courtesy of Hawkins Aerial Photography – Movement of sediment south-to-north toward the dam in Beaver Lake following Spring 2011 rains. Lost Bridge, with clear water, is to the north and Rocky Branch, with sediment-laden water, lies to the south of County Road 920.

Photograph Courtesy of D. Neely – House on a karst limestone bluff above War Eagle Creek.

Photograph Courtesy of Beaver Water District – Brad Hufhines, a Beaver Water District lab technician, measures stream flow in the White River tributary of Beaver Lake to determine the capacity of the stream to assimilate pollutants, especially nutrients (BWD The Source Newsletter – Summer 2006).

Photograph Courtesy of Audubon Arkansas – Installation of a watershed kiosk at Riverside Park in West Fork, AR on May 12, 2007 (BWD The Source Newsletter – Summer 2007).

Photograph Courtesy of Beaver Water District –War Eagle Appreciation Day participants (http://www.bwdh2o.org/war-eagle-appreciation-day/).

ACKNOWLEDGEMENTS

Many individuals contributed their time, energy, and expertise to the development of the Final Report of the Beaver Lake Watershed Protection Strategy. Deserving special credit are members of the Policy Advisory Group, the Technical Advisory Group, and the Northwest Arkansas Council Board and staff.

Funding for the May 2012 revision was provided by the U.S. EPA and the Arkansas Natural Resources Commission via the Clean Water Act, Section 319(h).

(Note: The Policy Advisory Group was initially a 23-member advisory body formed for the development of the original watershed protection strategy. However, certain organizations and agencies had different primary members serving over the course of the project. In addition, some organizations had alternate members who served in the absence of their primary representatives. The 2012 revision process included original Policy and Technical Advisory Group members whenever possible, as well as new stakeholders in the watershed. The tables below list all Policy Advisory Group and Technical Advisory Group participants.)

Policy Advisory Group Participants

Member	Agency/Organization
Doug Timmons	Association for Beaver Lake Environment
Tony Miltich	Association for Beaver Lake Environment
Bob Morgan	Beaver Water District, Beaver Watershed Alliance
Bob Caulk	Fayetteville Natural Heritage Association, Beaver Watershed Alliance
Gene Groseclos	Cooper Communities, Beaver Watershed Alliance
Barbara Taylor	Fayetteville Natural Heritage Association, Beaver Watershed Alliance
Ed Clifford	Bentonville Chamber of Commerce-Northwest Arkansas Council
Frank Winscott	Benton County Justice of the Peace
Dan Douglas	Benton County
Scott Borman	Benton/Washington Regional Public Water Authority
Scott Bounds	Benton/Washington Regional Public Water Authority
Richard Williams	Carroll County Judge
George Phillips (observer)	Carroll County
Mike Dodge	Carroll Electric
Susan Thomas	City of Fayetteville
John Coleman	City of Fayetteville
Patsy Christie	City of Springdale, Beaver Watershed Alliance

Hunter Haynes	Haynes Limited
Larry Garrett	Huntsville Wastewater Treatment Plant
Clarence Carson	Madison County Farm Bureau
Steven Ford	Madison County USDA Conservation Officer
Don Day	Northwest Arkansas Property Rights Association
Jeff Hawkins	Northwest Arkansas Regional Planning Commission
Rob Smith	Northwest Arkansas Council
Scott Van Laningham	Northwest Arkansas Council
Craig Smith	Prairie Creek Marina
Tom McAlister	Rogers Water Utilities
Walter Turnbow	Springdale Resident
Larry Beals	Superior Industries
Tim Snell	The Nature Conservancy
Kevin Igli	Tyson Foods, Inc., Beaver Watershed Alliance
Trish Ouei	University of Arkansas Benton County Extension Service, Beaver Watershed Alliance
Katie Teague	University of Arkansas Washington County Extension Service
Juliet Richey	Washington County Planner, Beaver Watershed Alliance
Henry Griffith	West Fork Environmental Protection Association
Jane Bryant	West Fork Watershed Alliance
Mike Faupel	University of Arkansas

Technical Advisory Group

Name	Agency
Sarah Clem	Arkansas Department of Environmental Quality
Jim Wise	Arkansas Department of Environmental Quality
Robert Hart	Arkansas Department of Health
Alan Fortenberry	Beaver Water District
Bob Morgan	Beaver Water District, Beaver Watershed Alliance
Ray Avery	Beaver Water District
Billy Ammons	CH2M-Hill, Beaver Watershed Alliance
Kent Thornton	FTN Associates, Ltd.
Nicole Hardiman	Northwest Arkansas Land Trust, Beaver Watershed Alliance
Brian Haggard	University of Arkansas
Marty Matlock	University of Arkansas
Ralph Davis	University of Arkansas
Susan Bolyard	United States Geological Survey
Reed Green	United States Geological Survey

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Mike Malone, Executive Director

Rob Smith, Communications and Policy Specialist

Beaver Watershed Alliance

Jason L. Kindall, Executive Director

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Section 1

Introduction

1.1 Why Are These Protection Measures Needed?

Beaver Lake is the primary drinking water source for more than 350,000 Arkansans, and a major recreational destination for people interested in boating, fishing, swimming, and picnicking. As the principal water supply for the Northwest Arkansas region, the lake is recognized as a lifeline for current citizens and businesses, and for the projected growth of the region. People in Northwest Arkansas also enjoy the beauty of the lake – the large open water and surrounding hills. Beaver Lake is a key to the region's quality of life. Clean water and quality of life are at the top of the list for businesses looking to start-up or relocate, and help sustain the region's economic vitality.

Beaver Lake is recognized as a lifeline for current citizens and businesses and for projected growth.

A recent study (Kemper, 2008) by the University of Arkansas highlighted Beaver Lake's economic contribution to the region: approximately 2.5 million visitors spend about $43 million annually in the region surrounding the lake, with about $24.5 million of that captured in the local economy. The spending generates 600 jobs and approximately $13 million in income for the region.

People appreciate that most areas of Beaver Lake are clean the majority of the year and meet the State's water quality standards. However, the upper end of the lake is impacted by sediment and algae. This in turn affects drinking water quality, recreation, and aquatic habitat in the upper lake. For example, customers of the Beaver Water District regularly experience taste and odor problems in their water during September to October (and occasionally during other months of high algal production). Without responsible water quality protection measures, the projected growth and development in the watershed will likely worsen this and other problems.

Most areas of the lake are clean the majority of the year, however the upper lake area is impacted by sediment and algae.

Projected growth could also cause economic impacts. For example:

- Under a do-nothing scenario[1], there would be a 14 percent increase in algae-feeding nutrients to the lake. The Beaver Water District conducted a study to evaluate different methods to control taste and odor problems and their associated costs related to excessive algae. The recommended alternative had a capital cost of $42.2 million and an annual operating and maintenance cost of $790,000. While the public may wish to invest in these upgrades just to address existing taste and odor problems, the need would increase substantially with increases in algae growth. Other water suppliers may also need to upgrade their facilities to address taste and odor problems associated with increased nutrient loading and subsequent algae growth.

- Doing nothing[1] would result in a 21 percent increase in sediment load to the lake. It would also contribute to further erosion of stream banks along the tributaries that feed into the lake, and increase loss of property. This would add to the list of "impaired streams" in the watershed, increasing stream restoration requirements and costs.
- Neglecting water quality measures would also impact the lake's local tourism and recreation industry including revenue, jobs, and income.

Without responsible protection measures, growth will worsen these problems.

In an effort to proactively address the potential for problems and protect water quality, the Northwest Arkansas Council initiated the development of a Beaver Lake Watershed Protection Strategy.

1.2 How Was the Protection Strategy Developed?

The Council contracted with Tetra Tech to develop the Protection Strategy. Tetra Tech worked closely with a 23-member Policy Advisory Group (PAG) representing diverse interests and a Technical Advisory Group (TAG) throughout the lake protection planning process (see Acknowledgements Pages for lists of members). The PAG represented a wide variety of stakeholder groups from the public and private sectors including local elected officials, farmers, developers, water providers, landowners, large industries, property rights advocates, conservation groups, chambers of commerce, lake marinas, and planners. Although PAG Members were encouraged to consider issues from a watershed-wide perspective, they were also asked to represent the issues and concerns of their constituencies in the four counties of the watershed, as well as water users outside the watershed. In addition, Tetra Tech held more than 10 focus group meetings throughout the four-county area with key constituencies to gain input and gather additional information for the PAG to consider.

To proactively address potential problems and protect water quality, the Northwest Arkansas Council initiated development of the Beaver Lake Watershed Protection Strategy.

[1] The data for both of these estimates were generated using SWAT modeling analyses. The methodological description is given in the technical document titled "SWAT Model Recalibrations", with "do-nothing scenario" used synonymously with "2055 Scenario" (document can be accessed at http://www.beaverlakewatershedstrategy.com/index.php?option=com_content&view=article&id=46&Itemid=54). TetraTech, utilizing a modified modeling method, generated land use/land cover (LULC) estimates for the year 2055 based on LULC data from 2006. Sediment loading estimates were extrapolated utilizing the estimated LULC changes and known/measured water quality parameters.

Early on, the PAG established guiding principles, goals and objectives for the Beaver Lake Watershed Protection Strategy (see Figure 1-1 and Figure 1-2). The PAG served as a sounding board for watershed characterization results and possible solutions to existing water quality impairments and threats. Importantly, the PAG selected the elements of the protection strategy – the combination of water quality enhancement techniques – that are believed to be the best starting point for accomplishing the lake protection goals.

Guiding Principles

- Success depends on a technical foundation and community support
- Recommendations
  - Address specific issues
  - Support diverse economy
  - Be cost-effective
  - Respect private property rights
- Implement primarily through
  - Outreach and education
  - Stewardship
  - Resource management
  - Compliance with existing regulations

Figure 1-1. Guiding Principles

A diverse Policy Advisory Group and Technical Advisory Group worked throughout the lake protection planning process.

Tetra Tech also met with focus groups representing property rights advocates, livestock and poultry producers, poultry integrators, developers, drinking water utilities, environmental and conservation groups, recreational interests, and local governments. These meetings elicited valuable input about Beaver Lake, the water quality protection goals, and solutions. The results of these discussions were shared with the PAG in their deliberations.

The TAG reviewed research, water quality data, and other scientific and technical information and provided input on the most important technical issues related to watershed and lake protection. The TAG also provided advice on water quality indicators and targets, linked to the lake protection goals, to help evaluate different options.

Tetra Tech worked with technical partners to develop a watershed modeling tool and lake response modeling tool that could help to evaluate existing conditions and predict future conditions (year 2055) under current policies. These initial modeling results are collectively referred to as the Baseline Conditions Analysis (methodology described in "SWAT Model

Recalibration"). The modeling framework was subsequently used to predict future conditions under different water quality protection alternatives. Results were evaluated and reported in light of the lake protection goals and targets. Costs for different management techniques were reviewed and evaluated to screen for the most cost-effective solutions (analyses can be viewed in Technical Reports "Management Options Cost Effectiveness – Phase 1 and Phase 2").

The Beaver Watershed Alliance was formed in 2011 to facilitate implementation of the Protection Strategy and adopt measures as conditions change in the future.

The Policy Advisory Group selected a combination of water quality enhancement techniques that are believed to be the best starting point for meeting the lake protection goals.

Overarching Goals

Three overarching goals were the result of discussion and consensus-building among the Policy Advisory Group (PAG), which was the stakeholder group that assisted in development of the management plan. One of the stated goals of the group was to utilize watershed protection strategies that were voluntary and/or did not impose additional regulation on landowners or municipalities. If water quality continues to degrade in the watershed, it was assumed that additional costs for drinking water treatment and potential regulatory compliance would exceed the preventative strategies recommended in this Plan.

- Maintain a long-term, high-quality drinking water supply to meet present needs and continuing growth of the region.
- Restore water quality of impaired stream and lake areas (as listed on ADEQ's list of impaired waters).
- Minimize additional costs and regulations for people living and working in the watershed.

Objectives for Beaver Lake

- Minimize risks to public health and safety.
- Minimize taste, odor, and color problems in the public drinking water supplies.
- Minimize impact on water supply intakes and treatment operations.
- Meet long-term needs for water supply in the region.
- Maintain recreation enjoyment and ensure that recreation reflects environmentally sound stewardship of the lake.
- Restore water quality in impaired areas to meet water quality standards.
- Provide an economically priced water supply.

Figure 1-2. Overarching Goals

Finally, solutions were also screened that could do the "double duty" of protecting Beaver Lake and addressing existing impairment in the West Fork and Lower White subwatersheds. These subwatersheds have Total Maximum Daily Load sediment allocations, which require significant reductions from existing levels.

In summation, the Northwest Arkansas Council engaged diverse stakeholders throughout the process to ensure meaningful input and support, and conducted a technical analysis based on sound science and good engineering practices. The Beaver Lake Watershed Protection Strategy presented in the following sections is a starting point for action. While receiving broad support, it is recognized that the strategy is not fully endorsed by every stakeholder group. Continuing to work with stakeholders to find solutions that address environmental, economic, and social concerns in the region remains important. The PAG recommended that a new group (a Watershed Council) be formed locally to help facilitate the implementation of the Watershed Protection Strategy and adapt the protection measures in the future as conditions change.

The Technical Foundation for the Beaver Lake Watershed Protection Strategy

This Beaver Lake Watershed Protection Strategy is built on a strong technical foundation of quality assured assessments and reports. This document is intended to synthesize the main findings and recommendations of the technical reports in a way that is more inviting and understandable to most readers. For readers who would like more detailed information regarding the project's technical foundation, please contact the Northwest Arkansas Council and request one or more of the following documents:

- Beaver Lake SWAT Model Recalibration, February 12, 2009, Tetra Tech
- Beaver Lake Watershed Baseline Analysis – Supplemental Pollutant Loading Analysis, February 16, 2009, Tetra Tech
- Beaver Lake Watershed Water Quality Targets/Benchmarks Analysis, February 18, 2009, Tetra Tech.
- Management Option Cost-Effectiveness Phase I, March 13, 2009, Tetra Tech
- Management Option Cost-Effectiveness Phase II, March 20, 2009, Tetra Tech
- Onsite Wastewater Analysis, November 13, 2008, Tetra Tech

1.3 DEVELOPMENT OF THE 2012 REVISION

In Spring 2012, the Beaver Watershed Alliance (formed following the recommendations in the original 2009 Beaver Lake Watershed Protection Strategy) solicited the original PAG and TAG organizations to revise and update the Strategy. The goal of the 2012 revision is to (a) address gaps identified in the 2009 document and (b) facilitate and clarify correlation with the 9 Elements identified in the U.S. EPA's Handbook for Developing Watershed Management Plans to Restore and Protect Our Waters (2008). The PAG and TAG members reconvened to suggest revisions, discuss the relevancy of the document, and to inform the Beaver Watershed Alliance of new and emerging issues on the watershed.

Funding for the 2012 revision of the Beaver Lake Watershed Protection Strategy was provided by the U.S. EPA and the Arkansas Natural Resources Commission.

1.4 THE EPA'S 9 ELEMENTS FOR WATERSHED MANAGEMENT PLAN DEVELOPMENT

The Beaver Lake Watershed Protection Strategy was developed using guidance from the U.S. EPA's Handbook for Developing Watershed Management Plans to Restore and Protect Our Waters (2008). Throughout the document, the reader can find references to the 9 Elements in the margins (highlighted in green text) corresponding to the text in the Strategy that addresses a specific EPA element. Additionally, the appendices contain a detailed and expanded cross-reference table of the 9 Elements with information on how the Protection Strategy addresses those elements and where the topics may be found in the document itself. For a quick reference, see Table 1.1.

References to the EPA's 9 Elements for Watershed Management Plan Development can be found in the margins in green text.

Table 1-1. EPA 9 Element - Beaver Lake Watershed Protection Strategy Component Correlation Quick Reference

Note – EPA Watershed Management Plan Elements in first column are linked to an expanded correlation table in Appendix D.

Required EPA 319 Element	Quick Reference Listing: BLWSPS Report Content Correlation to EPA 9		BLWSPS Report Section Description	ADDITIONAL REFERENCE DOCUMENT(S)
	PAGE	SECTION/TITLE		
a. Impairment Cause and Source Identification	16 - 21	**Section 2.3:** Existing and Future Loading to the Lake	**Section 2.3:** Existing and Future Loading to the Lake for a discussion of causes and sources.	“Beaver Lake SWAT Modeling Baseline Analysis” “Supplementary Pollutant Loading Analysis” technical document
	B-3	**Tables B-1 and B-2.** Core Voluntary BMPs and Estimated Total Sediment for the West Fork and Lower White River Reporting Subwatersheds	**Tables B-1 and B-2** in this **Appendix (B)** include estimated stream lengths and land acres with management opportunities	
b. Load Reduction Estimates Expected Per Management Measures	B-3	**Tables B-1 and B-2.** Core Voluntary BMPs and Estimated Total Sediment for the West Fork and Lower White River Reporting Subwatersheds	**Tables B-1 and B-2** in this **Appendix (B)** include estimated load reductions to be achieved through management measures.	“Cost-Effectiveness of Management Option – Phase 1” technical document
c. NPS Management Measures Descriptions and Critical Implementation Areas Identifications	37 - 50	**Section 4.2.2: #2.** Core Best Management Practices	**Section 4.2.2 #2.** Core Best Management Practices for descriptions of NPS management measures and maps of critical areas.	
d. Technical/Financial Assistance and Associated Costs Estimates and/or Implementation Plan Support Sources and Authorities.	37 - 57	**Section 4.2:** Five Components of Protection Strategy	**Section 4.2** Five Components of Protection Strategy and Appendix A for cost information; See **Section 5** Beaver Lake Watershed Protection Implementation Summary for potential sources of funding and assistance.	
	A1-11	**Appendix A**		
	61 - 73	**Section 5:** Beaver Lake Watershed Protection Implementation Summary		
e. Public Information & Education Component	37 - 50	**Section 4.2.2: #2.** Core Best Management Practices	See **Section 4.2.2 #2** Core Best Management Practices, **Section 4.2.3 #3** Developer and Contractor Lake Protection Certification Program and **Section 4.2.4 #4** Education and Stewardship Program for training, education, and outreach components.	
	50 - 53	**Section 4.2.3: #3** Developer and Contractor Lake Protection Certification Program		
	53	**Section 4.2.4: #4** Education and Stewardship Program		

Required EPA 319 Element	Quick Reference Listing: BLWSPS Report Content Correlation to EPA 9		BLWSPS Report Section Description	ADDITIONAL REFERENCE DOCUMENT(S)
f. NPS Management Measures Implementation Schedule	61 – 73 70 - 73	**Section 5:** Watershed Implementation Timeline **Table 5-2.** Beaver Lake Watershed Protection Strategy Implementation Timeline	**Section 5** Watershed Implementation Timeline **Table 5-2.** Beaver Lake Watershed Protection Strategy Implementation Timeline: Assuming five-year Adaptive Management cycle beginning January 2012 or at hiring of Council Executive Director	“Beaver Lake Water Quality Targets and Benchmark Analysis”
g. Interim “Milestone” Descriptions for NPS Management Measures Implementation				
h. Loading Reductions Achievement and Water Quality Standards Attainment Progress Criteria	21 - 25	**Section 2.4:** Water Quality Targets	**Section 2.3** Water Quality Targets for a discussion of criteria to measure progress.	“Beaver Lake Water Quality Targets and Benchmark Analysis”
i. Temporal Implementation Effort Efficacy Monitoring Component	54 - 59	**Section 4.2.5: #5** Monitoring and Adaptive Management	**Section 4.2.5** #5 Monitoring and Adaptive Management	

Section 2

Description of the Watershed

2.1 WATERSHED SIZE, LOCATION, AND NATURAL FEATURES

Beaver Lake is located in the Ozark Highlands of northwest Arkansas's Benton, Carroll, and Washington counties in the headwaters of the White River. The U.S. Army Corps of Engineers constructed the multipurpose reservoir in the mid-1960s for flood control, generation of hydroelectric power, and public water supply. The Beaver Lake watershed is 1,192 square miles, and includes portions of Benton, Carroll, Washington, and Madison counties and 17 incorporated municipalities or villages (see Figure 2-1). A small fraction of the watershed lies in Crawford and Franklin counties. As defined by the PAG, the watershed was defined as only the tributaries/reservoir located upstream from the Beaver Lake Dam. This management plan was analyzed at the 10-digit HUC scale, which included 1101000101 (Headwaters - White River), 1101000102 (Middle Fork – White River), 1101000103 (Lake Sequoyah – White River), 1101000104 (West Fork – White River), 1101000105 (Richland Creek), 1101000106 (War Eagle Creek), 1101000107 (Beaver Lake – White River).

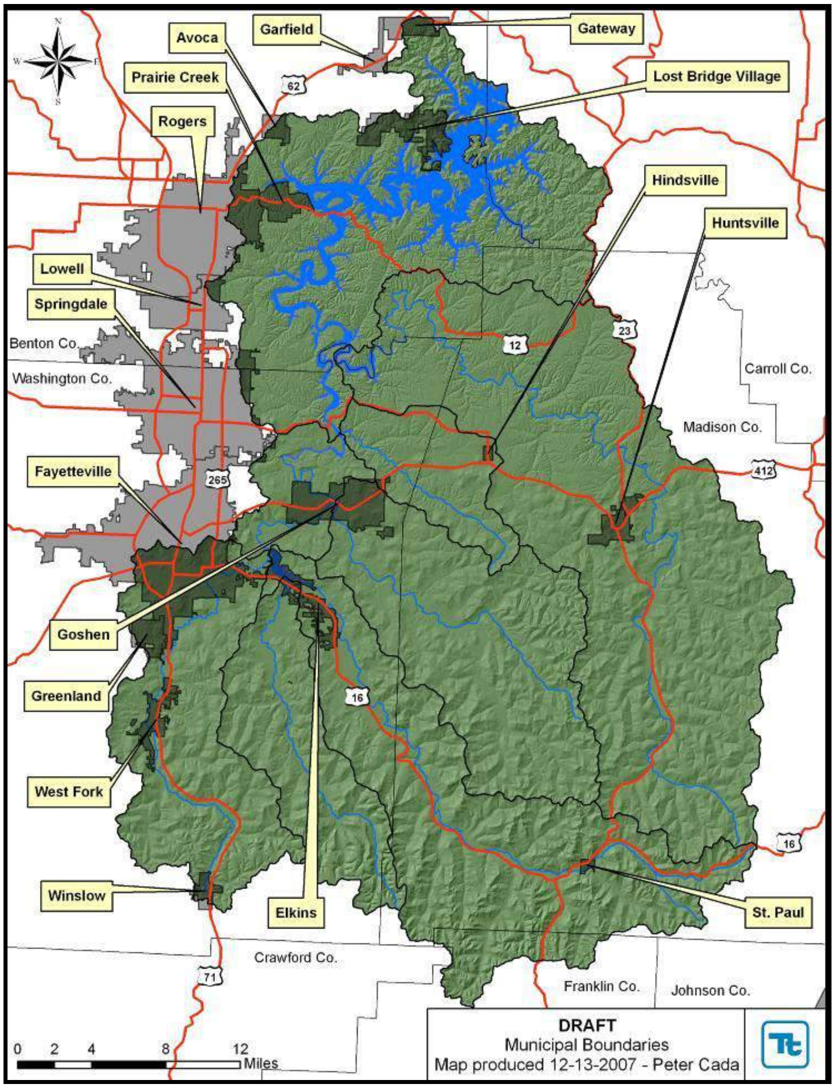


Figure 2-1. Beaver Lake Watershed Local Jurisdictions, includes HUC's 1101000101 (Headwaters - White River), 1101000102 (Middle Fork – White River), 1101000103 (Lake Sequoyah – White River), 1101000104 (West Fork – White River), 1101000105 (Richland Creek), 1101000106 (War Eagle Creek), 1101000107 (Beaver Lake – White River).

Major streams in the watershed draining to the lake include the White River, War Eagle Creek, Richland Creek, and Brush Creek. These were divided into eight subwatersheds for the purposes of evaluating existing and future watershed conditions and developing the Protection Strategy (see Figure 2-2).

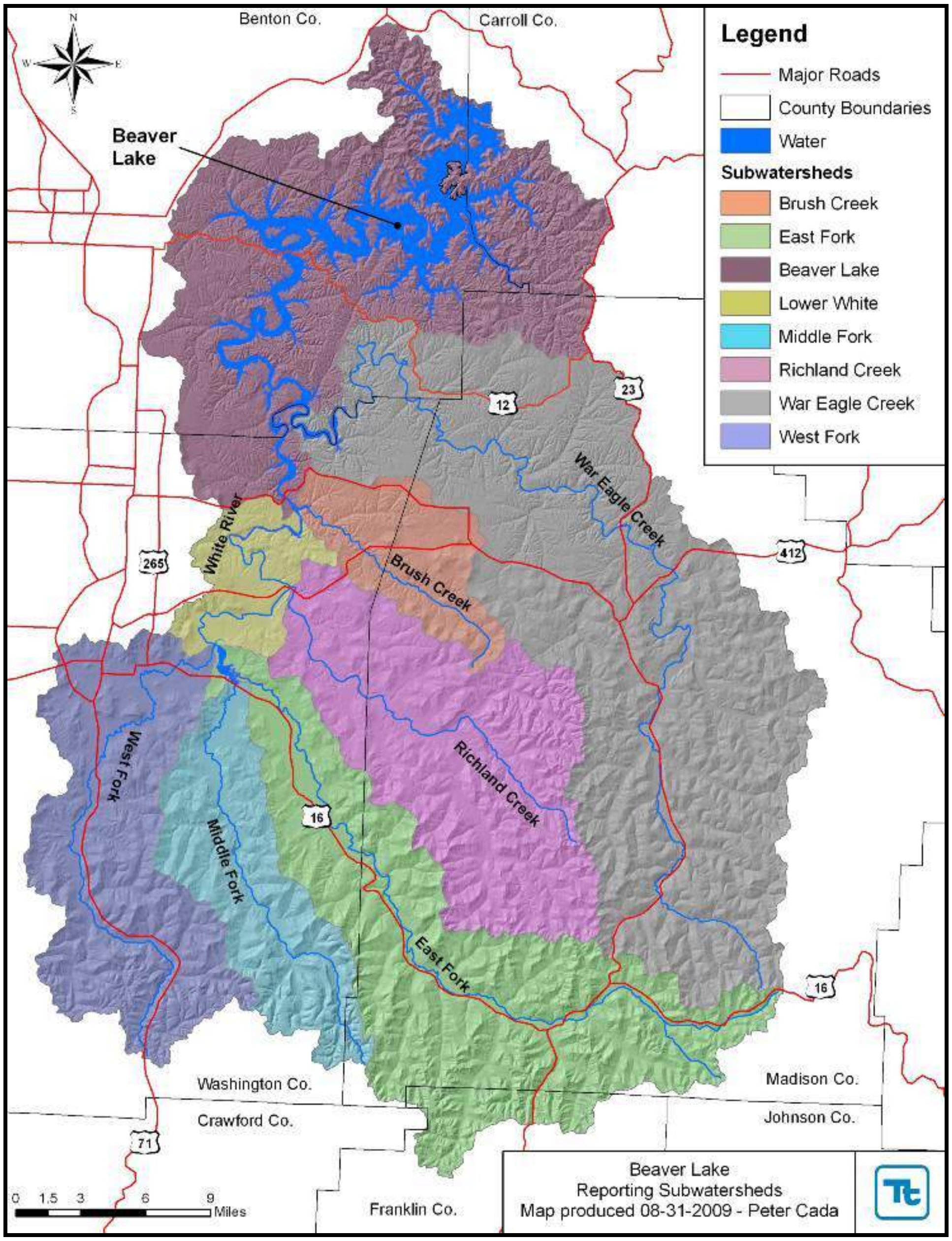


Figure 2-2. Beaver Lake Subwatersheds

The surface area of the lake covers approximately 44 square miles and its length is about 50 miles. The lake contains, on average, 539 billion gallons of water. The depth of the lake at the dam is about 200 feet, but average depth throughout the lake is 60 feet. The mean retention time for water in the reservoir is 1.5 years (i.e., the time for water to move from the upper lake to the lower lake and flow through the dam). Operated by the Corps of Engineers as part of a chain, Beaver Lake is the most upstream and youngest in the series of major reservoirs on the White River mainstem.

