East Walker River Watershed Assessment

March 2012

Contributors and Acknowledgements

Assessment and plan written by Rick Kattelmann Ph.D., retired hydrologist who specialized in watershed management and snow hydrology. He worked and contracted for a variety of agencies, public utilities, and conservation groups. Rick was the principal hydrologist for the Sierra Nevada Ecosystem Project in the mid-1990s and authored more than 150 scientific and technical papers. He served two terms on the Mono County Planning Commission and wrote watershed assessments for the other principal watersheds of Mono County. Rick holds B.S. and M.S. degrees in forestry and watershed hydrology at U.C. Berkeley and a Ph.D. in snow hydrology from U.C. Santa Barbara.

Assessment and plan production managed by Eastern Sierra Land Trust: Aaron Johnson, Lands Director, Heather Freeman, Office Coordinator, Karen Ferrell-Ingram, Executive Director

Assistance with cartographic design and spatial analysis: Kimberly Forkner

Funders/Support:

Funding for this project has been provided by the Sierra Nevada Conservancy, an agency of the State of California.

The maps and cartographic products included in this report were made possible through a generous grant of the ArcGIS software by Environmental Systems Research Institute (ESRI) through the ESRI Conservation Program.

Disclaimer

Watershed Assessments are a snapshot in time of a location, synthesizing all the known information concerning that area. Omissions, errors, and misunderstandings can occur. The authors request that corrections, additions, and suggestions be sent to the address below.

Eastern Sierra Land Trust
P.O. Box 755
Bishop, CA 93515

East Walker River Watershed Assessment

Table of Contents

Boxes

Maps

Tables

Figures

1. Introduction

The watershed of the East Walker River in northern Mono County is described and evaluated in this report funded by the Sierra Nevada Conservancy.

Watershed Approach

The natural unit for considering most water-related issues and problems is the watershed.

A watershed can be defined simply as the land contributing water to a stream or river above some particular point. Natural processes and human activities in a watershed influence the quantity and quality of water that flows to the point of interest. Despite the obvious connections between watersheds and the streams that flow from them, many water problems have been looked at and dealt with in an isolated manner. Many water problems have been treated within the narrow confines of political jurisdictions, property boundaries, technical specialties, or small geographic areas. Many water pollution problems, flood hazards, or water supply issues have been examined only within a short portion of the stream or within the stream channel itself. What happens upstream or upslope has been commonly ignored. The so-called watershed approach attempts to look at the broad picture of an entire watershed and how processes and activities within that watershed affect the water that arrives at the defining point. The watershed approach is a convenient means of considering water problems (as well as the absence of problems) in a comprehensive manner.

This report describes how the 401-square-mile watershed of the East Walker River above the California/Nevada border influences the quantity and quality of water that eventually flows into the East Walker River. The East Walker River watershed is designated #630 in the Calwater system of watershed delineation (http://www.ca.nrcs.usda.gov/features/calwater/ and http://cwp.resources.ca.gov).

California Watershed Programs and Mono County's Watersheds

Within California, the U.S. Environmental Protection Agency and the state Regional Water Quality Control Boards are the principal agencies charged with minimizing water pollution and maintaining or improving water quality. These entities have been largely successful at reducing water pollution that starts at a known point, such as a sewer outfall from a city or a waste pipe from a factory. As these so-called point sources have been brought under control, the agencies found that pollution from broader areas of land was still degrading water quality. Sediment from dirt roads and bare construction sites, pesticide runoff from farms, nutrients and bacteria from livestock operations, chemicals and oil residues from urban streets are all examples of so-called non-point-source water pollution. The agencies concerned with limiting water pollution have adopted the watershed approach to studying and controlling non-point-source pollution.

In 1997, the Governor's office directed state agencies that deal with natural resources (e.g., State Water Resources Control Board and Regional Water Quality Control Boards, Department of Fish and Game, Department of Conservation, and Department of Forestry and Fire Protection) to coordinate activities on a watershed basis. In March 2000, California voters passed Proposition 13, the Costa-Machado Water Act, which included substantial grant funding for local watershed management activities. In early 2001, Mono County in cooperation with the Mono County Collaborative Planning Team responded to a request for proposals from the State Water Resources Control Board (SWRCB) by submitting two proposals to develop watershed assessments and plans for the West Walker River, Mono Basin, and Upper Owens River watersheds. Both proposals were successful, and scopes of work were developed and eventually approved in 2004. Work was completed on these projects in 2008.

In response to the same SWRCB solicitation, a proposal to develop a watershed assessment and plan for the East Walker River watershed was prepared by the Mono Resource Conservation District (2000) in cooperation with the Desert Research Institute and U.C. Berkeley College of Engineering. Unfortunately, this project was not funded, presumably because the costs of the water-chemistry analyses necessary to adequately describe a nutrient budget exceeded the ceiling on funds available for these grants.

In 2006, another State of California funding opportunity for watershed projects became available, and Mono County submitted a proposal for watershed assessment and planning similar to the projects in the other major watersheds of Mono County. This proposal was not funded.

Yet another attempt was made to create a watershed plan for the East Walker River in 2008. The Eastern Sierra Land Trust submitted a proposal to the Sierra Nevada Conservancy to develop this assessment and plan and was successful. Work began in autumn of 2008, but the state freeze on funding of projects supported by bonds put the project in limbo for several months. Work resumed in September 2009. Because the project was supported by State of California funds, the geographical scope is limited to lands upstream of the California/Nevada border.

At least one other watershed assessment of the Walker River basin may be in progress by the U.S. Fish and Wildlife Service, focused on the Lahontan cutthroat trout (Walker River Basin Recovery Implementation Team, 2003).

What is a Watershed Assessment?

The California Watershed Assessment Manual (Shilling, et al., 2004) defines a watershed assessment as "a process for analyzing a watershed's current conditions and the likely causes of these conditions." The fundamental concept is to describe any known problems concerning water quantity and quality and attempt to connect those problems with conditions, processes, and activities within the watershed. Such linkages between problems and potential causes can provide the basis for subsequent planning and management that attempt to address the identified problems. Despite the focus on problems (because the underlying philosophy is to improve conditions), watershed assessments should not be regarded as having a fundamentally negative tone.

General Problems and Issues in the East Walker River Basin

The East Walker River contributes about one-third of the streamflow in the entire Walker River system that drains to Walker Lake in Nevada (Lopes and Allander, 2009). Water management in the basin has been controversial because of water rights conflicts between parties in the two states and the declining level of Walker Lake (e.g., Behney and Noblick, 1993). Throughout the Walker River basin, efforts are under way to restore viable populations of Lahontan cutthroat trout, which the U.S. Fish and Wildlife Service lists as threatened. The Lahontan RWQCB water body fact sheet for the East Walker River lists sedimentation, agricultural drainage, and water diversions as the primary water-quality problems in the East Walker River. Bridgeport Reservoir is eutrophic with high nutrient levels and consequent algal blooms in summer. The State of Nevada considers the water crossing the state line to be impaired because of ammonia and pH and recognizes excessive phosphorus and sediment as problems. Toxic metals suspected to be leaching from old mine tailings have been found in tributaries to the East Walker River. Releases of water loaded with sediment but minimal dissolved oxygen from Bridgeport Reservoir in 1988 severely impacted the downstream reach of the East Walker River that was once considered one of the premier trout fisheries in California. An oil spill from a tanker truck in 2000 has also caused long-term damage.

Although this assessment and other summaries of water conditions in the East Walker River (e.g., Timmer, et al., 2006: 155-158) emphasize identification of problems, so that they may be addressed, the river and its watershed can be judged to be in much better condition than the great majority of rivers throughout the western United States, simply because the watershed is relatively undeveloped. Refer to **Map 1**: Overview Map of East Walker Watershed (California Drainages).

Water Quantity

The fundamental problem regarding water quantity in the entire Walker River basin is the dramatic decline in the level and volume of Walker Lake and the consequent increase in salinity and changes in the lake's fishery. Between 1882 and 1994, as irrigation consumed water from the Walker River, the surface elevation of Walker Lake fell by about 140 feet and the volume decreased by about 75 percent (e.g., http://nevada.usgs.gov/walker/). By 2007, the elevation of Walker Lake had declined by another 9 feet to a surface elevation of 3,934 feet above sea level (Sharpe, 2010). Concentration of salts has increased five-fold in the past century (Thomas, 1995), with the concentration of total dissolved solids estimated to be about 2,500 mg/l in the mid-1800s before diversions, and measured as 10,300 mg/l in 1977 (Cooper and Koch, 1984), about 12,500 mg/l in 1994 (Horne, et al., 1994), and about 16,000 mg/l in 2007 (Sharpe, 2010). The native Lahontan cutthroat trout and other species in the lake barely survived this increase in salinity into the first decade of the 21st century. Anecdotal accounts suggest that Lahontan cutthroat trout ceased to exist within Walker Lake during 2009 or 2010 (e.g., Gregory, 2011). The volume of water subject to appropriation through existing water rights is 40 percent greater than the average annual inflow to the lake. Most of the water that actually reaches the lake enters during major floods that exceed the upstream capacity of storage reservoirs. Consumptive use of the East Walker River's water contributes to these basic problems.

Fisheries biologists with the Nevada Division of Wildlife have estimated that inflows to Walker Lake of at least 135,000 acre-feet per year, on the average, would be needed to reduce the concentration of dissolved salts to levels at which the cutthroat trout and other lake species would be healthy (http://nevada.sierraclub.org/conservation/walkerlake/WLbriefing.html). This estimated volume is similar to an estimated 137,000 acre-feet as the average annual evaporation from the surface of the lake under current conditions(Acton, et al., 1998). Although there is potential to improve water supplies by conjunctive use of groundwater and surface water and greater water conservation through ditch lining, upgrading distribution systems, and irrigation scheduling, the political will to acquire or alter water rights has been lacking until recent years. The National Fish and Wildlife Foundation's Walker Basin Restoration Program was appropriated about $200 million by Congress and has acquired water rights to about 6,500 acre-feet as of mid-2011 (Gregory, 2011). Purchases of water rights that would yield 60,000 to 85,000 acre-feet of water per year at Walker Lake would be necessary to stabilize Walker Lake's surface elevation near the 1990 level (California Department of Water Resources, 1992). Prospects for and consequences of water banking in the entire Walker River basin have been explored by Acton and others (1998). The rural character of the watershed and low population may contribute to the absence of an interstate allocation of water in the Walker River basin as has occurred in the Truckee and Carson basins to the north (California Department of Water Resources, 1992).

National interest in Walker Lake continues to grow. For example, Nevada's congressional delegation secured $95 million in the 2002 Farm Bill for Walker Lake related programs. Subsequent federal legislation has refined and continued to fund the Desert Terminal Lakes Program that includes Walker Lake. Portions of the 2010 Energy and Water Development Appropriations Act established the Walker River Restoration Program, to be administered by the National Fish and Wildlife Foundation (USDI-Bureau of Reclamation, 2011).

There are not any significant water supply problems within the California portion of the East Walker River watershed. Flooding within the East Walker River basin is much less of a hazard than along the West Walker River.

Water Quality

The water body fact sheet for the East Walker River issued by the Lahontan Water Quality Control Board in the mid-1990s listed sedimentation, ammonia, fecal coliform, and metals as the primary water-quality problems in the watershed. The State of Nevada has considered the river impaired at the state line in the past because of ammonia, pH, phosphorus, sediment, and fecal coliform. The current (2006) Nevada 303(d) list of impaired waters mentions that the East Walker at the state line does not meet standards for pH, total phosphorus, and temperature (Nevada Division of Environmental Protection, 2009). However, the report also stated that preparation of a TMDL for these impairments had a low priority. The East Walker River was delisted for nitrite in the 2006 list. High concentrations of metals, such as silver, copper, zinc, lead, and nickel, have been found in the East Walker below Bridgeport Reservoir as well as in tributaries, such as Rough Creek and Virginia Creek (Lahontan RWQCB, 1994a), although sampling in 2007 and 2008 did not find significant quantities of metals in the East Walker below Bridgeport Reservoir (Hershey, et al., 2010).

Bridgeport Reservoir has been known to be eutrophic for more than 50 years (Curry, 2001) and was designated as impaired from nutrients and sediment in 1994 (Lahontan RWQCB, 1994b). In 1999, fecal coliform was identified as another impairment (Elkins, 2002). As of 2000, ten water-quality objectives established by the Lahontan Water Quality Control Board were not met: ammonia, biostimulatory substances, dissolved oxygen, pH, taste and odor, temperature, total dissolved solids, total nitrogen, total phosphorus, and turbidity (Mono Resource Conservation District, 2000). Most of these problems have been presumed to be associated with high levels of nitrogen and phosphorus entering the reservoir, but the relative contribution of these nutrients from different sources is unknown (Mono Resource Conservation District, 2000). The Forest Service, Bridgeport Ranchers Association and the North Mono County Resource Conservation District have supported a water quality study on tributaries and high-elevation lakes in the East Walker watershed (USDA-Forest Service, 2004).

Habitat

Aspen stands critical as habitat for deer and migratory birds have been degraded by conifer encroachment (USDA-Forest Service, 2004). Conifers are also invading riparian zones because of the lack of significant disturbance, primarily fire.

Populations of mountain yellow-legged frog and Yosemite toad have decreased throughout the Sierra Nevada. Both species have recently been petitioned for listing under the federal Endangered Species Act. These amphibians have been found within the Hoover Wilderness near Peeler Lake and Frog Lakes, and these areas have been recommended as new Critical Aquatic Refuges (USDA-Forest Service, 2004).

Habitat of the Lahontan cutthroat trout has been reduced by over 90 percent throughout its original range by changes in streamflows and channel conditions and overfishing (Knapp, 1996). These fish further declined from predation by, competition with, and hybridization with introduced trout (Gerstung, 1988). With only a few isolated populations remaining, the Lahontan cutthroat trout was listed under the Endangered Species Act in 1970. The Lahontan cutthroat trout recovery plan (Coffin and Cowan, 1995) recommends removal of non-native trout from selected stream segments as a critical recovery strategy.

The East Walker River supports a recreational brown trout fishery that has been nationally-recognized for decades and was recently described as "the backbone of the year-round economy in Northern Mono County" (Mono County Board of Supervisors, 2010).

Recreation

The Humboldt-Toiyabe National Forest has found that recreational use (dispersed and developed camping areas along creeks and pack stock use) is creating watershed impacts in parts of the East Walker basin, including soil compaction, stream bank erosion, loss of vegetation, and water quality degradation from poor sanitation. In some areas, inappropriate road/trail alignment, design, maintenance, and unarmored stream crossings has resulted in stream bank erosion, upland erosion, trenching, poor drainage, and impacts to riparian vegetation (USDA-Forest Service, 2004). Conflicts exist between recreation fishing and restrictions for recovery of Lahontan cutthroat trout and amphibians.

Wildfire

As elsewhere in the West, the exclusion of natural wildfire has altered fire regimes throughout the East Walker River watershed. This change has resulted in denser timber stands, higher fuel loads, and the invasion of non-fire resistant species, with the consequence of increased risk of large stand replacing fires and threats to cultural resources, wildlife, water quality, scenic quality, and facilities. There have been several major fires in recent decades (USDA-Forest Service, 2004).

Invasive Species

Invasive weeds on National Forest System lands and adjacent federal, state, and private lands can alter natural ecosystems. Introduced trout have displaced native Lahontan cutthroat trout and amphibians in many parts of the watershed.

Driving Questions

- Is there much potential for the California portion of the East Walker River watershed to contribute additional water to Walker Lake?
- Can delivery of nutrients, pathogens, and metals to tributaries and the East Walker River be substantially reduced?

Watershed Description and Boundaries

The East Walker River is the smaller of the two forks of the Walker River and provides about one-third of the water for Walker Lake, the terminus of the Walker River. The East Walker River joins the West Walker River about seven river miles upstream from Yerington at the south end of Mason Valley. An overview of the Walker River basin can be found in Houghton (1986).

Any watershed is defined by its lowest point – by selecting a point along a stream or river, all lands upstream, upslope, and higher in elevation than that point have potential to deliver water toward that point. In our case, the defining point results from this study being financed by the Sierra Nevada Conservancy, an agency of the State of California. The watershed of the East Walker River within California as defined by the point where the river crosses the California / Nevada state line generally drains to the north-northeast. All of the watershed defined by this point is above the border crossing's elevation of about 6000 feet. The highest terrain of the watershed is in the Hoover Wilderness along the northeast side of Yosemite National Park. The Sawtooth Ridge area above Twin Lakes has a few summits above 12,000 feet (e.g, Matterhorn Peak and Twin Peaks) and some small pocket glaciers and/or permanent snow fields in the shaded cirques. The high point of the watershed happens to be east of the Sierra Nevada crest at Dunderberg Peak (aka Castle Peak) at 12,374 feet, just north of Virginia Lakes.

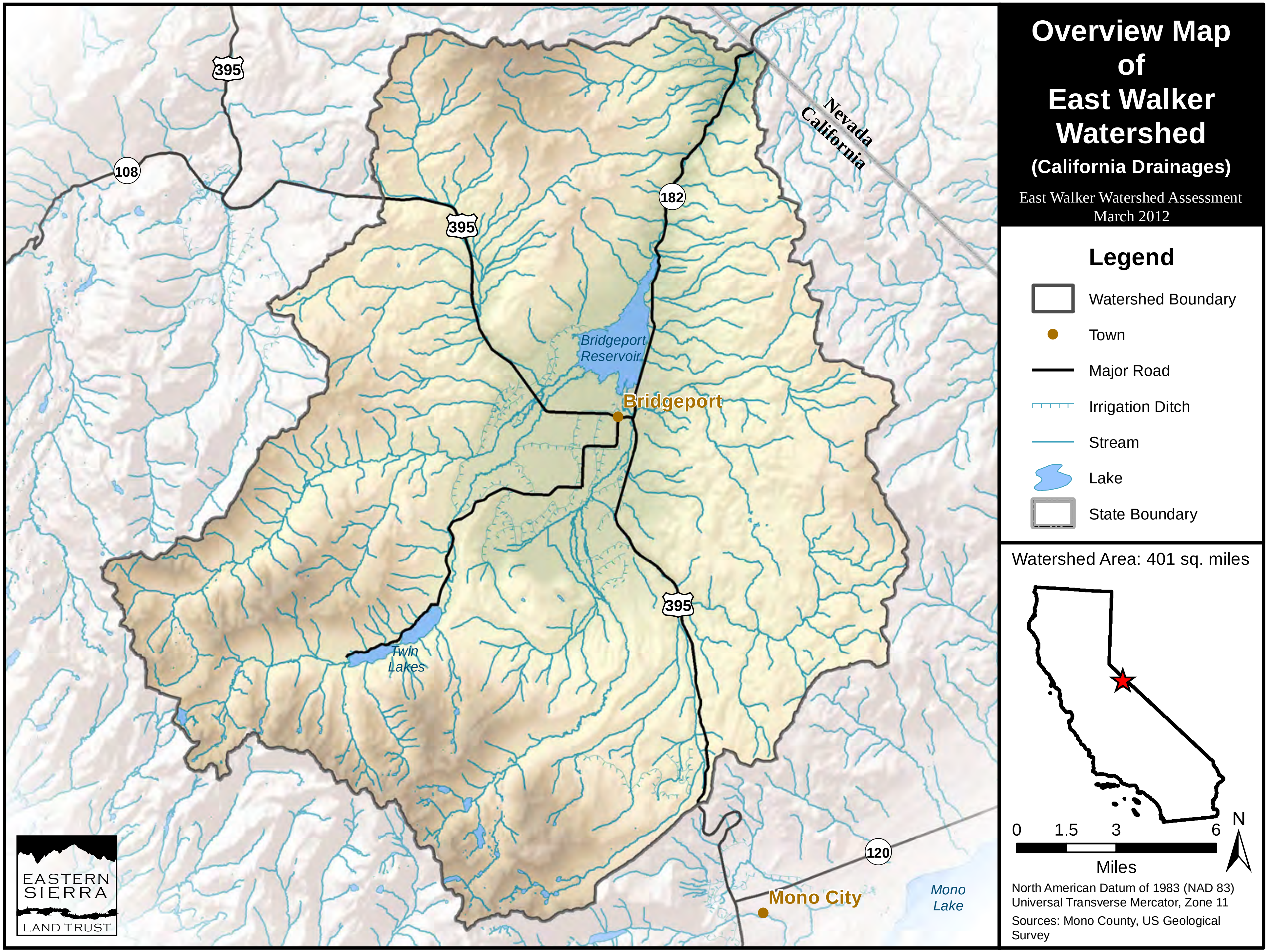
Going west from Sawtooth Ridge, the watershed divide crosses Slide Mountain (11,084 ft), skirts the west shore of Peeler Lake (9,489 ft), and winds around Grouse Mountain (10,734 ft) to Hanna Mountain (11,459 ft). The separation of the headwaters of the East Walker River from those of the West Walker River is continued to the north-northeast by Flatiron Ridge and Mahogany Ridge. The divide crosses U.S. Highway 395 at Devil's Gate (~7,500 ft) and continues north and then east into the Sweetwater Mountains. Another highpoint is reached at Wheeler Peak (11,660 ft) where the line then descends eastward to the arbitrarily-defined low point (about 6,000 ft) at the California / Nevada border just downstream from another Devil's Gate.

Returning to the highest portion of the watershed divide in the Sawtooth Ridge area, the line heads southeast to Camaica Peak (11,739 ft), skirts the west edge of Summit Lake (10,183 ft), and then turns east at peak 12,126. The divide continues past Black Mountain (11,760+ ft) and Mount Olsen (11,083 ft) to Conway Summit (8,143 ft) at U.S. Highway 395. The divide then goes northeast to Mt. Biedeman (8,981 ft) and north to Bodie Mountain (10,195 ft) and Potato Peak (10,236 ft). The line then continues north through the Bodie Hills to Masonic Mountain (9,217 ft) and then descends to the low point at the East Walker River and the state line.

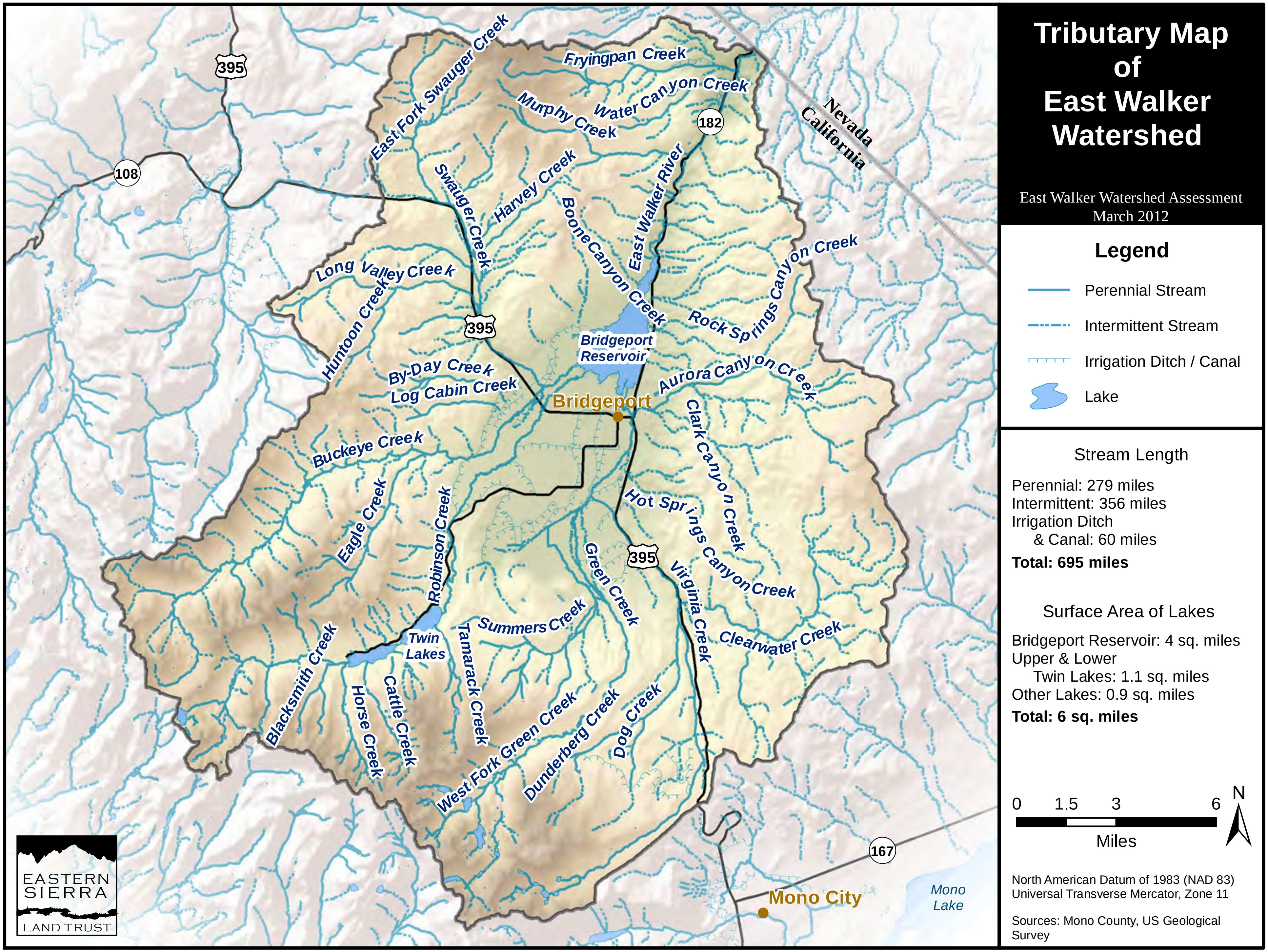
An alternative means of providing a geographic overview of the East Walker River is by means of the river's named tributaries. Proceeding upstream from the California / Nevada border, Fryingpan Creek, Water Canyon Creek, and Murphy Creek flow in from the east downstream of Bridgeport Reservoir. Boone Canyon Creek and Rock Springs Canyon Creek flow into the reservoir. Before the reservoir was built, Buckeye Creek was the next tributary to join the East Walker. Major tributaries of Buckeye Creek include Swauger Creek (which, in turn, has Long Valley Creek and Harvey Creek as principal tributaries), By-Day Creek, and Eagle Creek. Robinson Creek also flows into Bridgeport Reservoir and may have merged with Buckeye Creek before joining the East Walker in pre-reservoir times. Robinson Creek drains the north slopes of Sawtooth Ridge with main tributaries of Tamarack Creek, Cattle Creek, Horse Creek, and Blacksmith Creek. Upstream of Bridgeport Reservoir, the first tributary of the East Walker River is Aurora Canyon Creek, which includes Clark Canyon Creek. Several tributaries flowing from the south successively join to form the East Walker River as it enters Bridgeport Valley: Clearwater Creek, Virginia Creek, Dog Creek, Dunderberg Creek, Green Creek, and Summers Creek. The East Walker River within California is about 16.9 miles long, from the confluence of Virginia and Green Creeks to the Nevada border (Shumway, 1985).

Rough Creek and its tributary, Bodie Creek, are not part of the East Walker River watershed as defined by the point where the East Walker River crosses the California / Nevada state line. Rough Creek does not join the East Walker River until about 10 river miles downstream of the border at 5,579 ft. elevation. However, these creeks and their watersheds are part of the hydrologically-defined East Walker River basin and are largely within California. Therefore, these areas are discussed in an appendix.

Some aspects of the East Walker River watershed downstream of the state line are discussed in a report by the USDA-Soil Conservation Service (1989). Refer to **Map 2:** Tributary Map of the East Walker Watershed.



Map 1: Overview Map of East Walker Watershed (California Drainages)



Map 2: Tributary Map of East Walker Watershed

2. Descriptive Geography

Climate

The climate of a region can be considered to be the "average" weather as well as the extremes over some period of time. We are usually limited to the historical period and then often only a few decades during which some systematic measurements of precipitation and temperature were made and recorded. The term "normal" is a convention that includes only the past 30 years. Similar to the warnings that accompany a financial investment prospectus, we should remember that past climate is no guarantee of future conditions. Nevertheless, recent climate is the best indicator we have of what to expect in the near future. Where inferences are available regarding prehistoric climate, such information is valuable to suggest the range of extremes that are possible in a given region.

Precipitation

Precipitation is greatest in the headwater areas just east of the Sierra Nevada crest, which is related to the relatively consistent direction of winds during storms coming out of the southwest and crossing the Sierra Nevada. There is a steeply declining gradient in precipitation with distance east from the crest. This "rain shadow" effect is largely due to the descent of air in the lee of the crest that causes warming and evaporation of clouds (Powell and Klieforth, 2000). The areas immediately east of the crest also benefit from wind-driven carryover of precipitation that resulted from the lifting and cooling on the west side of the Sierra Nevada and some wind transport of snow initially deposited west of the crest. Precipitation increases again as air rises up the Sweetwater Mountains and Bodie Hills.

The average annual precipitation in the headwaters of the East Walker River basin has been estimated to exceed 40 inches and that within Bridgeport Valley to range from 12 to 20 inches (California Department of Water Resources, 1992), with about 9 inches at the town of Bridgeport. Average annual precipitation over the East Walker River watershed within California was estimated at 16.8 inches by Moore in Glancy (1971). Annual precipitation for the 37 mi^2 subwatershed of Clearwater Creek was estimated to average about 20 inches per year (Denio and Associates Engineering, 1999). Annual precipitation in the Clark Canyon Creek subwatershed was estimated to vary from 8 to 16 inches (Key and Gish, 1989). Precipitation continues to decline downstream in Nevada, with Hawthorne and Yerington receiving only about 5 inches of rain per year (California Department of Water Resources, 1992). Precipitation amounts can vary greatly between years. Refer to **Map 3:** Isohyetal Map of the East Walker Watershed.

Table 1: East Walker River Watershed Average Precipitation

Precipitation has been measured at five sites in and near the East Walker River basin:

Site	Period of Record	Average Annual Precipitation (in)
Bridgeport	1903 to present	9.4
Bridgeport Ranger Station	1987 to present	10.4
Bridgeport Reservoir Dam	1925 to 1957	9.9
Virginia Lakes Ridge	1979 to present	27.6
Bodie	1895 to present	12.8

The Bodie and Bridgeport sites are among the earliest climate-monitoring sites in California. Unfortunately, the records at both sites have long gaps. The Bridgeport record can be combined with records from the Bridgeport Dam site to provide a more continuous record. In addition to the gaps, there are assorted anomalies compared to other areas of the Sierra Nevada. For example, precipitation was higher than average in the drought years of 1976 and 1977. Although we presume the data are accurate and reflect local conditions, discrepancies such as those may be a cause to question some of the numbers. The Virginia Lakes Ridge site is an automated SNOTEL station at 9,445 feet elevation.

(Precipitation data accessed from Western Regional Climate Center at http://www.wrcc.dri.edu, Natural Resources Conservation Service at http://www.wcc.nrcs.usda.gov/snotel and California Data Exchange Center at http://cdec.water.ca.gov)

Table 2: Annual Precipitation at Five Stations in East Walker River Watershed

Station 1: Bodie
Station 2: Bridgeport
Station 3: Bridgeport Reservoir
Station 4: Bridgeport Dam
Station 5: Virginia Lakes

Year	St. 1	St. 2	St. 3	St. 4	St.5
1895	9.8				
1896	19.1				
1897	16.2				
1898	7.9				
1899	11.1				
1900	10.8				
1901	20.1				
1902	9.0				
1903					
1904					
1905					
1906					
1907					
1908					
1909					
1910					
1911					
1912					
1913		12.8			
1914		5.8			
1915		9.6			
1916		13.4			
1917					
1918					
1919					
1920					
1921					
1922					
1923					
1924					
1925					
1926					
1927					
1928				3.3	
1929				4.3	
1930				--	
1931				12.1	
1932				7.3	
1933				7.3	
1934				11.1	
1935				10.2	

Year	St. 1	St. 2	St. 3	St. 4	St.5
1936				15.0	
1937				9.3	
1938				9.7	
1939				5.4	
1940				13.5	
1941				12.2	
1942				6.4	
1943				9.3	
1944				9.3	
1945				15.6	
1946				10.2	
1947				3.1	
1948				--	
1949				7.6	
1950				19.7	
1951				10.3	
1952				11.8	
1953				8.0	
1954				7.5	
1955				13.4	
1956				7.2	
1957				5.1	
1958		10.9			
1959		5.7			
1960		7.6			
1961		5.6			
1962		11.1			
1963		15.9			
1964		7.6			
1965	26.4	11.8			
1966	10.4	5.6			
1967	21.1	9.8			
1968	9.5	8.0			
1969	19.2	18.1			
1970	12.9	9.9			
1971	16.1	10.0			
1972	10.1	5.9			
1973	16.2	10.5			
1974	11.8	8.0			
1975	11.5	10.4			
1976	11.6	5.6			

Year	St. 1	St. 2	St. 3	St. 4	St.5
1977	13.9	12.4			
1978	14.2	10.3			
1979	--	8.3			26.1
1980	--	12.0			38.3
1981	--	8.8			21.8
1982	17.6	17.7			43.9
1983	20.7	20.0			46.3
1984	13.5	5.5			30.3
1985	11.3	8.3			25.8
1986	12.4	12.6			40.7
1987	12.8	6.1			15.1
1988	9.5	5.2	6.8		17.1
1989	8.7	7.7	8.7		25.9
1990	8.3	3.0	4.2		17.6
1991	12.8	4.2	9.0		18.1
1992	12.0	7.3	7.3		19.8
1993	10.4	5.6	[5.9]		32.4
1994	10.9	4.0	7.2		17.8
1995	16.0	6.7	14.6		40.6
1996	20.2	14.9	14.5		32.9
1997	11.6	4.6	11.5		39.3
1998	16.5	12.9	12.5		36.4
1999	9.8	4.0	6.1		24.5
2000	6.8	7.8	6.9		24.0
2001	13.3	10.8	8.5		19.5
2002	8.5	7.2	7.8		21.4
2003	9.3	9.6	9.7		24.0
2004	7.7	--	8.9		21.7
2005	11.5	--	15.8		37.6
2006	7.1	--	10.9		31.9
2007	8.5	--	8.8		18.5
2008	11.1	10.9	11.1		25.5
2009	8.8	9.1	9.6		23.4
2010	11.8	14.8	14.8		28.5

Station 1: Bodie
Station 2: Bridgeport
Station 3: Bridgeport Reservoir
Station 4: Bridgeport Dam
Station 5: Virginia Lakes

Table 3: Average Monthly Precipitation (inches) at Bridgeport

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Monthly precip (in)	1.6	1.6	1.0	0.4	0.6	0.5	0.5	0.5	0.4	0.4	0.9	1.1	9.4
Monthly snowfall (in)	12	14	7	3	1	0	0	0	0	1	4	8	50

Source: Western Regional Climate Center at http://www.wrcc.dri.edu

Average annual precipitation for different elevation zones within the California portion of the East Walker River watershed was estimated by Moore in Glancy (1971):

Table 4: Average Precipitation by Elevation Band

		Estimated Precipitation		
Elevation zone (feet)	**Area (acres)**	**Range (inches)**	**Average (feet)**	**Average (acre-feet)**
above 11,000	1,550	>26	2.3	3,600
10,000-11,000	5,420	22-26	2.0	11,000
9,000-10,000	10,800	20-22	1.8	19,000
8,000-9,000	39,800	15-20	1.5	60,000
7,000-8,000	26,200	12-15	1.1	29,000
6,000-7,000	9,760	8-12	0.8	7,800
below 6,000	310	<8	0.5	160
Total	**93,800**			**131,000**

A study of precipitation in western Nevada provided broad estimates of precipitation in different parts of the Walker River basin (Lopes and Medina, 2007). Within the California portion of the East Walker River watershed, this study estimated annual precipitation averages for Bridgeport Valley at about 10 to 16 inches, the Sweetwater Mountains at about 27 inches, and the highest portion of the Sierra Nevada east slopes at up to 79 inches (Lopes and Medina, 2007).

