Otter Creek/East Fork Sevier Watershed Plan

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1.0 EXECUTIVE SUMMARY

The Otter Creek/East Fork Sevier watershed was settled in the 1870's by pioneers who established an agriculturally based economy. Its communities and economy have diversified since then, but the majority the land uses are still related to agricultural production. These land uses have sustained the local communities and have provided food, fiber and fuel within and outside of the watershed. Many land-use practices in combination with surface runoff, soil erosion, and other sources, have contributed to an increase in non-point source water pollution to several water bodies, resulting in impairment due to their inability to support all of their designated beneficial uses.

In 2006, a TMDL study was completed which analyzed sources of water pollution and recommended practices that would reduce pollutant loading to restore beneficial use to impaired waters. The work needed to achieve these pollutant load reductions is described in this watershed plan. The EPA requires that all approved watershed plans include nine planning elements that clearly define the water quality problem and provide solutions and reasonable assurance that full support of beneficial use can be met (EPA 2008). This plan includes each of these elements (Table 1.1).

The purpose of this watershed plan is to provide necessary information for successfully implementing the pollutant load reductions required by the TMDL. Load allocations for nonpoint sources rely on a voluntary, incentive-based approach rather than regulatory requirements. This voluntary plan must recognize both the constraints and opportunities inherent in this approach. Some of the incentives are public-sector cost-share grants and subsidized financing options. This plan recognizes these opportunities and is organized to meet the requirements of these types of programs, especially those offered by the EPA and the State of Utah.

This watershed plan is organized as follows:

Chapter 2 includes an introduction to the watershed plan along with an explanation of the purpose and need for the plan, a description of the watershed team, and public participation activities that have taken place during the process to complete the updated TMDL and this watershed plan.

Chapter 3 provides a description of the watershed and its stakeholders, including physical and natural features and demographic aspects.

Chapter 4 describes the watershed conditions including water quality standards, assessment methods, and available monitoring data.

Chapter 5 describes the point and nonpoint pollutant sources addressed in the TMDL.

Chapter 6 quantifies the pollutant loads and the load reductions necessary to meet the TMDL and resolve the water quality impairments.

Chapter 7 identifies the watershed goals, objectives, and indicators that will be used in implementing this watershed plan. It also includes a discussion of the load reduction target based on the load allocation in the TMDL.

Chapter 8 identifies the management strategies relevant for the Otter Creek/East Fork Sevier watershed and the relevant partners that can improve water quality. These strategies will ultimately attain the goals defined in Chapter 7.

Chapter 9 describes a program for implementing various management strategies. This program addresses the uncertainties of managing nonpoint pollutant sources including a tentative schedule for achieving milestones and estimates of the cost of implementing various practices. A key element to implementation is convincing local land managers to participate in various practices through an information and education program. This chapter concludes with a suggested monitoring program to assess water quality and help determine if and when beneficial uses are fully supported.

Table 1.1. Minimum planning elements required by the U.S. EPA for watershed planning.		
EPA Element	**Description**	**Location in plan**
a	Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan.	Chapter 5 (pollutant sources) Chapter 7 (watershed goals)
b	An estimate of the load reductions expected from management measures.	Chapter 6 (pollutant loads)
c	A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in element b, and a description of the critical areas in which those measures will be needed to implement this plan.	Chapter 8 (management strategies)
d	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.	Chapter 9 (implementation)
e	An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.	Chapter 9 (implementation)
f	Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.	Chapter 9 (implementation)
g	A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.	Chapter 9 (implementation)
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.	Chapter 9 (implementation)
i	A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item h immediately above.	Chapter 9 (implementation)
Source: EPA (2018).		

2.0 INTRODUCTION

A watershed management plan is "a strategy that provides assessment and management information for a geographically defined watershed, including the analysis, actions, participants, and resources related to developing and implementing the plan." (EPA 2008, Section 2.1) A successful watershed plan is supported by all stakeholders including landowners, private organizations, municipalities, and government agencies. The plan clearly defines a shared vision of what the watershed should be (goals), areas that need improvement (resource concerns), and how to turn the vision into reality (implementation).

Watershed planning incorporates many different interests and may have to rely on limited knowledge, but because planning is designed to be iterative, it can adjust over time as the environment changes or is better understood. Due to the complexity of the environments in which watershed planning occurs it usually takes several planning cycles to fully understand how to implement the plan.

2.1 WATER QUALITY IMPAIRMENTS

The most recent approved list of impaired waters for Utah is part of the 2016 DEQ Integrated Report (IR, Utah DWQ 2016). Some of these water bodies were previously included on the list of impaired waters in the 2014 IR. This watershed plan addresses seven river segments and four reservoirs/lakes in the Otter Creek/East Fork Sevier watershed (Table 2.1). Figure 2.1 shows the location of each impaired waterbody.

The most recent TMDL for the Otter Creek/East Fork Sevier watershed addresses the total phosphorus impairment only (Utah DWQ 2006). This watershed plan includes the measures needed to successfully implement the total phosphorus load reductions in that TMDL as well as restoring support of beneficial use for other impairments and pollutants of concern included in the 2016 IR. In most instances, the BMPs implemented for reducing phosphorus will also reduce pollutant loads that lead to other impairments in the Otter Creek/East Fork Sevier watershed.

Water bodies are also referred to as assessment units by the Utah Department of Water Quality (Utah DWQ). Assessment units can be segments of rivers or streams or individual water features such as lakes, or reservoirs. The water bodies in Table 2.1 include lakes, reservoirs, streams and segments of streams/rivers.

2.2 OTTER CREEK/EAST FORK SEVIER WATERSHED ADVISORY COMMITTEE

The Watershed Advisory Committee that provided input for this plan was organized in 2017. The purpose of this committee is to guide development of the watershed plan and provide input on selecting water quality improvement projects that restore beneficial use. The committee is comprised of local landowners, municipal leaders, and state and federal agencies. Table 2.2 lists all participating members of the Committee.

As part of developing the watershed plan, the Committee has met twice during 2018 and once during 2019. During these meetings, members of the Advisory Committee discussed and reviewed requirements of watershed planning, information on water quality monitoring and pollutant sources, participated in surveys, and discussed potential water quality improvement projects. Other local and regional committees in the area, comprised mostly of private landowners, meet more frequently to review concerns related to land and water resources. These groups have also provided input to this watershed plan and have a pivotal role in implementing the recommendations that it makes.

Table 2.1. Section 303(d) listing history of the Otter Creek/East Fork Sevier watershed and parameters of concern[1].

Waterbody Name	2000	2002	2004	2006	2008	2010	2012 / 2014	2016
Otter Creek – and tributaries from Koosharem Reservoir to headwaters							T	E, T
Otter Creek – and tributaries from Otter Creek Reservoir to Koosharem Reservoir, except Box and Greenwich creeks					Bio, T		Bio, T	Bio, pH, T
Greenwich Creek – and tributaries from confluence with Otter Creek to headwaters							S, P	S, P
Box Creek – and tributaries from confluence with Otter Creek to headwaters				T			H, DO S, P	H, DO S, P
East Fork Sevier River – and tributaries from confluence with Sevier River upstream to Antimony Creek confluence, excluding Otter Creek and tributaries	P	P	P	T			T	P, T
East Fork Sevier River – and tributaries from Antimony Creek confluence to Deer Creek confluence						Bio		Bio
East Fork Sevier River – and tributaries from Deer Creek confluence to Tropic Reservoir								Bio
Otter Creek Reservoir	P, T	P	P, T, pH	pH				P, pH, T
Lower Box Creek Reservoir	P	P	P, DO			pH		DO, P, pH
Pine Lake								pH
Koosharem Reservoir	P	P	P			P, T		P

[1] Parameters of Concern: P: total phosphorus, T: water temperature, E: E. coli, DO: dissolved oxygen, Bio: OE Bioassessment, S: Sediment

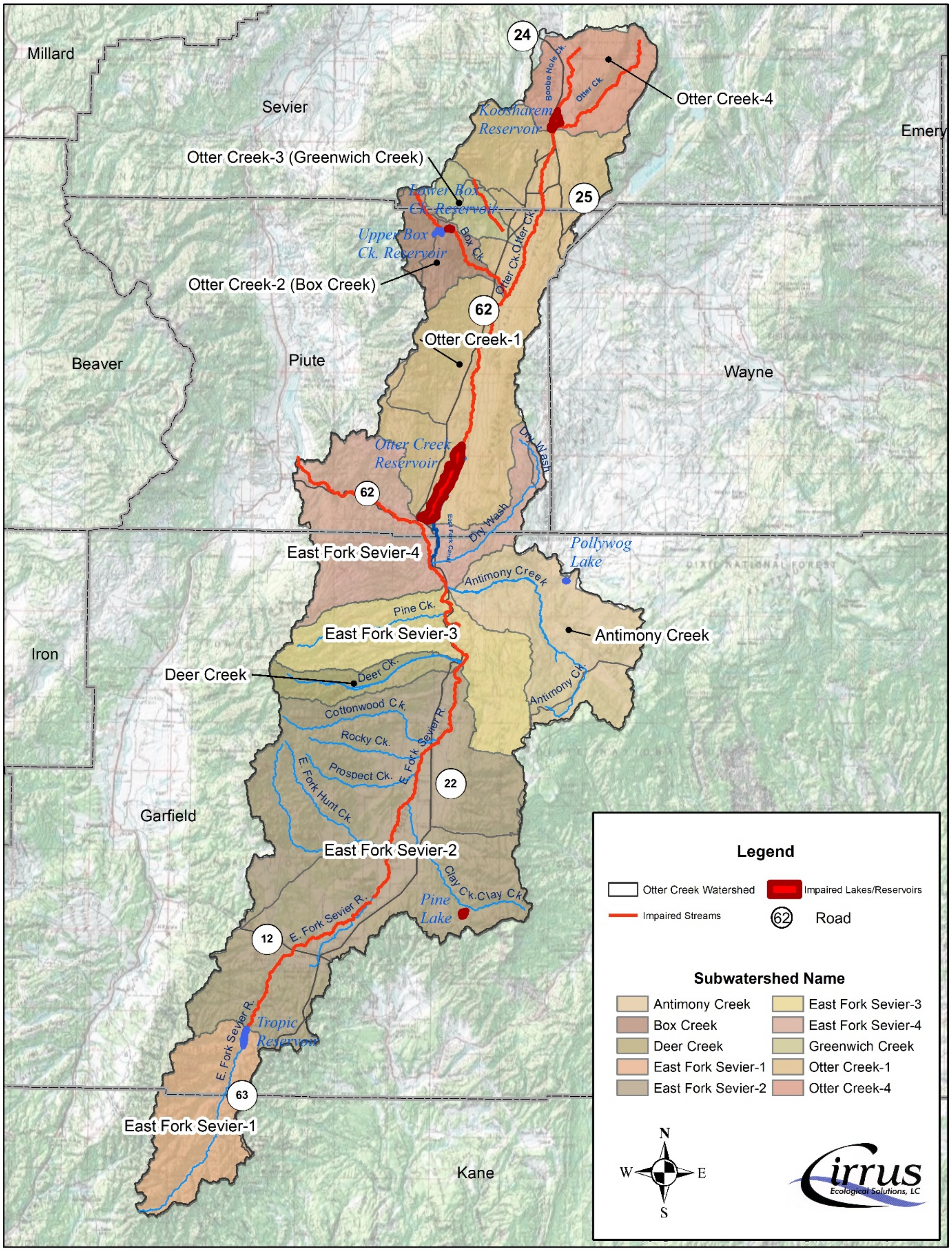

Figure 2.1. Otter Creek watershed and subwatershed boundaries.

Table 2.2. Membership of the Otter Creek Watershed advisory committee.		
Organization	**Organization**	**Organization**
Angle Irrigation Company	Greenwich Town	Sevier County
Angle Town	Koosharem Irrigation	Sevier County Commission
Beaver Creek Irrigation	Koosharem Town	Seven Mile Grazers
Bureau of Reclamation (BOR)	Parker Mountain Grazers	Sevier Conservation District
Burrville Irrigation	Piute County	State Land Grazers
Burrville Town	Piute County Commission	Utah School and Institutional Trust Lands Administration (SITLA)
Dark Valley Grazers	Piute Conservation District	Thousand Lake Grazers
Department of Environmental Quality (DEQ)	Piute Indian Tribe	Utah Division of Wildlife Resources (UDWR)
East Side Grazers	Private Landowners	UM Grazers
Farm Bureau	Natural Resources Conservation Services (NRCS)	United States Forest Service (USFS)
Forestry, Fire, and State Lands (FFSL)	Redbud Irrigation	United States Fish & Wildlife Service (USFWS)
Greenwich Creek Irrigation	Sheep Valley Grazers	

2.3 LAND OWNERSHIP AND PROJECT IMPLEMENTATION

Most land in the Otter Creek/East Fork Sevier River watershed is managed by federal and state agencies including the Forest Service (58 percent), BLM (19 percent) and SITLA (10 percent). Approximately 10 percent of the watershed is privately owned, including some of the land adjacent to impaired water bodies. Restoring water quality will require a combined effort from both public land managers and private land owners. Projects with the greatest opportunity to immediately affect impairment will occur on land that borders streams, rivers, lakes, and reservoirs. While private landowners typically express an interest in improving water quality, they are often unable or unwilling to invest in projects that do not result in immediate and tangible benefits to their own operations. Therefore, implementation of successful projects requires additional benefits, perhaps unrelated to water quality. In contrast, some agencies need to show demonstrable proof that funds spent on BMPs have produced measurable water quality improvements. A successful watershed plan will address needs of both groups.

Project implementation will most likely occur when it includes practices that stakeholders have confidence in, either from direct past experience or observations of successful implementation by neighbors or others in the watershed. An opinion survey was administered during the October 11, 2016 stakeholder meeting to identify practices that agencies and private landowners considered to be worthwhile and capable of improving water quality. The results of this survey are found in the appendix to the plan. The survey included four major pollutant sources identified in the updated TMDL including AFOs, land applied manure, livestock grazing, and surface erosion. Each category had a short list of NRCS- approved BMPs that could be applied to reduce total phosphorus loading. Stakeholders were asked to score each BMP ranging from 5 (highly effective) to 0 (waste of money). In general, BMPs with higher scores matched well with practices that have been previously implemented in the watershed. A few of the BMPs with high average scores included streambank vegetation, upland vegetation management, riparian herbaceous cover, brush management, and prescribed grazing. Some of the BMPs with lower scores included compost facility, waste treatment lagoon, and animal waste storage. These BMPs have potential to reducing pollutant loading from all non-point sources in the watershed. Additional training and incentives may be needed before these BMPs can be implemented.

2.4 FUNDING FOR NONPOINT SOURCE PROJECTS

Federal and state agencies provide subsidies for private investment in water quality projects. Each of these programs has requirements for project selection and funding participation. As an example, Figure 2.2 shows the maximum funding provided through two programs, the EQIP program administered through the USDA's Farm Bill program and Section 319 funds provided by EPA and administered through the Utah DWQ. Even with substantial subsidies, the private land owner must still provide at least 20 percent of a project's cost, although the private component can come from in-kind labor and equipment. Regardless of the contribution from EQIP funds, EPA 319 and private funds must cover 60 percent and 40 percent (respectively) of the remaining cost, no matter the contribution from EQIP funding.

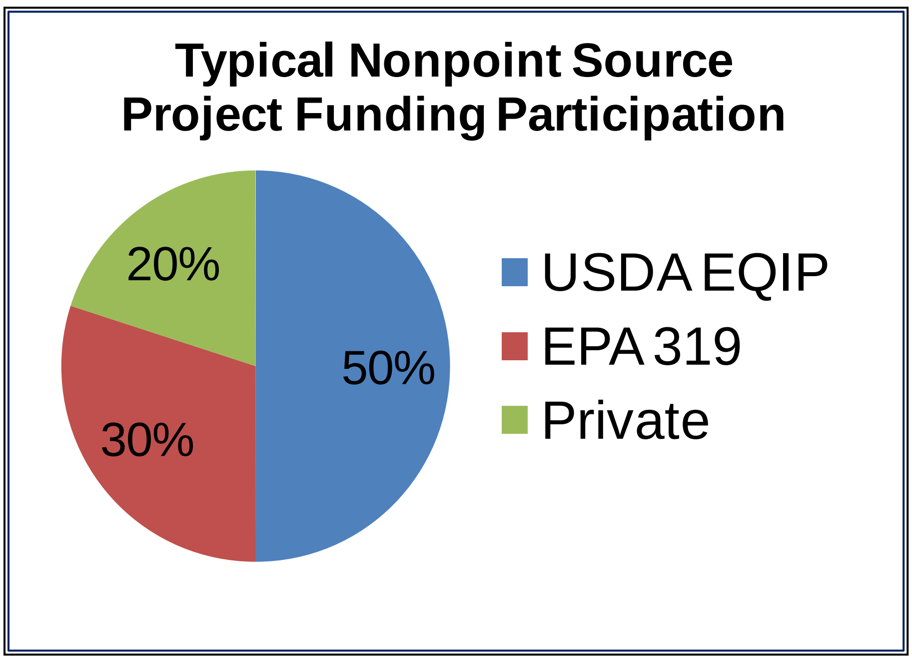

Figure 2.2. Typical structure of nonpoint source project funding.

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3.0 WATERSHED DESCRIPTION

The watershed plan will address all land that drains to Otter Creek and the East Fork Sevier River to the confluence with the Sevier River near Kingston, Utah. This project area incorporates impaired water bodies identified in the 2016 IR. The discussion in this chapter will briefly describe significant geographic features and processes in the area that influence flow and water quality, followed by a description of political and social factors that influence management of land and water resources.

Several studies have been completed in the project area that address aspects of water quality and watershed health. Each study was reviewed for useful information and many are cited in this chapter. A summary description of each study is included in the appendix to this plan. A digital copy of each study (where available) is also included in the project record.

3.1 WATERSHED BOUNDARIES

The Sevier River drains more than 9,900 square miles; an area larger than the state of Vermont. The Sevier River Watershed is divided into five major subregions, one of which is the East Fork Sevier River. The East Fork Sevier River watershed (HUC 16030002) constitutes the eastern part of the Upper Sevier River subregion and is more commonly known as the Otter Creek/East Fork Sevier watershed, naming the primary rivers that influence flow. This watershed encompasses approximately 790,000 acres or 1,234 square miles of drainage area including roughly 370 square miles in the Otter Creek watershed and 864 square miles in the East Fork Sevier watershed. The East Fork Sevier watershed can be classified further into upper and lower subwatershed areas above and below Otter Creek Reservoir, respectively.

Portions of the Otter Creek/East Fork Sevier watershed are found in 4 counties including (from north to south): Sevier, Piute, Garfield, and Kane counties (Figure 2.1). The watershed encompasses all water flowing into the East Fork Sevier River, including Otter Creek and Otter Creek Reservoir. Relatively higher elevations are found in the north end of the watershed as compared to the south end. The average gradient for the East Fork Sevier is 37 ft/mile (0.7%) while Otter Creek maintains a slightly steeper gradient at 105 ft/mile (2%).

3.2 CLIMATE/PRECIPITATION

The watershed has a semi-arid continental climate. Precipitation in the Sevier River Basin is influenced by two major storm patterns: frontal systems from the Pacific Northwest during winter and spring, and thunderstorms from the south and southwest during late summer and early fall (Utah Board of Water Resources 1999, Utah DWQ 2003). These thunderstorms develop as moist air from the Gulf of Mexico moves across the area (Swenson and Bayer 1984). Local topography influences these systems. As a result, precipitation and temperatures are highly variable and dependent upon location.

Although heavy thunderstorms are common during the summer and cause increased sheet erosion, the majority of precipitation falls as snow over the mountains during the winter (USFS 2004). The higher mountains receive up to 30 inches annually along the East Fork drainage and up to 40 inches on the Fishlake Plateau, in the northeast corner of the Otter Creek drainage. Valley bottoms receive less precipitation (5–15 inches annually) and a larger proportion of it comes from summer and fall storms. Local weather patterns are influenced by a valley restriction named Otter Creek Narrows, approximately 8 miles upstream of Otter Creek Reservoir. This land feature creates a rain shadow effect on the south side, which has created difficulties in reseeding efforts on areas adjacent to Otter Creek (Piute and Fremont River Soil Conservation Districts 2006).

3.3 HYDROLOGY

The purpose of the hydrologic description in this section is to establish flow volumes and patterns for rivers and lakes in the project area with particular emphasis on impaired water bodies. This information will be used in conjunction with a review of flow and water quality data in Chapter 4 to identify potential contamination sources and evaluate possible remediation strategies.

3.3.1 STREAMS

The headwaters of the Otter Creek watershed are located in the north end of Plateau Valley. Surface flows are concentrated into three stream channels including Otter Creek, Daniels Creek, and Boobe Hole Creek (Figure 3.1). Koosharem Reservoir stores water from Boobe Hole Creek and Otter Creek that is released throughout the spring and early summer season. Water stored in Koosharem Reservoir is delivered to Otter Creek, which flows south through Grass Valley for roughly 25 miles before entering Otter Creek Reservoir.

The headwaters of the East Fork Sevier begin above Tropic Reservoir (Figure 3.2). The East Fork is dammed at Tropic Reservoir and most of the water is diverted out of the watershed to the town of Tropic during summer months. As a result, the East Fork stream channel is typically dry during the summer from Tropic Reservoir down to the north end of John's Valley. Below Tropic Reservoir, the East Fork moves through Emery Valley and Johns Valley which provide a limited amount of flow from wetlands and perennial springs. At the north end of Johns Valley, the East Fork enters Black Canyon, where the river channel is confined to a narrow meander plain, roughly 0.1 miles wide and 5 miles long. Water enters the channel again from tributaries near Black Canyon, at the north end of Johns Valley.

Antimony Creek discharges into the East Fork approximately two miles below the mouth of Black Canyon and south of the town of Antimony. About a mile below the confluence with Antimony Creek, the entire flow from the East Fork is diverted to Otter Creek Reservoir during much of the year by way of the East Fork Canal. The canal also diverts flow from several intermittent streams prior to entering Otter Creek Reservoir. Flow in the East Fork Canal represents approximately 75 percent of annual inflow to the reservoir.

The lower East Fork begins at the confluence with Antimony Creek and continues down to the main stem of the Sevier River. As mentioned previously, the East Fork Canal diversion is located below Antimony Creek and periodically routes the entire flow from the East Fork into Otter Creek Reservoir. Below the diversion, the East Fork continues for roughly five miles before receiving release flow from Otter Creek reservoir via Otter Creek. Below the confluence with Otter Creek, the East Fork runs west through Kingston Canyon to the town of Kingston then north to its confluence with the Sevier River, just south of Piute Reservoir. State Road 62 runs along the East Fork from Otter Creek Reservoir to Kingston through the canyon.

Hydrologic inputs to the lower East Fork are principally from Otter Creek Reservoir, which represents the sum total flow produced by inflows from the upper East Fork and Otter Creek. Although several tributary streams do enter the East Fork within Kingston Canyon, the flows from these tributaries are typically intermittent in nature and are generally relatively minor contributions to the total flow in the East Fork. As a result, water quality impacts to the lower East Fork are highly dependent upon pollutant loads delivered to upstream water bodies, including Otter Creek.

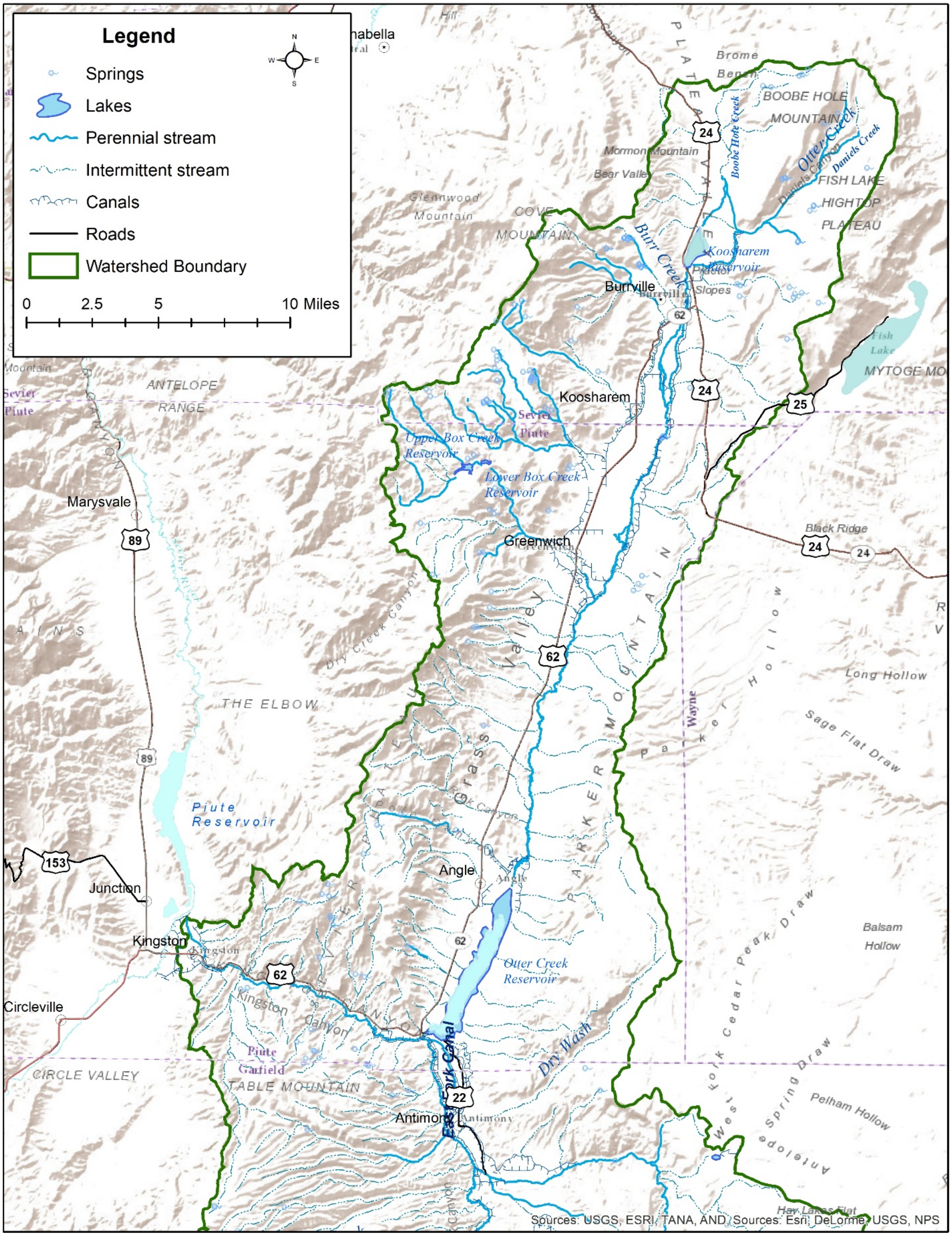


Figure 3.1. Water features in the Otter Creek watershed.

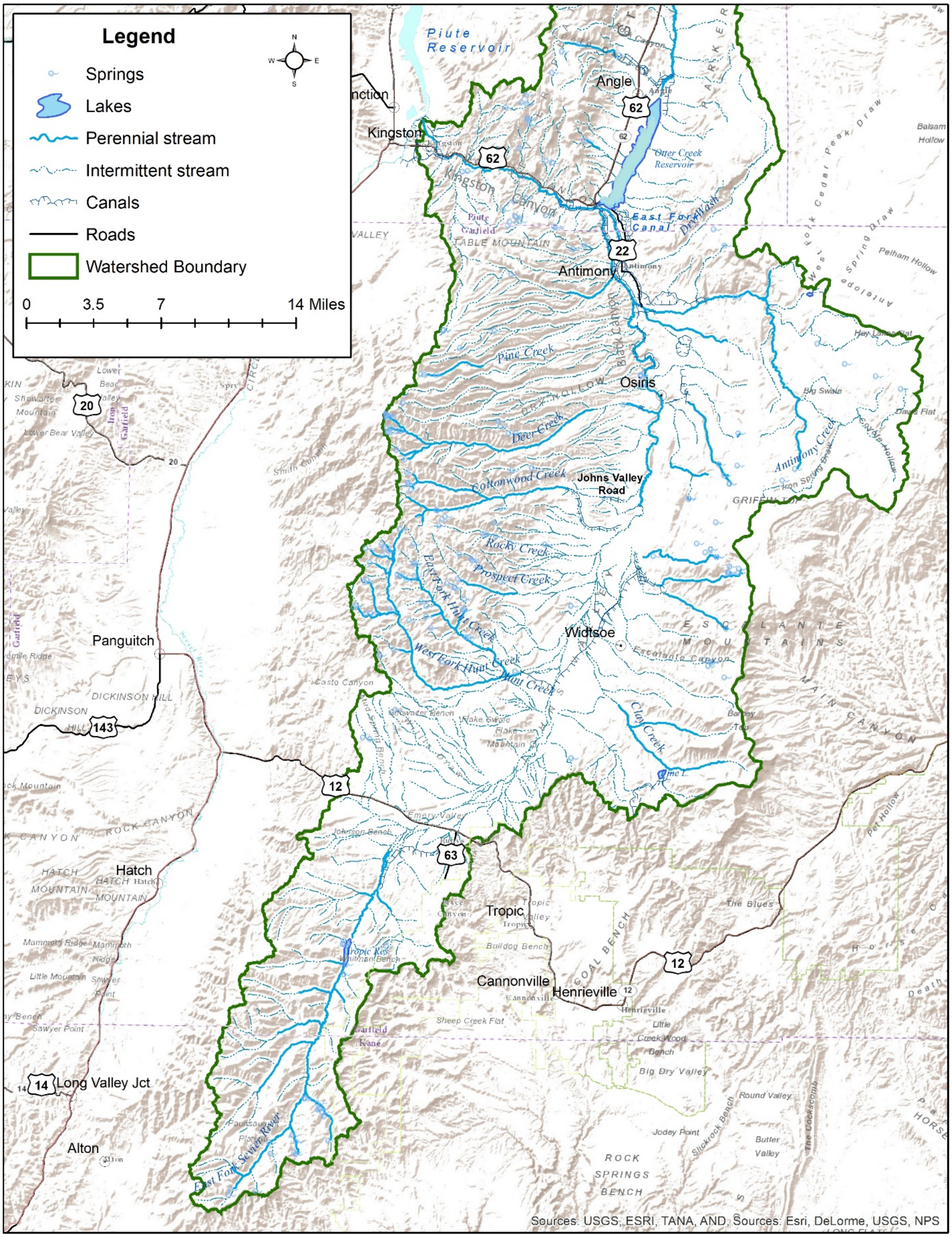


Figure 3.2. Water features in the East Fork Sevier watershed.

3.3.2 RESERVOIRS

The study area contains several reservoirs that are used primarily for storing water for irrigation. These reservoirs significantly influence the hydrology of downstream water bodies in terms of regulating peak runoff events and sustaining streamflow during drier parts of the year. Recreational use of the reservoirs occurs through fishing and boating activities.

Koosharem Reservoir is supported by two tributaries, including Otter Creek and Boobe Hole Creek Reservoir inflow is measured in Otter Creek but no streamflow data is available for Boobe Hole Creek and no diversions are located on the Creek (Burr 2004). The majority of tributary inflow to Koosharem Reservoir is provided by Otter Creek which is divided into a north ditch and a south ditch near the mouth of Daniels Canyon. Flow in the North Ditch is used completely and provides minimal return flow to Boobe Hole Creek. A portion of the flow in the South Ditch is diverted approximately one mile from the east border of Koosharem Reservoir and remaining flow continues to the reservoir. There are no diversions from tributaries to Koosharem Reservoir that send water around the reservoir. Koosharem Reservoir supports water rights held by the Koosharem Irrigation Company and the Meridian Irrigation and Reservoir Company. The majority of storage in Koosharem Reservoir is obtained each spring by snowmelt runoff from fields surrounding the reservoir (Burr 2004).

The upper reaches of Box Creek are dammed in two places to create Upper and Lower Box Creek Reservoirs, located in the mountains to the northwest of Greenwich. These reservoirs are currently owned and operated by the Beaver Creek and Reservoir Irrigation Company. No measurements of reservoir inflow to Upper Box Creek Reservoir and Lower Box Creek Reservoir are available. The operation of these reservoirs is usually based on the amount of precipitation received during the previous winter. Water is typically released from Lower Box Creek Reservoir first. Water from the upper reservoir is then used to maintain water levels in the lower reservoir. During a typical water year, the watermaster does not allow either one of the reservoirs to drain completely (Bagley 2004).

Otter Creek Reservoir, located at the lower end of Otter Creek, stores runoff from Otter Creek as well as the East Fork and is considered to be a significant storage reservoir within the Sevier River Basin. Otter Creek Reservoir is privately owned and operated by the Otter Creek Irrigation Company. All water used by the irrigation company is administered by the Upper Sevier River Commission who delivers water to the individual irrigation companies downstream of the reservoir. Many of these companies are located outside of the TMDL study area (Otter Creek Irrigation Company 2002). The two major inflows to the reservoir are Otter Creek and the East Fork Canal, contributing roughly one-fourth and three-fourths of the total annual inflow, respectively. A minor amount of water enters the reservoir as surface runoff from the area immediately adjacent to the shoreline. Water discharged from the reservoir flows through Kingston Canyon, eventually reaching Piute Reservoir.

Pine Lake is located on upper slopes of the south end of Johns Valley. Water enters the lake through snowmelt runoff from the surrounding slopes and from one unnamed tributary. Discharge from the lake enters Clay Creek which is an intermittent tributary to the East Fork Sevier River. No flow records are available for Pine Lake.

Peak monthly flow for segments of Otter Creek above Koosharem Reservoir and above Otter Creek Reservoir are different and are influenced by the timing of snowmelt and reservoir management. Otter Creek above Koosharem Reservoir receives flow from higher elevation watersheds which experience spring snowmelt in May and June. Flow in Otter Creek above Otter Creek Reservoir is regulated somewhat by management of Koosharem Reservoir and existing water rights. Peak monthly flows in Otter Creek above

Otter Creek Reservoir occur in March and reflect seasonal inflow from tributaries located downstream of Koosharem Reservoir that are dry during other times of the year.

Irrigation

A total of 17 irrigation companies are found in the watershed. Many of these organizations work closely with the owner/operators of the larger reservoirs to ensure proper delivery of water during the irrigation season. The locations of the major ditches and canals are shown in Figure 3.1 and Figure 3.2. Annual diversion amounts to canals have been estimated to be 16,000 acre-ft/yr in the Otter Creek watershed and 12,200 acre-ft/yr in the East Fork watershed (Thiros and Brothers 1993). The majority of canals and ditches used by irrigation companies are unlined and subject to a certain amount of seepage and loss to groundwater. Once the water is delivered to individual users, it is applied through flood irrigation or sprinkler irrigation. The majority of irrigation systems in the area rely upon pressurized irrigation systems. However, flood irrigation is typically preferred over pressurized systems on fields and pastures located near streams, which has potential for pollutant loading (Jarman 2004).

3.4 LAND OWNERSHIP/LAND USE

Approximately 80 percent of land within the watershed is federally owned, including 58 percent NFS land (parts of the Fishlake and Dixie National Forests), 19 percent Bureau of Land Management (BLM) land, 1 percent National Park land (part of Bryce Canyon National Park), and 1 percent Bankhead-Jones land (Table 3.1). The Bankhead-Jones Farm Tenant Act of 1937 required the Secretary of Agriculture to develop a program of land conservation and utilization to correct maladjustments in land use. It authorized the federal government to acquire damaged land for rehabilitation purposes. Bankhead-Jones land within the project area is managed by the Forest Service. An additional 10 percent of the land is state-owned, and 10 percent is private. A Native American reservation located near Koosharem Reservoir covers approximately 0.1 percent of the study area.

Table 3.1. Land ownership in the Otter Creek/East Fork Sevier River watershed.