Beaver Lake is the most upstream and youngest in the series of major reservoirs on the White River mainstem.

Downstream from Beaver Lake are Table Rock Lake, Lake Taneycomo, and Bull Shoals Lake.

One striking feature of the watershed is its steep topography.

One of the striking features of the watershed is its relatively steep topography: 41 percent of the Beaver Lake subwatershed nearest the lake, 40 percent of the East Fork drainage area, and 29 percent of the Middle Fork subwatershed are classified as having moderate to steep slopes (12 percent slope or higher). The soils in the watershed also can pose challenges for new development. Over 45 percent of the watershed is ranked moderate to severe in soil erosion hazard potential and over 78 percent of the watershed is considered very limited for conventional septic system suitability. The presence of highly porous karst topography in the watershed presents special challenges to water quality protection.

Soils in the watershed can pose challenges for new development.

In recent years, the Northwest Arkansas region has been the fastest growing area of the state—led by the Fayetteville-Springdale-Rogers Metropolitan Area located along the western boundary of the watershed. The regional planning agency and cities provided projections of future planned municipal boundaries (i.e., planning area boundaries). The current municipal area within the watershed is the solid red in Figure 2-3. The red cross-hatched area represents the future municipal boundaries and a quadrupling of municipal area in the coming decades (20 to 30 years). (Note: Official projections were not obtained for the City of Huntsville. Therefore a 2-mile radius around the City was used reflecting a typical planning area boundary. This corresponds to projected population and impervious area data.)

Where will the people live? How is the land currently used and how will it be used in the future? What are the implications for lake water quality? The following subsections answer these questions.

In recent years, the Northwest Arkansas region has been the fastest growing area of the State.

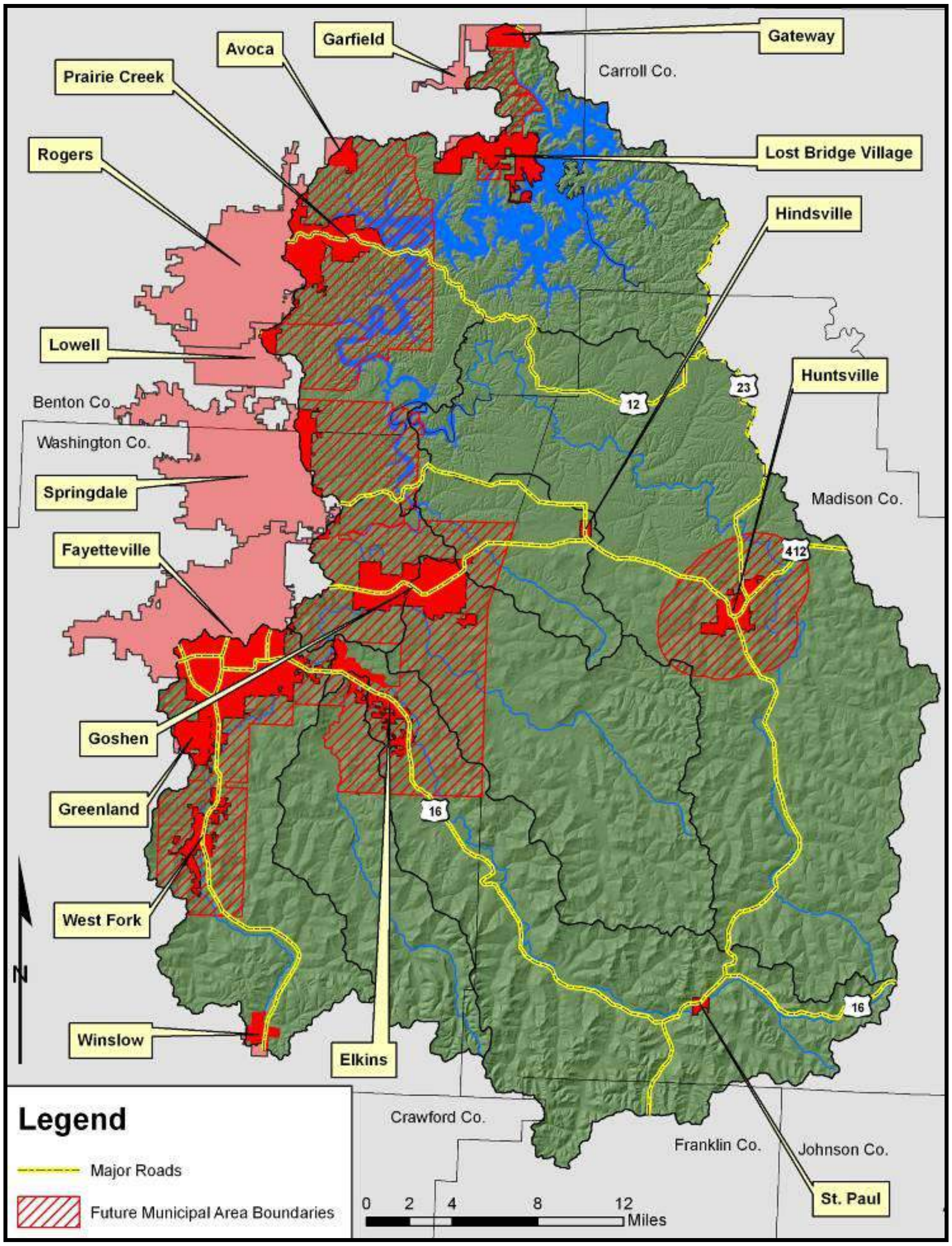


Figure 2-3. Comparison of Existing and Planned Future Municipal Boundaries

Planning projections show a quadrupling of existing municipal area in the coming decades.

LAND USE AND LAND COVER

Where do people live now in the watershed and where will new houses be built in the future? Figure 2-4 compares population density in the year 2000 with projections for 2055 based on data from the Beaver Water District. Population is expected to grow by more than 80 percent in the coming decades, with the majority of people living in the planned municipal areas and around Huntsville.

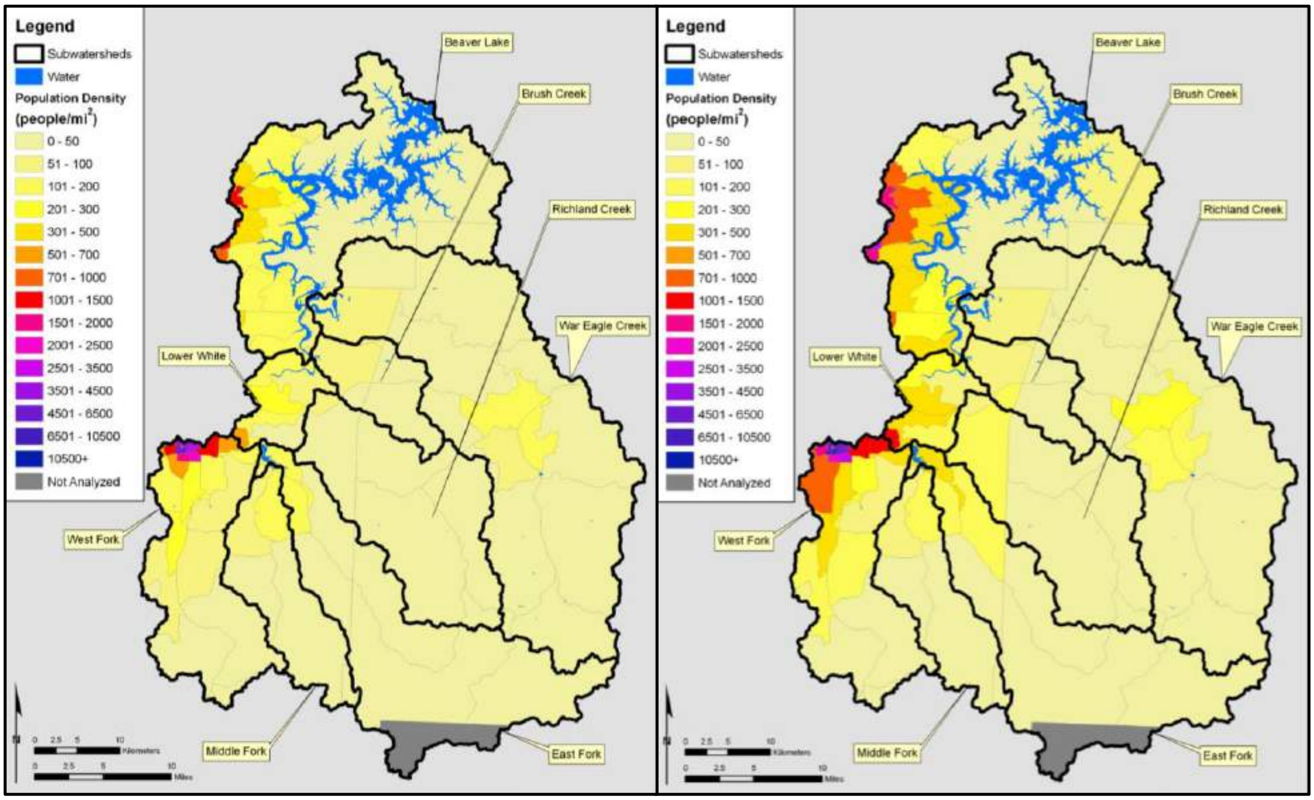


Figure 2-4. Comparison of 2000 and Projected 2055 Population Densities

Population in the watershed is expected to grow by more than 80 percent in the coming decades.

Local planners provided information about the types of future development expected in the watershed, based on existing land use plans and trends. Existing land use/land cover conditions were also supplied by the University of Arkansas' CAST Department, and baseline population statistics were from Census 2000. That information was used to estimate the amount of future impervious area (e.g., rooftops, driveways, streets, parking areas) in the watershed. Impervious areas are important because they channel rainfall quickly into streams, causing bank erosion and sediment inputs to the lake. Figure 2-5 compares the percentage of impervious area in 2001 and 2055. Impervious areas of 12 percent or less are shown in shades of green on the maps. Based on studies conducted by the Center for Watershed Protection and other groups, when watersheds have greater than 10 percent impervious area most indicators of stream water quality decline (Center for Watershed Protection, 2003). In some watersheds, degradation begins with as little as 5 or 6 percent imperviousness. Severe degradation is typically found in watersheds approaching 25 to 30 percent imperviousness or greater (shown in the orange, red, and purple tones). Figure 2-5 demonstrates that there is expected to be a significant growth in this level of imperviousness in the western portion of the watershed and the Huntsville area, coinciding with the growth in the municipal planning areas.

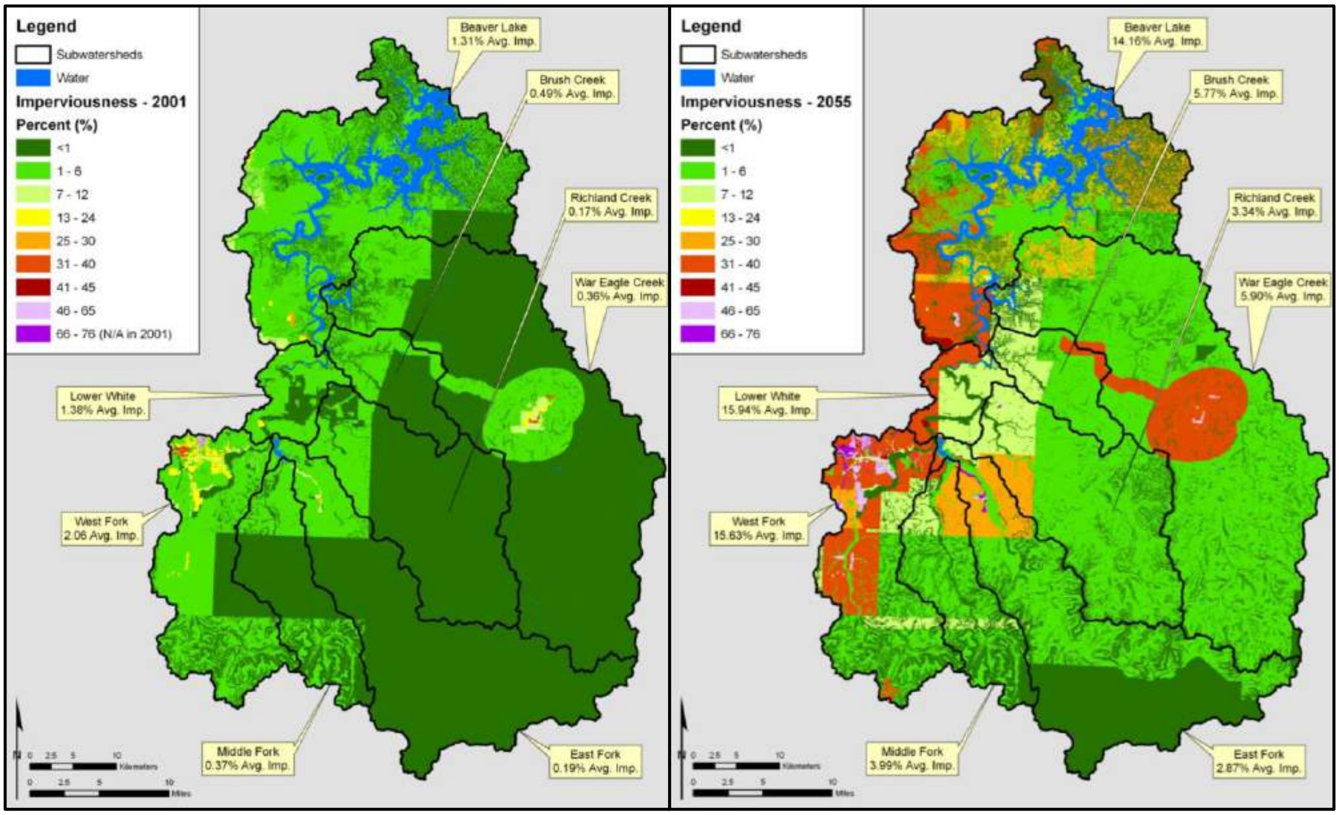
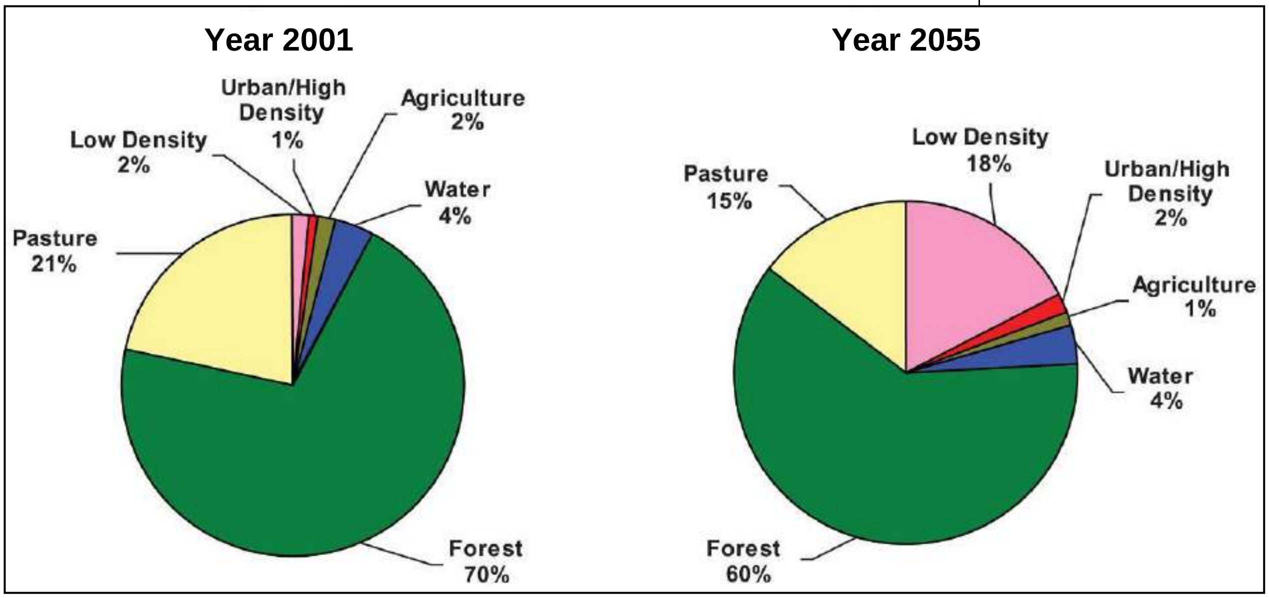


Figure 2-5. Comparison of 2001 and Projected 2055 Imperviousness

Figure 2-6 shows how land use and land cover is projected to change between 2001 and 2055. There are three key trends that have a bearing on water quality: forested areas drop from 70 percent to 60 percent of the total watershed; pasture decreases from 21 percent to 15 percent; and low density development (defined as development with impervious area of 35 percent or less) jumps from 2 percent to 18 percent. As noted previously, these predictions are based on existing plans, trends, and development models, and contain a degree of uncertainty. But if trends continue, these are the types of changes the watershed likely faces in the coming decades.

Low Density Development (i.e., development with 35 percent impervious area or less) will jump from 2 to 18 percent of the watershed.



Where can I find more information on the impervious area and land use analysis?

– [Beaver Lake SWAT Modeling Baseline Analysis, February 12, 2009, Tetra Tech]

Figure 2-6. Comparison of Year 2001 and Year 2055 Projected Land Uses in the Beaver Lake Watershed

2.2 Existing and Future Loading to the Lake

The Baseline Conditions Analysis addressed the question: How will projected growth under current water quality controls affect pollutant loading to the lake? Below are the study's estimates of loading for sediment, phosphorus and nitrogen predicted for existing and future land uses in the watershed and the expected corresponding changes in hydrology. Relative comparisons for pollutant loading are shown for the largest sources, along with the areas of the watershed posing the greatest threat to water quality.

Future annual sediment load is estimated to increase 21 percent.

Currently, and in the future, the Beaver Lake subwatershed is estimated to generate about 45 percent of the total sediment load to the lake.

Sediment

The future annual sediment loading is estimated to increase 21 percent or almost 50,000 tons per year. Without additional protective measures, stream channel erosion is estimated to contribute most (approximately 60 percent) of the sediment load to Beaver Lake. While the decrease in areas categorized as agriculture, pasture, and forest will reduce sediment loading by around 18,400 tons/year from those sources, channel erosion and land developed as low density residential tracts are estimated to increase sediment contributions by approximately 28,850 and 36,700 tons/year, respectively (see Figure 2-7, Comparison of Existing (Year 2006) and Future (Year 2055) Sediment Loading). The near-lake drainage area, defined as the 10-digit HUC that immediately surrounds Beaver Lake (1101000107), exhibits the highest relative rate of pollutant delivery to the lake. This is due to proximity to the lake as well the topography and soils of the area. Currently the Beaver Lake subwatershed generates about 45 percent of the total sediment load to the lake; and it will increase to about 46 percent in the future. By 2055, residential low density land uses, construction sites, and channel erosion in the near lake area are predicted to generate 102,930 tons per year of sediment, constituting 37 percent of the total watershed sediment load to the lake. It is important to note that the rate of construction is predicted to stay the same, but will result in significant increases in the amount of low-density, urban development. Loading estimates in Figure 2-7 are not cumulative over time, but are a snap-shot at the estimated 2055 condition.

By 2055, low density development, construction sites, and channel erosion in the near lake area are predicted to constitute 37 percent of the total watershed sediment load to the lake.

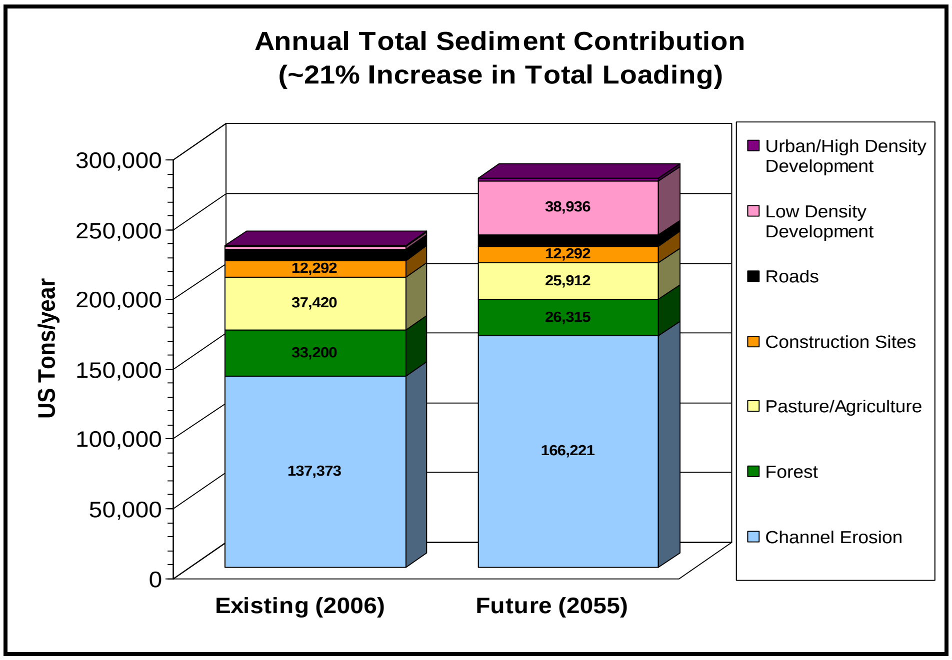


Figure 2-7. Comparison of Existing and Future Sediment Loading (methodology and results described in Supplemental Pollutant Loading Analysis)

The future projected Municipal Planning Area, where most of the development is predicted to occur, is also a key area of concern.

The future projected Municipal Planning Area is also a key area of concern for sediment loading. This area comprises the western portion of the watershed, where most of the development is predicted to occur, as well as the projected growth area around Huntsville. It includes portions of

West Fork, Middle Fork, East Fork, Lower White, Richland Creek, War Eagle, and the Beaver Lake subwatersheds. The Watershed Protection Strategy aims to mitigate projected future increases in sediment loading to the lake from these growth areas.

The West Fork and Lower White River subwatersheds also have Total Maximum Daily Load (TMDL) sediment allocations requiring significant reductions from existing levels (greater than 53 percent reduction for the West Fork and greater than 32 percent reduction for the Lower White). Multiple management practices will need to be applied throughout these watersheds to address the projected increase in sediment loads, in addition to the required TMDL decreases. Figure 2-8 shows the locations of the subwatersheds that are lake protection priorities, because they are 303d-listed, impaired subwatersheds. (Note: Appendix B lists the BMPs recommended for West Fork and Lower White subwatersheds to support TMDL reduction requirements. It also highlights how this Protection Strategy meets the U.S. Environmental Protection Agency's nine minimum elements for watershed plans for impaired waters.)

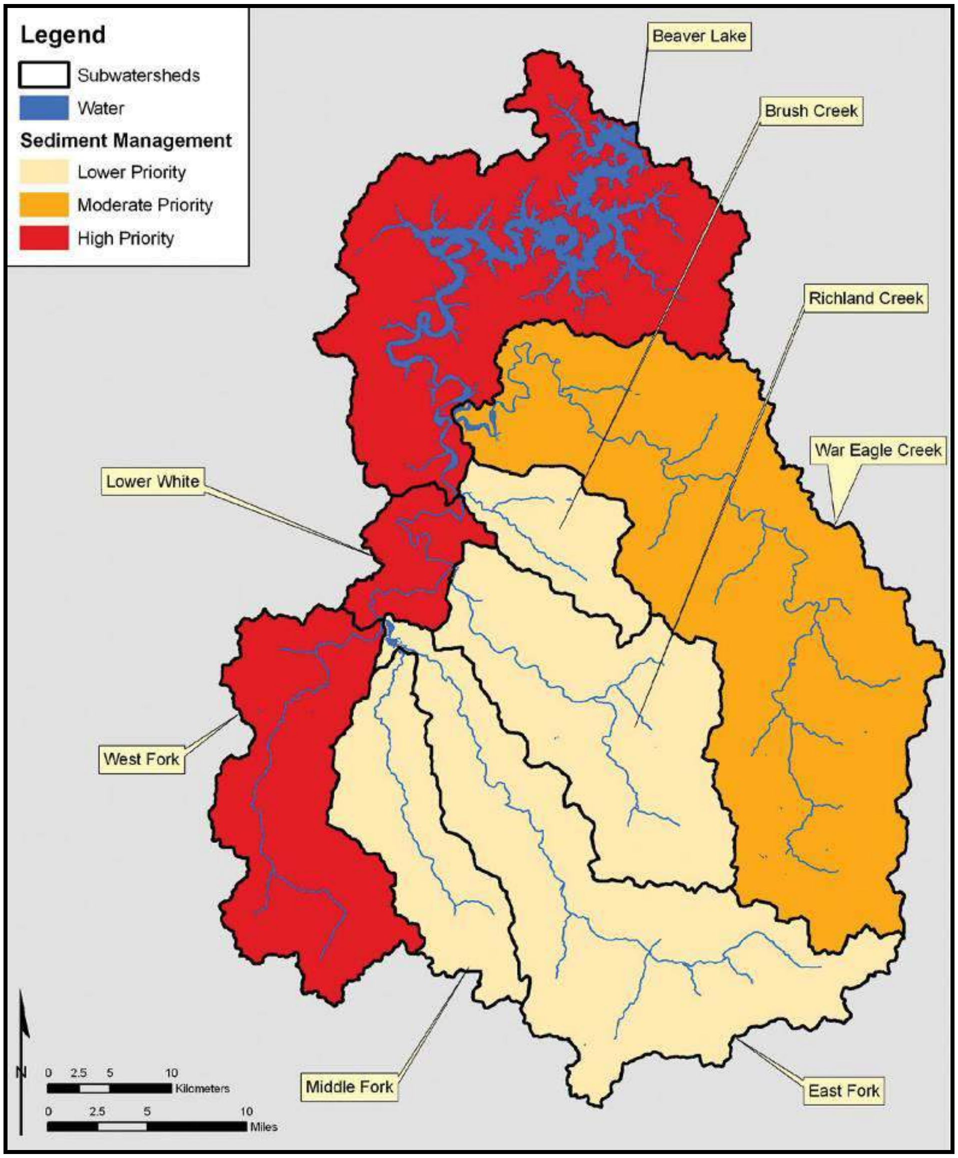


Figure 2-8. High, Moderate, and Low Priority Areas for Sediment Control

Phosphorus

By 2055, the total phosphorus in the lake is expected to increase by approximately 24,000 pounds per year (see Figure 2-9, Comparison of Existing and Future Phosphorus Loading). Phosphorus is a concern because it feeds algal growth, which can lead to taste and odor problems. Soil-borne phosphorus from stream channel erosion is the major contributor of phosphorus within the Beaver Lake watershed for both existing and future scenarios (50 percent and 54 percent, respectively). Wastewater treatment plants (WWTPs) and pasture land, which are the second and third largest sources of the phosphorus in the watershed, are predicted to decrease in their relative phosphorus contributions in the future, while low density development yields the greatest relative increase

Soil-borne phosphorus from stream channel erosion is the major contributor of phosphorus for existing and future conditions.

in phosphorus. As with sediment, the Beaver Lake and War Eagle Creek subwatersheds are predicted to be the largest sources of phosphorus to the lake. This is not surprising, given that sediment and phosphorus are closely associated.