Most of the precipitation falls from November through March during winter storms, which can last in duration from a few hours to three or four days. During these winter storms, precipitation in most of the basin falls in the form of snow. Warm winter storms occasionally affect the basin and can deposit several inches of rain over much of the basin. The largest such storms on record resulted in flooding of the East Walker River.

Large winter rainfall events:

Dec 1937
Nov 1950
Nov 1955
Dec 1963
Jan 1997

At the other extreme, California has had four anomalously dry periods in the past century: 1929-1934, 1976-77, 1987-1992, and 2007-2009 (Jones and Nguyen, 2010). Precipitation in the East Walker River watershed was significantly below average during those four drought periods.

Snowpack

The hydrology of East Walker River Basin is dominated by winter accumulation of snow in the upper elevations of the Sierra Nevada and subsequent snowmelt runoff in the May-July period. A few snowpack measurement stations have been maintained high in the East Walker River watershed by the California Department of Water Resources and the USDA-Natural Resources Conservation Service:

Table 5: Average Peak Snowpack Water Equivalence at Seven Sites

Courses or Sensors	Elevation	Period of Record	April 1 Average (in)
Virginia Lakes	9400	1947-2006	18.0
Virginia Lakes Ridge	9300/9445	1969 to present	19.5
Center Mountain	9400	1922 to 1984	38.6
Buckeye Roughs	7900	1930 to 1978	20.0
Buckeye Forks	8500	1930 to 1975	21.6
Sawmill Ridge	8750	1982 to present	18.8
Slide Canyon*	9200	1982 to present	41.1

** In the Tuolumne River basin just south of East Walker River basin.*

Snowfall at Bridgeport has averaged about 43 inches per year (Sharpe, et al., 2008). The largest recorded annual snowfall was 174 inches in 1916, including 121 inches during January (http://en.wikipedia.org/wiki/Bridgeport,_California, citing Western Regional Climate Center at http://www.wrcc.dri.edu).

Air Temperature

Parts of the East Walker River watershed are well-known as cold spots in California. Bridgeport and Bodie are occasionally in the winter-season news as the coldest locations in the nation when the upper Midwest is unusually warm. Over the past century at the Bridgeport climate station, the average annual maximum temperature was 62°F and the average annual minimum temperature was 24°F. The recorded extremes at Bridgeport have been 96°F and -37°F (California Department of Water Resources, 1992). During January, the average daily maximum air temperature is about 41°F and the average daily minimum air temperature is about 9°F. During July, the equivalent values are 83°F and 40°F. On the average, only 100 days each year have minima above 32°F (http://en.wikipedia.org/wiki/Bridgeport,_California). The Bridgeport Valley tends to be quite cold during calm periods between winter storms. The frost-free growing season lasts about 51 days in Bridgeport Valley (California Department of Water Resources, 1992; Sharpe, et al., 2008).

At Bodie, the average annual maximum temperature was 56°F and the average annual minimum temperature was 19°F (Western Regional Climate Center at http://www.wrcc.dri.edu).

Table 6: Average Monthly Maximum and Minimum Temperatures (°F) at Bridgeport

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Ave. Maximum Temp.	41	44	50	58	66	75	83	82	76	67	53	44	62
Ave. Minimum Temp.	9	12	18	23	29	36	40	38	31	22	16	10	24

Source: Western Regional Climate Center at http://www.wrcc.dri.edu

Wind

There is insufficient information to characterize wind patterns for the watershed.

Evaporation

The evaporation rate from Bridgeport reservoir has been estimated as 43 inches per year or a total volume of about 9,000 acre-feet per year (Lopes and Alexander, 2009). For comparison, evaporation at Topaz Lake has been estimated from evaporation pan measurements from 1957 through 2002 as about 69 inches per year (Source: Western Regional Climate Center at http://www.wrcc.dri.edu). Open-water evaporation from Mono Lake was estimated at about 40-45 inches per year in several studies through the 1960s and at 39 inches per year by the Los Angeles Department of Water and Power (1987). An estimate of 48 inches per year (apparently derived from a 1992 modeling study) was used in the EIR water balance (Jones and Stokes Associates, 1993: Appendix A). Evaporation from June Lake has been estimated as 38 inches per year (California Department of Water Resources, 1981). Open-water evaporation from lakes above 9,000 feet has been estimated at about 20-25 inches per year, and is limited by ice cover.

Evapotranspiration in the Bridgeport Valley has been estimated as about 29 inches per year from a combination of average annual values of 13 inches of water diverted from streams plus 16 inches of precipitation (Lopes and Allander, 2009). Over the estimated 15,900 acres of irrigated pasture, a volume of about 17,000 acre-feet of water is evaporated from the agricultural lands each year (Lopes and Allander, 2009). This rate is significantly less than the 34 to 53 inches per year estimated for irrigated pasture in the lower-elevation Carson Valley (Maurer, et al., 2006).

Evapotranspiration in the California portion of the watershed was estimated as 720 AF from agriculture and 860 AF from phreatophytes (Glancy, 1971).

Climate Change

Paleoclimatic inferences from a variety of residual evidence for the Sierra Nevada and western North America (e.g., Minnich, 2007; Sharpe, 2010) do not yet provide a consistent time sequence of wet and dry periods over the past few millennia. For the Walker River basin, a few studies offer some long-term context for climate variability, even though the inferred timing is not in complete agreement.

A U.S. Geological Survey study (Benson, 1988; Benson, et al., 1991) of sediment deposits at Walker Lake provided the basis for inferences about the climate and hydrology of Walker Lake over the past several millennia:

- 13,000 to 5,000 years before present (BP): Walker Lake was low or periodically dry
- After about 5,000 BP: inflows to Walker Lake increased, and the lake level rose
- 5,000-3,000 or 4,000-2,000 BP: Walker Lake remained high
- AD 1-1000: Walker Lake declined and was nearly dry for about 300 years
- AD 1000-1880: Walker Lake generally refilled except during drought periods

From several lines of evidence (stratigraphy, pollen, oxygen isotopes, biological remains in sediments, etc.), low levels of Walker Lake appear to have occurred:

- 5,000 to 4,700 years BP (Bradbury, et al., 1989: Benson, et al., 1991)
- 2,400 to 2,000 years BP (Bradbury, et al., 1989: Benson, et al., 1991)
- AD 500 to 1000 (Benson, et al., 1991; Adams, 2003)
- AD 900 to 1100 (Yuan, et al., 2004)
- AD 1200 to 1350 (Yuan, et al., 2004)
- AD 1500 to 1700 (Adams, 2003)

These low lake levels presumably resulted from prolonged drought, but geologic diversion through Adrian Valley has been proposed as an alternative mechanism (Benson, et al., 1991).

The most recent glacial advance peaked about 3,000 years ago (Minnich, 2007). Several lines of vegetation evidence also suggest that period was wetter and cooler than periods before and after. The climate also cooled and had relatively high precipitation during the so-called Little Ice Age between roughly 1300 and 1800 (Minnich, 2007; USDA-Forest Service, 2011).

Evidence of severe and persistent drought in pre-historic times has been found at sites near the East Walker River watershed: the canyon of the West Walker River, Mono Basin, and Tenaya Lake in Yosemite National Park (Stine, 1994). The most intriguing evidence was found in the West Walker River channel, where dozens of Jeffrey pine stumps are rooted in the main channel of the river. These trees could survive in that location only if streamflow was so low that the roots of the trees were not submerged for more than a few weeks each year. Radiocarbon dating of the wood showed that an older group of trees was alive between about AD 900 and 1100 and another set of trees grew in the bottom of the channel between about AD 1210 and 1350 (Stine, 1994). The channel is narrow and stable enough that changes in the location of the channel cannot explain the presence of the stumps. The age of the trees in the West Walker River corresponds to the age of other old stumps found in Tenaya Lake and near Mono Lake, suggesting that dry conditions during the same periods allowed establishment of trees in other locations in the region (Stine, 1994). The presence of these stumps indicates periods of 140 to 220 years with very little precipitation. Recent observations have found large trees rooted deep within Fallen Leaf Lake near Lake Tahoe, probably dating to the same period (Kleppe, 2005). A study published in 1922 also alluded to a drought in California's pre-history lasting more than a century (Clifford, 1994). The source of that account may have been lore passed between generations of Native Americans.

In modern times, the period of 1928 through 1934 is regarded as an extended drought within the entire Walker River basin. Other dry periods occurred in 1924-25, 1960-61, 1976-77, 1988-92, and 2007-2009 (Jones and Nguyen, 2010).

As global temperatures continue to rise as a result of anthropogenic increases in atmospheric carbon dioxide, changes in the climate of the Sierra Nevada can be expected. A wide variety of reports has been issued in the past decade suggesting that regional temperatures will rise, precipitation will decline, there will be more rain and less snowfall, there will be a lesser snowpack, the snowpack will begin to melt earlier, and the snowpack will melt faster. However, the situation and the underlying physical processes are not necessarily so simple. For example, snowmelt in the Sierra Nevada has surprisingly little direct response to air temperature. Solar radiation input to the snow surface is a far more important factor in energy exchange (and therefore, snowmelt) than processes involving the temperature of the air. However, if future climate change also resulted in more persistent cloud cover and less direct solar radiation, then energy exchange through processes where air temperature is a factor would become more important. Water managers relying on the East Walker River need to anticipate the possibility of change in the climate and, consequently, the hydrology of the watershed relative to the recent historical past but should not assume that the common predictions of significantly less snow are the only reasonable scenario.

Topography

The upper western parts of the basin are characterized by steep, rugged terrain. Elevations along the crest of the Sierra Nevada range from 9,000 to 12,000 feet. Streams dissect this terrain and initially flow to the north or northeast before joining the main channels. The altitude of the lowest point of the watershed at the California-Nevada border is approximately 6,000 feet. The highest elevation parts of the East Walker River watershed are found in the southwest, and the lowest elevation parts are found in the center in the Bridgeport Valley and downstream along the river to the Nevada border. Refer to **Map 4**: Elevation Map of the East Walker Watershed.

Bridgeport Valley is the main semi-flat area that is suitable for agriculture in the East Walker River basin. It lies between about 6,750 feet where Buckeye Creek enters and 6,450 feet at Bridgeport Reservoir and covers about 26,300 acres (California Department of Water Resources, 1992). The drainage area above Bridgeport Valley is about 358 square miles (229,120 acres) (U.S. Geological Survey, 2010) or about 90 percent of the watershed area above the state border.

The distribution of area within elevation zones provides a general impression of the overall topography of the East Walker River basin (**Table 7**).

Table 7: Distribution of Area within Elevation Zones above Bridgeport Reservoir

Elevation Range (feet above msl)	Area (acres)	Percentage of watershed area
Above 11,000	1,550	2
10,000-11,000	5,420	6
9,000-10,000	10,800	12
8,000-9,000	39,800	42
7,000-8,000	26,200	28
6,000-7,000	9,760	10
Total	**93,560**	

Elevation Range (feet above msl)	Area (mi^2)	Percentage of watershed area
11,501-12,500	1	0.25
10,501-11,500	23	5.75
9,501-10,500	46	11.5
8,501-9,500	72	18
7,501-8,500	126	31.5
6,501-7,500	114	28.5
6,000-6,500	18	4.5

Source: Glancy, 1971 and 2012 GIS analysis.

Geology and Soils

The steep, rugged peaks of the upper watershed are composed mostly of granitic rocks, with some volcanic and metavolcanic rocks. Granodiorite is common in the western part of the watershed and tends to be heavily jointed and fractured, resulting in steep cliff faces that are subject to rock fall. Volcanic rock and associated hot springs are present in the Bodie Hills above the Bridgeport Valley (Mono County Community Development Department, 2000). Talus slopes (piles of rock debris) are also found in much of the watershed (USDA-Forest Service, 2004).

Large glaciers once extended out of the Sawtooth Ridge area and down Robinson Creek. Lateral moraines are found along Robinson Creek and most of the other principal creeks draining headwater areas in the Sierra Nevada. The most recent glacial maximum, called the Tioga, which ended about 10,000 years ago, resulted in glaciers in most of the canyons extending north or east from the Sierra Nevada crest. The Tioga glaciation produced most of the lateral and terminal moraines in the canyons of the main tributaries to the East Walker River. Glacial till has been transported by the streams out of the mountains and into the Bridgeport Valley (California Department of Water Resources, 1992). The valleys of Robinson Creek, Cattle Creek, and Horse Creek are good examples of glacially eroded terrain.

Down warping along regional faults (Kleinfelder, Inc., 1992) has dropped the Bridgeport Valley relative to the surrounding hills, which contribute sediment to the valley (California Department of Water Resources, 1992).

The primary geologic reference maps for the area are those produced by the U.S. Geological Survey and the California Division of Mines and Geology (e.g., Chesterman and Gray, 1975). The Walker Lake Sheet of the Geologic map of California (Koenig, 1963; http://ngmdb.usgs.gov/ngm-bin/ILView.pl?sid=352_1.sid&vtype=b&sfact=1.5) covers the entire watershed at a scale of 1:250,000.   Refer to **Map 5**: Geology Map of Upper East Walker Watershed.

Although prospectors have presumably scoured most of the East Walker River watershed, the eastern portion has yielded far more mineral wealth than the Sierra Nevada portion. The first significant mineral find was gold in Dog Creek, a tributary to Virginia Creek in 1857. The Bodie Hills region has been mined extensively in the late 19th century, and exploration has resumed in the vicinity of the Paramount Mine in recent years.

In very broad terms, the soils at lower elevations are generally derived from granitic and volcanic parent material and are sandy loams and decomposed granite. Soil depth ranges from very shallow with lots of rocks to deep alluvium in the valleys (California Department of Water Resources, 1992). At higher elevations, soil depths range from a few inches to 3 or 4 feet. Sandy loam is the most common texture, but rock content is commonly up to 35 percent, especially on steeper slopes. Water retention tends to be low and decreases when rock occupies a greater proportion of the volume.

Soils on steeper mountain slopes are generally somewhat excessively to excessively drained, coarse-textured, and shallow. Soils that formed on the foothills are well to excessively drained, are shallow to moderately deep, and generally have coarse-textured surfaces with some having coarse- to fine- textured subsoils. Soils developed on the high terraces are well to moderately well drained on nearly level to sloping terrain. Soils developed on low terraces are somewhat poorly to poorly drained on nearly level terrain. Most terrace soils lie above a heavy textured subsoil with a variety of surface textures. Soils on alluvial fans include well to excessively drained soils except where groundwater is present (Mono County Resource Conservation District, 1990).

Soils on floodplains are generally loamy and sandy in texture, are deep to moderately deep with coarse-textured subsoils. Drainage is somewhat poor to very poor, and soils are eroded by past and present channels of the rivers. Soils formed in topographic depressions are generally clayey throughout and have a high organic matter content. These soils also exhibit poor drainage conditions. Many of the poorly and very poorly drained soils on the floodplains, basins and low terraces are affected by salts and alkali (Mono County Resource Conservation District, 1990). Within the Bridgeport Valley, much of the irrigated area is saturated throughout most of the irrigation season.

On the floodplain of Cottonwood Creek, just upstream of its confluence with Virginia Creek, the soils are alluvial silty and sandy clay loams (Denio and Associates Engineering, 1999). Permeability was described as moderate to moderately slow with a "slight" erosion hazard. However, the adjacent streambank soils apparently are more finely textured and are very susceptible to erosion (Denio and Associates Engineering, 1999).

Soils along Clark Canyon Creek have been described as "… moderately fine textured and poorly to somewhat poorly drained along the drainage bottoms; and dark colored, deep, moderately coarse to fine textured, and well drained along the drain ways and side slopes. Soils on the canyon sides are rocky and shallow to moderately deep, with moderately fine textured subsoils" (Key and Gish, 1989:127).

Soils at a site proposed for subdivision along the Twin Lakes Road were described as "gravelly very-coarse textured soils formed from granitic alluvium 36-60 inches in depth with a 3-4 inch surface mat of roots and organic matter" (ESA Planning and Environmental Services, 1987).

Except for the relatively flat terrain of Bridgeport Valley, soils within the East Walker River watershed are generally on steep slopes, are shallow, coarse-textured and stony, and are therefore subject to "severe soil erosion by water if not adequately covered and protected. Current problems center around rural development areas, and road and highway construction. Future problems could arise with the approval and development of additional subdivisions and their related facilities" (Mono County Resource Conservation District, 1990).

Soils along Green Creek and Dog Creek have been described as "mostly very gravelly" and "dominantly moderately to steeply sloping cold soils on Sierra Foothill-slopes and glacial deposits" (USDI-Bureau of Land Management, 2011: 41).

The soil survey portion of the Natural Resources Conservation Service website suggests that detailed soils mapping has not been completed for the East Walker River watershed.   Refer to **Map 6**: Soil Map of East Walker Watershed.

Upland Vegetation

The declining gradient in precipitation from west to east results in a rapid transition in vegetation -- from conifer forests in the Sierra Nevada to open woodlands in the hills to sagebrush scrub in the desert valleys (California Department of Water Resources, 1992).

In the subalpine zone, whitebark pine (*Pinus albicaulis*), western white pine (*Pinus monticola*), limber pine (*Pinus flexilis*), and mountain hemlock (*Tsuga mertensiana*) are the primary tree species. Farther down the slope, nearly pure stands of lodgepole pine (*Pinus contorta* ssp. *murrayana*) grow in many of the upper-elevation areas.

Mixed conifer stands at higher elevations are composed of western white pine, red fir (*Abies magnifica*), Jeffrey pine (*Pinus jeffreyi*), and lodgepole pine. At mid elevations, mixed conifer stands have more white fir (*Abies concolor*) and western juniper (*Juniperus occidentalis* var. *occidentalis*) and less red fir and western white pine. Aspen (*Populus tremuloides*) clones are found where soil moisture is high and along creeks (USDA-Forest Service, 2004). As in most other parts of the Sierra Nevada, decades of successful fire suppression have markedly changed the composition and density of the mixed conifer forest within the East Walker River watershed. Open stands of pinyon pine (*Pinus monophylla*) occur on some of the lower slopes of the Sierra Nevada as the forest transitions to shrub communities (Taylor, 1992).

At upper elevations, brushfields are comprised of buckbrush (*Ceanothus velutinus*) and chokecherry (*Prunus emarginatus*). At lower elevations, the brush community is mostly sagebrush (*Artemesia tridentata*), bitterbrush (*Purshia tridentata*), mountain mahogany (*Cercocarpus ledifolius*) and snowberry (*Symphoricarpus albus*) (USDA-Forest Service, 2004). The most common riparian vegetation consists of willow (*Salix* sp.) and quaking aspen.

The lower slopes of the Sierra Nevada (below 7,000 feet) and lower portions of the Bodie Hills are largely covered by a Big Sagebrush (*Artemisia tridentata*) Scrub community, intermingled with meadows and some curlleaf mountain mahogany (*Cercocarpus ledifolius*). Typical species of the sagebrush community include bitterbrush (*Purshia tridentata*), rabbitbrush (*Chrysothamnus* spp.), horsebrush (*Tetradymia canescens*), Mormon tea (*Ephedra nevadensis*), mule-ears (*Wyethia mollis*), plateau gooseberry (*Ribes velutinum*), snowberry (*Symphoricarpus albus*), sulfur buckwheat (*Erigonum umbellatum*), wheatgrass (*Agropyron* spp.), bluegrass (*Poa* spp.), ashy wild-rye (*Leymus cinereus*), creeping wild-rye (*Leymus triticoides*), big squirreltail (*Elymus elymoides*), needle-grass (*Stipa* spp. and *Achnatherum* spp.), and June grass (*Koelaria cristata*) (Taylor, 1992; Bagley, 1997; Paulus, 1998; USDI-Bureau of Land Management, 2011). In the Bodie Hills, ground cover by plants of the Big Sagebrush Scrub community ranges between 10 and 48 percent (Pacific Consultants, 1993).

At higher elevations in the Sweetwater Mountains and Bodie Hills, the main plant community is Great Basin Pinyon-Juniper (*Pinus monophylla*, *Juniperus osteosperma*) Woodland. Bitterbrush and sagebrush dominate the forest understory. The grass composition is similar to that of the lower-elevation Sierra Nevada front to the west (Thomas, 1984).

An Aspen Riparian Woodland occurs along creeks draining the Sierra Nevada and is dominated by quaking aspen (*Populus tremuloides*), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), and Jeffrey Pine (*Pinus jeffreyi*) (Johnston and Associates, 1992). Mountain alder (*Alnus tenuifolia*) and creek dogwood (*Cornus stolinifera*) may also be found along some reaches (Howald, 2000).

A Modoc-Great Basin Riparian Scrub community is found along the stream channels of the Bodie Hills. The main willow species is narrow-leaf willow (*Salix exigua*). Other common plants in this community include golden currant (*Ribes aureum*), wild rose (*Rosa woodsii*), sedges (*Carex* spp.), rushes (*Juncus* spp.), and creeping wild-rye (*Leymus triticoides*) (Bagley, 1997).

The vegetation at the lower elevations of the East Walker River basin (6,000 to 7,000 feet) has changed substantially since the 1860s from bunchgrass range to bitterbrush and sage (e.g., Howald, 2000). Prior to the arrival of Euroamericans in the mid-19th century, portions of the East Walker River basin below and between the coniferous forest stands was primarily habitat for antelope and desert bighorn sheep. As overgrazing by thousands of domestic sheep during the late 1800s and early 1900s removed the bunchgrass, brush species became established. The native grasses, sedges, and rushes of the meadows were also converted to alfalfa and other forage species. Refer to **Map 7:** Vegetation Map of the East Walker River Watershed.

Invasive Weeds

The term weed is typically used to describe any plant that is unwanted and grows and spreads aggressively. The term noxious weed describes an invasive unwanted non-native plant and refers to weeds that can infest large areas or cause economic and ecological damage to an area (USDA-Forest Service, 2004).

Perennial pepperweed (*Lepidium latifolium)* is found within moist of seasonally wet locations and forms dense stands that can exclude native species (Cal-IPC 2006). It is found within the watershed along the East Walker River just within the California border. This species has been identified as a high threat species that if allowed to become established could impair native plant communities to the detriment of both agricultural lands and important plant and wildlife habitats (Reade, 2012).

Both Russian knapweed (*Acroptilon repens)* and spotted knapweed (*Centaurea maculosa)* should be watched for as they have occurred locally in the last decade (Reade, 2010).These species can be found in disturbed open sites, grasslands, rangelands, and roadsides. Like pepperweed, it crowds out native species and forage for livestock, and can invade native plant communities (Cal-IPC 2006).

Cheat grass (*Bromus tectorum*) is found within the Big Sagebrush Scrub and Pinyon-Juniper Woodland communities of the Sierra Nevada (Johnston and Associates, 1992) and Bodie Hills (Bagley, 1999) (and presumably Sweetwater Mountains). Cheat grass accounts for 20 to 25 percent of the vegetation cover in the Dog Creek and Green Creek grazing allotments(USDI-Bureau of Land Management, 2011).

Wild iris (usually western blue flag [*Iris missourensis*]) displaces more palatable, more productive forage species. Once established in a meadow, iris spreads by underground plant parts as well as seed, and can eventually take over a productive pasture or hay meadow (Mono County Resource Conservation District, 1990). It is common in Bridgeport Valley, Huntoon Valley, and Bodie Hills.

Other invasive weeds that are considered threats in the watershed include Canada thistle (*Cirsium arvense)*, common teasel (*Dipsacus fullonum),* hoary cress (*Carderia draba),* and bull thistle *(Cirsium vulgare)*(Reade, 2010).

Table 8: Invasive Weeds occurring, or previously known to occur in the East Walker River Watershed

Scientific Name	Common Name	IPC Rating
Bromus tectorum	cheat grass	Moderate (B)
Iris missourensis	Western blue flag, wild iris	Not Rated
Cirsium arvense	Canada thistle	Moderate (B)
Lepidium latifolium	perennial pepperweed	High (A)
Dipsacus fullonum	common teasel	Moderate (B)
Carderia draba	hoary cress	Moderate (B)
Cirsium vulgare	bull thistle	Moderate (B)
Acroptilon repens	Russian knapweed	Moderate (B)
Centaurea maculosa	spotted knapweed	High (A)

California Invasive Plants Council (Cal-IPC) Inventory Categories:

- High: These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.
- Moderate: These species have substantial and apparent—but generally not severe—ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.

Source: Cal-IPC. 2006. California Invasive Plant Inventory. Cal-IPC Publication 2006-02. California Invasive Plant Council: Berkeley, CA.

Figure 1: Photographs of Selected Invasive Weed Species

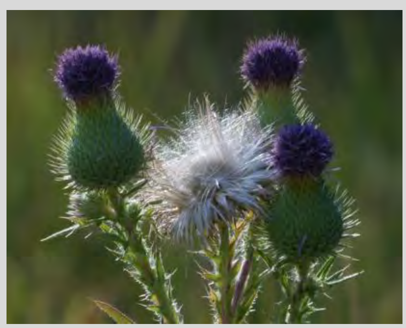
Selected Invasive Weed Species

Canada thistle (Nathan Reade)

perennial pepperweed (Nathan Reade)

spotted knapweed (Dr. Dean W. Taylor)

Russian knapweed (Nathan Reade)



bull thistle (Steve Matson)

Western blue flag iris (CDFA)

Sensitive Plant Species

The Masonic jewel flower (*Strptanthus oliganthus*) occurs in the Bodie Hills (Bagley, 1997) and presumably other pinyon-juniper communities of the East Walker River watershed. The Masonic jewel flower occurs on andesitic soils in talus or rocky slopes and flats at elevations ranging from 6,800 to 8,200 feet. Masonic jewel flower is often found growing in litter or duff cover under the canopy of pinyon-juniper woodlands (USDA-Forest Service, 2004).

Other sensitive plant species found in the Bodie Hills include Bodie Hills rock cress (*Arabis bodiensis* or *Boecherabodiensis)*, Masonic rock cress (*Arabis cobrensis*), small-leaved rock cress (*Arabis microphylla* var. *microphylla*), Bodie Hills cusickiella or draba (*Cusickiella quadricrostata*), Beatley's buckwheat (*Eriogonum beatleyae*), Tioga sedge (*Carex tiogana*), and Long Valley milkvetch (*Astragalus johannis-howellii*) and Mono County phacelia (*Phacelia monoensis*) (Bagley, 1997; Paulus, 1998; USDI-Bureau of Land Management, 2009).

The Bodie Hills draba is also known to occur at several sites along lower Green Creek (USDI-Bureau of Land Management, 2011).

Table 9: California Rare Plant Rank 1B species occurring in the East Walker River Watershed

Scientific Name	Common Name	Rare Plant Rank
Eriogonum alexanderae	Alexander's buckwheat	1B.1
Phacelia monoensis	Mono County phacelia	1B.1
Astragalus oophorus var. lavinii	Lavin's milk-vetch	1B.2
Cusickiella quadricostata	Bodie Hills cusickiella	1B.2
Streptanthus oliganthus	Masonic Mountain jewel-flower	1B.2
Boechera bodiensis	Bodie Hills rock-cress	1B.3
Boechera tiehmii	Tiehm's rock-cress	1B.3
Boechera tularensis	Tulare rockcress	1B.3
Carex tiogana	Tioga Pass sedge	1B.3
Draba incrassate	Sweetwater Mountains draba	1B.3
Erigeron miser	starved daisy	1B.3
Polemonium chartaceum	Mason's sky pilot	1B.3
Senecio pattersonensis	Mount Patterson senecio	1B.3

Source: California Department of Fish and Game, California Natural Diversity Database, February 2012.

According to the California Native Plant Society, "Plants with a California Rare Plant Rank of 1B are rare throughout their range with the majority of them endemic to California. Most of the plants that are ranked 1B have declined significantly over the last century." Furthermore, these species are considered eligible for state listing (CNPS Rare Plant Program 2011).

Figure 2: Photographs of Selected Sensitive Plant Species

Selected Sensitive Plant Species

Tioga Pass sedge
(Dr. Dean W. Taylor)

Bodie Hills cusickiella
(Steve Matson)

Masonic Mountain jewel-flower
(Margaret Williams and California Native Plant Society)

Sweetwater Mountains draba
(Steve Matson)

Lavin's milk-vetch (Steve Matson)

starved daisy (Steve Matson)

Mono County phacelia
(Steve Matson)

Mason's sky pilot (Steve Matson)

Tiehm's rock-cress
(Dr. Dean W. Taylor)

Wildfire History and Risk

Wildfires are uncommon and infrequent in the subalpine zone and usually limited to only a few trees. No large historic fires have been documented at elevations over 8,000 feet in the East Walker River watershed. Fires intensities tend to be low, and large fires rarely develop. The subalpine zone tends to be cooler and wetter than areas at lower elevation. Forest structure is probably the closest to reference conditions in the subalpine zone. Most of the late successional forest stands are found at these higher elevations (USDA-Forest Service, 2004).

Wildfire return intervals in the Jeffrey Pine and white-fir / Jeffrey Pine forests under pre-1850 conditions have been estimated to range from 5 to 20 and 20 to 50 years, respectively (USDA-Forest Service, 2004).

Lodgepole pine stands are common at higher elevations around streams and wet meadows. In most of the stands, there is evidence of relatively frequent, low-intensity fires (USDA-Forest Service, 2004). With few exceptions, the lodgepole pine stands in the wetter areas pose little risk of large fire occurrence. Only under severe weather conditions with strong winds, high temperatures, and low humidity would there be a threat of stand-replacing fire among the lodgepole pines (USDA-Forest Service, 2004).

Because of successful suppression of even low-intensity fires, lodgepole pine has recently encroached into areas that were historically aspen stands and wet meadows. Lodgepole can be aggressive in occupying these sites in the absence of disturbance. There is very little if any regeneration occurring in these stands. Mortality is mainly caused by mountain pine beetles during drought and windthrow during wet periods (USDA-Forest Service, 2004).

Aspen is common in areas of high soil moisture. Many of the aspen stands now survive longer than they did prior to fire exclusion. These are declining because of advanced age. Red fir, white fir, and lodgepole pine become established in most of the aspen stands where fire risk is minimal. Within the last 30 years, small fires have occurred in a few of the aspen stands, but entire stands burn only during extreme fire weather (USDA-Forest Service, 2004).

Before 1900, low-intensity fires were common in the lower-elevation conifer and shrub communities of the East Walker River watershed. Historical fire frequency is estimated to be 15-20 years (USDA-Forest Service, 2004). Stand densities were controlled by frequent low- to moderate- intensity fires that killed smaller trees only. This burning resulted in fewer trees per acre and more space between tree canopies. At the lowest elevations of the watershed, large fire occurrence in the sage communities has been infrequent. Most of the fires in this area are lightning caused during storms with rainfall that limits the fire spread and size (USDA-Forest Service, 2004).

The Mount Jackson Fire burned more than 1,000 acres north of Bridgeport Reservoir in August 1996 (Review-Herald, 1996). The fire scars from the changes in vegetation remain visibly obvious after fifteen years.

A large fire burned on the west side of the Bridgeport Valley in late summer of 2011. The Buckeye Fire was ignited on September 25, 2011 by a lightning strike north of Buckeye Hot Springs. About 1,200 acres were burned between the valley floor and the ridgetop and between Buckeye Creek and Log Cabin Creek (**Figure 3**).

Figure 3: The Buckeye Fire of 2011 is a recent example of the potential for wildfires throughout the East Walker River watershed. (Rick Kattelmann)

Some of the wildfires within the East Walker River watershed are listed in the box below and mapped in **Map 8**: Wildfire History of the East Walker Watershed.