	Area	
Ownership Category	**Acres**	**Percent**
BLM	147,785	18.7
Bankhead Jones	8,094	1.0
Forest Service	459,694	58.2
Intermittent Water	42	0.01
National Park	7,933	1.0
Native American Reservation	669	0.1
Private	79,461	10.1
State	82,553	10.5
Water	3,293	0.4
Total	789,524	100

Land use in the TMDL study area is mostly comprised of forest and rangeland with some areas of agriculture located in lower elevation areas. Table 3.2 and Figure 3.3 indicate the percent composition of land use categories and their associated acreage. The agricultural industry in the study area centers on the raising of livestock, due to the short growing season which limits the growth of many commercial crops. In cultivated areas, the main crops are hay, alfalfa and small grains, used to feed livestock during the winter.

Table 3.2. Land use distribution in the Otter Creek/East Fork Sevier River watershed.

	Area	
Land Use Category	**Acres**	**Percent**
Urban/Residential	1,565	0.2
Forest Land	344,726	43.7
Range Land	399,341	50.6
Irrigated Agriculture	20,645	2.6
Non-Irrigated Agriculture	495	0.1
Animal Feeding Operations	127	0.02
Wetlands	338	0.04
Barren	20,851	2.6
Water	1,442	0.2
Total	789,531	100

Figure 3.3 indicates that land use in the Otter Creek and East Fork Sevier River watersheds primarily consists of range land (50.6 %) and forest land (43.7 %), with less than 10 percent of the watershed area made up of agricultural, urban/residential, and other land use categories. This land use distribution is consistent with the land ownership in the watershed (Table 3.2), which is primarily made up of NFS land (58.2 %), BLM (18.7 %), and State lands (10.5 %), with smaller areas of private land (10.1 %) that are primarily associated with the low-lying areas near existing water courses.

Although traditional use of the area has centered around livestock grazing, increased recreational use of National Forest System (NFS) lands has created some concern with regards to water quality. State Highway 12 and Highway 63 transports over 1.5 million visitors annually to Bryce Canyon National Park, located adjacent to the east boundary of the East Fork watershed. Dispersed camping, high traffic volumes on unpaved roads and stream crossings as well as illegal use of ATVs within riparian and upslope areas have impacted soil and vegetation resources within fragile stream corridors on NFS lands. Natural processes such as wildfire and periodic drought conditions have further increased the impact of these activities.

Future land use is dependent in large part upon economic factors at the local and state levels as well as influences from regional economic patterns. Agriculture is a significant economic factor and is influenced by the cost of fuel, fertilizer, seed and products such as grain, hay and cattle, which can experience wide swings between years. Annual precipitation levels can also significantly influence crop production within any given year. Trends toward fewer but larger farms will likely continue in the future although the total amount of irrigated land will likely remain the same due to limitations on irrigated acreage dictated by the water supply and the Cox Decree.

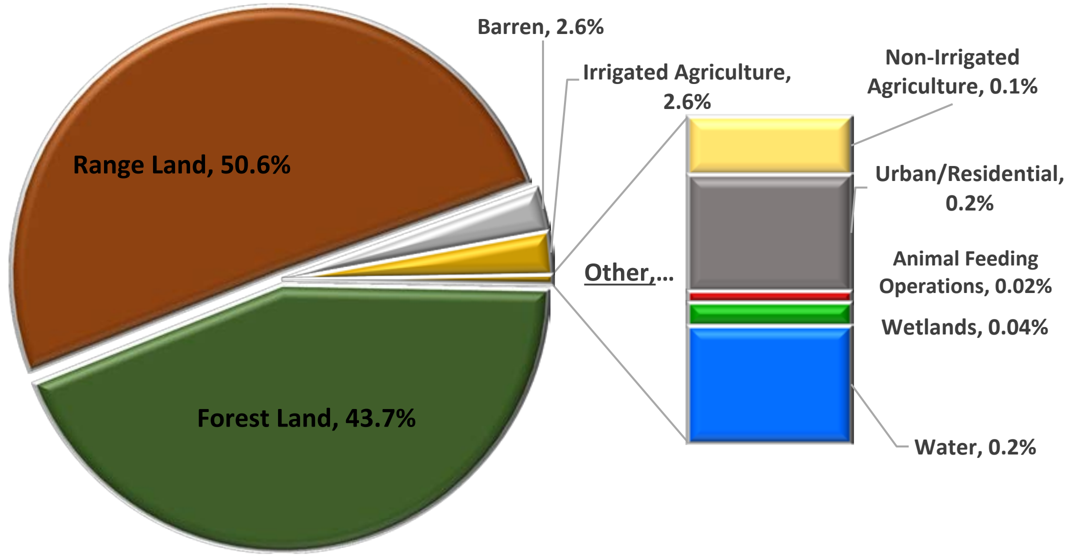


Figure 3.3. Land use distribution in the Otter Creek/East Fork Sevier River watershed.

3.5. DEMOGRAPHICS

Most of the Otter Creek/East Fork Sevier watershed is lightly populated, with higher concentrations located in a few cities. (U.S. Census 2010) This pattern is consistent with much of Utah outside of the Wasatch Front area, which has the highest concentration of population in the state. Population centers in the OtterCreek/East Fork Sevier watershed are located primarily along valley bottoms. Totals are provided for each county in the watershed in Table 3.3. These numbers reflect lower densities than the statewide average. Population increases or decreases can result in new development in previously undeveloped areas or higher density development within municipal boundaries. Both of these processes could impact water quality, particularly if new development occurred in critical areas where pollutant loads are easily transferred to impaired water bodies.

Table 3.3. Population, area, population density and estimated mean household income in counties of the Otter Creek watersheds.

	Population			Area (sq mi)	Density (persons/sq mi)			Median Household Income 2013-2017 est.
	2000	2010	2018 est.		2000	2010	2018 est.	
State of Utah	2,233,169	2,763,885	3,161,105	82,170	26.3	33.6	38.5	$ 57,783
Piute County	1,435	1,556	1,445	765	1.9	2.0	1.9	$ 36,667
Sevier County	18,842	20,802	21,539	1,917	9.8	10.9	11.2	$ 44,731

Source for population: U.S. Census (2010).

4.0 WATERSHED CONDITIONS

This chapter describes the watershed condition and health of the Otter Creek/East Fork Sevier watershed based on results included in recent Utah DWQ Integrated Reports (IR). These reports identify impaired water bodies throughout the state. The methods used to determine if a water body is impaired or not are described in this chapter and rely in large part on monitoring data and state standards that are designed to protect the beneficial use of waters of the State. The sections of this chapter describe the methods and data that were used to determine how and why each waterbody is impaired. Section 4.1 describes the standards and methods used to determine water quality impairment. Section 4.2 includes specific information on all impaired waterbodies in the Otter Creek/East Fork Sevier watershed and section 4.3 summarizes the monitoring results with regard to the extent of impairment. Chapters 5 and 6 of this watershed plan characterize pollutant sources and loads, respectively that contribute to the impairment. The remaining chapters in the plan describe the process to improve conditions that contribute to degraded water quality and meet the goals and objectives defined in this plan.

4.1. WATER QUALITY STANDARDS

Water quality standards are established to maintain or improve existing water quality and protect the beneficial use of each water body. The designated use of a body of water is based on goals adopted by the state to protect public health or welfare, enhance water quality, and protect its assigned beneficial uses. Numeric standards and criteria are science-based and incorporate the most recent understanding of human health, healthy ecosystem behavior, and response to pollutants. Narrative standards protect water quality from pollutants that are not suited for numeric criteria or haven't developed criteria so far. Pollution indicators are used in combination with standards to evaluate parameters that are not directly harmful (e.g. phosphorus) but contribute to a response and condition that can degrade water quality (e.g. algal blooms).

4.1.1. DESIGNATED AND DESIRED USES

Beneficial uses in Utah include drinking water, recreational use, aquatic life, wildlife, agriculture, and industrial use. Once beneficial uses are assigned to a water body, water quality standards to protect that beneficial use are established.

The beneficial uses assigned to water bodies in the Otter Creek/East Fork Sevier watershed include the following:

- Class 2B – Secondary contact recreation: protected for activities that have a low likelihood of ingestion of water or bodily contact such as wading, hunting, and fishing. Also protected for infrequent primary contact recreation (e.g. swimming).
- Class 3A – Cold water aquatic life: Protected for cold water species of game fish and other cold water aquatic life including necessary organisms in their food chain.
- Class 4 – Agriculture: Protected for agricultural uses including irrigation of crops and livestock watering.

4.1.2. NUMERIC CRITERIA/ STATE STANDARDS

All water quality standards associated with beneficial use classes 2B, 3A, and 4 can be found in Utah Administrative Code (UAC) R317-2-14. Many of these standards apply to pollutants that are currently not a concern in the Otter Creek/East Fork Sevier watershed. Table 4.1 includes a list of numeric criteria, pollution indicator values, narrative standards for the parameters of concern addressed in this watershed plan.

Table 4.1. Parameters of concern and water quality standards addressed in the Otter Creek/East Fork Sevier watershed plan.		
Beneficial use class	**Parameter of concern**	**Standard or indicator value**
Class 2B – secondary contact recreation	E. Coli	Maximum: 668 cfu 30-day geometric mean: 206 cfu
Class 3A – cold water aquatic life:	Dissolved oxygen	Acute conditions[1] = 4.0/8.0 mg/L Chronic conditions = 6.5 mg/L Reservoirs = 4.0 mg/L
	pH	Minimum = 6.5 su Maximum = 9.0 su
	Water temperature	Maximum = 20 ˚C
	O:E bioassessment	3 or more samples = 0.76 < 3 samples = 0.69
	Total phosphorus[2]	Streams = 0.05 mg/L Lakes = 0.025 mg/L
	Sedimentation, habitat	Narrative standards, non-pollutant

[1] First number indicates acute DO standard applicable to adult-life stage aquatic species, second number is applicable to early-life stage aquatic species.

[2] Total phosphorus is a pollutant indicator and cannot determine impairment by itself. It can be used in combination with other parameters that respond to high nutrients (e.g. dissolved oxygen) in order to determine impairment.

The standards for E. coli, dissolved oxygen, pH, and water temperature are based on the health of humans or aquatic species. The composition of macroinvertebrate (i.e. aquatic insects) communities in streams provides an overall indication of good water quality and ecosystem health. The standard for O:E bioassessment is based on a ratio of the observed number of macroinvertebrate species (i.e. aquatic insects) to the expected number of species if good water quality were present at a monitoring site. The expected number of species at any monitoring site in Utah is based on numerous site-specific conditions at the site and macroinvertebrate species identified in reference reaches (Ostermiller and Hawkins 2004, Utah DWQ 2016).

As mentioned previously, total phosphorus is an indicator of high nutrient concentrations that can lead to algal blooms and degraded water quality. The values for total phosphorus in Table 4.1 represent concentrations that minimize this occurrence and account for natural levels of nutrients in healthy streams and lakes.

Standards for sedimentation and habitat do not currently exist in Utah. They have been primarily used in situations where existing uses were unknown and standards had not been established for parameters of concern. Accumulated sediment can fill voids in gravel and cobble that are used for spawning by adult fish and protection by juvenile fish and aquatic insects. Aquatic habitat can be found in the stream channel and riparian corridors that border the stream channel. Stream channel sediment and aquatic habitat can be evaluated on the basis of overall stream ecosystem health, professional judgement, and comparison to reference reaches.

4.1.3. ANTIDEGRADATION POLICIES/PROCEDURES

Antidegradation policies in Utah are described in UAC R317-2 section 3. These policies apply to waters with quality that is better than established standards for the assigned beneficial use. In these situations, existing water quality is maintained unless “allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located” (R317-2-3 Antidegradation Policy). In all situations however, the existing water uses will be maintained and no degradation is allowed which would harm existing water uses.

Water bodies that are within the outer boundary of National Forest lands (i.e. whether on public or private land) are typically defined as High Quality Waters – Category 1. This definition includes antidegradation standards that do not permit water quality to decrease below existing levels of high quality. Other river segments outside of Forest boundaries may also be classified as Category 1 waters.

The East Fork Sevier River from the Kingston diversion to headwaters (UAC R317-2 section 12.1.b.9 Sevier River drainage) is classified as a Category 1 water including river segments inside and outside of Forest boundaries. All other stream channel segments located on National Forest lands are considered Category 1 waters including upper headwater segments of tributaries to Otter Creek found on the Fishlake National Forest.

4.2. AVAILABLE MONITORING / RESOURCE DATA

Water quality samples have been collected at surface and groundwater monitoring stations in the East Fork Sevier and Otter Creek watersheds since the early 1970s. The majority of monitoring stations are located on lower segments of the mainstem East Fork Sevier River and Otter Creek. A limited number of reservoir monitoring stations are found on Koosharem, Lower Box Creek, and Otter Creek Reservoirs. An in-depth review of monitoring data in the Otter Creek/East Fork Sevier watersheds is included in the previous TMDL study (Utah DWQ 2006). All data used by Utah DWQ in 2014 and 2016 to determine impairment have been analyzed as part of this watershed plan. This section of the watershed plan will discuss these results.

4.2.1. WATER QUALITY DATA (IMPAIRMENTS/THREATS)

Table 4.2 shows the water bodies or assessment units in the Otter Creek/East Fork Sevier watershed that were identified in the 2014 and 2016 IRs. The location of water bodies in Table 4.2 are shown in Figure 2.1. Water bodies are also referred to as assessment units by Utah DWQ. Assessment units can be segments of rivers or streams or individual water features such as lakes, or reservoirs. The water bodies in Table 4.2 include lakes, reservoirs, streams and segments of streams/rivers. The first and second columns in the table indicate the ID and description of impaired water bodies. The third column identifies the beneficial use class of the assessment unit. The last column of the table identifies the impairment category and parameter(s) contributing to impairment.

The data presented in this chapter is not exhaustive and addresses those records used to determine impairment. These results indicate the extent of water quality exceedances of recent measurements from each impaired water body. They also indicate the amount of change that must occur in order for water quality to fully support beneficial use. An extensive review of flow and water quality data is found in the 2006 TMDL for the watershed (Utah DWQ 2006) and the companion document for that report (Utah DWQ 2003).

Table 4.2. Impaired water bodies in the Otter Creek/East Fork Sevier River watershed included in Utah's 2016 and 2014 Integrated Reports.			
Abbreviated Assessment Unit ID[1] (Name)	**Unit Description**	**Impaired beneficial use**	**Impairment Category and Parameter**
UT_001 (Otter Creek 4)	Otter Ck. and tributaries from Koosharem Reservoir to headwaters	2B - secondary contact recreation 3A - cold water aquatic life	Category 5 Not Supporting – E. coli, temperature.
UT_002 (Otter Creek 1)	Otter Ck. and tributaries from Otter Creek reservoir to Koosharem reservoir, except Box and Greenwich creeks	3A - cold water aquatic life	Category 5 Not Supporting – OE bioassessment, pH, temperature.
UT_003 (Otter Creek 3)	Greenwich Ck. and tributaries from confluence with Otter Ck. to headwaters	3A - cold water aquatic life	Category 4A TMDL Approved[2] - Sedimentation and total phosphorus.
UT_004 (Otter Creek 2)	Box Ck. and tributaries from confluence with Otter Ck. to headwaters	3A - cold water aquatic life	Category 4C Non Pollutant – Habitat. Category 4A TMDL Approved[2]– Dissolved oxygen, sedimentation, and total phosphorus.
UT_005 (East Fork Sevier 4)	East Fork Sevier R. and tributaries from confluence with Sevier R. upstream to Antimony Ck. confluence, excluding Otter Ck. and tributaries	3A - cold water aquatic life	Category 4A TMDL Approved[2] – Total phosphorus. Category 5 Not Supporting – Temperature.
UT_006 (East Fork Sevier 3)	East Fork Sevier R. and tributaries from Antimony Ck. confluence to Deer Ck. confluence	3A - cold water aquatic life	Category 5 Not Supporting - OE bioassessment.
UT_009 (East Fork Sevier 2)	East Fork Sevier R. and tributaries from Deer Ck. confluence to Tropic Reservoir	3A - cold water aquatic life	Category 5 Not Supporting - OE bioassessment.
UT-L_004 (Otter Creek Reservoir)	Otter Ck. Reservoir	3A - cold water aquatic life	Category 4A TMDL Approved[2] – Total Phosphorus. Category 5 Not Supporting – pH and temperature.
UT-L_005 (Lower Box Creek Reservoir)	Lower Box Ck. Reservoir	3A - cold water aquatic life	Category 4A TMDL Approved[2] – Dissolved oxygen and total phosphorus. Category 5 Not Supporting – pH.
UT-L_007 (Pine Lake)	Pine Lake	3A - cold water aquatic life	Category 5 Not Supporting – pH.

Table 4.2. (cont'd) Impaired water bodies in the Otter Creek/East Fork Sevier River watershed included in Utah's 2016 and 2014 Integrated Reports.			
Abbreviated Assessment Unit ID[1] (Name)	**Unit Description**	**Impaired beneficial use**	**Impairment Category and Parameter**
UT-L_011 (Koosharem Reservoir)	Koosharem Reservoir	3A - cold water aquatic life	Category 4A TMDL Approved[2] – Total Phosphorus.

[1] Abbreviated assessment unit ID includes the last 3 digits only. The full assessment unit ID begins with 16030002 which is the 8-digit Hydrologic Unit Code (HUC) for the Otter Creek/East Fork Sevier River watershed. The HUC number is followed by an underscore (_) and a 3-digit number unique to each water body.

[2] Category 4 TMDL Approved indicates that an EPA-approved TMDL is in place for the impaired water body and efforts will continue to restore beneficial use until monitoring data indicate that impairment no longer exists.

All data used in the 2014 and 2016 IRs to identify impaired water bodies has been reviewed to identify location, number, and concentrations of samples that violate state standards. Water quality data is discussed for each parameter of concern in this section. A discussion of biological (macroinvertebrate) monitoring results is included below in section 4.2.3.

Conventional parameters (e.g. dissolved oxygen, temperature, pH, E. coli, etc.) require a minimum of 10 samples to determine impairment. If more than 10 percent of samples violate water quality standards for these parameters, the water body is considered impaired. If 10 percent or fewer of total samples violate standards, the water body is attaining its beneficial uses (Utah DWQ 2016).

In regard to E. coli, the method to determine impairment on lakes and reservoirs considers beach closures or health advisories that occurred in a recreation season due to high E. coli concentrations. If fewer than two closures or advisories occurred, impairment is based on E. coli concentrations (Utah DWQ 2016). If less than 10 percent of E. coli samples exceed the maximum criterion, the site is assessed using the 5-day geometric mean of five or more samples collected in 30 days with at least 48 hours between sample events. If fewer than five samples were collected in 30 days, the geometric mean is based on all samples collected during the recreation season.

Monitoring lakes and reservoirs typically includes measuring conventional parameters at 1-meter intervals from the water surface to the lake bottom. Some water bodies are monitored at several sites, and where this occurs, impairment is determined at the site with the deepest depth. In well-mixed lakes and reservoirs, if more than 10 percent of water column measurements violate standards, the water body is impaired. Some lakes and reservoirs are thermally stratified due to depth and other physical factors that prevent mixing. In these situations, 3 continuous meters of the water column must meet standards for temperature and dissolved oxygen to provide habitat for aquatic species and support beneficial use. If this is not present, the water body is considered impaired.

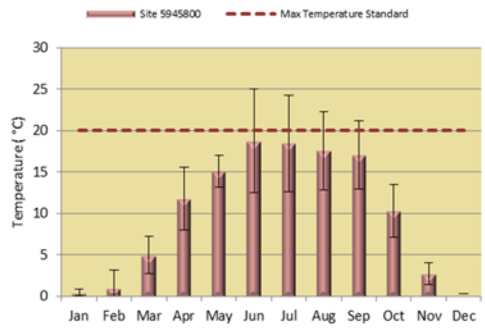
The remainder of this section includes a discussion of water quality for each parameter of concern in the Otter Creek / East Fork Sevier watershed area. Each water body is impaired for specific parameters shown in Table 4.2 and only those parameters related to impairment are discussed here. The location of all impaired water bodies is shown on Figure 2.1.

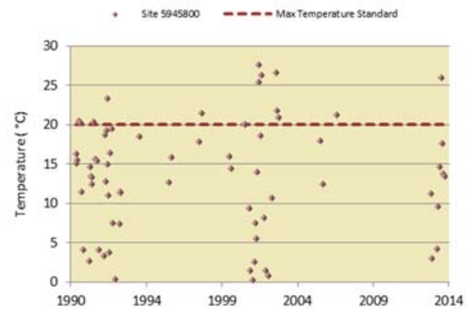
Temperature

Increased water temperatures can impact aquatic species by increasing rates of respiration, digestion, and increase oxygen consumption by aquatic organisms (Wetzel and Likens 1991). Other impacts of elevated temperature include decreased solubility of oxygen, increased solubility of toxic metals (WDOE 1991) and increased algal photosynthesis (Wetzel and Likens 1991). Each of these impacts can impair aquatic life.

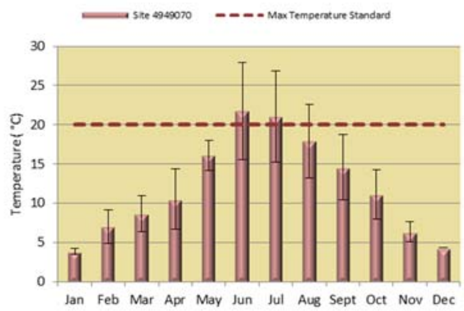
Measurements of temperature are shown for impaired water bodies including stream segments and Otter Creek Reservoir in Figure 4.1. Temperature charts include monthly average temperature (vertical bar chart) and a time series chart from a representative site on each water body. Variability in monthly measurements is indicated by the vertical line extending above and below the top of each bar in the chart. The length of the vertical line defines one standard deviation from the mean (i.e. a longer bar indicates more sample variability). The water quality standard used to evaluate temperature is 20 °C (Table 4.1) shown as a horizontal line on each chart.

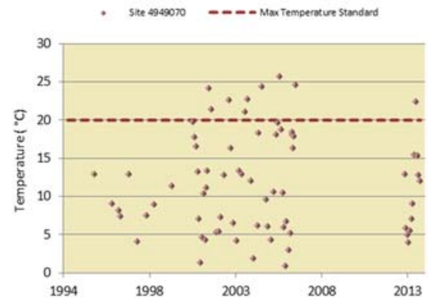
Figure 4.1. Monthly average temperature and all temperature measurements collected from selected stations on impaired river segments and reservoirs.



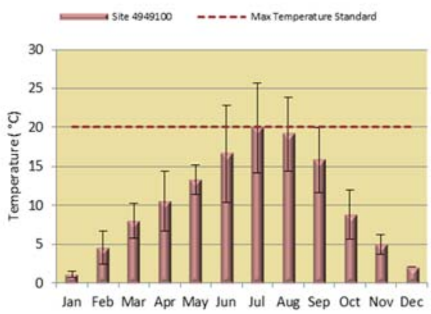


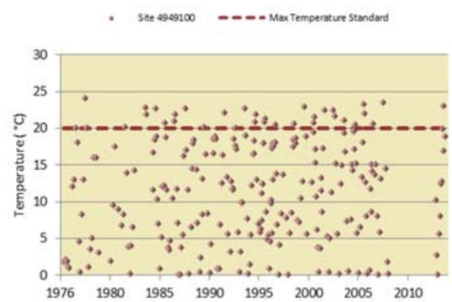
Site 5945800 Boobe Hole Creek above Koosharem Reservoir. Assessment Unit UT_001.



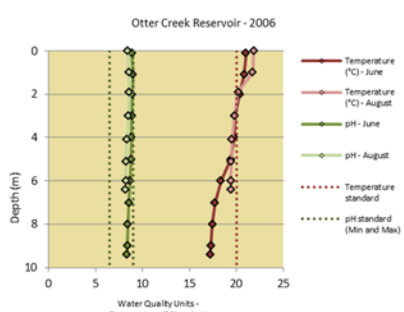


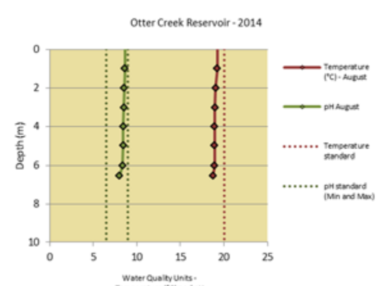
Site 4949070 Otter Creek at U62 crossing north of Koosharem. Assessment Unit UT_002.





Site 4949100 East Fork Sevier at U62 crossing east of Kingston. Assessment Unit UT_005.





Site 494220 Otter Creek Reservoir above Dam 01.

Monthly temperature measurements show a typical increase during the summer months due to increased solar radiation and longer days. Riparian shading can reduce this influence on narrow stream channels that are shaded by tree canopies. Streamflows decrease in summer due to irrigation diversions, reduced surface runoff, and limited groundwater inflow. These conditions result in shallow flow depths which are impacted by incoming solar energy.

Mean monthly temperatures shown in Figure 4.1 are below the standard for all assessment units with the exception of site 4949070 located on Otter Creek below Koosharem Reservoir which exceeds the standard during June and July. This site could also be influenced by warm water discharging from Koosharem Reservoir during these months.

Temperature profile measurements were collected from Otter Creek Reservoir at 1-meter increments beginning at the water surface and extending to the bottom of the reservoir. The profiles shown in Figure 4.1 were collected during summer months in 2006 and 2014. Near-surface temperature measurements are slightly above the standard in 2006 but decrease with depth and provide more than three continuous meters of cold-water habitat. These conditions support beneficial use per State methodology. All temperature profile measurements collected at this reservoir monitoring site during 2014 are below the standard and support beneficial use.

Time series charts in Figure 4.1 include measurements that exceed the temperature standard. A closer look at these measurements identifies a strong seasonal influence as violations occur almost exclusively during June-August. As discussed previously, impairment is based on percent of samples that exceed the 20 °C standard protecting cold water aquatic life. Data used in the 2016 IR at each monitoring site was assessed for samples violating the 20 °C standard. All monitoring sites on Assessment Units 1 and 2 either met standards or had < 10 percent of samples that violated the standard. Assessment Unit 5 had one of three sites with > 10 percent of samples that violated standards.

Sources and conditions that contribute to elevated temperature for each impaired segment are discussed in Chapter 5 below. Recommendations to improve water quality must address specific causes and sources that result in increased temperatures. These recommendations are discussed in Chapters 8 and 9 of this plan.

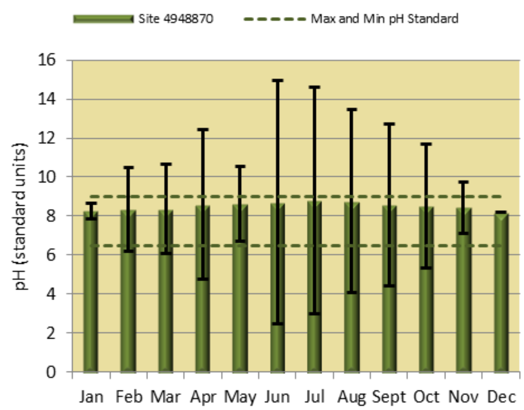
pH

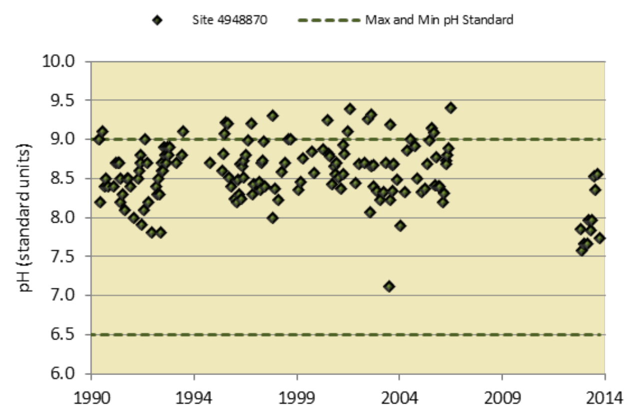
Changes in pH can reduce hatching and survival rates of aquatic species. When pH moves away from a desired range for fish, insects, and other aquatic life, toxic metals can become more soluble and easily absorbed (USGS 2018). Minor changes in pH can also influence the solubility of phosphorus which makes it more available to algal growth and subsequent changes in dissolved oxygen (WDOE 1991).

Measurements of pH are shown in Figure 4.2 for impaired assessment unit 2, lower Box Creek Reservoir, and Pine Lake. Figure 4.1 shows pH measurements for Otter Creek Reservoir. The maximum and minimum standards used to evaluate pH are 9.0 and 6.5, respectively. Any pH measurement between these standards is in support of the cold-water aquatic life beneficial use.

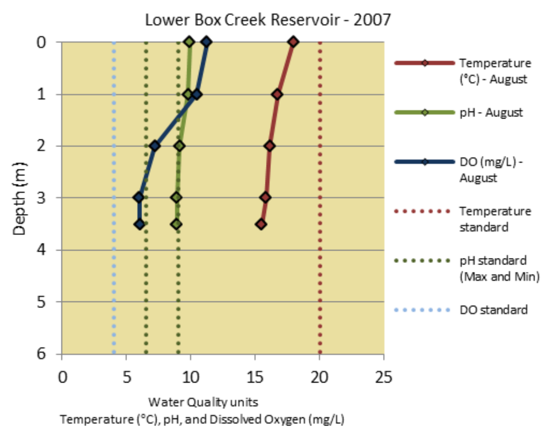
Monthly average pH shown in Figure 4.2 for Assessment Unit 2 does not change significantly between months but does show greater variation during June–October compared to other months of the year. Approximately 25 years of data have been collected from this site and Figure 4.2 shows several measurements that exceed the maximum 9.0 pH standard. A look at individual records indicates most of these violations occurred during the months of June and July. Note that all recent pH measurements at this site (2013–2014), including the data used in the 2016 IR, meet the pH standards.

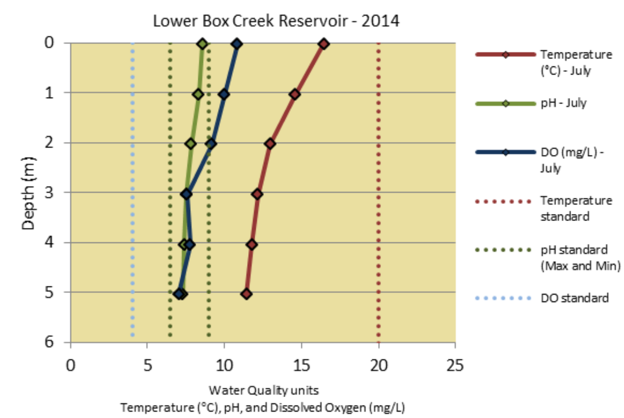
Figure 4.2 Monthly average pH values and all pH measurements collected from selected sites on impaired river segments and reservoirs. See Figure 4.1 for pH measurements from Otter Creek Reservoir.



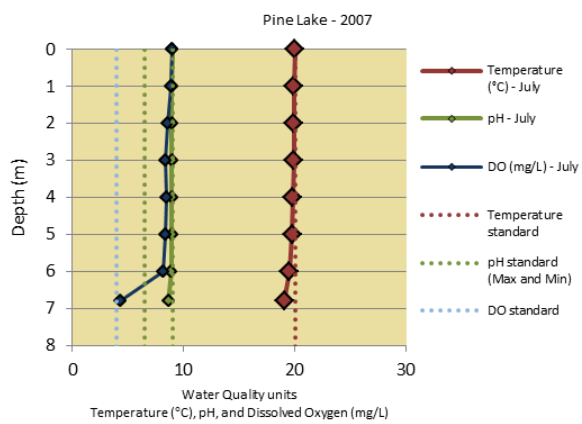


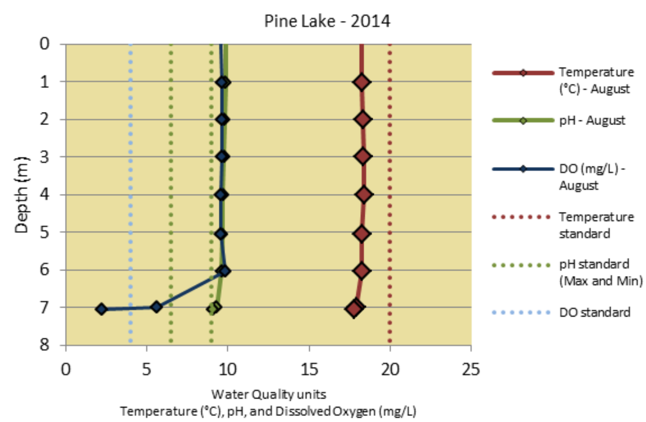
Site 4948870 – Otter Creek above diversion 1 mile north of Angle. Assessment Unit UT-002





Site 5945620 Lower Box Creek Reservoir 01. Assessment Unit UT-L_005.





Site 5946090 – Pine Lake 001. Assessment Unit UT-L_007.

Reservoir profiles from lower Box Creek Reservoir, Pine Lake, and Otter Creek Reservoir show measurements collected from monitoring sites during 2006 or 2007 and again in 2014. The pH profiles for each site were typically highest near the surface and during some years, included measurements that exceeded the maximum 9.0 pH standard. All reservoir profile measurements during 2014 at the lower Box Creek and Otter Creek sites met the pH standard. Profile measurements from Pine Lake during 2007 were all slightly below 9.0 pH. In contrast, all profile measurements during 2014 from Pine Lake violated the maximum 9.0 pH standard. All profile samples from Pine Lake showed little variation with depth, indicating well mixed conditions.

E. coli

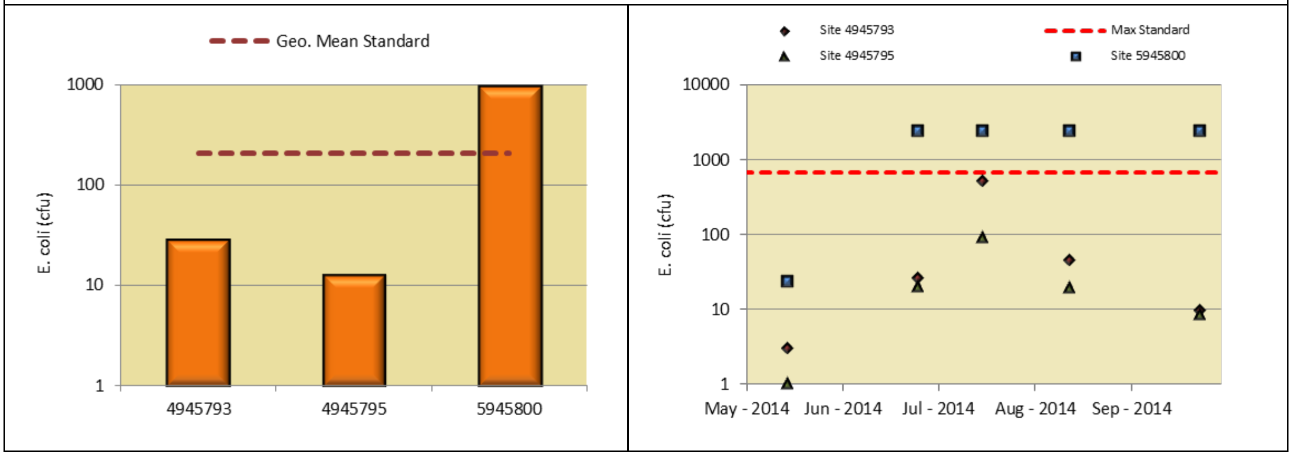
Escherichia coli (E. coli) are a large and diverse group of bacteria found in the environment and also in the intestinal tract of humans and animals that interact with humans (e.g. livestock, domestic pets, etc.). While some strains of E. coli are harmless, other strains can produce diarrhea, infections, respiratory illness, and other symptoms (CDC 2018).

Assessment Unit 1 is the only water body in the Otter Creek/East Fork Sevier River that is impaired for E. coli. Figure 4.3 shows the geometric mean of five samples collected during 2014 from each of three sites located on this stream segment. These are the only sites on Assessment Unit 1 that were sampled for E. coli. As described above, the method used to evaluate E. coli data requires five samples collected within 30 days. Insufficient data was available within 30 days, so the analysis of E. coli was extended to the entire data record (May–September 2014).