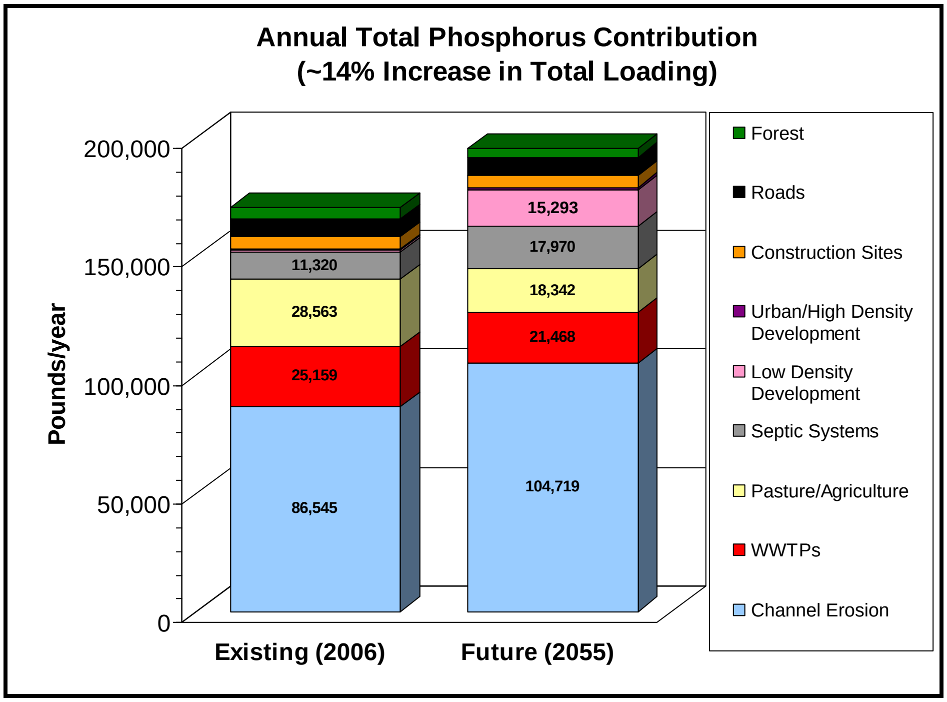


Figure 2-9. Comparison of Existing and Future Phosphorus Loading (methodology and results described in Supplemental Pollutant Loading Analysis)

Nitrogen loading to the lake is only expected to increase by about 4 percent.

Nitrogen

Overall, total nitrogen loading to the lake is only expected to increase by about 4 percent to approximately 267,000 pounds per year in the future (see Figure 2-10), Comparison of Existing and Future Nitrogen Loading). Under existing conditions, pasture land contributes more than half of the total nitrogen load to Beaver Lake (56 percent), followed by forest land (31 percent). As urban development occurs through 2055, pasture is predicted to remain the leading nitrogen contributor – but its relative load decreases considerably to 36 percent of the total load. Nitrogen from forest sources drops to 25 percent, but low density urban development becomes a significant contributor according to the 2055 land use scenario (24 percent). The War Eagle Creek subwatershed is predicted to deliver the largest nitrogen load under both existing and future scenarios. The Beaver Lake subwatershed is estimated to be the second leading contributor of nitrogen to the lake based on future land use conditions.

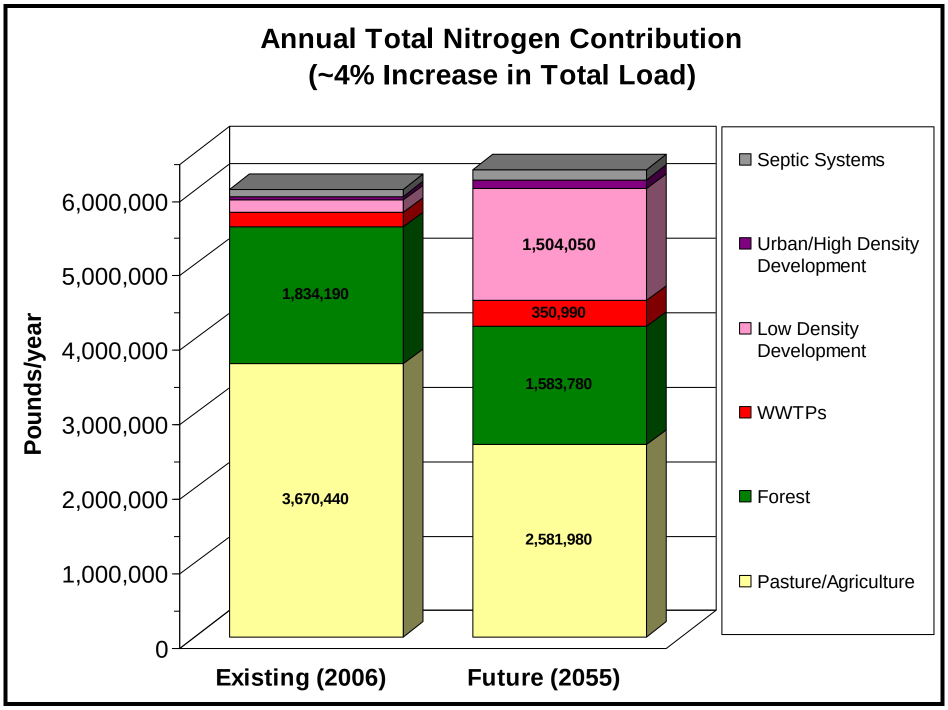


Figure 2-10. Comparison of Existing and Future Nitrogen Loading (methodology and results described in Supplemental Pollutant Loading Analysis)

Where can I find more information about the existing and future loading to the lake?

– Beaver Lake SWAT Modeling Baseline Analysis, February 12, 2009, Tetra Tech

– Beaver Lake Watershed Baseline Analysis – Supplemental Pollutant Loading Analysis, February 16, 2009, Tetra Tech

Riparian Areas

Another key finding is that 25% of the riparian area in the watershed lacks adequate vegetation along streams (results given in Supplemental Pollutant Loading Analysis). This contributes to channel erosion and reduces the capacity of the riparian area to filter nutrients and sediment before they reach the streams.

Twenty-five percent of the riparian area in the watershed lacks adequate vegetation along streams.

2.3 Water Quality Targets

EPA Watershed Management Plan Element H: Load Reduction Criteria = See Sections 2.3 and 2.4

Given the level of population growth and new construction anticipated in the watershed, Tetra Tech worked with the project's Technical Advisory Group to develop future water quality targets and benchmarks for Beaver

Lake. A target is based on a current (or currently proposed) regulation or standard, and a benchmark is a non-regulatory objective. Both are quantitative – they can be measured. The benchmarks are proposed when there are no regulatory targets, but certain conditions are desired in the lake, or as a safety factor for a regulatory target's minimum threshold.

Two locations are proposed for meeting the water quality targets and benchmarks: the Hickory Creek monitoring station and a monitoring station L3 near Lowell and the Beaver Water District's raw water intake (Figure 2-11). The Hickory Creek station is at the confluence of the major tributaries to Beaver Lake and the lake's "plunge point," where incoming water from the White River moves below the existing pool of impounded water in the lake. It is also upstream of the Beaver Water District intake. The Hickory Creek station was chosen as an early warning indicator for the rest of the lake. Also, if the Watershed Protection Strategy is protective of conditions in the lake at Hickory Creek, it is expected to be protective of the rest of the lake.

Water quality monitored by the USGS for three key indicators – Chlorophyll *a*, Secchi depth, and Total Organic Carbon – is summarized at Station L3 (near Lowell) for the period of 2001-2008 (Table 2-1).

Table 2-1. Water Quality Monitored by USGS at Beaver Lake Station L3

Monitoring Year	Chlorophyll *a* (µg/L – seasonal geometric mean)	Secchi Depth (m – seasonal mean)	Total Organic Carbon (TOC) (mg/L – seasonal mean)
2001	6.1	2.3	2.3
2002	4.5	2.0	3.2
2003	4.9	2.2	2.2
2004	5.3	1.3	5.0
2005	3.7	2.4	2.7
2006	4.2	2.2	3.6
2007	5.9	2.0	3.0
2008	8.1	1.1	3.9

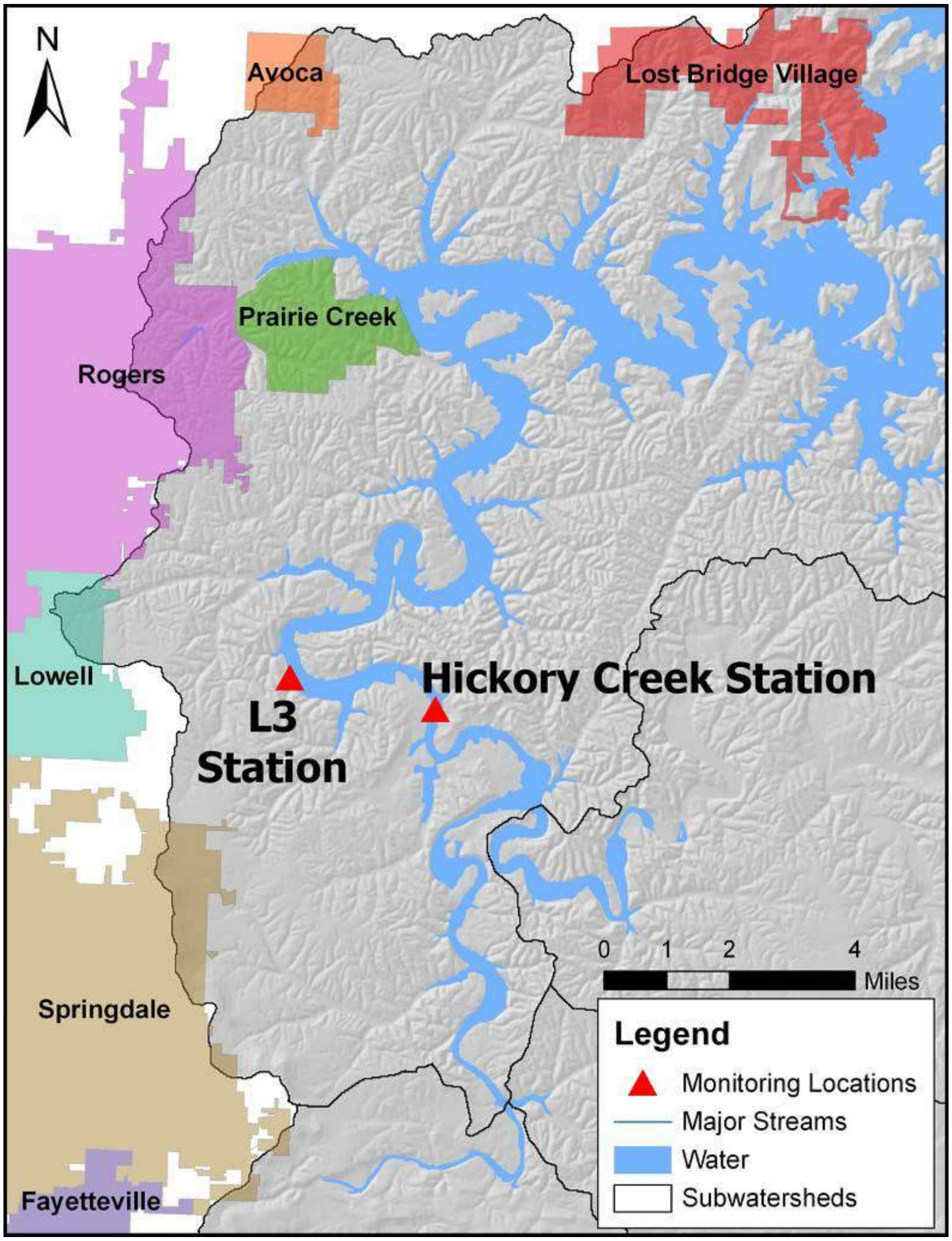


Figure 2-11. Lake Monitoring Stations for Targets and Benchmarks

The project's Technical Advisory Group helped develop future water quality targets and benchmarks for the Hickory Creek monitoring station and at Station L3 near the Beaver Water District's intake.

Proposed Chlorophyll-a Target *(linked to drinking water safety, taste, and odor; treatment operations; and lake recreation)*

Under a separate study commissioned by Arkansas Department of Environmental Quality (ADEQ), a Technical Workgroup has developed and recommended a site specific chlorophyll *a* water quality criterion for Beaver Lake: 8 micrograms per liter (µg/L) at the Hickory Creek station, measured as a growing season geometric mean. Tetra Tech and the project's TAG recommended using 8 µg/L as a target for the watershed protection strategy, along with a benchmark of 6.4 µg/L at the same station. The benchmark represents a safety factor (USEPA recommends

USGS monitoring of Chlorophyll-a in the upper lake shows conditions were approaching the precautionary benchmark in 2001 and 2007, and at the target threshold in 2008.

using 80 percent of a criterion as a safety cushion, to increase likelihood of staying below the criterion), and addresses variability between the modeling and monitoring. Lake monitoring conducted by the USGS from 2001 to 2008 at monitoring station L3 shows that chlorophyll *a* seasonal geometric mean concentrations have ranged from 3.7 to 8.1 µg/L. Conditions in 2001 and 2007 were approaching the benchmark, and conditions in 2008 were measured at the target level. Therefore, it would appear prudent to develop and implement a strategy to achieve no or relatively little increase in total phosphorus and total nitrogen loading to the lake.

Proposed Total Organic Carbon Target *(linked to drinking water safety, taste, and odor; treatment operations)*

The total organic carbon (TOC) target is based on meeting the Safe Drinking Water Act *Disinfection By-Products Rule* for finished (treated) water. The recommended TOC target is 3 milligrams per liter (mg/L) at the BWD drinking water intake, and the suggested benchmark is 3 mg/L at Hickory Creek. The USGS monitoring shows that the upper lake at station L3 averaged from 2.2 to 5.0 mg/L TOC between 2001 and 2008. Average TOC concentrations exceeded the benchmark in 2002, 2004, 2006 and 2008. Meeting the target on a consistent basis would mean developing a strategy to achieve relatively little or no increase in TOC loading to the lake.

USGS Monitoring of TOC in the upper lake shows that average concentrations exceeded the benchmark threshold in 2002, 2004, 2006, and 2008.

Proposed Turbidity and Sediment Target *(linked to public safety; drinking water aesthetics; treatment operations; recreation; restoration of impaired waters; and loss of private land)*

The sediment and turbidity targets are based on ADEQ water quality criteria for turbidity in streams, as well as the Total Maximum Daily Loads (TMDLs) for the West Fork and Lower White River. The targets are to meet instream turbidity criteria to address stream and lake turbidity. In addition, ADEQ TMDLs require a 53 – 58 percent (depending on flow category) reduction of the sediment load in the West Fork of the White River and a 32 – 40 percent reduction in the Lower White River subwatersheds.

The recommended benchmark related to turbidity in Beaver Lake is an average Secchi depth (water clarity) of 1.1 meters at Hickory Creek. A Secchi depth target of 1.1 meters was also recommended by the ADEQ commissioned Technical Workgroup developing site specific water quality criteria for Beaver Lake related to protection from excessive algae. Using Secchi depth as a benchmark to also address impacts of sediment would mean looking for protection measures that would result in relatively little or no increase in existing levels of sediment/turbidity loading to the lake.

Water quality in Beaver Lake is still good, but under stress due to sediment and algae feeding nutrients.

Where can I find more information about targets and benchmarks?

– Beaver Lake Watershed Water Quality Targets/Benchmarks Analysis, February 18, 2009, Tetra Tech

2.4 PRIORITY WATERSHED ISSUES

Water quality in Beaver Lake is still good, but under stress due to increasing levels of sediment and algae-feeding nutrients. Although some degradation in water quality has occurred, people in the region can act in the coming decades to ensure high quality drinking and recreational waters.

Although some degradation in water quality has occurred, people in the region can act in the coming decades to ensure high quality drinking and recreational waters.

The Baseline Conditions Analysis indicates that sediment is the key parameter of concern in the coming decades, both for lake water quality and localized stream impacts. Lake protection actions taken to mitigate sediment loading should also address much of the projected increase in phosphorus. Through the study, Tetra Tech identified priority actions for lake protection that maximize water quality benefits for the region:

- *Managing the quality and volume of runoff from new development* – Target additional water quality protection measures for new development in the Municipal Planning area with 12 percent or greater imperviousness (e.g., 1-acre lots).
- *Managing construction site runoff* – Employ best management practices to control sediment and pollutant runoff on construction sites throughout the watershed.
- *Preserving and restoring vegetation in stream buffers and along stream channels* – High priority opportunities are the Beaver Lake, Lower White, and West Fork subwatersheds. Medium priority is in the lower portion of Middle Fork, East Fork, Richland Creek, Brush Creek, and War Eagle Creek due to their proximity to Beaver Lake.
- *Enhancing pasture best management practices* – The priority opportunities are the existing pasture lands in the Beaver Lake, Lower White, and West Fork subwatersheds. Medium priority is pasture land in War Eagle Creek.
- *Improving unpaved roads* – The high priority subwatershed is Beaver Lake. Medium priority watersheds are West Fork, Lower White, and War Eagle Creek.

Emphasis on these priority actions assumes that key existing protection programs will continue and be strengthened including local stormwater regulation, nutrient management plans, and wastewater management with particular emphasis on phosphorus reduction from the largest point source discharges.

Section 3

Building Blocks and Gaps for Lake Protection

Efforts to protect and improve water quality have been ongoing for years.

A review of current regulations within the Beaver Lake watershed revealed a number of potential building blocks – and some gaps – for the Protection Strategy. Efforts to protect and improve water quality within the watershed have been ongoing for years. This section highlights three key water quality protection building blocks: local stormwater permits, nutrient management plans, and wastewater management. Gaps in these existing programs are also highlighted.

3.1 Local Stormwater Regulation

Stormwater discharges for large and medium size communities are regulated by federal Clean Water Act rules for the National Pollutant Discharge Elimination System (NPDES) permit program, but administered and enforced by ADEQ. This program regulates all major discharges of stormwater (i.e., polluted runoff from municipal areas) to surface waters. The purpose of the NPDES permits is to reduce pollutants in stormwater runoff from certain municipal separate storm sewer systems (MS4s), construction sites, and industrial activities by requiring the development and implementation of stormwater pollution prevention plans and programs.

The purpose of the NPDES stormwater permits is to reduce pollutants in the stormwater runoff from certain municipal separate storm sewer systems (MS4s), construction sites, and industrial activities.

ADEQ has designated certain communities with MS4s as regulated stormwater dischargers and has issued a general permit with stormwater management conditions that all regulated MS4 communities were supposed to meet by 2008, including:

- Public education
- Public involvement/participation
- Illicit discharge detection and elimination
- Construction site runoff control
- Post-construction stormwater management
- Pollution prevention/good housekeeping

In the Beaver Lake watershed, regulated MS4 communities include portions of Benton County, Washington County, and Elkins, Fayetteville, Greenland, Lowell, Prairie Creek, Rogers, Springdale, and the University of Arkansas. These MS4 communities have contracted with the University of Arkansas Cooperative Extension Service to develop and administer a Northwest Arkansas Regional Stormwater Education Program covering Benton and Washington counties, or the "Fayetteville-Springdale-Rogers" urbanized area. This program is designed to address the public education and involvement requirements of the MS4 permits through development of educational materials for the general public and schools (fact sheets, brochures, and posters), conducting public outreach and youth education, and hosting workshops and training events.

Tetra Tech evaluated stormwater programs in place and found they would need to be strengthened to meet lake protection goals.

Based on a review of the latest annual reports from the MS4s, several of the MS4s met the 2008 deadline for adopting a construction site runoff control ordinance or plan and an ordinance or plan for controlling post-construction runoff. Tetra Tech evaluated the stormwater programs in place and found that they would need to be strengthened in order to meet the lake protection goals. A number of the MS4s have not been able to develop and enforce construction and post-construction requirements, citing a lack of resources. There is an additional gap in the designation of regulated MS4 areas. Regulated areas are based on the census survey every 10 years and determined by population density. Densely populated areas are called urbanized areas for the purposes of future stormwater regulation. However, by the time the area has been designated as "urban," a significant amount of uncontrolled stormwater runoff has been generated which would not be covered by the regulations. In these situations, development designers do not incorporate appropriate stormwater best management practices into their projects and the cities and counties are forced to deal with stream channel erosion, water quality degradation, and other consequences linked to rapid stormwater runoff, low rates of infiltration and groundwater recharge, and a general absence of stormwater pollution controls.

A number of MS4 communities have been unable to develop and enforce construction and post-construction requirements, citing a lack of resources.

In terms of construction phase impacts, it is important to note that federal stormwater regulations require that all construction sites disturbing more than one acre, regardless of their location, must have sedimentation and erosion controls. If this land disturbance falls outside of a designated MS4 community, the Arkansas Department of Environmental Quality is required to administer and enforce the stormwater NPDES requirements unless a local government voluntarily enacts an ordinance. However, the state does not have adequate resources to enforce these requirements. Several Beaver Lake Focus Groups commented on the relative absence of enforcement of the construction phase stormwater rules.

In terms of construction phase impacts, if land disturbance of more than one acre falls outside a MS4 jurisdiction, the state is required to enforce stormwater requirements.

Arkansas Highway and Transportation Department (AHTD) construction projects and certain facilities and roadway drainage systems managed by the AHTD must also comply with the federal and state stormwater permitting and management regulations discussed in the previous sections. Roads, ditches, and drainage facilities on public property managed by the AHTD are considered to be MS4s under the stormwater permitting program. AHTD construction activities with a disturbed area of one acre or more and AHTD facilities (e.g., equipment and materials storage yards) draining to other municipal separate storm sewer systems – such as those owned and managed by cities and/or counties – are also regulated by the ADEQ MS4 permit and the ADEQ Construction Stormwater General permit. These permits require the reduction of stormwater impacts on surface waters "to the maximum extent practicable," through the following enforceable permit requirements:

- Development and implementation of an ordinance requiring erosion and sedimentation controls with sanctions necessary to ensure compliance.
- Implementation of appropriate erosion and sediment control best management practices.
- Control of waste materials that may adversely impact water quality such as building materials, truck washout, chemicals, litter, and sanitary waste.
- Site plan reviews that consider water quality impacts of project activities.
- Communication with the public.
- Site inspections and enforcement of control measures.

The AHTD stormwater program needs to be strengthened along with ADEQ enforcement.

The ADEQ Construction Stormwater General permit requires that operators (i.e., property owners, general contractors, etc.) of construction sites disturbing one acre or more develop and implement a Storm Water Pollution Prevention Plan (SWPPP), which must be maintained until site stabilization is complete. Projects disturbing more than five acres must meet more stringent permit requirements.

Windshield surveys of the watershed indicate that the AHTD stormwater program needs to be strengthened in the watershed along with ADEQ enforcement. Poor erosion, sediment, and stormwater controls were clearly visible at the majority of construction sites surveyed by Tetra Tech staff during 2008-2009. Problems included failure to quickly seed and/or mulch cleared areas, poor silt fence / sediment barrier installation and maintenance, lack of sediment traps, poor or no inlet protection, poor housekeeping practices, and no stabilization of ditches until late in the construction process.

Beaver Lake watershed has been designated as a Nutrient Surplus Area.

3.2 Nutrient Management Plans

The Beaver Lake watershed has been designated as a *Nutrient Surplus Area* under Arkansas Acts 1059 and 1061 of 2003, as implemented by Title XXII of the Arkansas Natural Resources Commission *Rules Governing the Arkansas Soil Nutrient and Poultry Litter Application and Management Program*, effective January 2006. The purpose of these rules is to maintain the benefits derived from the wise use of poultry litter and other soil nutrients while avoiding undesirable effects from excess nutrient applications on the waters of the State. Among other provisions, these rules state that persons applying nutrients to soils or residential/ non-residential land areas greater than 2.5 acres within a Nutrient Surplus Area must comply with a nutrient management plan or poultry litter management plan. Requirements for soil testing, record-keeping, placement and timing of litter application, and other elements of nutrient management plans are specified in the rules. Although the rules require the maintenance of records for five years and require their availability for inspection by Commission or Conservation District employees, there is no opportunity for review by other agencies or by the public.

The purpose of the nutrient management rules is to maintain the benefits derived from use of fertilizers and poultry litter while avoiding undesirable effects.

Specifically, Act 1061: *An Act to Require Proper Application of Nutrients and Utilization of Poultry Litter in Nutrient Surplus Areas* requires that:

- All nutrient applications on residential and nonresidential development exceeding 2.5 acres in a Nutrient Surplus Area must be done according to a Nutrient Management Plan.
- Applications within a nutrient surplus area on residential lands of 2.5 acres or less shall be applied at a rate not to exceed a protective rate (as defined in Title XXII).
- Nutrients may be applied only by a certified nutrient applicator if within nutrient surplus areas, except on residential lands of 2.5 acres or less.
- The landowner is responsible for maintaining documentation of the nutrient application in accordance with their plan.
- Poultry feeding operations within a nutrient surplus area shall develop and implement a poultry litter management plan acceptable to Arkansas Natural Resources Commission (ANRC).
- The poultry litter management planner shall by certified by ANRC in planning.

Although the rules require the maintenance of records for five years, there is no opportunity for review by other agencies or by the public.

Additional legislation supports Act 1061, including:

- Act 1059: *Arkansas Soil Nutrient Management Planner and Applicator Certification Act*, which requires the certification of persons to properly develop nutrient management plans or to properly supply soil nutrients and requires ANRC to develop and implement a nutrient management education, training and certification program.
- Act 1060: *An Act to Register Poultry Feeding Operations*, establishes annual registration with ANRC of poultry feeding operations where more than 2,500 poultry are housed or maintained.

Nutrient management plans for poultry litter in the Beaver Lake watershed are currently estimated using the Arkansas P index, which bases application rates on crop nitrogen requirements when a site is in the low or moderate risk category for phosphorous loading.