Table 10: Wildfires between 1953 and 2011

Year	Fire Name	Agency	Cause	GIS Acres
1953		USF	Unknown	122
1955		USF	Lightning	71
1959		USF	Lightning	101
1960	Summit	CDF	Unknown	611
1964		USF	Campfire	100
1964		USF	Miscellaneous	362
1966		USF	Lightning	19
1970		USF	Debris	4
1973		USF	Miscellaneous	189
1974		USF	Lightning	108
1977		USF	Lightning	352
1985		USF	Lightning	16
1985		USF	Lightning	117
1996	Mt. Jackson	USF	Lightning	857
2007	Conway	BLM	Lightning	89
2010	Potato	BLM	Lightning	632
2011	Buckeye	USF	Lightning	1045

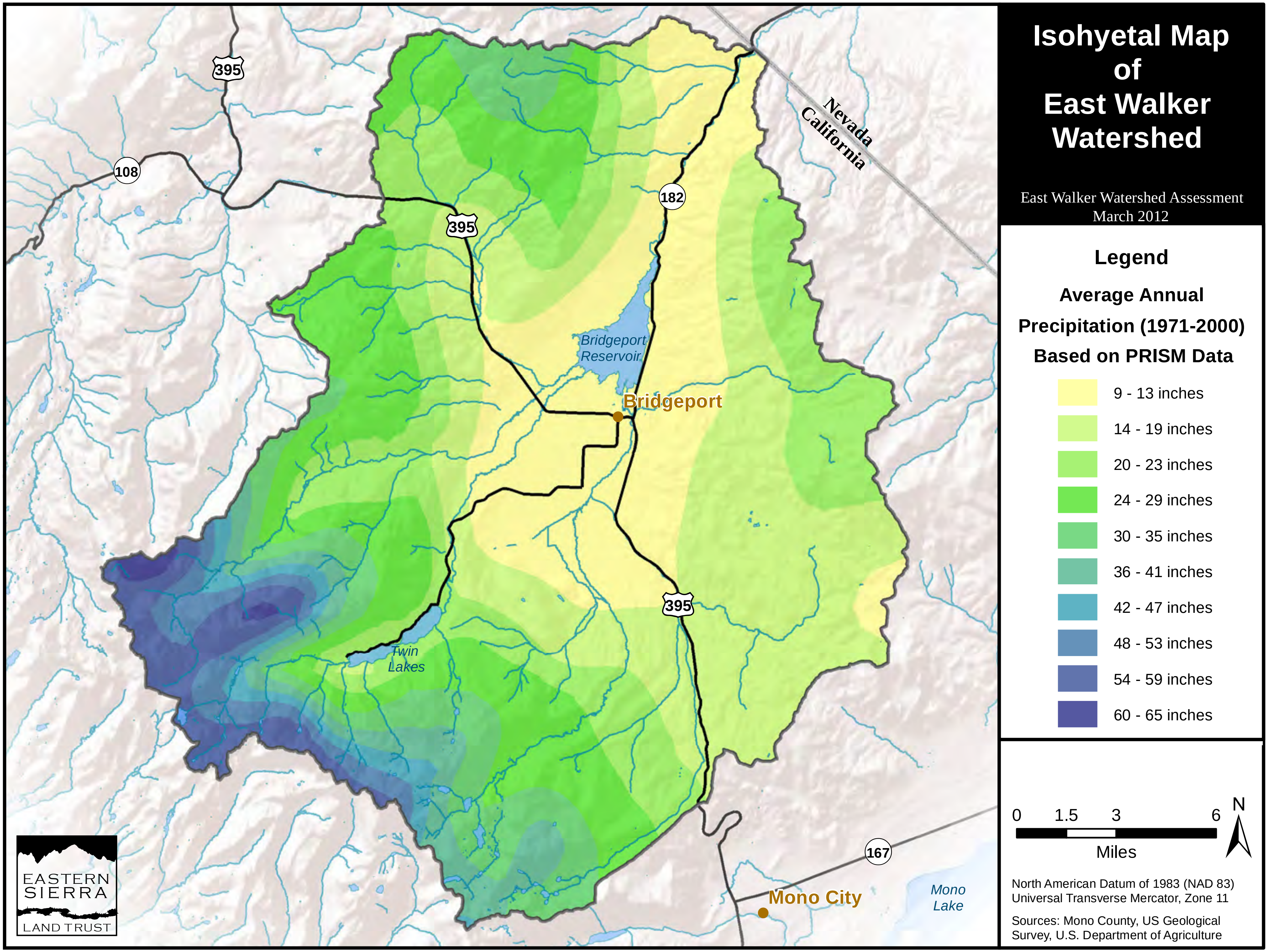
Source: State of California, Department of Forestry and Fire Protection, Fire and Resource Assessment Program (FRAP)

The following table (USDA-Forest Service, 2004) provides some fire regime intervals for ecosystems in which white fir occurs:

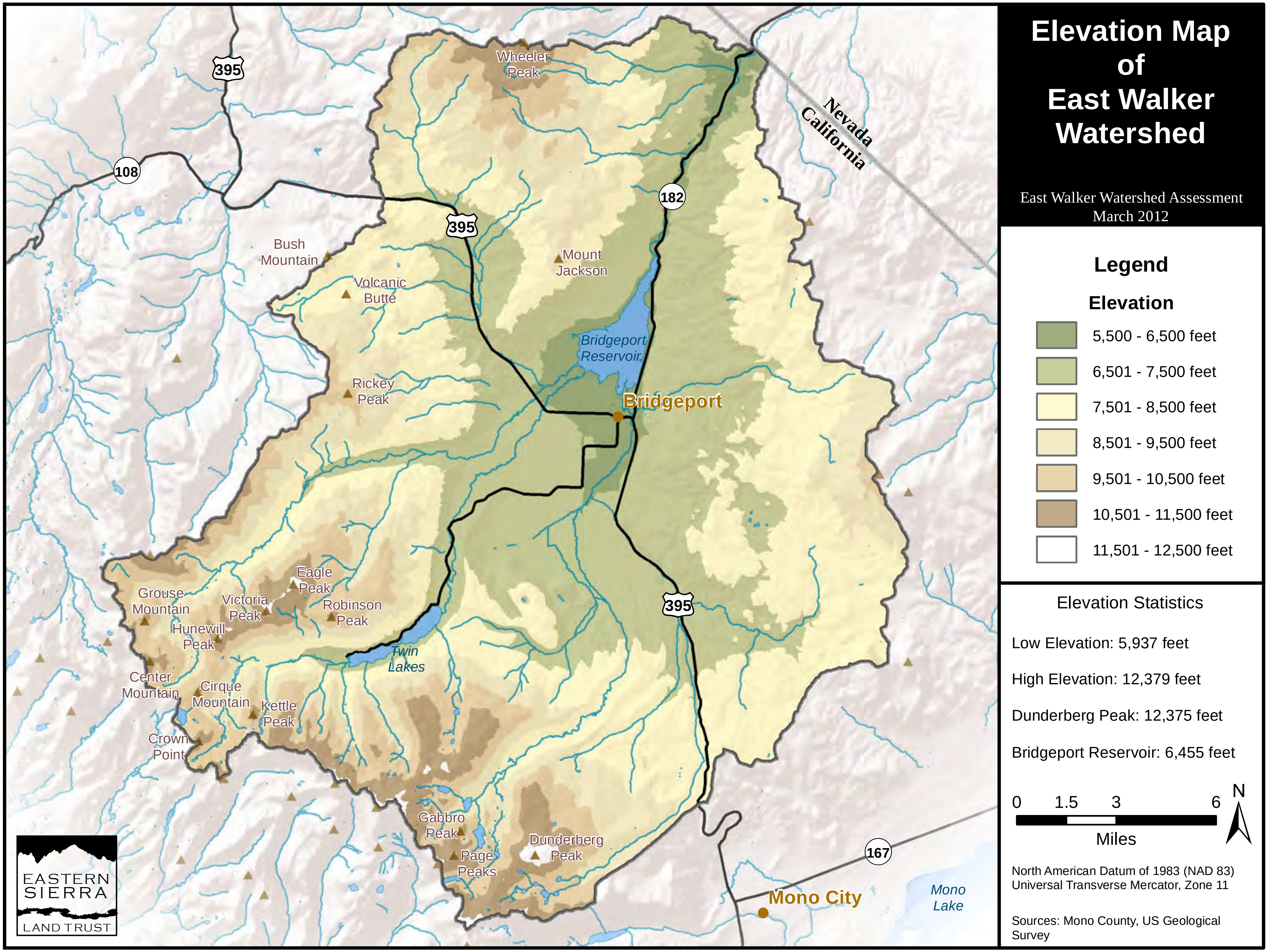
Table 11: Fire Return Intervals in the East Walker River Watershed

Community or Ecosystem	Dominant Species	Fire Return Interval (yrs)
curlleaf mtn mahagony	Cercocarpus ledifolius	13-1000
western juniper	Juniperus occidentalis	20-70
pinyon-juniper	Pinus-Juniperus spp.	<35
lodgepole pine	P. contorta var. murrayana	35-200
Jeffrey pine	Pinus jeffreyi	5-30
quaking aspen	Populus tremuloides	7-120

The Mono County Community Wildfire Protection Plan (Anchor Point Group, 2009) identified the Twin Lakes area as a community with an extreme level of wildfire risk. Since 2005, the Bridgeport Ranger District of the Humboldt-Toiyabe National Forest, the Twin Lakes Fire Safe Council, and homeowners have been cooperating on reducing fuel loads in and around the communities at Twin Lakes. The Fire Safe Council has treated more than 100 acres of private land since 2009 (USDA-Forest Service, 2011b). In 2011, the Forest Service began the environmental assessment work for a proposed fuel-reduction project at Twin Lakes. The goal of these treatments is to create vegetation of lower density that would have much less risk of catastrophic wildfire. More than 1,800 acres of forest and shrubland is proposed to be treated with mechanical thinning and prescribed fire (USDA-Forest Service, 2011b).



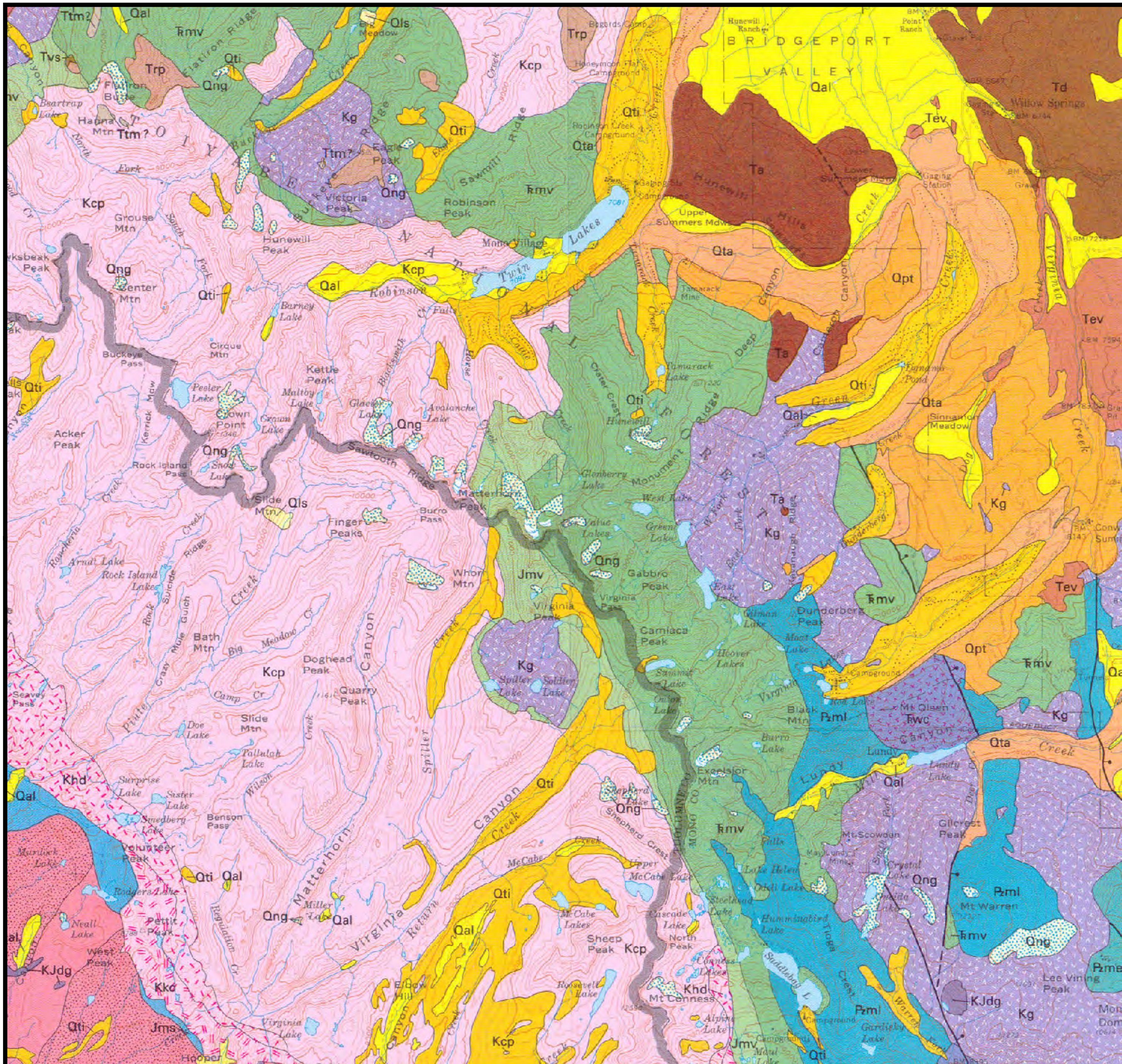
Map 3: Isohyetal Map of East Walker Watershed



Map 4: Elevation Map of East Walker Watershed

Geology Map of Upper East Walker Watershed

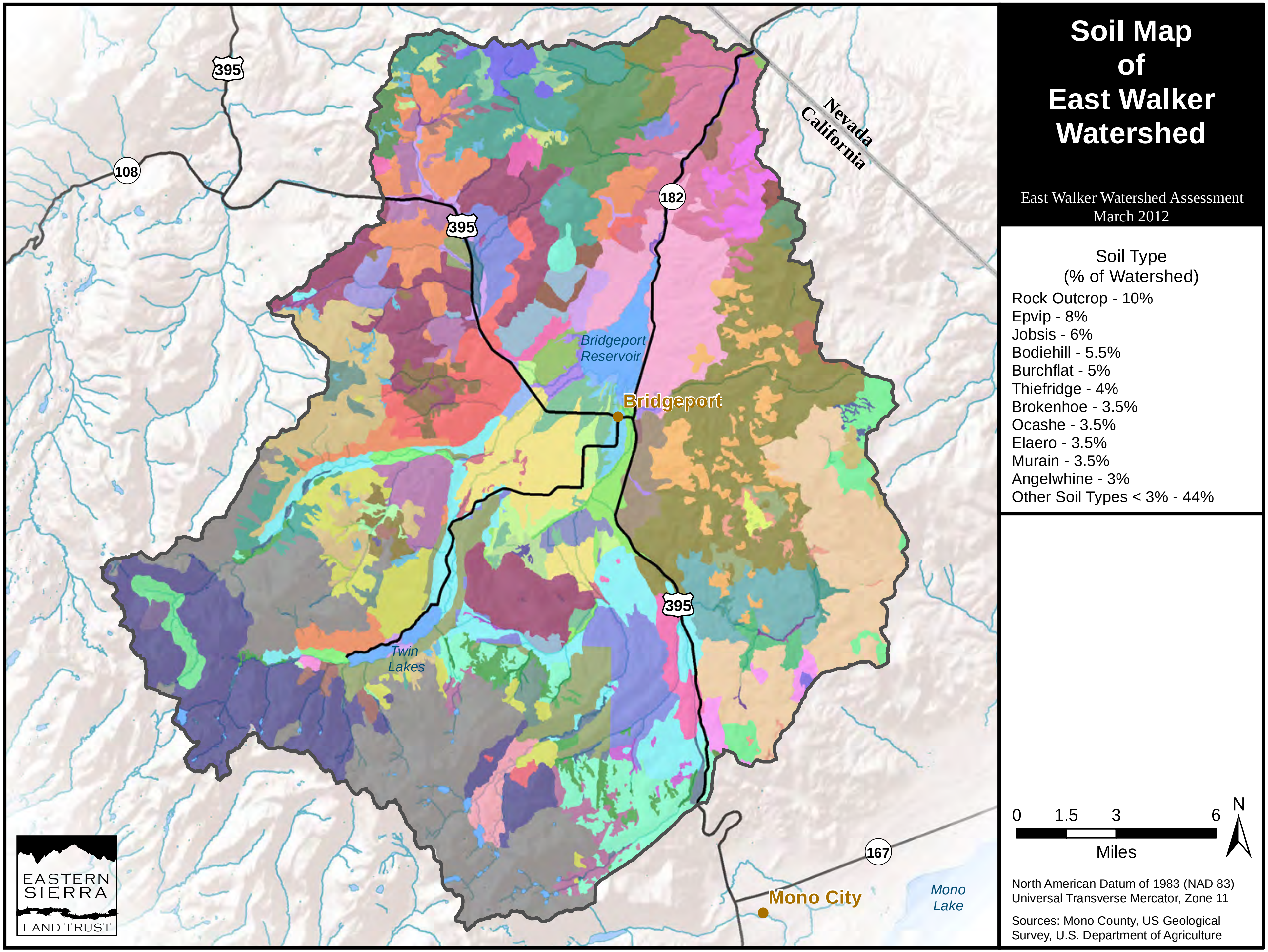
East Walker Watershed Assessment
March 2012



N

Sources: US Geological Survey

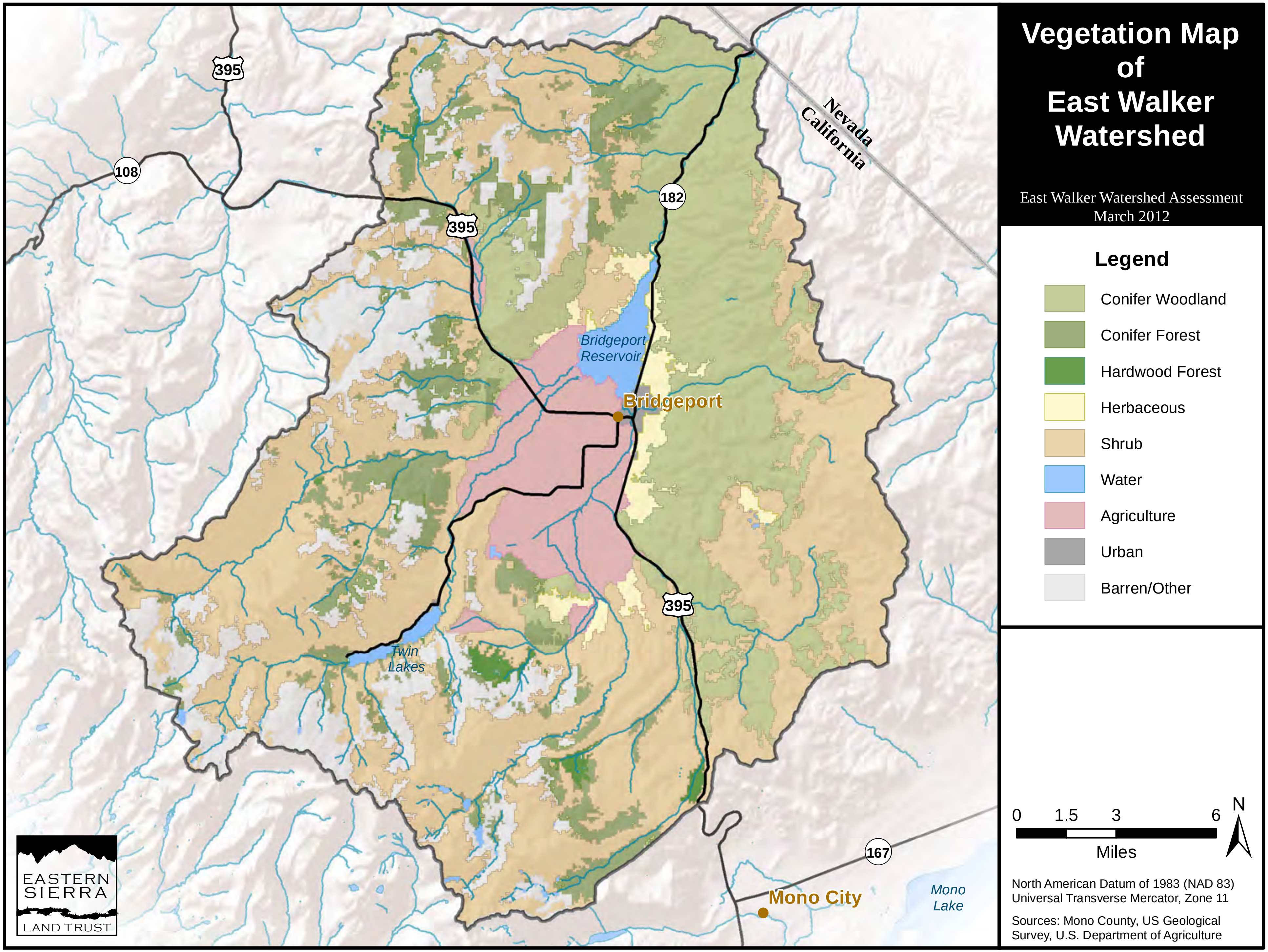
Map 5: Geology Map of Upper East Walker Watershed



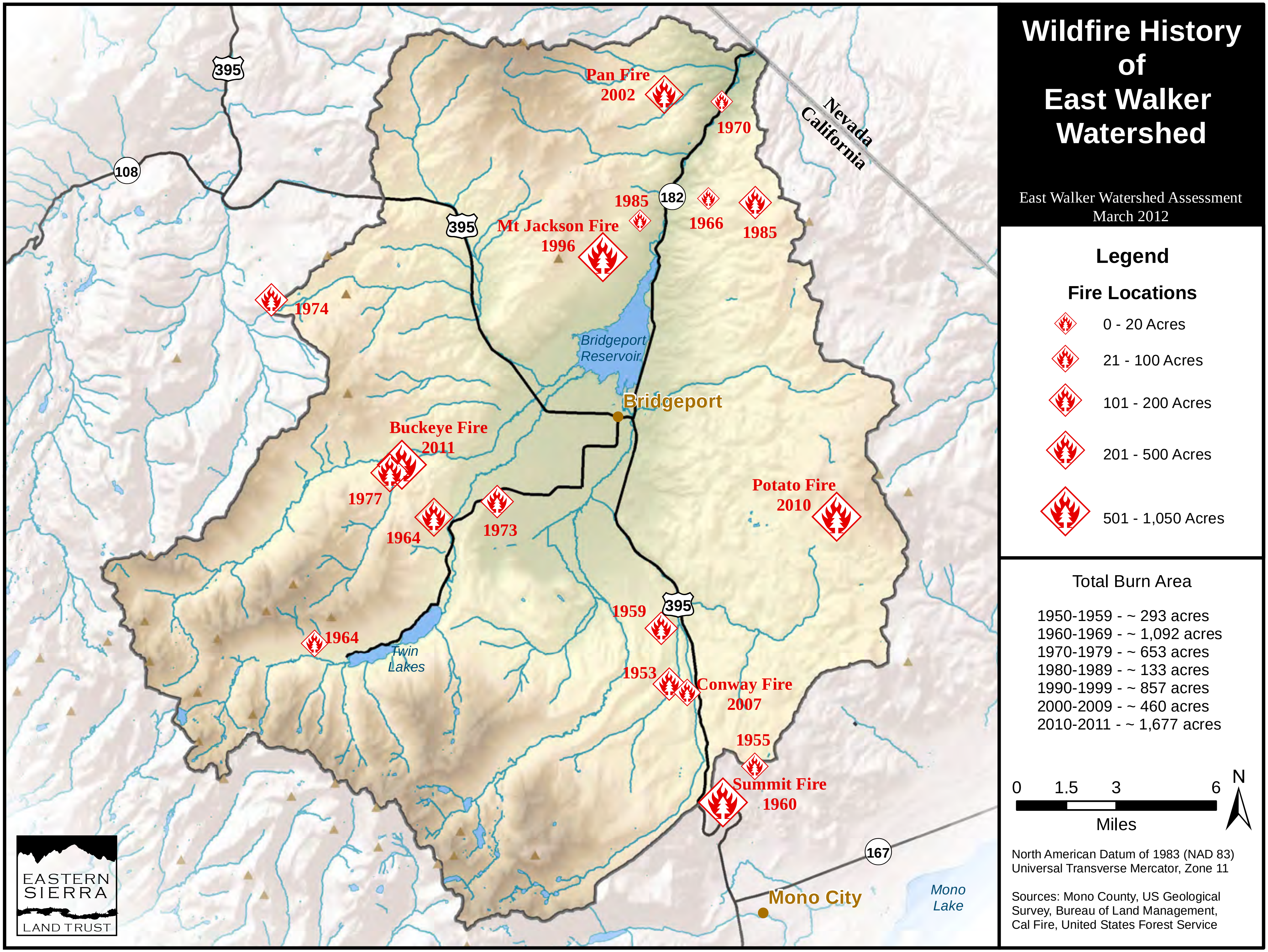
Map 6: Soil Map of East Walker Watershed

Soil Map of East Walker Watershed
Legend

- Adamatt
- Angelwhine
- Aquic Haplocryolls
- Aquic Torrifluvents
- Aquicambidic Haplodurids
- Ashflat
- Aspetill
- Aspocket
- Atastra
- Bodiehill
- Brokenhoe
- Buggin
- Burchflat
- Cloudburst
- Coldtree
- Dab
- Delhew
- Dogbed
- Dunderberg
- Eastwalker
- Elaero
- Epvip
- Fisherdig
- Floatybog
- Forsell
- Goodbye
- Grandridge
- Halfash
- Hardnut
- Hardtil
- Hawkinspeak
- Hawkridge
- Heenlake
- Hopeval
- Jobsis
- Joecut
- Joenchris
- Kiote
- Lastsummer
- Lavaspring
- Lonecabin
- Longdrive
- Loope
- Lostcannon
- Lunder
- Masonic
- Mostval
- Mountpatterson
- Murain
- Ocashe
- Oldgrade
- Pachic Argixerolls
- Pachic Haploxerolls
- Patididit
- Pinew
- Pullout
- Raindance
- Rock outcrop
- Rose Creek
- Roughridge
- Rubble land
- Seeya
- Shorthike
- Shree
- Sinnacut
- Sofgran
- Sonorapass
- Squishy
- Steerlay
- Steerstomped
- Stumpatil
- Sumeadow
- Sweetmount
- Tephzite
- Thiefridge
- Toejom
- Toiyabe
- Twojayay
- Uawda
- Vertic Palexerolls
- Water
- Waterpeak
- Willowak
- Windyridge



Map 7: Vegetation Map of East Walker Watershed



Map 8: Wildfire History of the East Walker Watershed

3. Riparian Areas and Wetlands

Although most of the riparian corridors at the higher-elevation portions of the Humboldt-Toiyabe National Forest are undisturbed (except by historic grazing), many of the riparian areas in lower valleys have been changed by road construction, grazing, and recreation. Roads follow many of the streams of the watershed for significant portions of the stream length and are often within the riparian zone. U.S. Highway 395 is immediately adjacent (within 100 feet) of Virginia Creek for 0.5 miles below the confluence of Clearwater Creek and is within a 100 feet of Swauger Creek for 0.8 miles. State Route 270 (Bodie Road) is within 100 feet of Clearwater Creek for 2.5 miles. State Route 182 is within 100 feet of the East Walker River below Bridgeport Reservoir for a total of 1.2 miles. GIS analyses determined that at least 50 Forest Service roads have portions of their route within 100 feet of some part of the following creeks: Virginia Creek, Tamarack Creek, Swauger Creek, Summers Creek, Robinson Creek, Murphy Creek, Long Valley Creek, Labrosse Creek, Harvey Creek, Green Creek, Fryingpan Creek, East Walker River, East Fork Swauger Creek, Eagle Creek, Dunderberg Creek, Dog Creek, Clearwater Creek, By-Day Creek, Buckeye Creek.

Analyses of GIS road and stream layers found that there are more than 360 road crossings of streams (perennial and intermittent). Additionally, more than 52 miles of road occur within 100 feet of perennial and intermittent streams within the East Walker River watershed. Although such road locations are often the only reasonable route for the road, riparian degradation is a cost of such of such locations. The high demand for recreation involving streams throughout the East Walker River watershed is recognized as an impact (of widely variable severity) to riparian habitat (e.g., USDA-Forest Service, 2010).

The largest areas of wetlands are flood-irrigated lands in the Bridgeport Valley (**Map 9**-**Map 16**). Most of these areas would not be classified as wetlands without the artificial application of water for more than a century. There are several sites labeled as meadows on Forest Service and U.S. Geological Survey maps (e.g., Sinnamon Meadow, Upper and Lower Summers Meadows, Mormon Meadow, etc.) that are obviously wetlands. Areas adjacent to and downstream of springs are likely to have some wetland characteristics and values. Although meadows without a road or obvious water development nearby can be assumed to relatively undisturbed (except for grazing), additional details and field observations are needed for an adequate evaluation. Wetlands adjacent to roads, structures, and engineered waterways can be assumed to be disturbed. Canals and irrigation ditches have both drained and created wetlands within the lower portions of the watershed.

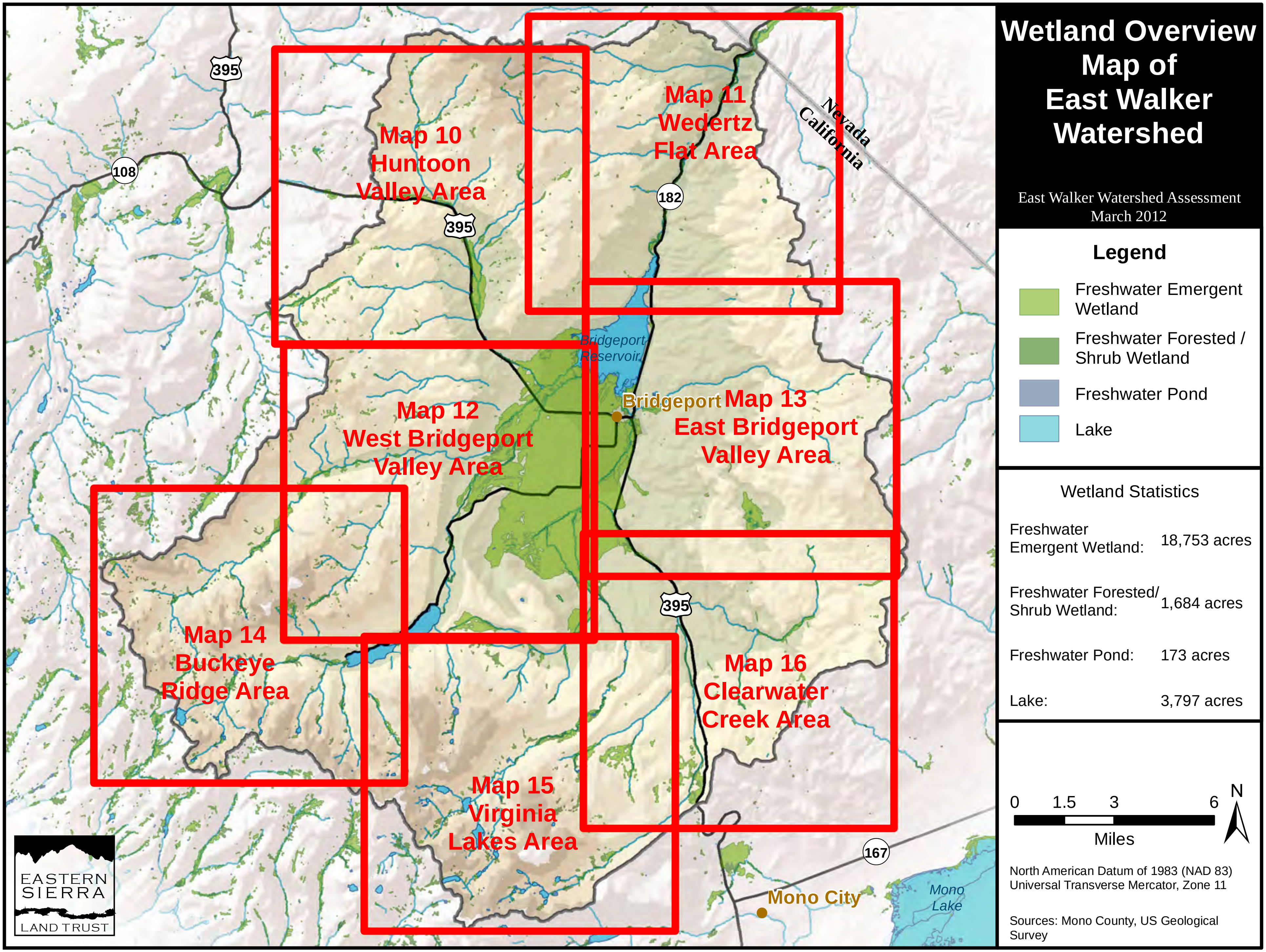
Typically, the riparian vegetation above 7,000 feet consists of willow (*Salix* sp.) and quaking aspen (*Populus tremuloides*) (USDA-Forest Service, 1989). Modoc-Great Basin Riparian Scrub is the main plant community found along and near the streams east of the Sierra Nevada forest zone. Willow (primarily narrow-leaf [*Salix exigua*] and yellow [*Salix lutea*]) is perhaps the most common member of this community along the tributaries to the East Walker River. Other associated species include big sagebrush (*Artemisia tridentata*), rubber rabbitbrush (*Chrysothamnus nauseosus*), wild rose (*Rosa woodsii*), golden currant (*Ribes aureum*), hoary sage (*Artemisia cana*), tarragon (*Artemisia dracunculus*), creeping wild-rye (*Leymus triticoides*), and various sedges (*Carex* spp.), rushes (*Juncus* spp.) and grasses (Bagley, 1997; Mono County Community Development Department, 2000).

The reach of Robinson Creek between Lower Twin Lake and the pastures of Bridgeport Valley is bordered by montane riparian woodland. The most common plants along this reach include Jeffrey Pine, quaking aspen, black cottonwood, mountain alder, creek dogwood, and willows (East Walker River Trustee Council, 2008).