Figure 4.3 shows one site with a geometric mean greater than the 206 colony forming unit (cfu) standard that protects recreational beneficial use. This site (4945800) is located on a tributary to Koosharem Reservoir. The remaining two sites had geometric means that were less than half of the standard. These sites are found on Otter Creek (4945795) and a diversion from Otter Creek (4945793).

Individual measurements from each site are shown in the right column of Figure 4.3. Four of five measurements from site 4945800 exceed the maximum standard (680 cfu) for individual E. coli samples. Measurements from sites 4945793 and 4945795 have peak concentrations in July but all measurements were below the maximum standard. Additional details are provided in Chapter 5 on potential sources that influence spatial and seasonal patterns of E. coli.

Figure 4.3. Geometric mean of E. coli concentrations (colony forming units - cfu) and all E. coli measurements collected from three monitoring sites in Assessment Unit UT-001 including Site 4945793 – Canal above Koosharem Reservoir at Piute Trail crossing in section 32, Site 4945795 – Otter Creek at USFS boundary, and Site 5945800 – Boobe Hole Creek above Koosharem Reservoir.



Dissolved Oxygen

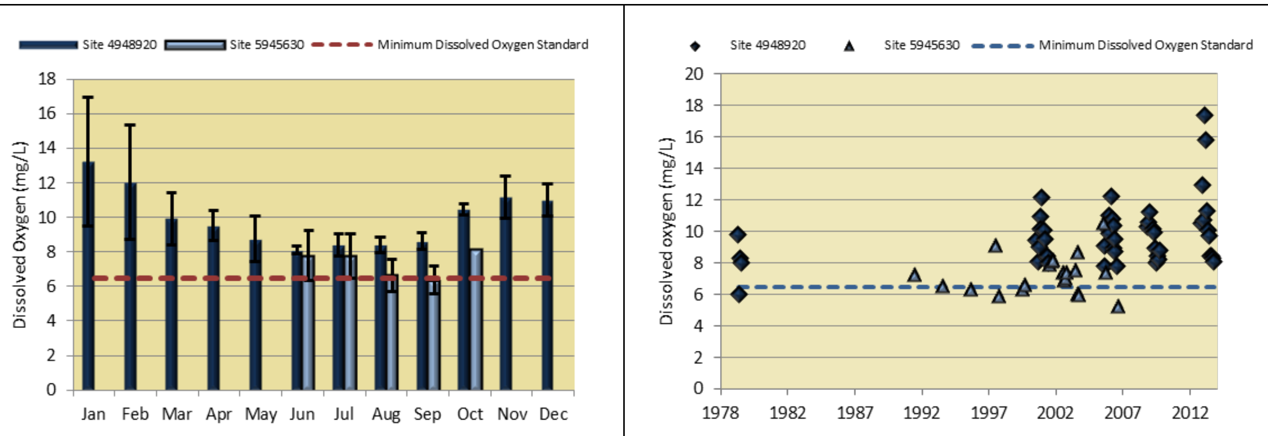
Similar to humans, oxygen is critical to the well-being of aquatic species. Low levels of dissolved oxygen cause fish to become inactive, even to the point of not reacting to predators. Under severe oxygen depletion, fish will die. A primary cause of oxygen loss is rapid growth of algae and phytoplankton in response to excessive phosphorus and nitrogen. Plant respiration consumes oxygen during the night and additional oxygen is lost to decomposing plant material.

Measurements of dissolved oxygen are shown in Figure 4.4 for Box Creek and in Figure 4.2 for Lower Box Creek Reservoir. Figure 4.4 shows monthly average dissolved oxygen at site 4948920 located near the Forest Service boundary and downstream of Upper Box Creek Reservoir and Lower Box Creek Reservoir. Site 5945630 is located between the two reservoirs. Monthly average dissolved oxygen on Box Creek is lowest during the summer months but still above the 6.5 mg/L minimum standard at site 4948920. Fewer measurements are available upstream but the monthly average at site 5945630 violates the dissolved oxygen standard during August–September.

Individual measurements of dissolved oxygen show nearly all samples at the downstream monitoring site were > 6.5 mg/L. Approximately 50 percent of samples at the upstream monitoring site between the two reservoirs, are below the standard. All samples used in the 2016 IR for this Assessment Unit were > 6.5 mg/L. Additional discussion on the processes and sources that influence dissolved oxygen in Box Creek will be discussed in Chapter 5.

Reservoir profiles of dissolved oxygen measured from Lower Box Creek Reservoir during 2007 and 2014 are shown in Figure 4.2. The minimum standard for dissolved oxygen in reservoirs is 4.0 mg/L. Note that concentrations of dissolved oxygen decrease with depth in the reservoir profile. Measurements in 2007 were collected slightly later in the summer season compared to the 2014 measurements and show lower concentrations of dissolved oxygen. All profile measurements of dissolved oxygen collected from Lower Box Creek Reservoir in 2007 and 2014 were above the minimum standard indicating full support of beneficial use.

Figure 4.4. Monthly average dissolved oxygen and all dissolved oxygen measurements collected from Site 4948920 (Box Creek near Canyon Mouth 1 mile west of Greenwich at USFS boundary) and Site 5945630 (Box Creek below Upper Box Creek Reservoir and above Lower Box Creek Reservoir) located on impaired segments of Box Creek – Assessment Unit UT-004. See Figure 4.2 for dissolved oxygen profiles from Lower Box Creek Reservoir.



Total Phosphorus

Total phosphorus is not toxic to aquatic life in most situations. High concentrations of total phosphorus can impact aquatic life by promoting excessive growth of algae and blue-green algae. Any aquatic plant life produces oxygen during photosynthesis but also consumes oxygen through respiration. Additional oxygen is consumed when dead plant material decomposes in water. Blue-green algae (cyanobacteria) can produce toxins that are harmful to humans and animals. Large growths or blooms of cyanobacteria can rapidly grow under certain conditions and impact recreation, aquatic life, and agriculture.

High levels of total phosphorous have impaired Assessment Units 3, 4 and 5 as well as Otter Creek Reservoir, Lower Box Creek Reservoir, and Koosharem Reservoir. Total phosphorous is considered by Utah DWQ as an indicator of pollution and cause of impairment to the aquatic beneficial use. Although high levels of total phosphorous may not directly affect aquatic life, excessive nutrients can result in low dissolved oxygen levels that are fatal to aquatic life. Several of these water bodies were addressed in the 2006 TMDL. The 2006 TMDL recommended concentrations of 0.05 mg/L for rivers and 0.025 mg/L for reservoirs (Utah DWQ 2006). These concentrations represent pollution indicator levels recommended by Utah DWQ for waters of the state.

Monthly mean concentrations of total phosphorous are shown in Figure 4.5. Total phosphorous concentrations in streams are generally highest during the spring season when sediment is transported by surface runoff. Phosphorous is bound to sediment through soil adsorption which allows it to move during surface erosion and runoff. Monthly average concentrations for Greenwich Creek are above 0.05 mg/L during spring and winter. Monthly average concentrations in Box Creek are below 0.05 mg/L during winter (January–March) only. Total phosphorus concentrations are above this level for all months except November at the East Fork Sevier monitoring site.

Individual measurements from Greenwich Creek are limited but show roughly half of the samples have total phosphorus concentrations below 0.05 mg/L. More samples are available at the Box Creek site which is located at roughly the same elevation and relative position in the watershed as the Greenwich Creek site. The Box Creek site shows numerous measurements that exceed 0.05 mg/L each year with most violations occurring in late spring and throughout the summer. Measurements of total phosphorous at the East Fork Sevier monitoring site show a wide range of concentrations with a general decreasing trend over time. The percent of samples that exceeded 0.05 mg/L at monitoring sites in each steam assessment unit was > 10 percent for all sites and > 50 percent of samples at most sites.

Monthly total phosphorous concentrations at reservoir monitoring sites are all above the pollution indicator level of 0.025 mg/L (Figure 4.5). Monthly peak concentrations were higher in the small reservoirs (i.e. Lower Box Creek and Koosharem reservoirs) compared to Otter Creek Reservoir. Monthly average concentrations at reservoir monitoring sites are greatest in August or September, although the range of concentrations is also generally higher during this same time compared to other months of the year.

Individual measurements of total phosphorous in reservoirs are also shown in Figure 4.5. Measurements were collected at the surface, mid-profile, and bottom elevations on some dates. In general, surface and bottom samples had relatively higher concentrations than mid-profile samples at depth although these differences were minor on most dates. Since 2006, the percent of all total phosphorus samples in Otter Creek Reservoir from surface, mid-profile, and bottom elevations that exceeded the recommended 0.025 mg/L concentration was 50 percent, 0 percent, and 100 percent. All total phosphorus measurements from Lower Box Creek Reservoir and Koosharem Reservoir during the same time period and sample elevations exceeded 0.25 mg/L.

4.2.2. FLOW DATA

Six continuous flow monitoring stations are located in the Otter Creek/East Fork Sevier watershed (Table 4.3). The earliest record of continuous flow spans 1913–2018 at a gauging station located at the East Fork of the Sevier River near Kingston UT (USGS 10189000). Five of the stations in Table 4.3 have sufficient data to develop average daily flow values that represent a meaningful range of wet and dry cycles experienced in Utah and the Sevier River Watershed. Station 10184450 has six years of available data and does not capture this climatic influence in a way that would support a meaningful comparison to the other sites.

Seasonality of flow strongly influences the magnitude and timing of pollutant loading. The exact timing of peak streamflow within a given year is influenced by both physical and climatic factors that are associated with the upstream contributing area. The magnitude of peak streamflow between years is greatly influenced by wet and dry periods that affect the total amount of snow accumulation throughout the winter season.

Average daily stream flow for gage stations in the project area is shown in Figure 4.6. Note that gages shown in Figure 4.6 are arranged from downstream to upstream locations in the watershed (reading each row in the legend from left to right).

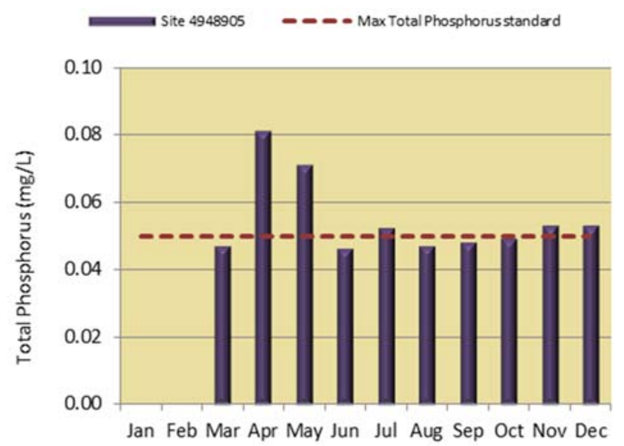
The peak flow at each station generally corresponds to the spring runoff season occurring in May-June of each year. Station 10189000 is the most downstream gage in the watershed and currently the only active continuous flow monitoring site operated by the USGS. It is located just above the confluence of the East Fork Sevier River and Sevier River. Flows at this site peak first during May and later again in July. The first peak is in response to seasonal flow from tributaries and headwater segments of upstream rivers and creeks. The second peak is in response to discharge from Otter Creek Reservoir to meet water rights and the irrigation demand accompanying those rights.

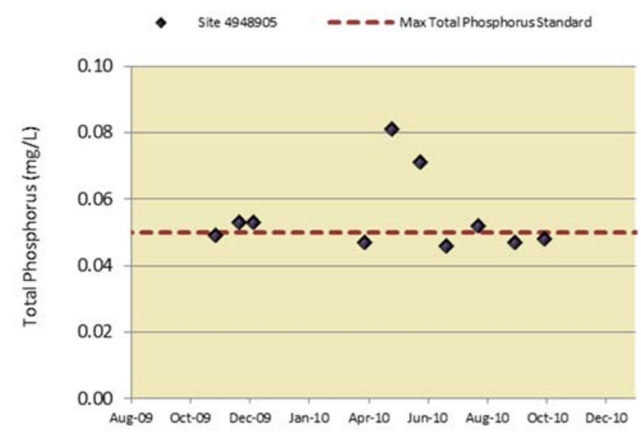
Station 10187500 is located on Otter Creek between Otter Creek Reservoir and Koosharem Reservoir. Peak flows at the station occur primarily in March, followed by a minor increase during May. The timing of the first peak corresponds to a release of water from Koosharem Reservoir to provide sufficient storage to capture spring runoff in May and June. The increased flow in May at this station is due primarily to tributary inflow from streams that enter Otter Creek below Koosharem Reservoir.

Table 4.3. USGS flow monitoring stations located in the Otter Creek/East Fork Sevier watershed.

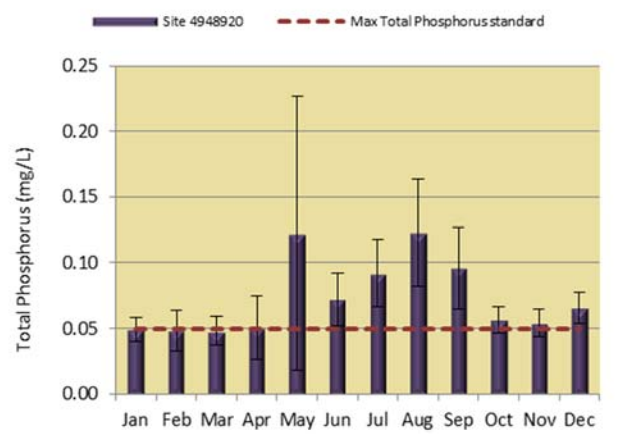
Site ID	Name	Date Range
10183900	East Fork of the Sevier River near Ruby's Inn UT	1961-1995
10184450	East Fork of the Sevier River near Antimony UT	1961-1966
10185000	Antimony Creek near Antimony	1946-1976
10187300	Otter Creek near Koosharem	1964-1982
10187500	Otter Creek Above Reservoir near Antimony	1961-1980
10189000	East Fork of the Sevier River near Kingston	1913-2018

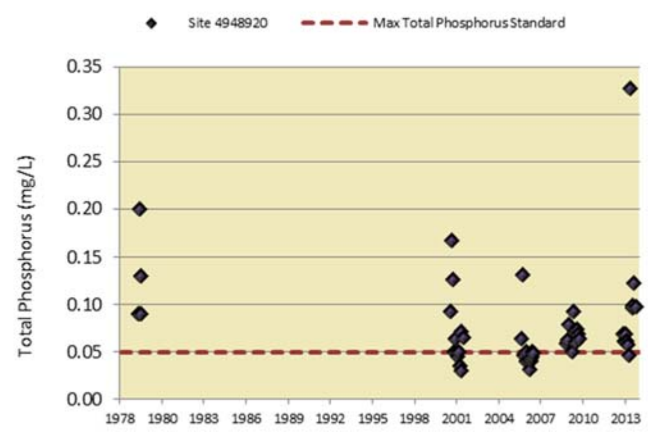
Figure 4.5. Monthly average concentrations of total phosphorus and all total phosphorus measurements collected from selected sites on impaired river segments and reservoirs.



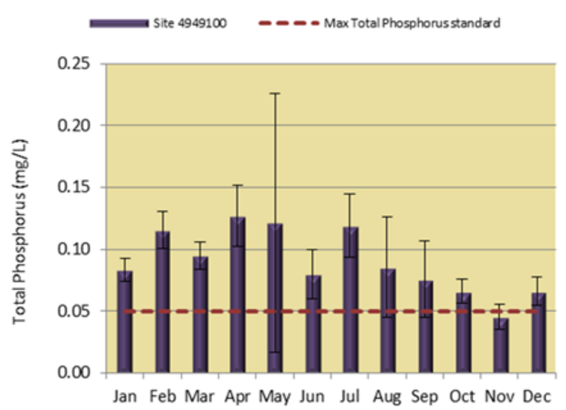


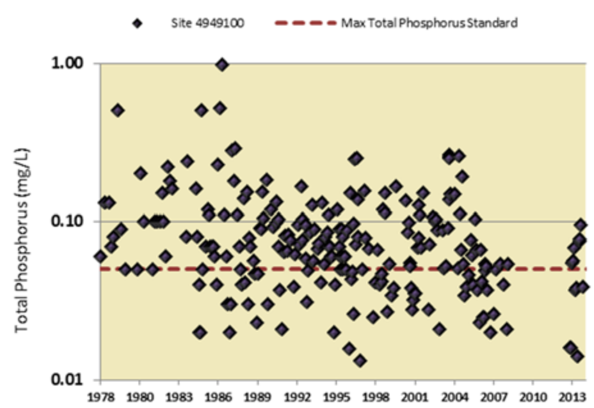
Site 4948905 – Greenwich Creek at USFS boundary. Assessment Unit UT_003.





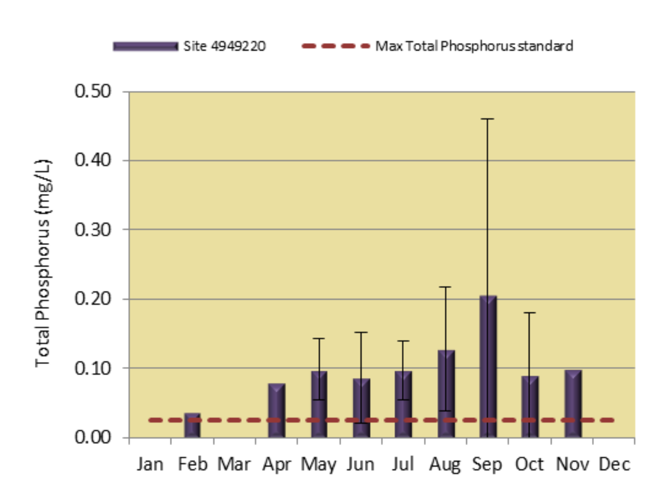
Site 4948920 – Box Creek near canyon mouth 1 mile west of Greenwich at USFS boundary. Assessment Unit UT_004.

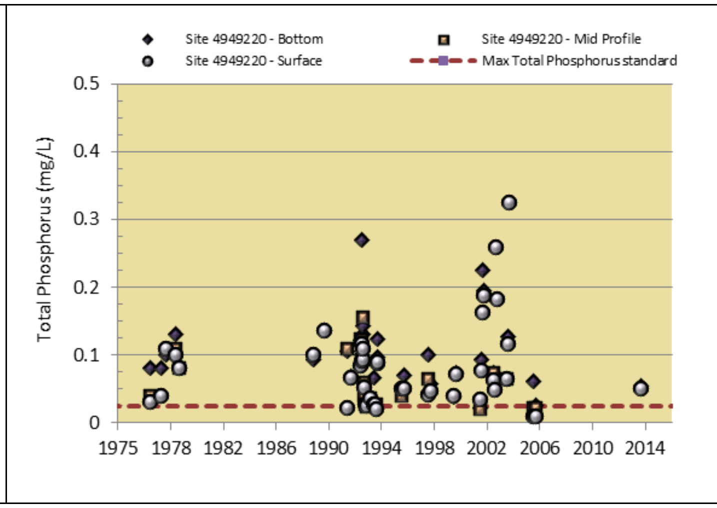




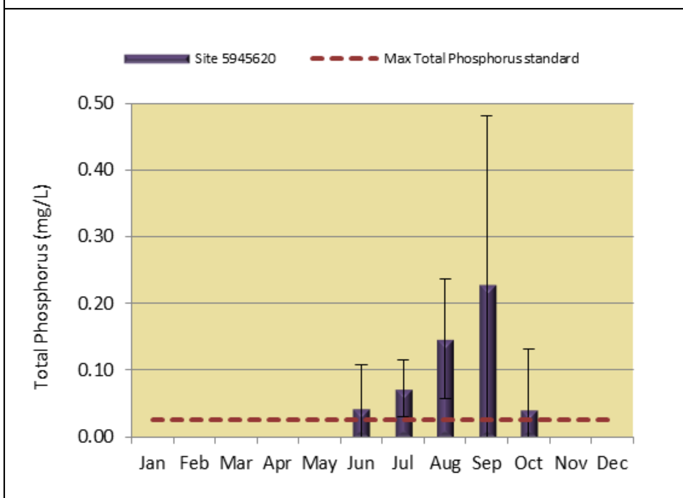
Site 4949100 – East Fork Sevier River at U62 crossing east of Kingston. Assessment Unit UT_005.

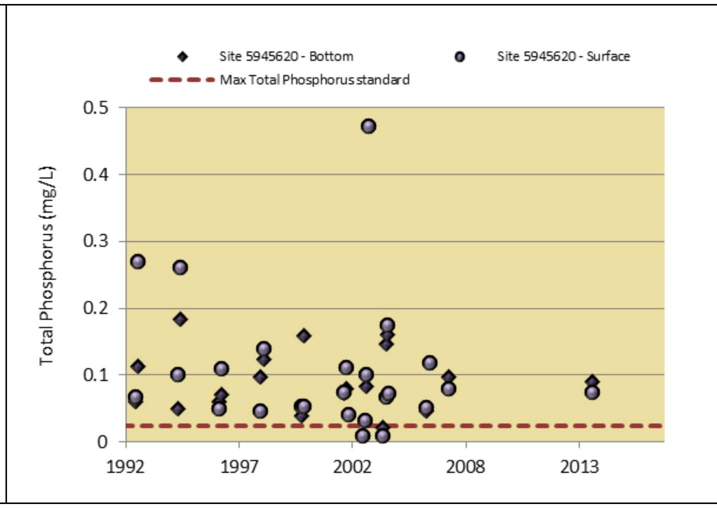
Figure 4.5(cont'd). Monthly average concentrations of total phosphorus and all total phosphorus measurements collected from selected sites on impaired river segments and reservoirs.



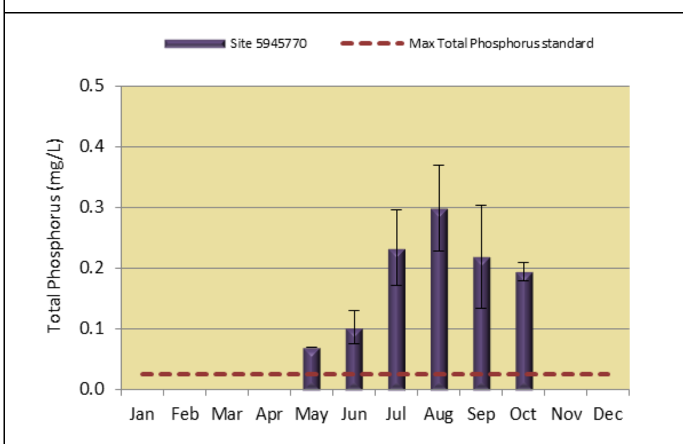


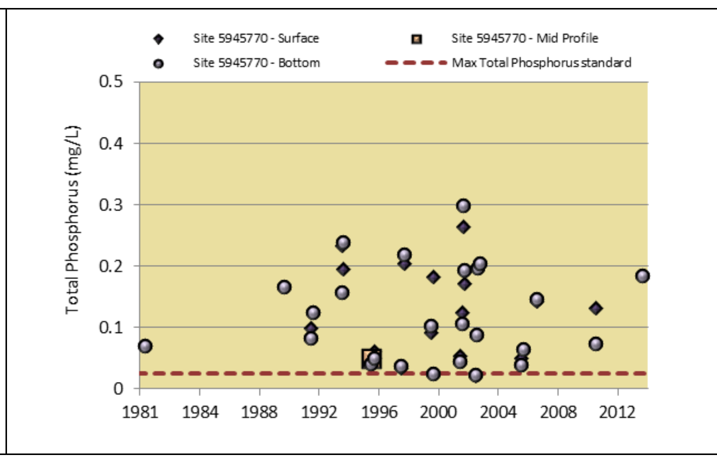
Site 494220 Otter Creek Reservoir above Dam 01. Assessment unit UT-L-004.





Site 5945620 Lower Box Creek Reservoir 01. Assessment Unit UT-L_005.





Site 5945700 – Koosharem Reservoir above Dam 01. Assessment unit UT-L_007.

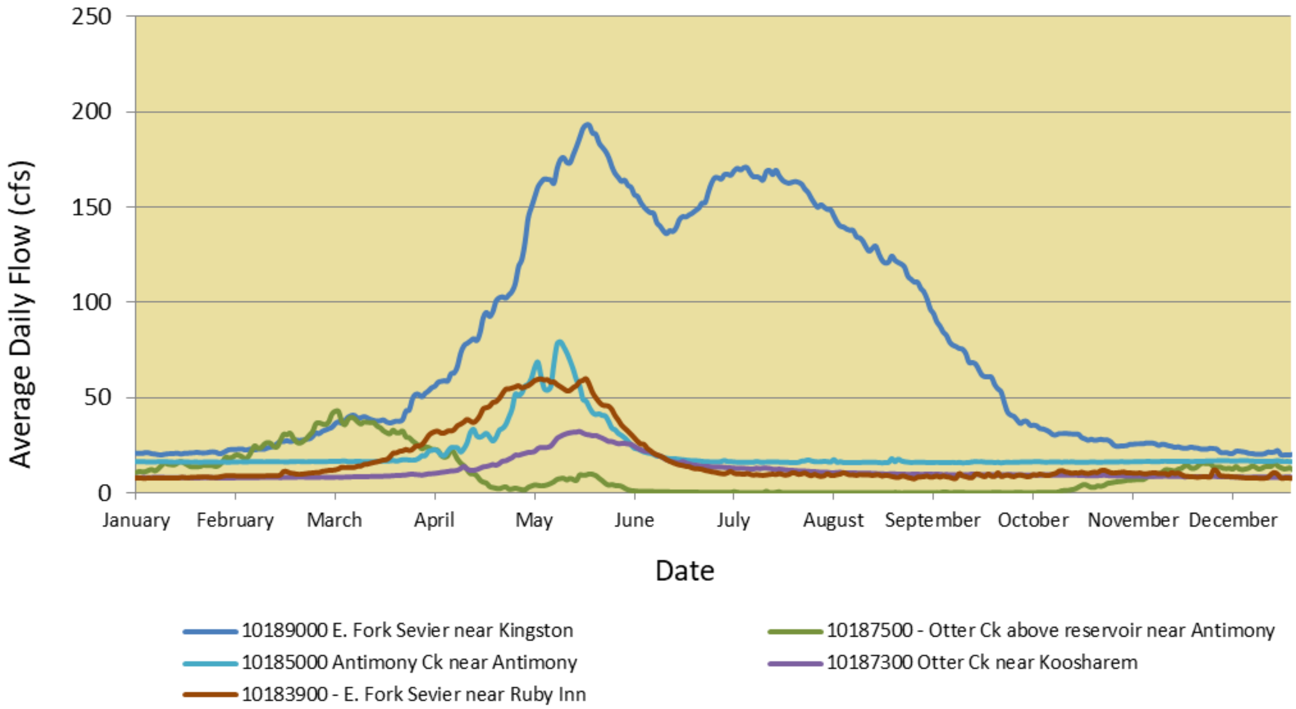


Figure 4.6. Average daily stream flow hydrograph for monitoring stations in the Otter Creek/East Fork Sevier watershed. Note that stations are organized in the legend according to their location (downstream to upstream) in the watershed.

4.2.3. Biological Data

Biological data can be evaluated by comparing a community of observed macroinvertebrate species to a community of species expected to be there in the absence of human impact. Utah DWQ assesses biological data using an empirical model that predicts the expected species at a given site using readily available ecological, physical and geographical data. The ratio of observed to expected macroinvertebrate species (OE) provides a value that accounts for natural variability as well as human impact. This value is used by Utah DWQ as the OE bioassessment that determines impairment.

OE bioassessment

Health of aquatic communities reflects the combined effects of all pollutants and provides a measure of how pollutants influence a stream ecosystem (Karr 1981). Macroinvertebrate (i.e. aquatic insects) populations are a critical part of aquatic food webs and provide a good indication of water quality. If healthy macroinvertebrate populations are present that are intolerant to pollution, water quality is likely good and supporting other desired aquatic species.

Sample size determines the threshold used to evaluate the OE bioassessment at each site. Monitoring sites with three or more samples need an average OE score of 0.76 or greater to support beneficial use. Sites with less than three samples must have an OE score of 0.69 to support beneficial use.

Three assessment units are considered to be impaired based on the results of OE bioassessment including Assessment Units 2, 6, and 9. The results at monitoring sites are shown in Figure 4.7. The left column of Figure 4.7 shows average OE scores for selected sites in each assessment unit and the right column shows all monitoring sites and available data for each assessment unit. Insufficient data were available to support seasonal analysis at any monitoring site.

In general, monitoring sites located at upper elevations and on small tributary streams, consistently had higher average OE scores than sites lower in the watershed. Assessment Unit 2 had three monitoring sites with eight or more sample measurements. Site 4949070 had a mean OE score > 0.76 while the remaining two sites had mean OE scores < 0.76, indicating non-support and impairment. During 1998–2005, individual OE scores from sites in Assessment Unit 2 were nearly all > 0.69. Recent measurements include three of four total samples that were < 0.69. However, no recent data was available from the same sites monitored during 1998–2005 so a meaningful comparison of OE trend cannot be completed to determine if water quality is improving or degrading.

Only two sites in Assessment Unit 6 had more than 1 sample. Mean OE scores from these two sites were both <0.69. A total of nine OE scores were measured from seven sites in Assessment Unit 6. Five OE scores were <0.69 and the remainder were above this standard. Three of the four most recent measurements were > 0.69, indicating potential improvements in water quality.

Data from Assessment Unit 9 includes eight measurements collected from eight sites located on East Fork Sevier and tributaries to the river. Samples collected from sites on the same water body were grouped to provide data to calculate mean OE scores. Figure 4.7 shows that tributaries to the East Fork Sevier in Assessment Unit 9 had mean OE scores above the appropriate standard. Mean OE scores on the East Fork Sevier were < 0.69. Individual measurements show six of the eight sites (all tributary sites) had OE scores > 0.69.

4.2.4. Stream Corridor Data

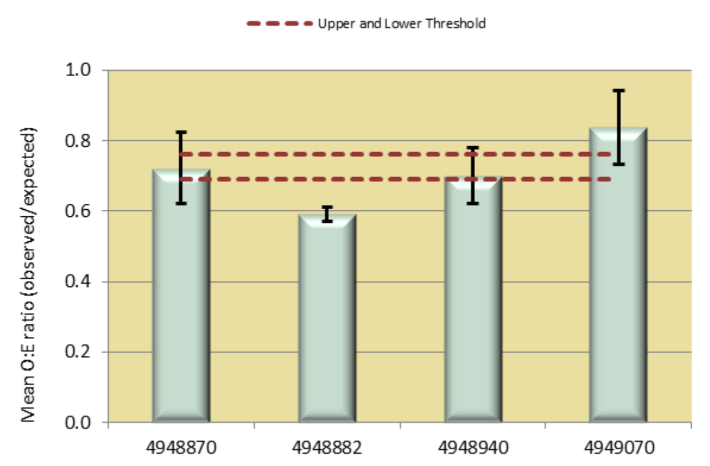
A comprehensive stream survey in the watershed was completed in July 2003 by local and state agencies as well as private landowners. The purpose of assessing Otter Creek and the East Fork Sevier River was to determine the overall condition of stream channels and riparian corridors and recommend BMPs for restoring beneficial to impaired water bodies addressed in the TMDL. Detailed survey results are provided in Appendix C of the TMDL (Utah DWQ 2006). Site visits to the watershed since the original stream survey indicate that positive and negative changes in stream conditions have occurred. Discussion with stakeholders suggest that existing conditions are similar to the 2003 survey.

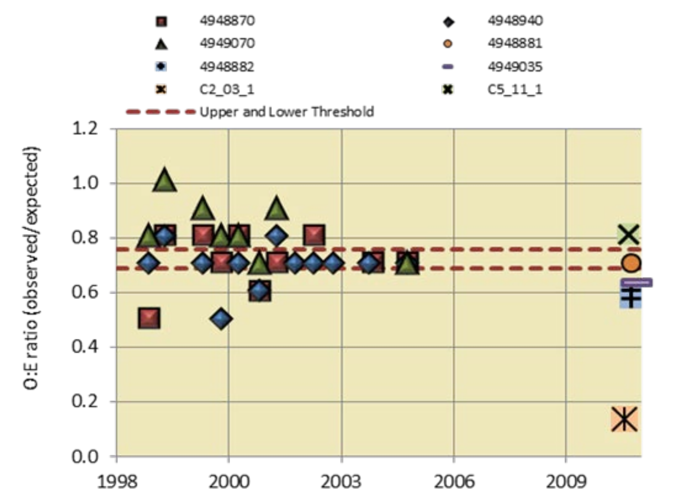
A total of 79.9 miles of stream channel were surveyed using the Stream Visual Assessment Protocol (SVAP) developed by the Natural Resource Conservation Service (NRCS 1998). Streambank erosion potential was also assessed using the Streambank Erosion Control Index (SECI) method.

Stream reaches classified as excellent or good condition were observed in the upper headwater areas of Otter Creek in Daniels Canyon (Assessment Unit 1) or along Antimony Creek (Assessment Unit 8). Stream reaches in fair condition were found on Otter Creek immediately below Koosharem Reservoir and just below the Narrows (Assessment Unit 2) as well as several locations along the lower East Fork Sevier below Otter Creek Reservoir (Assessment Unit 5). The remaining stream segments were identified to be in poor condition according to the SVAP protocol.

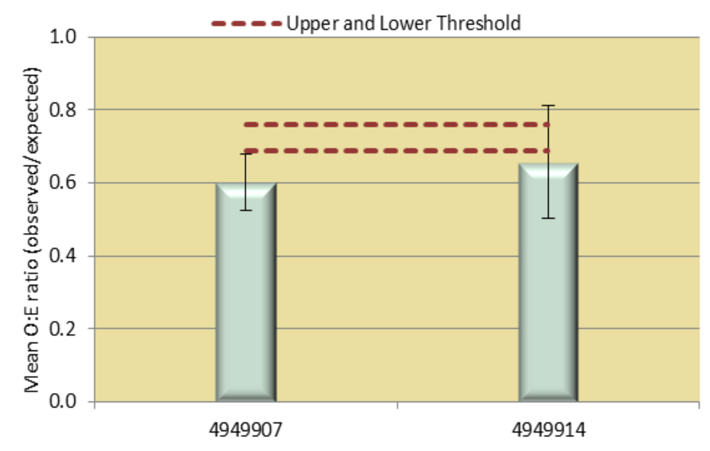
SECI scores indicated that of the nearly 80 miles surveyed, approximately 48 miles presented slight erosion, 21 miles presented moderate erosion, and extreme erosion was evident in approximately 2.4 miles. Stream reaches exhibiting severe erosion were located in the East Fork Sevier immediately below Otter Creek Reservoir (Assessment Unit 5). Reaches with moderate erosion were observed on the East Fork Sevier from Otter Creek Reservoir upstream to the confluence of Antimony Creek (Assessment Unit 5), as well as on Otter Creek near the confluence with Box Creek (Assessment Unit 2).

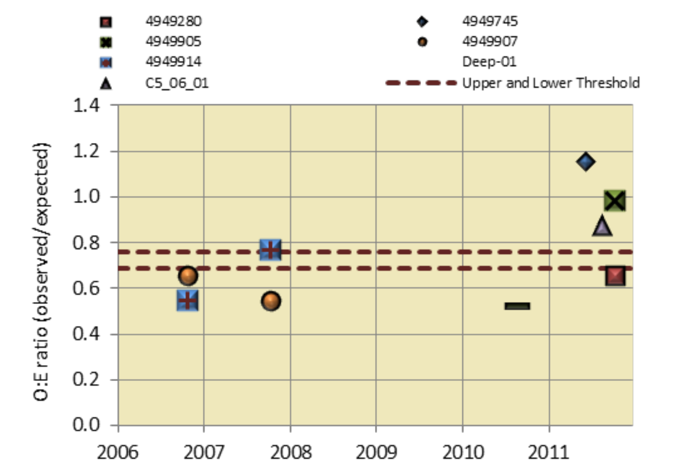
Figure 4.7 Macroinvertebrate measurements from impaired stream segments in the East Fork Sevier/Otter Creek watershed.