Interviews with resource agencies and poultry integrators indicated a high level of compliance with the Nutrient Management Plan requirements. Based on this, the watershed model assumed nutrient management plan implementation now and decades into the future. Without such long-term compliance, the lake protection goals would not be achieved. Thus, the Beaver Lake Watershed Protection Strategy emphasizes the importance of maintaining high compliance with Nutrient Management Plan requirements.

Interviews with resource agencies and poultry integrators indicated a high level of compliance with nutrient management plan requirements. Based on this, the watershed model assumed nutrient management plan implementation now and decades into the future. Without such long-term compliance, the lake protection goals would not be achieved.

3.3 Wastewater Management

The Clean Water Act requires the control of wastewater discharges to surface waters under the National Pollutant Discharge Elimination System (NPDES) program. The Arkansas Department of Environmental Quality, which has the delegated authority to administer the program, issues permits to treated effluent dischargers with limitations on wastewater flow and pollutants in order to protect surface water quality and the beneficial uses of the water. These permits must be renewed every five years. Dischargers must also obtain a permit from ADEQ to construct any waste collection, treatment, or discharge facility to ensure that proper engineering design is used. Dischargers are required to perform self monitoring, and those records, along with periodic inspections and monitoring by ADEQ, are used to determine compliance with permit requirements. Enforcement measures, including fines and revoking permits, are available to ADEQ when addressing noncompliance by dischargers.

There are currently two major active NPDES permits to discharge wastewater within the watershed (Fayetteville's Noland Plant and Huntsville's Plant), and several minor effluent discharger permits near Beaver Lake and West Fork. Much of the municipal wastewater is generated along the far western boundary of the Beaver Lake drainage area, in the cities of Fayetteville, Springdale, Lowell, Rogers, and Pea Ridge, which lie south-to-north along US 71. These cities are served mostly by the centralized Wastewater Treatment Plants (WWTPs) that discharge to surface waters of the Beaver Lake and the Upper Illinois watersheds, but adjacent subdivisions are increasingly served by smaller clustered (decentralized) facilities that discharge to the soil. Outlying and rural areas of the watershed are served mostly by individual or small clustered systems with soil discharges. The Fayetteville WWTP and its sewage collection system, which have likely been nutrient sources in years past due to collection system overflows and other problems, have completed major renovations which include construction of a new WWTP on the west side of Fayetteville. Since 1990, the City of Fayetteville's Noland WWTP has had a discharge permit limit of 1.0 mg/L for Total Phosphorus for discharge to the White River. The watershed model assumed that at least the same limit would be applied to future plant upgrades and expansion at the Huntsville and West Fork plants. If this or more protective limits are not used, then the lake protection goals will not be met. Therefore, the Beaver Lake Watershed Protection Strategy highly recommends continuance of the state regulation of phosphorus concentration through effluent limitations for the larger wastewater discharge permits. It is important to note that the City of Fayetteville and the Beaver Water District have an Agreement for the Protection of the Beaver Lake Watershed whereby Fayetteville agrees to maintain an average TP discharge concentration of 0.5 mg/L year round and will not exceed 93.4 pounds per day TP from July through October. In addition, the City of Fayetteville has made commitments to reduce nonpoint source loading of Total Phosphorus. The City of Fayetteville has taken a number of major steps to implement the Agreement.

Fayetteville's Noland WWTP is undergoing major renovations. Since 1990 it has had a discharge permit limit of 1.0 mg/L for Total Phosphorus. The watershed model assumed that at least the same limit would be applied to future plant upgrades of Huntsville and West Fork. If this or more protective limits are not used, then the lake protection goal will not be met.

In addition to loads from WWTPs, malfunctioning individual residential wastewater (septic) systems may be causing localized surface water quality problems in some areas. Wastewater treatment systems discharging to the soil can pose a threat to the White River, the lake, and its tributaries in areas where high densities of older, heavily used systems are located near surface streams or karst topography. Current rules specify the types of legally acceptable tanks, infiltration system components, and other devices, and provide for evaluation of the installation site, training and licensing of service providers, and the management of systems that serve multiple homes or other facilities. Individual home wastewater treatment systems in Arkansas are regulated by the Arkansas Department of Health (ADH) if they discharge to the soil on the system owner's property. Systems that discharge to the soil offsite, or to a surface waterbody, or that discharge to soil onsite with flows greater than 5,000 gallons per day are regulated by the Arkansas Department of Environmental Quality (ADEQ) under its NPDES discharge permit and other programs. In general, ADH will approve individual home systems with septic tanks and soil absorption fields if adequate space is available, soils are suitable (i.e., acceptable percolation rate), and setbacks can be met from groundwater tables, wells, public water supply intakes, streams, lakes, ponds, property lines, etc. Drain fields are sized in accordance with soil percolation rates: the slower the percolation rate, the larger the required drain field.

An enhanced monitoring program for individual onsite wastewater systems is recommended, along with enhanced landowner education regarding system maintenance.

Individual wastewater systems require regular maintenance, such as pumping every 3 to 5 years, in order to function as designed. There are no provisions for checking or reporting maintenance or malfunctioning systems. A monitoring program can help detect elevated bacteria and trace sources of problems. Such monitoring would be particularly important in Beaver Lake's coves and associated tributaries. An enhanced monitoring program is recommended in this Protection Strategy as well as enhanced landowner education regarding wastewater treatment and system maintenance.

Summary

It is important to note that this Strategy does not recommend phosphorus regulations that are more stringent than those of ADEQ. Of the municipalities that are MS4 permittees, most have done well at implementing the education component of the permitting requirements. On the other hand, other requirements of the MS4 permits have been implemented with less success. At all levels (cities, counties, and the state), lack of resources was cited as a reason for the lack of enforcement or conformation to MS4 requirements. The function of this strategy is to highlight these gaps and suggest solutions, but it is the responsibility of the municipality to conform to and enforce the requirements of their respective permits.

There are several major building blocks for the Beaver Lake Watershed Protection Strategy. ADEQ has issued stormwater permits for highly populated urbanized areas in Washington and Benton counties. This requires a local regulatory mechanism for erosion and sediment controls and enforcement capability, and a program to address stormwater runoff from new development and redevelopment after construction has been completed. Local governments currently have a strong education program, but for most there is a gap in regulation and enforcement. Also, the ADEQ/state minimum requirements do not cover a significant amount of development in urbanizing areas within the lake drainage area. For other counties, ADEQ has construction site management requirements for activities disturbing greater than one acre. Currently there is a significant gap in ADEQ inspection and enforcement. Filling these gaps to carry out the existing stormwater management regulations as intended is recommended under the Beaver Lake Watershed Protection Strategy.

The State Nutrient Management Plan Requirements for development and farmland appear to have a high rate of compliance according to interviewees. Continued compliance is essential in meeting the lake protection goals.

Protective phosphorus limits on municipal WWTPs are needed to meet the lake protection goals. As the smaller WWTPs plants expand, it will be critical for ADEQ to require at least the same protective limits as those currently at the Noland Plant in order to meet the lake protection targets.

Proposed Beaver Lake Watershed Protection Strategy

The building blocks listed in the preceding section will serve as the foundation for the Beaver Lake Watershed Protection Strategy described below. Measures that address the gaps in watershed protection and further enhance efforts to reduce nutrient and sediment inputs to the lake round out the proposed approach. The elements of this Strategy represent the level of effort required to improve the quality of impaired waters and maintain water quality on unimpaired areas of the main body of the lake.

The elements of this strategy represent the effort required to improve quality of impaired waters and maintain water quality on unimpaired areas of the lake.

4.1 Overview of the Beaver Lake Watershed Protection Strategy

The function of this plan is to identify gaps in enforcement of current regulations.

- Increase enforcement of existing federal, state, and local requirements. This could be accomplished in two ways: 1) to educate cities, counties and possibly the state on existing enforcement gaps, and 2) be a method of local enforcement that would utilize volunteer efforts to work with and educate individuals who may be violating current regulations, ordinances or laws.
- Provide guidance and support for adoption of voluntary BMPs
  - Basic voluntary water quality protection BMPs
  - Guidance and incentives to go beyond core BMPs
- Create a mechanism for implementing the Protection Strategy
- Adapt management efforts when trigger points indicate that changes are needed

The Beaver Lake Watershed Protection Strategy has five complementary components:

Beaver Lake Watershed Council: A diverse group representing different interests that would provide sustained leadership for lake protection, including the facilitation of the implementation and adaption of the Beaver Lake Watershed Protection Strategy.

Core Best Management Practice (BMPs): Voluntary BMPs that do double duty of reducing sediment and phosphorus load to the lake and help reduce current sediment loading in existing impaired streams.

Developer and Contractor Lake Protection Certification Program: For local governments, site design engineers, developers, and contractors willing to implement protective stormwater controls for new development in the Municipal Planning Area and sign a Lake Protection Pledge.

Education and Stewardship Program: Community outreach to teach property owners about lake protection efforts and how they can help.

Monitoring and Adaptive Management: To address uncertainty and changing conditions and provide early warning signs for needed changes.

The following sections provide more details about these five components as well as implementation actions for each.

EPA Watershed Management Plan Element C: NPS Management Measures descriptions and Critical Implementation Areas – See Section 4.2.2 #2.

4.2 Five Components of Protection Strategy

4.2.1 Component #1 – Beaver Lake Watershed Council

Stewardship and protection of the Beaver Lake watershed depends on the organized, collective, targeted efforts of citizens, businesses, property owners, managers, non-governmental organizations (NGOs) and governmental agencies. A Beaver Lake Watershed Council is recommended as a way to establish and support a strong partnership among those organizations which have significant authority or resources for protecting the watershed. The purpose of the Beaver Lake Watershed Council would be to provide sustained leadership, ensure that the partnership is strong, coordinate protection practices, and allocate resources necessary to implement Strategy recommendations as needed. In the context of the Overarching Goal of minimizing regulations, the Council's function will be to implement educational and voluntary programs. The Council would also ensure meaningful public participation in the decision-making. Any changes in the functionality of the Council will be at the discretion of the Board of Directors. A Watershed Council Director should be hired to staff the Council and ensure implementation of the measures needed to protect lake water quality.

The purpose of the Watershed Council would be to coordinate policy and resource allocations, provide sustained leadership, ensure that the partnership is strong, and adapt practices as needed.

Watershed management should be adaptive—a living process that responds to changing conditions, needs, and information. Instituting a Watershed Council establishes an approach that can adapt to changing needs and will allow current and future issues to be addressed in ways that are both environmentally sound and fiscally responsible. It is an approach in which all stakeholders can pool and coordinate their technical and financial resources to achieve the watershed management goals.

The Beaver Lake Watershed Council could be modeled on the region's existing Illinois River Watershed Partnership, and efforts of the two groups could be coordinated as it makes sense from a policy and cost-savings perspective. The Watershed Council would not have regulatory authority. Rather, it would be a non-profit organization allowing interested parties to work together, carry out mutually beneficial projects, track progress, and make recommendations as needed. It is important to recognize that expert organizations exist that would logically be partners or leaders in specific BMP implementation; the Watershed Council would actively identify and fill gaps in implementation or programming and facilitate the execution of the Protection Strategy.

Potential costs: $200,000 for salary and annual operating expenses for a Beaver Lake Watershed Council and Director, based on profit-and-loss statements from other watershed partnership organizations.

Note: The recommendation of the formation of a watershed council resulted in the development and launch of the Beaver Watershed Alliance in 2011. Hereafter, the group will be referred to as the Beaver Watershed Alliance (or, "the Watershed Alliance" where appropriate).

4.2.2 Component #2 – Core Best Management Practices

EPA Watershed Management Plan Element D: Estimates of Technical/Financial Costs of Implementation – See also Appendix A.

The Core Best Management Practices were screened and evaluated against a large number of potential BMPs and determined to be the most cost-effective in meeting the Goals and Objectives. The Core Voluntary Best Management Practices hinge on a voluntary and targeted land conservation program. They also include improved construction site management, riparian buffer and bank restoration, pasture BMPs, buffer preservation, unpaved road improvements, and stormwater BMP retrofits in developed areas. A number of these voluntary BMPs do "double duty" in reducing sediment and phosphorus loads to the lake and helping to mitigate current sediment loading in the existing impaired streams (West Fork of the White River and Lower White River subwatersheds). Below are descriptions of the core BMPs and where in the watershed it is most important to gain participation from land owners and local governments.

The land conservation program involves conservation easements or conservation agreements achieved through donation or purchase, a voluntary carbon credit program, a voluntary Transfer of Development Rights program, or other voluntary measures.

Land Conservation

The voluntary land conservation program involves conservation easements or conservation agreements. Easements can be achieved through donation or purchase, a voluntary carbon credit program, and/or a voluntary Transfer of Development Rights program. Currently, there are federal and state tax incentives for donating conservation easements on land that meet necessary criteria. Conservation agreements are for a shorter period of time (e.g., 20 years) rather than easements which typically last in perpetuity. There are a number of federal and state programs, particularly agriculture and wildlife programs that provide incentives and financing to purchase easements and enter into conservation agreements.

The City of Fayetteville is exploring development of a Transfer of Developments Rights (TDR) program that could be a model for voluntary land preservation in the watershed. In a TDR program, areas in the watershed are identified where less development is desired (called development rights "sending areas") and areas where more intense development is appropriate (called development rights "receiving areas"). On a market driven, voluntary basis, property owners in the receiving area pay property owners in the sending area for development rights, and transfer those development rights to parcels in the receiving area. The landowner in the sending area can continue to live on and enjoy the use of his or her property, but there can be no additional development on the property in the future beyond that associated with the current use.

A carbon credit program is another way to provide incentives for establishing conservation easements in the watershed. In this program, businesses that need or desire to become more carbon neutral could establish conservation easements on land in the Beaver Lake watershed. A program would need to be established to determine which land should be targeted (e.g., riparian buffer areas, highly erodible lands) and the amount of carbon credit available per acre of conservation easement.

The Environmental Quality Incentives Program (EQIP) and the Conservation Reserve Enhancement Program (CREP) provide incentives and funding for entering into conservation agreements. EQIP is administered by the Natural Resources Conservation Service (NRCS) and CREP is administered by the Farm Service Agency.

In both the conservation easement and conservation agreement programs, there are financial incentives and rewards for businesses and landowners to establish conservation areas. Easements or agreements would prohibit development or any disturbance of vegetation within the easement area while providing the landowner continued use of the property. For conservation easements, successful land conservation will also require stewardship funds set aside for maintaining the easement in perpetuity and covering any legal expenses after the easement has been purchased. Figure 4-1 shows that those lands closest to the lake, in the Beaver Lake subwatershed, have the highest priority for land conservation. Lands in the Lower White and West Fork subwatersheds are also high priority due to TMDL requirements.

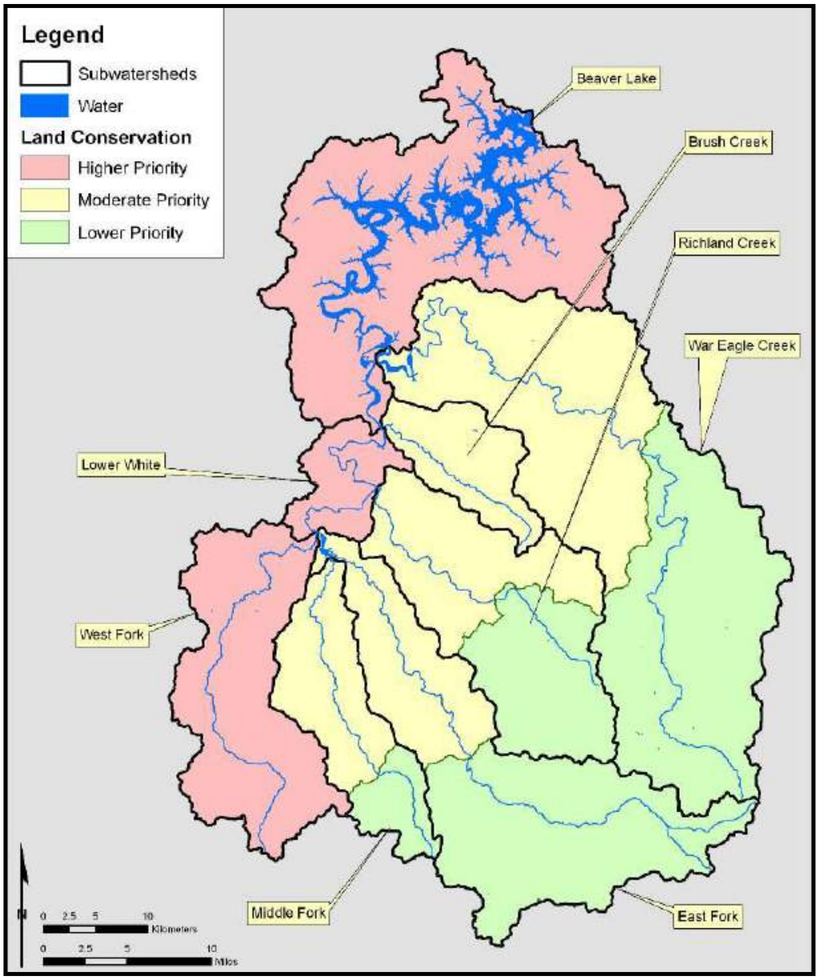


Figure 4-1. Priority Conservation Area

Under the Protection Strategy, cities and counties in the Beaver Lake watershed will enhance their construction oversight programs throughout the areas that drain into Beaver Lake.

Improved Construction Site Management

A key aspect of the Beaver Lake Watershed Protection Strategy will be to address the runoff of sediment and other pollutants from active construction sites as development continues in the lake's watershed. In the built-out areas regulated under the Arkansas Department of Environmental Quality's Stormwater Permit Program, cities and counties with municipal separate storm sewer systems (MS4s) are responsible for overseeing construction sites and implementing measures to prevent water quality degradation to the maximum extent practicable. This responsibility, which is a requirement of their state MS4 Stormwater Permit, will help to address construction site runoff in the MS4 communities in the watershed.

EPA Watershed Management Plan Element C: NPS Management Measures, descriptions, and Critical Implementation Areas

Construction sites with a disturbed area of one acre or more that are not in the ADEQ MS4 permit areas are still subject to regulation under the Arkansas Pollutant Discharge Elimination System (APDES) program for construction sites. Under the approach described in this Protection Strategy, cities and counties in the Beaver Lake watershed will enhance their construction oversight programs throughout the areas that drain into Beaver Lake, to protect long-term drinking water quality and aquatic life. Cities and counties will adopt a consistent set of enhanced measures in their jurisdictions and directly enforce them in their MS4 permit areas. At the option of the local governments, polluting construction sites not in the MS4 area may be subject to city or county enforcement or referred to ADEQ in the event of violations of construction site permit rules. ADEQ has been advised of this approach, and has noted that construction site operators have a number of responsibilities regarding their operations. The following text from the ADEQ statewide permit for construction sites was provided by ADEQ in response to questions about enforcement of erosion, sediment, and stormwater requirements:

> "Responsibilities of the Operator. Permittees with operational control are responsible for compliance with all applicable terms and conditions of this permit as it relates to their activities on the construction site, including protection of endangered species and implementation of BMPs and other controls required by the Stormwater Pollution Prevention Plan (SWPPP). Receipt of this general permit does not relieve any operator of the responsibility to comply with any other applicable federal, state or local statute, ordinance or regulation."

ADEQ also confirmed that local ordinances may go beyond the state's minimum requirements pursuant to protection of Beaver Lake and local stream conditions. The Protection Strategy recommends implementing a program that goes beyond the minimum state standards in two ways:

(1) First, the Strategy recommends that all local governments in the watershed have a local enforcement program, to the extent feasible, even in the non-urbanized area where there is currently state jurisdiction. It is assumed that local governments are enforcing their current regulations to the greatest extent possible, but (some) are not in compliance with the NPDES requirements. It is important to note that enforcement has been an issue for some municipalities, citing a lack of resources and manpower. Where local governments outside the MS4 area cannot take on enforcement, it is recommended that problem sites be identified and referred to the ADEQ for follow-up and possible enforcement. A voluntary construction site monitoring program could help to support local governments in this effort.

The Arkansas Department of Environmental Quality has confirmed that local ordinances may go beyond the State's minimum requirements pursuant to protection of Beaver Lake and local stream conditions.

(2) Second, the Strategy recommends more protective controls than those found in the minimum state requirements. The recommended controls include silt fencing with other controls and sediment basins for all sites that will disturb five acres or more during the construction period, with project phasing and rapid stabilization of bare areas at final grade (i.e., no more than 33 percent of the site bare at any time and stabilization within 10 days of reaching final

grade). Disturbed areas inactive for 14 days would also be stabilized with mulch until grading resumes.

A Construction Site Compliance Assistance Program should be developed that would target all jurisdictions in the Beaver Lake watershed, both MS4 and non-MS4 communities. There are several non-profit watershed partnerships that have instituted similar types of programs. For example, the Upper Chattahoochee River Keepers have the "Get the Dirt Out" program (http://geththedirtout.org), which educated developers and contractors across Georgia on permit requirements and assisted these business owners with compliance issues. The function of the proposed program is to identify gaps between current regulations and on-the-ground practices. The Beaver Lake Watershed Council would own the program and recruit volunteer inspectors. Development and implementation of the Program would include the following:

- Develop inspection protocols and a BMP manual that can be used by local staff and contractors.
- Develop a "Compliance Assistance Inspection Program," and recruit and train volunteer retired engineers and/or others experienced in construction site runoff controls. The volunteer inspectors would inspect construction sites, evaluate the BMPs, report to the contractor any site deficiencies, and provide consultation on how to address the deficiencies.
- The volunteer inspectors acting on behalf of the MS4s should be authorized to conduct inspections of regulated construction sites in the MS4 jurisdiction. Refusal to allow entry of the inspector may constitute grounds for issuance of a warning, a stop work order or monetary fine. The volunteers would supplement the work of existing county and municipal staff.
- Inspections will be conducted under a "compliance assistance inspection" protocol, whereby the inspector identifies conditions that do not comply with construction site stormwater regulations, provides consultation and recommendations regarding compliance approaches, and conducts re-inspections several days later to determine whether or not noncompliant conditions have been addressed. Failure to correct noncompliant conditions may result in a referral to the MS4 and ADEQ for enforcement action, such as a fine or stop work order. The main goal of this program, however, is to be completely transparent in working with developers, contractors, and businesses.
- Inspections will focus on permit documents – stormwater pollution prevention plan, ADEQ notice of permit coverage, inspection reports, local grading/other permits; and a field inspection – drainage system controls (ditches, traps, ponds, etc.), protection measures for slopes and bare areas, and housekeeping controls

A Construction Site Compliance Assistance Program should be developed that would target all jurisdictions in the Beaver Lake watershed.

Volunteer inspectors would inspect construction sites, evaluate the BMPs, report to the contractors any deficiencies, and provide consultation on how to address them.

(rock pad exit, concrete washout, materials storage, fueling areas, etc.).

- Volunteer inspector training would be consistent and coordinated. This training would build on the existing UA education/training program. The inspector training session would last two days. Successful completion of the training would allow the trainee to be added to the list of Certified Volunteer Inspectors. Continuing education would also be provided. The Compliance Assistance Program Administrator would keep the list of certified volunteers up-to-date. The Program Administrator or the local staff could assign the inspectors to sites that need inspections, depending on program inspection implementation in each jurisdiction.

- A Voluntary Contractor Certification Program. Training would be available to familiarize design engineers and contractors with how to prepare the stormwater pollution prevention plans, how to select/install/maintain the controls, how to conduct their inspections, and how to comply with the permit program. In order to get a high participation rate with contractors, it is recommended that the training sessions be held in the winter months, with an 8-hour training event broken into two 4-hour sessions. Incentives for participation could include allowing contractors to advertise as "Certified," working with suppliers of erosion control products to provide discounts to Certified Contractors, and publicly recognizing certified design engineers and contractors and their outstanding projects.

- Draw from the experience of Wal-Mart and the City of Hot Springs, which have existing successful certification programs.

Riparian Buffer and Bank Restoration

Streambank restoration, as considered in this Protection Strategy, involves the conversion of eroded vertical banks to gradually sloping banks, which are then stabilized and vegetated. Streambank restoration is needed to significantly reduce bank and channel erosion rates along streams without bank vegetation; vegetation restoration will also be required to maintain the stability of the restored banks. Restoration of vegetation will also provide nutrient and sediment removal from upland runoff. The vegetation restoration is termed "riparian buffer restoration" because vegetation would be restored in riparian areas (land near streams) that provide a protective buffer for streambanks and water quality. Priority areas for riparian buffer and bank restoration are shown in Figure 4-2. The streams colored red currently have impacted buffers. Impacted buffers are defined as having less than 30 percent vegetation (such as trees and wild shrubs) along the stream (Roy, 2005). The streams closest to the lake and existing impaired streams have the highest priority for restoration because

EPA Watershed Management Plan Element E: Education and Information Component

Training would be available to familiarize design engineers and contractors with how to comply with construction site requirements.

EPA Watershed Management Plan Element C: NPS Management Measures, Descriptions, and Critical Implementaion Areas

Streambank restoration involves the conversion of eroded vertical banks to gradually sloping banks, which are then stabilized and vegetated.

they are most effective in meeting lake protection and TMDL requirements.