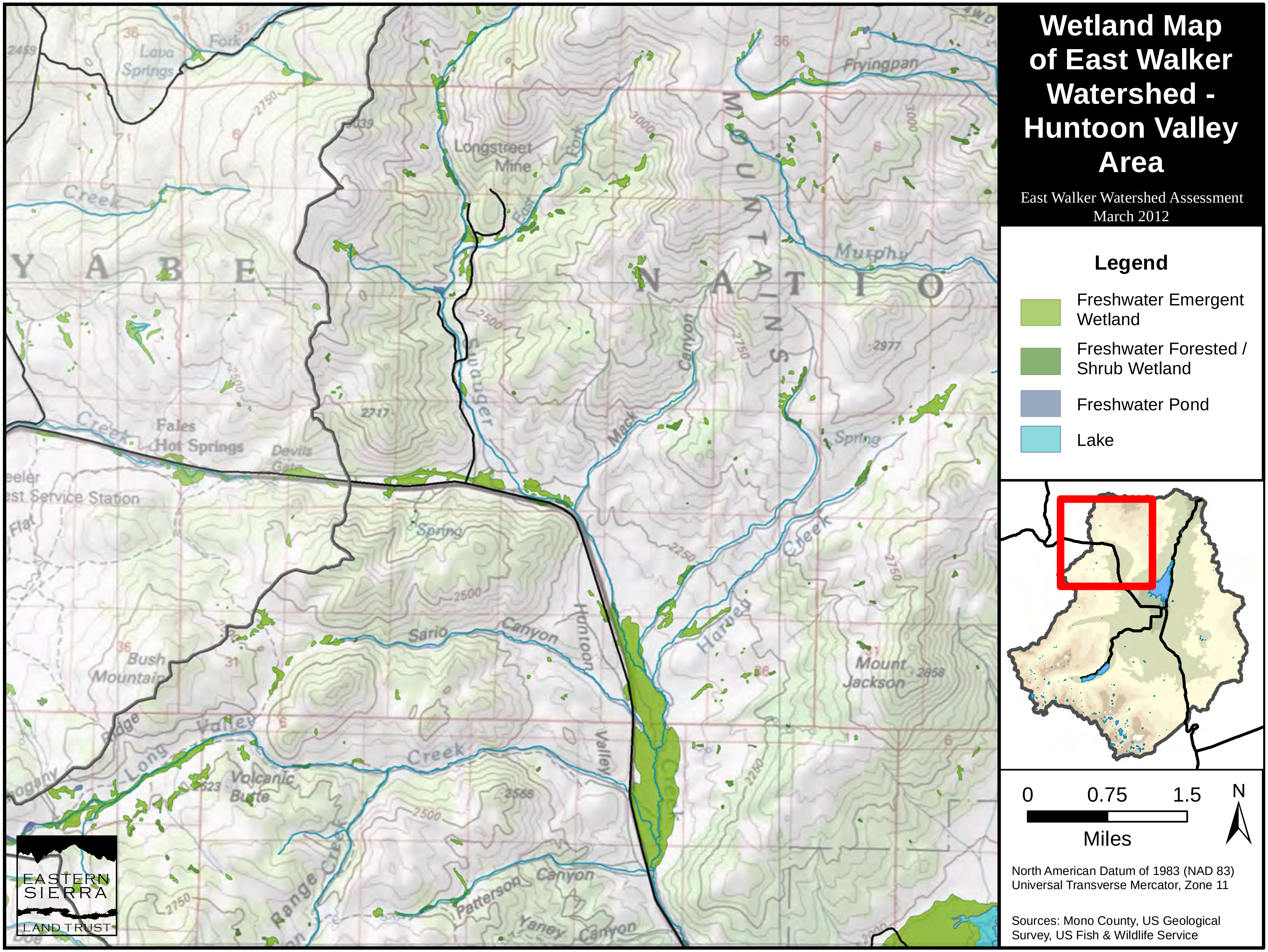
The East Walker River below Bridgeport reservoir has adjusted to the managed flow regime over the past 87 years. Reduced flood peaks, less total volume during the spring snowmelt period, and higher flows throughout summer are the principal influences from the dam. Riparian vegetation is probably much older and more dense than might be the case in the absence of the dam. Cottonwood (*Populus* sp.), birch (*Betula occidentalis*), arroyo willow (*Salix lasiolepis*), and wild rose are the most common species along this reach of the river (Howald, 2000).

Most of this riparian land just downstream of the Bridgeport Reservoir was conserved in 1994 through purchases by the Trust for Public Land and the Wildlife Conservation Board (Du Fresne, 1994). About 7.5 miles of the East Walker River was included in this parcel of 1,376 acres, which will be managed by the State of California for wildlife habitat and recreational fishing access (California Trout, 1994; Lewis, 1994). The Trust for Public Land also acquired an 80 acre parcel along Green Creek and traded it to the Bureau of Land Management in 1996 (Du Fresne, 1996a).

Large areas of the surface of Bridgeport Reservoir are covered by water smartweed (e.g., Ivey, 2004) during the summer.



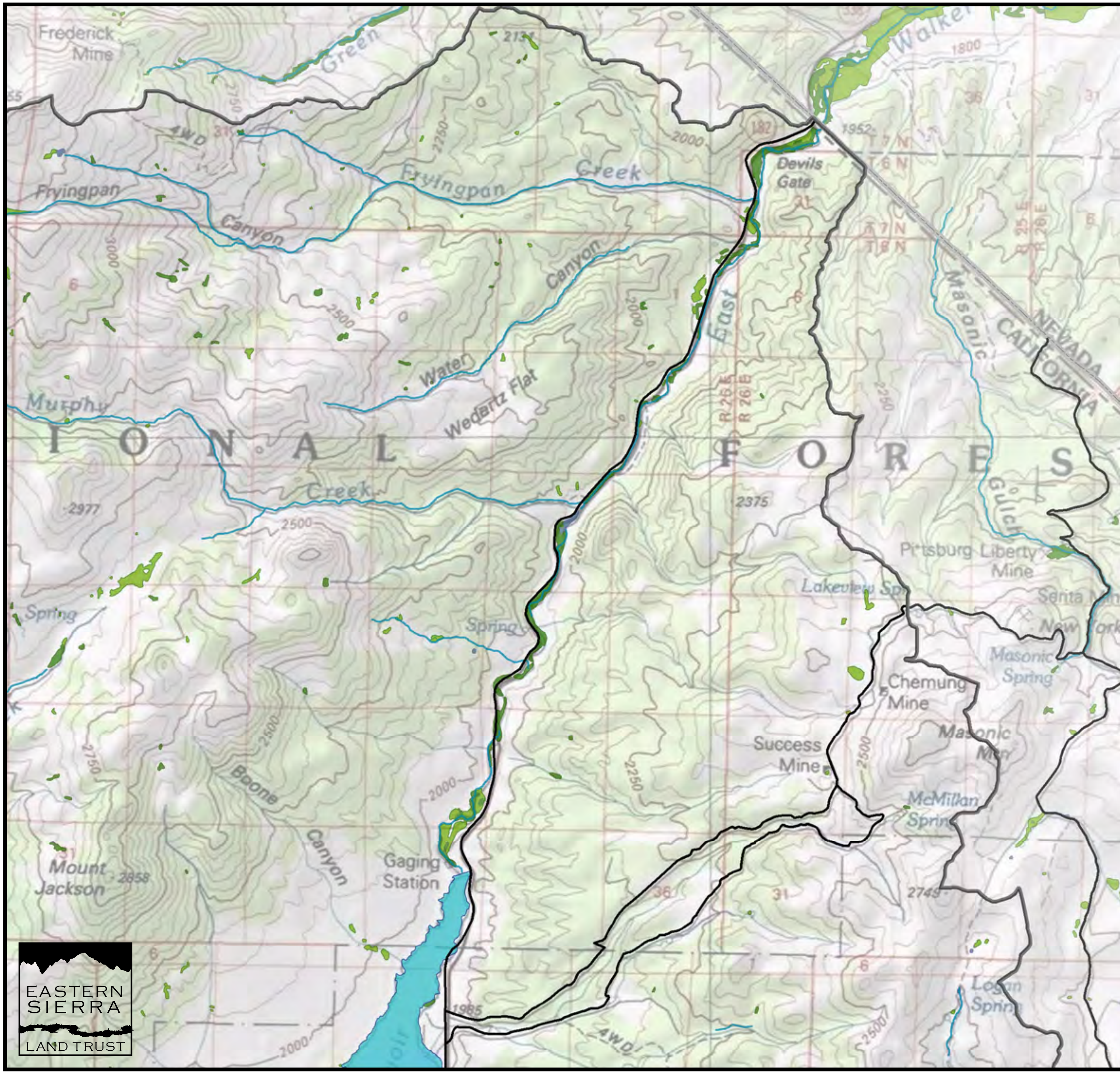
Map 9: Wetland Overview Map of East Walker Watershed



Map 10: Wetland Map of East Walker Watershed - Huntoon Valley Area

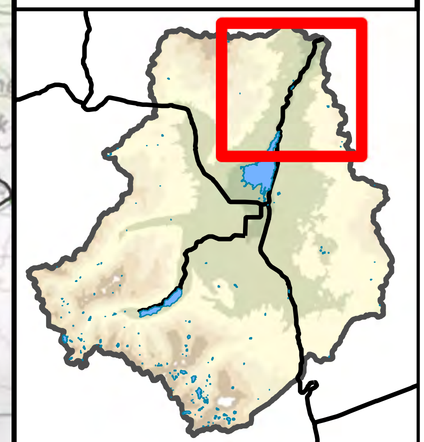
Wetland Map of East Walker Watershed - Wedertz Flat Area

East Walker Watershed Assessment
March 2012



Legend

- Freshwater Emergent Wetland
- Freshwater Forested / Shrub Wetland
- Freshwater Pond
- Lake

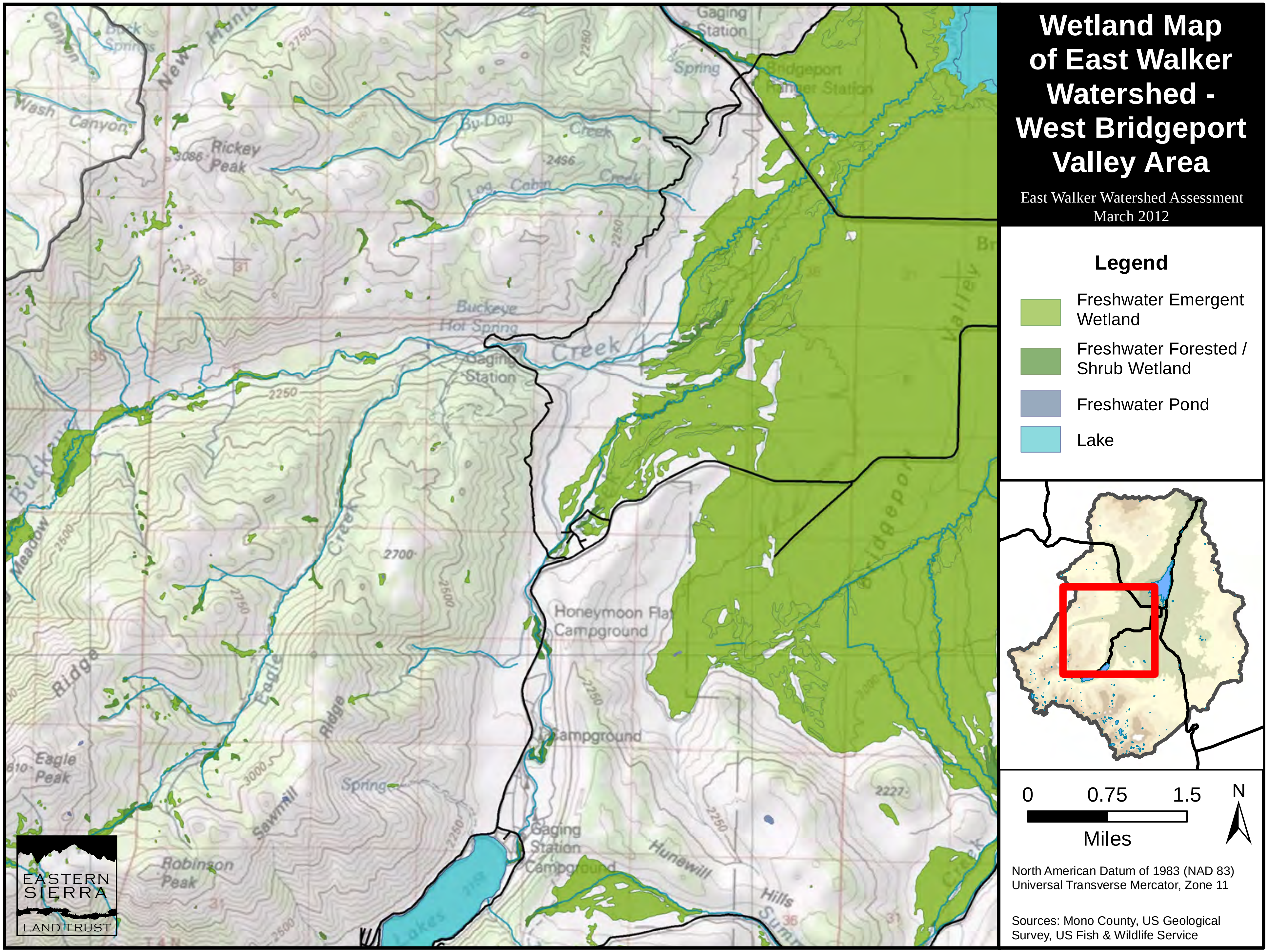


0 0.75 1.5
Miles
N

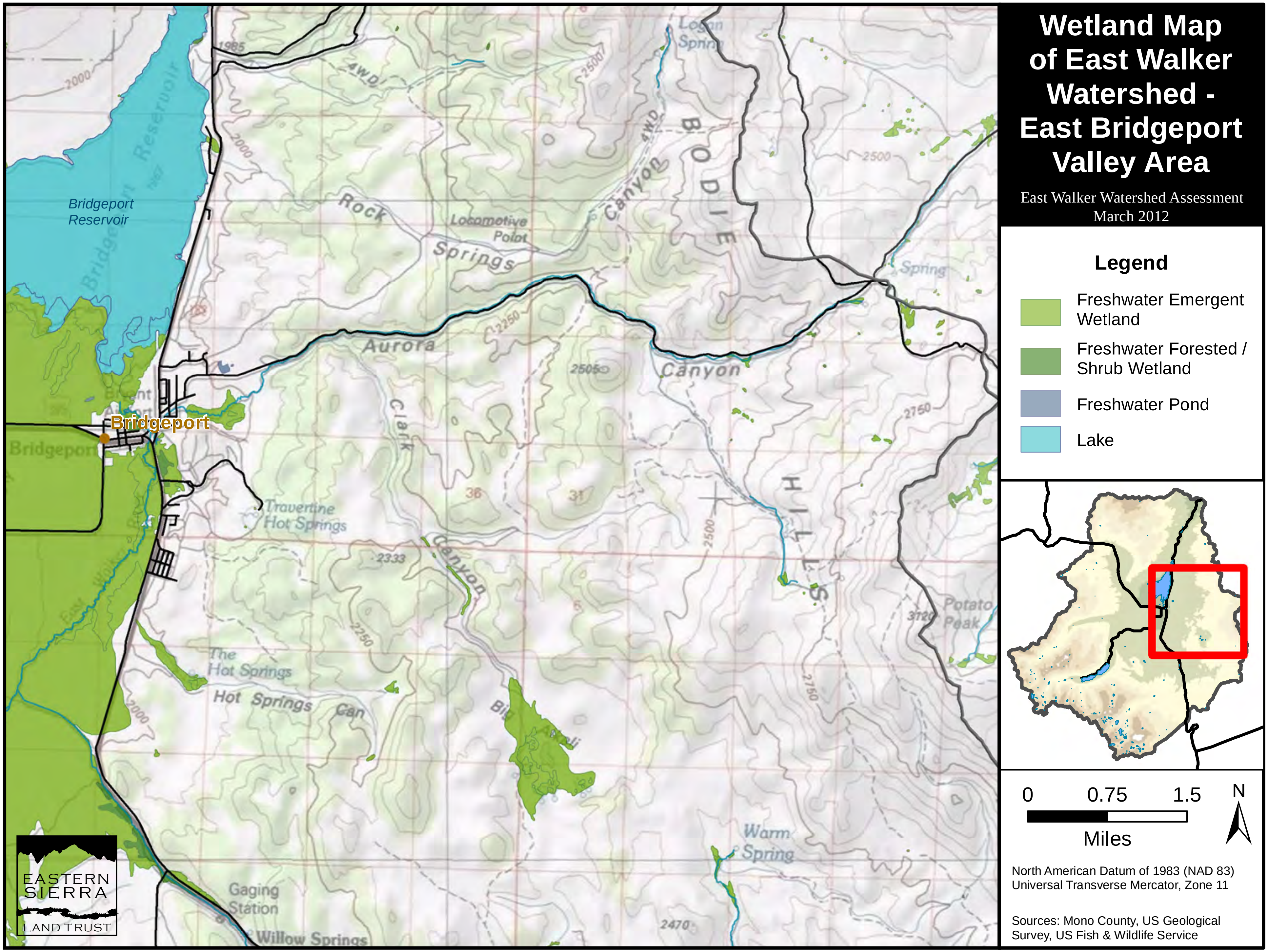
North American Datum of 1983 (NAD 83)
Universal Transverse Mercator, Zone 11

Sources: Mono County, US Geological Survey, US Fish & Wildlife Service

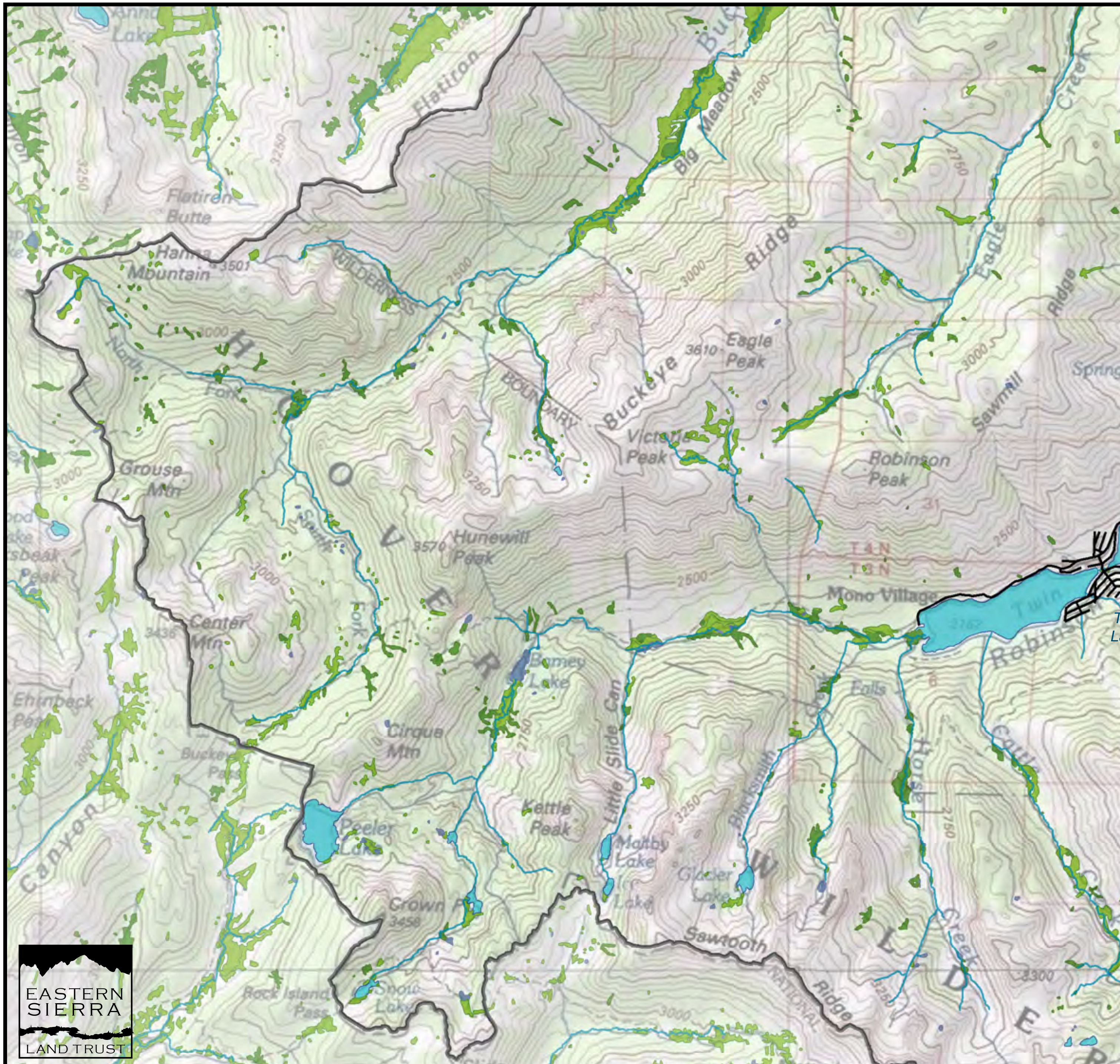
Map 11: Wetland Map of East Walker Watershed - Wedertz Flat Area



Map 12: Wetland Map of East Walker Watershed - West Bridgeport Valley Area



Map 13: Wetland Map of East Walker Watershed - East Bridgeport Valley Area

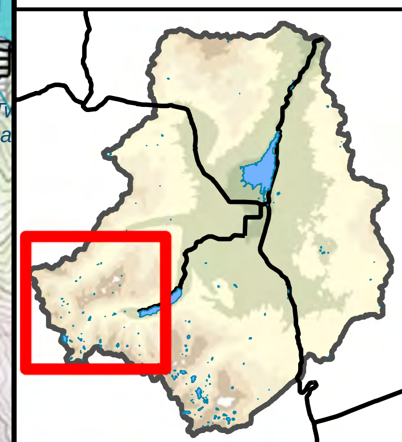


Wetland Map of East Walker Watershed - Buckeye Ridge Area

East Walker Watershed Assessment
March 2012

Legend

- Freshwater Emergent Wetland
- Freshwater Forested / Shrub Wetland
- Freshwater Pond
- Lake

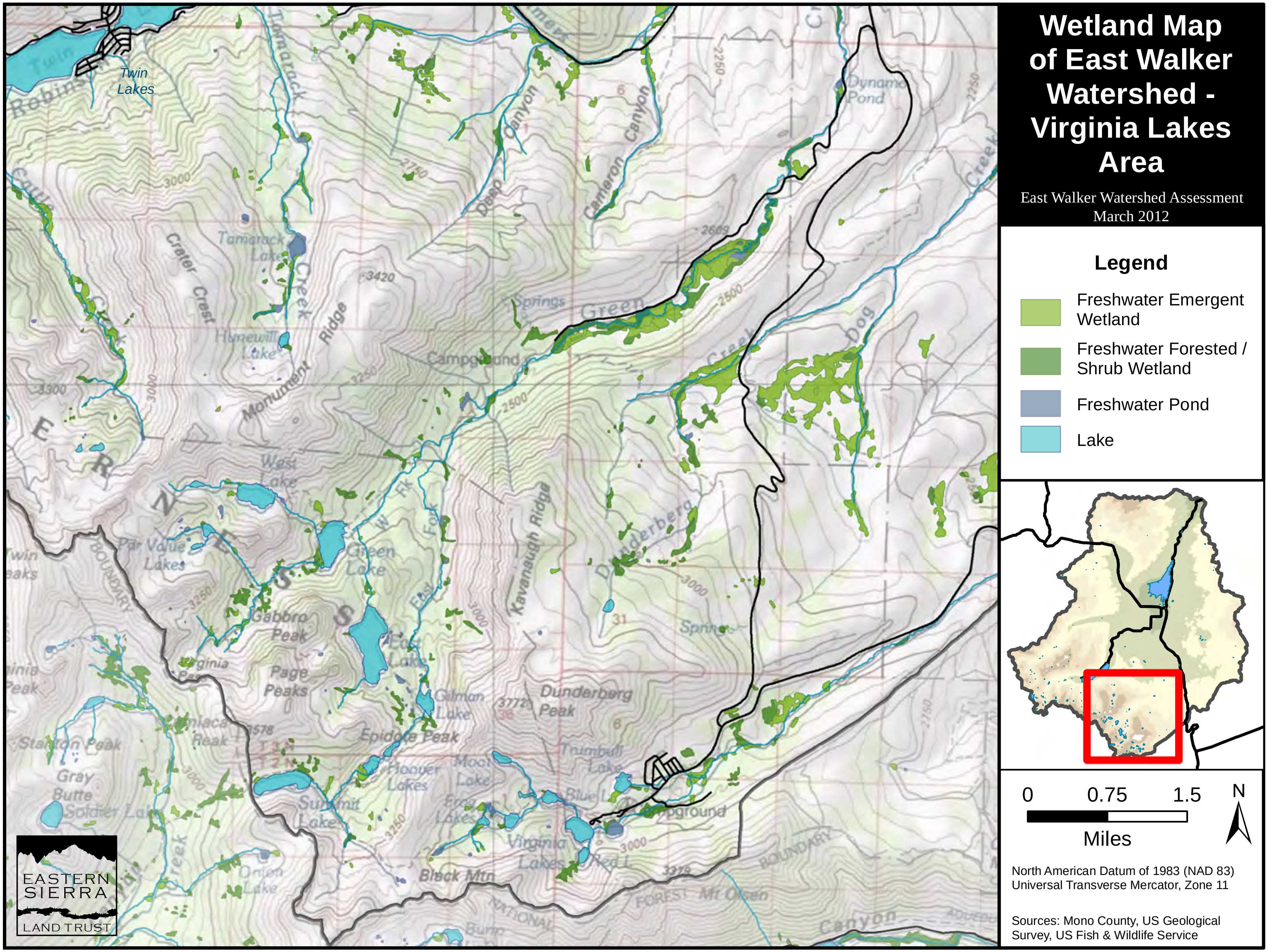


0 0.75 1.5
Miles
N

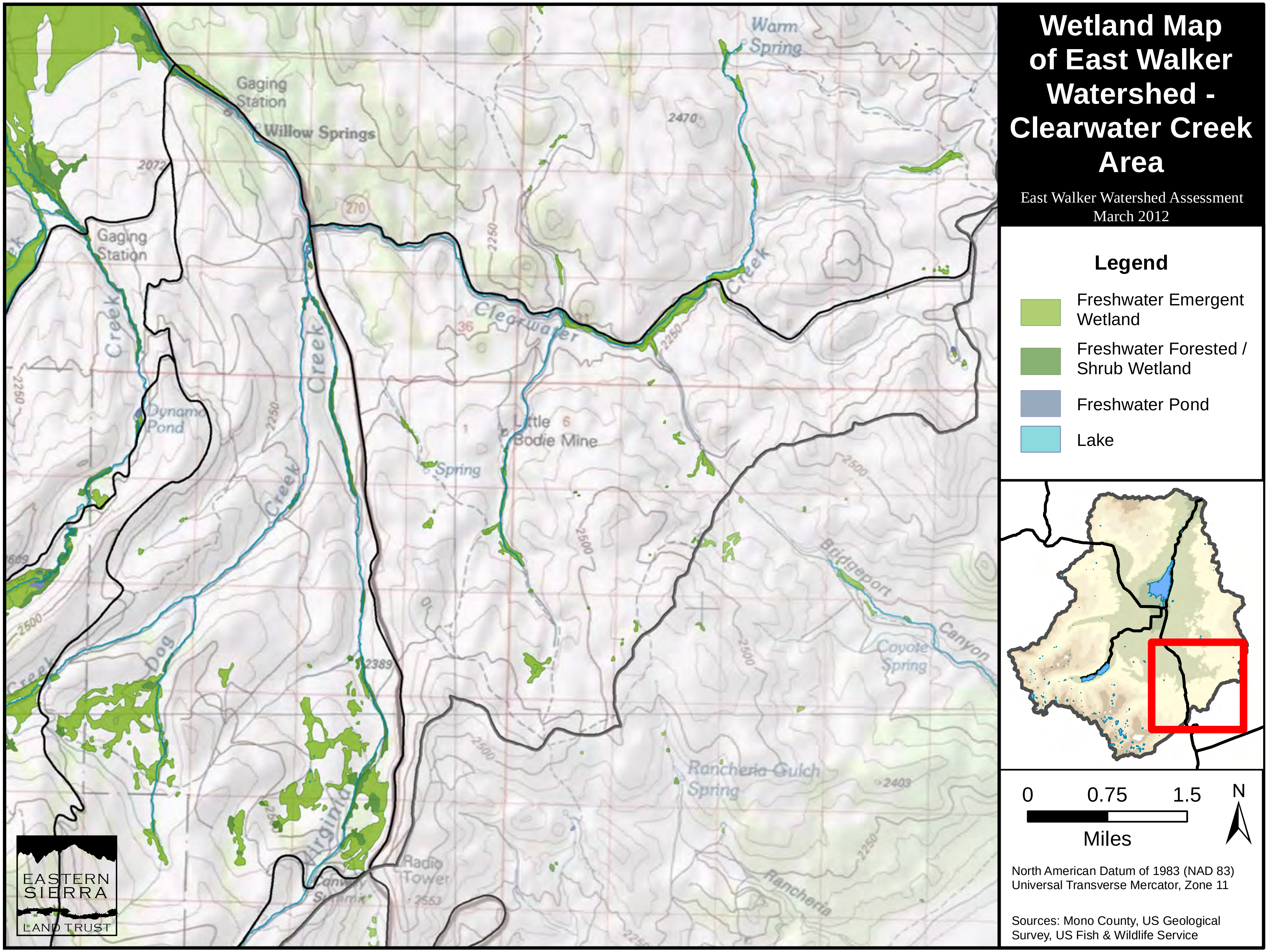
North American Datum of 1983 (NAD 83)
Universal Transverse Mercator, Zone 11

Sources: Mono County, US Geological Survey, US Fish & Wildlife Service

Map 14: Wetland Map of East Walker Watershed - Buckeye Ridge Area



Map 15: Wetland Map of East Walker Watershed - Virginia Lakes Area



Map 16: Wetland Map of East Walker Watershed - Clearwater Creek Area

4. Fish and Wildlife

Fish

The East Walker River and many of its tributaries have become well known for trout fishing. Rainbow trout, brook trout, and brown trout have been introduced and stocked in waters of the East Walker River and are well established as the dominant fish species. The East Walker River below Bridgeport Reservoir has became legendary during the 1950s, 1960s, and 1970s as one of the premier river reaches in the West for trout fishing.

Although trout began to be introduced into many Sierra Nevada lakes as early as the mid-1800s, the extent and numbers of non-native trout increased dramatically when aerial stocking of trout became widespread in the 1950s. Brown trout and brook trout compete with native Lahontan cutthroat trout for food and habitat, and rainbow trout spawns at the same time as the Lahontan cutthroat trout, which can produce hybrid strains (e.g., Gerstung, 1988; Milliron, et al., 2004). Many strains of rainbow trout and brook trout have been planted in lakes and tributaries of the East Walker River, and many of these trout have successfully spawned, producing "wild trout" progeny. The term "wild trout" is distinct from "native trout," which refers to trout that existed in streams prior to European settlement and have a defined natural range without human intervention (Milliron, et al., 2004). Rainbow trout continue to be stocked in Bridgeport Reservoir by the California Department of Fish and Game (Sharpe, et al., 2007).

Other fish present in streams of the East Walker River watershed include several native species found at lower elevations (mountain whitefish, mountain sucker, Tahoe sucker, Paiute sculpin, Lahontan tui chub, Lahontan redside, and speckled dace) and introduced rainbow trout, brook trout, and brown trout (Sada, 2000; Umek and Chandra, 2010). Bridgeport Reservoir is known to contain rainbow and brown trout, Sacramento perch, green sunfish, carp, tui chub, Lahontan speckled dace, Tahoe sucker, and mountain sucker (California Regional Water Quality Control Board--Lahontan Region, 2003). Kokanee salmon are found in Upper and Lower Twin Lakes (Barbier, 1995). Brown trout and rainbow trout from the Mason Valley Fish Hatchery are stocked in the East Walker River (East Walker River Trustee Council, 2008).

Carp were introduced into the East Walker River in the late 1970s by unknown persons (Lewis, 1994). The carp quickly damaged the trout fishery, and the California Department of Fish and Game believed the only solution was to poison all the fish with Rotenone and start over with hatchery-raised trout (Lewis, 1994).

Water releases from Bridgeport Reservoir have occasionally been small enough to damage the fishery in the East Walker River below the dam (Mono County, 1992).

Lahontan Cutthroat Trout

The Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) is the prominent species of native fish in the East Walker River basin. The species was once widespread throughout much of the Walker River system. Although periodically extirpated from parts of the basin by localized natural events, the fish were able to disperse from other habitats and repopulate disturbed areas as a successful survival mechanism for the species (e.g., Dunham, et al., 1997). Prior to dams and other water-management activities, cutthroat trout from Walker Lake were reported as far upstream as Robinson Creek, above the Bridgeport Valley (California Department of Water Resources, 1992) and inhabited Upper and Lower Twin Lakes (Coffin and Cowan, 1995). Construction of the Bridgeport Reservoir dam cut off access to spawning habitat in the upper East Walker River and its tributaries. Lower Twin Lake once supported wild cutthroat trout and was the only lake in the basin besides Walker Lake occupied by Lahontan cutthroat trout (East Walker River Trustee Council, 2008). A remnant population in the East Walker River below the Bridgeport Reservoir was used reintroduce the fish in other portions of the river system (Stockwell, 1994; cited by Sharpe, et al., 2007). The original range of the Lahontan cutthroat trout has been reduced by over 90 percent by changes in streamflows and channel conditions and overfishing (Knapp, 1996). Predation by, competition with, and hybridization with introduced trout have also greatly impacted the remaining groups of these fish (Gerstung, 1988). Lahontan cutthroat trout were not found in any of the eight locations sampled throughout the entire Walker River basin during electroshocking samplings in 2007 and 2008 (Umek and Chandra, 2010).

A wide variety of factors have contributed to the decline of Lahontan cutthroat trout throughout its original range: competition and hybridization with introduced trout species; alteration of stream channels and riparian zones; loss of spawning habitat because of sedimentation and pollution from historic logging, mining, and grazing; fishing and other recreational impacts; loss of connectivity between habitats; and habitat alteration from road construction and maintenance (USDA-Forest Service, 2010).

As the once huge population in Walker Lake has declined drastically with increasing salinity, efforts have begun to ensure survival of the species in streams of the upper watershed. When only a few isolated populations could be found, the Lahontan cutthroat trout was listed as endangered under the Endangered Species Act in 1970 and then reclassified as threatened in 1975. The fragmentation of habitat leading to the isolation of small groups of fish is a primary concern.

Lahontan cutthroat trout mainly feed on drifting aquatic and terrestrial insects, but will also eat bottom-dwelling insect larvae, crustaceans, and snails. Within lakes, smaller trout feed primarily on surface insects and zooplankton and larger trout feed on other fish. Lahontan cutthroat trout spawn in streams between April and July. Appropriate spawning gravels found in riffles and other areas of rapid flow contain open-pore space without silt and are well oxygenated. The temperature of the stream should be less than 57°F from April through July for successful reproduction. During the summer, water temperatures should remain less than 72°F (USDA-Forest Service, 2004).

Lahontan cutthroat trout tolerate higher water temperatures, lower concentrations of dissolved oxygen, and higher salinity levels than almost any other trout in North America (Sada, 2000).

By-Day Creek, a tributary to Buckeye Creek, is believed to contain the last pure native Lahontan cutthroat trout population in the Walker River basin (e.g., Dodge, 1992). By-Day Creek was never stocked with other species of fish, and Lahontan cutthroat trout from the small creek are used as brood stock for attempts at reestablishing the species in other parts of the Walker River basin (Gerstung, 1988; Walker River Basin Recovery Implementation Team, 2003). The size of the population in By-Day Creek was estimated from electrofishing at about 1,000 in 1986, but subsequent drought conditions probably reduced the population to about 250 in the early 1990s (Dodge, 1992). Much of the upper watershed of By-Day Creek is owned by the California Department of Fish and Game and has been managed as a refuge for Lahontan cutthroat trout since 1979.