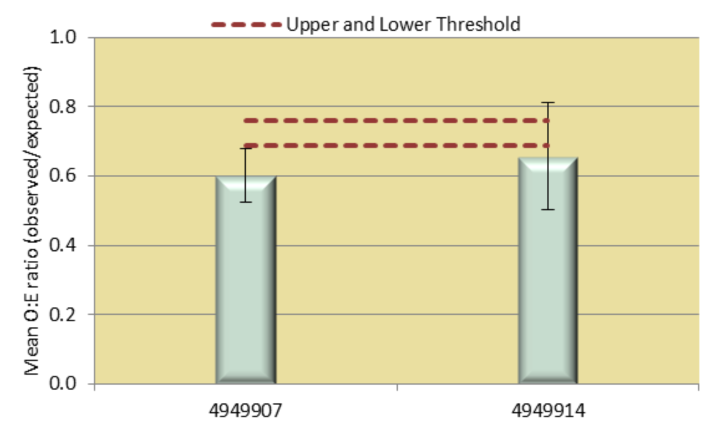


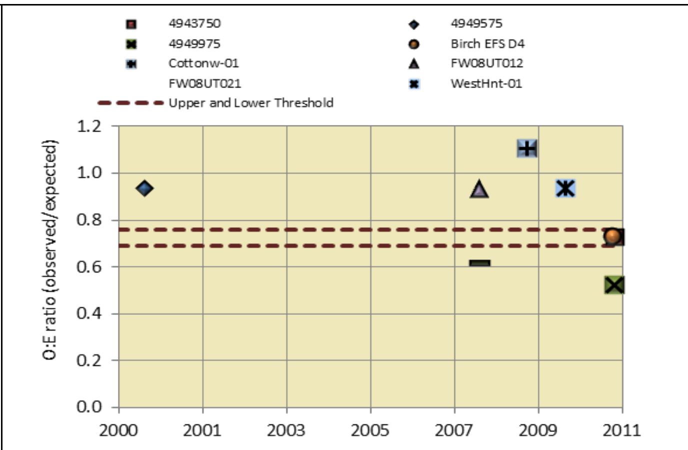
Assessment Unit UT_002.





Assessment Unit UT_006.





Assessment Unit UT_009.

Stream reaches with poor channel condition or severe bank erosion can also be indicative of conditions such as lack of riparian habitat, shallow and wide channels, sediment deposits and other degraded features. These physical characteristics lead to increased water temperatures and eliminate habitat for fish and desired macroinvertebrate species. Improvements in water chemistry can improve water quality but in the absence of good stream conditions, these improvements are limited in their ability to create long-term positive change.

Specific conditions leading to poor channel condition or severe bank erosion were identified in the survey and these details will be discussed further in Chapter 5 of the watershed plan.

4.2.5 Other Data

Algae and other forms of aquatic plant life are a normal part of healthy aquatic ecosystems. When excessive nutrients are present, algae can quickly multiply, forming "blooms" or large masses of plant material. Other factors that influence algae blooms include abundant sunlight, warm water temperatures, and stagnant water. Blue-green algae are comprised of cyanobacteria which are not actually algae but single-celled organisms which can photosynthesize like algae. These microorganisms multiply rapidly under the right conditions and can produce harmful toxins to nerves and other organs in humans and animals.

The Utah Department of Agriculture and Food (UDAF) reported that livestock could eat mats of cynobacteria or drink contaminated water. They recommended restricting livestock where opportunities exist for exposure. In regard to impacts on crops, limited results are currently available. Controlled studies have shown that some plants can accumulate cyanotoxins and uptake is more likely with extended exposure. (UDAF 2017).

Harmful algal blooms (HABs) have been regularly monitored by Utah DWQ since 2014 and prior to that as part of routine and intensive monitoring at select locations. Public education and reporting play a significant role in identifying existing HABs. Records show that HABs were identified in Upper Box Creek Reservoir during August 2017 (Utah DWQ 2017) and in Upper and Lower Box Creek Reservoir during July 2018 (Utah DWQ 2018a). HABs were reported in Otter Creek Reservoir during August 2018 (Utah DWQ 2018b). Warning advisories were issued each time HABs were identified. These warnings included recommendations to avoid swimming, water skiing, and drinking, keep pets and livestock away from water, clean fish well, and avoid scum when boating.

4.3 SUMMARY

The Otter Creek/East Fork Sevier watershed includes 7 stream assessment units and 4 reservoirs/lakes that were determined to be impaired in 2016 by Utah DWQ. Conditions leading to impairment include elevated temperature, pH, E. coli, and phosphorus as well as low concentrations of dissolved oxygen. Data used in the 2014 and 2016 IRs from representative monitoring sites have been reviewed in this chapter. Recent data from several sites indicate full support of beneficial use (e.g. Otter Creek Reservoir – temperature, pH, dissolved oxygen; Otter Creek above Koosharem Reservoir – temperature; lower Box Creek Reservoir – pH, dissolved oxygen, etc.). These assessment units could be considered for delisting if additional monitoring data confirm beneficial use support. Other data indicate exceedances for recent measurements (e.g. Pine Lake – pH, Otter Creek above Koosharem Reservoir – E. coli, East Fork Sevier from Antimony Creek upstream to Tropic Reservoir – OE bioassessment, etc.).

The main objective of the watershed plan is to restore support of beneficial use to all impaired water bodies in the Otter Creek/East Fork Sevier watershed. Recommendations for improving water quality in order to meet this objective are included in Chapters 8 and 9. The positive impact of these actions will affect multiple water quality parameters discussed in this chapter that contribute to existing impairment.

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CHAPTER 5: POLLUTANT SOURCE ASSESSMENT

The impaired water bodies identified in the 2016 IR are impaired by different water quality parameters to different degrees. Chapter 4 reviewed all data used by Utah DWQ to determine the recent impairment. The 2006 TMDL addressed only one of the parameters contributing to existing impairment - total phosphorus. The TMDL described pollutant sources, calculated loads of total phosphorus for each source, defined a TMDL for impaired segments and allocated loads to each source.

The major sources of pollutant loading that were described in the TMDL included animal feeding operations, livestock grazing, septic tanks, diffuse runoff, and natural background. The TMDL also discussed a process whereby phosphorus is drawn from reservoir sediments (i.e. internal loading) and determined it was not a concern. Based on recent discussions with agencies, private landowners, and field reconnaissance, existing conditions in the watershed remain like those described in the TMDL. The population in the watershed remains relatively small and dispersed in nature, with limited industrial activity. Agriculture in the watershed is mainly related to ranching activities with most crops being raised for animal forage. Because of this, the pollutant contributions from sources such as urban runoff and stormwater discharge are relatively insignificant. Some pollutant sources have expanded regarding location (e.g. feedlots and septic tanks) and the coverage of these sources have been updated using readily available information.

Many pollutant sources of total phosphorus addressed in the TMDL can also contribute to other existing impairments. For example, livestock grazing generates phosphorus loading to streams, but it can also contribute E. coli and remove riparian vegetation and the shade that maintains steam temperature. Runoff from rangeland or other areas with sparse vegetation and exposed surfaces will generate erosion and deposit sediment in stream channels. Phosphorus is attached to eroded soil, but the sediment deposits also fill openings in the channel substrate (e.g. cobble and gravel) and other instream habitat that are needed by macroinvertebrates and spawning fish. As a result, surface erosion and sedimentation of streams can result in low OE scores. Finally, an overabundance of phosphorus will cause eutrophication in rivers and lakes, which leads to low dissolved oxygen.

Results from the TMDL are considered accurate in defining pollutant sources that contribute to existing impairment from any parameter listed in Table 4.1. Each major pollutant source contributing to these parameters is described in Chapter 5.

5.1 ANIMAL FEEDING OPERATIONS

Recognition of animal feeding operations (AFO) and confined animal feeding operations (CAFO) as a contributor to water quality impairment has been addressed by the Utah CAFO Advisory Committee (2001) and more recently by the Utah Animal Feeding Operation Committee (2009). The strategy proposed by the State reflects a desire to implement responsible management techniques while maintaining a local decision-making process. A voluntary incentive-based approach is emphasized that reverts to a regulatory approach only for larger facilities or situations where voluntary methods have failed. A critical element of this program is to maintain open communication between stakeholders and agencies.

AFOs have been defined in the Code of Federal Regulations 40 CFR 122.23(b)(1) as an area where animals "have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12 month period and crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility."

Field surveys were completed to identify locations of all CAFOs and AFOs as part of the previous TMDL (Utah DWQ 2006). No operations that met the definition of CAFOs were identified during the survey.

Thirteen locations where animals appeared to be contained for 45 days or longer were identified (Figures 5.1 and 5.2). Discussions with NRCS personnel in the Richfield, Utah field office after the survey indicated two of the operations were currently inactive (Jarman 2004) and recent discussions have indicated that the current number of AFOs would be the same or less than 13 (Ingram 2018). Furthermore, any AFOs on or near stream channels were relocated outside the stream corridor and floodplain, between 2006-2009 (Ingram 2018). These actions followed recommendations made in the TMDL and should result in decreased loading to streams where operations were located. Recent assessment of satellite imagery has identified many feedlot areas in the watershed. It is uncertain if each operation has a nutrient management plan in place. Recommendations are made later in this watershed plan to identify the status of each operation.

Animal feeding operations in the watershed have varying degrees of nutrient management practices in place. Of the 11 estimated active operations, all have had to develop nutrient management plans to minimize pollutant loading (Ingram 2018). Many of the beef-feedlot operations scrape and haul manure annually while dairy operations stockpile manure daily and haul it to the surrounding fields during the spring and fall seasons. Land application of manure generally occurs to fields within a five-mile radius of each facility. Most of the manure is applied as a nutrient supplement to fields managed in a rest-rotation system alternating between small grain crops and alfalfa. As a result, land areas supporting alfalfa will typically not receive manure applications until these areas are returned to small grain crops (Turner 2004).

In regard to temperature and pH impairment, AFOs are not considered a pollution source that would influence these parameters. This conclusion is based primarily on the location and operating characteristics of AFOs. Runoff from AFOs can degrade water quality by introducing pathogens including E. coli. This pathogen is found in the digestive system of warm-blooded animals and is spread through feces. The detection of E. coli often indicates that other dangerous types of bacteria might be present. E. coli cannot live for long periods of time outside of a host body; therefore, when found in surface water, the source must be relatively close. Other factors that influence survival of E. coli in an open environment can include temperature, livestock diet, bacteria strain, and soil type (Franz et al. 2005, van Elsas et al. 2011). In regard to AFOs, fecal contamination could occur by runoff from any operation to a nearby surface water body. Otter Creek above Koosharem Reservoir (Assessment Unit 1) is the only water body currently impaired by E. coli. No AFOs are located above Koosharem, so direct runoff from AFOs is not considered a potential source of E. coli. Runoff from land applied manure could happen in this area although the potential is low due to distance from the nearest AFO. Potential causes of E. coli impairment are discussed further in Section 5.2 Livestock Grazing.

Nutrients in surface runoff can contribute to eutrophication in rivers and lakes, resulting in low dissolved oxygen (USU Extension 2010, NDSU Extension 2017). To reduce runoff into streams and rivers, AFOs on or near streams were moved away from the river between 2006 and 2009 (Ingram 2018). As a result, direct runoff from these facilities is unlikely to reach surface water bodies. Nutrients and runoff from fields receiving land applied manure do not exist in the watershed above lower Box Creek Reservoir and are limited along Box Creek to areas near the confluence with Otter Creek.

Erosion from AFOs could potentially contribute sediment detached by runoff flowing from any part of the lot not covered by vegetation. The potential sediment impacts from AFO erosion on impaired streams (OE bioassessment) is based primarily on distance. Due to recent actions to move AFOs away from streams, this contribution is considered negligible.

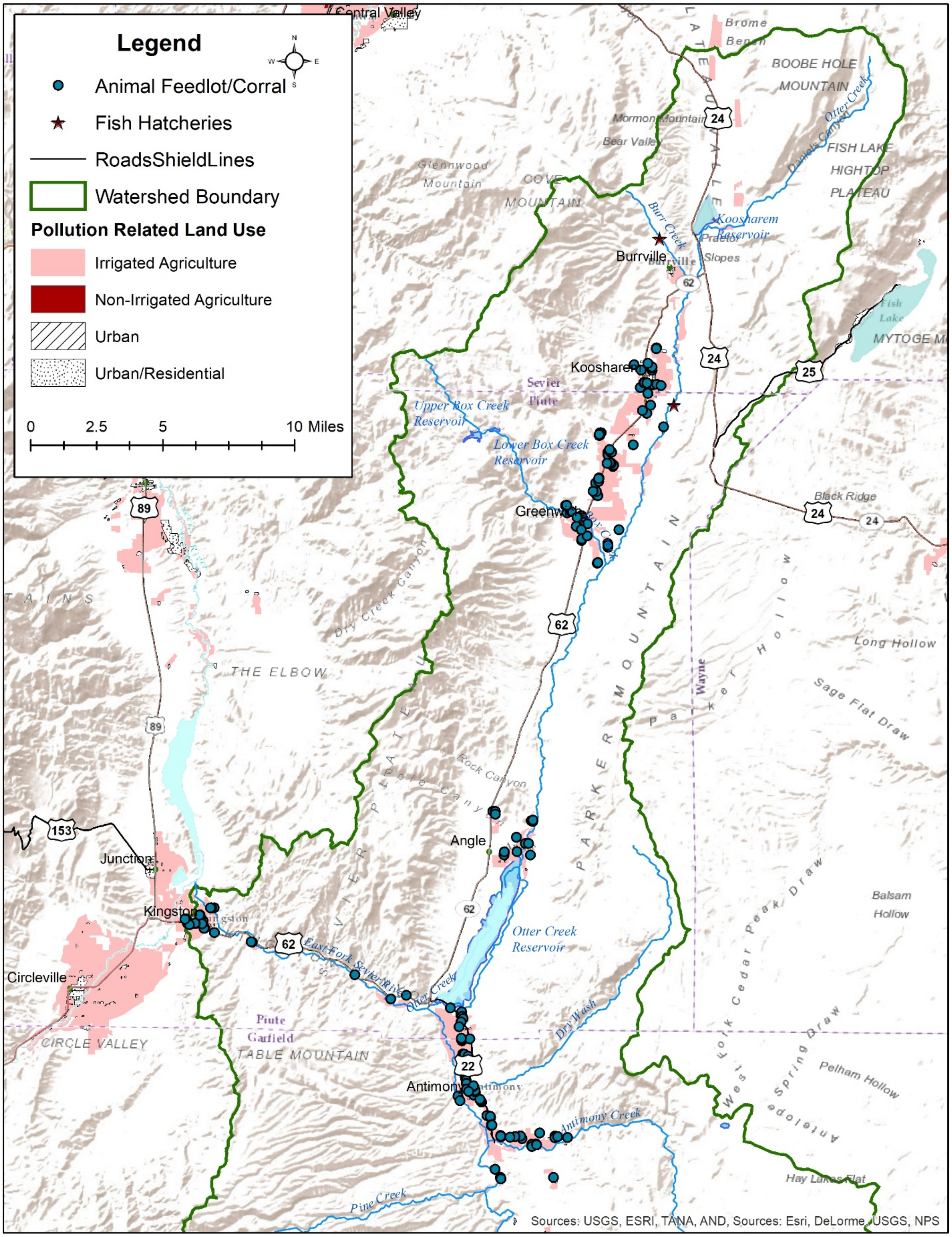


Figure 5.1. Otter Creek Watershed Feedlots, Fish Hatchery, and Agricultural Lands.

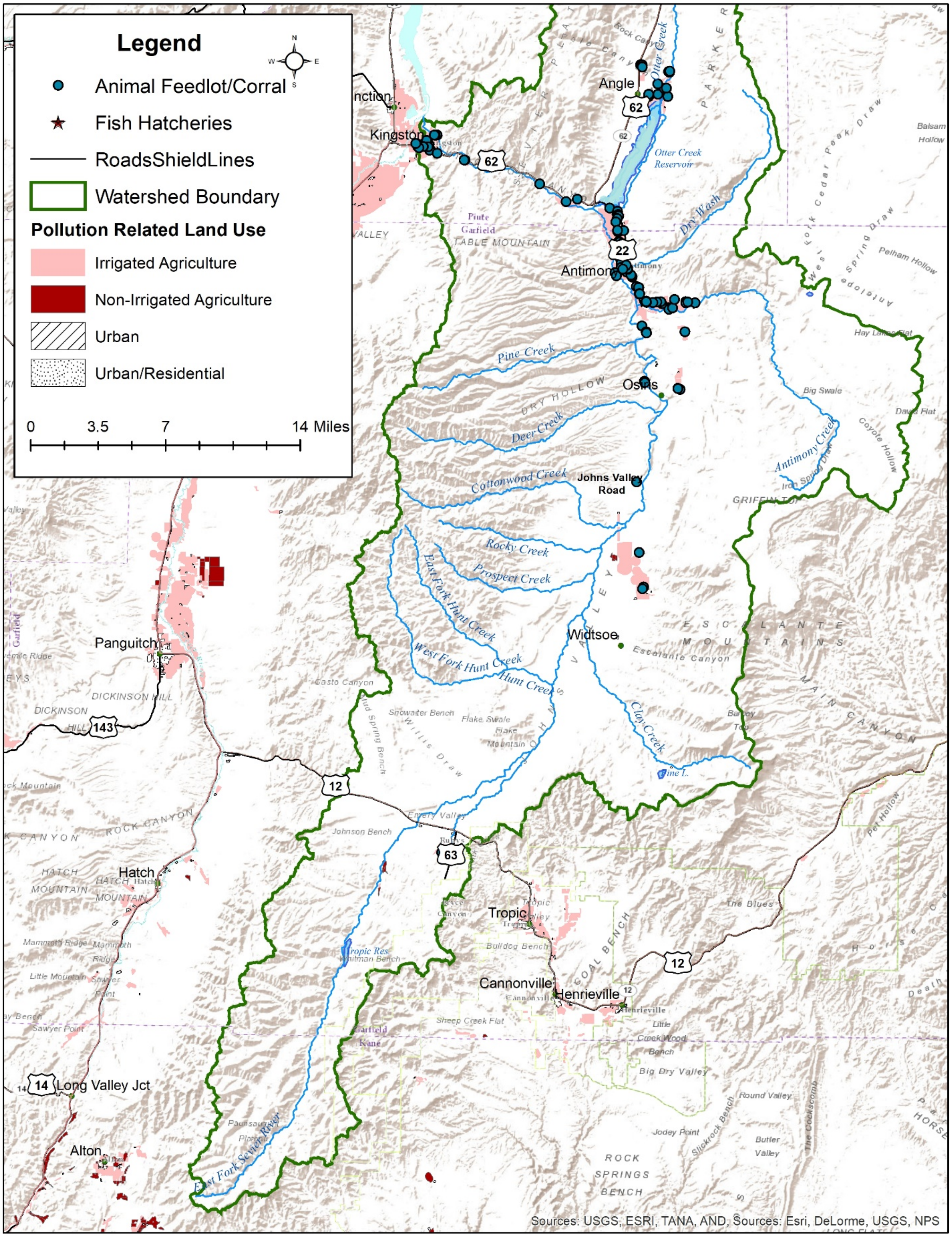


Figure 5.2. East Fork Sevier Watershed Feedlots, Fish Hatchery, and Agricultural Lands.

5.2 LIVESTOCK GRAZING

Water quality impacts from livestock grazing occur from manure production and removing riparian vegetation that provides shade. Any other grazing impacts on water quality associated with erosion and surface runoff are addressed below under diffuse runoff.

Livestock grazing can be a significant pollutant source in many watersheds where historic grazing has occurred. This is especially true where cattle are concentrated in or near the riparian zone surrounding existing streams, lakes or reservoirs. Livestock prefer these areas because they provide shade, the best source of forage, and often the only source of drinking water.

Extensive grazing occurs in the Otter Creek and East Fork Sevier watersheds. Figures 5.3 and 5.4 show the grazing allotment boundaries associated with public and private lands in these two areas. Grazing allotments are found on nearly all public land in the watershed. Over 90 percent of the Otter Creek and East Fork Sevier River watersheds are in grazing allotments permitted by the Forest Service, the Bureau of Land Management, or operated by private landowners (Utah DWQ 2006). Except for grazing exclosures, all allotments provide open access to stream channels and reservoirs or lakes. Grazing allotments have varying numbers of permitted animals and seasons of use which influence the potential for pollutant loading. Annual use of public land grazing allotments in the watershed has not varied substantially over the past decade (Pace 2018).

The timing of grazing activities within the watershed is also important. Livestock numbers in low-elevation pastures are higher during the late fall, winter, and spring months, as these are where animals spend the winter. The exact location of herds during this time varies depending on available forage and weather extremes that make it difficult for grazing to occur. A typical grazing pattern during this time will find animals in the lower valley pastures until late November through mid-December or when snow depths make grazing difficult. Animal herds are then moved into smaller pastures that are easily accessible or sometimes feedlots where hay can be fed. Animal herds are moved away from hay feeding areas as soon as grass forage becomes adequately available in the spring season, typically during March or early April. Some herds are transported out of the watershed entirely to other locations within the Sevier Valley (Bagley 2004).

During the summer months, many herds are moved away from the low to mid-elevation pastures and on to higher elevation grazing allotments on public lands. Many of the grazing allotments managed by the BLM and SITLA provide early or late season grazing opportunities (e.g., March and April or November–January) while Forest Service allotments are primarily used during the late spring through early fall. BLM and SITLA grazing allotments may not be used consistently in the watershed on an annual basis. These allotments typically receive greater use during periods of drought, when management of Forest Service allotments requires a shorter grazing season or lower grazing density (Chamberlain 2018).

In general, many animal herds are moved to public lands during May or June and return to private lands in late October. However, some herds continue to be rotated through privately owned pastures in the lower valley areas throughout the spring, summer and fall. Many of lower valley pastures provide open access to Otter Creek and the East Fork Sevier river channels as well as some tributaries. This pattern has resulted in degraded streambanks and riparian areas in some locations. Intense use of near stream areas has resulted in heavy manure deposits, streambank degradation, and surface and channel erosion that subsequently contribute to phosphorus loading.

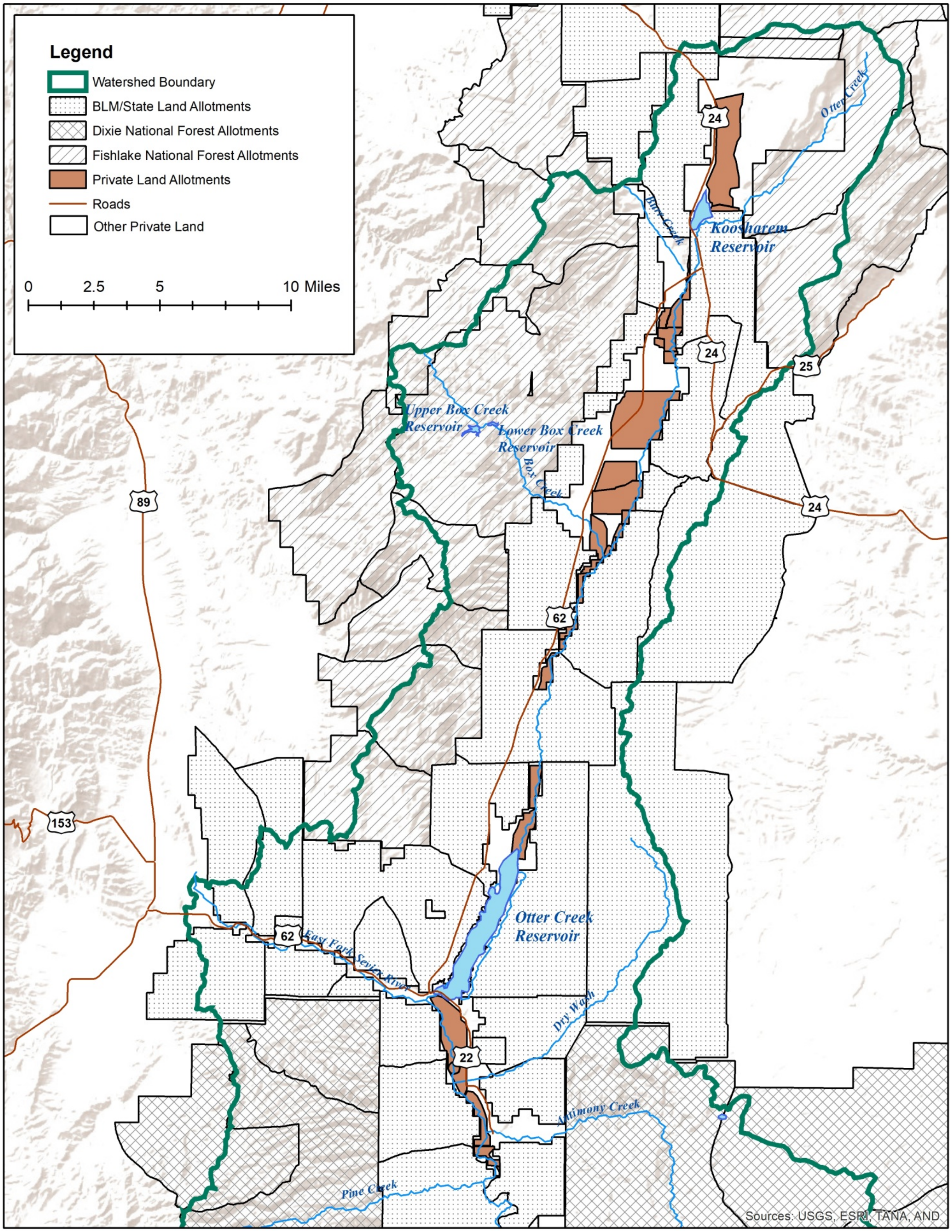


Figure 5.3. Otter Creek Watershed Grazing Allotments.

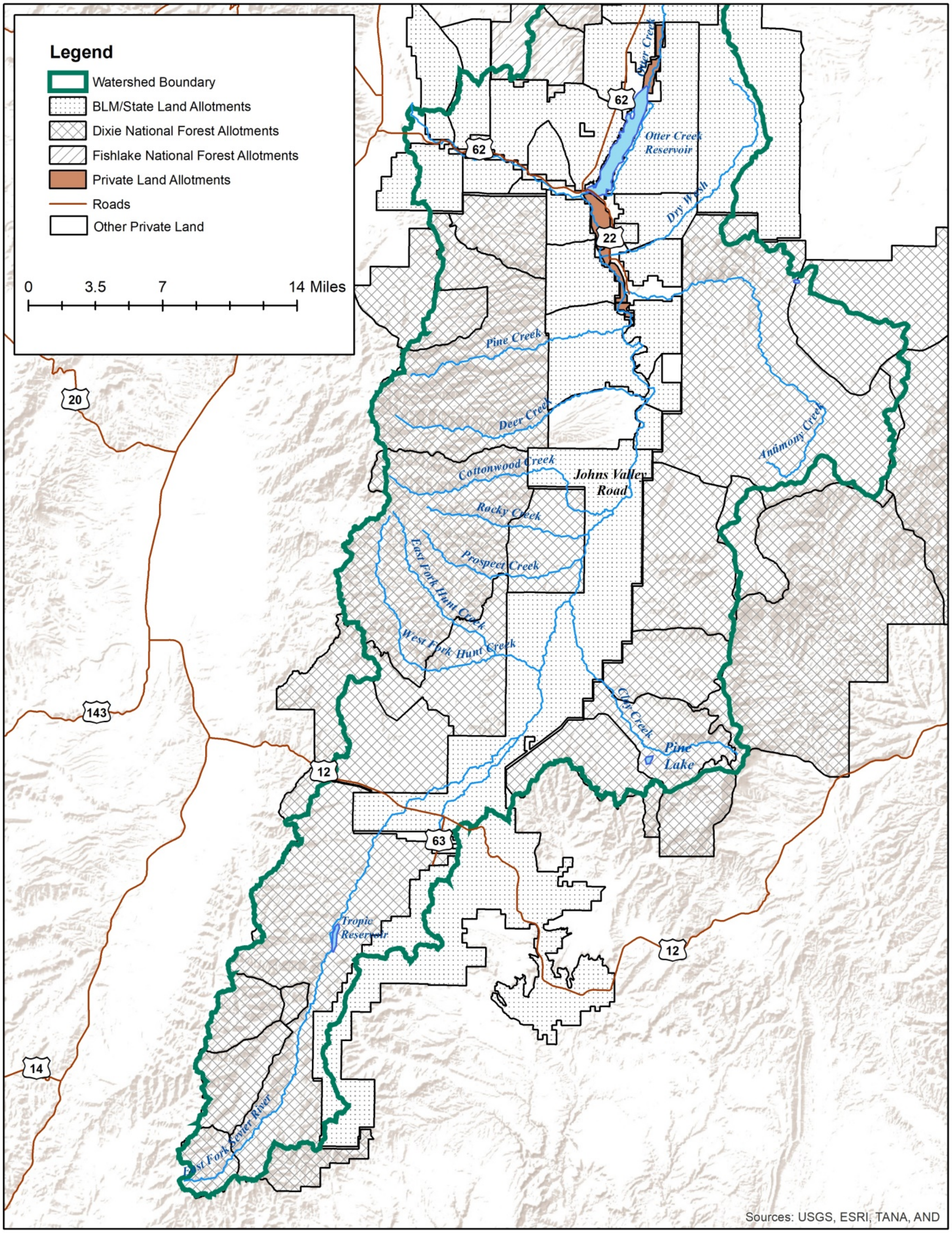


Figure 5.4. East Fork Sevier Watershed Grazing Allotments.

Extended livestock grazing near water bodies can remove streamside vegetation that provides shade and helps maintain temperatures crucial to cold-water fish survival (Belsky et al. 1999, McGinty et al. 2009). Livestock grazing can also trample stream banks and potentially increase the width of the channel (Hudson 2008). Wide and shallow stream channels are more exposed to solar radiation compared to narrow and deep channels protected by streamside vegetation. Based on channel width, livestock grazing near impaired streams above and below Koosharem Reservoir (Assessment Units 1 and 2, respectively) and Box Creek (Assessment Unit 4) could result in greater temperature impacts compared to larger streams and rivers. Based on water body size, livestock grazing impacts on riparian vegetation along the East Fork Sevier below Antimony (Assessment Unit 5) and Otter Creek Reservoir would have negligible impacts on temperature.

The impact of grazing on soil pH can vary. Soil pH can increase due to nitrification of ammonia, but this is typically where large amounts of livestock manure and urine are deposited. Most studies identify slight increases in soil pH in areas where heavy long-term grazing has occurred compared to similar pastures with light grazing (Dormaar and Williams 1998, Tamartash et.al. 2007). The pH impairments observed at various monitoring sites in the watershed are a result of high pH. Livestock grazing could therefore impact the pH of water if erosion from high pH soils reach impaired water bodies.

The greatest influence of livestock grazing on E. coli in the watershed is by direct deposition of manure in streams and reservoirs or lakes. Manure can be easily carried into receiving waters when deposits are in stream floodplains or areas inundated by reservoirs. Surface runoff in areas further from the stream channel can also transport manure but the potential for E. coli loading decreases with distance. In regard to Assessment Unit 1, the greatest potential sources of E. coli loading are from grazing in and near Boobe Hole Creek and Otter Creek above Koosharem Reservoir. Access by livestock to these stream channels provides opportunities for direct deposition of manure and E. coli.

Nutrient loading from livestock manure can occur quickly during direct deposition to streams or more slowly over time as manure is transported to the stream channel by surface runoff. Nutrients delivered from livestock grazing to Box Creek and Lower Box Creek Reservoir can result in eutrophication and low dissolved oxygen. Monitoring data suggest the dissolved oxygen impairment is limited in the segment of Box Creek between the upper and lower reservoirs. Any sources of nutrients near this stream segment or upstream Upper Box Creek Reservoir could likewise contribute to eutrophication and low dissolved oxygen.

Nutrient loading could also influence the presence of desired macroinvertebrate species that are intolerant of nutrient-rich streams and low dissolved oxygen. When the population of desired (or expected) macroinvertebrate species is replaced with pollution tolerant species, impairment will be identified by low OE bioassessment scores.

5.3 ONSITE WASTEWATER TREATMENT SYSTEMS

Less than 1 percent of the watershed is classified as urban or urban/residential. None of these areas are sewered, and consequently all the residences in the watershed rely on onsite wastewater treatment systems. The main concentrations of these systems are found in the municipal areas of Burrville, Koosharem, Greenwich, Antimony, and the part of Kingston that lies within the watershed (Figure 5.1). Onsite wastewater treatment systems located in all other areas of the watershed, including the contributing areas for Koosharem and Lower Box Creek Reservoirs, are assumed to be so diffuse that their loading to the system is negligible.

Onsite wastewater treatment systems are not currently considered a source of pollution for water temperature, pH, or OE bioassessment although discharge from these systems could influence these parameters in some situations. Due to the low number and dispersed nature of homes in the watershed and relative distance to streams, this pollutant source is not a concern.

E. coli can be a major concern with wastewater treatment systems, particularly where poor maintenance of tanks and drain fields occurs. Again, due to the dispersed nature of homes in the watershed, this source is not considered to influence impairment, particularly in Assessment Unit 1 above Koosharem Reservoir.

Total phosphorus and other nutrients discharged from poorly maintained onsite wastewater systems could cause a reduction in dissolved oxygen. As described earlier, excessive nutrients in receiving waters can cause eutrophication followed by a drop in dissolved oxygen when algal matter and other dead plant material decomposes. Like other parameters, due to the dispersed nature of homes in the watershed, nutrient loads from this source are considered negligible.

5.4 FISH HATCHERIES

Two privately-owned fish hatcheries have been identified in the watershed (Figure 5.1). Due to the operational size and discharge volumes, they are permitted under a statewide general permit. Limited information is available regarding their current status. The TMDL determined that neither of these fish hatcheries discharges directly to Otter Creek. Any flow from the two fish hatcheries that reaches Otter Creek does so in the form of agricultural return flows in the summer and tributary flows in the winter (Utah DWQ 2006).

The Road Creek fish hatchery is supported by flow from Burr Creek. Water from the fish hatchery is directly discharged to Burr Creek approximately 800 feet below the point of diversion. Field surveys (fall 2002) noted that all flow in Burr Creek passed through the Road Creek fish hatchery. During the spring season and other periods of high flow, much of the streamflow in Burr Creek likely bypasses the Road Creek fish hatchery. Burr Creek eventually discharges into Otter Creek below Koosharem Reservoir. The TMDL indicated the Road Creek fish hatchery was not active. Measurements used to calculate loads for the Road Creek fish hatchery were collected during the period when the facility was active.

Deans Fish hatchery is supported by a series of nearby springs. Discharge from the hatchery enters a series of ponds which eventually flow into a canal located immediately to the west. The canal is supported by additional flow from multiple springs and seeps located on west facing slopes that are one to three miles upstream of the hatchery. Discharge from the canal provides flood irrigation flows to several pastures on the east side of Otter Creek. Based on discharge rate, slope, surface cover, and distance to Otter Creek, a very limited amount of discharge from Deans Fish hatchery reaches Otter Creek.

Both fish hatcheries in the Otter Creek Watershed are supported by stock from by the Road Creek Ranch, located outside of the watershed. The TMDL noted that several efforts had been made recently to improve the quality of discharge water, including aeration structures and settling ponds (Jarman 2004).

5.5 DIFFUSE LOADS FROM RUNOFF

Diffuse loads from runoff are defined for the purposes of this watershed plan as anthropogenic (i.e. human influenced) loads associated with surface runoff that are not the result of manure produced by grazing animals or one of the other already specifically accounted for loading sources. Some examples of diffuse loads include the following:

- Surface runoff from agricultural areas that contains fertilizers (e.g., chemicals and manure) and pesticides.
- Pollution carried by runoff and erosion from human disturbed areas (including trails, roads, and dispersed camping sites).
- Pollution carried by runoff and erosion from upslope areas disturbed by managed grazing activities.
- Sediment runoff that impacts the habitat of aquatic organisms.