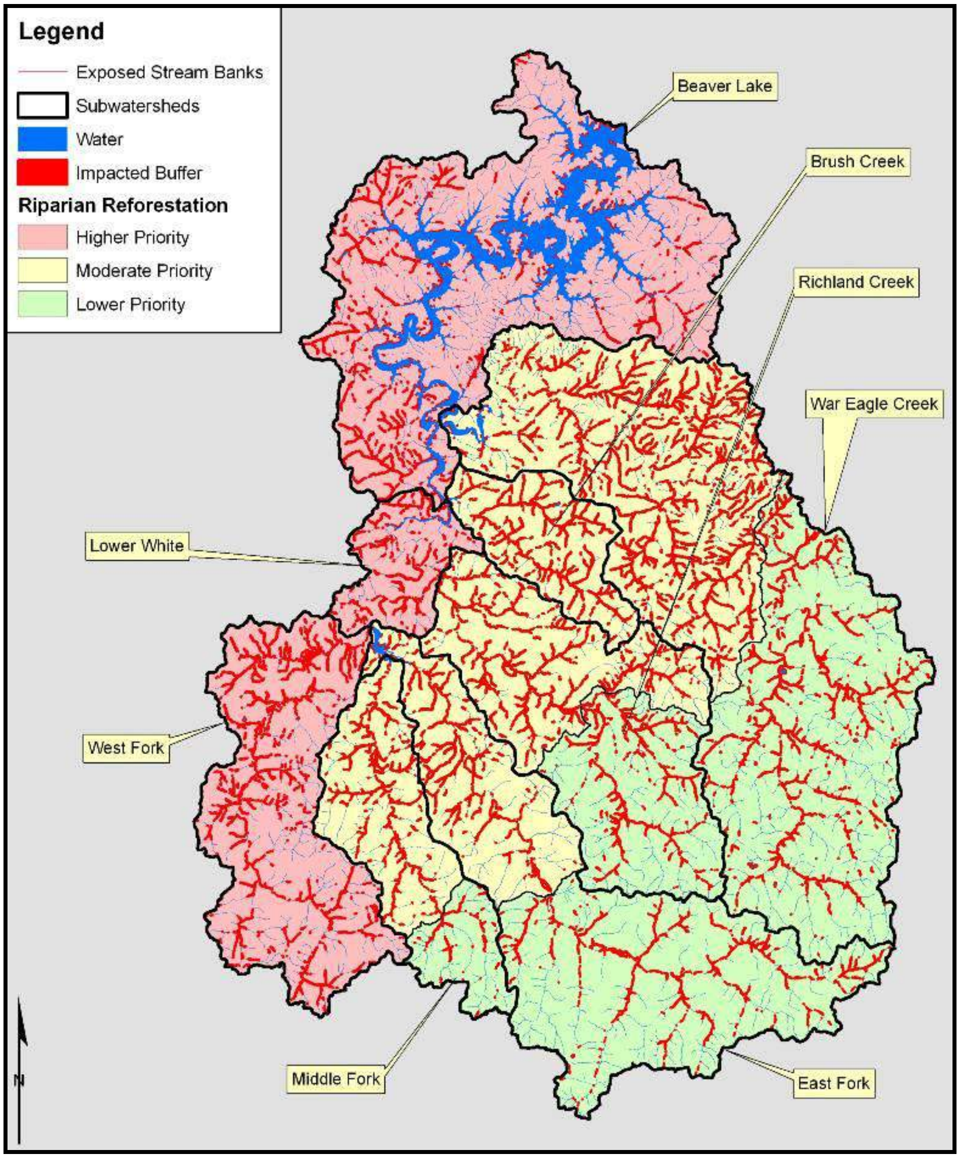


Figure 4-2. Riparian Reforestation and Restoration Priority

Pasture Management BMPs

Cattle manure can be a source of nutrient and bacteria loading to streams, particularly where direct cattle access is not restricted and/or where cattle feeding structures are located adjacent to riparian areas. Direct deposition of feces into streams may be a primary mechanism of pollutant loading during baseflow periods. During storm events, overbank and overland flow may entrain manure accumulated in riparian areas, resulting in pulsed loads of nutrients and other pollutants. In addition, cattle with unrestricted stream access typically cause severe streambank erosion. Recommended pasture BMPs involve excluding cattle from streams using fencing,

EPA Watershed Management Plan Element C: NPS Management Measures, Descriptions, and Critical Implementation Areas providing an alternative water source, and providing stream crossings where necessary.

Recommended pasture BMPs involve excluding cattle from streams, providing alternative water sources, providing stream crossings, and pasture renovation.

Pasture renovation can also be a cost-effective strategy to reduce nutrient and sediment loading from pastures. Pasture renovator equipment uses large spikes (found in various shapes and sizes) to create many small indentions in the ground that hold water and nutrients. Pasture areas along slopes leading to surface waters and pasture streamside zones are high priority areas for treatment by the renovator. This practice produces multiple benefits to forage growth and water quality. The green areas highlighted in Figure 4-3 show the existing agricultural areas in the watershed, with the Beaver Lake, Lower White, West Fork, and War Eagle Creek watersheds having the priority for pasture management BMPs.

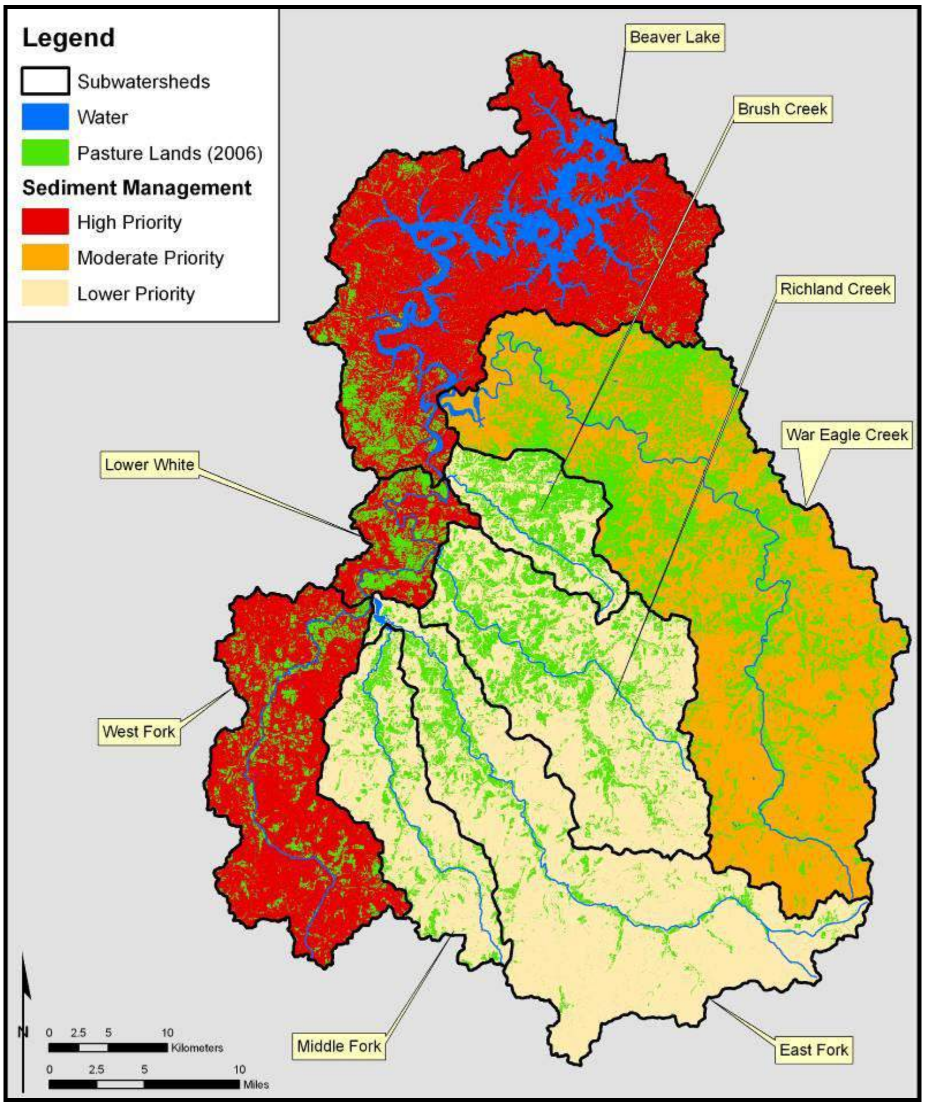


Figure 4-3. Pasture Management Priority Areas

Buffer Preservation

Like riparian buffer restoration, preservation of existing riparian buffers will help maintain the existing stability of streambanks and provide pollutant removal from upland runoff. The preservation of riparian buffers involves voluntary protection and/or the purchase of a conservation easement/agreement, which prohibits development or any disturbance of vegetation in the riparian area, while providing the landowner continued use of the property. Successful preservation may also require stewardship funds set aside for maintaining the easement in perpetuity and covering any legal expenses after the easement has been purchased. The priority areas for buffer preservation are the same as those for land conservation (Figure 4-1).

Preservation of riparian buffers involves the voluntary protection and/or purchase of conservation easements, which prohibits development or disturbance of vegetation on a property along the stream.

Unpaved Road Improvements

EPA Watershed Management Plan Element C: NPS Management Measures, Descriptions, and Critical Implementation Areas

Studies nationally and in Arkansas have documented that roads can be a major source of sediment and associated pollutant loading through both direct and indirect means. Unstabilized roadside ditches are often a significant source of sediment load. In addition, unpaved roads are a major direct source of sediment loading including fine sediment that leads to elevated turbidity in Beaver Lake and its tributary streams. Traffic continuously grinds the bed material of unpaved roads, resulting in a source of fine sediment that may be washed off or eroded by storms. Paving the road surface reduces direct erosion, but can still result in large sediment loads as runoff from paved roads generates high energy flows that can erode road margins and ditches.

The Beaver Lake Watershed Protection Strategy recommends several types of improvements to unpaved roads. These include wing ditches and turnouts that direct runoff from the road into undisturbed (vegetated) areas, hydroseeding ditches, and stabilizing stream crossings. Culverts should also be installed at regular intervals that pass drainage from adjacent land underneath roads and reduce stormwater flow passing across road surfaces. The black lines in Figure 4-4 indicate unpaved roads in the watershed, with the Beaver Lake, Lower White and West Fork subwatersheds having the highest priority for road improvements. Beaver Lake subwatershed is critical to reducing existing loading to the lake. Improvements in the Lower White and West Fork are important to helping meet TMDL requirements.

The Protection Strategy recommends several types of improvements to unpaved roads: wing ditches and turnouts, hydroseeding ditches, and stabilizing stream crossings.

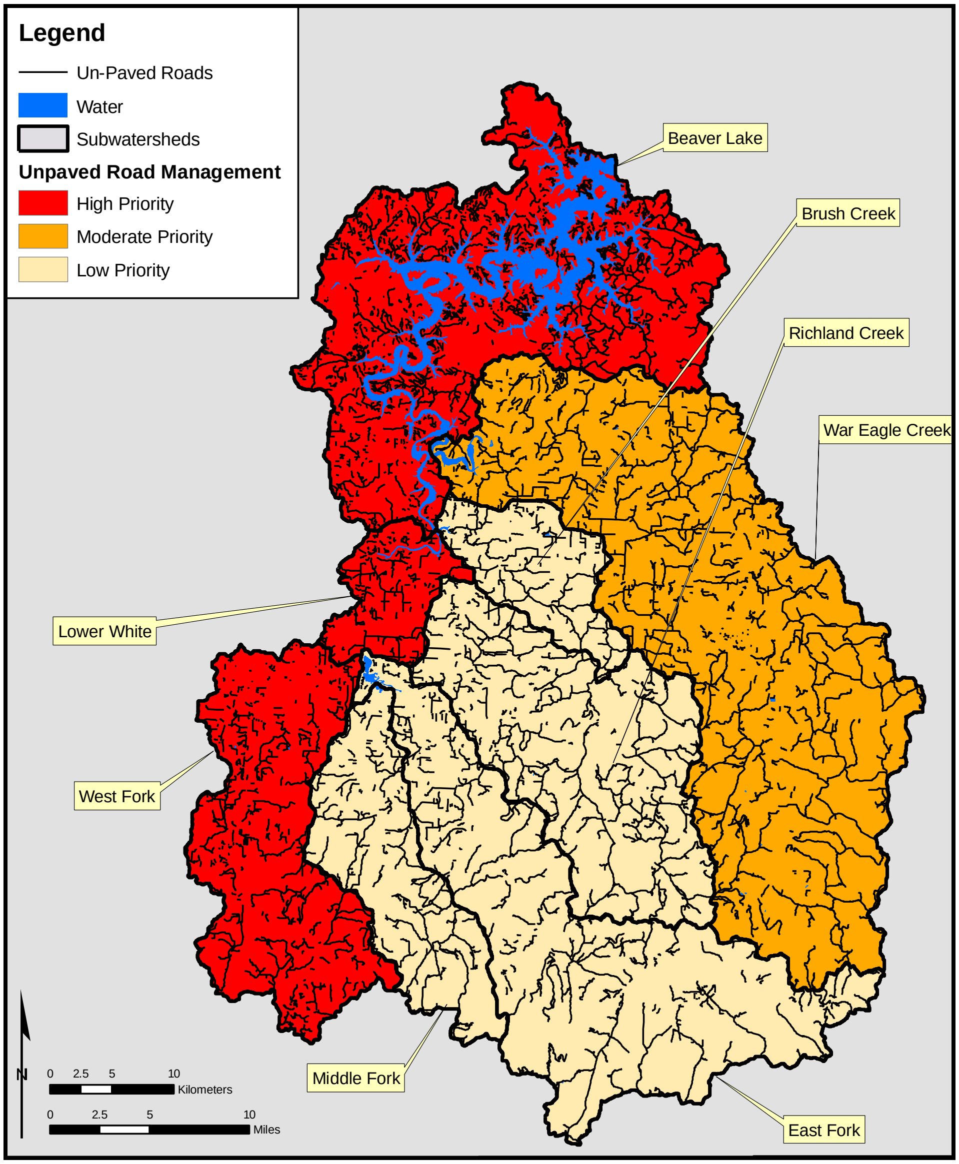


Figure 4-4. Unpaved Road Improvement Priorities

Stormwater BMP retrofits would include retrofitting existing stormwater ponds to improve pollutant removal and stormwater volume control. They also involve construction of new stormwater facilities to control and treat runoff from existing development.

Stormwater BMP Retrofits

Implementation of additional stormwater BMPs would include retrofitting existing stormwater ponds to improve pollutant removal and provide additional volume and peak control. Retrofit projects would also involve the targeted construction of new stormwater facilities to treat and control runoff from existing development. New stormwater facilities may include wet detention, dry detention, stormwater wetlands, bioretention, or other similar facilities. Drainage areas in the existing impaired watersheds (West Fork and Lower White) with high percentages of impervious area should

EPA Watershed Management Plan Element C: NPS Management Measures, Descriptions, and Critical Implementation Areas be prioritized for BMP retrofits, especially if these drainage areas lack stormwater treatment and control facilities (see orange and red areas in Figure 4-5).

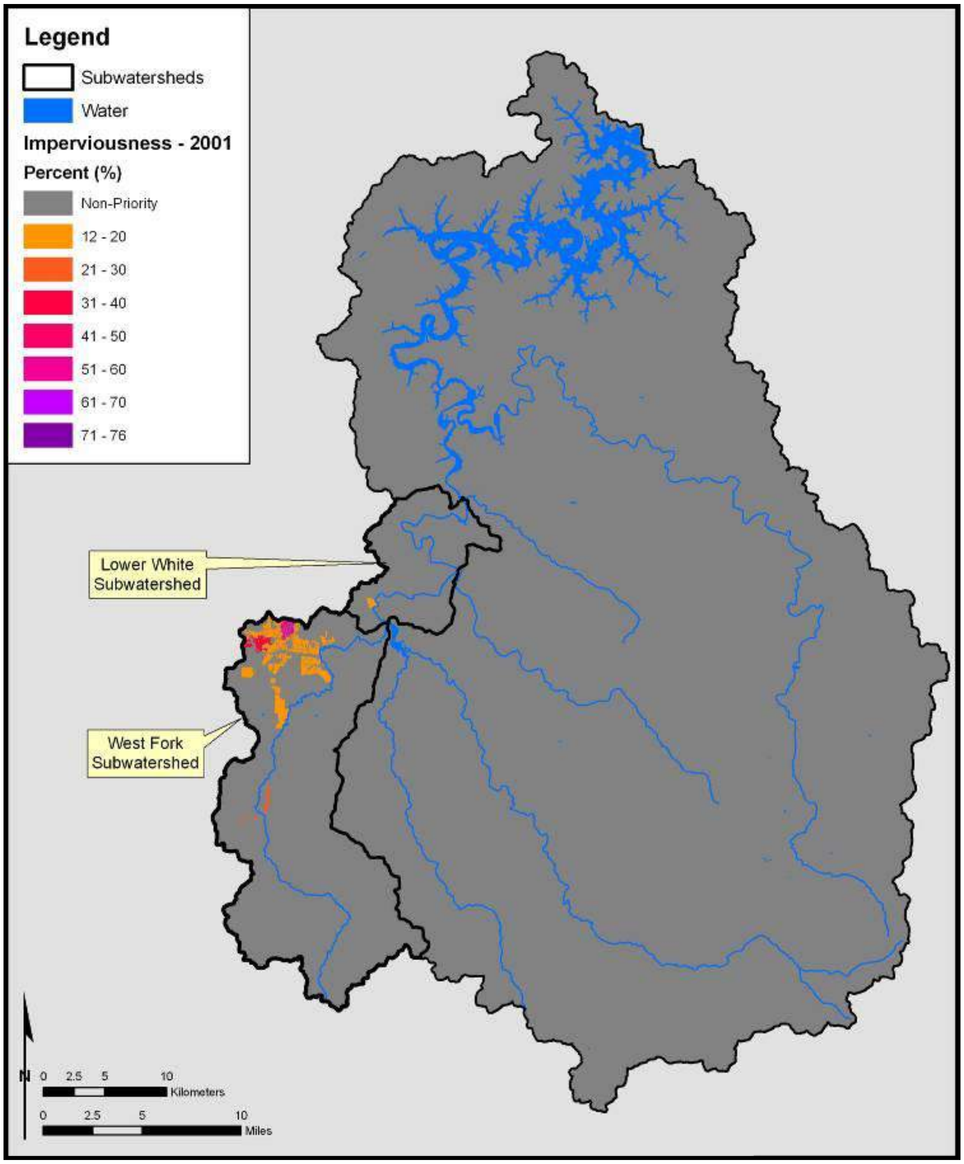


Figure 4-5. Stormwater BMP Retrofit Priority Areas

Table 4-1 shows the minimum BMPs and total load reductions associated with this Protection Strategy. Note that these core BMPs could be implemented over the next 40 years. Other BMPs may be substituted for portions of the core BMPs. For example, if it is difficult to achieve the participation rate for conservation easements/agreements, then additional acres of pasture renovation or other practices on the core BMP menu could be targeted.

The potential cost for Core BMPs is $15 million annualized, using a combination of local pricing sources and national cost averages (see

"Management Options Cost Effectiveness, Phase 1 and Phase 2"). However, a significant portion of this cost is associated with meeting existing ADEQ requirements, such as construction site stormwater management and TMDLs. Appendix A provides details on the cost-per-unit and the cost-effectiveness of each BMP.

Table 4-1. Core Voluntary BMPs and Estimated Total Sediment and Phosphorus Load Reduction (by 2055; methodology here)

BMP	Land Area Assumed to Participate in BMP Program	Reduction in Future Sediment Load to Lake
Land Conservation Program – Existing Pasture	7,930 acres	3,920 tons/year
Land Conservation Program – Existing Forest	12,810 acres	6,760 tons/year
Improved Construction Site Management	1,060 acres per year	3,440 tons/year
Buffer/Bank Restoration in Developed Areas Non-lakefront (non-pasture land uses)	410,100 feet of stream	2,800 tons/year
Pasture Buffer/Bank Restoration Non-lakefront	94,450 feet of stream	620 tons/year
Alternative Water Source and Fencing	8,670 acres	220 tons/year
Pasture Renovation	41,040 acres	3,450 tons/year
Buffer Preservation, Non-lakefront (developed areas)	1,446,490 feet of stream	1,150 tons/year
Unpaved Road Improvements	680 miles of road	810 tons/year
Stormwater BMP Retrofits	990 acres	280 tons/year
Estimated Total Reduction in Sediment Load	**23,450 tons/year**	
Estimated Total Reduction in Phosphorus Load	**14,780 lbs/year**	

Table 4-2 compares existing conditions to predicted water quality conditions in the future if the core BMPs are implemented. The modeling results show that Total Suspended Solids (TSS) concentrations are slightly higher in the upper portion of the lake (stations L1 – L3) and that the corresponding chlorophyll *a* concentrations are predicted to be the same or slightly lower (due to slightly lower light availability affecting chlorophyll *a* production). Middle Lake main stem conditions are expected to be about the same as existing conditions under these core BMPs, whereas Lower Lake chlorophyll *a* concentrations are expected to increase slightly.

Table 4-2. Predicted Lake Water Quality Indicators Under Existing Conditions and Future Core BMPs

Modeled Scenario: Indicator	Upper Lake Stations				Mid Lake Station	Lower Lake Station
	L1	L2	Hickory Creek	L3	L4	L5
Existing Conditions: TSS (mg/L) [1]	16.7	7.8	4.7	4.5	3.8	2.4
Future BMPs: TSS (mg/L) [1]	17.4	8.1	4.7	5.8	3.8	2.4
Existing Conditions: Chl *a* (µg/L) [2]	3.2	8.3	6.3	6.1	4.9	2.7
Future BMPs: Chl *a* (µg/L) [2]	3.2	6.7	6.3	5.8	4.9	3.1

[1] Modeled growing season average concentration
[2] Modeled growing season geometric mean concentration

Given these results, how well do the core BMPs in this alternative meet the lake water quality objectives? Table 4-3 summarizes the estimated protection levels. Tetra Tech recommended lake water quality targets and benchmarks at the Hickory Creek station based on the findings of the ADEQ Technical Work Group of regional water quality experts. Modeling results for the main stem of the mid and lower lake segments indicate that water supply and recreational objectives would be met in the main stem under this alternative, given the limited change expected from existing conditions.

The core voluntary BMPs would enable communities to meet the water supply and recreational objectives in the main stem of the lake.

Protection of the mid and lower lake areas below the Hickory Creek station is less clear regarding meeting recreational objectives in the small tributary and cove areas. The roughly 12 percent increase in both sediment and phosphorus is likely to manifest itself in the small tributaries and coves, which may, in turn, result in more turbid waters in these cove areas immediately following storm events, followed by more algae growth as sediment settles to the bottom of the water column. Some additional algae growth may be considered desirable for fishing use, whereas too much turbidity and algae might detract from other recreational uses (e.g., canoeing and lakeshore viewing). The lake model is not calibrated for the tributary coves so magnitude of impact in these portions of the lake cannot be analyzed reliably at this time. Thus, Table 4-3 shows a range reflecting this localized uncertainty.

The lake model is not calibrated for the tributary coves in the mid and lower lake areas. Recreational impacts in these cove areas cannot be analyzed reliably at this time.

The core BMPs also support meeting ADEQ TMDL requirements for the West Fork and Lower White watersheds. Appendix B provides more detail on BMPs recommended and sediment reduction achieved for each watershed. It also demonstrates how this Protection Strategy meets EPA's nine minimum elements for watershed plans for impaired waters. This is essential for securing funding for projects under EPA's 319 grant program.

Because there is some uncertainty regarding planning and modeling projections, additional protection measures are recommended in the final three components of the Protection Strategy.

Table 4-3. How Well do the Core BMPs Meet Lake Water Quality Objectives?

Lake Area	Water Supply	Recreation
Upper Lake (Hickory Creek)	●	●
Mid and Lower Lake	●	◐ - ●

Key to Symbols:
- ● Protection of Objectives Expected
- ◐ Protection of Objectives Uncertain
- ○ Protection of Objectives Not Expected

Where can I find more information about the cost and cost-effectiveness of BMPs?

– Management Option Cost-Effectiveness Phase I, March 13, 2009, Tetra Tech

– Management Option Cost-Effectiveness Phase II, March 20, 2009, Tetra Tech

– Appendix A

4.2.3 Component #3 – Developer and Contractor Lake Protection Certification Program (for all communities and developers willing to participate)

Tetra Tech recommends that, to the extent practicable, channel protection dry detention basins or Low Impact Development techniques be used for all new development in the Municipal Planning Area with imperviousness that is 12 percent or greater.

The Center for Watershed Protection reports those watersheds with 10 percent or more impervious area exhibit degradation of stream conditions. Other studies have shown degradation of streams at imperviousness levels as low as 5 to 6 percent. To help mitigate post-construction stormwater impacts from new development, Tetra Tech is recommending that, to the extent practicable, channel protection dry detention basins or Low Impact Development techniques be used for all new development in the Beaver Lake Watershed Municipal Planning Areas (see Figure 4-6) with imperviousness that is 12 percent or greater. This would include new commercial and industrial development and subdivisions with lots of 1 acre or less per house. Appendix C provides cost information regarding implementation of channel protection basins and LID for different types of development. Ideally, design standards for new construction would require that stormwater flows from developed areas would not exceed preconstruction characteristics.

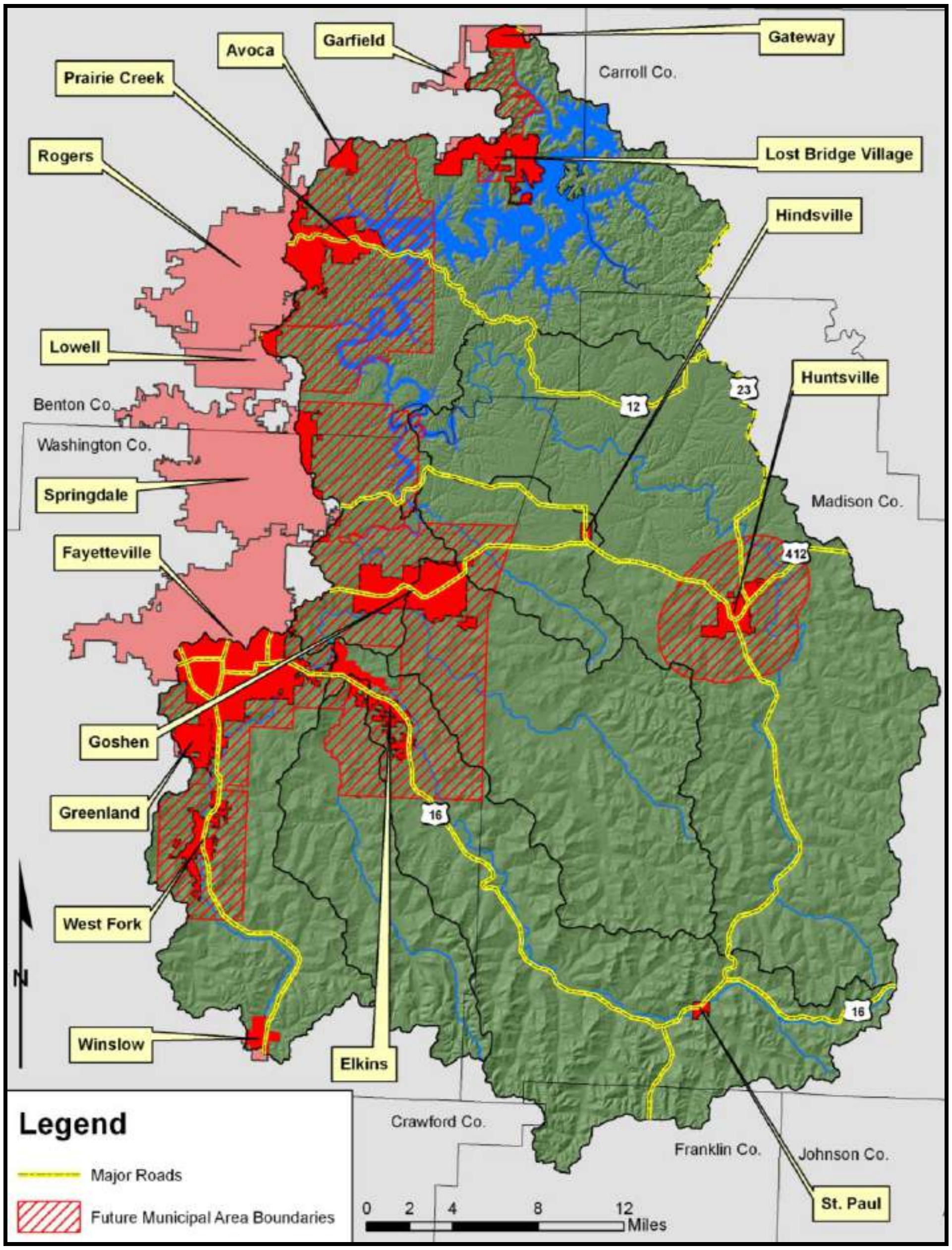


Figure 4-6. Priority Area for Lake Protection Certification Program – Planned Municipal Area

Management of post-construction stormwater runoff could be accomplished through a Developer and Contractor Lake Protection Certification Program.