Box 1: Recovery of Lahontan Cutthroat Trout in Tributaries to the East Walker River

Lahontan cutthroat trout was initially listed as an endangered species in 1970. The classification was changed to threatened in 1975 to improve management and permit some angling in waters with adequate local populations. A recovery plan (Coffin and Cowan, 1995) was issued by the U.S. Fish and Wildlife Service in 1995, and a "Short-Term Action Plan" focused on the Walker River basin (Walker River Basin Recovery Implementation Team, 2003) followed eight years later. This local action plan determined that the various life stages and year classes of Lahontan cutthroat trout historically used different portions of the river system as interconnected habitat. This plan further recognized that development of water and other resources have fragmented the habitat so much that recovery to the pre-settlement period is just not possible.

The Short-Term Action Plan for the Walker River basin (Walker River Basin Recovery Implementation Team, 2003: page 4) recommended the following criteria to evaluate successful recovery of the species:

1. A self-sustaining, networked Lahontan cutthroat trout population composed of wild, indigenous strains, established in interconnected habitat, i.e., in streams, lakes, mainstem and tributaries of the Walker River basin.
2. Connectivity exists between suitable spawning and rearing habitats to support natural reproduction and recruitment, to restore self-sustaining laustrine Lahontan cutthroat trout in lakes, mainstem and tributaries of the Walker River basin.
3. A self-sustaining lacustrine population is naturally reproducing with an age class structure consisting of at least four age classes, a stable or increasing population size supported by documented reproduction and recruitment. These conditions must be demonstrated to have been met for a minimum period of 20 years.
4. Water is obtained through water right purchases or other means to protect and secure a stable Walker Lake ecosystem and meet life history and habitat requirements of Lahontan cutthroat trout.
5. A flow regime for the mainstem Walker River is implemented which facilitates Lahontan cutthroat trout migration, life history, and habitat requirements.
6. A commitment is secured from respective responsible entities operate and maintain reservoirs and fish passage facilities within the basin in a manner that facilitates migration and reproductive behavior of Lahontan cutthroat trout.
7. Threats to Lahontan cutthroat trout and its habitat have been reduced or modified to a point where they no longer represent a threat of extinction or irreversible population decline.

As strategies for recovery were considered, the impracticalities of reestablishing Lahontan cutthroat trout in the main stems of the Truckee, Carson, and Walker rivers under current habitat conditions and competing fisheries interests were obvious (Nevada Division of Wildlife, 2000). Instead, the fish will be raised in hatcheries and stocked in reaches of smaller tributaries to the three main rivers that have physical barriers to other fish. Nevertheless, the Lahontan cutthroat trout recovery plan (Coffin and Cowan, 1995) recommends removal of non-native trout from selected stream segments as a critical recovery strategy. The non-native fish are eliminated from the stream reach by electrofishing, gill-netting, or poisoning with rotenone. After the reach is observed to be fishless for two or three years, Lahontan cutthroat trout from a hatchery will be planted and allowed to reestablish for a couple of years before the stream is opened to fishing. This process is, of course, not very popular with anglers because some stream reaches may be closed to fishing for several years.

There are also practical and legal difficulties for the land management agencies (Forest Service or Bureau of Land Management) once a threatened species reoccupies its former habitat. Beaver dams have been a physical impediment to Lahontan cutthroat trout re-establishment on some streams. As of 2011, the author of this assessment is unaware of any plans for removal of non-native fish within the East Walker River watershed.

As of 1995, there were three populations of Lahontan cutthroat trout in the East Walker River basin (Coffin and Cowan, 1995). An endemic population occurs in By-Day Creek, and the trout have been introduced to Murphy and Bodie Creeks. Suitable habitat in these three streams totals about seven miles.

Endemic Fishes

Endemic fish surveys of the East Walker River watershed were conducted in 1972, 1973, and 1978 by the California Department of Fish and Game. Prior to these years endemic fish species were known to inhabit the East Walker River watershed, but the distribution and extent of each population was unknown.   Field crews using backpack electroshocker units sampled 50- to 100-yard sections of stream channel in all streams for the purpose of locating endemic fish species. These were not population censuses, rather a sampling of species found in each stream (California Department of Fish and Game, 1979).

Tahoe sucker (*Catostomus tahoensis*), speckled dace (*Rhynicthys osculus robustus*), Lahontan redside (*Richardsonius egregius*), Paiute sculpin (*Cottus beldingi*), and mountain whitefish (*Prosopium williamsoni*) are known to inhabit waters of the East Walker River (Sada, 2000; East Walker River Trustee Council, 2008).

Ice formation in streams of the eastern Sierra Nevada is regarded as a limiting factor on fish survival. Ice on the bed and banks of the channel as well as ice on the surface reduces flow, habitat volume, and food resources. Overhanging banks, thick riparian vegetation, and higher streamflow tend to minimize the formation of ice in stream channels. Channel ice as well as high snow banks along a channel can also influence erosion processes if flow increases suddenly while ice and snow are present.

Concern about New Zealand mud snails led to the denial of stocking permits to the Alpers Ranch hatchery in early 2005 by the California Department of Fish and Game and the Nevada Division of Wildlife (Reed, 2005b), causing public confusion and frustration.

Amphibians

The upper East Walker River watershed provides important habitat for Yosemite toad (*Bufo canorus*) and mountain yellow-legged frog (*Rana muscosa*) (USDA-Forest Service, 2004). Pacific tree frog (*Hyla regilla*) is also presumed to inhabit the higher elevation areas of the watershed because it is known in the adjoining West Walker River watershed. The Mount Lyell salamander (*Hydromantes platycephalus*) may occur above Twin Lakes (Sharpe, et al., 2008) but specific observations have not been reported.

Amphibian populations are assumed to be declining in the East Walker River basin as is the case in most of the Sierra Nevada (e.g., Jennings, 1996). In past decades, anecdotal accounts suggested that frogs and toads were very common, abundant, and widespread. During the 1980s, biologists began to note that amphibians were becoming relatively uncommon and detected diseases and deformities that have not been noticed or at least widely described in the past. A variety of factors appear to contribute to the observed declines of amphibians in the Sierra Nevada, including natural and/or introduced diseases (Berger et al. 1988; Fellers et al. 2001), the introduction of non-native fishes into originally fishless habitats (Bradford, 1989; Bradford et al. 1993; Jennings, 1996; Knapp, 1996; Knapp et al., 2000), and deposition of airborne pesticides and residues from agriculture in the Central Valley.

The Yosemite toad is found in a wide variety of high mountain wet meadows, lakes, springs, and small ponds. They are most commonly found in shallow, warm-water areas in habitats surrounded by lodgepole or whitebark pine. They inhabit thick meadow vegetation and patches of low willows. Yosemite toads are found from 6,400-11,300 feet elevation. The Yosemite toad is a California Species of Special Concern because it experienced large range-wide population declines. The species is considered "warranted but precluded" by the U.S. Fish and Wildlife Service for listing as a Threatened or Endangered species. The interactions between fish and Yosemite toads appear less problematic than in the case of mountain yellow-legged frogs, because the toads commonly use ephemeral waters for breeding and live mostly on land as adults (Milliron, et al., 2004).

Mountain yellow-legged frogs historically inhabited ponds, tarns, lakes, and streams from 4,500 to over 12,000 feet. Tadpoles are primarily herbivores, grazing on algae, diatoms, and detritus in the aquatic environment. Adults eat invertebrates but also take tadpoles of other frogs. Over-wintering habitat condition is important for both tadpoles and adults. Tadpoles do not turn into frogs in their first year and may spend 2-3 winters in aquatic habitats (USDA-Forest Service, 2004). Mountain yellow-legged frogs were once described (Grinnell and Storer, 1924) as the most abundant amphibian species in the Yosemite area (Knapp, 1996). The species is now considered "warranted but precluded" by the U.S. Fish and Wildlife Service for listing as a Threatened or Endangered species.

Wildlife

Mammals known to inhabit portions of the East Walker River watershed include mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), mountain lion (*Felis concolor*), striped skunk (*Mephitis mephitis*), Sierra Nevada mountain beaver (*Aplodontia rufa*), pygmy rabbit (*Brachylagus idahoensis*), sagebrush chipmunk (*Eutamias minimus*), chickaree (*Tamiasciurus douglasii*), Sierra Nevada golden mantled ground squirrel (*Callospermophilus lateralis*), Great Basin kangaroo rat (*Dipodomys microps*), western harvest mouse (*Reithrodontomys megalotis*), pinyon mouse (*Peromyscus truei*), and deer mouse (*Peromyscus maniculatus*) (Dodge, 1992; Mono County Community Development Department, 2000). Sierra Nevada red fox (*Vulpes vulpes necator*) (e.g., USDA-Forest Service, 2010) has been sighted in the Conway Summit at an unknown time in the past. After no confirmed sightings in the Sierra Nevada since 1991, at least two individuals were photographed east and west of Sonora Pass in August 2010.

Some of the birds known to inhabit portions of the East Walker River watershed include sage grouse (*Centrocercus urophasianus*), prairie falcon (*Falco mexicanus*), golden eagle (*Aquila chrysaetos*), northern harrier (*Circus cyaneus*), Cooper's hawk (*Accipter cooperi*), bank swallow (*Riparia riparia*), willow flycatcher (*Empidonax traillii*), loggerhead shrike (*Lanius ludovicianus*), mountain quail (*Oreortyx pictus*), pinyon jay (*Gymnorhinus cyanocephalus*), mountain chickadee (*Parus gambeli*), common raven (*Corvus corax*), hairy woodpecker (*Dendrocopus villosus*), Clark's nutcracker (*Nucifraga columbiana*), and great horned owl (*Bubo virginianus*) (Dodge, 1992; Mono County Community Development Department, 2000). Riparian areas along Virginia Creek are thought to be habitat for willow flycatcher (USDA-Forest Service, 2000).

Birds that are commonly found at Bridgeport Reservoir include gulls (*Larus* sp.), pelicans (*Pelicanus* sp.), egrets (e.g., *Egretta thula*), and herons (e.g., *Andea herodia*, *Nycticorax nycticorax*, and *Butorides virescens*) (Sharpe, et al., 2007). The reservoir is an important nesting site for Western and Clark's grebes (*Aechmophorus occidentalis* and *Aechmophorus clarkii*). A survey in 2003 indicated that about one percent of total population of Aechmophorus grebes in the western United States was at Bridgeport Reservoir (Ivey, 2004).

Two herds of mule deer inhabit the East Walker River watershed. The East Walker herd’s winter range is mainly downstream and east of California-Nevada border. About two-thirds of that herd summers in the Swauger Creek and Buckeye Creek watersheds from Devils Gate to Twin Lakes or beyond into the West Walker River watershed. A narrow migration corridor along the East Walker River and slopes north of the river and Bridgeport Reservoir connects the winter and summer ranges (Taylor, 1992).

Mule deer found in the Bodie Hills are mostly part of the Mono Lake herd. After wintering near Hawthorne, the deer migrate through the Bodie Hills in April enroute to their summer range along the eastern slope of the Sierra Nevada and again in the autumn on the return to their winter range. The Mono Lake herd and the East Walker herd share some parts of their summer range (Taylor, 1992). During the 1990s, the Mono Lake herd was declining because of poor forage conditions resulting from drought (Mono County Community Development Department, 2000). The Conway Summit area hosts up to 4,000 deer during their spring and autumn migrations. In addition to migration, some fraction of the Mono Lake and East Walker herds stays in the Bodie Hills during the summer (USDI-Bureau of Land Management, 2009). Fawning occurs between late June and early August. Habitat conditions have been judged to be adequate, and the area is currently below carrying capacity (USDI-Bureau of Land Management, 2009).

Small groups of pronghorn antelope (*Antilocarpa americana*) occupy the Bodie Hills between April and November, depending on snow conditions (USDI-Bureau of Land Management, 2009).

Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*) have used the upper elevations of the East Walker River watershed in the past. One observation of a ram and at least two ewes in the vaguely-described Robinson Creek-Green Lake area was documented in 1969 (Houghton, 1986). A radio-collared bighorn ram was observed on the north end of Kavanaugh Ridge in 2004 (California Department of Fish and Game, 2004). The sheep have been protected from hunting by California law since 1878, and under the California Endangered Species Act, were classified as rare in 1970, threatened in 1984, and endangered in 1999. Listing as a federal endangered species occurred in 2000 (U.S. Fish and Wildlife Service, 2007). Although only bighorn skulls have been found in the vicinity of Matterhorn Peak, herd units for Twin Lakes and Green Creek areas are designated on a map in the bighorn sheep recovery plan (U.S. Fish and Wildlife Service, 2007). The plan mentions that habitat limitations within the Twin Lakes and Green Creek herd units may restrict the establishment of bighorn sheep in those areas.

Bald eagles (*Haliaeetus leucocephalus*) have been seen, but the dates were not recorded (California Department of Fish and Game, 1990). A bald eagle was found during the oil spill cleanup activities in 2001 (East Walker River Trustee Council, 2008).

Mono Basin area (or Bi-State Distinct Population Segment [U.S. Fish and Wildlife Service, 2010]) sage grouse are considered a subpopulation of greater sage grouse (*Centrocercus urophasianus*). A petition for listing the Mono Basin area sage grouse as threatened or endangered was filed in November 2005 (Stanford Law School Environmental Law Clinic, 2005) and denied in late 2006. In March 2010, the Fish and Wildlife Service made a finding that the Bi-State Distinct Population Segment of greater sage grouse was warranted for adding to the list of threatened and endangered species but precluded because of high priority actions involving other species (U.S. Fish and Wildlife Service, 2010). The birds are found in many parts of Mono County. Active leks have been noted in the Bodie Hills (Stanford Law School Environmental Law Clinic, 2005). Suitable habitat consists of large expanses of sagebrush range with an interspersion of small meadows. Overgrazing of meadows and sagebrush range, over-hunting of the grouse, and human disturbance at leks have contributed to a depletion of habitat and abundance. The sage grouse tend to use the higher-elevation meadows and springs of the Bodie Hills during summer and move between such areas in search of water and insects (USDI-Bureau of Land Management, 2009). In January 2012, rumors of a forthcoming ESA listing of the species continued to be heard.

Reptiles expected within the East Walker River watershed include western fence lizard (*Scleroporus occidentalis*), common leopard lizard (*Crotaphytus wislizenii*), sagebrush lizard (*Scleroporus gracious*), gopher snake (*Pituophis melanoleucus*), and western rattlesnake (*Crotalus viridis*) (Dodge, 1992).

Table 12: State and Federal Species of Concern in the East Walker Watershed

Scientific Name	Common Name	Federal Status	State Status
Oncorhynchus clarkii henshawi	Lahontan cutthroat trout	Threatened	None
Anaxyrus canorus	Yosemite toad	Candidate	None
Rana sierra	Sierra Nevada yellow-legged frog	Candidate	Threatened
Centrocercus urophasianus	greater sage-grouse	Candidate	None
Gulo gulo	California wolverine	Candidate	Threatened
Vulpes vulpes necator	Sierra Nevada red fox	None	Threatened

Source: California Department of Fish and Game, California Natural Diversity Database, February 2012.

Figure 4: Photographs of Selected Species of Concern

Selected Species of Concern

Lahontan cutthroat trout (Jeannie Stafford/USFWS)

Sierra Nevada red fox (USFS)

greater sage-grouse (Alisa Ellsworth/CDFG)

Sierra Nevada yellow-legged frog (Todd Vogel)

wolverine (Gerald and Buff Corsi © California Academy of Sciences)

Yosemite toads (Marcel Holyoak)

Refuges and Reserves

The Humboldt-Toiyabe National Forest has established several "critical aquatic refuges" to promote recovery of threatened amphibians. The only one within the East Walker River watershed is the By-Day Creek Critical Aquatic Refuge.

Much of the upper watershed of By-Day Creek is owned by the California Department of Fish and Game as the ByDay Ecological Reserve. The creek has been managed as a refuge for Lahontan cutthroat trout since 1979.The California Department of Fish and Game also owns two designated “Wildlife Areas” in the watershed: the Green Creek Wildlife Area (720 acres) and East Walker River Wildlife Area (1,367 acres). These areas are shown on **Map 19**: Conservation Easement Map of North Bridgeport Valley Area.

5. Human History and Land Use

Native Americans of the Paiute and Washoe tribes lived in the East Walker River basin for at least several hundred years. There is some evidence of human habitation dating back more than 10,000 years (USDI-Bureau of Land Management, 1995; WRBRIT, 2003). Their history in this region is not as well known as in areas to the north and south. The Bridgeport Valley provided fish, deer, pronghorn, small game, and edible plants (Burton and Farrell, 1992). In addition to hunting and fishing, gathering Pinyon pine nuts provided a major food source. The tribes established settlements in valley bottoms along rivers and lakes. Smaller temporary settlements and campsites were occupied at higher elevations during warmer months and while on food gathering and trading forays (USDA-Forest Service, 2004). Trade was believed to have occurred with the Miwok, Monache, southern Piute, and Washoe tribes (Burton and Farrell, 1992; Jackson, 2010).

Trappers including Jedediah Smith and Joseph Walker apparently crossed within the lower Walker River basin in 1827 and 1833 (USDI-Bureau of Land management, 1995), but whether they entered the California portion of the East Walker River watershed is uncertain. In 1841, the Bartleson-Bidwell party, who were the first overland emigrants to California, may have entered the East Walker River watershed enroute to crossing the Sierra Nevada about eight miles south of the present Sonora Pass. John C. Fremont and Kit Carson apparently ascended the East Walker River into Bridgeport Valley and then proceeded north to Swauger Creek and Devils Gate in 1844 (Houghton, 1986; Burton and Farrell, 1992).

The Whitney brothers settled in Big Meadows (later Bridgeport) in 1859-60 and ran a hay yard and stable. The first known land survey and mapping of Big Meadows was done in 1861. Byron Day settled land east of Bridgeport and had By-Day Creek named for him (Burton and Farrell, 1992). Bridgeport was established as the county seat for Mono County in 1863.

Gold was discovered along Dog Creek, a tributary to Virginia Creek, in 1857. Dogtown grew quickly during the following two years, until most prospectors moved over Conway Summit to form Monoville in 1859. Although gold was discovered near Bodie in 1859 and silver was found in Aurora in 1861, these mining areas did not take off until the late 1860s and early 1870s. The mining booms drew lots of travelers through the East Walker River basin and produced heavy demand for agricultural products from the rapidly growing farms of the Bridgeport Valley. Several small mining communities were established in the Sweetwater Mountains, such as along Fryingpan Creek. The Sonora-Mono road over Sonora Pass was completed by 1864. Sheep herding expanded in the uplands in response to the demand from the mining towns, and continued in large numbers into the early 1900s. James Sinnamon used his earnings from placer mining near Monoville to purchase land in the Bridgeport Valley by 1873. Sinnamon Meadow, on upper Dog Creek, bears the family name.

There was a brief logging period from the 1860s to 1880s to supply construction lumber, mine timbers, and fuel wood to the mines at Aurora and Bodie. The demand for wood stripped much of the Bodie Hills of pinyon pine (California Department of Water Resources, 1992).

When Napoleon Bonaparte (N.B.) and Esther Hunewill arrived in Big Meadows (later Bridgeport) in the autumn of 1861, there were already three sawmills providing lumber to Aurora, Bodie, and the Mono Diggings. N.B. Hunewill soon filed for water rights on portions of Buckeye and Robinson Creeks. In 1862, the Hunewills homesteaded 160 acres west of Buckeye hot springs and built a sawmill. After the timber near that sawmill was harvested, N.B. Hunewill acquired another 160 acres and built a second sawmill near the confluence of Eagle and Buckeye Creeks. In the next few years, he filed on 800 acres of forest land and bought meadowland in the south side of Big Meadows where the Hunewill Ranch is today (Mono County Historical Society, 2006).

During the late 1870s, most of the lumber and cordwood for Bodie was coming from Mono Mills, on the south side of Mono Lake. N.B. Hunewill realized that he could not compete successfully with the better access from Mono Mills and sold the sawmill equipment in 1879 to focus on raising cattle to supply meat to the miners. The Hunewill Ranch became one of the major beef suppliers to Bodie and Lundy. N.B. Hunewill organized a group of water users that diverted water from Robinson Creek and obtained storage rights for lower Twin Lake. A low rock-filled dam was built and releases were controlled by a wooden headgate and spillway (Mono County Historical Society, 2006).

Box 2: Walker River Chronology

Paleohydrology: A U.S. Geological Survey study (Benson, 1988; Benson, et al., 1991) of sediment deposits at Walker Lake provided the basis for inferences about the climate and hydrology of Walker Lake over the past several millennia:

- 13,000 to 5,000 years before present (BP): Walker Lake was low or periodically dry
- After about 5,000 BP: inflows to Walker Lake increased, and the lake level rose
- 5,000-3,000 or 4,000-2,000 BP: Walker Lake remained high
- AD 1-1000: Walker Lake declined and was nearly dry for about 300 years
- AD 1000-1880: Walker Lake generally refilled except during drought periods

From several lines of evidence (stratigraphy, pollen, oxygen isotopes, biological remains in sediments, etc.), low levels of Walker Lake appear to have occurred:

- 5,000 to 4,700 years BP (Bradbury, et al., 1989: Benson, et al., 1991)
- 2,400 to 2,000 years BP (Bradbury, et al., 1989: Benson, et al., 1991)
- AD 500 to 1000 (Benson, et al., 1991; Adams, 2003)
- AD 900 to 1100 (Yuan, et al., 2004)
- AD 1200 to 1350 (Yuan, et al., 2004)
- AD 1500 to 1700 (Adams, 2003)

These low lake levels presumably resulted from prolonged drought, but geologic diversion through Adrian Valley has been proposed as an alternative mechanism (Benson, et al., 1991).

(The following material was excerpted verbatim from Horton, 1996)

Pre-History It is estimated that in these early times Walker Lake received the total combined flow of both the East and West Walker rivers, amounting to some 250,000-300,000 acre-feet of water per year. Such an inflow would have been sufficient to maintain the lake's surface level at 4,080 feet MSL.

1844 From the Carson River, John C. Fremont continued further south to the Walker River and Bridgeport Valley, passing through Devil's Gate, turned north and then proceeded up into the Sierra Nevada Mountains. Fremont named the Walker River for another guide who had accompanied his party, Joseph Walker, who had been in the area in 1833.

1849 Rush to the gold fields began in earnest. California's population would explode from approximately 14,000 in 1848 to over 100,000 by 1850 and to 250,000 by late 1852. [Many traveled via Sonora Pass]

1859 Waterman S. Body (Bodey), a placer miner, made the first discovery of gold in a mountainous area approximately 12 miles east southeast of Bridgeport, California. Shortly after making his discovery, Body froze to death in a snowstorm, a forewarning of the extremely harsh weather that frequented this site, located at an elevation of almost 8,370 feet above sea level in the Bodie Hills. The mining boom at Bodie, as the town would later be named, actually did not begin until the late 1870's when the peak of the Comstock Lode mining had been reached and that area began a gradual decline. Bodie's population subsequently peaked in 1880 at some 10,000 persons. The town itself was destroyed by fires in 1882 and again in 1932, and was a ghost town by the late 1930's. In 1962 the ghost town of Bodie was added to the California State Park system.

1860 Federal court records indicate that white men began irrigating lands on the upstream tributaries of the Walker River system.

1861 Gold was discovered in Aurora and the California State Legislature made the bustling mining town, located approximately 12 miles north of Bodie, the county seat of the new created Mono County. The eastern border of the new county was to mark the state line between California and Nevada, although its exact position had not yet been determined. In fact, for a while Aurora claimed the unique distinction of being the county seats for both Mono County, California and Esmeralda County, Nevada Territory. By 1863 Aurora's population had peaked at about 5,000 persons and the mining activity supported seventeen stamping mills. Aurora's heyday was very brief, however, with a general collapse occurring in 1864. Some lesser mining activity took place again from 1884 to 1886 and then again from 1906 to 1918. Today, virtually nothing remains of the original city in which gold and silver fortunes were briefly, but nonetheless warmly contested by the two states.

1862 Homestead Act signed by Lincoln as a means for the federal government to encourage the settlement of the Western states.

1864 Alfalfa seed, which had been grown in California since the 1850s, was first introduced into Carson Valley and soon became an intensive forage crop covering the expanding agricultural fields along the Carson, Truckee, and Walker Rivers. Alfalfa was found to tolerate salt saturation in soils, variable climates, drought, and insects.

1870 Although first discovered in 1859, extensive mining did not begin in Bodie until 1870.

1880 (circa) Thomas Rickey began his cattle ranching operations upstream on the West Walker River in California. His holdings would come to be known as the Rickey Land and Cattle Company and include much of Antelope Valley and adjoining valleys, plus extensive acreage in Bridgeport Valley.

1882 I.C. Russell undertook the first extensive survey of the geology and hydrology of Walker Lake, recording its surface elevation at 4,080 feet, total surface area of 95 square miles, maximum depth of 224 feet, total volume estimated at nearly 9 million AF, and TDS of 2,560 mg/l.

1902 Congress passed the National Reclamation Act. While a number of sites in the Walker River Basin were surveyed by the USRS and USBR for further development under this act, particularly potential reservoir sites at Bridgeport (on the East Walker River) and Topaz (at Alkali Lake near the West Walker River), no federal projects resulted.

1923 (December) Walker River Irrigation District's Bridgeport Reservoir was completed with a capacity of 42,460 acre-feet. Storage rights to waters in both Bridgeport and Topaz reservoirs were awarded by WRID to those farmers without adequate decreed rights (i.e., 1874 priority dates or later). By this action, those irrigated farmlands in the district which had the most tenuous water rights (and hence faced being potentially the least productive agricultural lands during low-water years) were obligated to pay off bonds issued by WRID for the construction of these reservoirs).

1928 [severe drought through 1935]

1929 Due primarily to drought conditions in the Walker River Basin, Walker River flows into Walker Lake averaged just over 28,000 acre-feet per year, down from lake inflows of 250,000 acre-feet estimated in the 1800's and an inflow of 174,000 acre-feet recorded as recently as 1919 (before upstream storage in Topaz Reservoir from the West Walker River and Bridgeport Reservoir on the East Walker River). Walker Lake's surface elevation was recorded at 4,034 feet MSL, 46 feet below its 1882 level …

1933 Walker River Irrigation District, having defaulted on its debt obligations for the construction of Topaz Reservoir on the West Walker River and Bridgeport Reservoir on the East Walker River, applied for a Reconstruction Finance Corporation loan to pay off the debt.

1936 (April 14) In adjudication of the 1924 filing of *United States v. Walker River Irrigation District, et al*., Decree C-125 was issued by the Federal District Court for Nevada. In addition to recognizing the water rights defined in Decree 731 (March 24, 1919) as to priority date, amount and place of use, and defined other storage and diversion rights, the Walker River Indian Reservation's attempt to acquire a right to divert 150 cfs for the irrigation of reservation lands was rejected. While Decree C-125 adjudicated most of the irrigation rights of the Walker River system, the court did not define domestic rights, irrigation uses on natural forest land, some private riparian lands, and any storage rights for Weber Reservoir, which had recently been constructed on the Walker River Indian Reservation. Also, no rights were included for Walker Lake itself. A federal watermaster would be responsible for its enforcement.

1950 The Walker River Basin was subjected to particularly damaging floods, although property damage was not as severe as that incurred in the Carson and Truckee River basins to the north due to the limited of urbanized land within the Walker River Basin.

1953 (August 25) Paragraph (Section) 15 of Decree C-125, the "Rules and Regulations for the Distribution of Water, of the Walker River Stream System under Provisions in Paragraph 15 of the Decree in Equity No. C-125," was adopted by the U.S. Board of Water Commissioners. By these rules, lands in California above Bridgeport Reservoir on the East Walker River (primarily Bridgeport Valley), and lands above the Topaz Reservoir intake canal on the West Walker River (primarily Antelope Valley and surrounding areas) were reaffirmed a water duty of 1.6 cfs per 100 acres of land. Most notably, these rules and regulations exempted the Bridgeport Valley Division water users from the requirement in Decree C-125 that all water users measure their withdrawals at the point of diversion. The irrigation season was also reaffirmed to be from March 1 to September 15 (199 days) for East Walker River lands above Bridgeport Reservoir and for West Walker River lands above the Coleville streamflow gage.

1955 The Walker River Basin was again subjected to particularly severe flooding.

1957 The California Department of Water Resources issued a report on Walker River Irrigation District's loan application under Public Law 984 (Small Reclamation Projects Act) intended to make modifications to Bridgeport Reservoir. The report included comments from the California Department of Fish and Game which emphasized the need to formalize reservoir operations and monitor and stabilize water releases so as to avoid endangering fishermen and other stream users, prevent scouring of the stream channel, stranding of fish, and destruction of fish habitat.

1958 Walker River Irrigation District received a federal loan in the amount of $563,000 to raise the level of the spillway at Bridgeport Dam and thereby increase its storage capacity from 42,000 acre-feet to 48,000 acre-feet.

1963 An agreement between the California Department of Fish and Game and the Walker River Irrigation District allowed WRID to enlarge and modify Bridgeport Reservoir and Dam so long as WRID would maintain a minimum pool in the reservoir of 1,500 acre-feet for the protection of fish life, except during defined years when WRID would maintain a minimum pool of at least 300 acre-feet. The agreement also specified minimum streamflow releases, generally the lesser of 50 cfs or natural inflow during the irrigation season and 8 cfs the rest of the year, subject to dry year provisions.

1964 Walker Lake's surface water level was recorded at 3,972 feet MSL, a decline of 108 feet from an elevation of 4,080 feet recorded in 1882.

1975 (October 24) Based on the accumulation of stream gaging data compiled since 1954 demonstrating a lack of adverse impacts on prior water rights, the Board of United States Water Commissioners' petition under Decree C-125 filed with the U.S. Federal District Court for Nevada was approved. This petition, filed on July 3, 1975, sought to amend the "Rules and Regulations" adopted on August 25, 1953. The intent was to show that the cost of maintaining the required gaging stations in several small creeks above Bridgeport Reservoir far outweighed any further benefits and consequently the Board should no longer be required to maintain the gaging stations on Virginia, Swauger, Green, Buckeye, and Robinson creeks. These gaging stations had been required for the Bridgeport Valley Division in lieu of individual water flow measurements at the point of diversion as required of other water users under the 1953 "Rules and Regulations".

[1976-1977 drought]

[1987-1994 drought]

1988 (Summer) In response to farmers' desperate need for irrigation water, Walker River Irrigation District drained Bridgeport Reservoir, flushing warm water and considerable quantities of sediment from the bottom of the reservoir into the East Walker River, subsequently causing an extensive fish kill downstream.

1988 In response to the draining of Bridgeport Reservoir by Walker River Irrigation District, the California Trout, Inc., a sport-fishing association, filed a complaint with the California State Water Resources Control Board claiming that WRID's draining of the reservoir violated several state fish protective statutes and caused a loss of fisheries in the reservoir and downstream (see entry under February 5, 1963). When subsequent negotiations between the California Department of Fish and Game and WRID proved fruitless, the SWRCB moved ahead with an investigation and eventual water rights hearing.

1988 Mono County, California, in which Bridgeport Reservoir is located, filed suit against Walker River Irrigation District for its draining of that reservoir earlier in the summer. In 1993 WRID was subsequently convicted in Justice Court of Mono County of misdemeanor violations under the California Fish and Game Code. Terms of probation imposed on WRID included a monetary fine, the maintenance of a minimum pool within the reservoir, temporary instream flow release requirements, and the requirement to remove some of the sediment deposited in the East Walker River below Bridgeport Reservoir.

1990 With the participation of Walker River Irrigation District, California Trout, Inc., and the Lahontan Regional Water Quality Control Board, the California State Water Resources Control Board completed its hearing process for the draining of Bridgeport Reservoir in the summer of 1988 by the WRID. SWRCB amended WRID's license for water storage in Bridgeport Reservoir, requiring minimum downstream flows and minimum reservoir pool requirements.

1991 Based on the 1990 actions of the California State Water Resources Control Board in amending Walker River Irrigation District's license for water storage in Bridgeport Reservoir, WRID filed suit against SWRCB in federal district court having jurisdiction over Decree C-125. The suit challenged SWRCB's authority to impose state law requirements on water rights specified by Decree C-125.

1993 The Walker River Irrigation District was convicted in Justice Court of Mono County of misdemeanor violations under the California Fish and Game Code. Terms of WRID's probation required:

(1) WRID was to pay compensation of $633,000 to the State of California;
(2) WRID was to pay a fine of $250,000 to California Department of Fish and Game to cover the costs of legal fees and fishery research;
(3) WRID was ordered to maintain a minimum pool for Bridgeport Reservoir in the amount of 2,000 acre-feet;
(4) WRID was ordered to flush the sediment out of the East Walker River below Bridgeport Reservoir; and
(5) California Department of Fish and Game was allowed to monitor the fishery of the East Walker River.

1993 (November) In accordance with a Court settlement, Walker River Irrigation District was ordered to release 6,000 acre-feet of stored water from Bridgeport Reservoir to flush accumulated sediment in the East Walker River below the reservoir. In response to this release, the Walker River Indian Tribe released 4,500 acre-feet of water from Weber Reservoir, a portion of which reached Walker Lake and constituted the only river water to reach the lake in six years.

1994 (September) USGS measurements showed Walker Lake's surface elevation at 3,942.4 feet MSL.

(Horton, 1996)

Abbreviations used by Horton:

WRID Walker River Irrigation District

CDWR California Department of Water Resources

USBR United States Bureau of Reclamation

USRS United States Reclamation Service

Other important dates not included in the summary by Horton (1996) above:

1870 Bridgeport became the Mono County seat of government when Aurora was found to be over the Nevada border. At that time, about 9,000 acres of the Bridgeport Valley were cultivated for wheat, oats, hay, barley, and forage. [http://www.maturango.org/Histdates.html]

Dynamo Pond was developed in the 1890s to generate hydroelectric power to supply the Standard Consolidated Mine in Bodie (13 miles away). The project had 350 feet of head between the pond and the powerhouse downstream on Green Creek (California State Water Resources Control Board, 1988). The original dam forming Dynamo Pond was built in 1895 and modified several years during its lifetime.

1919 Decree 731 was issued adjudicating water rights between the Pacific Live Stock Company and Antelope Valley Land and Cattle Company (CDWR 1992).