Most runoff in the watershed is associated with spring snowmelt and a few summer thunderstorms that pass through the area. In general, pollutant loading from runoff is essentially related to land use and land cover, although physical factors such as soil type, vegetative cover, slope, riparian conditions, etc. are also important. Land use near streams is particularly important when considering pollutant loads from runoff. In the Otter Creek and East Fork Sevier River watersheds, nearly all land in a narrow one to two-mile-wide strip along major streams is used for grazing or growing crops (Figures 5.1 through 5.4). The condition of this area is important as it has a greater likelihood to contribute pollutant loads, especially when poor conditions exist (trampled stream banks, lack of vegetative cover, disturbed soils, etc.).

Increases in stream and reservoir pH could occur if eroded sediments come from alkali soils with high pH. Alkali salts produce hydroxide ions when dissolved in receiving water which raises pH (Fondriest 2013). Other increases in pH could occur during the day from increased photosynthesis by algae and other plant material in water (USU Extension 2005). Excessive algal growth could also be a response to nutrient inputs from floodplains or surface runoff.

Sediment delivery to streams can occur during erosion and runoff from heavily grazed areas with exposed soils. Extended livestock grazing near streams can remove vegetation that would normally filter sediment and other pollutants transported in runoff. Excessive sediment loads deposited in streams can fill openings in the channel bed used by macroinvertebrates as living space or by fish for spawning. This process would remove desired macroinvertebrate species and their place in the aquatic food chain, leading to poor OE bioassessment scores as well as fish spawning habitat.

5.6 NATURAL BACKGROUND

Background conditions that influence water quality are assumed to occur under "natural" or undisturbed conditions and are generally considered to be uncontrollable. They can come from any natural process that is not man-enhanced or man-induced. Natural background conditions can include surficial geologic formations, atmospheric deposition (through rain or snow), wildlife species, and naturally occurring levels of soil erosion and stream channel dynamics.

In regard to total phosphorus, background loadings are not insignificant in the Otter Creek and East Fork Sevier River watersheds. Merritt et al. (1996) estimate that background concentrations of total phosphorus in the East Fork of the Sevier River watershed are approximately 0.06 mg/L and approximately 0.04 mg/L in the Otter Creek watershed. These concentrations are close to if not exceeding the 0.05 mg/L pollution indicator value for total phosphorus in streams and rivers. The 2006 TMDL completed a review of water quality measurements from springs and upper headwater streams, tributaries, and reservoirs/lakes in the watershed. Based on the estimates of Merritt et al. (1996) and the review of water quality data from sites high in the watershed (Utah DWQ 2006), it is estimated that natural background concentrations of TP in the Otter Creek and East Fork Sevier River watersheds are approximately 0.03 mg/L.

Conditions that naturally influence water temperature include solar radiation, season, surface exposure to sunlight, topography, surface vegetation, and water depth. Geothermal heating and discharge from springs or by diffuse groundwater flow can raise water temperature but these natural features do not occur in the watershed. Water discharging from a reservoir can moderate temperatures downstream by reducing the range of maximum and minimum temperatures in the short (daily) and long (seasonal) term. Reservoir discharge is created and manipulated by humans, but its presence can create long-term conditions that influence temperature. Temperature-impaired stream segments occur below Koosharem and Otter Creek Reservoir. Both reservoirs can be shallow during some months and years and likely influenced by solar radiation. Seasonal influences on monthly average temperature are apparent at all stream monitoring sites. Both reservoir discharge and seasonal conditions should be considered as natural influences on temperature impairment. Based on conditions in the Otter Creek and East Fork Sevier watersheds, the natural range of water temperature has potential to remain below 20 C for healthy water bodies and functioning riparian corridors.

Many natural environmental conditions and processes influence pH in the watershed. Natural pH of rainwater is slightly acidic and can decrease by passing through airborne particulates from wildfire and lightning (NADP 2012). Water can also become acidic when it flows across sulfur bearing minerals. Needles and litter from conifer tree species can decrease pH in soil and any surface runoff from these soils. Limestone geology found in Utah acts as a buffer by maintaining pH levels at near-neutral conditions. However, groundwater flowing through buffered soils can be slightly alkaline and raise the pH in receiving waters. Soil in most Utah landscapes is considered alkaline with a pH above 7. Natural processes such as algae respiration and decomposition can decrease pH in water, while algal photosynthesis causes pH to increase. The natural pH range for all waters in the Otter Creek and East Fork Sevier watersheds is generally considered to be 6.5 – 9.0. Based on information available at this time, there are no natural processes in the watershed that would cause pH to be consistently outside of this range.

Contamination by E. coli pathogens in water and soil can occur in even pristine waters. Natural concentrations of E. coli in the watershed are contributed by wildlife, birds, and even fish. These natural amounts are mitigated by temperature, pH and other factors that contribute to mortality of bacteria. E. coli is generally considered to be present even in pristine waters but at levels less than 100 cfu/100 ml (McFeters et al. 1978, Hyer 2007).

Oxygen from the atmosphere naturally enters the water in a dissolved form through reaeration and mixing at the water surface. In a healthy water body, natural processes continue to consume and contribute additional dissolved oxygen in a balanced way. Natural processes also influence conditions where oxygen can remain dissolved in the water for a longer period (e.g. cold vs. warm water temperatures). When these processes are out of balance, insufficient oxygen remains to support native aquatic species (i.e. oxygen deficit). This imbalance is a naturally occurring condition for some water bodies such as a stratified lake or a backwater segment of a river. Based on existing data, these conditions do not exist in the watershed for impaired water bodies. Natural conditions in the Otter Creek and East Fork Sevier watersheds are enough to provide dissolved oxygen at levels needed to support desired and native aquatic species.

The desired composition of macroinvertebrate species at any monitoring location is determined from the OE model used by Utah DWQ. The model estimates species composition expected at a river site with similar characteristics in an undisturbed condition. Natural conditions that would prevent the expected species from living at a monitoring site would be accounted for in the model.

5.7 INTERNAL RESERVOIR PROCESSES

Water quality in reservoirs is influenced by physical conditions inherent in the reservoir itself. This section will briefly describe how those processes can influence the water quality parameters and impaired water bodies addressed in this watershed plan. In regard to E. coli and OE bioassessment (macroinvertebrates), internal reservoir processes have little influence.

In regard to temperature, pH, and dissolved oxygen, these parameters are influenced by lake stratification which isolates upper and lower layers of water. As mentioned, these conditions occur in deep impoundments. Monitoring data reviewed in Chapter 4 indicates that lakes and reservoirs in the watershed are well mixed and as a result, likely have limited influence on temperature, pH and dissolved oxygen due to stratification. By their physical size, lakes and reservoirs have significant exposure to incoming solar radiation. This influence would be greater in shallow water bodies with limited volume. These water bodies do not have deep, relatively cooler water that can offset solar warming. Water temperature in Otter Creek Reservoir during some years and at some monitoring sites, could potentially be influenced by this condition.

5.8 SUMMARY

Major pollutant sources that influence parameters of concern addressed in this watershed plan include livestock grazing, diffuse runoff, and natural background conditions. Other known sources such as AFOs, onsite wastewater treatment systems, fish hatcheries, and internal reservoir processes could have some influence on impairment, but the relative impacts are minor.

It is important to note that descriptions of pollutant sources in this chapter are based upon information in the TMDL report and updated information from stakeholders. Additional monitoring efforts will be recommended later in the watershed plan.

6.0 POLLUTANT LOADS AND WATER QUALITY (EPA ELEMENT B)

This chapter summarizes pollutant loads created by the sources described in Chapter 5. A pollutant load can be calculated at a monitoring site from a measured concentration in a water quality sample and a flow measurement. These two values are used to define the mass of pollutant produced by a source during a certain time period. Figure 6.1 shows total phosphorus loads calculated from monitoring data at locations where paired measurements of flow and water quality were collected by Utah DWQ (Utah DWQ 2006). Loads for nonpoint sources can also be calculated without flow measurements if needed, using accepted values that define contributions from each source (e.g. land cover types, livestock manure, etc.). This chapter will review pollutant loads calculated using both methods.

Chapter 6 will use results from the 2006 TMDL to define total phosphorus loading for some of the water bodies that are currently impaired including Otter Creek Reservoir, Lower Box Creek Reservoir, Koosharem Reservoir, segments of Otter Creek downstream and upstream of Koosharem Reservoir, and East Fork Sevier downstream of Antimony Creek. The methods used to calculate phosphorus loads for these waterbodies are summarized in this section and described in detail in the TMDL.

Some waterbodies addressed in this watershed plan are impaired for parameters of concern besides total phosphorus (see Table 2.1). Recent monitoring data for some of these parameters, including temperature, pH, and dissolved oxygen, suggests that impairment may be limited (see Chapter 4). However, the recommendations made by this watershed plan will address all pollutant sources for any currently impaired water body in the watershed.

Impaired water bodies not addressed by the 2006 TMDL include Greenwich Creek, Box Creek, East Fork Sevier between Antimony and Deer Creek, East Fork Sevier from Deer Creek upstream to Tropic Reservoir, and Pine Lake. The Spreadsheet Tool for Estimating Pollutant Loads (STEPL) computer model was used to determine pollutant loads for watershed areas contributing to these streams and lake. The STEPL model is a customized spreadsheet that calculates nutrient and sediment loads at a watershed scale from different land uses and load reductions that result from implementing various BMPs (EPA 2018). Model input for livestock numbers and land cover data were obtained from the 2006 TMDL (Utah DWQ 2006). The surface area of animal feedlot operations and number of onsite wastewater treatment systems were measured from recent aerial photos. Natural background loads of total phosphorus were based on the percent contribution to the total watershed load determined in the TMDL for the Otter Creek and East Fork Sevier watersheds (Utah DWQ 2006).

This chapter will review pollutant loads for sources of total phosphorus and E. coli. Chapter 7 will recommend pollutant load reductions to restore beneficial use for all impaired water bodies. Water quality improvement for other parameters of concern (i.e., temperature, pH, dissolved oxygen, OE bioassessment, sediment, and habitat) will also occur as pollutant loads for phosphorus and E. coli are reduced. As BMPs reduce total phosphorus and E. coli, they will subsequently; 1) increase dissolved oxygen by decreasing algae growth and decomposition, 2) improve riparian vegetation and shade that can reduce water temperature in streams; and 3) improve infiltration and reduce runoff and transport of sediment and other suspended material that could influence pH levels and/or degrade stream habitat used by macroinvertebrates.

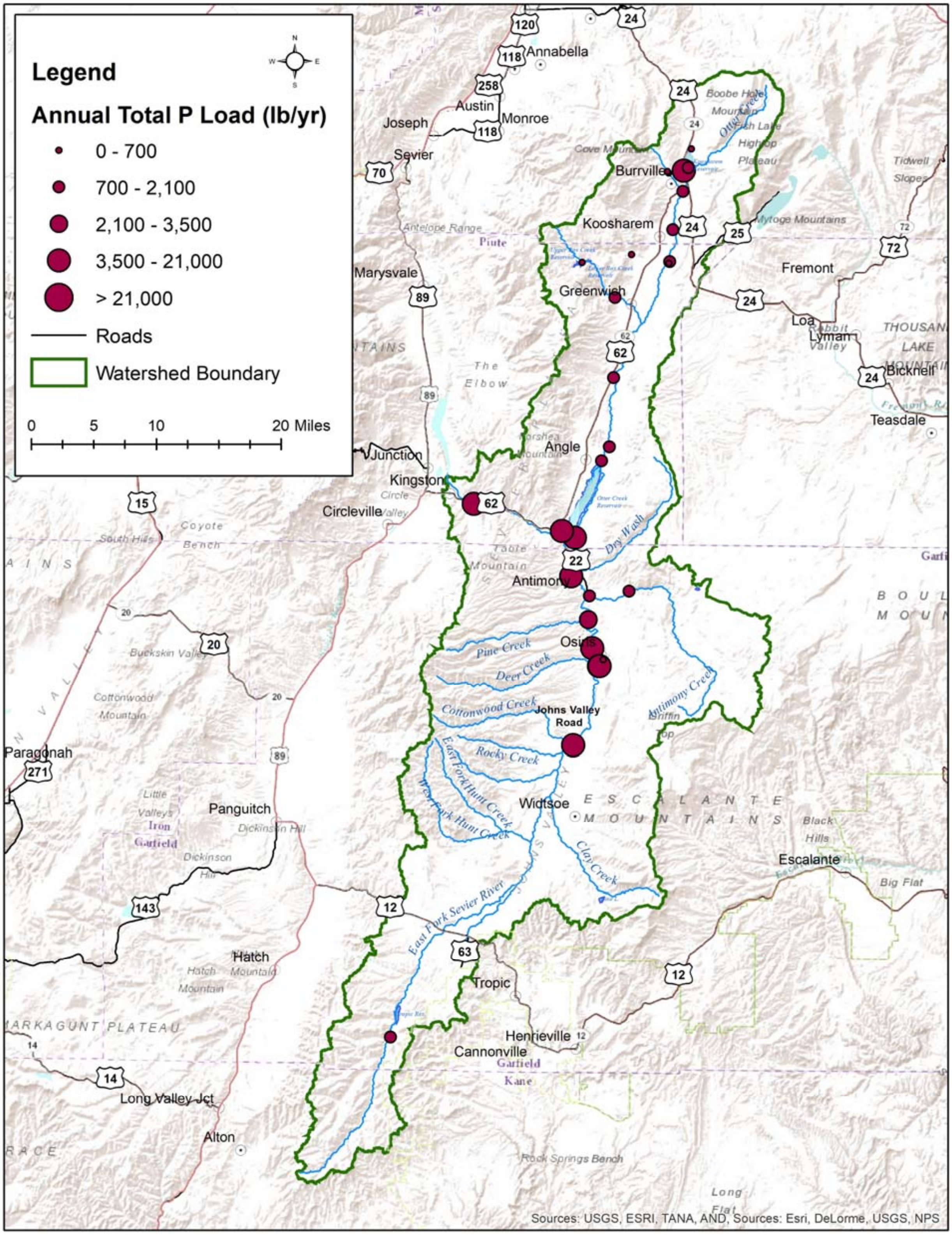


Figure 6.1. Annual average TP loads in the TMDL study area. TP loads were calculated with the simple average approach using only paired measurements of flow and TP concentration collected at DWQ monitoring stations for the entire period of record.

6.1 OTTER CREEK WATERSHED AND IMPAIRED WATERBODIES

This section describes pollutant loading to Otter Creek Reservoir and all impaired water bodies in the watershed above the Reservoir. Moving upstream from Otter Creek Reservoir, these water bodies include:

- Otter Creek and tributaries from Otter Creek Reservoir to Koosharem Reservoir
- Box Creek
- Lower Box Creek Reservoir
- Greenwich Creek
- Koosharem Reservoir
- Otter Creek and tributaries above Koosharem Reservoir

The discussion in this section begins with Otter Creek Reservoir and moves upstream to include all impaired waters bodies in the watershed as noted above.

Existing total phosphorus loads to Otter Creek Reservoir from its tributaries were calculated using available streamflow and water quality sampling information. The major inflows to Otter Creek Reservoir are Otter Creek and the East Fork Canal. Data characterizing water quality in Otter Creek upstream of the reservoir are generally good. Fewer flow and water quality measurements are available to characterize loading to the reservoir from the East Fork Canal, despite the fact the majority of flow to the reservoir is from this source.

Annual loads of total phosphorus to Otter Creek Reservoir are summarized in Table 6.1. Natural background loads and anthropogenic loading from the East Fork Canal (a diversion from the East Fork Sevier River) contribute approximately 15 and 75 percent of the loading to Otter Creek Reservoir, respectively. Note that loads from livestock grazing and diffuse runoff are combined in Table 6.1. The complicated hydrology, along with the dispersed nature of the loading from grazing animals and diffuse loads from runoff make it unlikely that a separate load category would be accurate.

Pollutant sources contributing to the East Fork Canal will be discussed further in section 6.2. Loads from sources in the Otter Creek watershed are relatively small compared to those from the East Fork Sevier watershed due largely to the relative differences in flow.

Table 6.1 Summary of annual average total phosphorus loads to Otter Creek Reservoir by source.

	Annual Total Phosphorus Load lb – (%)	
Estimated Loads by Source	**Otter Creek**	**East Fork Canal[1]**
Animal Feeding Operations	309 (13%)	1,730 (10%)[2]
Onsite Wastewater Treatment Systems	42 (2%)	13 (<1%)
Fish Hatcheries	379 (16%)	0
Grazing and Diffuse Loads from Runoff	1,005 (43%)	12,571 (75%)
Natural Background	586 (25%)	2,518 (15%)
Total	2,321 (12%)	16,832 (88%)
Total Measured Loading to Otter Creek Reservoir	19,154	

[1]East Fork Sevier diverted at the East Fork Canal.

[2]In-stream contribution from this source is based on STEPL watershed load.

The load of total phosphorus for Otter Creek before it enters Otter Creek Reservoir is defined in Table 6.1 as 2,321 lbs/yr. This load is based on paired samples of total phosphorus and flow collected near where Otter Creek flows into Otter Creek Reservoir. As such, these measurements represent the combined load for all sources upstream of that point. Major inflows to this stream segment include Box Creek, Greenwich Creek, and Koosharem Reservoir.

A watershed model was used to estimate total phosphorus loads for each significant pollutant source in the Box Creek and Greenwich Creek watersheds (EPA 2018). Load calculations for Lower Box Creek Reservoir, Koosharem Reservoir, and Otter Creek and tributaries above Koosharem Reservoir were included in the 2006 TMDL.

Figure 6.2 shows pollutant source loads of total phosphorus in the watersheds that contribute to each impaired water body. These loads are generated by three nonpoint sources including grazing, diffuse loads from runoff, and natural background conditions. Note that values in Figure 6.2 represent loads generated by each source before entering a stream or reservoir. Total phosphorus loads measured at the outlet of a watershed or reservoir would be reduced by processes that occur in each water body or as surface runoff flows to a water body. Some of these processes include deposition, plant uptake, and adsorption to soil.

Loads for Box Creek incorporate the load delivered to Lower Box Creek Reservoir. Loads to the reservoir include a relatively larger contribution from livestock grazing compared to the entire Box Creek watershed. Pollutant sources downstream of Lower Box Creek include livestock grazing as well as AFOs. The composition of the total load among pollutant sources is similar for Box Creek and Greenwich Creek.

Total phosphorus loads to Koosharem Reservoir are approximately 2,670 lb/yr. About 33 percent of this load can be attributed to natural background, with diffuse loads from runoff making up approximately 42 percent of the estimated load. The TMDL divided the grazing load between cattle grazing adjacent to the reservoir and those further away that contributed loading to streams. Annual loads for each source were 370 lb/yr and 302 lbs/yr respectively. The load of total phosphorus to Otter Creek and tributaries above Koosharem Reservoir is 2,300 lb/yr which is the difference between the total Reservoir load of 2,670 lb/yr less the 370 lb/yr from grazing adjacent to the Reservoir.

Otter Creek and tributaries from Koosharem Reservoir to headwaters are also impaired for E. coli. Seasonal E. coli monitoring data (May–September) collected from one canal and two stream sites were reviewed in Chapter 4. Results showed four of five samples from site 5945800 on Boobe Hole Creek were all greater than the maximum detection limit and well above the permitted geometric mean of 206 cfu/100 ml that protects recreational use. Monthly average flow and E coli measurements (see Chapter 4) were used to calculate loads at this site (Table 6.2). There is currently no information to determine the biological source of coliforms or to indicate if the source is local or from an upstream location. This site is located adjacent to the north edge of Koosharem Reservoir and in a private grazing allotment (see Figure 5.3). It is likely that livestock grazing contributes some of the E. coli load, either by manure carried in surface runoff or from direct deposition in the stream channel.

Table 6.2. E. coli daily load at Utah DWQ 5945800 Boobe Hole Creek above Koosharem Reservoir (2014).

Month	Sample size	MPN (cfu/100 ml)	Mean daily flow (cfs)	Daily Load (cfu)
May	1	24.1	4.00	2.36E+07
June	1	2419.6	3.53	2.09E+09
July	1	2419.6	1.69	1.00E+09
August	1	2419.6	1.66	9.85E+08
September	1	2419.6	1.14	6.76E+08

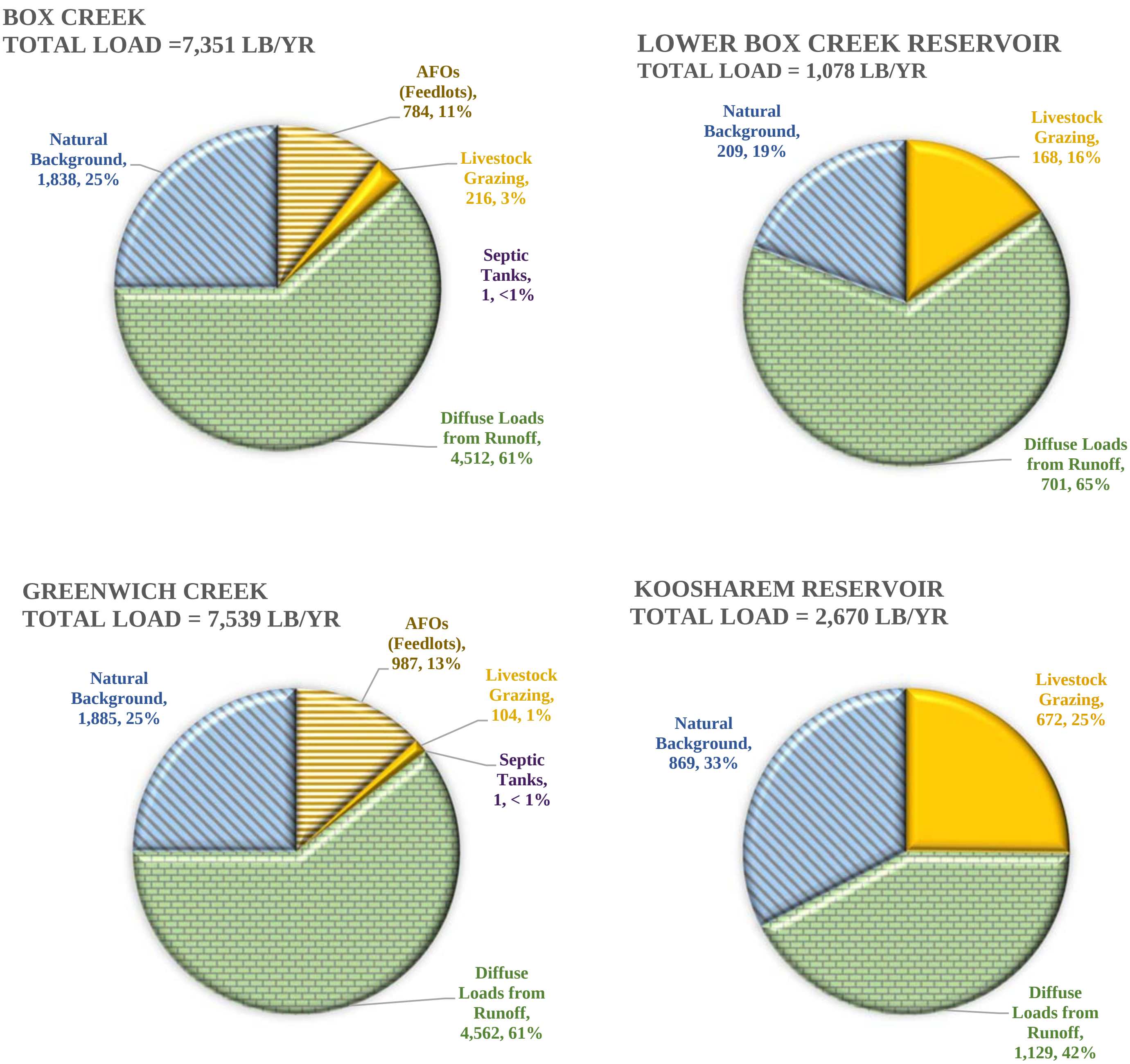


Figure 6.2. Annual pollutant source loads (lb/yr) of total phosphorus in the watersheds that contribute to impaired water bodies including Box Creek, Lower Box Creek Reservoir, Greenwich Creek, and Koosharem Reservoir.

6.2 EAST FORK SEVIER WATERSHED AND IMPAIRED WATERBODIES

This section describes pollutant loading to the East Fork Sevier River and all impaired water bodies in the watershed that contribute to the East Fork Sevier River with the exception of the Otter Creek watershed and discharge from Otter Creek Reservoir. Moving upstream from the confluence of the East Fork Sevier with the Sevier River, these include:

- East Fork Sevier River and tributaries from confluence with Sevier River upstream to Antimony Creek confluence, excluding Otter Creek and tributaries
- East Fork Sevier River and tributaries from Antimony Creek confluence to Deer Creek confluence
- East Fork Sevier River and tributaries from Deer Creek confluence to Tropic Reservoir
- Pine Lake

The 2006 TMDL included pollutant loads for the East Fork Sevier River upstream to the Antimony Creek confluence, based on water quality and flow monitoring data. Upstream segments of the East Fork Sevier are also impaired, including from Antimony Creek to Deer Creek and from Deer Creek upstream to Tropic Reservoir. Pollutant loads for impaired waters that were not included in the 2006 TMDL were determined using the STEPL model (EPA 2018). The discussion in this section begins with the East Fork Sevier River at the confluence with the Sevier River and moves upstream to include all impaired water bodies in the watershed as noted above.

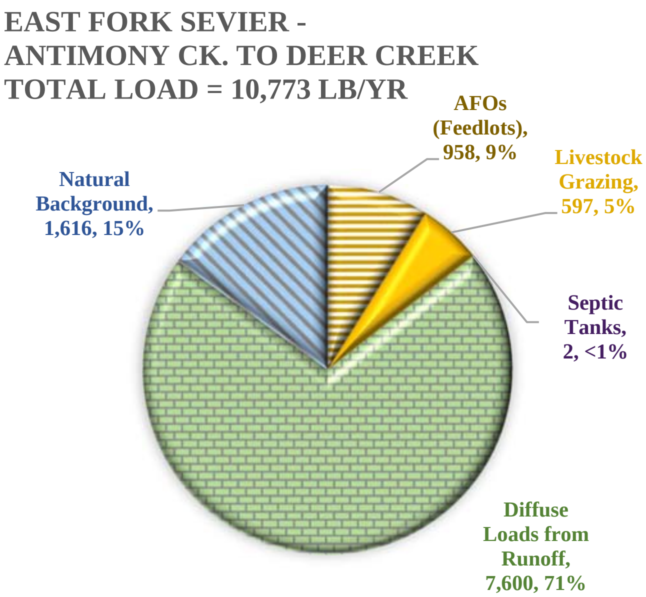
The East Fork of the Sevier River from its confluence with the Sevier River upstream to Antimony Creek receives flows from the East Fork Sevier and Antimony Creek. Downstream of this confluence, water is diverted from the East Fork Sevier into the East Fork Canal, which feeds Otter Creek Reservoir and represents a loss of flow and loading from this impaired reach. Further downstream, the releases from Otter Creek Reservoir enter the East Fork via Otter Creek, representing another loading contribution. In addition, there are several small tributaries along the length of the reach that are ephemeral in nature.

Table 6.3 includes a summary of loadings to the East Fork of the Sevier River for each major pollutant source. Positive values in the table indicate loads that would be measured near the end of the listed reach. Negative values represent phosphorus that is loaded to the listed reach but lost from the system by diversion (via the East Fork Canal). These loads would not be measured at the end of the listed reach. The largest portion of the measured loading (approximately 56 percent) at the end of the reach is associated with releases from Otter Creek Reservoir. Loads from onsite wastewater treatment systems and animal feeding operations are relatively minor. Approximately 28 percent of the measured loading is from natural concentrations of total phosphorus in the East Fork Sevier that bypass Otter Creek Reservoir. Grazing and diffuse loads represent a large load upstream of Antimony Creek, but much of this loading is diverted into Otter Creek Reservoir via the East Fork Canal (approximately 14,314 lb/yr). In addition, it is estimated that approximately 2,518 lb/yr of the total loading diverted to Otter Creek Reservoir is due to natural background, leaving approximately 3,794 lb/yr from grazing and diffuse loads from runoff that either bypasses the diversion or is generated below the diversion and would be measured downstream.

Figure 6.3 shows the results of STEPL model calculations of total phosphorus loads for segments of the East Fork Sevier river upstream of Antimony Creek. Note these are pollutant loads that have not entered a receiving water body. The largest contribution to the total load for each source is from diffuse runoff. Other load contributions come from AFOs and livestock grazing. Most AFOs in the watershed area upstream of Deer Creek are located near Tropic Reservoir.

Pine Lake is located in a remote upper-elevation area near the east watershed boundary (see Figure 2.1). Pollutant sources found in the watershed area of Pine Lake include livestock grazing and diffuse runoff. Based on the minor impairment indicated by monitoring data, separate loads were not calculated for Pine Lake. Loads to Pine Lake are included in the total watershed load for the East Fork Sevier between Deer Creek and Tropic Reservoir. Recommendations for reducing loads to Pine Lake are included in Chapter 8.

Table 6.3. Summary of annual average Total Phosphorus loads to the East Fork Sevier River from confluence with the Sevier River upstream to Antimony Creek, excluding Otter Creek and tributaries.	
Pollutant Source Category	**Annual Total Phosphorus Load – lb (%)**
Animal Feeding Operations	617 (5%)
Onsite Wastewater Treatment Systems	13 (<1%)
Estimated Loads, excluding Natural Background	
Diverted into East Fork Canal	-14,314
Bypass or generated below the East Fork Diversion	3,794 (28%)
Loading from Otter Creek Reservoir Releases	7,476 (56%)
Natural Background	
Diverted into the East Fork Canal	-2,518
Bypass or generated below the East Fork Diversion	1,541 (11%)
Total Loading Diverted into Otter Creek Reservoir	-16,832
Total Measured Loading in the East Fork Sevier River	13,442
Source: Utah DWQ (2006).	



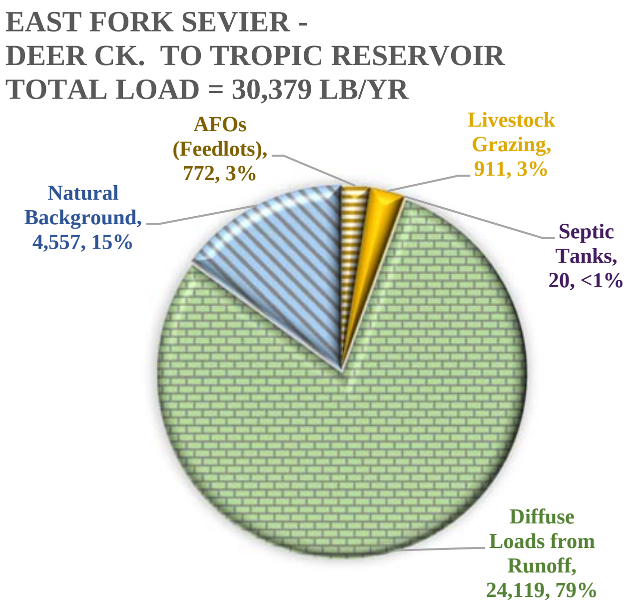


Figure 6.3. Annual pollutant source loads (lb/yr) of total phosphorus in the watersheds that contribute to impaired segments of the East Fork Sevier between Antimony Creek and Deer Creek and from Deer Creek upstream to Tropic Reservoir.

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7.0 WATERSHED GOALS

The Otter Creek/East Fork Sevier watershed plan expresses goals and objectives of stakeholders. These goals are derived from concerns by individuals, management directives of organizations active in the watershed, or needs specific to a particular group of stakeholders. In most cases, a watershed goal is broad enough to encompass multiple concerns. Watershed goals should be specific and clearly written. To ensure that progress is made toward achieving the goals, it is helpful to define indicators, milestones, targets, and management objectives that articulate actions necessary to move toward the goals. In order to accomplish these management objectives, this plan articulates management strategies and management practices that would help to reduce nonpoint source pollution.

A conceptual description of each planning term is provided in Table 7.1. Some of these planning terms are reviewed in the sections below. Other terms will be mentioned in Chapters 8 and 9 in the discussion on how to implement the watershed plan.

Table 7.1. Definition of watershed planning terms.

Watershed Planning Term	Description
Watershed Goals	What the watershed should be, sometimes defined by what it should not be. Goals can be defined by stakeholders' concerns.
Indicators	What to measure to know the watershed is getting closer to the goal(s).
Targets	Measurable values of indicators that show when goals have been achieved and when enough has been done.
Management Objectives	Management actions that affect the creation, movement, deposition, or treatment of pollutants such that water quality indicators move toward their target levels.
Milestones	How much management action should be accomplished and when. Milestones include a management objective, a measured amount of progress, and a timeline.

Goals can be extracted from several sources. Examples include concerns expressed by stakeholders, hopes and desires for better land or water conditions, or scientific understanding of what is required for water quality to meet a beneficial use. Goals should incorporate concerns from all stakeholder groups and all geographic areas within the Otter Creek/East Fork Sevier watershed. Some of the organizations on the TMDL advisory committee that contribute to developing goals for this watershed are shown in Figure 7.1. Goals can also be taken from previous watershed planning activities including TMDL efforts, land and resource management plans, source water assessments, and stream corridor/riparian assessments.

Watershed goals in the Otter Creek/East Fork Sevier watershed include concerns identified by the Utah DEQ in the 2006 TMDL (Utah DWQ 2006), previous resource assessments, and stakeholder concerns. This watershed plan will focus primarily on restoring impaired water bodies by meeting Utah water quality standards. Future iterations of this plan are strongly encouraged to evaluate progress and incorporate changes to watershed goals. Plan updates may be necessary if other impairments are identified in future IR documentation addressing other pollutants of concern.

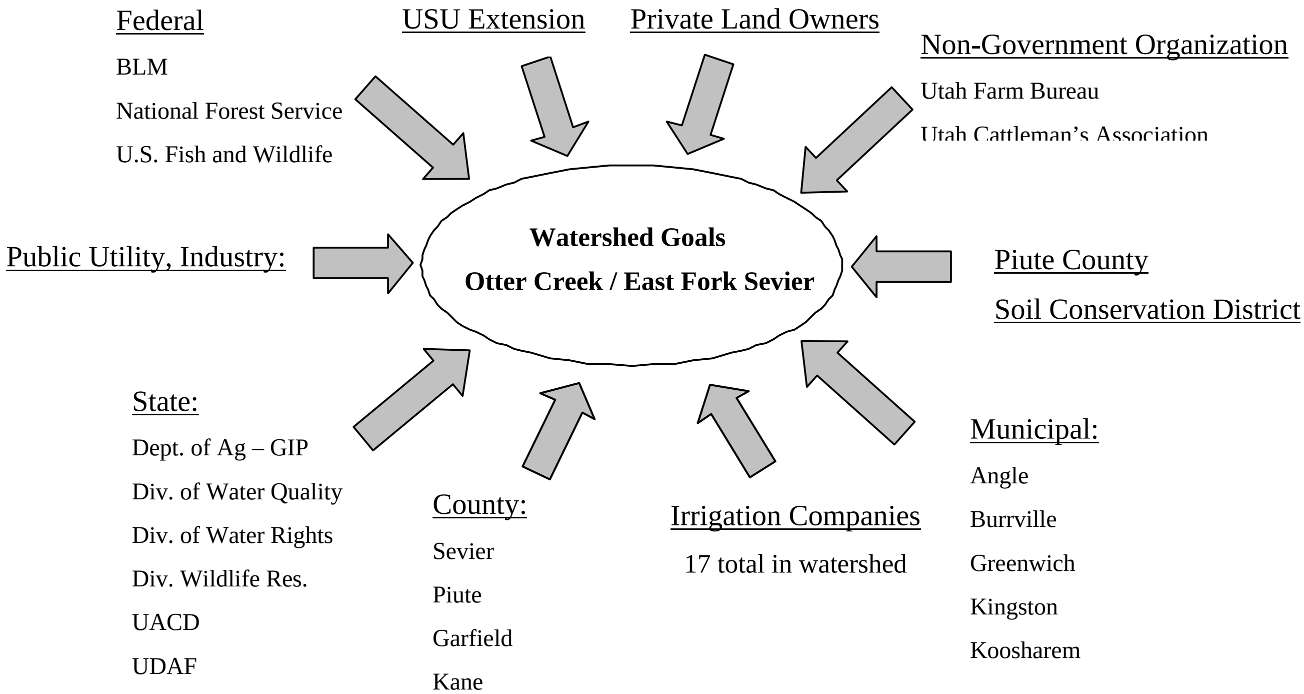

Figure 7.1. Entities that are developing watershed goals for the Otter Creek/East Fork Sevier.