Management of post-construction stormwater runoff could be accomplished though a Developer and Contractor Lake Protection Certification Program. Local governments, site design engineers, developers, and contractors who are willing and able to participate in the program would sign a Lake Protection Pledge. To help meet the pledge, the Beaver Lake Watershed Council and University of Arkansas-Fayetteville (UA-Fayetteville) could implement a Stormwater Compliance Assistance Program, which is educational in nature and includes a volunteer-driven outreach effort. Similar to the Construction Site Management Compliance Assistance Program described above, the components of the Post-Construction Stormwater Compliance Assistance Program would include:

- Development of site design standards, inspection protocols, and a channel protection/LID BMP manual that can be used by local staff, developers, and contractors. The site design standards would seek to eliminate or minimize increases in stormwater flow and pollutant runoff from newly developed and redeveloped sites. Note that UA-Fayetteville has received a grant to develop a LID Manual for NW Arkansas.

- Training local staff in participating local governments on how to review plans for new development and redevelopment in order to calculate stormwater flow and projected pollutant runoff from the site.

Local governments, site design engineers, developers, and contractors who are willing and able to participate would sign a Lake Protection Pledge.

- Development of a “Compliance Assistance Inspection Program,” recruiting and training volunteer retired engineers. The volunteer engineers would inspect installation of channel protection dry detention basins and LID BMPs and report to the contractor any site deficiencies. The volunteer engineers would also conduct routine inspections of channel protection basins and LID BMPs to ensure long-term maintenance. The volunteers would supplement the work of existing staff.

EPA Watershed Management Plan Element E: Education and Information Component.

- BMP installation inspections will be conducted under a “compliance assistance inspection” protocol, whereby the inspector identifies conditions that do not comply with the BMP manual or the site permit, provides consultation and recommendations regarding compliance approaches, and conducts re-inspections to determine whether or not noncompliant conditions have been addressed. Prolonged failure to correct noncompliant conditions may result in decertification in the Lake Protection Certification Program for the developer and/or contractor.

- Routine post-construction BMP inspections would also be conducted under a compliance assistance inspection protocol, whereby the volunteer inspector checks for routine maintenance and proper functioning of the BMP, provides recommendations to the homeowners’ association or other responsible BMP owner/operator, and conducts re-inspections to determine whether noncompliant conditions have been addressed. Prolonged failure to correct noncompliant conditions may result in a referral to participating local government.

- Volunteer Inspector training would be consistent and coordinated. This training would build on the existing UA-Fayetteville education/training program and be coordinated through the University and Beaver Lake Watershed Council. The training session would last two days. Successful completion of the training would allow the trainee to be added to the list of Certified Volunteer Inspectors. Continuing education would also be provided. The Compliance Assistance Program administrator would keep the list of certified volunteers up-to-date. The Program Administrator or the local staff could assign the inspectors to sites that need inspections.
- Develop a Voluntary Contractor Certification Program. Training would be available to familiarize design engineers and contractors with how to select/design/install/maintain channel protection and LID BMPs. It is recommended that the sessions be held in the winter months, with an 8-hour training event broken into two 4-hours sessions. To provide incentives to participate, the Program would allow contractors to advertise as "Lake Protection Certified," work with suppliers of BMP construction products to provide discounts to Certified Contractors, and publicly recognize certified design engineers and contractors and their outstanding projects. One example of a program that recognizes outstanding development projects is the Lower Cape Fear Stewardship Development program in North Carolina, which awards two levels of recognition for development projects that protect water quality and other natural resources (www.stewardshipdev.com).

Building on existing education programs, an outreach program should be established to educate landowners about lake protection efforts and how they can participate.

It is estimated that a regional Developer and Contractor Lake Protection Certification Program would have a startup cost of approximately $66,000 and recurring annual cost of approximately $35,000.

4.2.4 Component #4 – Education and Stewardship Program

EPA Watershed Management Plan Element E: Education and Information Component – See Section 4.2.4 #4.

Building on existing educational programs, an outreach program should be established to educate landowners about the lake protection efforts and how they can participate. This should include reaching out to landowners and businesses in the priority watersheds for land conservation, buffer/bank restoration, buffer preservation, and pasture BMPs. The message should stress that "doing it for the lake" also protects your local streams, and helps maintain a high quality of life for the region. Other messages might include "Protect Your Private Property – Keep Your Land Out of the Lake!" and "White River ♥s Green Buffers."

In addition, there are "good housekeeping" practices that should be encouraged for all homeowners including proper fertilizing of lawns, maintenance of septic systems (and use of enhanced onsite wastewater systems for new development), and maintaining vegetation along streams.

4.2.5 Component #5 – Monitoring and Adaptive Management

The Beaver Lake Watershed Protection Strategy was developed based on historical monitoring data for the watershed and lake, projections of future development through the year 2055, and modeling that predicted the watershed processes and lake responses to that new development. While monitoring data provide information on current conditions, we cannot monitor future conditions in advance of when they occur – for prediction of future conditions we rely on models. There is uncertainty in all long-range growth projections and in modeling, and conditions change: new water quality protection technologies will emerge, climate conditions may change, and lake water quality may improve or decline. Historical and ongoing monitoring efforts provide critical information in characterizing the current stressors and impacts within the Beaver Lake watershed. However, additional monitoring and assessment efforts are needed to protect Beaver Lake's water supply and recreation in the coming decades. This Strategy recommends an annual formulation and evaluation of programs at the organizational level for the Watershed Alliance and participating stakeholder organizations, along with a five-year cycle of adaptive management as Strategy implementation occurs. Monitoring can occur either continuously or at the end of a management cycle, depending on resources and funding.

Additional monitoring and assessment efforts are needed to protect Beaver Lake's water supply and recreation in the coming decades.

EPA Watershed Management Plan Element I: Monitoring of Implementation Efforts and Their Efficacy

It is important a long-term monitoring program exists to provide a technical foundation for an adaptive management process. As a part of the iterative adaptive management approach, Tetra Tech recommends several types of additional monitoring to serve as early warning indicators:

- *Water Quality Monitoring.* Are water quality targets being met at the Hickory Creek station? Monitoring should be conducted at the Hickory Creek station, which was chosen by the Technical Workgroup as an early warning indicator site for the Beaver Water District water supply and the rest of the lake. In addition, studies have determined that there is potential for significant loading of sediment and phosphorus from the Beaver Lake subwatershed downstream from the Hickory Creek station, which could pose threats to recreational uses and water supplies in the mid and lower lake areas.

  As of Spring 2012, there are 46 monitoring stations located throughout the watershed (Table 4-4); while these stations do not all monitor every parameter necessary to detect changes in water quality with program implementation, the list collectively

There is uncertainty in all long-range growth projections and in modeling. Also, conditions change.

represents a level of monitoring that may be helpful in evaluating program and BMP impact.

Table 4-4. Water Quality Monitoring Stations on the Beaver Lake Watershed

Count	Station ID	Description	Latitude	Longitude	Host Agency	Funding Source	Monitoring Type	Monitoring Frequency
1	BUFET003	Hock Creek near Wesley, Arkansas	36.0223	-93.8602	ADEQ	ADEQ	Water Quality	6 times/year
2	BUFS702	Hurricane Cave Spring	36.0547	-93.9333	ADEQ	ADEQ	Water Quality	6 times/year
3	LWHI009A	Lake Sequoyah near dam	36.0658	-94.0667	ADEQ	ADEQ	Water Quality	6 times/year
4	LWHI013B	Beaver Lake near War Eagle Park	36.2088890 1	-94.01583099	ADEQ	ADEQ	Water Quality	6 times/year
5	LWHI013C	Beaver Lake near Hwy. 12 Access - upper site	36.3333168	-94.01785278	ADEQ	ADEQ	Water Quality	6 times/year
6	WHI0051	West Fork White River east of Fayetteville, Arkansas	36.053889	-94.083056	ADEQ	ADEQ	Water Quality	6 times/year
7	WHI0052	White River near Goshen, Arkansas	36.106	-94.0114	ADEQ	ADEQ	Water Quality	6 times/year
8	WHI0070	Holman Creek below Huntsville, Arkansas	36.1248	-93.7339	ADEQ	ADEQ	Water Quality	6 times/year
9	WHI0098	West Fork White River at Co. Rd. 240 above Dye Creek	35.9422	-94.1853	ADEQ	ADEQ	Water Quality	6 times/year
10	WHI0101	Middle Fork White River at Co. Rd. 1-1/2 mi. NW of Hazel Valley	35.86938	-94.01097	ADEQ	ADEQ	Water Quality	6 times/year
11	WHI0102	Middle Fork White River at Co. Rd. Bridge 1 mi. S of Sulfphur City	35.95147	-94.05894	ADEQ	ADEQ	Water Quality	6 times/year
12	WHI0103	Middle Fork White River southwest of Elkins, Arkansas	36.0142	-94.0644	ADEQ	ADEQ	Water Quality	6 times/year
13	WHI0105	White River at Co. Rd. near Crosses, adjacent to AR Hwy 16	35.8778	-93.9083	ADEQ	ADEQ	Water Quality	6 times/year
14	WHI0106	White River at Durham, Arkansas	35.9561	-93.9769	ADEQ	ADEQ	Water Quality	6 times/year
15	WHI0109	Richland Creek at Co. Rd. 1-1/4 mi. N of AR Hwy 74 near Tuttle	36.0483	-93.9728	ADEQ	ADEQ	Water Quality	6 times/year
16	WHI0112	Brush Creek off AR Hwy 303	36.1336	-93.9519	ADEQ	ADEQ	Water Quality	6 times/year
17	WHI0113	War Eagle Creek at Co. Rd. bridge 1/4 mi. W of Ar Hwy 23	36.0069	-93.7111	ADEQ	ADEQ	Water Quality	6 times/year
18	WHI0114	War Eagle Creek at AR Hwy 412	36.1214	-93.695	ADEQ	ADEQ	Water Quality	6 times/year
19	WHI0116	War Eagle Creek at Hwy. 45	36.2017	-93.8569	ADEQ	ADEQ	Water Quality	6 times/year
20	RC45	Richland Creek at Goshen, AR	36.104167	-94.0075	AWRC	ANRC 319	Water Quality	46 times/year

Count	Station ID	Description	Latitude	Longitude	Host Agency	Funding Source	Monitoring Type	Monitoring Frequency
21	TB 16	Town Branch Trib at Hwy 16 at Fayetteville, AR	36.098333	-94.162222	AWRC	ANRC 319	Water Quality	46 times/year
22	TB 62	Town Branch at BR 62 at Fayetteville, AR	36.056944	-94.176111	AWRC	ANRC 319	Water Quality	46 times/year
23	WEC	War Eagle Creek near Hindsville, AR	36.2017	-93.8569	AWRC	ANRC 319	Water Quality	46 times/year
24	WFWR	West Fork White River east of Fayetteville, AR	36.053889	-94.083056	AWRC	ANRC 319	Water Quality	46 times/year
25	WR45	White River near Fayetteville, AR	36.073056	-94.081111	AWRC	ANRC 319	Water Quality	46 times/year
26	BWD 05	White River at Elkins, AR	36.000783	-94.003992	BWD	BWD	Water Quality	Monthly
27	BWD 07	MF White River at Black Oak, AR	35.995739	-94.072739	BWD	BWD	Water Quality	Monthly
28	BWD 09	War Eagle Creek at War Eagle, AR	36.267628	-93.943444	BWD	BWD	Water Quality	Monthly
29	BWD 10	White River Near Fayetteville, AR	36.073056	-94.081111	BWD	BWD	Water Quality	Monthly
30	BWD 12	Pond Overflow East of Parson's Landfill	36.181167	-94.049417	BWD	BWD	Water Quality	Monthly
31	BWD 13	White River near Wyman, AR	36.087806	-94.069806	BWD	BWD	Water Quality	Monthly
32	BWD 15	War Eagle Creek near Huntsville, AR	36.121569	-94.694111	BWD	BWD	Water Quality	Monthly
33	BWD 16	WF White River near Fayetteville, AR	36.053889	-94.083056	BWD	BWD	Water Quality	Monthly
34	BWD 17	Nelson Hollow at Rogers Group Lowell Quarry	36.22775	-94.075167	BWD	BWD	Water Quality	Monthly
35	USGS 07048480	Town Branch at BR 62 at Fayetteville, AR	36.056944	-94.176111	USGS	City of Fayetteville	Discharge	Instantaneous
36	USGS 07048490	Town Branch Trib at Hwy 16 at Fayetteville, AR	36.098333	-94.162222	USGS	City of Fayetteville	Discharge	Instantaneous
37	USGS 07048550	West Fork White River east of Fayetteville, AR	36.053889	-94.083056	USGS	ANRC, ADEQ, OWW	Discharge	Instantaneous
38	USGS 07048600	White River near Fayetteville, AR	36.073056	-94.081111	USGS	US ACE Little Rock, BWD, ANRC	Discharge	Instantaneous
39	USGS 07048800	Richland Creek at Goshen, AR	36.104167	-94.0075	USGS	BWD, OWW	Discharge	Instantaneous
40	USGS 07049000	War Eagle Creek near Hindsville, AR	36.2017	-93.8569	USGS	UA ACE Little Rock, BWD	Discharge	Instantaneous

Count	Station ID	Description	Latitude	Longitude	Host Agency	Funding Source	Monitoring Type	Monitoring Frequency
41	USGS 7048910	Beaver Lake at HWY 412 Bridge near Sonora	36.103889	-94.007222	USGS	BWD	Water Quality	6 times/year
42	USGS 7049160	White River at Beaver Dam near Eureka Springs	36.420833	-93.847222	USGS	BWD	Water Quality	6 times/year
43	USGS 7049187	Beaver Lake ds Hickory Ck Landing nr Springdale,AR	36.250278	-94.026333	USGS	USGS, BWD	Water Quality	6 times/year
44	USGS 7049200	Beaver Lake near Lowell	36.259167	-94.068889	USGS	USGS, BWD	Water Quality	6 times/year
45	USGS 7049500	Beaver Lake @ Hwy 12 bridge near Rogers, AR	36.332222	-94.018889	USGS	USGS, BWD	Water Quality	6 times/year
46	USGS 7049690	Beaver Lake near Eureka Springs, AR	36.420833	-93.847222	USGS	USGS, BWD	Water Quality	6 times/year

A group of experts should be organized to identify other appropriate monitoring locations, review data on a regular basis, and develop recommended criteria (as needed to go beyond that recommended at the Hickory Creek and L3 stations). The group's responsibilities would include the determination of appropriate water quality "triggers" for the mid and lower portions of the lake (to go along with the benchmarks and targets already recommended for the upper lake) that would stimulate implementation of an adapted protection strategy, which could include enhanced oversight of development projects, advanced wastewater treatment, and focused promotion of lake-friendly lawn and property management practices.

It should be noted that in 2008, the Arkansas Department of Environmental Quality listed the White River, segment 11010001-27, and the War Eagle Creek, segment 11010001-34, as not supporting the drinking water supply designated use because of Beryllium (ADEQ, 2008 Integrated Water Quality Monitoring and Assessment Report). The White River was previously listed for the same pollutant in 2004 and 2006. The War Eagle Creek had been previously listed in 2006. At the time, the source of the Beryllium was not known. Starting with the 2010, and continuing into the 2012 draft 305(b) report, Beryllium was no longer identified as a source of impairment for any stream segments tributary to Beaver Lake. The State continues to monitor stream segments for Beryllium. Should segments in the Beaver Lake watershed re-appear on future section 305(b) reports, a management plan for that pollutant will be developed.

EPA Watershed Management Plan Element I: Monitoring of Implementation Efforts and Their Efficacy

- *Observational monitoring.* Are there increasing frequencies of algae blooms, sediment plumes, and/or beach closings in the upper lake and lower lake cove areas? If so, monitoring personnel would track upstream to identify sources of the problem. Are stream channels widening and deepening in urbanizing areas and are sediment islands forming instream? This information would also be fed into the Watershed Council to determine if the current protection strategy needs to be adapted.
- *Programmatic Monitoring for Core BMPs.* Are core BMP and other voluntary participation programs working as anticipated? Are landowners participating in conservation and stewardship programs at levels anticipated in the Beaver Lake Watershed Protection Strategy? Are developers and local governments participating at a high rate in the Beaver Lake protection efforts, installing stormwater and channel protection controls on construction sites and new development areas?

These early warning indicators, used together, would indicate when the lake's protection targets are not being met and voluntary efforts are not sufficient, and determine when the Protection Strategy needs to be adjusted. These efforts would be part of the Council's adaptive process for management of the watershed.

Early warning indicators would indicate when the lake's protection targets are not being met and voluntary efforts are not sufficient, and determine when the Protection Strategy needs to be adjusted.

Citizen- and volunteer-level programs may play an increasing role in water quality monitoring. For example, Beaver Lake Secchi Day, which is organized by the Beaver Water District, provides invaluable turbidity data on the lake. It is both an important monitoring tool and community engagement effort. Furthermore, in 2012 a voluntary citizen science based monitoring program will launch that will increase the extent and frequency of water quality monitoring in the Beaver Lake Watershed. This program, called *StreamSmart*, was developed by the Beaver Water District, Audubon Arkansas, and the Arkansas Water Resources Center (AWRC). The steering committee also includes the newly formed Beaver Watershed Alliance. The goal of the program is to eventually gather seasonal data on water quality at an additional 30 locations throughout the watershed. Citizen volunteers will undergo training and then collect data at predetermined monitoring sites. Data and samples will be analyzed by the AWRC. Quality assurance protocols include data quality verification through random duplicate sampling by the AWRC staff.

Section 5

Implementation Summary

There is much work to do and success will depend on many agencies, community leaders, and landowners.

The Protection Strategy is not a new law or regulation. It depends on enforcing existing regulations and/or voluntary actions hinging on good stewardship.

5.1 Overall Prioritization of Subwatersheds

Subwatershed prioritization for sediment, nutrients, and recommended BMPs has been described above in the Protection Strategy. While it is clear that partnering organizations will ultimately determine which subwatersheds they will focus on to meet their own organizational goals, some overall prioritization of watersheds for work must be established. The following represents the overall cumulative ranking of subwatersheds per recommended contaminant and BMP:

1. West Fork and Lower White River subwatersheds
2. Beaver Lake subwatershed
3. War Eagle Creek subwatershed
4. Brush Creek, East Fork, Middle Fork, and Richland Creek subwatershed

It should be recognized that directing programs and projects along this overall suggested prioritization should not preclude any organization from seizing opportunities that may arise (due to funding, emerging needs, or otherwise).

5.2 Implementation Timeline

EPA Watershed Management Plan Element F & I: NPS Management Measures Implementation Schedule and Milestones – See also Table 5-2.

The timeline suggested for implementation of components of this strategy include short-term (i.e., ~2 year), mid-term (~5-8 year), and longer-term or ongoing actions. Implementation of the 5 key components of the Protection Strategy constitute the short-term actions: (1) development of the Beaver Watershed Alliance; (2) implementation of key best management practices; (3) creation of a Developer and Contractor Lake Protection Certification Program; (4) initiation of an educational and stewardship program; and (5) establishing a monitoring and adaptive management program. The formation of and onboarding of staff for the Beaver Watershed Alliance would be an appropriate beginning milestone for short-term actions, though this watershed group certainly is not the only organization that should implement the Protection Strategy.

Mid-term actions will be the further development, refinement, and operation/maintenance of the 5 key components. Long-term actions will be the ongoing operation/maintenance of the key components and related programs as described above, and will also include new programs and actions, such as monitoring and adapting the stragy.

Table 5-1 provides a snapshot of the key actions recommended in the Protection Strategy, the potential funding and assistance, who needs to take the lead, and other groups responsible for implementation. As can be seen, there is much work to do and success will depend on many agencies, community leaders, and landowners. Table 5-2 provides an estimated timeline or schedule for taking action, with shorter-term priority actions denoted. Implementation capability will depend on many factors, including available funding and resources and other community priorities requiring attention. In this regard, this section should be viewed as a starting point and a guide to help the Beaver Lake Watershed Alliance and others implementing the Strategy. Estimated timelines are not absolute, rather based on best available information.

Implementation capability will depend on many factors, including available funding and resources, and other community priorities requiring attention.

5.3 ADAPTIVE MANAGEMENT

Because priorities can and will shift as new data are acquired and new water quality issues emerge, the Watershed Alliance and partnering organizations will utilize an adaptive management approach, where the goals of the organization and programming will be assessed every five years, approximately. Annual or biannual workplans and program agendas should be developed and evaluated organizationally. For example, for each project or program implemented, the Alliance's staff and Board of Directors will need to determine success criteria in terms of community involvement and water quality improvement, and adjust programmatic goals and focus in the shorter terms. The Beaver Watershed Alliance has adopted the Protection Strategy and is committed to ongoing review and updating of the document to ensure long-term relevancy. On a 5-year basis, the Policy and Technical Advisory Groups should reconvene to examine and discuss new trends in water quality and to identify emerging issues on the watershed in order to evaluate and revise the Protection Strategy. Furthermore, as opportunity or need arises, the Protection Strategy should be amended through notification and engagement of

Annual work plans should be developed organizationally, and the Watershed Council and its partners will periodically review the key actions and timeline and update them when new information is available and success is achieved.

stakeholders and program partners. In summary, this is a living document that provides a starting point for the long-term protection of Beaver Lake and the restoration of the West Fork and Lower White rivers. It is anticipated that the Watershed Council and its partners will review the key actions and timeline and revise them as new information is available, experience is gained, and success is achieved.

Table 5-1. Beaver Lake Watershed Protection Strategy Implementation Summary

Protection Strategy Component	Potential Funding/ Technical Assistance	Responsible Group(s)
Core Voluntary Best Management Practices		
Land Conservation Program - Conservation Easements for Stream Buffers and Upland Areas • Conduct screening and field evaluation of priority areas • Conduct landowner outreach • Secure funding sources • Identify/secure stewardship organizations • Develop stewardship plan • Explore Transfer of Development Rights Program • Explore Carbon Credit Program	State and federal tax credits Conservation Reserve Program Environmental Quality Incentives Program Local water suppliers Local businesses Local governments Trust for Public Lands (technical assistance only) The Nature Conservancy (technical assistance only)	Lead: Beaver Watershed Alliance County Farm Service agencies Natural Resources Conservation Service Local water suppliers Local governments Arkansas Game and Fish Commission Arkansas Forestry Commission Land trusts
Improved Construction Site Management • Enforce minimum federal, state, and local requirements • Develop and administer compliance assistance program • Require silt fencing, detention ponds, and phased land disturbance • Note: This Protection Strategy recommends going beyond minimum standards where feasible to have local enforcement in non-urbanized area where there is currently state jurisdiction	Stormwater impact fee on new development via local governments or stormwater utility Fines for noncompliance Local water suppliers Volunteer construction site monitoring program (e.g., Upper Chattahoochee Riverkeeper; KY Waterways Alliance) (technical assistance only)	Lead: MS4 permittees in designated urbanized areas and Beaver Watershed Alliance ADEQ in non-urbanized areas UA-Fayetteville Extension Service

Protection Strategy Component	Potential Funding/ Technical Assistance	Responsible Group(s)
Stream Buffer and Bank Restoration • Conduct field evaluation • Conduct landowner outreach • Contact COE and other permitting agencies • Coordinate with trails and infrastructure • Develop preliminary design and cost estimate • Secure needed permits • Secure funding • Secure stewardship organizations • Final planning and design • Develop stewardship plan	Conservation Reserve Program Conservation Reserve Enhancement Program (CREP) Arkansas Stream Team Arkansas Forestry Commission Environmental Quality Incentives Program (EQIP) Wildlife Habitat Incentives Program 319 Grants/ANRC Local water suppliers Federal Stimulus Funds	Lead: Beaver Watershed Alliance County Farm Service agencies Arkansas Game and Fish Commission Natural Resource Conservation Service Local governments (cost share) Local water supplier (cost share) Land trusts US Army Corps of Engineers (COE)
Farm Best Management Practices	Water Users/Local Governments using Beaver Lake water supply Environmental Quality Incentives Program 319 Grants/ANRC The Poultry Federation UA-Fayetteville Extension Service	Lead: Natural Resource Conservation Service UA-Fayetteville Extension Service Beaver Lake Watershed Council
Unpaved Road Improvements (emphasizing BMP retrofits including ditch hydroseeding, wing ditches, and stream crossing stabilization)	Legislative appropriations Local government road maintenance fund	Lead: Local governments
Stormwater BMP Retrofits	Stormwater impact fee on impervious area	Lead: Local governments

Protection Strategy Component	Potential Funding/ Technical Assistance	Responsible Group(s)
Beaver Lake Watershed Council: Please note, the stakeholder-driven Beaver Watershed Alliance had bylaws approved in December of 2010		
Form Watershed Council Develop recommended draft structure, group membership, funding mechanism(s) and by-laws Form task force to review draft Send invitation to groups to appoint representative Establish non-profit status	Local businesses Local governments Local water suppliers Foundations ANRC	Lead: Northwest Arkansas Council Task Force (similar to PAG) Local governments
Hire Watershed Council Coordinator/Director Identify dedicated funding source Draft job description and post position Interview and hire coordinator/director	Local businesses Local governments Local water suppliers Foundations ANRC	Lead: Beaver Watershed Alliance
Developer/Contractor Lake Protection Certification Program		
Conduct outreach to communities, developers and contractors Educate on importance of implementing MS4 requirements for post-construction stormwater management Identify communities, developers and contractors willing to sign "Lake Protection Pledge" to use stormwater Best Management Practices Note: This plan recommends going beyond state minimum stormwater requirements where feasible to include engineered stormwater controls for new intensive development in the Municipal Planning Area and conservation design for development in the rural area.	Local water suppliers Local stormwater programs Homebuilders Association ADEQ	Lead: Beaver Watershed Alliance Northwest Arkansas Council Local governments UA-Fayetteville Extension Service

Protection Strategy Component	Potential Funding/ Technical Assistance	Responsible Group(s)
Develop site design standards, inspection protocols, and a channel protection/Low Impact Development Manual	319 Grant/ANRC	Lead: Beaver Watershed Alliance Local governments UA-Fayetteville
Develop incentives for program participation Advertise participants Work with suppliers of construction products to provide discounts Establish annual awards program	319 Grant/ANRC Homebuilders Association	Lead: Beaver Lake Watershed Council Northwest Arkansas Council Homebuilders Association
Develop and administer compliance assistance/certification program for developers and contractors	Local stormwater impact fee on new development via local governments or stormwater utility	Lead: Beaver Lake Watershed Council Local governments UA-Fayetteville Extension Service
Education and Stewardship Program		
Coordinate with other Partnerships and UA-Fayetteville to build on existing education efforts	Capacity-building and education/awareness grant programs	Lead: Beaver Watershed Alliance UA-Fayetteville Extension Service Illinois River Watershed Partnership Ozark Water Watch Kings River Watershed Partnership NRCS
Educate communities, developers, and contractors on importance of implementing MS4 requirements for construction and post-construction stormwater management (see above)	Local stormwater impact fee on new development	Lead: Beaver Watershed Alliance UA-Fayetteville Local governments