1996 (June 3) Settlement approved in U.S. District Court in Reno with respect to the 1991 suit by WRID. This settlement approved the SWRCB's amendments of 1990 to WRID's license for water storage in Bridgeport Reservoir (California Trout, 1996).

1997 Flood of record

2000 The Mono North CCD Census Tract 1 Block Group 3 (essentially the town of Bridgeport) had a population of 817 and a median income of $36,281.

2000 Oil spill into East Walker River below reservoir

2006 Mono County submitted a grant application for the SWRCB Consolidated Grants Program to prepare an East Walker watershed assessment and plan but was unsuccessful.

Land Use

More than eighty-two percent of the East Walker River watershed is in public ownership by the USDA-Forest Service (58%), USDI-Bureau of Land Management (23%), and the State of California (1%) for resource management purposes. Most of the private land is in Bridgeport Valley where agriculture, primarily cattle ranching, is the dominant land use. Pasture irrigation is the largest single use of agricultural water in Bridgeport Valley (California Department of Water Resources, 1992). Of the watershed contributing water to Bridgeport Reservoir (about 363 mi^2), about 10 percent of the area (roughly 36 mi^2or 23,000 acres) is irrigated pasture in Bridgeport Valley (Elkins, 2002). About 43 percent of that area is forest, 34 percent is shrubland, 6 percent is alpine, and 6 percent is water surface, riparian, meadow, and urban (Elkins, 2002). Other estimates of the area of irrigated pasture in the Bridgeport Valley are 20,300 acres (31.7 mi^2) (Mono County, 1992) and 21,000 acres (32.8 mi^2) (California Regional Water Quality Control Board--Lahontan Region, 2003).

Three year-round communities are found in the watershed: Bridgeport, Twin Lakes, and Swauger Creek / Devil's Gate. There is also a community of homes near Virginia Lakes, but only a few are occupied during the winter because the access road off of Conway Summit is not plowed. The population of the Bridgeport census unit (includes about 21.7 square miles) was 573 in 1980, 843 in 1990, 704 in 2000, 776 in 2008, and 575 in 2010.

The community of Bridgeport includes residences, motels and restaurants, a few commercial businesses, Mono County offices and courthouse, county road yard, county park, community center, ballfields, U.S. Forest Service District Ranger station, Caltrans yard, and a county landfill.

Several isolated parcels of private land exist within the watershed. Road access to some of these parcels is limited or nonexistent. Construction of new roads across National Forest land may be necessary in a few cases.

Forest Service summer home tracts are located at Twin Lakes, Green Creek, and Virginia Lakes.

The Bridgeport Indian Colony is a federally recognized tribe that was established in 1974. The Colony's 40 acres of land is just east of the town of Bridgeport, about one mile northeast of the junction of U.S. Highway 395 and California State Route 182. The Colony does not have decreed water rights (Sharpe, et al., 2007). Approximately 120 people are members of the community. The community is composed of descendants from Mono, Miwok, Shoshone, Paiute, and Washoe tribes. The Bridgeport Indian Colony became a federally recognized tribe in October 1974. Refer to **Map 17**: Land-Use Designation Map of the East Walker Watershed and **Map 18**: Land Ownership Map of East Walker Watershed.

Recreation

Recreation is a major land use within the East Walker River watershed and includes concentrated use areas with some facilities, such as campgrounds, and dispersed recreation. The Humboldt-Toiyabe National Forest provides developed campgrounds at Virginia Lakes, on Green Creek, on Buckeye Creek, and along Robinson Creek below Twin Lakes. The five Robinson Creek campgrounds are particularly popular and probably account for roughly half of the 130,000 visitor-days of campground use within the Bridgeport Ranger District. The Forest also has 60 summer recreational residences within tracts at Twin Lakes, Virginia Lakes, and Green Creek. Resorts operating under special-use permits are found on Robinson Creek and at Virginia Lakes.

The [Lower] Twin Lakes Resort offers cabins, an RV park, marina, and general store. It reported 21,000 visitor-days of use during their five-month-duration season in 1979 (Horne, et al., 2003). Annett's Mono Village at the inlet to Upper Twin Lake offers rooms and cabins, a 300-space campground, cafe, boat ramp, and grocery store.

A variety of dispersed camping opportunities occur along the major creeks. Virginia, Green, and Buckeye (especially near the hot springs) are particularly popular. The Forest Service has improved or "hardened" some of the most popular sites to minimize erosion and vegetation damage (USDA-Forest Service, 2004). User-created trails accessing Buckeye Hot Springs have eroded the hillside above the springs. Dispersed camping along Green and Dunderberg Creeks has caused bank erosion and potential water quality problems from human waste (USDA-Forest Service, 2004).

Off-highway vehicle use has also increased in the past decade with impacts near the most popular dispersed camping areas (USDA-Forest Service, 2004)

Following the oil spill in 2000, there was a drastic drop in fishing along the East Walker River below Bridgeport Reservoir. Although the expected or actual number was not reported, one study estimated that 5,500 angler-days were lost as a direct result of the oil spill and the local financial value of an angler-day in Mono County at that time was $42 (East Walker River Trustee Council, 2008).

Agriculture and Grazing

There was a period of severe overgrazing in the late 1800s to early 1900s throughout the Sierra Nevada that resulted in widespread changes in vegetation cover and composition and active channel erosion. The East Walker River watershed was assumed to have been impacted in a manner similar to the bulk of the mountain range. An estimated 200,000 head of sheep grazed the Walker River country around 1900 (USDA-Forest Service, 1947). The rangelands have been recovering ever since under less intense grazing pressure. The Forest Service gradually improved grazing practices during the first half of the 20th century by establishing allotments with limits on numbers of animals and season of use (Menke, et al., 1996). Since about 1980, riparian areas and other resources have been given higher priority in management of federal grazing allotments (Menke, et al., 1996).

The large-scale cattle operation of Thomas Rickey, later known as the Antelope Valley Land and Cattle Company, included “extensive acreage” in the Bridgeport Valley around the turn of the century (California Department of Water Resources, 1992).

Early photographs from the 1870s suggest livestock numbers in the Bridgeport Valley estimated at about 10,000. Densities may have been even greater during the peak mining period (Horne, et al., 2003). Summer seasonal cattle grazing in the Bridgeport Valley continues to be a primary land-use and economic force in the East Walker River watershed. Approximately 20,000 acres of pasture have been irrigated in the Bridgeport Valley on the average over the period 1926 through 1995 (Pahl, 2000, cited by Yardas, 2007). Approximately 8,000 cattle have grazed in the Bridgeport Valley in recent summers (Tate, et al., 2001).

Meadow areas along Green Creek and Summers Creek have been grazed by sheep in summer and fall for decades (California Department of Fish and Game, n.d.).

Several grazing allotments have been established on federal lands in the East Walker River watershed. The allotments allow ranchers based in the Bridgeport Valley and elsewhere to utilize forage from a much larger area than their private ranchlands alone. The USDA-Forest Service and Bureau of Land Management administer these allotments with permit conditions such as season of use, number of animals, forage utilization standards, noxious weeds, and streambank disturbance. Additional conditions apply to areas with at-risk species, such as Lahontan cutthroat trout in Murphy Creek and By-Day Creeks. The principal grazing allotments on National Forest land in the East Walker River watershed include: Buckeye Creek (cattle), Eagle Creek (cattle), Hunewill Hills (cattle), Robinson Creek (cattle), Murphy Creek (cattle), North Swauger (sheep), South Swauger (sheep), Rickey (sheep), Cameron Canyon (sheep), Summers Meadow (sheep), Tamarack (sheep), and Dunderberg (sheep). The Green Creek allotment is currently vacant.

A large portion of the Bridgeport Valley was conserved for cattle grazing in 2002 when the California Rangeland Trust and American Land Conservancy obtained a conservation easement on 6,350 acres of the Dressler Ranch. Now called the Centennial Ranch, an additional agricultural conservation easement was completed in December 2011 and is held by Eastern Sierra Land Trust (**Map 19**: Conservation Easement Map of North Bridgeport Valley Area).

Box 3: Forest Service Grazing Allotment Utilization Standards

An example of current utilization standards on the Humboldt-Toiyabe National Forest was excerpted from an annual permit letter (USDA-Forest Service, 2010b):

Riparian sites:

Disturbance of meadow-associated streambanks and natural lake and pond shorelines is not to exceed 20 percent of the stream reach or 20 percent of the natural lake or pond shoreline.

In meadows that are in early seral status (an early stage of succession in a plant community or vegetation type, generally characterized by plant species that are adapted to colonizing disturbed areas with a high proportion of bare soil) livestock utilization of grass and grass-like plants must be limited to 30 percent (or minimum six-inch stubble height).

In meadows that are in late seral status (fifty percent or more of the relative cover of the herbaceous layer is late seral with high similarity to the potential natural community, a diversity of age classes of hardwood shrubs is present, and regeneration is occurring) livestock utilization of grass and grass-like plants must be limited to a maximum of 40 percent (or minimum four-inch stubble height).

In meadows that are degraded (such as those in early seral status with a greater than ten percent meadow area in bare soil and active erosion) total rest from grazing is required until they have recovered and have moved to a mid or late seral status.

In riparian areas browsing on mature riparian shrubs (including willow and aspen) is not to exceed 20 percent of the annual leader growth and is not to exceed more than 20 percent of individual seedlings.

Livestock grazing will be modified or suspended on meadow ecosystems when it is determined that ecological status is moving in a downward trend.

Pesticide application to livestock is prohibited within riparian conservation and critical aquatic refuge areas.

Upland and Aspen plant communities:

45% use of grass or forb species; 40% use on shrubs.

An Environmental Assessment for grazing permits on the Dog Creek and Green Creek allotments of the BLM was recently completed (USDI-Bureau of Land Management, 2011). The primary issues of concern were risk of contact with bighorn sheep and impacts to habitat for greater sage grouse. Other BLM allotments within the East Walker River watershed include the Little Mormon, Travertine Hills, and Potato Peak allotments.

Mining

The principal mining area within the East Walker River watershed was at and near Dogtown and along Virginia and Dog Creeks. Dredging activity in both creeks left large piles of tailings that are still visible but stable. Widespread prospecting led to few other productive mines. There is a Tamarack Mine south of Upper Summers Meadow. Travertine has been quarried from the vicinity of Travertine Hot Springs.

Roads

Many of the roads in the East Walker River watershed have direct impacts on channels and riparian systems because the roads are built on floodplains, in the riparian zone, and/or make frequent crossings of the stream. The most obvious example is California Highway 182 along the East Walker River downstream of Bridgeport Reservoir. Slopes disturbed by the road placement and construction were long-term sources of sediment to the East Walker River. Portions of other paved roads, such as U.S. Highway 395 and the Twin Lakes Road, are often adjacent to or cross major streams. Unpaved forest roads have many areas of contact with streams and riparian zones and are sources of sediment. GIS analyses found that the watershed contains more than 402 miles of mapped roads, these roads cross streams (perennial and intermittent) in at least 360 places, and more than 52 miles of roads are within 100 feet of a stream (perennial and intermittent).

Since 2005, National Forests have been directed to prepare "Travel Management Plans" that designate roads, trails, and areas that are open to use by motor vehicles. The directive grew out of an Executive Order issued by President Nixon in 1972 to identify the legal roads within the National Forests. These designations also mention class of vehicle and (where appropriate) time of year that the routes are open. The Bridgeport Ranger District conducted a "Travel Analysis Process" that mapped existing parts of the Forest Transportation System, documented road-related resource issues, identified unauthorized routes and their suitability for continued use, and collected public input regarding routes and use (USDA-Forest Service, 2010). At the beginning of the process, there were about 1,290 miles of Forest Transportation System roads throughout the 1.2 million acre Bridgeport Ranger District (which includes but is larger than the East Walker River watershed). The process added about 220 miles of previously unauthorized routes to the so-called "system" roads. These additions acknowledged that such routes have been actively used for years even though they were not officially engineered or constructed. About 180 miles of system roads were reclassified as trails open to all vehicles. All cross-country travel off of designated routes was prohibited (USDA-Forest Service, 2010).

A lawsuit filed in November 2010 by the Center for Biological Diversity sought to close and declassify the routes designated as additions to the Forest Transportation System. Although these routes have physically existed for long periods of time, the lawsuit apparently contends (Geisel, 2010) that official designation will have negative consequences not considered by the environmental impact report(USDA-Forest Service, 2010).

As a means of evaluating the theoretical impact of the road network within portions of the Bridgeport Ranger District during the Travel Analysis Process, a cumulative-effects analysis known as Equivalent Roaded Area (e.g., McGurk and Fong, 1995) was used. Because roads are considered to have the greatest impact on erosion and sediment delivery (resulting from complete vegetation removal and soil compaction) of all land-use alterations in forests and rangelands, other land uses have been indexed relative to the impact of roads. For example, a particular type of timber harvest and removal might be estimated to have one-tenth the impact of a road, so 10 acres of a 0.1 coefficient timber harvest is roughly equivalent to 1 acre of road surface. Furthermore, various operational studies on National Forest lands have found that when more than about 10 percent of a small watershed is covered by roads (or greater areas with less-intensive impacts indexed to the equivalent of a road), then sediment delivery to the stream becomes substantial. The risk of significant erosion and sedimentation as correlated with the amount of disturbance (as indexed with the Equivalent Roaded Area approach) has been termed the Threshold of Concern by forest planners and hydrologists. This analysis was applied to selected streams within the Bridgeport Ranger District that were previously identified as impaired by the Lahontan Regional Water Quality Control District. Some of those streams are within the East Walker River watershed and included below (USDA-Forest Service, 2010):

Table 13: Equivalent Roaded Acres by Sub-Watershed

Watershed	Total Area (acres)	Road ERA	Other Activity ERA	Total Percent ERA	ERA as Watershed Area
Buckeye Creek	28,300	10	735	745	3
East Walker / Murphy Creek	18,800	30	700	730	4
Lower Swauger Creek	14,700	50	1,030	1,080	7
Upper Swauger Creek	12,100	30	640	670	6
Robinson Creek	28,100	55	390	440	2

This analysis shows that road surface area is a tiny fraction of these watersheds and that other land uses (primarily grazing) have greater net impacts, resulting from much more extensive coverage while being of lower intensity per unit area. Refer to **Map 20**: Major Roads in the East Walker Watershed.

Many of the roads on National Forest land were recently evaluated by a Forest Service team (USDA-Forest Service, 2004). This review found that most of the forest roads were in good condition and were consistent with their maintenance level. The evaluation found only a few areas of particular concern with respect to erosion or other resource damage, such as a non-system road between Snow Lake and Kavanaugh Ridge and Forest Road 178 near Sinnamon Meadow, where the road and creek are coincident and sedimentation has been observed.

Wild and Scenic River Status

The U.S. Forest Service classified 35 miles of the East Walker River downstream of the Bridgeport Reservoir as eligible for federal designation as a "wild and scenic river" (East Walker River Trustee Council, 2008). The then-Toiyabe National Forest plan (USDA-Forest Service, 1985) mentioned that the East Walker River was inventoried as a potential wild and scenic river by the National Park Service and would be studied for its suitability by the Bureau of Land Management. However, the eligibility determination has not resulted in any action toward designation.

Conservation Areas

The Sierra Nevada Forest Plan Amendment (aka Sierra Nevada Framework) process of the USDA-Forest Service initiated a series of new aquatic conservation measures. The Humboldt-Toiyabe National Forest applied this management direction to the establishment of several “critical aquatic refuges.” These refuges were identified in the Framework amendment as small watersheds that contain either:

- Known locations of threatened, endangered, or sensitive species,
- Highly vulnerable populations of native plant or animal species, or
- Localized populations of rare native aquatic- or riparian-dependent plant or animal species.

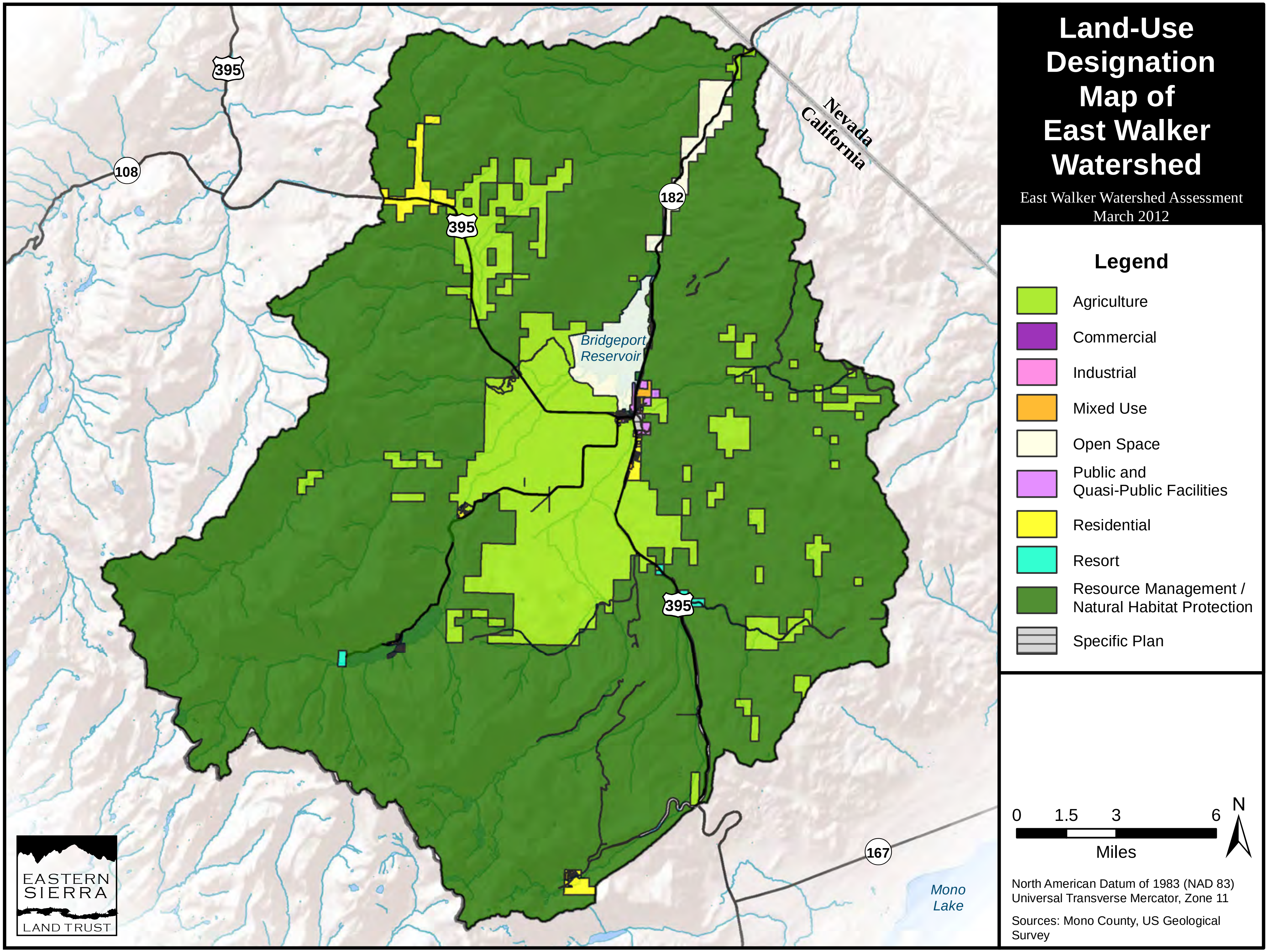
The primary management goal for critical aquatic refuges is to preserve, enhance, restore or connect habitats distributed across the landscape for sensitive or listed species to contribute to their viability and recovery (USDA-Forest Service, 2004). The only one within the East Walker River watershed is the By-Day Creek Critical Aquatic Refuge (USDA-Forest Service, 2010).

The Sierra Nevada Framework process also identified riparian conservation areas along perennial and intermittent streams and around lakes. These areas are managed to maintain or restore the structure and function of aquatic, riparian and meadow ecosystems. Specific standards and guidelines apply to these riparian areas (USDA-Forest Service, 2004).

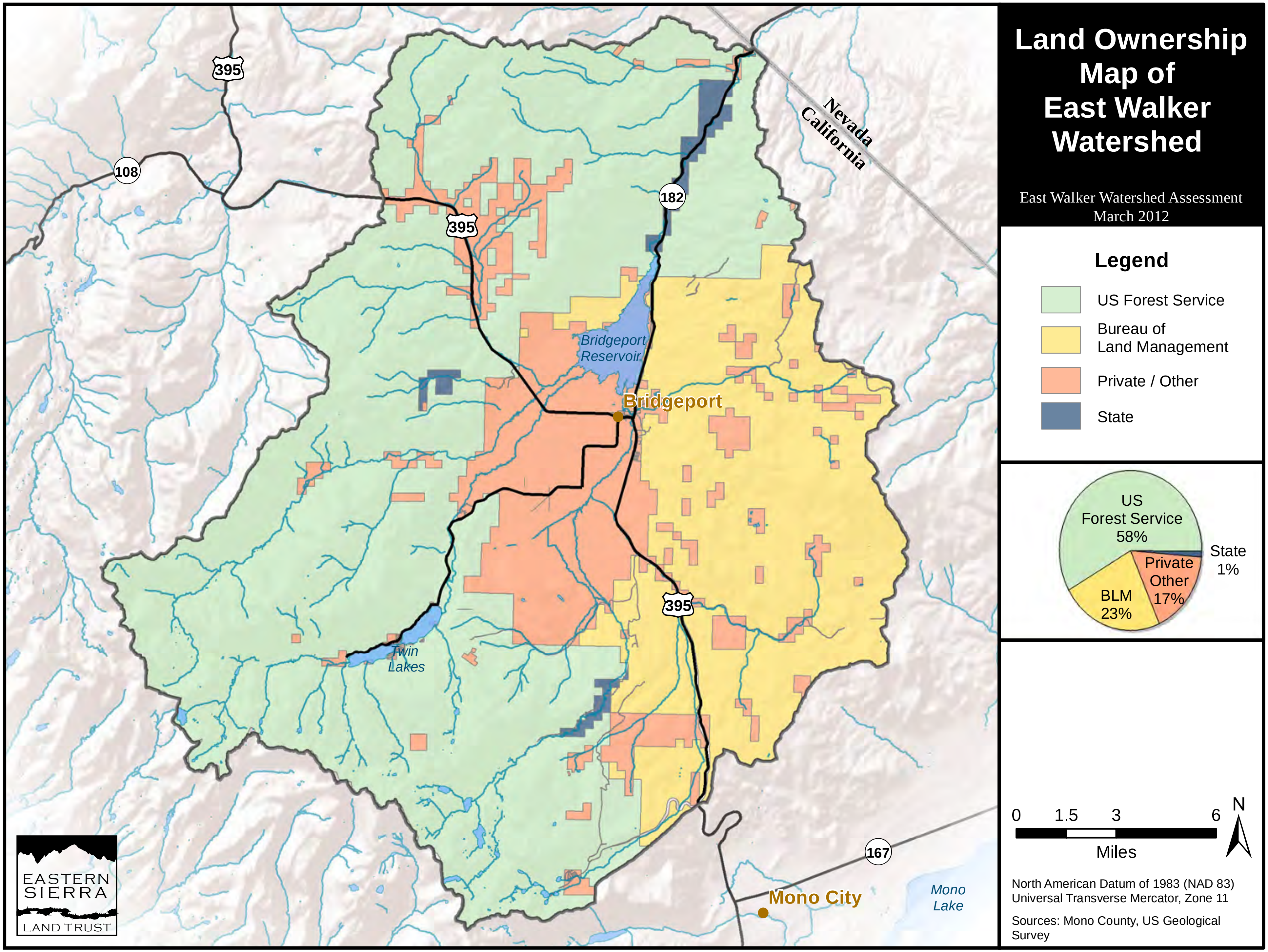
Much of the upper watershed of By-Day Creek is owned by the California Department of Fish and Game as the By Day Ecological Reserve. The creek has been managed as a refuge for Lahontan cutthroat trout since 1979. The California Department of Fish and Game also owns two designated “Wildlife Areas” in the watershed: the Green Creek Wildlife Area (720 acres) and East Walker River Wildlife Area (1,367 acres).

Travertine Hot Springs, just east of Bridgeport, was designated as an "Area of Critical Environmental Concern" (ACEC) by the Bureau of Land Management in 1987 (USDI-Bureau of Land Management, 1995). A plan was developed to provide for recreational access while minimizing resource damage and protecting the Paiute cultural heritage and native species (particularly the Travertine band-thigh diving beetle).

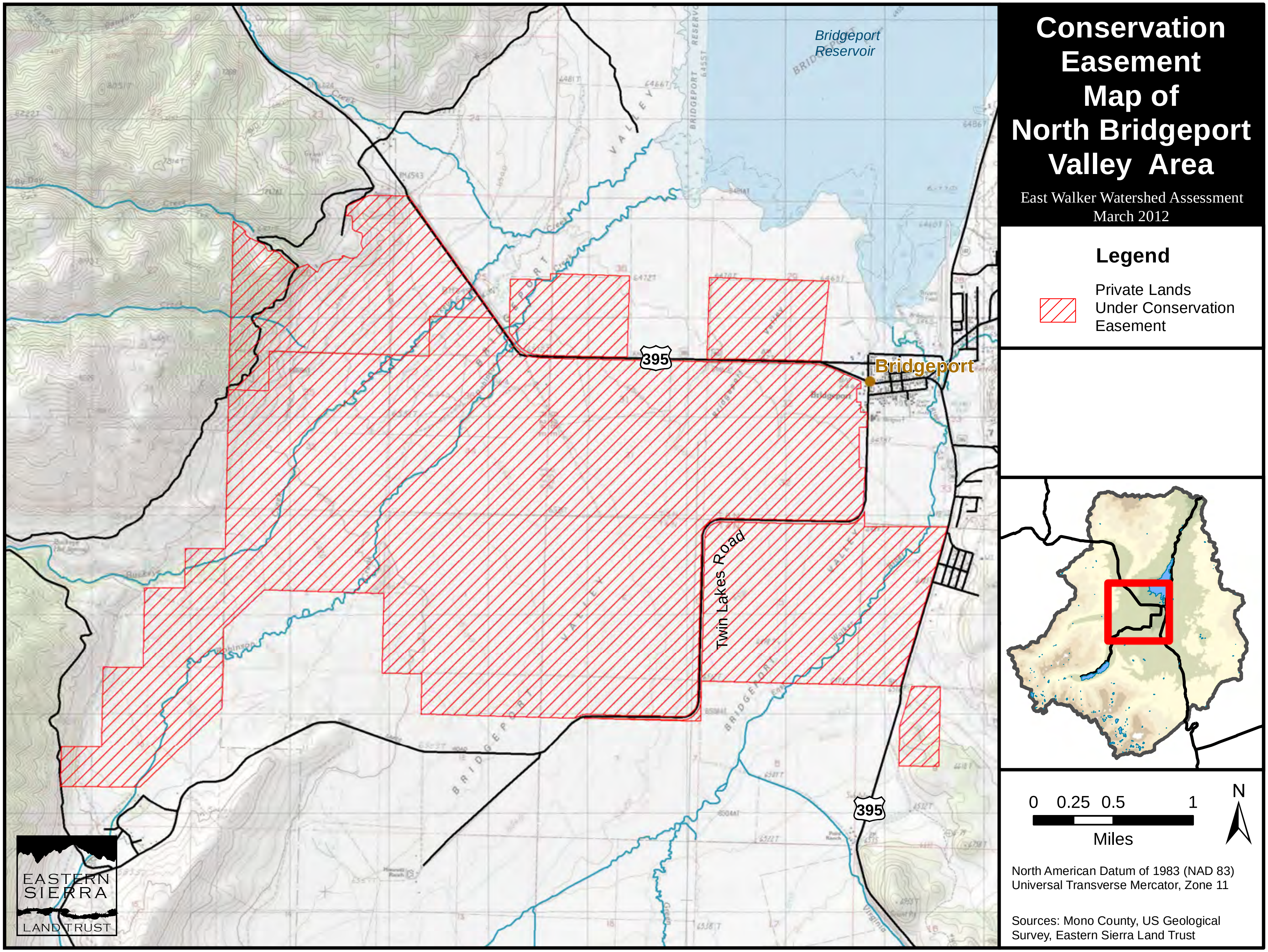
The Bureau of Land Management has designated a 3,000 acre area just north of Conway Summit and west of U.S. Highway 395 as another ACEC. Much of this area was purchased by the Trust for Public Land and transferred to the public domain. The Conway Summit area is a mixture of wet meadows, enhanced by ditch irrigation, and aspen groves. The area is critical for both the Mono Lake and East Walker herds of mule deer with up to 4,000 deer migrating through between winter and summer ranges. The Sierra Nevada red fox has been spotted in the area. The Kirkwood Meadow portion of the Conway Summit ACEC is considered important habitat for greater sage-grouse (USDI-Bureau of Land Management, 2010). Refer to **Map 19**: Conservation Easement Map of North Bridgeport Valley Area.



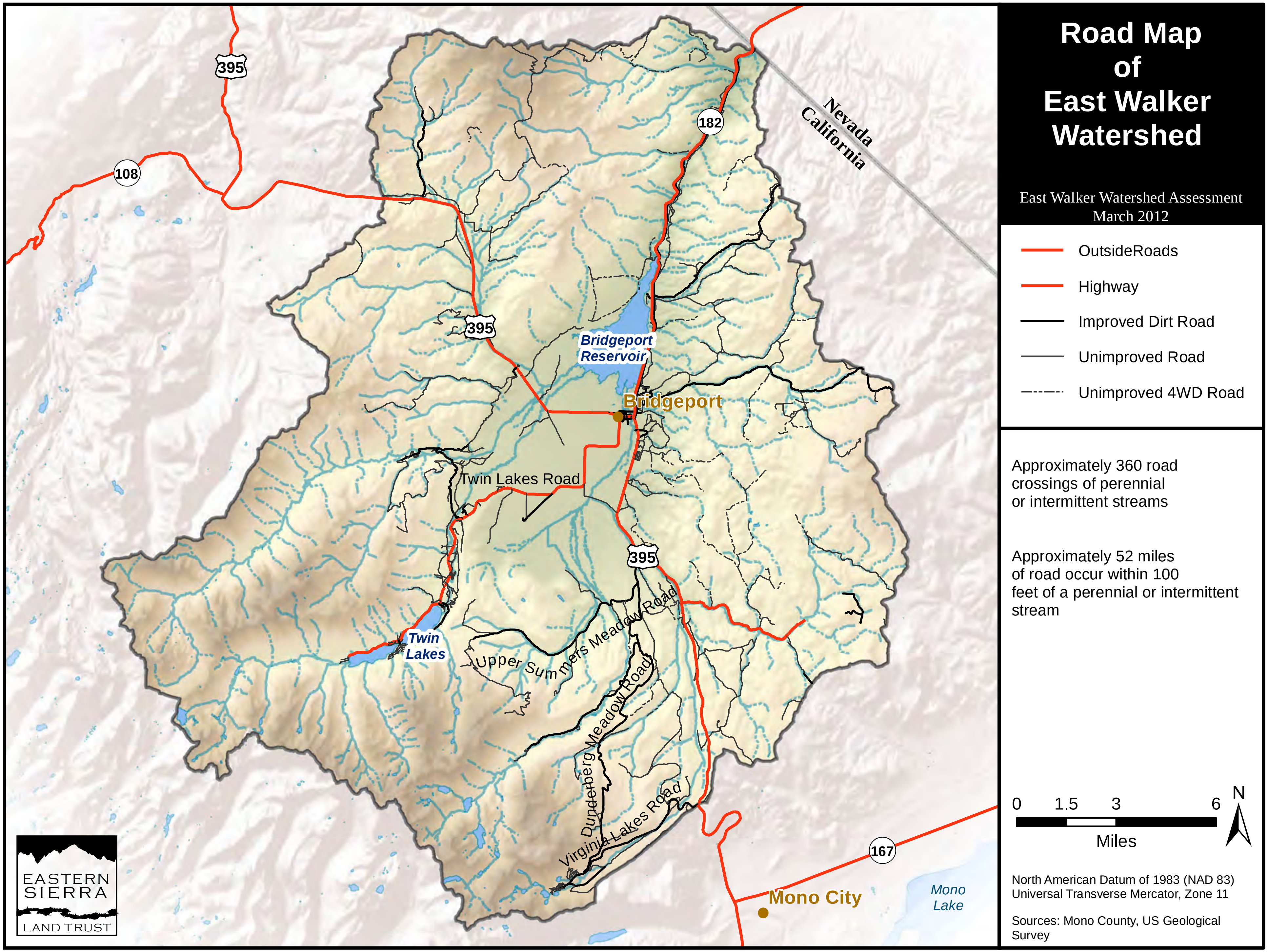
Map 17: Land-Use Designation Map of East Walker Watershed