Concerns expressed by agencies and private landowners include goals that are specific to water quality as well as other goals for the watershed that may indirectly benefit water quality. Water quality-specific goals are associated with thresholds that protect and support beneficial uses. Other watershed goals may be associated with topsoil conservation, bank stabilization (to protect property and wildlife habitat), proper grazing management, and effectively managing manure in a way that minimizes cost and maximizes crop yield. Each of these goals can indirectly improve water quality while directly benefiting the agriculture operations of private landowners.

Watershed goals are also reflected by management objectives. These objectives are essentially actions that influence pollutant sources and how they are transferred to receiving water bodies. Indicators are measured to determine if progress is being made towards watershed goals. This chapter will define management objectives and indicators with regard to current understanding of pollutant sources described in Chapter 5 and achieving the load reductions defined in the 2006 TMDL. The remainder of this chapter will describe the load reduction target and the method used to determine what reductions are needed from nonpoint pollutant sources in the watershed.

7.1 MANAGEMENT OBJECTIVES AND INDICATORS

Before deciding what strategies to use to resolve water quality problems, it is important to define the objectives for management. Management objectives should move the indicators of water quality in the desired direction and address the location and timing of pollutant sources that are causing water quality problems. Specific management objectives should be defined to support each goal, but the same management objective may affect more than one indicator.

7.1.1 Management Objectives

The primary watershed goal at this time is to restore beneficial uses impaired by total phosphorus. However, management objectives should also consider factors that could influence the success of different activities that have potential to improve water quality. Some of these factors are specific to location, land ownership, and land use. Initial management objectives in this plan were selected based on discussions with stakeholders, field survey results, and a watershed scale review of GIS information. Some of the factors that were considered include the following:

- **Impaired water bodies:** Do impairments exist in other locations of the watershed, beyond those water bodies identified in the TMDL? What does monitoring data indicate in regard to the level of impairment?
- **Conditions that mitigate pollutant loading:** Where do good management practices and conditions currently exist that provide some control of nonpoint source loading? What areas can be assigned a lower priority for responsibility of pollutant loading, because, for example, they are distant from the impaired segment, or impractical to change?
- **Opportunities and barriers to implementation:** What is the potential for success in implementing management practices in different locations or among various stakeholder groups? What success has been achieved in the past with nonpoint source control measures with respect to BMP location or type of practice? Do stakeholders realize benefits such as increases to livestock forage production, stream flow volume, or property value as well as water quality improvements?
- **Location with respect to impaired water bodies:** What is the distance between impaired reaches and pollutant sources? How does this distance vary by pollutant source and season?
- **Land ownership:** Most pollutant sources are located on public land. What influence does agency funding or cooperation between agencies and watershed stakeholders have on the likelihood of BMP implementation?

Once management objectives have been established, management strategies can be developed to guide the choice of specific management practices. Management objectives that were identified for the Otter Creek/East Fork Sevier watershed included:

1. Reduce land erosion that transports sediment (and total phosphorus) to waterways, especially from disturbed lands, agricultural fields, and public and privately owned pastures.
2. Increase acceptable livestock management practices on private and public grazing allotments.
3. Actively manage the number and duration of livestock in proximity to receiving water bodies and their defined bed and banks.
4. Increase use of better nutrient management practices including land application of manure.
5. Increase percentage of AFOs following CNMPs and utilizing waste management structures and practices.

7.1.2 Water Quality Indicators

Water quality indicators provide a means for measuring progress towards watershed goals in several phases of watershed planning and development. Indicators can be used before and after implementing water quality improvement projects to determine progress. Environmental indicators (such as desired macroinvertebrates) are used to define the linkage between pollutant sources and environmental health. The cause and effect relationship defined between indicators and watershed goals can be used to determine pollutant load reductions. Programmatic and social indicators are indirect measures of progress towards watershed goals. They include measures of information and education programs used to protect water quality and changes in behavior that result in improvements to water quality. Regardless of type, indicators should be a quantified measure of progress towards watershed goals.

The water quality indicators selected for this watershed plan include the following:

1. In-stream total phosphorus concentration at monitoring sites located at watershed outlets, immediately below reservoirs, and at additional sites recommended in Chapter 9.
2. Water quality parameters that indicate impairment from total phosphorus including dissolved oxygen, chlorophyll-a, and OE bioassessment scores. These parameters will be measured at the same sites monitored for total phosphorus. All water quality samples will need to be paired with in-stream flow measurements at any site that does not have continuous flow monitoring managed by irrigation companies or federal agencies (e.g. USGS).

7.2 LOAD REDUCTION AND SOURCE ALLOCATION

This section describes the load reduction needed to meet the TMDL load allocation for nonpoint sources. The load reduction needed from nonpoint sources is defined as the difference between the observed load from nonpoint sources and the load allocation in the TMDL.

The load allocation is the portion of the TMDL assigned to nonpoint sources and natural background levels. It was calculated as the remainder of the loading capacity after allocations were made for a margin of safety and loads from future growth.

Load allocations were made in the TMDL to individual nonpoint sources or categories. These allocations were based on analysis of available monitoring data and standard approaches to modeling hydrology and water quality. This watershed plan will make similar allocations and percent reductions of loading to impaired water bodies that were not included in the TMDL. Load reductions for all impaired water bodies included in this plan are preliminary. Load reductions could be adjusted in the future as additional information becomes available to evaluate aquatic health and progress towards beneficial use.

7.2.1 LOAD REDUCTION TARGET

The primary target for the watershed plan at this time is the load reductions (lbs/day) from nonpoint sources needed to restore beneficial use to all impaired water bodies in the watershed. Other targets will be mentioned in Chapter 8 when BMPs are recommended to reduce pollutant loading. Each of these targets are related to meeting the main watershed goal of restoring beneficial use to all impaired water bodies in the Otter Creek/East Fork Sevier watershed.

Table 7.2 shows the load reductions needed for each impaired water body in the Otter Creek/East Fork Sevier watershed. Reasonable assurances that load reductions will restore beneficial use to impaired water bodies include the following:

- Conservative assumptions have been used in loading calculations and the amount of reduction needed to restore beneficial use.
- Pollution indicator values for total phosphorus are conservative in protecting beneficial use of impaired water bodies in the watershed. Future monitoring may indicate that concentrations of total phosphorus could be higher than existing pollution indicator values.
- An adaptive management approach will allow adjustments to load reductions as indicated by monitoring data and progress towards full support of beneficial use for cold water aquatic species.
- Some of the necessary reductions from AFOs in the watershed have already taken place (Ingraham 2018). Based on past levels of activity, any remaining feedlots or new feedlots will likely implement nutrient management plans.

- Load allocations do not account for losses that occur through settling in reservoirs.
- Federal agencies and other agency stakeholders have successfully implemented projects and management practices in the past that support improved water quality.
- Private landowners have worked well with agency stakeholders during the past to implement water quality improvement projects in key areas.
- Although project funding is limited at times, existing levels of cooperation are expected to continue in the future. Stakeholder cooperation is a key element of improving water quality, particularly when managing nonpoint source pollution.

Table 7.2. Total phosphorus load allocations for impaired water bodies in the Otter Creek/East Fork Sevier watershed. Impaired water bodies are listed upstream to downstream and italicized text indicates water bodies included in the TMDL.

Impaired water body	Existing Load (lb)	Reduction	Reduction Target (lb)	Allocation (lb)
Otter Creek watershed				
Otter Creek upstream of Koosharem Reservoir	2,300	48%	1,106	1,194
Koosharem Reservoir	2,670[1]	48%	1,284	1,386
Greenwich Creek	7,539	50%	3,772	3,766
Lower Box Creek Reservoir	1,078	80%	866	212
Box Creek	7,351[1]	50%	3,678	3,673
Otter Creek	2,321	50%	1,160	1,161
Otter Creek Reservoir	19,154[1]	77%	14,662	4,492
East Fork Sevier watershed				
East Fork Sevier from Deer Ck. to Tropic Reservoir	30,379	48%	14,551	15,827
East Fork Sevier from Antimony Ck to Deer Ck.	10,773	48%	5,160	5,613
East Fork Sevier upstream to Antimony Creek	13,442[1]	48%	6,439	7,003

Source: Utah DWQ (2006).

[1] Existing load accounts for direct loading to impaired water body and loading from upstream water bodies.

7.2.2 Source Allocations to Meet the Load Reduction Target

Nonpoint source loads of total phosphorus were defined in Chapter 6 for each significant source including animal feeding operations, livestock grazing, diffuse runoff, onsite wastewater treatment systems, and fish hatcheries. The amount of pollution from each source that reaches impaired water bodies is uncertain and does not imply a need to focus on any single source. The allocation for each pollutant source requires a corresponding large reduction in order to meet the load reduction target for each impaired water body (Table

7.3) with the exception of fish hatcheries. The status of fish hatcheries is uncertain therefore no allocations are currently recommended in the watershed plan.

Given the amount of anthropogenic manipulation that has occurred in the watershed (e.g., dams, irrigation withdrawals, returns, etc.) it is likely that pathways between sources and surface waterbodies are very complex and remove additional phosphorus loads between the source and receiving water.

Uncertainty in the relationship between pollutant sources and the delivered load can be addressed through the use of an adaptive management approach to meeting load reductions. This is a systematic approach for improving resource management that allows for flexible decision-making. There is an inherent amount of uncertainty involved in the TMDL process that includes determining effects of BMP implementation, among other things. Use of an adaptive management approach in the Otter Creek/East Fork Sevier watershed allows for adjustments to allocations and load reduction targets, as necessary. Future changes will be made to the plan based on measurements of proposed indicators and milestones.

Table 7.3. Annual total phosphorus reduction targets for each impaired water body and pollutant source in the Otter Creek/East Fork Sevier watershed.

Impaired water body[1]	Reduction Target (lbs)	AFOs	Livestock Grazing	Septic Tanks	Fish Hatcheries	Diffuse Loads from Runoff	Total Reduction[2]
Otter Creek watershed							
Otter Creek upstream of Koosharem Reservoir	1,106	0 lbs (0%)	211 lbs (70%)	0 lbs (0%)	0 lbs (0%)	903 lbs (80%)	1,115
Koosharem Reservoir	1,284[3]	0 lbs (0%)	470 lbs (70%)	0 lbs (0%)	0 lbs (0%)	847 lbs (75%)	1,317
Greenwich Creek	3,772	888 lbs (90%)	73 lbs (70%)	0 lbs (0%)	0 lbs (0%)	3193 lbs (70%)	4,155
Lower Box Creek Reservoir	866	0 lbs (0%)	168 lbs (100%)	0 lbs (0%)	0 lbs (0%)	701 lbs (100%)	869
Box Creek	3,678[3]	706 lbs (90%)	151 lbs (70%)	1 lbs (80%)	0 lbs (0%)	2933 lbs (65%)	3,790
Otter Creek	1,160	278 lbs (90%)	0 lbs (0%)[4]	29 lbs (70%)	0 lbs (0%)	855 lbs (85%)	1,162
Otter Creek Reservoir[5]	14,662[3]	1,835 lbs (90%)	0 lbs (0%)[4]	39 lbs (70%)	0 lbs (0%)	12,898 lbs (95%)	14,771
East Fork Sevier watershed							
East Fork Sevier from Deer Ck. to Tropic Reservoir	14,551	695 lbs (90%)	364 lbs (40%)	10 lbs (50%)	0 lbs (0%)	14,471 lbs (60%)	15,541
East Fork Sevier from Antimony Ck to Deer Ck.	5,160	862 lbs (90%)	299 lbs (50%)	1 lbs (50%)	0 lbs (0%)	4,560 lbs (60%)	5,722
East Fork Sevier upstream to Antimony Creek	6,439[3]	556 lbs (90%)	0 lbs (0%)[4]	7 lbs (50%)	0 lbs (0%)	2,276 lbs (60%)	6,807

[1] Italicized text indicates water bodies included in the TMDL (Utah DWQ 2006). Percent reduction from existing loads are shown for each source.
[2] Reductions meet targets and load allocations included in the TMDL.
[3] Reduction target incorporates the reduction target for water bodies located upstream (e.g. reduction target of 1,284 lbs for Koosharem Reservoir includes the 1,106 lbs for Otter Creek upstream of Koosharem Reservoir).
[4] Combined with Diffuse Loads from Runoff.
[5] Reductions for Otter Creek Reservoir incorporate reductions to Otter Creek and East Fork Sevier upstream of Antimony Creek.

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8.0 IDENTIFICATION OF MANAGEMENT STRATEGIES (EPA ELEMENT C)

Management strategies are those activities that accomplish particular management objectives, e.g., replanting riparian vegetation along an eroding streambank (strategy) to reduce streambank erosion (objective). The ultimate implementation of a management strategy is referred to as a management practice, but these are typically just variations in regard to a specific practice—planting willow bundles versus cottonwood cuttings, size and material of a pipe for irrigation projects, choice of concrete or wood walls for animal waste storage, etc.

The key to choosing successful management strategies for nonpoint source water pollution is finding those that are effective in controlling sources of pollution, economical, and easy to maintain. The construction and maintenance costs of management strategies are of primary concern to private landowners. The process followed to choose strategies must consider these and other concerns besides reduction efficiency in order to achieve the desired levels of implementation.

8.1 EXISTING MANAGEMENT STRATEGIES

Information on existing management strategies in the Otter Creek/East Fork Sevier watershed was retrieved during a request to local agencies for summary documentation. No confidential information was released in response to this request. These records provide valuable information on strategies that have worked well in the project area. The reports also provided insight on overall progress and attitudes toward implementation and where improvements can be made.

8.1.1 STRUCTURAL CONTROLS

Structural controls are BMPs that include a structure or built feature. Examples of structural controls include detention basins, filter strips, fencing, diversion berms, etc. Structural controls usually include a maintenance cost that occurs over time to keep the structure functioning properly.

Utah DWQ is required to track and document all water quality improvement projects associated with their section 319 nonpoint source pollution control program. Projects funded from this source require matching funds from private landowners. Planning efforts for these projects sometimes include work on adjacent public land that is funded by federal or state agencies. Table 8.1 includes information on water quality improvement practices implemented on private land as well as some BLM- managed land in the project area. Many earlier projects shown in this table were associated with the Otter Creek Hydrologic Unit Area Assessment which addressed pollutant sources near Koosharem Reservoir, Otter Creek, and Otter Creek Reservoir (USDA-SCS 1992). As support grew for implementation, additional projects were completed on private land in other areas of the watershed. In general however, locations for most of these projects were not identified.

About 80 percent of land in the Otter Creek/East Fork Sevier watershed is managed by federal and state agencies (section 3.4). Forest and range lands managed by these agencies are primarily used for livestock grazing, timber harvest, and recreation. Federal and state agencies have implemented practices to improve watershed health by managing livestock grazing, forage vegetation, and timber, which also reduce nonpoint source pollution and improves water quality. Figures 8.1 and 8.2 show the location of practices implemented on public land in the Otter Creek/East Fork Sevier watershed. Table 8.2 shows the number and type of projects shown in each figure that are located on National Forest Land. This level of detail was not available for projects located on land managed by the BLM.

Table 8.1. Water quality improvement projects implemented on private land in the Otter Creek/East Fork Sevier watershed.[1]		
Fiscal Year	**Cost**[2]	**Project**
2020	$80,000	Beaver Dam Analogs – Utah State University[3]
2012-2015	-	Bagley Restoration Project – Otter Creek[4]
2008	$60,677	East Fork Sevier River Enhancement #831 (4,700 feet of fence, 3,600 feet of stream channel, rip-rap, plantings)[5]
	$300,000	East Fork Sevier River Enhancement #833 (5.5 miles of riparian fence, 2.5 miles of stream channel, rip-rap, log reinforcement, bank shaping)[5]
2003	$47,164	Otter Creek and Reservoir TMDL Development
1997 - 2002	$190,000	Stockwater Troughs (23 total)
		Fencing (46 miles)
		Range Seeding (14,859 acres)
		Pipeline (6,000 feet)
		Stream Bank Protection (4.4 miles)
		Prescribed Grazing (120,944 acres)
		Hayland Management (2,500 acres)
		Brush Management (13,359 acres)
		Streambank Stabilization Structures (13 total)
		Restroom Facility (1 total)
		Improved Fishery Habitat (23 miles)
		Informational Pamphlets
		Contracts Executed (42 total)
		Non-point Source Practices Implemented (116 total)
		Annual Reports Prepared (3 total)
1996	$150,000	Otter Creek Watershed Project (continuation)
1995	$80,000	Otter Creek Watershed Project (continuation)
1994	$112,000	Otter Creek Watershed Project
1993	$98,500	Otter Creek
1993 - 2004	$338,004	DWQ Monitoring Activities
1992	$62,000	Otter Creek Watershed
1991	$30,000	Streambank stabilization (3,334 feet), brush management (380 acres), water troughs (3 total), pipeline (4,500 feet), pasture improvement (200 acres), fencing (27,350 feet), sprinkle irrigation (155 acres)
Total	$1,548,345	

[1] All projects 1991–2002 were associated with the USDA Otter Creek Hydrologic Unit Assessment project. Information is from the Utah Grants, Reporting and Tracking System (DWQ 2020) unless noted otherwise. [2] Does not include matching funds from land owners. [3] Utah Division of Water Quality. [4] Utah 2016 NPS Annual Report (cost not available). [5] Utah 2008 NPS Annual Report.

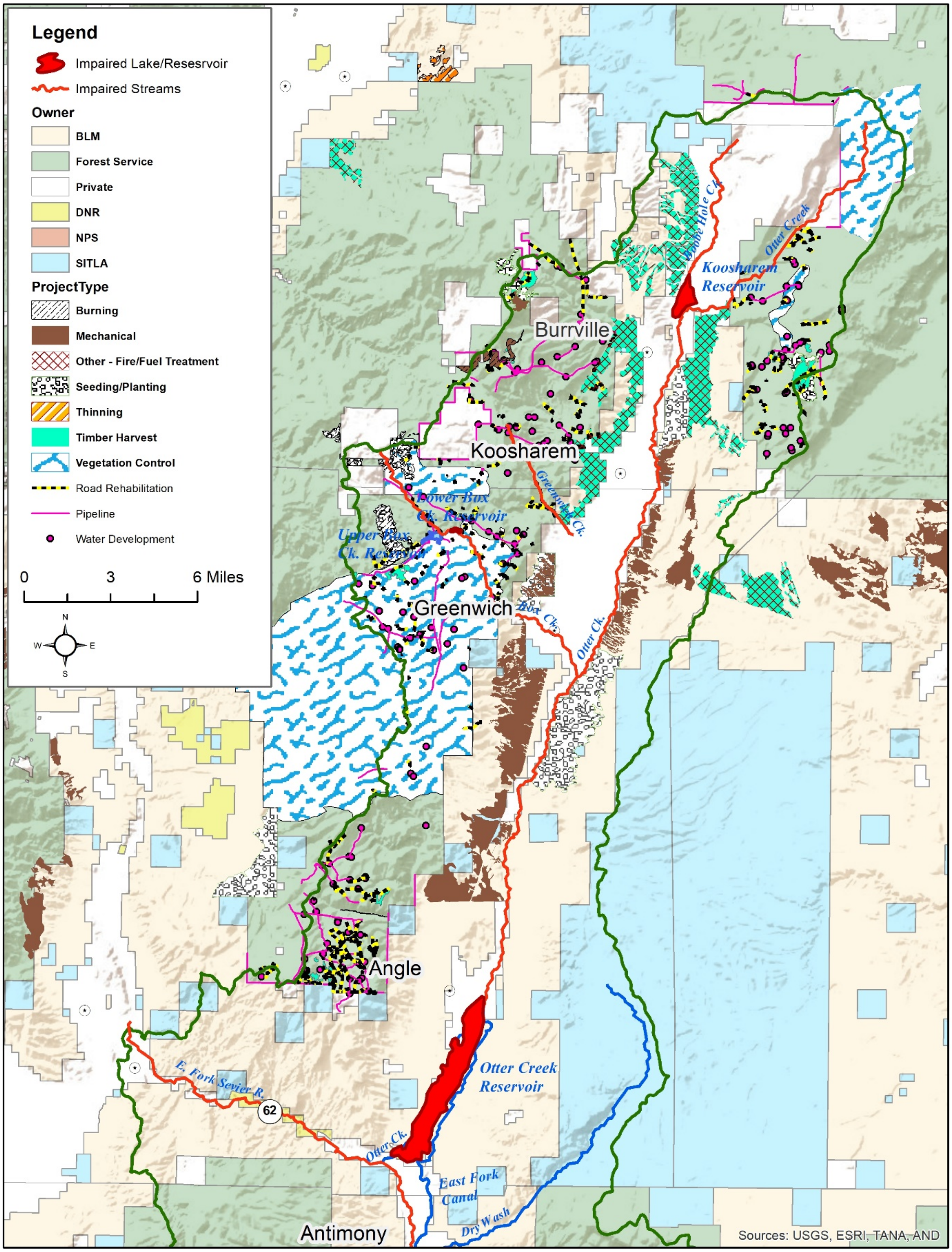

Figure 8.1. Past watershed projects implement in the north half of the Otter Creek/East Fork Sevier Watershed (BLM 2018, USFS 2018).

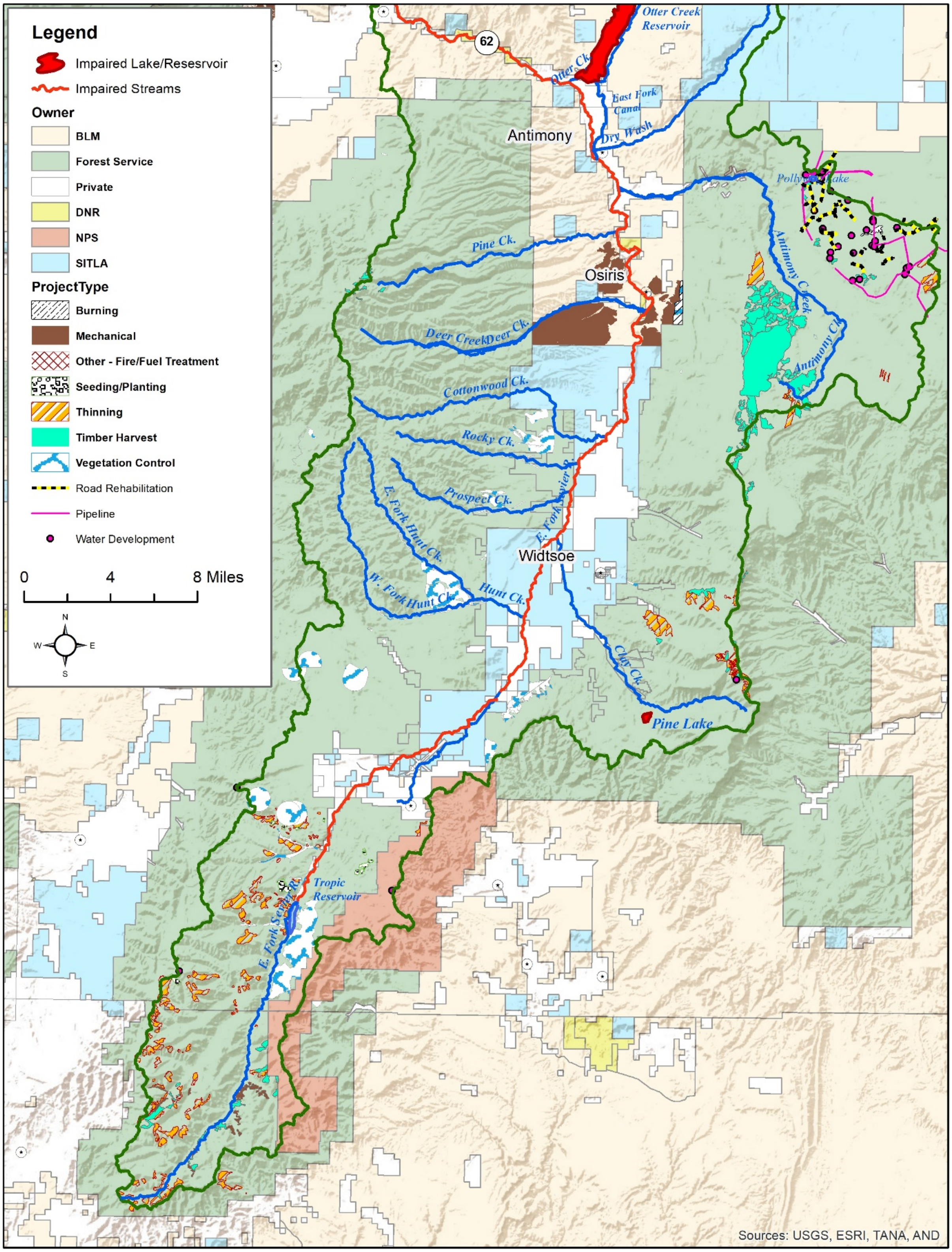

Figure 8.2. past watershed projects implement in the south half of the Otter Creek/East Fork Sevier Watershed (BLM 2018, USFS 2018).

Table 8.2. Number and type of treatment projects completed 2010-2018 on National Forest land in the Otter Creek/East Fork Sevier watershed.										
Practice	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Thinning		6	1	1	1	1				10
Burning			1	1			1	1	1	5
Seeding/Planting			1		1	4	3	1		10
Vegetation Control		1				3		3		7
Mechanical				1	3	23		14		41
Water Development						9[1]		22[1]		31
Road Rehabilitation										
Timber Harvest	3	67	16	39	1	2	8		18	154
TOTAL	3	74	19	42	6	42	12	41	19	258

[1] Estimated completion date based on review date provided in project documents.

Many of the projects implemented on public land address vegetation management in some way. These projects have direct and significant benefits to improving infiltration, reducing or eliminating erosion, and removing a variety of pollutants (e.g. phosphorus, sediment, E. coli, etc.). Similar water quality benefits occur on private land but have less of a direct financial benefit to a landowner compared to projects that provide a more rapid return on investment, such as improving irrigation efficiency, noxious weed control, or topsoil management. As a result, extra incentives may be needed on private land to implement projects that directly benefit water quality and have less benefit for landowners.

The projects included in Tables 8.1 and 8.2 and Figures 8.1 and 8.2 include work that was completed after the most recent TMDL assessment (DWQ 2006). The TMDL reviewed the most recent available data including results through the 2002 monitoring period. The results in Chapter 4 of this watershed plan include a review of the most recent water quality data currently available which included data in 2014 and 2016 for some parameters at some locations. No total phosphorus data was available after 2014 (Figure 4.5). The most extensive total phosphorus data record is from the East Fork Sevier near Kingston (Site 4949100). The range of concentrations shows an obvious drop between 2007 and 2013, indicating positive improvement in water quality at a watershed level.

The recommendations in section 8.3 of the watershed plan are based on the allocations and reductions from the TMDL (DWQ 2006). They do not account for the water quality benefits produced by some of the projects mentioned above. Therefore, it is likely the actual level of BMP implementation needed to meet TMDL reductions will be less than recommended levels in section 8.3.

8.1.2 Nonstructural Controls

Nonstructural controls are BMPs that do not involve a structured solution. They include practices such as information and education (I&E), record keeping, livestock management (e.g. timed grazing), etc.

The greater Sevier River Basin has a long history of outreach to stakeholders that include I&E activities. Some of these activities include:

- distributing water quality fact sheets at conferences, fairs, and other gatherings;
- staffing booths at conventions and seminars to provide updates on water quality projects;

- holding regular conservation district meetings to promote discussion on water quality issues;
- arranging for watershed tours of past water quality projects that include agencies and land owners; and
- arranging meetings for watershed groups.

Table 8.1 includes non-structural practices such as prescribed grazing (e.g. deferred grazing, timed grazing, etc.). These practices may require limited infrastructure in some situations (e.g. fencing) but primarily require planning and a change in existing behavior.

Implementing nonstructural controls are critical to achieving improved water quality. Aside from cost, one of the largest barriers to implementing projects can be perspectives about water quality and traditions that influence how land and water resources are managed. If stakeholders can see secondary benefits to improved water quality, they are more likely to change behaviors that influence nonpoint source pollution. Consistent opportunities to discuss or observe these projects with landowners whose land has experienced secondary benefits is an effective way to change perspectives and tradition.

8.2 CRITICAL SOURCE AREAS

Watershed plans should identify and focus on areas where implementing BMPs will be most effective in achieving watershed goals (EPA 2018). Critical source areas (CSAs) are watershed areas where disproportionate amounts of pollution are generated and delivered to impaired water bodies (Giri et al. 2016). Improvements in water quality are most likely to occur when practices are implemented in critical source areas. The process for defining CSAs and opportunities for implementing BMPs is the last step in a four-step process that includes (EPA 2018):

1. Establish priorities by defining goals, objectives, and necessary reductions in pollutant loading.
2. Describe connections between pollutant sources and monitoring data.
3. Estimate relative contributions from each pollutant source.
4. Define CSAs and options for implementing BMPs.

Previous chapters of this watershed plan have defined the necessary components to complete steps 1-3. This section of the plan will provide information for step 4 of the process and provide a basis for recommending BMPs for each pollutant source identified in Chapter 5.

Livestock grazing currently occurs below the ordinary high-water line of Koosharem Reservoir, Lower Box Creek Reservoir, and portions of Otter Creek Reservoir. Grazing livestock directly deposit manure in these areas and remove protective riparian vegetation from shorelines. Any land area near impaired water bodies with visual signs of heavy surface erosion, riparian degradation, and stream bank or shoreline instability is considered a critical source area for contributing pollutants of concern including phosphorus, sediment, and E. coli.

The monitoring and stream survey data in Chapter 4 and the pollutant loads in Chapter 6 can be also be used to identify critical source areas. Based on stream survey data and visual observations, the Otter Creek stream channel directly below Koosharem Reservoir is heavily damaged due to grazing. Other channels in poor condition include segments of the East Fork Sevier immediately below Otter Creek Reservoir and between Antimony Creek and the East Fork Canal diversion.

Figure 6.1 shows total phosphorus loading at monitoring sites in the watershed. Table 6.1 includes phosphorus loads to Otter Creek Reservoir from Otter Creek and the East Fork Sevier (via the East Fork Canal). Phosphorus loads to the Otter Creek Reservoir from the East Fork Sevier are much greater than loads from Otter Creek. Furthermore, Table 6.3 indicates the majority (56 percent) of annual phosphorus loads to the lower East Fork Sevier (below the East Fork Canal) are from Otter Creek Reservoir releases. These results indicate that sub watersheds draining to the East Fork Sevier above Otter Creek Reservoir are a critical source area for Otter Creek Reservoir and lower East Fork Sevier. Stream flow in these watersheds is seasonal and typically flows only during peak spring runoff or following intense storm events. Exposed soil surfaces are common on channel banks and in upslope areas. These conditions have a primary influence on the magnitude of erosion and loading to the East Fork Sevier.

This watershed plan will address pollutant sources that contribute to each impaired water body in the Otter Creek/East Fork Sevier watershed. In general, areas near to these water bodies should be considered first for project implementation. Impaired water bodies with few water quality violations should have a lower priority compared to those where violations consistently occur throughout the year. Figure 6.3 and Table 7.2 show substantial loading to the East Fork Sevier between Deer Creek and Tropic Reservoir. This large area will require careful review to determine how and where to implement BMPs.

8.3 OTHER STRATEGIES NEEDED TO ACHIEVE WATERSHED GOALS

The next step in the planning process is to quantify how much implementation would be required to achieve the load reductions defined in the TMDL. Tables 8.3-8.5 show how much of each management strategy would be recommended to reduce annual pollutant loads and meet allocations in the updated TMDL. These recommendations generally include the BMPs ranked highest in survey results collected from private landowners and agency representatives during meeting with stakeholders (Appendix A).

Several assumptions have been made to complete the necessary calculations to quantify load reductions resulting from BMP implementation. Key assumptions include the following:

1. Load allocations in the TMDL (DWQ 2006) were used to guide the amount of implementation, when available. They reflect the level of reasonable assurance outlined in the TMDL that recommended BMPs can be implemented and water quality standards will be met following implementation. Load allocations for impaired water bodies not in the TMDL used similar conservative assumptions,
2. The same BMP can be recommended for different pollutant sources and different pollutants of concern. Although reductions were not double counted, the same BMP could in fact, reduce pollutant loads from more than one source. For example, improving riparian buffers could reduce loads from livestock grazing as well as diffuse runoff. Pollutant loads of phosphorus, sediment, and E. coli can also be reduced by the same BMP.
3. Field level recommendations were not made for implementing BMPs. GIS data was used to calculate existing opportunities at a watershed level. Practices are already implemented in some areas but opportunities still exist at the levels needed to implement BMPs and meet the load allocations in Table 7.3.
4. Unit reductions (phosphorus removed for each treated acre or length of stream) assumed that pollution was distributed equally where sources exist (e.g. grazed pastures, cultivated fields, etc.). Reduction benefits can be greater where BMPs are implemented in highly degraded areas.
5. Differences exist in load reductions estimated by models, defined in literature, and based on best professional judgement. Adaptive management is a critical element to adjusting how, when, and where BMPs should be implemented to meet load allocations.
6. Reductions from implementing BMPs are based on published literature and information from other watershed plans in the Sevier River Basin. Some of the uncertainty in reduction calculations is addressed with conservative estimates of reduction efficiency and recommendations for focusing on critical areas where pollutant sources have more potential to impact water quality.

8.3.1 STRUCTURAL CONTROLS

Recommendations for reducing total phosphorus from each nonpoint source of pollution are included in Tables 8.3 – 8.5. Cost estimates for implementing the BMPs for livestock grazing, diffuse runoff, and septic tanks are included in Appendix B along with additional BMP information that could be used to select other practices in order to meet local needs and conditions.

This section will discuss BMPs for each pollutant source category along with suggestions for how and where practices should be implemented. The amount of BMPs recommended for each water body is based on load reductions in the TMDL (DWQ 2006). These reductions are shown as reduction targets in Table 7.2. As mentioned previously, a portion of these reductions may have already occurred based on water quality projects that have taken place since the TMDL was approved.

Reduction efficiencies and the primary assumptions they are based on include:

- Animal feedlot BMPs reduce existing total phosphorus loads by 90 percent. This reduction is considered achievable due to the small size and distance from receiving waters for most operations and livestock enclosures. BMPs occur primarily as part of CNMPs that address all potential loading from each operation including runoff from any enclosures and grazed pastures or cultivated fields where manure is present.
- Livestock grazing BMPs reduce total phosphorus loads by approximately 0.2 lbs/acre through a combination of brush management, range planting, heavy use area stabilization, off-stream watering facilities, and grazing management (e.g. herding and removal from riparian corridor, fencing, pasture management, etc.).
- Stream channel BMPs reduce total phosphorus loads by 132 lb/yr for every mile of implementation. These BMPs could generally include streambank and shoreline protection, channel bank vegetation, and riparian herbaceous cover. Livestock fencing could be used to protect sensitive areas.
- Diffuse runoff BMPs reduce total phosphorus by approximately 0.2 lbs/acre through a combination of practices focused on promoting infiltration and reducing surface erosion.

Table 8.3 includes recommendations for reducing loads from AFOs. These facilities are a source of nutrients that was considered in the TMDL (Utah DWQ 2006). The NRCS has worked with landowners to relocate AFOs outside of existing stream corridor and floodplains (Ingram 2018). Additional information was collected as part of this watershed plan that identified many feedlots in addition to the locations identified in the TMDL. The recommendations and reductions shown in Table 8.3 are based on working with landowners of each operation to implement Conservation Nutrient Management Plans (CNMPs). These plans address all sources of manure and recommend methods for managing nutrients in a way that eliminates potential loading to receiving water bodies. CNMPs may already be implemented for several operations in the watershed. Based on AFO locations and past successful efforts by the NRCS, a 90 percent reduction in existing loads is anticipated following CNMP implementation.