Protection Strategy Component	Potential Funding/ Technical Assistance	Responsible Group(s)
Adapt "Landowner's Guide to Streamside Living" by Kings River Watershed Partnership to Beaver Lake watershed. Distribute online and hardcopies. Address such issues as: Finalize and use "Lake Smart," good stewardship providers for landowners around the lake. Property and stream modification Gravel mining Onsite wastewater treatment Floodplain development Nutrient management Streambank erosion Riparian buffers Riparian restoration	319 Grant/ANRC UA-Fayetteville Extension Service Local water suppliers	Lead: Beaver Watershed Alliance UA-Fayetteville Extension Service Conservation groups Landowners
Develop Conservation Design guidelines and examples for new development in rural areas Develop guidelines Revise local ordinances to allow conservation design as an alternative to traditional subdivisions	319 Grant Northwest Arkansas Regional Planning Commission (technical assistance only) UA-Fayetteville	Lead: Beaver Watershed Alliance UA-Fayetteville Local governments
Continue educational efforts to stress implementation of farm Nutrient Management Plans and to highlight innovative practices	Natural Resources Conservation Service UA-Fayetteville Extension Service	Lead: Natural Resources Conservation Service and UA-Fayetteville Extension Service Beaver Watershed Alliance

Protection Strategy Component	Potential Funding/ Technical Assistance	Responsible Group(s)
Continue and enhance good lake management practices Shoreline maintenance and erosion control Buffer for nutrient sources Draw down lake elevation slowly to minimize impacts on water supply intakes	Local water suppliers US Army Corps of Engineers	Lead: US Army Corps of Engineers Beaver Watershed Alliance Arkansas Game & Fish Commission UA-Fayetteville Extension Service
Monitoring and Adaptive Management*: *Please note a Beaver Watershed Alliance Technical Advisory Group has formed and is in the process of designing a watershed-wide, HUC 12 scale monitoring plan.		
Develop overall assessment program, including stewardship report Establish questions that should be answered by ongoing assessment to evaluate performance Establish indicators that will be tracked Establish appropriate methods and procedures for assessment Produce triennial stewardship report *Assume five-year adaptive management cycle	Local water suppliers ADEQ ANRC US Geological Survey	Lead: Beaver Watershed Alliance Local water suppliers UA-Fayetteville US Geological Survey
Enhance long-term watershed and lake monitoring Review current state, local, and UA-Fayetteville monitoring programs in context of Protection Strategy and corresponding assessment program to clarify gaps Identify monitoring needed Develop monitoring plan and estimated costs Secure funding Implement monitoring program, which addresses five-year adaptive management cycle	Local water suppliers ADEQ ANRC US Geological Survey Farm Stewardship Council	Lead: Beaver Watershed Alliance Local water suppliers UA-Fayetteville US Geological Survey

Table 5-2. Beaver Lake Watershed Protection Strategy Implementation Timeline: Assuming five-year Adaptive Management cycle beginning January 2012 or at hiring of Council Executive Director

Protection Strategy Component	Timeline*	Short Term Priority (Y=Yes)
Core Voluntary Best Management Practices		
Land Conservation Program - Conservation Easements for Stream Buffers and Upland Areas	Initial Phase July 2012-2016	
• Conduct screening and field evaluation of priority areas	July 2012-July 2013	Y
• Conduct landowner outreach	January 2013-December 2013	Y
• Secure funding sources	July 2012-July 2014	Y
• Identify/secure stewardship organizations	July 2014-December 2015	Y
• Develop stewardship plan	July 2014 – December 2015	Y
• Implement	January 2016 – January 2017	Y
• Explore Transfer of Development Rights Program	July 2015 – January 2017	
• Explore Carbon Credit Program	July 2015 – July 2016	
Improved Construction Site Management	Initial Phase July 2011 -2014	Y
• Enforce minimum federal, state, and local requirements	July 2011 – July 2013	Y
• Develop and administer compliance assistance program	January 2014	Y
• Require silt fencing, detention ponds, and phased land disturbance		
• Note: This Protection Strategy recommends going beyond minimum standards where feasible to have local enforcement in non-urbanized area where there is currently state jurisdiction		
Stream Buffer and Bank Restoration	Initial Phase July 2013 – July 2018	
• Conduct field evaluation	July 2013 – July 2014	
• Conduct landowner outreach	January 2015 – December 2015	
• Contact COE and other permitting agencies	January 2015 – March 2016	
• Coordinate with trails and infrastructure	January 2015 – March 2016	
• Develop preliminary design and cost estimate	July 2015 – July 2016	
• Secure needed permits	July 2016 – July 2017	
• Secure funding	July 2013-July 2018	
• Secure stewardship organizations	July 2016 – July 2017	
• Final planning and design	July 2016- December 2017	
• Develop stewardship plan	July 2016 – December 2017	
• Implement	July 2018 – January 2020	
Farm Best Management Practices	January 2012 – January 2017	
Unpaved Road Improvements (emphasizing BMP retrofits including ditch hydroseeding, wing ditches, and stream crossing stabilization)	Initial Phase July 2019-July 2020	
Stormwater BMP Retrofits	Initial Phase July 2012 – July 2017	

Protection Strategy Component	Timeline*	Short Term Priority (Y=Yes)
Beaver Lake Watershed Council (currently called Beaver Watershed Alliance)		
Form Watershed Council	Completed December 2011	Y
• Send invitation to groups to appoint representative	Completed April 2010	Y
• Form task force to review draft; solicit input	Completed November 2010	Y
• Develop recommended draft structure, group membership, funding mechanism(s) and by-laws	Completed December 2010	Y
• Establish non-profit status	Completed July 2011 Completed September 2011	Y
Hire Watershed Council Coordinator/Director	Completed December 2011	Y
• Identify dedicated funding source	Completed March 2011	Y
• Draft job description and post position	Completed May 2011	Y
• Interview and hire coordinator/director	Completed November 2011	Y
Developer/Contractor Lake Protection Certification Program		
Conduct outreach to communities, developers and contractors	March 2012 – January 2017	
• Educate on importance of implementing MS4 requirements for post-construction stormwater management	January 2012 – January 2017	Y
• Identify communities, developers and contractors willing to sign “Lake Protection Pledge” to use stormwater Best Management Practices	March 2012 –June 2012	Y
• Note: This Plan recommends going beyond state minimum stormwater requirements where feasible to include engineered stormwater controls for new intensive development in the Municipal Planning Area and conservation design for development in the rural area.		
Develop site design standards, inspection protocols, and a channel protection/Low Impact Development Manual	July 2011 – July 2014	
Develop incentives for program participation	March 2012 and January 2017	
• Advertise participants		Y
• Work with suppliers of construction products to provide discounts		Y
• Establish annual awards program		
Develop and administer compliance assistance/certification program for developers and contractors (in conjunction with construction site compliance assistance program)	July 2011-July 2013	Y
Education and Stewardship Program		
Coordinate with other Partnerships and UA-Fayetteville to build on existing education efforts	January 2012 – January 2017	

Protection Strategy Component	Timeline*	Short Term Priority (Y=Yes)
Educate communities, developers, and contractors on importance of implementing MS4 requirements for construction and post-construction stormwater management (see above)	January 2012 – January 2017	
Education and Stewardship Program (con't.)		
Adapt "Landowner's Guide to Streamside Living" by Kings River Watershed Partnership to Beaver Lake watershed. Distribute online and hardcopies. Address such issues as: • Property and stream modification • Gravel mining • Onsite wastewater treatment • Floodplain development • Nutrient management • Streambank erosion • Riparian buffers • Riparian restoration	July 2012 – December 2012	
Develop Conservation Design guidelines and examples for new development in rural areas • Develop guidelines • Revise local ordinances to allow conservation design as an alternative to traditional subdivisions	July 2014- July 2017	
Continue educational efforts to stress implementation of Nutrient Management Plans and to highlight innovative practices	January 2012 – January 2017	Y
Continue and enhance good lake management practices • Shoreline maintenance and erosion control • Buffer for nutrient sources • Draw down lake elevation slowly to minimize impacts on water supply intakes	January 2012 – January 2017	
Monitoring and Adaptive Management		
Develop overall assessment program, including stewardship report • Establish questions that should be answered by ongoing assessment to evaluate performance • Establish indicators that will be tracked • Establish appropriate methods and procedures for assessment • Produce triennial stewardship report	Initial Phase March 2012- July 2014 March 2012 – July 2013 March 2012 – July 2013 January 2013 – July 2013 July 2013-July 2014	

Protection Strategy Component	Timeline*	Short Term Priority (Y=Yes)
Enhance long-term watershed and lake monitoring	Initial Phase July 2012 – 2013	
• Review current state, local, and UA-Fayetteville monitoring programs in context of Protection Strategy and corresponding assessment program to clarify gaps	Completed	Y
• Identify monitoring needed	Completed	Y
• Develop monitoring plan and estimated costs	In progress	Y
• Secure funding	March 2013- July 2013	Y
• Implement monitoring program	October 2013 – January 2017	Y

*Assume five-year cycle Adaptive Management plan, beginning May 2012

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Appendix A. BMP Cost and Cost Effectiveness

EPA Watershed Management Plan Element D: Estimates of Technical/Financial Costs of Implementations – See Table A-1-9

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Table A-1. Core BMPs Unit Cost and Cost-effectiveness Summary Table

	20-Year Cost per Unit			Annualized Cost per Unit			Cost per Ton Sediment Load Reduced To Lake		
BMP	**Low**	**High**	**Median**	**Low**	**High**	**Median**	**Low**	**High**	**Median**
Land Conservation Program -- Existing Pasture	$2,000	$3,000	$2,500	$100	$150	$125	$200	$300	$250
Land Conservation Program -- Existing Forest	$2,000	$3,000	$2,500	$100	$150	$125	$200	$300	$250
Improved Construction Site Management	$24,180	$32,080	$28,100	$1,209	$1,609	$1,409	$400	$500	$450
Buffer/Bank Restoration in Developed Areas Non-Lakefront (non-pasture land uses)	$188	$273	$231	$9	$14	$12	$1,400	$2,000	$1,700
Pasture Buffer/Bank Restoration Non-lakefront	$188	$273	$231	$9	$14	$12	$1,400	$2,100	$1,750
Alternative Water Source and Fencing	$820	$1,110	$970	$41	$56	$48	$1,600	$2,100	$1,850
Pasture Renovation	$479	$739	$609	$24	$37	$30	$300	$400	$350
Buffer Preservation, Non-lakefront (in developed areas)	$10	$30	$20	$0.5	$1.5	$1.0	$600	$1,900	$1,250
Unpaved Road Improvements	$16,910	$23,090	$20,000	$846	$1,155	$1,000	$700	$1,000	$850
Stormwater BMP Retrofits	$8,020	$28,040	$18,000	$401	$1,402	$902	$1,400	$4,900	$3,150
Total	--	--	--	--	--	--	$500	$800	$600

Table A-2. Cost Estimates for Land Conservation Program (Both Pasture and Forest)

	Cost per Acre			Potential Funding Sector(s)	Notes
Practice	**Low**	**High**	**Median**		
Stewardship Endowment	$2,000	$3,000	$2,500	Federal, State, Local Water Suppliers	To maintain easement in perpetuity or for given term.

Sources: T. Snell, The Nature Conservancy, Personal Communication to H. Fisher, January 13, 2009

Table A-3. Cost Estimates for Improved Construction Site Management

Practice	Cost per Acre Disturbed			Potential Funding Sector(s)	Notes
	Low	High	Median		
Upfront Administrative Cost (first year)	$70	$90	$80	Federal, State, Local	Inspection protocols, BMP guidance, volunteer inspector training, construction contractor training, program management
Annual Administrative Cost (after first year)	$30	$40	$40	Local	Same as above
20-year Administrative Present Value Cost ($/acre)	$450	$600	$530	Local	
Silt fencing and related controls – existing control costs subtracted ($/acre/year)	$560	$740	$650	Developer	Correctly sited, installed, and maintained; other minimum controls (i.e., inlet/outlet protection, rock exit pad)
Sediment Basins ($/acre/year)	$650	$850	$750	Developer	Basins, transitioned to permanent stormwater basins after construction
Phasing ($/acre/year)	$380	$520	$450	Developer	Project phasing with rapid seeding of disturbed areas after final grade is reached
Total Developer Costs ($/acre/year)	$1,590	$2,110	$1,850	Developer	
20-year Developer Present Value Costs ($/acre)	$23,660	$31,390	$27,500	Developer	
Total Present Value Costs ($/acre)	$24,180	$32,080	$28,100	Federal, State, Local, Developer	

Sources: USEPA (2008a); US EPA (2008b); USEPA (2009b); Mason (2009); Wisconsin DNR (2001); Knoxville/Knox County (2006)

Table A-4. Buffer and Bank Restoration Cost Estimates (Both Pasture and Non-Pasture)

Practice	Cost per Foot			Potential Funding Sector(s)	Notes
	Low	High	Median		
Upfront cost of streambank and buffer restoration	$160	$220	$190	Federal, state, local water suppliers	50-ft buffer, both sides of stream
Upfront cost of conservation easement, lakefront	$29	$78	$54	Federal, state, local water suppliers	Property is on or within view of Beaver Lake
Upfront cost of conservation easement, non-lakefront	$5	$23	$14	Federal, state, local water suppliers	Property is not within view of Beaver Lake
Monitoring Endowment	$18	$23	$21	Federal, state, local water suppliers	Monitoring should occur annually during the first five years following restoration
Stewardship Endowment	$5	$7	$6	Federal, state, local water suppliers	To maintain easement in perpetuity
Total Upfront Cost, lakefront	$212	$328	$270	Federal, state, local water suppliers	
Total Upfront Cost, non-lakefront	$188	$273	$231	Federal, state, local water suppliers	

Sources: AFC (2008), Faucette Real Estate (2009); NCEEP (2004);

David Evans, Arkansas Game and Fish Commission, Region 1 Stream Team, personal communication to H. Fisher, January and February 2009;

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Table A-5. Cost Estimates for Pasture Alternative Water Source and Fencing

Practice	Cost per Acre			Potential Funding Sector(s)	Notes
	Low	High	Median		
Paddock Fencing	$30	$40	$35	Federal, State, Farmer	2 strand electric fencing, including fencing, energizer, and gate
Water Development	$480	$650	$565	Federal, State, Farmer	Well, pump, wellhead protection, piping, gravel pad, geotextile, tank and trough system

Practice	Cost per Acre			Potential Funding Sector(s)	Notes
	Low	High	Median		
Stream Crossing	$60	$80	$70	Federal, State, Farmer	Fence, geotextile cloth, stone
Upfront Total	$570	$770	$670	Federal, State, Farmer	
Annual Maintenance	$17	$23	$20	Farmer	
20-year Present Value Maintenance	$250	$340	$300	Federal, State, Farmer	
Total Present Value Cost	$820	$1,110	$970	Federal, State, Farmer	

Sources: Tetra Tech (2004); Ron Morrow, State Grasslands Specialist, Natural Resources Conservation Service-Arkansas, Little Rock, AR, personal communication to B. Tucker, November 2008.

Table A-6. Pasture Renovation Cost Estimates

Practice	Cost per Acre			Potential Funding Sector(s)	Notes
	Low	High	Median		
Upfront program setup cost	$29	$39	$34	Federal, state, local water suppliers	Purchase of equipment and setup of program administration
Annual operating cost	$20	$27	$23	Local	Operation of program and equipment maintenance
20-year Present Value operating cost	$300	$400	$350	Local	
Annual farmer cost	$10	$20	$15	Farmer	Operation of farmer-owned tractor and city-owned equipment
20-year Present Value farmer cost	$150	$300	$225	Farmer	
Total Present Value Cost	$479	$739	$609	Federal, state, local, local water suppliers, farmer	

Sources: Geosyntec (2008); RS Means (2009)

Table A-7. Riparian Buffer Preservation Cost Estimates (assuming 50-ft buffer preserved on both sides of the stream)

Practice	Cost per Foot[1]			Potential Funding Sector(s)	Notes
	Low	High	Median		
Upfront cost of conservation easement, lakefront	$29	$78	$54	Federal, state, local water suppliers	Property is on or within view of Beaver Lake
Upfront cost of conservation easement, non-lakefront	$5	$23	$14	Federal, state, local water suppliers	Property is not within view of Beaver Lake
Stewardship Endowment	$5	$7	$6	Federal, state, local water suppliers	To maintain easement in perpetuity
Total Upfront Cost, lakefront	$34	$85	$60	Federal, state, local water suppliers	
Total Upfront Cost, non-lakefront	$10	$30	$20	Federal, state, local water suppliers	

[1]Assuming that a 50-ft buffer is preserved on both sides of the stream.

Sources: Faucette Real Estate (2009); T. Heisel, Ozark Regional Land Trust, Inc., Personal Communication to H. Fisher, October 13, 2008;

T. Snell, The Nature Conservancy, Personal Communication to H. Fisher, January 13, 2009.

Table A-8. Unpaved Road BMP Cost Estimates

Practice	Cost per Mile			Potential Funding Sector(s)	Notes
	Low	High	Median		
Install Drainage Practices	$14,400	$19,600	$17,000	Local Government	Install wing ditches/turnouts and culverts at Arkansas Forestry Commission recommended spacing
Repair Existing Drainage	$260	$350	$310	Local Government	Remove material from wing ditches.
Hydroseed Ditches	$1,800	$2,400	$2,100	Local Government	
Total Upfront Cost	$16,460	$22,350	$19,410	Local Government	
Annual Maintenance	$30	$50	$40	Local Government	Inspect, reseed, repair during quarterly grading
20-year Present Value Maintenance	$450	$740	$600	Local Government	
Total Present Value Cost ($/mile)	$16,910	$23,090	$20,000	Local Government	

Sources: USDA (2008); RS Means (2009)

Table A-9. Stormwater BMP Retrofit Cost Estimates

Practice	Cost per Mile			Sector(s)	Notes
	Low	High	Median		
Stormwater BMP Retrofits (based on Stormwater Retention Pond costs)	$8,000	$27,000	$18,000	Local Government	Includes construction, design, engineering, and 20-year maintenance.

Source: Previous Tetra Tech cost estimates for BMP retrofits

Cost-effectiveness Results

Tetra Tech's Supplemental Pollutant Loading Analysis indicated that the greatest increases in pollutant loading to Beaver Lake in the future will come from sediment and phosphorus loading. Total nitrogen is only expected to increase by 4.4 percent by 2055, whereas sediment and phosphorus loading are expected to increase by 21 and 14 percent, respectively, by 2055. Upland loading from new development and channel erosion are estimated to contribute to the majority of the sediment and phosphorus load increases, and a significant majority of the total future loading. Since phosphorus load increases are largely tied to sediment load increases, Tetra Tech focused on evaluating management options by cost-effectiveness for sediment reduction. Management options that are cost-effective for sediment reduction are expected to also be cost-effective for phosphorus. Figure A-1 illustrates the cost-effectiveness ratios for sediment reduction across the management options. The high and low cost-effectiveness estimates are based on the high and low cost-estimates documented above, and the median estimate is the average of the high and low estimates.

Since the Beaver Lake subwatershed has substantially different loading rates to the lake, as well as topography and soils, Tetra Tech calculated cost-effectiveness ratios separately for the Beaver Lake subwatershed (BL) and the other subwatersheds in the municipal planning area (represented by WFLW).

The Centralized Wastewater management options provide a cost-effective option for phosphorus reduction but do not provide sediment reduction benefits. Tetra Tech recommends that management options for sediment reduction be prioritized for protection of Beaver Lake. The WWTP upgrades and decentralized alternatives could be considered to achieve additional improvement in phosphorus loading beyond what can be achieved by sediment reduction.

To streamline the evaluation process, management options with similar cost-effectiveness ratios were combined. Post-construction options in karst areas are not shown but exhibited roughly 10 to 60 percent increases in cost per ton removed above non-karst management options. Buffer preservation (non-lakefront) and buffer/bank restoration in developed areas were combined, and the unpaved road and stream crossing improvements were also combined. Figure A-1 shows the combined cost-effectiveness ranges for these options.

Post-construction Cost-effectiveness

Upland sediment from new development and new development impacts on channel erosion generate the highest increase in sediment loading to the Lake. Channel erosion and future development represent 75 percent of the total future sediment loading to the Lake. Therefore, evaluation of the cost-effectiveness of post-construction stormwater controls is critical to the Beaver Lake Watershed Protection Strategy.

In the post-construction management options for the 1-acre and ¼-acre lot, the conventional options were the least cost-effective for sediment reduction. This effect is partially attributed to the assumptions for instream loading reduction, but similar trends are seen when cost-effectiveness due to upland load treatment is reviewed separately. For example, conventional development cost-effectiveness would range from $1,800 to $3,200 per ton of upland sediment reduction, while the corresponding ratios for LID would range from $500 to $900 per ton of upland sediment reduction.

The conventional options range from $600 to $1,700 per ton of sediment removed, whereas most of the channel protection and LID options were under $800 per ton of sediment removed. For the 1-acre lot BL and WFLW management options, the 1/2-acre cluster option was the most cost-effective, but the ranges overlap between the channel protection, LID non-cluster, and LID cluster options, indicating that some channel protection and LID-non-cluster designs may be as cost-effective as the cluster option.

Trends in cost-effectiveness differ between the BL and WFLW ¼-acre options. In BL, channel protection is the most cost-effective option, while in WFLW, channel protection and LID are estimated to have similar cost-effectiveness. This occurs because greater upland loading, resulting in greater pollutant reductions, is estimated for BL, and this results in more pronounced differences in cost-effectiveness across BL options compared to WFLW.

The channel protection option was estimated as most cost-effective among the mixed-use management options. The LID option was estimated to be least cost-effective, which is due to the higher costs for bioretention in high density development as well as the lack of opportunity to reduce clearing and grading costs compared to the lower density options.

In addition to pollutant load reduction benefits, the post-construction options also provide hydrology benefits. These benefits could not be addressed in the cost-effectiveness analysis, but the hydrologic performance of the options is compared below using SET results.

Other Management Options Cost-effectiveness

Buffer preservation on lakefront properties is estimated to be similar in cost-effectiveness to many of the post-construction management options as shown in Figure A-1. The non-lakefront buffer preservation and the buffer/bank restoration options (in developed areas) were more cost-effective, similar to the most cost-effective post-construction options, ranging from about $60 to $220 per ton of sediment loading reduced. The pasture alternative water source and fencing and the unpaved road management options exhibited a similar range of cost-effectiveness.

Across all management options, pasture renovation, pasture buffer/bank restoration, and improved construction site management present the most cost-effective options for sediment reduction. However, the pasture management options, other than buffer/bank restoration, only reduce upland loading, which represents a small percentage of the future sediment load to the Lake. It should be noted that on most pasture land, alternative water sources and fencing will be needed in order to implement buffer/bank restoration; therefore, the cost-effectiveness of both options combined will likely fall between $20 and $140 per ton of sediment removed.

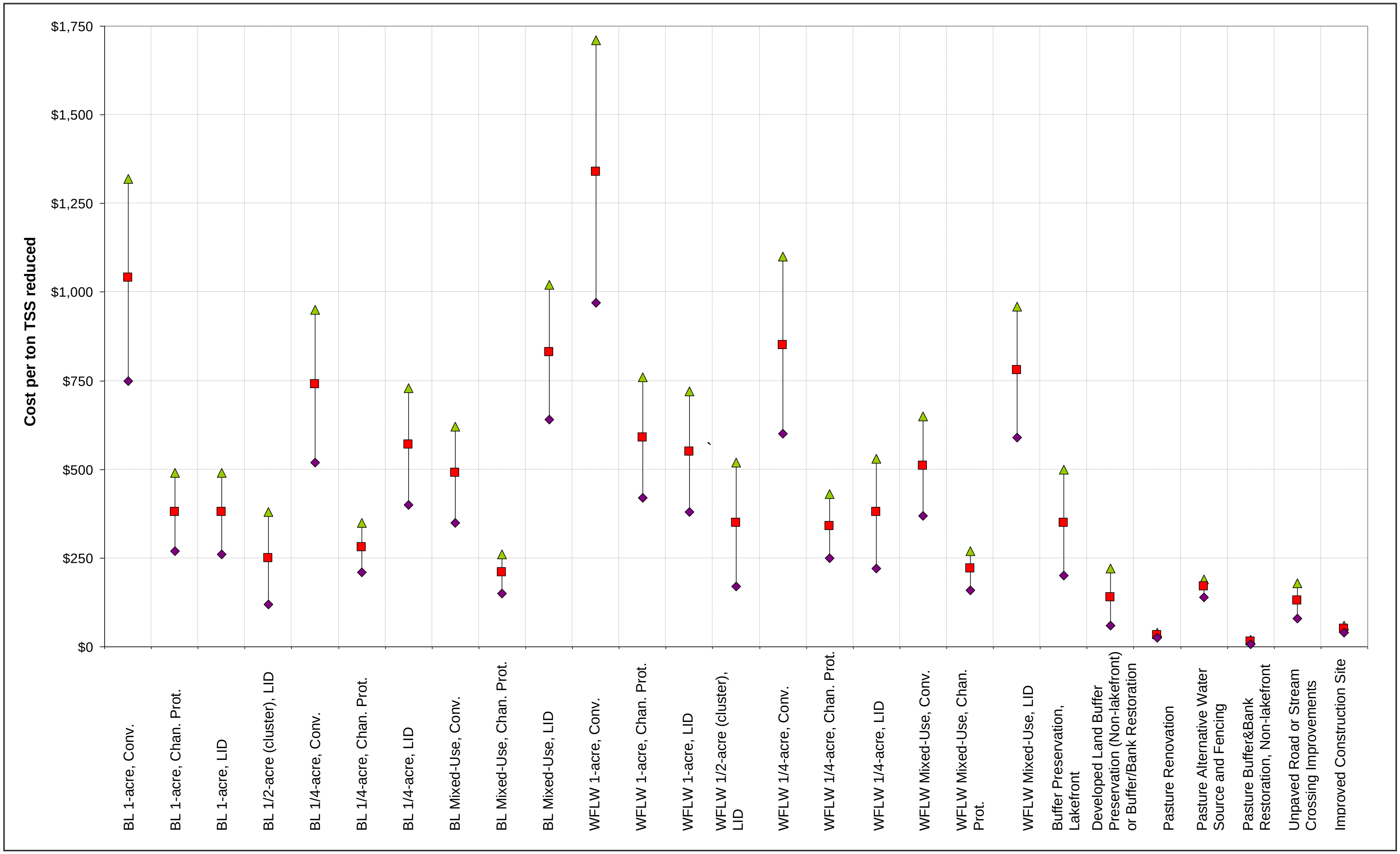

Figure A-1. Cost-effectiveness Ratios for Sediment

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Appendix B. Information for TMDL Implementation Efforts in the West Fork and Lower White River Reporting Subwatersheds

EPA Watershed Management Plan Element A: Identification of Impairment Cause and Source – See Tables B-1 and B-2

EPA Watershed Management Plane Element B: Load reduction estimates expected per management measure – See Tables B-1 and B-2

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Table B-1. Core Voluntary BMPs and Estimated Total Sediment for the West Fork of the White River Reporting Subwatershed

BMP	Land Area Assumed to Participate in BMP Program	Reduction in Future Sediment Load to Stream
Improved Construction Site Management	200 acres per year	5,480 tons/year
Buffer/Bank Restoration in Developed Areas Non-Lakefront (non-pasture land uses)	88,930 feet of stream	6,750 tons/year
Pasture Buffer/Bank Restoration Non-lakefront	9,890 feet of stream	740 tons/year
Alternative Water Source and Fencing	910 acres	270 tons/year
Pasture Renovation	5,520 acres	5,140 tons/year
Unpaved Road Improvements	110 miles of road	1,190 tons/year
Stormwater BMP Retrofits	920 acres	3,010 tons/year
Estimated Total Reduction in Sediment Load		22,580 tons/year

Table B-2. Core Voluntary BMPs and Estimated Total Sediment for the Lower White River Reporting Subwatershed

BMP	Land Area Assumed to Participate in BMP Program	Reduction in Future Sediment Load to Stream
Improved Construction Site Management	60 acres per year	2,020 tons/year
Buffer/Bank Restoration in Developed Areas Non-lakefront (non-pasture land uses)	13,800 feet of stream	1,070 tons/year
Pasture Buffer/Bank Restoration Non-lakefront	4,370 feet of stream	340 tons/year
Alternative Water Source and Fencing	400 acres	120 tons/year
Pasture Renovation	3,180 acres	2,960 tons/year
Unpaved Road Improvements	40 miles of road	380 tons/year
Stormwater BMP Retrofits	70 acres	210 tons/year
Estimated Total Reduction in Sediment Load		7,090 tons/year

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Appendix C. Supplemental Information on Post-construction Stormwater Management

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Post-construction stormwater management can reduce loading from roofs, streets, lawns, and other developed land uses as well as reduce stormwater flow and volume that degrades downstream channels. Three approaches to stormwater management were considered: conventional, channel protection, and low impact development (LID). In the conventional option, Tetra Tech assumes that communities and developers in the watershed using stormwater BMPs in the future will employ conventional dry detention basins for flood control and design those basins using the City of Fayetteville's current stormwater regulations, which specify that post-development flow rate not exceed pre-development flow rates for the 2-yr, 10-yr, 25-yr, 50-yr, and 100-yr 24-hour storm events. The channel protection option uses extended dry detention basins both to meet the flood control goals of the conventional option and to greatly reduce degradation of channels downstream of the development. The LID option uses infiltration practices, rainwater harvesting techniques, impervious surface reduction, land preservation, and extended dry detention basins to meet the goals of the preceding options and achieve additional pollutant load reduction and annual hydrology benefits. Appropriate LID techniques were selected based on development density and through consultation with local engineers.