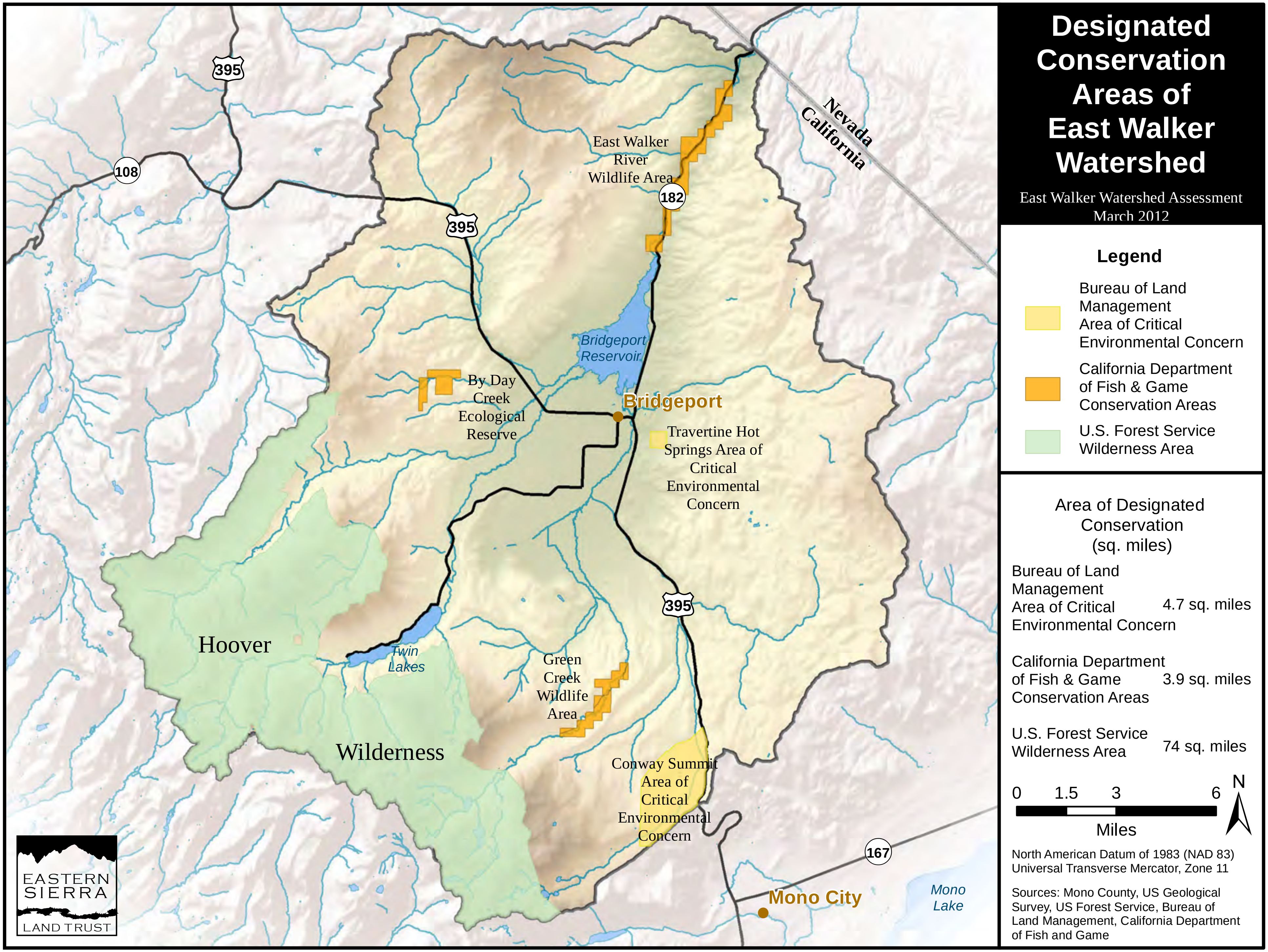
Map 18: Land Ownership Map of East Walker Watershed



Map 19: Conservation Easement Map of North Bridgeport Valley Area



Map 20: Road Map of East Walker Watershed

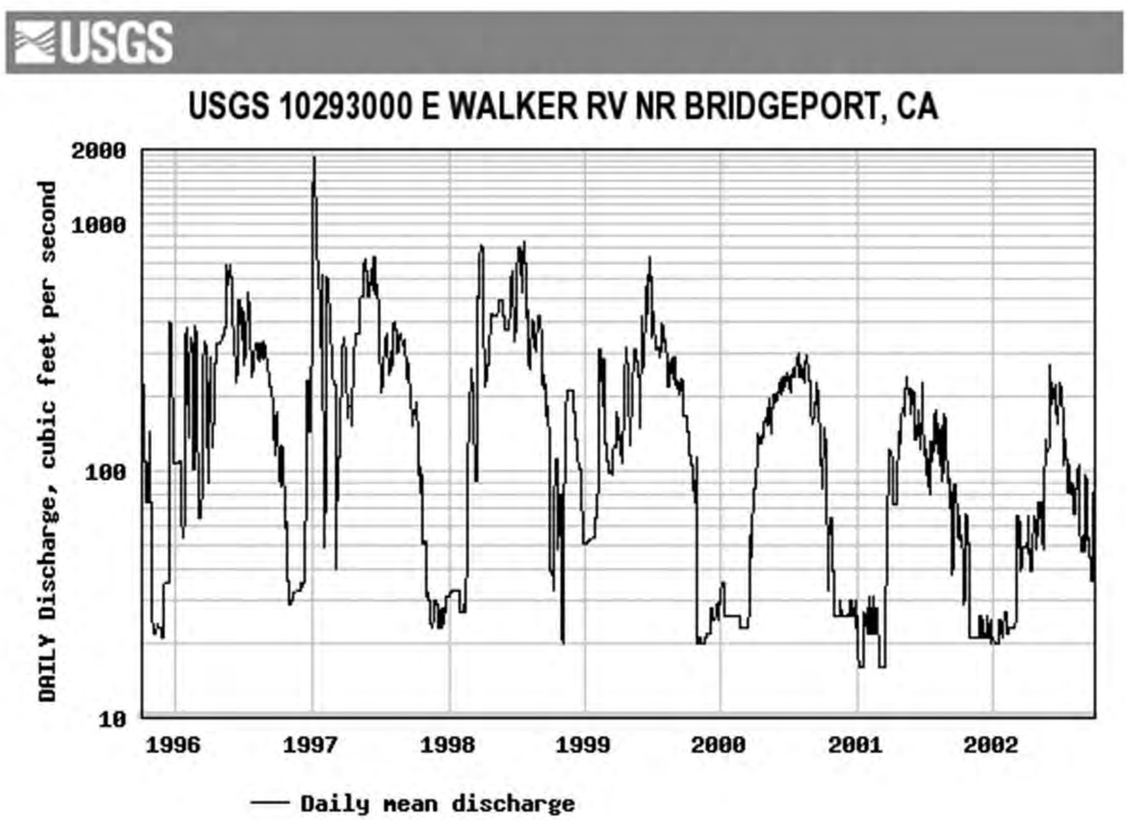


Map 21: Designated Conservation Areas of East Walker Watershed

6. Descriptive Hydrology

The East Walker River has a runoff pattern (**Figure 5**) dominated by snowmelt from April through July that is typical of most Sierra Nevada rivers. A winter snowpack usually begins to accumulate in November at the higher elevations, attains maximum water storage in late March or early April, and then melts over the next couple of months. After several months of low discharge during autumn and winter, the streams begin to rise during April with the initial snowmelt and carry sustained high flows through May and into June. As the snowpack gets thinner and snow cover disappears from successively higher elevations, streamflow declines through summer and eventually reaches the minimal flows of autumn. Occasionally, a warm storm brings enough rainfall over enough of the watershed to raise streamflow for a few days. On rare occasions, these storms lead to significant rainfall and runoff that have generated the largest floods on record.

Figure 5: Annual Pattern of Streamflow for East Walker River for Seven Years, including a Rainfall-Generated Flood in January 1997



Annual pattern of streamflow for East Walker River for seven years, including a rainfall-generated flood in January 1997. Flow is regulated by Bridgeport Reservoir, just upstream of the gaging station. Data and graph from U.S. Geological Survey (http://waterdata.usgs.gov/ca).

The East Walker River supplies about 38 percent of the water that would naturally (in the absence of diversions) enter Walker Lake [107,000 AF / 285,000 AF] (Mono County, 1992) or about 37 percent of the total surface-water flow within the Walker River basin before losses 137,000 AF / 387,000 AF] (Lopes and Allander, 2009).

Runoff Generation Processes

Most of the runoff volume over the course of a year in the East Walker River watershed is produced during the spring snowmelt season. Water produced from melt at or very near the surface of the snowpack that has accumulated over the winter percolates through the snowpack and arrives at the soil surface. Depending on the degree of saturation of the soil and its infiltration characteristics, the water may enter the soil and percolate to greater depths or it may flow over the soil surface, combining with other melt water in progressively larger surface channels and eventually in a stream. Water may also flow downslope at the soil/snow interface where the soil is frozen, covered by a basal ice lens, compacted to near impermeability, or covered with an impermeable surface such as concrete or asphalt. Snowmelt that infiltrated into the soil flows between the soil particles in a saturated or unsaturated state (air may occupy some of the pore space). Water percolating through the soil may enter the deep groundwater zone, remain stored in the soil temporarily, or emerge from the soil farther downslope onto the soil surface or within a channel. Water that has percolated deep into the ground continues to move down gradient under the influence of gravity and hydraulic pressure and may resurface in a spring, within a surface channel, or be extracted in a well. The degree of contact that flowing water as well as water in temporary storage has with mineral grains in or on the soil and other substances on the soil surface or within channels determines the chemical composition of the water and any particulate load that the water may transport. Rainfall-runoff processes function largely similar to snowmelt-runoff with the additional possibility of the rainfall intensity and physical impact altering the rate of infiltration into the soil.

Water in channels on alluvial fans and other sedimentary deposits may alternate between being on the surface within the channel and below the surface as it flows downhill. The porosity and permeability of the materials constituting the slope and channel may vary considerably along the water's course. The discharge of a stream flowing through permeable materials may vary substantially along the channel with alternating areas where water infiltrates into the ground and other areas where water exfiltrates into the channel.

Water Balance

A simple water balance of the form of

Precipitation = Runoff + Evapotranspiration +/- change in storage

can be very illustrative about how water is transformed and distributed within a watershed.

The U.S. Geological Survey (Thomas, 1995) estimated that of an average (1939-1993) of 132,000 AF entering the Bridgeport Valley per year, 25,000 AF is evaporated and 107,000 AF flows downstream.

As part of the recent studies of the entire Walker River basin, the U.S. Geological Survey has prepared a detailed water balance of the watershed (Lopes and Allander, 2009).

The following hydrologic characteristics and quantities were estimated by Glancy (1971) for the "East Walker area" of 735 square miles extending far downstream of the California-Nevada border [units are acre-feet]:

Average annual river inflow	98,000
Surface-water runoff to the valley fill	30,000
Potential ground-water recharge	31,000
Ground-water inflow	200
Consumptive use by crops	11,000
Natural evapotranspiration	7,500
Average annual river flow	97,000
Pumpage (1969)	15
Ground-water outflow	150
Minimum system yield	17,000
Ground-water in storage	800,000

As part of an overall water balance for the entire Walker River basin, Pahl (2000) calculated an average annual water balance for the East Walker River watershed, upstream of the dam for Bridgeport Reservoir, based on the period 1926-1995 [units are acre-feet]:

River inflow	130,600
Non-channelized inflow	28,100
River outflow	103,900
Irrigation diversions	50,000
Net open-water evaporation	4,300
Changes in lake storage	500
River outflow minus inflow	-26,700

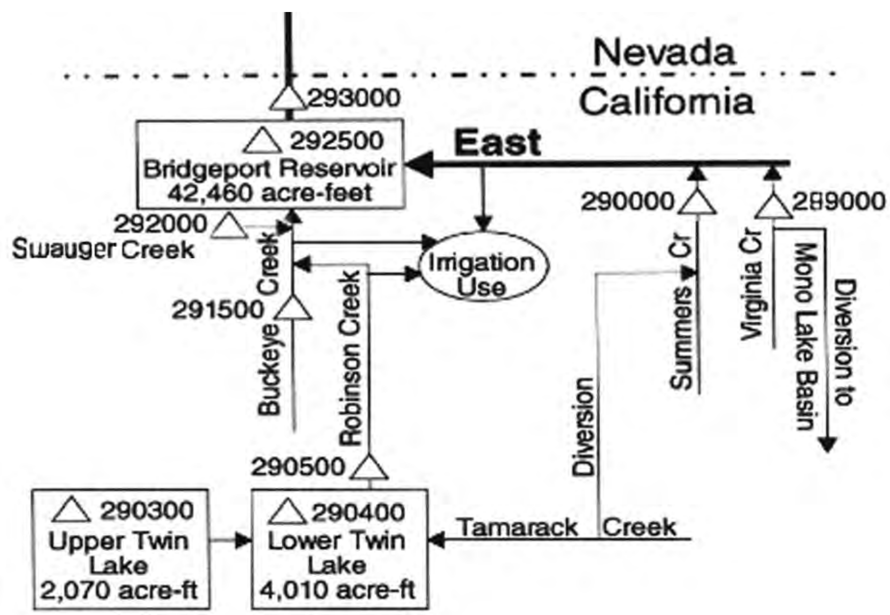
Streamflow Averages and Extremes

The active interest in maximizing use of the water resources of the East Walker River resulted in the operation of several long-term stream gages within the basin:

Table 14: U.S.G.S. Stream Gages in the East Walker River Watershed

Station	USGS #	Period of Record	Area (mi2)	Ave. Volume
East Walker near Bridgeport	10293000	1925-present	359	105,700 AF
Virginia Creek near Bridgeport	10289000	54-75, 04-present	64	12,200 AF
Swauger Creek near Bridgeport	10292000	53-75, 05-06	53	19,620 AF
Buckeye Creek near Bridgeport	10291500	53-79, 95-08	44	43,350 AF
Robinson Ck at Twin Lakes Outlet	10290500	53-75, 94-08	39	45,530 AF
Green Creek near Bridgeport	10289500	53-75, 04-present	20	20,780 AF
Summers Ck near Bridgeport	10290000	53-59	8	4,278 AF

Figure 6: Schematic Diagram of Location of Stream Gages in East Walker River Watershed



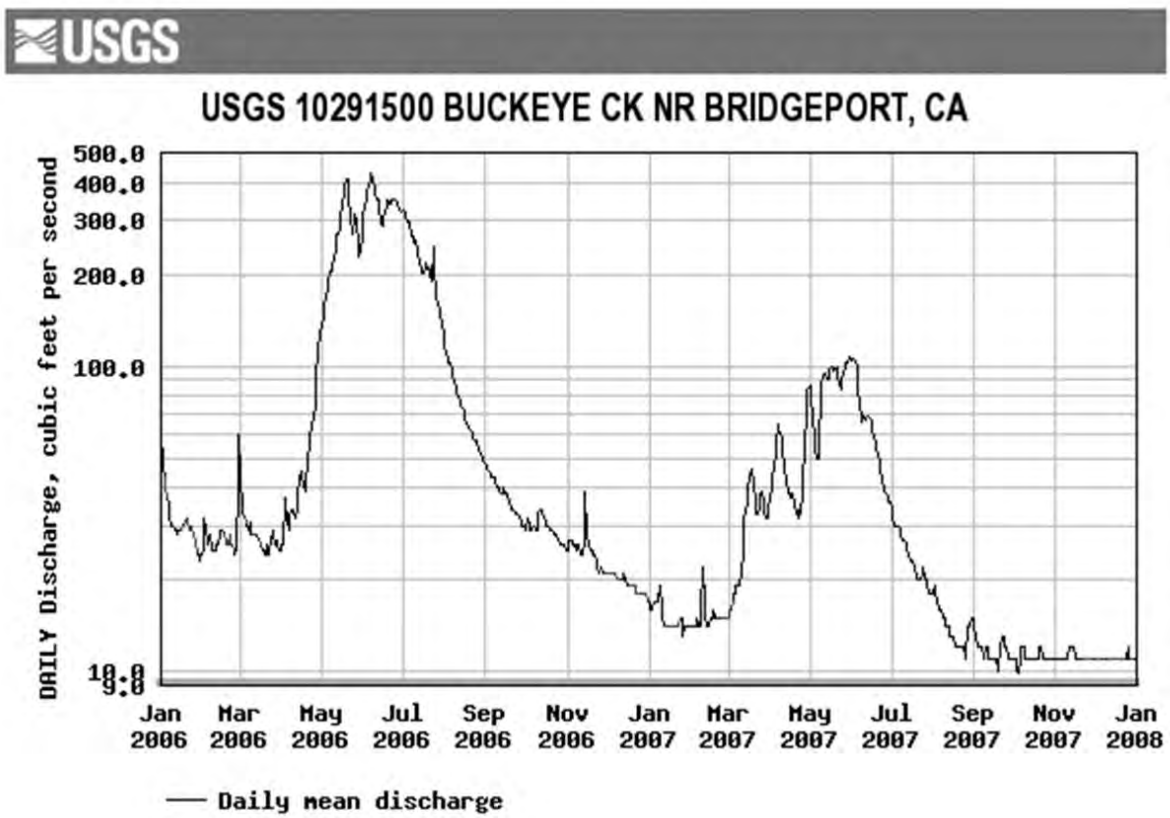
Green Creek (tributary to Virginia Creek) is not shown. Data and basis for diagram from U.S. Geological Survey (http://waterdata.usgs.gov/ca).

A U.S. Geological Survey report (Thomas, 1995), estimated the average inflow to the Bridgeport Valley from six streams over the period of 1954 to 1974 was 132,000 AF (or 182 cfs) and the average flow of the East Walker River below Bridgeport Reservoir over the period 1926 to 1993 + 1923 was 107,000 AF (or 148 cfs) (Thomas, 1995).

For comparison, the historical (including the effects of diversions) average annual inflow to Walker Lake is about 76,000 acre-feet, which is insufficient to maintain the lake level and salinity (Thomas, 1995). The estimated natural inflow in the absence of diversions is 285,000 acre-feet.

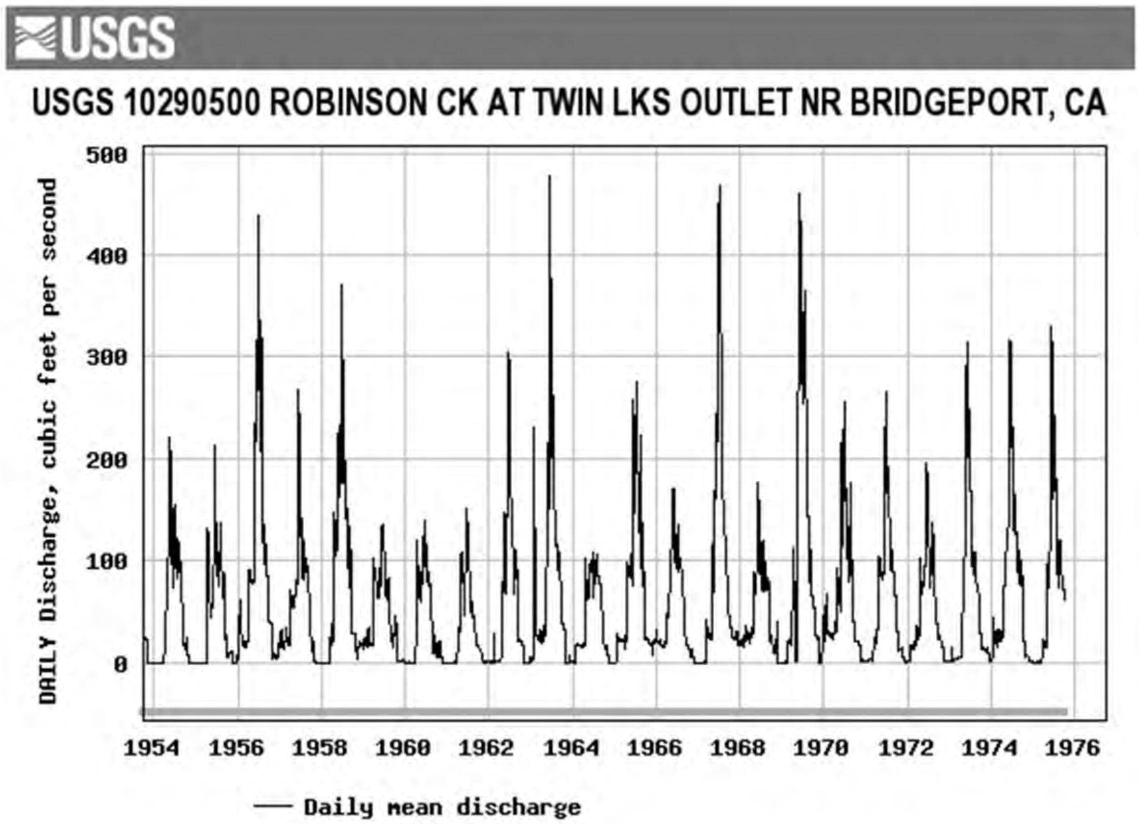
The minimum and maximum annual volumes for the East Walker River near Bridgeport were 27,000 AF in 1931 and 321,000 AF in 1983. The minimum and maximum annual volumes for Robinson Creek at the outlet from Twin Lakes were 24,000 AF in 1961 and 79,000 AF in 2006 (source: U.S.G.S. National Water Information System).

Figure 7: Monthly Discharge Reaches a Maximum in June from Snowmelt and Remains Low from September through March



In this example hydrograph from Buckeye Creek in 2006 and 2007, stream discharge for the tributaries of the East Walker River reaches a maximum in June from snowmelt and remains low from September through March. Snowmelt peaks can vary considerably between years. Data and graph from U.S. Geological Survey (http://waterdata.usgs.gov/ca).

Figure 8: The Hydrograph of the East Walker River Illustrates the Variability in Flows from Year to Year over the period of 1954 to 1975.



The hydrograph of Robinson Creek (as regulated by Twin Lakes reservoirs) illustrates the variability in flows from year to year over the period of 1954 to 1975. Data and graphs from U.S. Geological Survey (http://waterdata.usgs.gov/ca).

Table 15: Total Volume of Snowmelt Period (April-August) Runoff

Ranked high to low (source: National Weather Service National Water Resources Outlook) and total volume for the water year (previous October 1 through September 30) for selected years.

Year	Volume (1000 AF)	Percent of Average	Total Volume Water Year (1000 AF)
1969	224	335	249
1983	218	325	320
1952	170	254	196
2006	152	226	214
1967	146	218	167
1986	146	217	206
1982	145	217	172
2011	138	205	--
1958	132	197	153
1980	132	197	175
1956	131	196	162
2005	128	191	153
1978	102	153	111
1996	95	142	
1963	95	141	
2009	94	140	
1965	94	140	
1984	91	136	
1995	86	128	
1973	82	122	
1975	80	120	122
1974	80	119	
1962	79	118	
1993	73	109	
1979	68	102	
1971	66	98	
1999	63	93	
2008	60	90	61
2010	60	90	
1970	59	88	
1953	55	82	
1957	54	80	
1951	51	77	98
2000	47	70	
1985	46	69	
2003	44	65	
1998	43	64	
1949	42	63	
1950	41	61	
1966	40	60	107
1954	37	55	
1948	34	51	
1989	34	50	
2004	31	47	
1988	31	46	
1955	30	44	53
2001	28	42	
1981	28	42	
1972	28	41	
1964	27	40	
2007	25	38	
2002	23	35	
1959	23	34	
1968	22	33	
1960	21	31	
1991	20	29	40
1994	20	29	
1987	18	28	
1961	18	27	
1990	14	20	
1992	12	18	
1977	9	14	31
1976	8	12	54

Source: U.S.G.S. National Water Information System

Droughts and Floods

As noted in the climate and history sections, paleoclimate studies suggest that dramatic fluctuations in precipitation (and resultant runoff) have occurred in the Walker River basin in the geologic past.

Paleoclimatic inferences from a variety of residual evidence for the Sierra Nevada and western North America (e.g., Minnich, 2007; Sharpe, 2010) do not yet provide a consistent time sequence of wet and dry periods over the past few millennia. For the Walker River basin, a few studies offer some long-term context for climate variability, even though the inferred timing is not in complete agreement. Low levels of Walker Lake appear to have occurred:

- 5,000 to 4,700 years BP (Bradbury, et al., 1989: Benson, et al., 1991)
- 2,400 to 2,000 years BP (Bradbury, et al., 1989: Benson, et al., 1991)
- AD 500 to 1000 (Benson, et al., 1991; Adams, 2003)
- AD 900 to 1100 (Yuan, et al., 2004)
- AD 1200 to 1350 (Yuan, et al., 2004)
- AD 1500 to 1700 (Adams, 2003)

These low lake levels presumably resulted from prolonged drought, but geologic diversion through Adrian Valley has been proposed as an alternative mechanism (Benson, et al., 1991).

Severe and persistent droughts occurred in the Walker River watershed during AD 890-1110 and 1210-1350 (Stine, 1994). These dry periods had so little streamflow that Jeffrey pine trees grew on the bottom of the channel in the nearby [West] Walker River Canyon. Modern dry spells are short and wet by comparison.

During the past century, periods with well-below average precipitation occurred in 1924-25, 1928-34, 1960-61, 1976-77, 1988-92, and 2007-2009 (Jones and Nguyen, 2010). In the adjacent Mono Basin, the first two periods were considered as one long dry period from 1923 through 1935 with an average of 74 percent of average runoff. By comparison, the 1987 through 1992 period only had about 60 percent of the long-term average runoff in the Mono Basin (Jones and Stokes Associates, 1993). Bridgeport Reservoir was drained below its operating level on several occasions during each of these dry periods. Downstream in Nevada, the Walker River stopped flowing at the Wabuska stream gage in 1924-25 and 1931 (California Department of Water Resources, 1992).

At the opposite extreme, there has been a variety of floods in the watershed. Particularly damaging floods occurred in 1950, 1955, and 1997. Floods that cause widespread damage throughout the entire watershed are relatively uncommon. Types of floods in the East Walker watershed include winter rain floods, spring snowmelt floods, and localized floods often associated with summer thunderstorms. The most recent California Water Plan Update (California Department of Water

Resources, 2009) lists the flood of record on the East Walker River near Bridgeport as 1,910 cfs with a peak stage of 6.7 feet.

The East Walker River generally has its highest flow of each year in May during the snowmelt period. In most years, at the USGS stream gage below Bridgeport Reservoir, these annual peak flows range between 300 and 400 cfs (Davis, et al., 2010).

The large volume of snowmelt runoff in 1995 led to high water levels along the East Walker River and its tributaries from May through July but did not cause any structural damage. The large runoff also raised the level of Walker Lake by 4 to 5 feet.

The flood peak of record at the East Walker River near Bridgeport gage was about 1,910 cfs on January 4, 1997. Other floods above (an arbitrary) 1,000 cfs at this gage include:

1390	June 19, 1963
1380	July 2, 1980
1370	June 3, 1986
1360	July 6, 1967
1240	January 22, 1943
1220	June 12, 1938
1170	July 8, 1995
1110	June 30, 1983
1080	June 30, 1982
1050	June 4, 1969

All of these flows were affected by regulation at Bridgeport Reservoir. Nine of these highest flows were generated by spring snowmelt. The 1997 and 1943 events were caused by warm winter storms with rainfall and snowmelt.

Table 16: Annual Peak Flows for Buckeye Creek, 1954-2011

Water Year	Month-Day [-Yr]	Peak Discharge (cfs)
1954	5-20	404
1955	6-7	438
1956	12-23-55	700
1957	6-3	414
1958	6-23	540
1959	6-6	201
1960	6-2	261
1961	8-22	526
1962	6-22	388
1963	2-1	947
1964	5-19	216
1965	12-23-64	700
1966	5-22	231
1967	7-3	772
1968	5-28	241
1969	6-8	633
1970	6-3	308
1971	6-27	422
1972	5-31	287
1973	5-31	454
1974	6-12	384
1975	6-6	392
1976	5-14	198
1977	6-9	160
1978	6-14	372
1979	1-11	614
1980-1995	no record	
1996	5-15	500
1997	1-2	2,750
1998	7-9	397
1999	6-23	369
2000	5-28	345
2001	5-25	321
2002	5-30	286
2003	5-28	373
2004	5-28	233
2005	5-29	526
2006	6-7	486
2007	5-28	129
2008	5-19	204
2009	no record	
2010	6-7	540
2011	6-23	>515

Table 17: Annual Peak Flows for East Walker River below Bridgeport Reservoir, 1923-2011

All values are controlled releases from Bridgeport Reservoir.

Water Year	Month-Day [-Yr]	Peak Discharge (cfs)
1923	5-22	714
1924	7-22	550
1925	7-25	513
1926	6-27	334
1927	7-1	491
1928	7-11	326
1929	7-12	255
1930	6-17	304
1931	5-21	169
1932	5-21	363
1933	8-2	408
1934	7-29	221
1935	8-2	287
1936	7-1	510
1937	6-12	452
1938	6-12	1,220
1939	3-24	297
1940	6-27	289
1941	7-7	652
1942	6-18	674
1943	1-22	1,240
1944	4-8	368
1945	7-11	856
1946	5-5	325
1947	5-7	279
1948	6-19	249
1949	6-9	297
1950	7-25	282
1951	6-24	714
1952	7-31	985
1953	7-16	475
1954	6-4	328
1955	6-12	242
1956	7-1	981
1957	7-19	385
1958	6-26	882
1959	10-1-58	259
1960	7-7	265
1961	6-23	191
1962	6-23	487
1963	6-19	1,390
1964	5-22	302
1965	8-17	535
1966	11-24-65	366
1967	7-6	1,360
1968	6-2	257
1969	6-4	1,050
1970	1-17	860
1971	7-21	720
1972	3-4	342
1973	6-4	668
1974	6-16	728
1975	3-25	590
1976	9-1	279
1977	7-25	284
1978	5-3	514
1979	5-29	655
1980	7-2	1,380
1981	6-26	332
1982	6-30	1,080
1983	6-30	1,110
1984	5-31	667
1985	7-4	314
1986	6-3	1,370
1987	3-3	348
1988	7-25	173
1989	8-22	292
1990	10-2-89	144
1991	6-16	206
1992	5-13	137
1993	8-13	371
1994	10-21-93	1,000
1995	7-8	1,170
1996	5-16	767
1997	1-4	1,910
1998	7-22	865
1999	6-24	738
2000	8-15	306
2001	5-12	246
2002	6-2	274
2003	8-11	254
2004	6-22	271
2005	5-21	916
2006	6-13	945
2007	10-1-06	193
2008	5-21	277
2009	7-8	379
2010	7-8	396
2011	6-27	>922

Flood events that have been observed in other streams in the central Sierra Nevada include rainfall events on 11-18/20-1950, 12-23-55, Dec 63, Dec 64, 1-2/4-97; spring snowmelt in 1967, 1969, 1995, 1996, 2011; and summer thundershowers 7-52, 7-28-60, 7-30/31-65, 8-16-65. Some, but not all, of these events were apparent in the observed record of streamflows within the East Walker River watershed. The record from the stream gage below Bridgeport Reservoir is not particularly useful for observing small flood peaks because of the attenuation of any flood wave as well as the management of releases from the dam.

Streamflow gaging stations were established on a few of the tributaries in the East Walker River watershed in autumn 1953. There were no gaged records of floods in prior years. The December 23, 1955 event produced the highest peak of the limited records for Swauger Creek, Summers Creek, and Virginia Creek. In Green Creek, several spring snowmelt peaks were greater than the 1955 flood. The February 1, 1963 rain-on-snow flood produced the second highest peak in the limited records of Virginia Creek and Swauger Creek. The December 1964 storm produced the peak of that water year for Virginia Creek and Swauger Creek, but the peak flow value was exceeded by several spring snowmelt peaks in other years. Gaging stations on the main tributaries were not active during the January 1997 flood.

Box 4: January 1997 Flood

The January 1997 flood is the highest flood on record in the East Walker River but caused much less damage than along the West Walker River. Antecedent conditions within the basin and heavy rainfall combined to produce excessive runoff for several days. Snow was present throughout the basin, and soil moisture was high from rainfall and snowmelt at the end of December. The elevation of the rain-snow level rose dramatically on December 30 and 31, 1996, with rain falling up to at least 10,000 feet, so that virtually all the basin was contributing runoff. Rainfall intensities increased as well. Total rainfall averaged over the basin area may have been as much as 15 inches during the storm (Horton, 1997). In addition, there was at least two inches of water contributed by snowmelt. The massive amount of runoff from most of the basin over a short period of time resulted in very high rates of discharge in the East Walker River and its tributaries.

The only stream gage that was operating on an unregulated tributary during the January 1997 flood was on Buckeye Creek. A peak discharge of 2,750 cfs was observed at the stream gage on Buckeye Creek. That value is almost three times greater than the previous peak of record: 947 cfs on February 1, 1963. The flood peak on Buckeye Creek can be expressed as 62 cfs per square mile (over the watershed area of 44.1 square miles). That value is comparable to the 68 cfs per square mile value generated over the 181 square-mile West Walker River watershed and greater than 40 cfs per square mile value produced on the 63 square-mile Little Walker River watershed (a few miles to the west over Flatiron Ridge) during the same January 1997 flood. Peak discharge at the gage on Robinson Creek (below Twin Lakes) was 1,170 cfs.

The peak discharge of about 1,910 cfs at the USGS gage below Bridgeport Reservoir on January 4, 1997, was about 50 percent larger than the previous flood of record (1,390 cfs on June 19, 1963). On the West Walker River, the 1997 flood was about twice as great as the previous high flow. Flood peaks on the Truckee and Carson rivers to the north in 1997 were less than historic peaks in 1950 and 1955.

Clearwater Creek rose above bankfull stage near its confluence with Virginia Creek and flowed across U.S. Highway 395 in that vicinity (Mono County Community Development Department, 2000). The flood also eroded portions of State Highway 270 upstream of the site of a proposed RV park (Denio and Associates Engineering, 1997).

None of the reservoirs in the East Walker River watershed are operated to provide flood control, but if there happens to be available storage in Bridgeport Reservoir at the time of a flood event, then the flood peak is reduced downstream of the dam (California Department of Water Resources, 1992).

Clearwater Creek has damaged State Highway 270 during high flows in areas where the roadway encroaches into the stream channel (Mono County Community Development Department, 2000).

Baseflow

The recorded low flows in Buckeye Creek generally ranged from 5 to 10 cfs (or about 0.1 to 0.2 cfs per square mile -- somewhat below typical values for upper-elevation Sierra Nevada streams). Similarly, the recorded low flows at the Virginia Creek gage generally ranged from 2 to 5 cfs (or about 0.03 to 0.08 cfs per square mile). These relatively low baseflow values suggest that there is comparatively less groundwater discharge into the tributaries of the East Walker River than in other semi-comparable Sierra Nevada streams. During dry years such as 1977, baseflow discharges dipped to about half the average values.

An analysis of the likelihood of very low flows for a week and a month was conducted for a few of the streams in the watershed, based on discharge records at the USGS gaging stations from 1955 to 1971 (USDA Nevada River Basin Study Staff, 1975). The values below are discharge (cfs) that would not be exceeded for either 7 or 30 days at a 1 and 10 percent probability of occurrence.

Table 18: Probability of Very Low Flows in Selected Streams

	1% chance		10% chance	
	7 day	30 day	7 day	30 day
East Walker	1.0	1.2	3.0	3.3
Virginia Creek	0.5	0.7	1.5	2.0
Green Creek	2.0	2.4	3.2	3.6
Buckeye Creek	5.6	6.5	8.4	9.5

For example, there is a 1 percent chance (1 year in a century) that flows at the gage on the East Walker River would be less than 1 cfs for an entire week.