Table 8.4 includes recommendations for reducing loads from livestock grazing. Additional information supporting the recommendations in Table 8.4 is found in Appendix B. Reducing loads from livestock grazing should focus on enticing livestock away from streams and river channels or limiting opportunities to directly access waterbodies. This effort would lower the potential for manure deposition in streams and areas near streams where surface runoff is likely to reach the channel or reservoir. There are numerous water bodies in grazing allotments on private and public lands (Figures 5.3 and 5.4) and fencing is one method that can be used to reduce loads from these areas. Fences can also provide opportunities to implement grazing management. The amount of recommended fencing will cover approximately half of the impaired stream channels (both sides) in a moderate-severe erosion condition as well as the entire shoreline of Koosharem Reservoir, Upper and Lower Box Creek Reservoir, and roughly ten percent of Otter Creek Reservoir; and additional amounts that could be applied to degraded streams in critical source areas. The remainder of degraded channel banks and shorelines will be treated with riparian herbaceous cover and filter strips.

Table 8.3. Recommended BMPs for reducing total phosphorus loads from Animal Feeding Operations in the Otter Creek/East Fork Sevier watershed.

Impaired water body	Existing load (lb/yr)	Reduction Target (lb/yr)	Opportunities			BMP - CNMP[2]	Reduction (lb/yr)
			Feedlot Area[2] (ac)	Livestock Enclosures[2]	Known Feedlots[1]		
Otter Creek upstream and Koosharem Reservoir	0	0					
Greenwich Creek	987	888	7	7	1	1	888
Box Creek and Lower Box Creek Reservoir	784	706	8	11	1	1	706
Otter Creek and Otter Creek Reservoir	309	278	95	67	9	11	278
East Fork Sevier upstream to Antimony Creek	617	556	79	93	2	7	556
East Fork Sevier from Antimony Creek to Deer Creek.	958	862	7	8		1	862
East Fork Sevier from Deer Creek. to Tropic Reservoir	772	695	13	6		2	695
Total			209.1	192	13	23	

[1] From Table 7.3. [2] Based on recent satellite imagery. [3] Based on the 2006 TMDL (Utah DWQ 2006). [4] Conservation nutrient management plan.

Riparian herbaceous cover and filter strips are a highly effective method for removing total phosphorus from surface runoff. Vegetation in these buffers also provides bank stability and reduces potential loading from bank erosion. However, private landowners sometimes view filter strips negatively due to the loss of crop land or pasture.

Table 8.5 includes recommendations for reducing loads from diffuse runoff. Additional information supporting each recommendation in Table 8.5 is found in Appendix B. Phosphorus loading from diffuse runoff can occur at any location in the watershed. Some of the recommended BMPs for other sources will also reduce surface runoff and potential loading from diffuse runoff in critical areas near impaired waters. A method to reduce loads from diffuse runoff will include irrigation management to apply water efficiently and reduce return flows. This can be accomplished through land leveling or installing pressurized irrigation systems.

Table 8.4. Recommended BMPs for reducing total phosphorus loads from livestock grazing in the Otter Creek/East Fork Sevier watershed.[1]									
			BMP - Fencing		BMP-Riparian Herbaceous Cover		BMP- Filter Strip		
Impaired water body	**Existing load (lb/yr)**	**Target reduction (lb/yr)**	**Amount (mi.)**	**Reduction (lb/yr)**	**Amount (ac)**	**Reduction (lb/yr)**	**Amount (ac)**	**Reduction (lb/yr)**	**Total (lb/yr)**
Otter Creek watershed									
Koosharem Reservoir and Otter Creek upstream of Koosharem Reservoir	672	470	7	235	24	235			470
Greenwich Creek	104	73	2	37	5	18	19	18	73
Box Creek and Lower Box Creek Reservoir	216	319	7	160	13	80	52	80	319
Otter Creek[2]	1,005	855	6	214	17	107	67	107	428
Load to Otter Creek Reservoir from Otter Creek and East Fork Sevier[2]	15,307	14,541	24	795	75	590	138	205	1,589[3,4]
East Fork Sevier watershed									
East Fork Sevier from Deer Ck. to Tropic Reservoir	911	364	13	182	71	182			364
East Fork Sevier from Antimony Ck to Deer Ck.	597	299	3	150	16	150			299
East Fork Sevier upstream to Antimony Creek[2]	3,794	2,276	3	569	9	285	35	285	1,138[4]

[1] Water bodies are arranged in upstream to downstream order for Otter Creek and East Fork Sevier.
[2]Existing load and target reduction are combined with Diffuse Loads from Runoff as defined in the TMDL (DWQ 2006).
[3] Sum of load reductions from Otter Creek and upstream water bodies and East Fork Sevier from Antimony Creek to Deer Creek.
[4]Total reductions do not meet the target reduction. The remaining reduction is obtained from diffuse runoff BMPs.

Table 8.5. Recommended BMPs for reducing total phosphorus loads from Diffuse Runoff in the Otter Creek/East Fork Sevier watershed.[1]									
Impaired water body	Existing load (lb/yr)	Target reduction (lb/yr)	BMP – Irrigation management		BMP - Land erosion prevention		BMP - streambank and shoreline protection		Total Reduction (lbs)
			Amount (ac)	Reduction (lbs)	Amount (ac)	Reduction (lbs)	Amount (mi)	Reduction (lbs)	
Otter Creek watershed									
Koosharem Reservoir and Otter Creek upstream of Reservoir	1,129	903	800	25	2,691	593	3	350	968
Greenwich Creek	4,449	3,193	15	< 1	15,000	3,307	1	140	3,447
Box Creek and Lower Box Creek Reservoir	5,099	3,634	20	1	15,000	3,306	7	932	4,239
Otter Creek[2]	1,005	855	3320	103	1,000	220	8	1,056	1,379
Load to Otter Creek Reservoir from Otter Creek and East Fork Sevier[2]	15,307	14,541	4,160	129	54,691	12,055	26	3,439	14,777[3]
East Fork Sevier watershed									
East Fork Sevier from Deer Ck. to Tropic Reservoir	22,865	14,471	500	15	62,000	13,667	8	1,014	14,696
East Fork Sevier from Antimony Ck to Deer Ck.	6,456	4,560	5	< 1	18,000	3,968	6	776	4,745
East Fork Sevier upstream to Antimony Creek[2]	3,794	2,276	1,800	56	5,000	1,102	11	1,505	2,663[4]

[1] Water bodies are arranged in upstream to downstream order for Otter Creek and East Fork Sevier.

[2]Existing load and target reduction are combined with Livestock Grazing loads as defined in the TMDL (DWQ 2006).

[3] Sum of load reductions from Otter Creek and upstream water bodies and East Fork Sevier from Antimony Creek to Deer Creek

[4]Total reductions do not meet the target reduction. The remaining reduction is obtained from livestock grazing BMPs.

Land erosion can also be reduced through brush management, range planting, and other techniques that increase surface cover in ways that are compatible with existing land uses (e.g. grazing, wildlife habitat, timber management, wildfire suppression etc.). This practice can be enticing to grazing permittees or others that benefit from changes in forage cover. As a result, this practice could present opportunities for collaboration between private landowners and public land managers. Increased vegetation will also increase infiltration and decrease surface runoff and erosion.

Streambank and shoreline protection include protecting banks with wood, stone, and other materials to provide short-term stability to degraded areas. With assistance, banks and shorelines can achieve a balance in deposition and erosion processes that occur naturally in hydrologic systems. This change will also result in decreased erosion and phosphorus loading.

8.3.2 NONSTRUCTURAL CONTROLS

Some recommendations for nonstructural controls have already been identified, including those practices where a change in behavior is needed. These practices primarily include nutrient management and prescribed grazing. A critical part of implementing and maintaining these types of projects occurs when a landowner is able to experience secondary benefits (i.e. other than water quality). These benefits can occur as a cost-savings in regard to the amount of time or materials needed to support past practices. Sometimes benefits are hard to quantify and may not occur immediately. As they do, opinions and perspectives can change which in turn can change traditional behaviors that influence nonpoint source pollution.

Reductions in phosphorus loads from septic tanks will occur through implementing regular maintenance and cleaning on each structure. This will require some investment by the owner but the change in behavior can occur through an information and education program that identifies short term and long term benefits. One program should cover the small municipalities in the Otter Creek watershed. A second program would be designed to work with owners in the East Fork Sevier watershed. Target reductions in phosphorus loads from this source could be met by a change in behavior encouraged by implementing these two programs. Additional detail on nonstructural controls for septic tanks are included in Appendix B. Other nonstructural controls are described in section 9.6 Information and Education.

A significant contribution to the existing total phosphorus load is associated with diffuse runoff and livestock grazing. Prescribed grazing and other forms of grazing management should be considered in all areas as a low-cost alternative to structural controls to reduce loads from these two sources. It should be included as a fundamental component in future watershed planning efforts, particularly in the East Fork Sevier watershed.

8.4 SUMMARY AND CONCLUSIONS

Past management strategies that have been used to improve water quality are generally considered to be acceptable to private land owners. Some of the recommendations made here can be used to improve water quality by reducing loads from several pollutant sources. A review of recent management strategies implemented in the watershed includes riparian and stream channel restoration, range seeding, prescribed grazing, and vegetation management. Many of these practices have occurred since the TMDL was approved in 2006. The most recent monitoring data suggest some reduction in total phosphorus may have occurred in response to these efforts (see Figure 4.5 Site 4949100).

Critical source areas include land directly adjacent to impaired streams and reservoirs with a high potential to contribute surface runoff and loading. These areas are considered to generally extend one-quarter mile from the channel bank or shoreline. Land in the East Fork Sevier watershed above Antimony Creek is also considered a critical source area due to the large total phosphorus loads delivered to Otter Creek Reservoir.

Opportunities for implementing BMPs were based on field surveys and available mapping information. Selection of management strategies can now be made based on knowledge of where pollutant sources are located and where opportunities exist for implementation. Greatest opportunities seem to exist for improvements to livestock grazing and managing vegetation cover. Ultimately, any success achieved with regards to water quality improvement is dependent upon the willingness of landowners to implement and maintain management strategies.

Load reductions corresponding to implementation will take time to be reflected in water quality monitoring data. Measurable reductions in loading will be easier to detect when implementation occurs in critical source areas. The cost of implementation should be carefully considered prior to implementation in order to maximize reductions.

The estimated cost of implementing the recommended practices is included in Appendix B. The amount of recommended BMPs are determined conservatively. It is likely that the actual amount of BMP implementation needed to meet target loads is less than the recommendations presented in Chapter 8.

The total cost of implementing the watershed plan ranges from a minimum of about $1,300,000 to more than $20,000,000. Details supporting this cost estimate for each practice and impaired water body are found in Appendix B. The majority of the maximum cost estimate is associated with the two watersheds of the East Fork Sevier upstream of Antimony. The total cost for reducing diffuse runoff loads from these watersheds alone is approximately $13,000,000. Based on these cost projections a reasonable approach would be to move forward with work in other areas in the near future. Work should continue in the East Fork Sevier to carefully identify sources of erosion upstream of Antimony. If sufficient funds become available to support larger projects in this area, they can be applied in a cost-effective way.

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9.0 IMPLEMENTATION PROGRAM DESIGN

This section describes a proposed schedule to implement the BMPs and other measures to improve water quality in the Otter Creek/East Fork Sevier watershed. Defining specific tasks and the associated timeframes with their implementation is necessary to develop a focused and purposeful approach to implement the recommendations in this watershed plan. In addition, this section describes a monitoring approach to quantify the effectiveness of BMPs and other measures to achieve the needed water quality improvements.

9.1 IMPLEMENTATION APPROACH

The Otter Creek/East Fork Sevier River TMDL is a phased TMDL. Implementation of pollutant controls in the project area is most likely to be successful using an adaptive management strategy. This approach is a systematic process for improving resource management by learning from management outcomes and implementing that knowledge with flexible decision-making. There is an inherent amount of uncertainty involved in the TMDL process, including establishing water quality targets, calculating existing pollutant loads and necessary load allocations, and projecting the effectiveness of BMP implementation. This process is especially important when addressing nonpoint source pollution. Use of an adaptive management approach based on continued monitoring of project implementation will help manage resource commitments and achieve success in meeting water quality standards and supporting water quality beneficial uses. This approach allows for adjustments to restoration goals, TMDLs, and/or allocations, as necessary.

Adaptive management allows for changes in recommended BMPs as new information is acquired, but it still sets milestones for implementation to ensure progress toward water quality goals. Section 9.3 establishes milestones for implementing various strategies. Applying adaptive management to remedy nonpoint pollutant sources relies on incentive-based approaches, which require substantial outreach to encourage land owners to adopt best management practices. The information and education components used to encourage landowners are outlined in Section 9.6.

Finally, successful adaptive management relies on intensive monitoring of water quality indicators, pollutant loading, implementation success, and water body response, as well as how the public views success of the watershed plan itself. Section 9.7 addresses the monitoring needed to reduce uncertainty in the Otter Creek/East Fork Sevier River watershed so that adaptive management can be successful in achieving state water quality standards.

9.2 IMPLEMENTATION SCHEDULE (EPA ELEMENT F)

Remedying water quality impairments in the Otter Creek/East Fork Sevier River watershed will take several years. This section proposes an outline and timeline for implementing programs and strategies for the initial planning horizon of 10 years.

There are three components to implementing this watershed plan including (1) Information and Education (I&E) to promote adoption of BMPs to reduce NPS pollution, (2) implementing on-the-ground BMP projects to achieve NPS pollution reduction, and (3) monitoring effectiveness of these efforts to reduce NPS pollution. Table 9.1 provides a list and schedule for necessary actions to implement the watershed plan. Water quality monitoring is already on-going in some areas of the Otter Creek/East Fork Sevier River watershed, although additional monitoring sites are needed to improve spatial resolution of the data. Increasing the number of monitoring stations is an early task. Long-term studies of water quality, e.g., monitoring intermittent streams after storm events, need to begin as soon as possible. Defining connections between streams and contributing areas is a short-term activity, but necessary if a water quality model will be used to define this linkage.

Table 9.1. Best management practices implementation schedule in the Otter Creek/East Fork Sevier River watershed.										
Implementation Task	**Year**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Information and Education (I&E) (Section 9.6)										
a. Identify target audience and means of delivering I&E message.	X									
b. Develop I&E message.	X									
Tasks to Support Implementation of Best Management Practices (BMPs)										
a. Secure funding to support implementation of BMPs outlined in Section 8.	X									
b. Obtain commitments of land managers to implement BMPs outlined in Section 8.	X	X	X	X						
BMPs (Section 8.2)										
a. Prioritize implementation of BMPs based on participant interest, potential effectiveness, and funding.		X	X	X						
b. Develop participant commitments to participate in BMPs.		X	X	X	X					
c. Implement BMPs to reduce pollutant loading.			X	X	X	X	X	X	X	X
Monitoring (Section 9.7)										
a. Ongoing collection of water quality data at existing monitoring stations.	X	X	X	X	X	X	X	X	X	X
b. Establish additional monitoring stations.	X	X	X	X	X	X	X	X	X	X

Two activities in particular should be implemented in the first year. The first activity should update the datasets on AFO/CAFO operations and projects that have been implemented at these facilities since the previous TMDL was approved. Each AFO/CAFO should be evaluated to determine if the facility has an updated, functional nutrient management plan in place. A special focus should be made on operations within a quarter mile of any impaired water body in the project area. Information from this evaluation will add spatial detail to results of the updated TMDL and help focus actions recommended in this plan.

Most projects to reduce NPSs will require voluntary actions by individual landowners. This is a difficult task as water quality benefits resulting from NPS improvement projects accrue downstream and sometimes do not directly benefit landowners that implement projects. The second activity occurring in the first year of implementing the plan should include a concerted effort to promote the adoption of better management practices on livestock grazing that occurs within a quarter mile of any impaired stream or reservoir. This is a primary role of the local Conservation District. Table 9.2 outlines a number of actions and a schedule that should be undertaken by members of this group or by professional staff under their direction.

The first set of tasks focus on convincing private and public land managers of the importance of adopting better management practices for the entire watershed. This plan has discussed some of the benefits that are expected following implementation of listed BMPs, but support is needed to implement these practices, both on public and private land.

Table 9.2. Implementation Schedule - Watershed Stewardship Group or Conservation District.										
Implementation Task	**Year**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Promote better management on private ground.										
a. Review benefits of BMPs with landowners; Survey landowners to determine awareness.	X	X	X							
b. Define WQ and other benefits relevant for landowners whose lands have direct impacts on impaired segments.	X	X	X	X	X	X	X	X	X	X
c. Develop materials for stakeholder groups needing education regarding nonpoint pollution and sources.	X	X	X	X	X					
Promote BMP strategies in public sector management plans.										
a. Determine awareness and priorities of public agencies regarding sources of water quality problems.	X	X	X							
b. Participate in processes to incorporate water quality strategies in long term planning efforts in the Otter Creek/East Fork Sevier River watershed.		X	X	X	X	X	X	X	X	X
Develop and coordinate capabilities for technical assistance from federal, state, and local agencies.										
a. Program offerings and requirements.	X	X	X	X						
b. Nonpoint strategies.	X	X	X	X						
c. Secondary benefits.	X	X	X	X						
d. Using technical assistance.	X	X	X	X	X	X	X	X	X	X

Such long term and diffuse programs as those required to control NPSs are often complex and change over the years in terms of eligibility, application requirements, etc. A strong role exists for providing technical assistance to individual landowners. Past technical assistance has already made many projects possible throughout the watershed. It is important these technical assistance efforts continue and are coordinated to focus on critical areas that influence water quality and the objectives and watershed goals in this plan. Table 9.2 lists several categories of efforts, from providing information on program offerings to helping landowners obtain technical assistance.

9.3 INTERIM MILESTONES (EPA ELEMENT G)

This watershed plan builds on findings and recommendations developed in the updated TMDL. Table 9.3 proposes specific milestones for implementing BMPs to reduce total phosphorus loading. This table refers to projects triggered by new actions beginning in year 2, assuming it will take some time to develop the necessary programs and materials to promote those actions. It should be recognized that substantial efforts are already ongoing that will result in some projects being undertaken in year 1.

Table 9.3. Specific milestones for implementing BMPs to reduce total phosphorus loading.												
Implementation Task	**Year**										**Total**	**Target**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
BMPs to reduce loads from AFOs.												
a. Implement CNMPs	4	5	5	5	4						23	23
BMPs to reduce loads from livestock grazing.												
a. Fencing (mi)	5	8	10	10	5	2					40	39.8
b. Riparian Herbaceous Cover (ac)			10	10	25	50	20	20			175	154.4
c. Filter strip (ac)	25	25	25	50	25	25					175	172.3
BMPs to reduce loads from diffuse runoff.												
a. Irrigation management (ac)	500	500	500	1,000	1,000	1,000	500	500	500	500	6,500	6,460
b. Land erosion prevention (thousand acres)	10	10	10	10	20						60	121
c. Streambank and shoreline protection (mi)	2	4	4	10	6	4	2				32	32.1
BMPs to reduce loads from septic tanks.												
a. Implement information and education program				1				1				
Determine locations to collect monitoring data.	x	x										
Collect water quality and related data		x	x	x	x	x	x	x	x	x		

Note that only a portion of the total needed projects will be accomplished in this first 10-year planning horizon. This recognizes a realistic lag in increasing program participation, but also recognizes a need to learn more about the watershed so as to refine the recommendations on specific kinds and locations of needed projects. The next planning horizon for years 10-20 should build on the knowledge gained during the first 10 years and assumes this plan will be revisited toward the end of that first horizon. This action is critical in determining how much additional effort is needed to meet water quality goals.

Recent monitoring data is particularly needed to determine the current level of impairment for each waterbody listed in Table 4.2. The data reviewed in Chapter 4 indicated minimal impairment at some locations. A full year of data should be collected from each monitoring site that was reviewed in Chapter 4 sometime during the next five years. Monthly monitoring should begin immediately at the inlet and outlet points of Koosharem Reservoir, Otter Creek Reservoir, and at the site near Kingston on the East Fork Sevier (site 4949100). These sites would provide valuable information on water quality trends and guide BMP implementation.

9.4 INDICATORS TO MEASURE PROGRESS

Indicators listed in this section will facilitate the assessment of progress toward the watershed goals and objectives listed in Chapter 7. The BMPs recommended in this plan are designed to move indicators in the direction of accomplishing watershed goals and objectives regarding total phosphorus. Ultimately, the most important measurement of progress toward water quality goals are the actual water quality concentrations, measured at the right location, frequency, and time of year. These concentrations will also result in eliminating HABs. Careful attention to monitoring details is particularly important due to the dynamic processes that influence NPS pollution. A water quality monitoring strategy for evaluating progress in the Otter Creek/East Fork Sevier River watershed is included in Section 9.7.

Indicators other than water quality concentrations are also useful, such as assessments of macroinvertebrate populations, riparian habitat conditions, streambank height, vegetative cover in upland areas, and participation in conservation programs. Although the cause and effect relationships between these types of indicators and water quality concentrations may not be as direct, they are still considered to be important measures of water quality progress for impaired water bodies and their contributing watersheds.

The indicators suggested for monitoring progress in this watershed plan include the list of water quality indicators in section 7.1.2 as well as the following:

1. Percent of AFOs in the watershed with functioning nutrient management plans.
2. Linear feet of installed fence to restrict or eliminate livestock access to receiving water bodies.
3. Acres of riparian herbaceous cover planted adjacent to intermittent or perennial streams.
4. Linear feet of buffer filter strip planted next to intermittent or perennial streams.
5. Acres of land where irrigation management is applied.
6. Acres of land where range planting or brush management has occurred.
7. Miles of streambank (intermittent or perennial) or reservoir shoreline protection.

9.5 COSTS AND TECHNICAL ASSISTANCE NEEDED

Nonpoint source pollution control programs are usually incentive-based. Therefore, the total cost to design and implement conservation practices is typically shared between public sector agencies charged with improving water quality and stakeholders who must implement the practices. In recent years, the typical distribution of funding sources discussed in section 2.4 represents costs associated only with implementation of particular projects; it does not include the costs of technical assistance or program management.

Technical assistance is an important component; information and education programs recommended in this chapter suggest how resource managers can encourage participation. Once stakeholders agree to participate in conservation practices, agencies can help directly by providing assistance with application forms to qualify for federal and state funding sources, as well as design and construction consultation. Technical assistance in designing simple conservation projects (e.g. fencing, and livestock grazing management) can be provided at no cost by trained technicians and engineers. For more complex practices, applicants may also choose to hire independent technical service providers.

Ongoing operation and maintenance is also a consideration. Individuals who receive water quality program funding are required by contract to maintain projects for a minimum time period depending upon the type of project. In some cases, however, they may choose not to continue maintenance beyond the required period, which may reduce the effectiveness of the project. The watershed coordinator can play a vital role by maintaining communication over the long term with individuals who have implemented conservation practices to encourage them to continue to maintain these projects. In the process, the watershed coordinator should also take advantage of educational opportunities to demonstrate and reinforce the benefits of water quality.

Cost tables in Appendix B provide a range of cost estimates for implementing recommended BMPs and management strategies. Costs to implement various management strategies in the Otter Creek/East Fork Sevier River watersheds were estimated based on the NRCS cost list (NRCS 2016) a recent cost report that provided multiple scenarios with cost information for each NRCS practice code (NRCS 2015), and cost estimates included in the Middle Lower Sevier River Watershed Plan (Cirrus 2010). Public involvement efforts including I&E are a critical part of the success of this plan and should be funded along with structural controls.

The minimum cost for implementing the watershed plan is approximately $1.3 million dollars. The maximum cost would include treating watersheds in the East Fork Sevier to reduce erosion and runoff processes. It is uncertain at this time how much effort would be needed to restore beneficial use to impaired waters in these areas. As mentioned previously, a substantial number of water quality improvement projects have taken place in the past 10 – 15 years that are not accounted for due to a lack of monitoring data. The most recent monitoring data indicate some reduction in total phosphorus concentrations at a watershed level. If this trend of improving water quality continues, it is reasonable to assume the minimum cost of implementation could result in meaningful water quality improvements.

Documentation to date indicates the cost of past I&E activities are low and typically less than $5,000 per year of implementation. The cost of I&E could increase in the future as additional efforts are made to engage stakeholders which could require a larger portion of the total plan cost.

9.6 INFORMATION AND EDUCATION ACTIVITIES (EPA ELEMENT E)

The I&E component of the watershed plan fulfills EPA Element E of the nine minimum elements in a watershed plan. An I&E program is 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." Activities associated with an I&E program should be integrated directly into efforts to implement the watershed plan. Participation in water quality improvements is voluntary and depends on many factors that are not easily recognized and defined. The I&E program presented in this section should be periodically evaluated to determine which methods are effective and which are not.

9.6.1 GOALS AND OBJECTIVES

Goals and objectives of the I&E program should support and reinforce the goals and objectives defined in Chapter 7. The primary goal of this watershed plan is to restore beneficial uses impaired by total phosphorus. Impairment of water bodies has resulted in part from human activities that generate pollution. Therefore, I&E goals and objectives should work to change human behaviors and activities that contribute to pollution. Changes in human behavior require time and voluntary participation. In general, efforts to change human behaviors that contribute to NPS pollution should focus on creating awareness, providing information, and encouraging action. The initial goals and objectives of the I&E program for this watershed plan consider these areas. I&E considerations that support objectives listed in Chapter 7 are discussed in the following sections.

9.6.1.1 Target Audience

The target audience for the I&E program will be those individuals who have the greatest potential for improving water quality. These individuals primarily include land owners and managers of land areas that contribute to water quality impairment through their management actions. Efforts to inform and educate people living in the Otter Creek/East Fork Sevier watershed should initially focus on those individuals who have the greatest potential for improving water quality. This potential can be defined in terms of the following factors:

- Location: Where do people live with respect to critical areas and impaired water bodies?
- Livelihood: What do people do for a living or participate in that may directly or indirectly affect water quality? Do these daily actions contribute pollution to impaired water bodies?

- History: Have individuals participated in water quality improvement projects in the past? If so, are these projects being properly maintained?
- Visibility: Do people with potential to influence others have opportunities to implement conservation practices?

Individuals that live adjacent to impaired water bodies or manage property in river corridors have the greatest opportunities to reduce pollutant loading from processes that were identified in the TMDL. These individuals can be located geographically by examining property ownership adjacent to impaired water bodies. This information can be obtained by searching public records, including plat maps and tax records. Prior to contacting this group, the list of individuals should be cross referenced with NRCS records to identify which individuals have already participated in conservation programs. Land owners with no prior involvement in programs should be contacted first to discuss key principles of the I&E program, including funding opportunities to improve water quality, and the secondary benefits of doing so.

9.6.1.2 I&E Message

The core principles of the I&E message must be centered on the benefits of improving water quality in impaired segments. These principles tie directly back to the watershed goals outlined in Section 7.1.1. The watershed goal is focused on restoring beneficial uses impaired by total phosphorus. The path to achieving this goal includes implementing practices that restore watershed conditions. The basic task of the I&E program is to convince stakeholders that involvement in activities that achieve watershed goals is desirable.

Few people are opposed to enjoying the benefits of good water quality. Difficulties arise when it becomes necessary to take actions or make changes to stop pollution or improve degraded conditions. People can be opposed to participating in improvement efforts for a number of reasons including lack of conviction (e.g. disbelief that their actions are contributing pollution), cost of implementation, lack of information, and even apathy. It is likely that good water quality is important to most individuals, particularly those individuals (both public and private) involved with land and resource management. In regard to private landowners, good water quality may be a lower priority simply due to the cost or inconvenience of implementing conservation practices.

Voluntary participation in this watershed plan is a reality that must be addressed in the I&E program. Therefore, the focus of the I&E message should be directed towards helping stakeholders recognize the secondary benefits of implementing conservation practices to themselves as well as direct water quality benefits to downstream locations. These benefits should be clearly defined and incorporated in any messages delivered to the target audience.

9.6.1.3 Delivering the message

The I&E program can be implemented by delivering the message to stakeholders. Characteristics of the target audience should be considered when delivering the message such as age, background, experience and other factors that may influence how the message is received. For instance, older members of the target audience can be reached through radio, newspaper, or television while younger members are more likely to be reached through the internet, social media, public schools, and youth programs. Some methods that can be used to deliver the I&E message include:

- Conduct public awareness campaign through radio, newspaper, and printed media (flyers or brochures) in the local communities regarding the watershed plan and goals and objectives established by the plan.
- Provide information via radio stations that can be heard in Koosharem, Antimony, and the surrounding areas including KWUT 97.7 FM, KMXD 100.5 FM, and KSVC 980 AM.
- Distribute information regarding water quality concerns and secondary benefits of conservation practices at the Sevier County Fair.

- Contact members of the target audience through in-person interviews.
- Collaborate with individuals to implement conservation practices. Discuss secondary benefits of implementing conservation practices.
- Attend Sevier County and Piute County Conservation District meetings and present information regarding secondary benefits of conservation practices and funding opportunities.
- Submit monthly editorial column to *The Richfield Reaper* (Richfield), discussing a water quality topic, accomplishments of stewardship group, and meeting times and dates.
- Participate in education programs to be held at public schools including elementary, middle, and high schools located in Sevier, Piute, and Garfield counties. Create age-appropriate activities to involve students including hands-on demonstrations that will indicate influences of degraded water quality.
- With support of teachers and staff in middle and high school science programs, develop and implement an on-going water quality monitoring curriculum. Subjects could include collection and assessment of data, publication of results through internet-based media, and interaction with other schools in different geographic regions involved in similar programs.
- Develop and maintain website discussing watershed goals and objectives, recent water quality improvement activities, water quality data, and information describing secondary benefits of conservation practices. Provide links that contain data and helpful resources that characterize water quality concerns in the Otter Creek/East Fork Sevier watershed.
- Establish a Facebook page for watershed stakeholders to disseminate information and follow-up on programs identified above.

9.6.1.4 Evaluation

Progress towards achieving I&E goals and objectives should be evaluated and measured on a regular basis. It is recommended the I&E program be evaluated every year following approval of this watershed plan. The methods and approaches used to implement the I&E program will change over time. Evaluation of the I&E program is critical to ensure the best methods and approaches are being used to provide information to stakeholders and promote participation in conservation practices and programs.

Measurements of I&E success and progress towards goals and objectives can be defined by measuring indicators that reflect change in programmatic, social, and environmental categories. Some examples of each indicator include:

Programmatic	Social	Environmental
Newspaper articles printed.	People surveyed with increased knowledge of issues.	AFO/CAFOs with nutrient management plans.
People educated/trained.	People surveyed with changes in behavior.	Acres of range planting or brush management.
Public meetings held.	Participation at watershed events.	Miles of riparian herbaceous cover, filter strips or fencing near streams.
Volunteers attending.		

Progress towards goals and objectives may be difficult to directly measure, such as raising awareness of water quality or defining opinions regarding water quality issues. Opinion surveys are a valuable tool in quantifying perceptions and attitudes. Education of stakeholders can be evaluated based in part on opinion surveys as well as the number and type of activities where water quality information is distributed. Changes in human behavior are one of the most conclusive metrics for evaluating progress of the I&E program.

9.7 MONITORING APPROACH (EPA ELEMENTS H AND I)

One purpose of a watershed monitoring program is to determine if progress is being made toward the watershed goals and objectives specified in Section 7.1. Watershed goals are currently defined in terms of restoring beneficial uses impaired by total phosphorus. Watershed objectives include actions that reduce or eliminate pollutant loading. An additional purpose of a monitoring plan is to clearly define existing water quality conditions. The TMDL contained an initial review of existing water quality in impaired segments but also identified areas where data is limited. This watershed plan recommends collecting additional data to define existing water quality conditions and characterize the cause and effect relationship between water quality and pollutant sources.

The relationship between water quality and pollutant sources is difficult to define in nearly any situation. Two factors that complicate this relationship include total area of the watershed (approximately 1,240 square miles) and the distance between receiving water bodies and pollution sources. Both factors are prevalent in the Otter Creek/East Fork Sevier watershed. A simple question the monitoring program attempts to answer is "What will concentrations be after this practice is implemented?" A properly designed watershed monitoring program will determine if the recommended conservation practices are being effective in improving water quality and reducing pollutant loads. In order to accurately respond to this question, monitoring must take place before, during, and after conservation practices are implemented.

Monitoring efforts will measure indicators listed in Section 7.1.2 as well as the recommended practices and programs that are implemented. The design of the monitoring program will change over time as additional information is gathered that defines critical locations, events, and sources that contribute to water quality impairment.

The objectives for monitoring and assessment in the Otter Creek/East Fork Sevier watershed include:

1. Developing a better understanding of:
    a. watershed hydrology,
    b. nutrient source pathways, and
    c. the importance of individual pollutant source categories.
2. Tracking restoration projects as they are implemented to assess their effectiveness.
3. Monitoring trends over time to assess progress toward water quality targets in the TMDL.

9.8 CONCLUSION

Water quality in the Otter Creek/East Fork Sevier watershed is impaired. Remedying these impairments will require substantial short and long-term actions on the part of both private and public land managers. Many pollutant sources in the watershed are nonpoint in nature. This requires promoting benefits beyond water quality improvements, which accrue mainly downstream. It is possible to calculate an initial set of project requirements that could resolve all of the impairments due to NPS loading, but it will take many years to implement them and realize the benefit from the results. An adaptive management approach can help to ensure a focus on projects relevant to the impairments, and flexibility with respect to new understandings of the dynamics of the watershed. It is possible to provide appropriate direction even as the necessary implementation plans are refined over time. Significant improvements are possible even in the first 10-year planning horizon. Measuring and reporting improvements are critical for successfully implementing this plan. Stakeholders will be much more willing to engage in increased efforts during the continual planning process if they see positive results in response to implementing water quality improvement projects.

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10.0 WATERSHED PLAN IMPLEMENTATION UPDATES

This chapter reserved for future updates to the Otter Creek/East Fork Sevier River Watershed Plan.

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APPENDIX A:

STAKEHOLDER SURVEY RESULTS

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Fax (435) 787-1495

MEMO

DATE: April 30, 2018

TO: Tracey Balch

CC: Amy Dickey

FROM: Eric Duffin

RE: Results of BMP survey – Otter Creek Watershed Plan

A stakeholder meeting was held in the Koosharem Town Hall on February 7, 2018. Approximately 25 people were in attendance. The meeting included a discussion of the purpose, goals, and objectives of the Otter Creek watershed plan. A survey was provided to everyone at the meeting to evaluate past experience and level of interest that stakeholders have for implementing water quality improvement projects (i.e. best management practices or BMPs).

A critical piece of a successful watershed plan is to include BMPs that are economically feasible, supported by stakeholders, and produce measurable reductions in pollution loading to impaired water bodies. The survey results will be used to assist in identifying BMPs that meet these criteria. Results of the survey are detailed in Table 1 and Figure 1. A description of survey participants and useful conclusions from the survey are included in the bullet lists below.

A summary of participants in the survey includes:

- A total of 13 surveys were returned by stakeholders at the meeting including four individuals that identified as agencies, one from Trout Unlimited, one that identified as both a landowner and an agency representative, and seven as landowners only.
- Two of the seven landowner surveys answered the first four questions about program involvement but did not rank any BMPs in the remainder of the survey.
- Results in the Figure 1 are based on five agency (including Trout Unlimited) and six landowner surveys. The landowner identified as both a landowner and an agency representative was counted as a landowner in the summary of results.

Information from the survey that can be used in the watershed plan includes the following:

- In regard to the first four questions in the survey:

- Four landowners have participated in federal cost-share programs. If funds are available, two landowners want to participate in stream bank restoration and BMPs related to pasture management such as fencing, grazing rotation, and managing herd size. No landowners have a conservation plan in place. Reasons for not participating in cost-share programs include: expense, available projects are not applicable, lack of project information, concern about restrictions (i.e. lack of choice under cost-share programs), and lack of interest.
- All agencies have participated in cost-share programs and are looking for opportunities to continue. One person specifically identified weed control projects and another expressed concern about obtaining cost-share funds. Two agency representatives indicated they have updated some conservation plans in 2008 and 2016.