Why is channel protection important, and why does it have its own option? Stream channel erosion has been identified as one of the largest contributors to sediment delivery to Beaver Lake under the future development option and also would result in degraded integrity of stream biology. Development – even at relatively low densities – changes the flow regime of streams. Disturbance of land cover and addition of impervious surfaces increases runoff volume and decreases the amount of time that it takes for runoff to reach streams. Simply reducing peak flow to pre-development levels for flood control is not sufficient to protect streams in areas experiencing development. Instead, flows are reduced but are released from detention basins for an extended period of time. When many peak-matching detention basins are present in a watershed, their combined discharge leads to a large increase in the duration of midbank and bankfull channel forming flows, which typically occur across a range of small storm events (e.g., 0.5-year storm events to 3-year storm events). For example, MacCrae (1997) found that in a 21 km^2 urbanizing watershed with stormwater control facilities, the frequency of midbank flows increased by more than four times, while the bankfull cross-sectional area increased by a factor of three. With proper basin sizing and outlet design, a detention basin's stage-discharge relationship can be optimized to minimize changes to channel forming flows. An additional benefit of a basin designed specifically to reduce downstream channel erosion is that these basins typically achieve much greater pollutant removal than a basin designed for flood control. The channel protection option was designed to test the influence of an enhanced basin design on cost, pollutant removal, and mitigation of downstream channel erosion.

The LID option incorporates the enhanced basin design, but in addition uses LID practices to enhance pollutant removal and improve annual water balance. Development often alters the way rainfall is partitioned between runoff, infiltration, and evapotranspiration; urbanizing areas often experience higher stream flashiness paired with lower baseflow, all of which contributes to impaired stream aquatic communities. LID practices work together to restore much of the lost infiltration and evapotranspiration.

Across all approaches, the following structural stormwater BMPs were considered:

Conventional Dry Detention Basin

Dry detention basins are typically grass-lined basins that are dry between storm events. These devices store stormwater runoff and reduce stormwater peak flow rates. Stormwater enters the device through an inlet, which may be a grass-lined channel or stormwater pipe. An embankment detains stormwater, and an outlet riser controls the downstream release rate of the impounded water. Conventional dry detention basins are generally designed to allow post-development peak flow rates to match pre-developed conditions (for flood control), usually for a series of large design storm events. While not designed specifically for pollutant removal, grass-lined conventional dry detention basins do remove some pollutants via filtration and nutrient transformation/uptake.

Extended Dry Detention Basin

Extended dry detention basins are designed to detain stormwater for a longer period of time than conventional dry detention basins (between one to three days); the longer detention time allows for more removal of TSS and nutrients from the stormwater. Extended dry detention basins can also be designed to reduce not only the peak flow but also the duration of elevated flows during storm events. A well-designed basin and outlet structure can more closely mimic the pre-development storm event hydrograph. Channel-forming flows extend across a range of small storm events, including those occurring more frequently than once per year. For these small storms that contribute to the greatest in-stream sediment transport, limiting the period of time that the post-development hydrograph greatly exceeds the pre-development hydrograph reduces the risk of channel erosion and bank failure. The basin in the picture doubles as a volleyball court.

Urban Bioretention

Bioretention areas are depressions filled with two to four feet of sandy soil and planted with drought and flood tolerant plants. Stormwater drains into the surface of the bioretention area and, as the water infiltrates through the sandy soil, the soil and plants remove a portion of pollutants. In areas with permeable soils, the water treated by the bioretention cell will infiltrate into the native soil. In areas that have soils with low permeability (typically clay-dominated soils) or in areas with groundwater vulnerability concerns (such as karst areas), a gravel layer and underdrain pipe are placed below the sandy soil layer. Once the stormwater infiltrates through the treatment cell's sandy soil, it is drained out through the underdrain pipe. Bioretention areas are designed so that a particular depth of water can pond in the cell during a rain event; the storage depth varies from 6 to 12 inches depending upon local design standards. Sometimes a weir is included in the bioretention area to bypass excess water above the ponding depth; other installations allow excess water to filter onto adjacent pervious areas. Since bioretention areas use mulch and a variety of shrubs and small trees, they can be easily incorporated into existing landscaping.

Cisterns with Irrigation Systems

Cisterns are tanks that hold rainwater for irrigation and other uses. The cistern pictured to the right can hold over 200 cubic feet of water. They are generally configured to capture roof runoff and can be incorporated inconspicuously into the side of a building. If enough storage volume is provided and if water is reused frequently, they can be used to control stormwater runoff, reduce stormwater flow, and remove pollutants by preventing them from entering runoff. Providing a consistent use of cistern water is one way to ensure stored water is used. One effective method involves a co-installation of an underground irrigation system, which uses cistern water as a primary source, and potable water as a secondary source if the cistern runs dry.

Bump-out Bioretention and Roadside Bioswales

Bump-out Bioretention cells and Roadside Bioswales are generally located between the street and sidewalk, and contain shrubs and other vegetation to slow runoff, take up pollutants, and improve soil infiltration. When properly designed and maintained, they can reduce peak flows, and infiltrate and treat a large percentage of annual runoff. They can be integrated with new development, and also as retrofit projects in urban areas. Municipalities have documented significant cost savings for controlling flooding and sewer overflow problems when compared to traditional engineering approaches, as well as high rates of infiltration and pollutant removal.

Dry Well

A dry well, also called a French drain, seepage pit, or Dutch drain, is a gravel-filled pit or trench designed primarily to capture and infiltrate roof runoff, usually by directing the downspout into the well. Dry wells have been used for decades to solve drainage problems, but are also a practical stormwater BMP. Design recommendations call for locating dry wells a safe distance away from the building, ensuring they are separated from the water table and that soils support infiltration, and providing a way to safely pass large storms. While rooftops usually have lower pollutant loads than other impervious surfaces, dry wells do effectively store and treat a significant volume of runoff.

Grass Swale

A vegetated or grass swale is a grass-lined channel with sloped banks. Culverts are used to pass stormwater under driveways and streets. Vegetated swales are used to convey stormwater runoff and slow stormwater flow. They are an alternative to storm sewer pipes, which produce higher stormwater flows than vegetated swales, especially for smaller storm events. Vegetated swales also remove some sediment if the stormwater flow is controlled.

These techniques were applied to representative development densities that were considered important for addressing impacts from new development. To select representative development densities, Tetra Tech reviewed the common impervious surface distributions within the municipal planning area where most development is projected to occur that would require stormwater BMPs. Residential developments with 1-acre and ¼-acre lots were among the most common development densities projected for future, new development. Subdivision lots of one acre or less (or 18 percent impervious or more) were assumed to trigger the need for structural stormwater controls due to their greater pollutant loading or hydrologic impacts. A significant number of larger lot developments are also projected to occur, particularly outside the municipal planning area. Given that many of the larger lot developments are projected to be in 5-, 10-, or 15-acre lots, Tetra Tech assumed these densities would reflect runoff of LID management using conservation design. Management for mixed-use development was also included as a representative density for high density development. High density development (>36 percent impervious) is projected to represent less than two percent of the watershed in the future, but this density may become more important if land use planning strategies change and favor more dense development. Table C-1 outlines the techniques used for each development density and approach.

To estimate detention basin volume for each of the options, a spreadsheet tool was developed to aid in the simulation of storm event hydrology and basin design. Storm event hydrology was simulated for each development density (18 percent, 33 percent, and 65 percent impervious area) for an assumed 15 acres of contributing development area to a detention basin. Hydrographs were generated using a method that combines TR-55 (USDA, 1986) with a Soil Conservation Service method (USDA, 1972) that uses unit hydrographs to simulate incremental runoff from excess rainfall. Hydrographs were simulated for both pre- and post-development conditions on a one-minute timestep, for a series of storms: 0.5-yr, 1-yr, 1.5-yr, 2-yr, 3-yr, 5-yr, 10-yr, 25-yr, 50-yr, and 100-yr 24-hr storm events. Available storm event depths were estimated from the Rainfall Frequency Atlas of the United States (USDA, 1961); the remaining storm event depths were extrapolated from a curve of depth versus year. The series of high occurrence storms (≤ 5-yr) were needed for designing for channel protection, while the low occurrence storms (≥ 10-yr) were necessary for flood control design. The post-development hydrographs were routed through a conceptual basin, where stage, storage, basin dimension, and multiple outlet (both orifices and weirs) were simulated. An optimization was performed to minimize basin volume while maintaining a maximum stage of four feet and meeting the goals of the option. Estimated basin volume was then used for the cost analysis; figures showing example hydrographs from the analysis are shown in the results. A separate analysis was not performed for the LID option; however, the LID detention basin volume was estimated by reducing the channel protection option detention basin volume by the storage volume of the LID practices.

Table C-1. Densities, Approaches, and Techniques for Post-Construction Stormwater Management Options

Density	Approach	Techniques
1-acre lots	Conventional	Conventional dry detention used to meet design standards for flood control.
	Channel Protection	Extended dry detention used to meet design standards for flood control and to protect downstream channel conditions.
	LID	Reduced impervious surface and disturbed area, replacement of curb and gutter with grass swales, dry wells draining rooftops, and extended dry detention, combined to meet design standards for flood control, protect downstream degradation, and further reduce pollutant loading and hydrologic impacts.
	LID Cluster (1/2-acre lots)	Lot size reduced to ½-acre, lots clustered to preserve undisturbed forested area, reduced impervious surface and disturbed area, dry wells draining rooftops, and extended dry detention, combined to meet design standards for flood control, protect downstream degradation, and further reduce pollutant loading and hydrologic impacts.
1/4-acre lots	Conventional	Conventional dry detention used to meet design standards for flood control.
	Channel Protection	Extended dry detention used to meet design standards for flood control and to protect downstream channel conditions.
	LID	Reduced impervious surface and disturbed area, roadside bioswales or bump-out rain gardens, cisterns and underground sprinklers used to treat roof runoff, and extended dry detention, combined to meet design standards for flood control, protect downstream degradation, and further reduce pollutant loading and hydrologic impacts.
Mixed-Use	Conventional	Conventional dry detention used to meet design standards for flood control.
	Channel Protection	Extended dry detention used to meet design standards for flood control and to protect downstream channel conditions.
	LID	Reduced impervious surface, urban bioretention, cisterns and underground sprinklers used to treat roof runoff, and extended dry detention, combined to meet design standards for flood control, protect downstream degradation, and further reduce pollutant loading and hydrologic impacts.

The presence of karst topography in the Beaver Lake watershed presents a special challenge for stormwater management. While ground subsidence is not known to be an issue, the risk of groundwater contamination remains high in some areas. Site grading and the addition of impervious surfaces changes flow patterns at developed sites and alters the way water moves across the landscape and infiltrates into the ground. Practices that store and infiltrate runoff in one location allow pollutants to be concentrated in one location. The pollutants can move into the aquifer and affect multiple resources, including well-water, connected surface waters, and rare and endangered species in caves. For infiltration practices, pervious geotextile and extra stone were added to the cost estimates to account for a design that would prevent sediment intrusion into karst areas. For detention basins, a plastic liner was assumed to prevent infiltration and potential groundwater contamination. For each post-construction management option considered, separate costs were estimated for development in karst and non-karst areas.

Unit cost assumptions are listed in Table C-2. These costs were applied to estimated development dimensions (e.g., square feet of roadside bioswales) to estimate the total cost for each type of practice. Cost savings from reduction in impervious surface and disturbed area were also estimated, considering reduction in clearing, grading, paving, and curb and gutter costs. The cost savings were conservatively estimated and additional cost savings are likely to be realized through LID; in particular, the LID cluster option is likely to achieve greater cost savings than estimated since storm drain and catch basin costs would also be reduced (these costs could not be estimated due to high variability in design). Annual maintenance costs were estimated for all structural stormwater BMPs, as documented in Table C-2.

For a stormwater program to be successful, education and training would need to be provided to development professionals. The application of the stormwater techniques listed above were considered voluntary for the purposes of this analysis. The costs for a voluntary compliance assistance program were estimated through interviews with local government representatives, local engineers, and Tetra Tech's experience in other communities. The cost estimates for the first year (upfront) and subsequent years (annual) are provided in Table C-2. These costs include development of inspection protocols and BMP guidance, volunteer inspector training (up to 10 trainees), construction contractor training (up to 80 trainees in each class), and program management. To calculate a cost per acre of development, the total costs for the program were divided by 5 percent of the acres projected annually for development within the municipal planning area (5 percent of 1,494 acres, or 75 acres). The 5 percent assumption was based on discussions with Center for Watershed Protection (CWP) staff regarding their experience with voluntary compliance for stormwater management practices (M. Novotny, Center for Watershed Protection, personal communication to H. Fisher, December 2008). This is consistent with Tetra Tech's observations as well. Tetra Tech's recommendations for the compliance assistance program are described in more detail in *Preliminary Draft Alternatives for Beaver Lake Watershed Construction Site and Post Construction Stormwater Management Compliance Assistance Program*, February 25, 2009.

The application of low impact development involves a detailed site assessment and identification of the most beneficial locations for site elements, including infiltration practices, preserved areas, buildings, infrastructure, and detention facilities. To evaluate these costs, Tetra Tech interviewed several development professionals who are experienced in LID site assessment, and they provided the following information (C. Hinman, Washington State University; J. Cox, Triad Associates; Catherine Benotto, Weber Thompson; Paul Hans Thompson, Arborea Consultants, LLC; personal communication to H. Fisher, February 2009). An LID site assessment may take more time than a site assessment for a conventional development; however, LID site assessments often provide information and insight into development design that can help prevent problems during construction and may reduce overall development costs compared to a conventional design. During construction, the application of LID may also increase time spent coordinating development layout and construction activities. Fencing around preserved areas would be required, and the construction of infiltration practices would need to be timed so that other construction activities would not introduce sediment to the filter media. The cost of this increased time is difficult to estimate and would vary depending on the experience and training of the project staff. These costs could not be quantified for this analysis, but the recommended compliance assistance program would help reduce the time required for LID site assessment and construction activities.

Tetra Tech also interviewed local engineers about the difference between LID and conventional design costs. The application of LID stormwater BMPs like bioretention, tend to increase design costs by 40 to 50 percent (T. Jacobs, Appian Centre for Design, personal communication to Scott Job, February 2009). The design costs assumed in this analysis reflect, at a minimum, this increase. The design costs for most LID options were estimated to increase to a greater degree because the LID designs are achieving improved stormwater treatment and control, and the design costs assumptions are tied to construction costs, which are higher for the LID options (prior to subtracting cost savings).

Local staff and professionals interviewed also stressed the obstacles in current regulations and procedures, necessitating multiple variances. This adds time and costs to LID projects in the region. Tetra Tech assumed that such barriers would be addressed in the future and did not include these costs in the analysis.

Table C-2. Unit Costs for Post-Construction Options

Element	Unit	Low	High	References
Roadside grass swales	square foot	$0.4	$0.5	USEPA, 2009a
Culverts for grass swales	number of houses	$530	$710	RS Means, 2009
Roadside bioswales or bump-out bioretention (with underdrain)	square foot (filter media portion)	$5	$12	USEPA, 2009a; C. Suneson, McClelland Consulting Engineers, Inc., personal communication to H. Fisher, February 2009.
Urban bioretention with underdrain	square foot (filter media portion)	$20	$30	M. Matlock, University of Arkansas Department of Biological and Agricultural Engineering, personal communication to H. Fisher, December 2008.
Dry wells	cubic feet of storage	$4.00	$5.00	USEPA, 2009a
1,500-gallon cistern	number of units	$1,000	$1,500	Low Impact Development Center, 2003; The Tank Depot, 2009

Element	Unit	Low	High	References
5,000-gallon cistern	number of units	$4,000	$6,000	Best professional judgment based on range of per cubic foot cistern costs.
Sprinkler system	square foot	$0.5	$0.7	RS Means, 2009
Conventional and Extended Dry Detention[1]	V=cubic foot of detention volume	$8.16V^{0.78}$		Center for Watershed Protection, 2000
Increase in cost for infiltration practices in karst areas	percent of infiltration practice cost	15%	15%	M. Matlock, University of Arkansas Department of Biological and Agricultural Engineering, personal communication to Heather Fisher, December 2008.
Pond HDPE liner (for detention in karst areas)	square foot of pond	$0.90	$1.20	RS Means, 2009
Cost savings from reduced clearing and grubbing	reduced acre disturbed	-$9,800	-$7,300	RS Means, 2009
Cost savings from reduced grading	reduced acre disturbed	-$670	-$490	RS Means, 2009
Cost Savings from replacing curb and gutter with grass swales	acre of low-density development	-$500	-$400	RS Means, 2009; past Tetra Tech case studies.
Cost savings for reducing impervious surface	square feet of reduced impervious surface	-$4.00	-$3.50	RS Means, 2009; B. Cook, Ozark Patterned Concrete, personal communication to H. Fisher, February 2009.
Upfront administrative and education cost	acre of development	$800[2]	$1,000[2]	Interviews with local government staff
Annual administrative and education cost	acre of development	$400[2]	$500[2]	Interviews with local government staff
Annual maintenance of structural stormwater BMPs	percent of construction cost	5%	5%	W. F. Hunt, North Carolina State University Department of Biological and Agricultural Engineering, personal communication to H. Fisher, 2004.

[1] Cost range was calculated using plus or minus 15 percent of the equation result. Cost range and volume estimates will account for the potential differences in cost between conventional and extended dry detention; some extended dry detention designs may not be more expensive than conventional dry detention.

[2] The administrative and education costs are spread over a small number of developments assuming a 5 percent participation rate. If BMPs are required for new development, we would assume a 100 percent participation rate for sites with 18 percent impervious or greater. This substantially reduces the cost per acre of development.

Table C-3 presents the upfront and annual maintenance costs estimated for the post-construction stormwater management options. These costs are reported per acre of development. The cost estimates indicate that the LID cluster option in non-karst areas may result in a net cost savings for the developer. Developers may save up to $3,000 per acre by clustering 1-acre lots into 1/2-acre lots.

Costs estimated for karst areas resulted in an increase of between about 10 to 60 percent above costs in non-karst areas. Cost-effectiveness ratios were not specifically calculated for karst areas, but it should be noted that stormwater management cost per load removed would likely increase by a percent within this range if karst areas require protection from groundwater contamination.

Table C-3. Upfront and Maintenance Cost Estimates per Acre of Development (does not include compliance assistance costs, which are constant across all options)

Management Option	Upfront Cost per Acre (Design, Engineering, and Construction)			Annual Maintenance (per acre)		
	Low	High	Median	Low	High	Median
1-acre, Conv.	$5,000	$6,000	$5,500	$190	$250	$220
1-acre, Conv., Karst	$7,000	$9,000	$8,000	$190	$250	$220
1-acre, Chan. Prot.	$6,000	$9,000	$7,500	$260	$350	$305
1-acre, Chan. Prot., Karst	$9,000	$12,000	$10,500	$260	$350	$305
1-acre, LID	$5,000	$10,000	$7,500	$410	$540	$475
1-acre, LID, Karst	$12,000	$19,000	$15,500	$410	$540	$475
1/2-acre (cluster), LID	-$3,000	$2,000	-$500	$270	$400	$335
1/2-acre (cluster), LID, Karst	$2,600	$10,100	$6,350	$270	$400	$335
1/4-acre, Conv.	$5,000	$7,000	$6,000	$210	$280	$245
1/4-acre, Conv., Karst	$7,000	$10,000	$8,500	$210	$280	$245
1/4-acre, Chan. Prot.	$7,000	$9,000	$8,000	$270	$370	$320
1/4-acre, Chan. Prot., Karst	$10,000	$13,000	$11,500	$270	$370	$320
1/4-acre, LID	$16,000	$30,000	$23,000	$940	$1,470	$1,205
1/4-acre, LID, Karst	$23,000	$45,000	$34,000	$940	$1,470	$1,205
Mixed-Use, Conv.	$6,000	$8,000	$7,000	$250	$340	$295
Mixed-Use, Conv., Karst	$9,000	$12,000	$10,500	$250	$340	$295
Mixed-Use, Chan. Prot.	$8,000	$11,000	$9,500	$340	$460	$400
Mixed-Use, Chan. Prot., Karst	$12,000	$16,000	$14,000	$340	$460	$400
Mixed-Use, LID	$47,000	$74,000	$60,500	$2,210	$3,260	$2,735
Mixed-Use, LID, Karst	$96,000	$147,000	$121,500	$2,210	$3,260	$2,735

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Appendix D. Correlation of Beaver Lake Watershed Protection Strategy Components to EPA 9 Required Elements for Watershed Plans under Section 319 of the Federal Clean Water Act

Table D-1. Correlation of Beaver Lake Watershed Protection Strategy Components to EPA 9 Required Elements for Watershed Plans under Section 319 of the Federal Clean Water Act

EPA 319 Required Element	Quick Reference Listing: BLWSPS Report Content Correlation to EPA 9		BLWSPS Report Section Description	ADDITIONAL REFERENCE DOCUMENT(S)
	PAGE(S)	SECTION/TITLE		
a. An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X numbers of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).	16 - 21	**Section 2.3:** Existing and Future Loading to the Lake	**Section 2.3:** Existing and Future Loading to the Lake for a discussion of causes and sources.	“Beaver Lake SWAT Modeling Baseline Analysis” “Supplementary Pollutant Loading Analysis” technical document
	B-3	**Tables B-1 and B-2.** Core Voluntary BMPs and Estimated Total Sediment for the West Fork and Lower White River Reporting Subwatersheds	**Tables B-1 and B-2** in this **Appendix (B)** include estimated stream lengths and land acres with management opportunities	
b. An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded streambanks).	B-3	**Tables B-1 and B-2.** Core Voluntary BMPs and Estimated Total Sediment for the West Fork and Lower White River Reporting Subwatersheds	**Tables B-1 and B-2** in this **Appendix (B)** include estimated load reductions to be achieved through management measures.	“Cost-Effectiveness of Management Option – Phase 1” technical document
c. A description of the NPS management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.	37 - 50	**Section 4.2.2: #2.** Core Best Management Practices	**Section 4.2.2 #2.** Core Best Management Practices for descriptions of NPS management measures and maps of critical areas.	

EPA 319 Required Element	Quick Reference Listing: BLWSPS Report Content Correlation to EPA 9		BLWSPS Report Section Description	ADDITIONAL REFERENCE DOCUMENT(S)
	PAGE(S)	SECTION/TITLE		
d. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, USDA's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds that may be available to assist in implementing this plan.	37 - 57 A1-11 61 - 73	**Section 4.2:** Five Components of Protection Strategy **Appendix A** **Section 5:** Beaver Lake Watershed Protection Implementation Summary	**Section 4.2** Five Components of Protection Strategy and Appendix A for cost information; See **Section 5** Beaver Lake Watershed Protection Implementation Summary for potential sources of funding and assistance.	
e. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.	37 - 50 50 - 53 53	**Section 4.2.2: #2.** Core Best Management Practices **Section 4.2.3: #3** Developer and Contractor Lake Protection Certification Program **Section 4.2.4: #4** Education and Stewardship Program	See **Section 4.2.2 #2** Core Best Management Practices, **Section 4.2.3 #3** Developer and Contractor Lake Protection Certification Program and **Section 4.2.4 #4** Education and Stewardship Program for training, education, and outreach components.	
f. A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.	61 – 73 70 - 73	**Section 5:** Watershed Implementation Timeline **Table 5-2.** Beaver Lake Watershed Protection Strategy Implementation Timeline	**Section 5** Watershed Implementation Timeline **Table 5-2.** Beaver Lake Watershed Protection Strategy Implementation Timeline: Assuming five-year Adaptive Management cycle beginning January 2012 or at hiring of Council Executive Director	"Beaver Lake Water Quality Targets and Benchmark Analysis"
g. A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.				

EPA 319 Required Element	Quick Reference Listing: BLWSPS Report Content Correlation to EPA 9		BLWSPS Report Section Description	ADDITIONAL REFERENCE DOCUMENT(S)
	PAGE(S)	SECTION/TITLE		
h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPS TMDL has been established, whether the NPS TMDL needs to be revised.	21 - 25	**Section 2.4:** Water Quality Targets	**Section 2.3** Water Quality Targets for a discussion of criteria to measure progress.	"Beaver Lake Water Quality Targets and Benchmark Analysis"
i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.	54 - 59	**Section 4.2.5: #5** Monitoring and Adaptive Management	**Section 4.2.5** #5 Monitoring and Adaptive Management	