- Scores for livestock grazing and surface erosion BMPs generally scored higher than other BMP groups.
- Scores for BMPs used with AFOs primarily received the lowest overall scores from both landowners and agencies.
- Significant differences were observed in average BMP scores between agencies and landowners in the list of BMPs below. Agency support for each of the BMPs in this list was significantly higher than support indicated by landowners.
    - BMP 2: Channel bank vegetation
    - BMP 5: Riparian herbaceous cover
    - BMP 6: Use exclusion
    - BMP 16: Vegetation management
    - BMP 20: Waste Storage Facility
    - BMP 21: Short term animal waste
    - BMP 22: Waste treatment lagoon
    - BMP 26: Field border
    - BMP 27: Filter Strip
- The top agency BMP is channel bank vegetation. Landowners ranked this BMP as number six. The top landowner BMP is brush management. Agencies ranked this BMP as number six.
- The top three agency BMPs include channel bank vegetation, stream bank and shoreline protection, and riparian herbaceous cover.
- The top three landowner BMPs include brush management, range planting, and stream bank and shoreline protection.
- Both landowner groups ranked vegetation management as number four.
- The top five BMPs from each group contain three of the same practices including stream bank and shoreline protection, vegetation management, and prescribed grazing.
- The top ten BMPs from each group include nine of the same practices including stream bank and shoreline protection, channel bank vegetation, vegetation management, riparian herbaceous

cover, brush management, prescribed grazing, range planting, off steam watering, and conservation cover.

- BMP practices were ranked by numeric score for each group (agency and landowner) and include several BMPs that resulted in a tie (i.e. had the same numeric score). Therefore, the top ten BMP numeric scores for each group include more than 10 total BMPs.
- The mean overall BMP score from agencies (mean =3.54, standard error = +/- 0.11) was significantly higher than the mean overall BMP score from landowners (mean = 2.66, standard error = +/- 0.14) indicating a more overall favorable opinion of BMP effectiveness by agencies when compared to landowners.
- The sequence of the top 10 BMPs for either group is very similar (see red text in Table 1). Although preferences for individual BMPs varies between groups, the similar pattern of top 10 BMPs indicates good potential for partnerships and cooperation between agencies and landowners.
- It is noted the sample size of the survey is small. However, the sample population comprises a good mixture of landowners and agencies and is considered representative of stakeholders in general.

In general, water quality improvements installed on private land must have landowner support and as a part of that, provide some measure of economic benefit to the landowner. Projects on public land must support agency goals and objectives to sustain water quality and other resources such as riparian vegetation and habitat for aquatic and terrestrial wildlife.

Based on survey results and our understanding of pollutant sources in the watershed, a reasonable approach to managing pollutant loads would be to first recommend BMPs associated with livestock grazing and vegetation management. These BMPs are preferred by landowners and would address several significant nonpoint sources of pollution in the watershed. Many of these BMPs are also supported by agencies, based on survey results. Recommendations for BMPs that improve stream banks and riparian areas would be included in the plan to promote practices that are most preferred by agencies.

Table 1. Stakeholder survey (2/15/18) results - BMPs ranked by overall mean score. Values in red text indicate the top ten Best Management Practices (BMPs) identified by agencies and landowners. Note that some BMPs have identical scores and ranking.							
Overall Mean Score	**Agency Mean Score**	**Landowner Mean Score**	**Overall BMP Rank**	**BMP Rank - Agency**	**BMP Rank - Landowner**	**BMP**	**BMP Category**
4.22	4.60	3.75	1	2	3	Stream bank and shoreline protection	Livestock Grazing
4.20	4.80	3.60	2	1	6	Channel bank vegetation	Livestock Grazing
4.00	4.40	3.67	3	4	4	Vegetation Management	Surface Erosion
4.00	4.60	3.40	3	2	8	Riparian herbaceous cover	Livestock Grazing
3.91	4.00	3.83	5	6	1	Brush management	Livestock Grazing
3.91	4.20	3.67	5	5	4	Prescribed Grazing	Livestock Grazing
3.70	3.60	3.80	7	9	2	Range Planting	Surface Erosion
3.50	3.80	3.20	8	7	10	Off-stream watering facility	Livestock Grazing
3.40	3.40	3.40	9	15	8	Heavy use area stabilization	Surface Erosion
3.40	3.60	3.20	9	9	10	Conservation cover	Surface Erosion
3.36	3.20	3.50	11	21	7	Irrigation Water Management	Surface Erosion
3.30	3.50	3.17	12	13	12	Fence	Livestock Grazing
3.30	3.60	3.00	12	9	13	Land reclamation	Surface Erosion
3.22	3.50	3.00	14	13	13	Filter strip	Livestock Grazing
3.00	3.40	2.50	15	15	15	Grade stabilization	Surface Erosion
3.00	3.60	2.25	15	9	20	Use exclusion	Livestock Grazing
2.91	3.40	2.50	17	15	15	No-till or minimum tillage	Surface Erosion
2.71	3.33	2.25	18	18	20	Conservation cover	Land Applied Manure
2.71	3.33	2.25	18	18	20	Grassed Waterway	Land Applied Manure
2.70	3.00	2.40	20	22	19	Stormwater runoff control	Surface Erosion
2.57	2.67	2.50	21	24	15	Nutrient Management	Land Applied Manure
2.56	2.60	2.50	22	28	15	Diversion	Surface Erosion
2.43	3.67	1.50	23	8	23	Filter Strip	Land Applied Manure
2.00	3.33	1.00	24	18	25	Field Border	Land Applied Manure

Table 1 (cont'd). Stakeholder survey (2/15/18) results - BMPs ranked by overall mean score. Values in red text indicate the top ten Best Management Practices (BMPs) identified by agencies and landowners. Note that some BMPs have identical scores and ranking.							
Overall Mean Score	**Agency Mean Score**	**Landowner Mean Score**	**Overall BMP Rank**	**BMP Rank - Agency**	**BMP Rank - Landowner**	**BMP**	**BMP Category**
1.86	2.67	1.25	26	24	24	Nutrient Management	AFO
1.86	3.00	1.00	25	22	25	Waste Storage Facility	AFO
1.57	2.67	0.75	27	24	28	Short term animal waste storage	AFO
1.57	2.67	0.75	27	24	28	Waste Treatment Lagoon	AFO
1.44	2.33	1.00	29	29	25	Composting Facility	Land Applied Manure

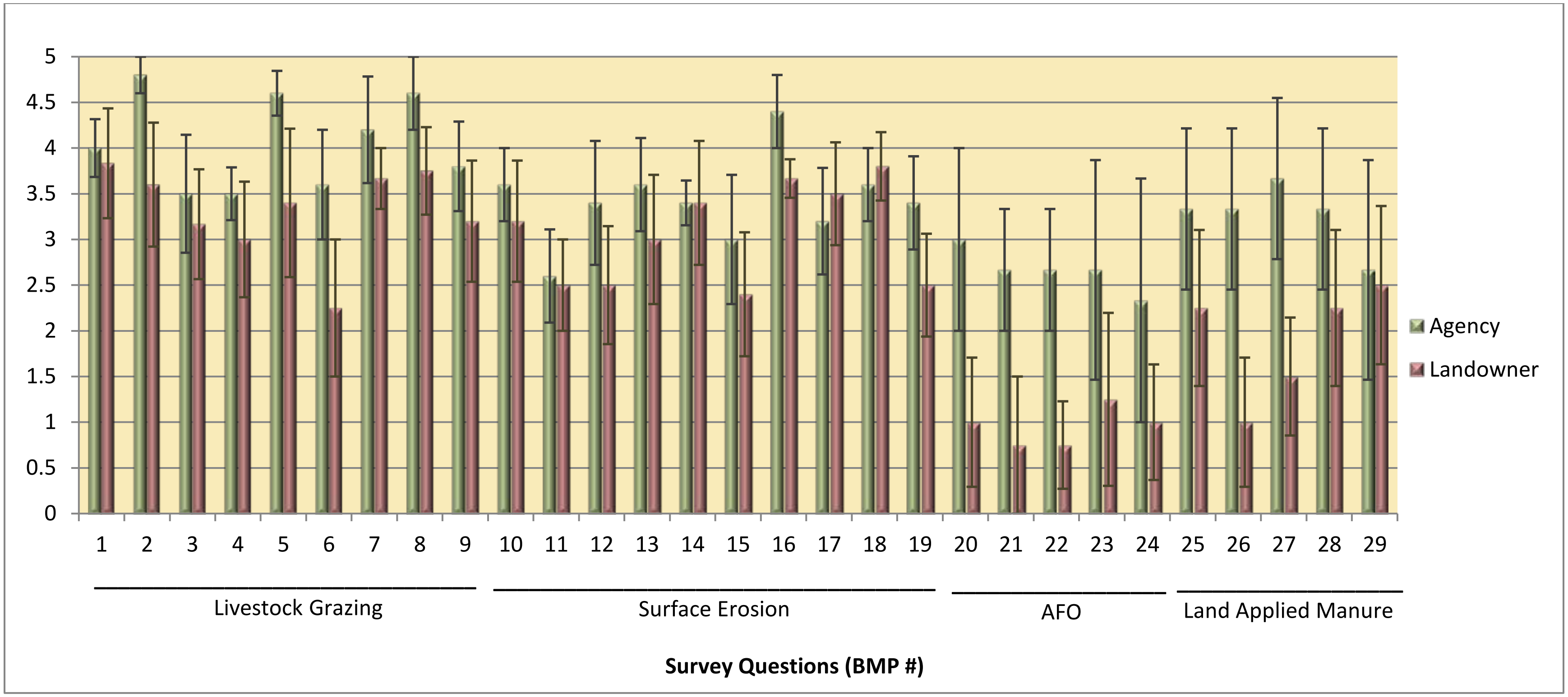

Figure 1 - Survey results collected during an Otter Creek Watershed stakeholder meeting held February 15, 2018 in Koosharem, Utah. Lines at the top of each vertical bar represent one standard error of the mean BMP score for agencies and landowners. Lines that do not overlap indicate a significant difference in mean BMP score between agencies and landowners.

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APPENDIX B:

BEST MANAGEMENT PRACTICES

- Animal Feeding Operations
- Livestock Grazing
- Diffuse Runoff
- Septic Tanks

Table B1. Cost estimate for implementing Conservation Nutrient Management Plans (CNMPs) at Animal Feeding Operations in the Otter Creek/East Fork Sevier watershed. Feedlot area and number of livestock enclosures is based on recent satellite imagery. These details were used to estimate number of CNMPs needed to meet load reduction target.

Impaired water body	CNMPs[2]	Feedlot Area (ac)	Livestock Enclosures	Known Feedlots[1]	Cost
Otter Creek upstream and Koosharem Reservoir					
Greenwich Creek	1	7.1	7	1	$ 35,000
Lower Box Creek Reservoir					
Box Creek	1	8.4	11	1	$ 35,000
Otter Creek and Otter Creek Reservoir	11	95.1	67	9	$ 385,000
East Fork Sevier from Deer Creek. to Tropic Reservoir	2	13.2	6		$ 70,000
East Fork Sevier from Antimony Creek to Deer Creek.	1	6.7	8		$ 35,000
East Fork Sevier upstream to Antimony Creek	7	78.5	93	2	$ 245,000
Total		209.1	192	13	$ 805,000

Table B.2. Cost estimates for implementing recommended BMPs to reduce loading from Livestock Grazing.									
	BMP - Fencing (mi.) Unit Cost ($/mi.) = # - #			**BMP - Riparian Herbaceous Cover (ac) Unit Cost ($/ac) = # - #**			**BMP- Filter Strip (ac) Unit Cost ($/ac) = # - #**		
Impaired water body	**Amount (mi.)**	**Min Cost ($)**	**Max Cost ($)**	**Amount (ac)**	**Min Cost ($)**	**Max Cost ($)**	**Amount (ac)**	**Min Cost ($)**	**Max Cost ($)**
Otter Creek upstream and Koosharem Reservoir	7.1	$22,608	$192,918	24.2	$22,294	$42,919			
Greenwich Creek	1.6	$5,052	$43,108	4.8	$4,455	$8,577	19.3	$1,218	$4,658
Lower Box Creek Reservoir									
Box Creek and Lower Box Creek Reservoir	7.2	$22,853	$195,016	12.9	$11,890	$22,889	51.6	$3,250	$12,431
Otter Creek upstream and Otter Creek Reservoir	5.5	$17,453	$148,936	16.7	$15,393	$29,633	66.8	$4,207	$16,094
East Fork Sevier upstream to Antimony Creek	2.9	$9,049	$77,220	8.7	$7,981	$15,364	34.6	$2,181	$8,344
East Fork Sevier from Antimony Ck to Deer Ck.	2.6	$8,380	$71,506	16.0	$14,780	$28,455			
East Fork Sevier from Deer Ck. to Tropic Reservoir	12.9	$40,742	$347,665	71.1	$65,517	$126,131			
Total	39.8	$126,137	$1,076,369	154.4	$142,309	$273,968	172.3	$10,856	$41,527
Grand Total Min. ($)	$279,302								
Grand Total Max. ($)	$1,391,865								

Table B.3. BMPs recommended for nonpoint source loading from livestock grazing.							
NRCS Code	**Name and Description**	**Effect[1]**	**Rationale**	**% reduction**	**Cost**	**Unit**	**Reference**
576	Livestock Shelter Structure	Moderate Improvement	Moving livestock away from streams and riparian areas will decrease the probability of excess manure nutrients in the water		$3.61-$5.93	ft²	
528	Prescribed Grazing	Slight Improvement	The action increases plant vigor and uptake of nutrients.	10	$3.44-$23.70	ac	
550	Range Planting	Slight Improvement	Improving vegetative cover will reduce runoff and erosion, and reduce the delivery of organics and nutrients to surface water.		$166-$246.87	ac	
580	Streambank and Shoreline Protection	Slight Improvement	Stabilizing eroding banks will reduce the delivery of nutrients and organic material in the soil profile to surface water.	10	$17.26-$126.15	ft	
614	Watering Facility	Moderate to Substantial Improvement	When used in place of an in-stream water source, this action decreases manure deposition in stream.	80 - 99	$0.89-$3.48	gal	Sheffield et al. 1997, Miner et al. 1992
472	Access Control	Slight Improvement	Excluding animals, people and vehicles influences vigor and health of vegetation and soil condition reducing runoff when applied with other management practices.		$26-$33	ac	
382	Fence	Slight to Substantial Improvement*	Fencing will prevent or restrict access to stream channels	40 - 79	$0.60-$5.12	ft	Meals, 2001, Line et al. 2000
561	Heavy Use Area Protection	Slight Improvement	HUAs will allow collection of manure that would otherwise runoff to contaminate surface water		$1.05-$3.69	ft²	
390	Riparian Herbaceous Cover	Substantial Improvement	Permanent vegetation will uptake excess nutrients.	50	$922-$1,775	ac	
393	Filter Strip	Substantial Improvement	Solid organics and sediment-attached nutrients are filtered out. Soluble nutrients infiltrate the soil and may be taken up by plants or utilized by soil organisms.	19 - 80	$63 - $241	ac	EPA 2002, Allaway 2003, Schmitt, T.J. et.al. 1999, USDA 1991, Dillaha et al. 1988, Daniels and Gillman 1996

1 Effect categories defined by the Conservation Practices Physical Effects (CPPE) – National Template. Indicates the magnitude of the practice's effect on the resource concern (i.e.total phosphorus) assuming the practice is fully functional. The term Slight generally signifies no more than a 10 percent change in measurable quantities achievable at the site level. The term Moderate generally indicates change between 10 – 50 percent at the site level. The term Substantial usually indicates more than a 50 percent change at the site level.
*Effect based on CPPE and additional literature reference material.

Table B.4. Cost estimates for implementing recommended BMPs to reduce loading from Diffuse Runoff.									
	BMP - Irrigation Management Unit Cost ($/ac) = # - #			**BMP - Range Planting Unit Cost ($/ac) = # - #**			**BMP - streambank and shoreline protection Unit Cost ($/mi.) = # - #**		
Impaired water body	**Amount (ac)**	**Min Cost ($)**	**Max Cost ($)**	**Amount (ac)**	**Min Cost ($)**	**Max Cost ($)**	**Amount (mi)**	**Min Cost ($)**	**Max Cost ($)**
Otter Creek upstream and Koosharem Reservoir	800	$5,760	$26,352	2,691	$0	$449,369	2.7	$10,070	$132,235
Greenwich Creek	15	$106	$483	15,000	$0	$2,505,000	1.1	$4,028	$52,894
Lower Box Creek Reservoir	0	$0	$0	3,000	$0	$501,000	1.4	$5,320	$69,860
Box Creek	20	$144	$659	12,000	$0	$2,004,000	2.8	$10,754	$141,217
Otter Creek upstream and Otter Creek Reservoir	3,320	$23,904	$109,361	1,817	$0	$403,558	3.0	$11,400	$149,700
East Fork Sevier upstream to Antimony Creek	1,800	$12,960	$59,292	4,000	$0	$668,000	11.4	$43,320	$568,860
East Fork Sevier from Antimony Ck to Deer Ck.	5	$36	$163	18,000	$0	$3,006,000	5.9	$22,344	$293,412
East Fork Sevier from Deer Ck. to Tropic Reservoir	500	$3,600	$16,470	65,000	$0	$10,855,000	3.8	$14,592	$191,616
Total	6,460	$46,509	$212,780	121,508	$0	$20,391,927	32.1	$121,828	$1,599,794
Grand Total Min. ($)	$168,337								
Grand Total Max. ($)	$22,204,501								

Table B.5. BMPs recommended for nonpoint source loading from diffuse runoff and overland flow. Shaded rows indicate practices that were recommended in the watershed plan.

NRCS Code	Name and Description	Effect[1]	Rationale	% reduction	Cost	Unit	Reference
327	Conservation Cover	Moderate to Substantial Improvement	Less erosion and runoff reduces transport of nutrients. Permanent cover can take up excess nutrients and convert them to stable organic forms.		$72 - $414	ac	
328	Conservation Crop Rotation	Slight to Moderate Improvement	Crops can remove excess phosphorus and nutrients in soil. Slow release nitrogen is provided by legumes and reduce need for additional nitrogen.	83	$2 - $356	ac	Smith et al. 2015
393	Filter Strip	Substantial Improvement	Solid organics and sediment-attached nutrients are filtered out. Soluble nutrients infiltrate the soil and may be taken up by plants or utilized by soil organisms.	19 - 80	$63 - $241	ac	EPA 2002, Allaway 2003, Schmitt, T.J. et.al. 1999, USDA 1991, Dillaha et al. 1988, Daniels and Gillman 1996
484	Mulching	Slight to Moderate Improvement	The action reduces erosion and runoff, reducing the loss of dissolved and sediment-bound nutrients from the site.		$299	ac	
464	Irrigation Land Leveling	Slight to Moderate Improvement	The uniform surface that results from this practice increases infiltration and reduces the potential for transport of nutrients to surface water.	10 - 50	$1,406 - $1,500	ac	
345	Residue and Tillage Management, Reduced Till	Slight to Moderate Improvement	Less erosion and runoff reduces transport of nutrients.		$39.41 - $171.93	ac	
390	Riparian Hebaceous Cover	Substantial Improvement	Permanent vegetation will uptake excess nutrients.	19 - 80	$922-$1775	ac	EPA 2002, Allaway 2003, Schmitt, T.J. et.al. 1999, USDA 1991, Dillaha et al. 1988, Daniels and Gillman 1996
359	Waste Treament Lagoon	Moderate to Substantial Improvement	Storage provides flexibility in rate, timing, and location of waste application, with the potential for reductions of contaminants available for transport.	60	$0.22	ft^3	EPA 2002
340	Cover Crop	Slight to Moderate Improvement	The action reduces erosion and runoff and transport of nutrients. Cover crops can uptake excess nutrients.	27-52	$59.14-$122.15	ac	Aronsson et al. 2011, Nelson, et al. 2015, Iowa Agriculture Water Alliance 2018
550	Range Planting	Slight Improvement	Improving vegetative cover will reduce runoff and erosion, and reduce the delivery of organics and nutrients to surface water.	10	$166-$246.87	ac	

1 Effect categories defined by the Conservation Practices Physical Effects (CPPE) – National Template. Indicates the magnitude of the practice's effect on the resource concern (i.e.total phosphorus) assuming the practice is fully functional. The term Slight generally signifies no more than a 10 percent change in measurable quantities achievable at the site level. The term Moderate generally indicates change between 10 – 50 percent at the site level. The term Substantial usually indicates more than a 50 percent change at the site level.
*Effect based on CPPE and additional literature reference material.

Table B.6. Cost estimates for implementing recommended BMPs to reduce loading from Septic Tanks.		
	BMP – homeowner outreach program	
Impaired water body	Amount (no. of programs)	Cost ($)
Otter Creek upstream of Koosharem Reservoir	1	$18,000
Koosharem Reservoir		
Greenwich Creek		
Lower Box Creek Reservoir		
Box Creek		
Otter Creek		
Otter Creek Reservoir		
East Fork Sevier upstream to Antimony Creek	1	$18,000
East Fork Sevier from Antimony Ck to Deer Ck.	1	$18,000
East Fork Sevier from Deer Ck. to Tropic Reservoir		
Total	3	$54,000

Table B.7. BMPs recommended for nonpoint source loading from septic tanks. Shaded rows indicate practices that were recommended in the watershed plan						
Name and Description	**Effect**	**Rationale**	**% Reduction**	**Cost**	**Unit**	**Reference**
Replace Failing Septic System	Substantial Improvement	Failing septic systems often discharge wastewater to the surface.	100	$2,000 - $10,000	Per unit	Illinois EPA 2008
Maintenance Septic Systems	Substantial Improvement	Regular pumping and inspection of septic tank will maintain optimal nutrient removal and prolong lifetime.	50 - 100	$168 - $459 per year	Per unit	Illinois EPA 2008
Septic Drain Field Design and Installation	Substantial	Proper design, siting, and installation of septic drain field and tank will prevent nutrient loading from occurring.	100	$3,200 - $6,300	Per unit	Owen and Rutledge undated
Information and education program	Moderate to Substantial Improvement	Education on proper maintenance of septic systems to encourage homeowners to adopt BMPs as a cost savings measure and reduce nutrient loading.	50 - 100	$18,000	Area program cost, 1 year	SMRC 2001a

APPENDIX C:

PREVIOUS WATER QUALITY STUDIES

This appendix to the watershed plan includes a summary of water quality studies that examined conditions in Otter Creek/East Fork Sevier watershed or a portion of the watershed. Some of the studies were identified in the 2006 TMDL and selected excerpts from that document are included here.

Many of the earlier water quality and flow studies incorporated the Otter Creek/East Fork Sevier watershed as part of a larger assessment of the Sevier River Basin (Table C.1). More recent studies have addressed current water quality concerns within the watershed as guided by state and federal legislation. A brief summary of each study that specifically addressed the project area is included below.

Table C.1. Selected water quality and flow investigations completed on the Otter Creek/East Fork Sevier Watershed.

Year	Description/Title	Author
1966	Ground-Water Resources of Selected Basins in Southwestern Utah	USGS
1974	Comprehensive Water Quality Management Plan, Sevier River	Utah Water Research Lab
1977	National Eutrophication Survey (Working Paper 850)	EPA
1982	State of Utah Clean Lakes Inventory and Classification	Utah Department of Health (DWQ)
1988	State of Utah Nonpoint Assessment Report	Utah Department of Health (DWQ)
1991	Hydrologic inventory of the Sevier River Basin	Utah DNR/DWR
1992	Otter Creek/Koosharem Watershed Hydrologic Unit Area Plan	USDA – Soil Conservation Service (NRCS)
1993	Ground-water hydrology of the upper Sevier River Basin, south-central Utah, and simulation of ground-water flow in the valley-fill aquifer in Panguitch Valley	USGS
1996	Otter Creek Reservoir – Phase I EPA Clean Lakes study Diagnostic and Feasibility Report	Merrit et al. (as directed by Utah DWQ)
1999	Field Evaluations and Progress Report (1993-1998) Otter Creek	State of Utah Nonpoint Source Interagency Monitoring Workgroup
2004	Upper Sevier Watershed Management Plan	Upper Sevier River Community Watershed Project (USRC)
2006	Otter Creek TMDL	Cirrus Ecological Solutions
2008 - 2016	Utah Nonpoint Source Pollution Program Report	Utah Division of Water Quality

OTTER CREEK/KOOSHAREM WATERSHED HYDROLOGIC UNIT AREA PLAN - 1992

In June 1990, the watershed area above Otter Creek Reservoir was submitted for approval to the USDA as a Hydrologic Unit Area (HUA). This submittal was accompanied by a request for funding to support nonpoint source water quality improvement projects in the area. Funding was subsequently approved for the HUA, officially described as the Otter Creek/Koosharem Watershed, and became the second HUA in Utah at that time.

Initial efforts to locate water quality pollutant sources identified several processes contributing to water quality degradation including sedimentation, nutrient and coliform loading from agricultural lands, streambank erosion, elevated in-stream temperatures and degraded riparian conditions. Increasing algae growth and decreasing oxygen levels were also noted in both Koosharem Reservoir and Otter Creek Reservoirs. An inventory of conditions near the stream channel indicated that approximately 50 percent (3,000 acres) of the subirrigated pastures, wet meadows, and riparian areas located adjacent to 30 miles of Otter Creek were in poor to fair condition.

A reconnaissance of sediment source areas in the Otter Creek/Koosharem watershed was also completed in the fall of 1990 to provide input data to a sediment yield model. The results from this effort were summarized in the HUA plan along with results from previous sediment yield studies completed on the East Fork Sevier/Otter Creek watershed (USDA-SCS 1992). The sediment analysis indicated that Otter Creek Reservoir received about 26 acre-feet/year of sediment from Otter Creek and about 32 acre-feet/year of sediment from the East Fork Sevier River by way of the East Fork Canal.

A Coordinated Resource Management Plan (CRMP) was completed for the HUA in 1991. The plan identified specific water quality goals and expected results of implementing water quality improvement projects including:

1) Full support of designated uses and compliance with Utah Water Quality Standards in Otter Creek, Otter Creek Reservoir, and Koosharem Reservoir.
2) Reduce rangeland sediments loads by 70 percent.
3) Reduce excessive runoff flows caused by irrigation and intense precipitation events (including heavy rainstorms and snowmelt) thus reducing nutrient and coliform loading to streams and reservoirs.
4) Reduce streambank erosion by 70 percent on 20 miles of designated segments of Otter Creek.
5) Increase recreational use of streams and reservoirs.
6) Restoration of aquatic wildlife populations in streams and reservoirs to natural levels.

During 1991 through 1998, the HUA has obtained approximately $1.9 million in funding from federal, state, and private entities. These funds have been used to complete a number of practices that support resource management systems on private and federal land. A summary of these practices is included in Table C.2.

Table C.2 Water quality improvement projects associated with the Otter Creek/ Koosharem HUA (1991 – 1998).

Practice	Completed	Practice	Completed
Brush management	13,359 acres	Water Catchments	2 locations
Range seeding	13,359 acres	Pasture Planting	1,500 acres
Fence	23 miles	Hayland Management	2,500 acres
Stock Water development	3 locations	Streambank Protection	3,800 feet.
Pipeline	32,200 feet.	Channel Vegetation	3,300 feet
Troughs	10 locations	Prescribed Grazing	96,944 acres

OTTER CREEK RESERVOIR – PHASE I EPA CLEAN LAKES STUDY - 1996

Water quality conditions in Otter Creek Reservoir were addressed in 1996 as part of an EPA Phase I Clean Lakes Study (Merrit et al. 1996). Results from the study were submitted as a TMDL for the reservoir by Utah DWQ. The study examined all watershed areas adjacent to the main tributaries of the reservoir, including Otter Creek and the East Fork Canal. Water samples were collected from the reservoir and contributing streams from May 1993 through June 1994. A review of TP concentrations indicated that although the Otter Creek watershed had experienced some nutrient reduction (compared to data collected in 1977), actual improvements in water quality were countered by increased loads of sediment and nutrients delivered to the reservoir from the East Fork through the East Fork Canal. Many of the samples collected during 1993-94 exceeded the numeric criteria recommended for streams and lakes in Utah. Water quality conditions in the reservoir were described as eutrophic or "over-productive" resulting from high nutrient loads. An average Carlson's Trophic State Index of 55 was calculated for Otter Creek Reservoir during the summer 1993 monitoring period.

The major sources of pollution in the Otter Creek watershed were identified as "farm/ranch/rangeland" operations and erosion from stream channel segments in the East Fork Sevier River. Pollutant loads from agriculture areas were determined to occur through four processes including 1) direct drainage and storm runoff from dairy/feedlot operations; 2) direct stream access from animals grazing in pastures; 3) return flows from irrigated fields and stock watering; 4) general storm runoff from upslope areas. Distance from the reservoir and flowing tributaries was noted to have a direct influence on the magnitude of pollutant impacts to the reservoir. Grazing on vegetation growing from the exposed reservoir bed and pastures adjacent to the reservoir were noted to be of particular concern. No information was provided indicating the number of operations where animals could be kept in a concentrated area such as a dairy or feedlot operation. However, few operations were noted in the East Fork Sevier watershed. A rough estimate of the number of animals located within one-half mile of streams identified 1,000 animals in this corridor during the summer season (June – September) and 2,000 animals during the winter season (October – May). No specific description of stream channel erosion was identified in the report. It was noted that years with high runoff rates (including 1993), increased the level of erosion and channel instability and subsequent sediment and nutrient loads to the reservoir.

The results of this study recommended that TP loads be reduced by 45 percent and Nitrogen loads reduced by 23 percent. The study also recommended that during years of high runoff, flow from the East Fork Canal be diverted around Otter Creek Reservoir until the latter part of the runoff season. As a result, a large portion of the sediment loads would not enter the reservoir. Removal of livestock grazing on the exposed reservoir bed was also recommended. Projected water quality improvements from these measures included a lower Trophic status (from eutrophic to slightly eutrophic), significant reduction in algae blooms, healthier fish habitat and increased water transparency.

OTTER CREEK FIELD EVALUATIONS AND PROGRESS REPORT TMDL - 1999

In August 1993, 1994, 1995 and 1998 the Otter Creek watershed was monitored by the Interagency Nonpoint Source (NPS) Monitoring Workgroup to evaluate the effectiveness of Best Management Practices (BMP) and Section 319 funded watershed restoration projects. The initial pilot study in 1993 took place prior to the implementation of restoration projects and served as baseline data for subsequent monitoring and trend analysis. The study reaches included three sites: Otter Creek at Angle, Otter Creek above Narrows-Treated, and Otter Creek above Narrows-Untreated.

Whirling disease was discovered in Otter Creek in 1991 and in an attempt to stop the spread of the pathogen, all trout were removed and/or chemically killed over the next two years and then later reintroduced. Additionally, the effects on macroinvertebrate populations were undetermined. The underlying habitat problems were not addressed and could lead to the disease returning.

To effectively evaluate the fish habitat conditions, field studies were performed using Binns's Habitat Quality Index (HQI), which indicated extremely stressed benthic communities at each site. At the three studied reaches the results show a positive upward trend in channel geomorphology and fish habitat.

UPPER SEVIER WATERSHED MANAGEMENT PLAN - 2004

The Upper Sevier Watershed Management Plan is the result of a collaborative effort between federal, state, and local entities to identify resource issues and concerns within the Upper Sevier Watershed. As defined in the plan, this watershed encompasses the Upper Sevier River and tributaries from the headwaters down to Panguitch Reservoir. Although water quality and meeting water quality standards was noted to be a major focus of the report, a variety of resource disciplines were utilized. Ensuring water quality and quantity for ranchers and farmers while providing for the needs of fish and wildlife was identified as a primary concern in the plan. The need to maintain and restore riparian and upland vegetation communities to a resilient and viable condition was also noted.

Pollutant sources and processes contributing to water quality impairment were identified within the Upper, Middle, and Lower segments of the East Fork Sevier. Some of the more significant concerns included the following:

- Accelerated erosion from unstable stream channels.
- Increased sediment transport from areas associated with dispersed camping and illegal ATV use.
- Poor road design and placement within stream corridors.
- Lack of vegetative diversity in riparian corridors. Many riparian areas are devoid of sedges, woody forbs and trees.
- Wildfire and livestock impacts to riparian areas.
- Pasture management in the Lower East Fork Sevier (below Otter Creek Reservoir).

No schedule of water quality improvement projects was provided in the plan. Information in the plan is intended to prioritize and rank watershed issues in an effort to guide future management decisions. The Upper East Fork Sevier River (above Johns Valley) and the Antimony Creek watershed were described as two priority treatment areas where restoration efforts should be focused.

OTTER CREEK TMDL - 2006

A TMDL study addressing impairment to Otter Creek Reservoir, Koosharem Reservoir, Lower Box Creek Reservoir and the East Fork Sevier River from the Sevier River confluence upstream to Antimony Creek was completed during 2002 - 2006. Total phosphorus was the pollutant of concern in each water body. Low levels of dissolved oxygen were also a concern in Lower Box Creek Reservoir. As part of completing the TMDL, more than 70 miles of stream corridors were surveyed in the project area. The survey provided detailed information on the magnitude and extent of pollutant sources, riparian health, and bank erosion and valuable input to a Project Implementation Plan completed in support of the TMDL.

Available data to characterize existing loads to Lower Box Creek Reservoir were very limited. Daily time series of inflow, outflow, precipitation, and evaporation were modeled using available data as calibration points. A reservoir water budget model was run on a daily time step to produce estimates of reservoir volume, surface area and outflow and then used to calculate permissible loadings to Lower Box Creek Reservoir.

Livestock grazing information was provided for all grazing allotments in the watershed. This data was utilized with GIS modeling to develop pollutant loading from animal manures. Field surveys identified and characterized all animal feeding operations. Pollutant loads for feedlots were determined using the Utah Animal Feedlot Runoff Risk Index (UAFFRI) model developed by the Utah NRCS.

In addition to the TMDL report, useful information is found in four 4 appendices including:

- Appendix A: Modeling methods and results used to determine hydrology for Koosharem Reservoir and Lower Box Creek Reservoir.
- Appendix B: Statistical assessment of all available water quality and flow data collected in the watershed.
- Appendix C: Summary of all stream survey results from Otter Creek, Boobe Hole Creek, Antimony Creek, Box Creek, and East Fork Sevier. Results indicate stream health per the Stream Visual Assessment Protocol (SVAP) and estimates of bank erosion per the Stream Erosion Condition Index (SECI) method.
- Appendix D: A Project Implementation Plan for all impaired water bodies. The Plan included BMP recommendations and cost estimates for implementation that would meet the TMDL load reductions.

Load allocations to meet the TMDL were distributed between septic tanks, fish hatcheries, feedlots, livestock grazing, and diffuse runoff from a variety of land cover types. The recommended load reductions to meet the Utah 0.05 mg/l pollution indicator level ranged from 45 percent for the East Fork Sevier, 48 percent for Koosharem Reservoir, 77 percent for Otter Creek Reservoir, and 80 percent for Lower Box Creek Reservoir. The Otter Creek TMDL was approved by the EPA in August 2006.

UTAH NONPOINT SOURCE POLLUTION PROGRAM REPORT 2008 – 2016

The mission of the Utah Nonpoint Source Pollution Management Program (Utah NPS Program) is to support the environmental protection goals of the state as described in the Utah Administrative Code R317-2 in part to: 1) to conserve the waters of the state; 2) to protect, maintain, and improve the quality of the waters of the state for public water supplies, species protection and propagation and for other designated uses; and 3) to provide for the prevention, abatement and control of new or existing sources of polluted runoff. The Utah NPS Management Program works to achieve these goals by working in concert with numerous local, state and federal agencies and private parties pursuant to the Utah NPS Pollution Management Plan.

The Utah NPS program submits an annual report documenting program achievements each fiscal year. Among other information, the reports document past water quality improvement projects throughout the state, including the Otter Creek/East Fork Sevier watershed (as they occur). Useful information includes project descriptions, cost, and projected future schedule for implementing projects.

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