Lakes

In the steep terrain of the East Walker River watershed, there are few lakes. In the Robinson Creek drainage, named lakes include (from west to east) Peeler, Snow, Robinson, Little, Crown, Barney, Maltby, Ice, Glacier, Avalanche, Frances, Turquoise, Glenberry, Hunewill, Tamarack, and Upper and Lower Twin Lakes. In the Green Creek drainage, named lakes include (from west to east) Bergona, Par Value, West, Summit, Green, East, Hoover, Nutter, and Gilman Lakes. In the Virginia Creek drainage, named lakes include (from west to east) Frog, Moat, Cooney, Blue, Virginia, Red, and Trumbull Lakes. The total surface area of lakes (excluding Upper and Lower Twin Lakes and Bridgeport Reservoir) is about slightly under one square mile (0.9 sq. mi) or 0.2% percent of the entire watershed area. Hydrologically, the small lakes of the East Walker River watershed offer little detention storage except in late summer or autumn when their level drops below their natural spillway. Even the small lakes act as efficient sediment traps.

Simulation Modeling

As part of the Walker Basin Project of the University of Nevada-Reno and Desert Research Institute, a "decision support tool" was developed to evaluate potential impacts of possible acquisition of water rights within the Walker River system (Boyle, et al. 2010). One portion of this computer model was an independent hydrologic model, the Precipitation-Runoff Modeling System of the U.S. Geological Survey (Leavesley, et al., 1983). Applied to the upper East Walker River, this hydrologic model simulated observed streamflow reasonably well in the Buckeye Creek and Robinson Creek watersheds, but did not simulate observed streamflow very well at the stream gage downstream of Bridgeport reservoir because reservoir operations and irrigation diversions were not inputs to the model (Boyle, et al., 2010). For the decision support tool, the research team used observed streamflow from the gage below Bridgeport Reservoir instead of the simulation results.

Groundwater

Within the East Walker River basin, groundwater is found in two relatively distinct portions of the hydrologic system. Some water is below the ground surface for short periods of time (hours to months) as it flows downslope toward a surface channel or into the Bridgeport Valley groundwater basin. This shallow groundwater can be considered as the slow portion of the runoff generation, and most of it ends up as streamflow or is captured by plant roots and lost to the atmosphere. The second type of groundwater can be considered to be in long-term storage (years to centuries), either within fractured bedrock or in the deep groundwater basin of the Bridgeport Valley. Alluvial sediments have accumulated to depths of dozens to hundreds of feet within this structural basin and have much storage space in the pores between the particles.

The Bridgeport Valley groundwater basin has a surface area of about 51 square miles and an average surface elevation of 6,500 feet (California Department of Water Resources, 2004). The basin is filled with interbedded alluvial fans, floodplain and stream channel deposits, and lake sediments of Recent age. Groundwater in Bridgeport Valley is found in both unconfined and artesian zones. The valley fill consists of unconsolidated brown or bluish sandy silty gravel and some boulders. This material, initially eroded by glaciers and peri-glacial processes in the Sierra Nevada, was transported in large quantities by streams flowing from the glacial areas and deposited in the Bridgeport Valley area. The thickness and properties of the valley deposits are unknown because of the lack of any bore hole data, but it is assumed that unconsolidated materials extend to a depth of at least several hundred feet. Average specific yields are estimated to range from 13 percent to 26 percent (California Department of Water Resources, 2004). Layers of glacial till in the Bridgeport Valley act as good aquifers where the pore space is not clogged with clays (California Department of Water Resources, 1992). The estimated storage capacity of the Bridgeport Valley groundwater basin can be crudely estimated to be between 250,000 and 4,000,000 AF. These estimates were based on a storage interval between 50 and 500 feet and a specific yield of 15 percent to 25 percent. A figure of 280,000 AF was used by the California Department of Water Resources (1975) in an early version of its groundwater bulletin series. Definitive studies quantifying the groundwater resources of the Bridgeport Valley have not been published (Sharpe, et al., 2007).

The water table in the vicinity of a subdivision proposed in the 1980s along the Twin Lakes Road was within two feet of the ground surface in spring and early summer (ESA Planning and Environmental Services, 1987). A 330 foot deep well near this site is used for the domestic water supply of Bridgeport (ESA Planning and Environmental Services, 1987).

In areas of the East Walker beyond the alluvial fill of the immediate Bridgeport Valley, groundwater also occurs within fractures and joints of volcanic, granitic, or metamorphic rocks.

The fractured volcanic rock composing the Bodie Hills allows water to percolate thousands of feet below the ground surface. Geothermal processes also force water back to the surface. Analysis of water issuing from hot springs and cold-water springs in the Bodie Hills indicates that the geothermal waters have high levels of dissolved minerals while the cold-water springs have generally good water quality (Mono County Community Development Department, 2000). Interpretation of the geology in the Bodie Hills and a water balance for Rough Creek suggests there could be an "appreciable amount" of groundwater movement from the Rough Creek subwatershed into the Mono Lake basin (Glancy, 1971).

Due to the lack of borehole data, descriptions of material underlying the glacial outwash are not available. No published data about groundwater level trends were found. Insufficient data are available for a groundwater budget.

A recent report by the California Department of Water Resources contained a little information on groundwater levels within the Bridgeport Valley. There is no routine monitoring of well levels reported to the state (California Department of Water Resources, 2004). The storage capacity of the Bridgeport Valley groundwater basin has been estimated as 280,000 acre-feet at depths of 20 to 120 feet below the ground surface (California Department of Water Resources, 2004).

Within the East Walker River basin, most domestic water supply comes from groundwater. The Bridgeport Public Utilities District has two wells that supply water within the town of Bridgeport (Mono County, 1992). Many private wells serve individual homes in the watershed, both in the alluvial valley-fill deposits thought of as aquifers in the conventional sense, and in the fracture zones in otherwise less pervious rock.

Agricultural irrigation is a significant contributor to groundwater recharge throughout the Bridgeport Valley. Water infiltrates from the canals, and a lot of applied water infiltrates below the root zone of alfalfa (California Department of Water Resources, 1992). Bridgeport Reservoir also contributes to the groundwater basin, although when the reservoir is low, there is likely to be a net outflow of groundwater into the reservoir.

Travertine Hot Springs

Travertine Hot Springs is a set of geothermal springs located about a mile southeast of Bridgeport and uphill from the Bridgeport Ranger Station. The springs have been used by native peoples for thousands of years (USDI-Bureau of Land Management, 1995). Travertine is a form of calcium carbonate that precipitated from the hot water as it cooled. Travertine at the hot springs is colored both by mineral “and biological action” (Department of Water Resources, 1992). Some of the rock has been removed for use as decorative stone. The Bureau of Land Management designated the area around Travertine Hot Springs an Area of Critical Environmental Concern and completed a management plan for the area in 1995.

The travertine band-thigh diving beetle (Hygrotus foninalis) has been found in Travertine Hot Springs, which is the only known location (Sharpe, et al., 2008). It is recognized as an endangered species by the State of California and was listed by the U.S. Fish and Wildlife Service in 2001, though not in 2007 (Sharpe, et al., 2008).

Buckeye Hot Springs

Another geothermal spring called Buckeye Hot Springs is located on the north bank of Buckeye Creek about a mile above the creek's entrance on the floor of Bridgeport Valley. These hot springs are quite popular with recreational visitors, and the surrounding area has a large number of dispersed campsites. User-created trails accessing Buckeye Hot Springs from the Buckeye Road have eroded the hillside above the springs (USDA-Forest Service, 2004).

Diversions and Storage

Soon after the Bridgeport Valley was first settled in the mid-1800s, streams were diverted by cattlemen on to their pastures by creating small, temporary dams in the natural channels. As ranching operations became more stable, the landowners constructed head gates, canals, and ditches to create effective means of irrigating much of the Bridgeport Valley. Most of irrigation water is diverted from Robinson Creek and Buckeye Creek and directed eastward across the valley. Several miles of tributaries to the East Walker River are affected by these diversions, which can reduce the late-summer discharge to a series of marginally connected pools (Lahontan Regional Water Quality Control Board, 1975). Diversions for irrigation within Bridgeport Valley total about 50,000 AF per year out of a total inflow to the Bridgeport Valley of about 130,600 AF per year (Humberstone, 1999). However, estimates of evapotranspiration (e.g., Glancy, 1991) suggest that about half that amount returns to the river or groundwater storage.

Smaller-scale water storage and management began in the East Walker River watershed when ranchers and farmers constructed a few small reservoirs at the higher-elevation portions of the watershed. Some of these reservoirs were formed by building low dams across the natural outlets of existing lakes to increase their storage capacity (California Department of Water Resources, 1992).

Dynamo Pond was developed in the 1890s to generate hydroelectric power to supply the Standard Consolidated Mine in Bodie (13 miles away) and the Silverado Mine in the Sweetwater Mountains. The project became operational in 1893. The project had 350 feet of head between the pond and the powerhouse downstream on Green Creek (California State Water Resources Control Board, 1988). Dams controlling Green Lakes (actually the set of East Lake, West Lake, and Green Lake) were constructed in the 1890s to control water release into Green Creek for hydroelectric generation. The three reservoirs have a total managed storage of 400 acre-feet, a priority date of 1895, and a decreed place of use for the managed water in the Bridgeport Valley (Horton, 1996). Dynamo Pond was created by a timber crib and earth fill dam. It served as the forebay for a dual-wheel powerhouse about half-way down the steep canyon of Green Creek (California Department of Fish and Game, n.d.). The Green Creek hydroelectric facility operated until 1941. A Federal Energy Regulatory Commission license for the site remained active until at least 1990, and a water-rights application was filed for a potential new project on Green Creek (California Department of Fish and Game, n.d., California Department of Water Resources, 1992). This application (#26627 filed on November 20, 1980) was to divert up to 20 cfs throughout the year (California State Water Resources Control Board, 1988).

Upper Twin Lake on Robinson Creek has a managed storage capacity of 2,050 acre-feet behind the 14-foot tall dam. The 16-foot tall dam forming Lower Twin Lake impounds 4,050 acre-feet (California Department of Water Resources, 1992) and was built in 1888. Water rights for storage in Upper Twin Lake have priority dates of 1905 and 1906. Water rights for storage in Lower Twin Lake have priority dates of 1888 and 1906. The decreed place of use for waters managed in both reservoirs is Bridgeport Valley (Horton, 1996).

The principal storage facility in the East Walker River watershed is Bridgeport Reservoir. The Walker River Irrigation District was formed in 1919 with the purpose of building and operating Bridgeport Reservoir and Topaz Reservoir (on the West Walker River). The 63-foot tall earthfill, rock-faced dam on the East Walker River was completed in 1923 (Horton, 1996) or 1924 (California Department of Water Resources, 1992). The reservoir has a large surface area (2619 acres) and relatively shallow depth (only 40 feet at the dam and a mean of 15 feet). During the late summer, much of the surface is covered by aquatic plants, primarily water smartweed (*Polygonum amphibium*). The contributing area upstream of the reservoir is about 358 square miles (U.S. Geological Survey, 2010). The storage capacity is 42,455 acre-feet, and the Walker River Irrigation District has a refill right of about 57,000 acre-feet (Horton, 1996). The crest of the spillway is at an elevation of 6,450.75 feet, but four siphons begin to operate before water rises to the spillway elevation (U.S. Geological Survey, 2010). Water is released from storage to serve irrigation needs along the East Walker River in Nevada and in Mason Valley. The reservoir is eutrophic with large amounts of blue-green algae and little dissolved oxygen (Horne, et al., 2003).

The reservoir has been completely empty during drought periods in 1929, 1930, 1960, 1977, 1988, and 1989 (U.S. Geological Survey, 2010).

The Walker River Irrigation District completed studies of other potential reservoir sites in the early 1970s, but the District did not pursue any projects (California Department of Water Resources, 1992).

Water has been diverted from the East Walker River in the three miles upstream of the California - Nevada border for irrigation. As a total from a few points of diversion, the Walker River Irrigation District has reported an average of about 5,700 acre-feet of water diverted annually (Shumway, 1985).

Water Rights, Use and Management

Most of large ranches of the Bridgeport Valley have riparian rights to the various streams that run through their properties. In addition, there are appropriative rights that date to the early 1860s on the Dressler/Centennial Ranch. Storage rights in Lower Twin Lake date back to 1888. These priority dates were confirmed in Decree C-125, which is the primary legal document for water rights in the Walker River basin.

A lawsuit filed in 1902 and settled in 1919 was the first adjudication of water rights in the Walker River basin. Although the principal dispute was over summer flows of the West Walker River and potential diversion of that river into Alkali Lake (site of present-day Topaz Reservoir), the eventual court decision known as Decree 731 also affected the East Walker and its tributaries. However, the decree was somewhat vague about rights to water in the Bridgeport area, as illustrated by the following quote:

> *"The water now and heretofore reservoired by the Antelope Valley Land and Cattle Company in the several tributaries of Walker River situated above Bridgeport during the winter, or during times when all appropriations herein set forth are supplied, may be used by the Antelope Valley Land and Cattle Company in Bridgeport Valley irrespective of any of the priorities herein set forth, but the same shall not be removed from the watershed of the said river and any surplus or waste therefrom shall be returned to the river and may be used by the other parties hereto in accordance with their several priorities in and to the waters of said river."*(California Department of Water Resources, 1992).

The Walker River Irrigation District was formed in 1919 by farmers in Smith and Mason Valleys, partly in response to Decree 731. The District is a Nevada agency that supplies water to lands in Nevada, but built and continues to manage Topaz and Bridgeport reservoirs upstream of the state border (California Department of Water Resources, 1992).

A few years after Decree 731 was issued, the U.S. government filed a lawsuit on behalf of the Walker River Indian Reservation to secure water rights for the reservation. This action, filed in 1924, was known as United States of America *v.* Walker River Irrigation District *et al*. The litigation concluded in 1936 with issuance of Decree C-125. In addition to establishing the tribe's water rights as the most senior in priority, this decree assigned priorities and quantities of irrigation water for particular parcels (e.g., Curry, 1992). The decree also further establishes a water right for diversion from Virginia Creek into Conway Ranch in the Mono Basin of 6 cfs or about 1,000 acre-feet per year (California Department of Water Resources, 1992). Because neither California nor Nevada was a participant in the litigation, the decree does not allocate water between the states.

In 1955, a California-Nevada Interstate Compact Commission began to draft an agreement that would allocate flows of the Truckee, Carson, and Walker Rivers between the two states (Sharpe, et al., 2008). After 15 years of negotiation, the California legislature adopted the California-Nevada Compact for Jurisdiction of Interstate Waters in 1970, and the Nevada legislature followed in 1971. However, the Compact was never ratified by the U.S. Congress and is not legally binding (Pisani, 1978). Nevertheless, both states tend to operate under the guidelines of the Compact (Sharpe, et al., 2008), and the Compact has continued to be considered a useful concept (e.g., Curry, 1992).

Most of the water rights in the East Walker River watershed continue to be administered under Decree C-125 from 1936. The decree is administered by the U.S. Board of Water Commissioners, a six-person board appointed in accordance with orders of the federal district court, which serves as the water master for the Walker River (California Department of Water Resources, 1992; Mineral County v. State, Department of Conservation, 2001; Sharpe, et al., 2007). The Chief Deputy Commissioner of this board oversees the operational details of allocating water among users (Yardas, 2007).

The priority for storage water rights in Green Lakes dates to 1895. The first priority for storage from Lower and Upper Twin Lakes are 1895 and 1905, respectively. A second priority of 1906 coincided with raising both dams to create additional storage. Both reservoirs have refill rights under Decree C-125.

In Decree C-125, the irrigation season above Bridgeport Reservoir was defined as March 1 to September 15, based on the number of frost-free days.

Although Decree C-125 allowed the Walker River Irrigation District to store 42,000 acre-feet of water in Bridgeport Reservoir and sometimes even more under specified conditions, the District's water rights with respect to the reservoir have been modified over time. The District drained Bridgeport Reservoir in the summer of 1988 to supply some additional irrigation water during the relatively-dry year. During the two months that the reservoir gates were open (Montiel, 1993), the release of warm sediment-laden water killed most of the fish downstream of the dam as well as those barely surviving in the small reservoir pool. California Trout filed a formal complaint with the California Water Resources Control Board alleging that the dewatering of the reservoir and resulting fish kills violated several California statutes. In 1990, the water board issued Water Rights Order 90-16, which amended the District's license for water storage to require a minimum pool in the reservoir and established seasonal minimum instream flows downstream of the dam.

Further developments in the early 1990s were described by Horton (1996). In 1991, the Walker River Irrigation District filed suit against the California SWRCB in federal court challenging the water board's legal capability to impose state requirements on water rights specified by Decree C-125. In 1993, the Justice Court of Mono County convicted the Walker River Irrigation District of misdemeanor violations of sections of the California Fish and Game Code. Under this judgement, WRID was required to pay compensation of $633,000 to the State of California, pay a fine of $250,000 to the California Department of Fish and Game, maintain a minimum pool of 2,000 acre-feet in Bridgeport Reservoir, and flush sediment out of the East Walker River below the dam. In another legal settlement in 1993, WRID was ordered to release 6,000 acre-feet from Bridgeport Reservoir to sediment flushing purposes (Horton, 1996). As of 1992, the District could divert up to 39,700 acre-feet per year for storage in Bridgeport Reservoir and could withdraw 36,000 acre-feet (California Department of Water Resources, 1992).

Litigation seeking water rights for lands added to the Walker River Paiute Tribe since the 1936 issuance of Decree C-125 began in 1992 (United States of America and Walker River Paiute Tribe v. Walker River Irrigation District, et al. [U.S. District Court, District of Nevada, Case No. C-125-ECR]). In 1994, Mineral County filed a motion to intervene in the Decree litigation, which sought reallocation of the waters of the Walker River. This motion claimed that the actions of the California State Water Resources Control Board "began the death of Walker Lake" (Mineral County v. State, Department of Conservation, 2001). In April 2000, the court ordered the case to be split (subproceedings C-125-B and C-125-C) so that the Tribal claims could be considered independently from the remainder of the case. A confidential mediation process was attempted for a few years but apparently has been abandoned. A Stakeholders' committee was also formed and operated under the name of Walker Basin Project. This long-simmering action continues to underlie many of the water allocation issues that are pending throughout the Walker River basin.

Mineral County and the Walker Lake Working Group filed a writ proceeding in June 2000 complaining that the Nevada Department of Conservation, Nevada State Engineer, Walker River Irrigation District, Lyon County, and the City of Yerington had abrogated their duty to protect and maintain Walker Lake for the benefit of the public. The Nevada Supreme Court ruled against this action and found that the continuing litigation in the Decree Court was the proper forum for resolving the dispute (Mineral County v. State, Department of Conservation, 2001).

Congress and federal agencies got involved with policies and programs to partially restore Walker Lake through the Desert Terminal Lakes Program, which was established by section 2507 of Public Law 107-171, the "Farm Bill" of 2002. This first piece of legislation prohibited lease or purchase of water rights. Public Laws 108-7 and 108-137 followed in 2003 but did not provide much funding. In 2005, Public Law 109-103 allocated $95 million to Walker Lake programs, including $70 million to the University of Nevada, largely for acquisition of water rights. Public Law 110-161, enacted in 2007, included a variety of specific programs for the Truckee, Carson, and Walker River basins. The next year, section 2807 of Public Law 110-234, appropriated $175 million "to provide water to at-risk natural desert terminal lakes", including leasing water, and "to purchase land, water appurtenant to the land, and related interests in the Walker River Basin". In October 2009, Sections 207 and 208 of Public Law 111-85 modified previous Desert Terminal Lake legislation and, in part, allocated $66.2 million to establish the Walker River Restoration Program, to be administered by the National Fish and Wildlife Foundation (USDI-Bureau of Reclamation, 2011).

Much attention and controversy have been directed at the federally-funded water rights acquisition program. However, the 2005 law (Public Law 109-103, Title II, Section 208(a)) uses the language, "acquire from willing sellers land, water appurtenant to land, and related interests in the Walker River Basin, Nevada". Therefore, this law has been interpreted to not authorize **acquisitions** within the California portion of the basin (e.g., Yardas, 2007). The "in Nevada" wording is also present in the Purpose and Need section of the revised draft Environmental Impact Statement prepared for the acquisition program after transfer from the University of Nevada to the National Fish and Wildlife Foundation: *The purpose of the Walker River Basin Acquisition Program is to provide water to Walker Lake, an at-risk natural desert terminal lake in Nevada, by acquiring, from willing sellers, land, water appurtenant to the land, and related interests in the Walker River Basin in Nevada; and to make acquisitions that are the most beneficial to environmental restoration in the Walker River Basin. The Acquisition Program is needed to implement section 208(a) of PL. 109-103 and Sections 206-208 of PL 111-85 in accordance with section 2507 of PL 101-171 (as amended) and section 207(a)(1) of PL 108-7.*(ICF International, 2010: ES-3). The document goes on to specify: *The project area as described in the Revised DEIS refers to the Nevada portion of the Walker River Basin. The California portion of the basin accounts for 25% of the basin area (Lopes and Smith 2007), and is not part of the project area or included in the Acquisition Program. No land in California, water appurtenant to that land, or related interests would be acquired through the Acquisition Program; however, WRID's rights to stored water in California, which are appurtenant to and used on lands in Nevada, may be included in the Acquisition Program if offered by willing sellers* (ICF International, 2010: 1-11).

The Water Leasing Demonstration Program appears to apply to the entire Walker River basin. This program was authorized by Public Law 111-85, the 2010 Energy and Water Development Appropriations Act. This act included new funding for the National Fish and Wildlife Foundation under Section 208 and allocates $25 million to the Walker River Irrigation District to: *(I) to administer and manage a 3-year water leasing demonstration program in the Walker River Basin to increase Walker Lake inflows; and (II) for use in obtaining information regarding the establishment, budget, and scope of a longer-term leasing program* (ICF International, 2010:

1-11). Extension of the three-year term of the leasing demonstration program was being considered by Congress in 2010. As of August 2011, the Walker Basin Restoration Program had not posted any news on their website (http://www.nfwf.org/wb/water_leasing.cfm) about potential leasing in California during 2011. Attorneys for the Walker River Irrigation District have stated that any lease arrangements within Mono County and changes in the District's management of their storage rights in Bridgeport Reservoir will need to be approved by the California Water Resources Control Board and the federal court [presumably overseeing Decree C-125] (DePaoli and Ferguson, 2010).

Irrigation is by far the largest water use within the East Walker River watershed. Decree C-125 (and the subsequent 1953 document *Rules and Regulations for the Distribution of Water of the Walker River Stream System Under the Provisions of Paragraph 15 of Decree in Equity, No. C-125*) specify which lands have water rights associated with them and how much water can be applied under the water right for the beneficial use of irrigation. Upstream of Bridgeport Reservoir, land with water rights totals about 23,768 acres (Sharpe, et al., 2007), 26,277 acres (California Department of Water Resources, 1992), 26,426 acres (Pahl, 1999, cited by Yardas, 2007), or 29,862 acres, according to the Federal Watermaster, as cited by Horton (1996). The reason for this discrepancy is unknown. The Walker River Irrigation District also holds a water right for the 2,660 acres that are flooded by Bridgeport Reservoir (Sharpe, et al., 2007). The Bridgeport Valley lands were assigned a duty (amount of water needed to irrigate a given area for a specified crop; the duty is the amount applied, rather than the amount transpired by the plants) of 0.016 cfs per acre (equivalent to 0.38 inches per day). The irrigation season is also specified as March 1 to September 15 upstream of Bridgeport Reservoir. Although irrigation is not practiced during the spring months when the soils are saturated or nearly saturated naturally, the duration of actual irrigation within this legal period determines the total depth of water applied to the average acre (and the number of the acres irrigated in turn determines the total volume of water applied). A water balance study estimated that the total applied-water rate in the Bridgeport Valley for irrigated pasture is 2.4 feet per year (Lopes and Allander, 2099). Another estimate provides an annual average of 2.5 feet (or 50,000 AF over 20,000 acres) of water was applied per year from 1926 through 1995 over the irrigated portion of the Bridgeport Valley (Pahl, 2000, cited by Yardas, 2007).

Municipal water use for Bridgeport is tiny by comparison to the irrigation use. The Bridgeport Public Utility District supplies water to the town from two wells and has water storage capacity of 535,000 gallons. In 1990, the total demand was about 243 acre-feet (California Department of Water Resources, 1992). In 2007, total demand was about 374 acre-feet and the maximum daily demand was about 750,000 gallons (USDI-Bureau of Land Management, 2009).

Small water supply systems serve a portion of the homes at Twin Lakes and Virginia Lakes. An environmental impact report for a proposed subdivision along the Twin Lakes Road estimated that the project at build-out (32 homes) would use about 20,000 gpd for domestic use and 42,900 gpd for outside irrigation over a 120-day irrigation season (ESA Planning and Environmental Services, 1987).

The Virginia Lakes Mutual Water Company has about 120 connections (as of 2010), supplied by three interconnected delivery systems. The water company started in the 1950s to serve up to 176 lots, which is now down to 160 lots because several parcels have been combined over the past 60 years. Water is supplied during a five-month-long season, and the system has had many upgrades over the years. The recreational housing tract on Forest Service land in the Virginia Lakes area has its own water system.

All other domestic demand throughout the East Walker River watershed is self-supplied by individual homeowners, primarily from wells.

Urban Runoff and Stormwater Management

There are no significant issues of stormwater management within the small communities of the watershed.

Wastewater Treatment and Disposal

The Bridgeport Public Utilities District operates a collection system and treatment lagoon, northeast of town, for most of the town of Bridgeport (Mono County, 1992).

The high groundwater table within the Bridgeport Valley makes the area unsuitable for septic systems (California Regional Water Quality Control Board--Lahontan Region, 1992). Nevertheless, a few parts of the district area remain on septic tanks (Mono County, 2003), presumably in upland areas.

7. Descriptive Geomorphology

The aspects of geomorphology that are of primary interest in the context of watershed management involve erosion and sediment transport and potential human influences on those processes. There are few known studies of geomorphic processes within the East Walker River watershed, so this section of the assessment is particularly limited.

Glacial Remnants

Most of the landforms in the Sierra Nevada portion of the East Walker River watershed were molded by glacial activity. Past glaciation is apparent in the erosion patterns seen around the high peaks and by the great amounts of glacial till deposited downstream. Bridgeport Valley is filled with a mixture of alluvial deposits carried down by the rivers and with till eroded and moved by glaciers (California Department of Water Resources, 1992). The valley has been described as glacial outwash benchlands (Curry, cited by Horne, et al. 2003).

Channel Processes

In forested mountain areas like the East Walker River watershed, most of the geomorphic work occurs in stream channels rather than across the broad landscape. Rocks and soil particles are eroded from the channel banks and bed, transported some distance down the channel, and redeposited. At higher elevations of the watershed, stream channels have steep gradients with plenty of energy to transport small and moderately sized material if it is available. At lower elevations, stream gradients diminish and materials are deposited. Although most of the stream channels in the upper elevations are stable with bedrock and boulder beds, there are also many deposits of glacial till that the streams cut through and that provide a source of erodible material (Mann, 2000).

Catastrophic flooding can cause major erosion of stream channels, such as during the flood of 1997. The enormous power of large volumes of water moving at high velocity can undercut canyon walls and add to the sediment load (USDA-Forest Service, 2004).

Mono County's (2003) Master Environmental Assessment mentions channel erosion as a concern in several creeks in the watershed: Long Valley, Clearwater, Rough, and Bodie. Field observations in 2011 indicated that although examples of channel erosion can be found along most, if not perhaps all, of the tributaries to the East Walker River, such reaches are limited in extent and dense willow thickets along the channels are the prevalent condition except in meadow reaches.

Beavers have become a geomorphic influence by creating dams across channels, such as Virginia Creek (USDI-Bureau of Land Management, 1980s). The dams trap sediment for a few years until they fail. If the failure is sudden, a pulse of water and sediment is released, altering the channel downstream. In extreme cases, a cascade of beaver-dam failures can perform a lot of geomorphic work.

Surface Erosion

There are no known studies or measurements of surficial erosion within the East Walker River basin. We can only state that it is likely to occur where soils are exposed, disturbed, and compacted. Sufficient rainfall or snowmelt must occur to saturate the soil or exceed the local infiltration capacity and allow water to flow over the surface, dislodging and transporting soil particles. Roads and construction activities are the primary means of accelerating erosion over natural background rates.

Intense thunderstorms occurring July 30 and 31 of 2011 were observed to result in sediment mobilization in the northeastern portion of the Bodie Hills. Serious ruts on roads in the area were still apparent in the following October.

Hillslope Processes

Mass movement of soils and rock on hillsides occur as landslides, mudflows, and soil creep. Mass movements are more likely to occur in the presence of shallow groundwater under pressure and in saturated soils.

The Humboldt-Toiyabe National Forest has noted evidence of old landslides throughout the watershed. Springs are also common. The Forest also mentioned that springs may contribute to the instability of steep slopes (USDA-Forest Service, 2004).

Sediment Transport

A generalized estimate of average annual sediment yield over the upper East Walker River watershed of 0.2 to 0.5 acre-feet per square mile was made by the USDA Nevada River Basin Study Staff (1975). In comparison, average annual values from reservoir sediment surveys in other parts of the Sierra Nevada averaged 0.2 acre-feet per square mile (Kattelmann, 1996).

Human Influences

Few studies are known to have examined human influences on erosion and sediment delivery within the East Walker River watershed. Unfortunately, because almost all of the watershed has been extensively grazed in the past, there is little terrain that can be considered as undisturbed reference conditions. Little information exists on the condition of stream channels, riparian areas, and meadows before Euroamerican settlement. Grazing pressure was quite heavy between 1880 and 1912, and again during the 1930s and 1940s. Stream channels and meadows have slowly recovered since that time. Heavy recreation began in the 1960s (USDA-Forest Service, 2004).

There are a few reports of localized erosion problems, such as portions of the Sinnamon Meadow road coinciding with the creek and issues at trailhead stream crossings at Virginia Lakes, Green Creek, and Buckeye Creek (USDA-Forest Service, 2004). The lower reach of Clearwater Creek, just above its confluence with Virginia Creek, has been described as gullied and eroding where State Highway 167 and other development encroach on the stream channel (Denio and Associates Engineering, 1999:7; Mono County Community Development Department, 2000:I-52).

The release of stored sediment from Bridgeport Reservoir in 1988 into the East Walker River below the dam resulted in sedimentation of the river channel. In 1993, the WRID was ordered to spill a large volume of water from the reservoir in an attempt to flush some of the sediment down the channel. Surveys of aquatic invertebrates by entomologist David Herbst beginning in January 1992 demonstrated that the excess sediment altered the species composition of the stream community.

8. Description of Water Quality

The water body fact sheet for the East Walker River issued by the Lahontan Water Quality Control Board in the mid-1990s listed sedimentation, ammonia, fecal coliform, and metals as the primary water-quality problems in the watershed. The State of Nevada considers the river impaired at the state line because of ammonia, pH, phosphorus, sediment, and fecal coliform. High concentrations of metals, such as silver, copper, zinc, lead, and nickel, have been found in the East Walker below Bridgeport Reservoir as well as in tributaries, such as Rough Creek and Virginia Creek (Lahontan RWQCB, 1994a).

The same water quality issues continue to be documented via California's "303(d)" list. Section 303(d) of the federal Clean Water Act requires all states to submit a list of impaired waters (segments of streams and rivers or lakes) to the U.S. Environmental Protection Agency every two years. These lists identify particular water bodies where a standard for a particular pollutant is known to have been exceeded, such as Bridgeport Reservoir being above standards for nitrogen, phosphorus, and sedimentation/siltation. Other 303(d) listings are mentioned in the next chapter about subwatersheds.

Bridgeport Reservoir and Bridgeport Valley

Bridgeport Reservoir has been known to be eutrophic for many years (Lahontan RWQCB, 1994b; Horne, et al., 2003). As of 2000, ten water-quality objectives established by the Lahontan Water Quality Control Board were not met: ammonia, biostimulatory substances, dissolved oxygen, pH, taste and odor, temperature, total dissolved solids, total nitrogen, total phosphorus, and turbidity (Mono Resource Conservation District, 2000). The low level of dissolved oxygen is suspected to kill fish within the reservoir, and substantial mortality of fish was documented in the reservoir in 1996 (Walker River Irrigation District, 1998). Most of these problems have been presumed to be associated with high levels of nitrogen and phosphorus entering the reservoir, but the relative contribution of these nutrients from different sources is unknown (Mono Resource Conservation District, 2000). The Forest Service, Bridgeport Ranchers Organization and the North Mono County Resource Conservation District have supported a water quality study on tributaries and high-elevation lakes in the East Walker watershed (USDA-Forest Service, 2004).

The proposal for a watershed assessment and plan prepared by the Mono Resource Conservation District (2000) suggests that some preliminary water-quality analyses indicated conflicting or uncertain interpretations of nutrient cycling above Bridgeport Reservoir. The following text is quoted verbatim from the proposal (Mono Resource Conservation District, 2000: I-4 and I-5) to avoid any further interpretations of these preliminary findings. The outline of the proposed study plan to better understand the nutrient cycling is included as well.

"Limited surface-water inflow, shallow surface water-groundwater interactions in agricultural areas, nutrient data, and water-quality data have been collected by the USGS and Dr. Linda Vance of U.C. Davis. The USGS has ongoing surface-water flow monitoring at Robinson and Buckeye Creeks at locations above irrigation diversions and at the East Walker River below Bridgeport Reservoir; Bridgeport Reservoir water level and water storage data; and an ongoing project collecting in-stream nutrient measurements at 10 stream sites in the basin. Dr. Vance's studies suggest significant phosphorus input to the basin from headwater streams.

In-reservoir data have been collected by Alex Horne of U.C. Berkeley. These data include chlorophyll, dissolved oxygen, ammonia, temperature, and algae identification and quantity. Dr. Horne's study suggests that nutrients in Bridgeport Reservoir may be attributed mostly to sources within the reservoir with lesser input of external studies. Further research he is conducting to address this question includes limnological analysis, numeric targets for selected indicators, and GIS-based load allocation.

Desert Research Institute (DRI) will be subcontracted for further assessment work and they will work closely with Drs. Vance and Horne and the USGS to coordinate data collection efforts so that assessments will augment and not duplicate current data collection efforts. These sub-contracted assessments of water quality will describe the processes and causes of impaired water quality, not just the symptoms. This assessment will consist of four parts; 1) determining nitrogen and phosphorus loads into the basin above the irrigated part of the valley, 2) determining nitrogen and phosphorus loads into the reservoir from external sources, i.e. surface water, groundwater, and atmospheric; 3) determining nitrogen and phosphorus loads from internal reservoir sources, i.e. sediments, and 4) evaluating nutrient cycling in agricultural areas."

A report from the Department of Civil and Environmental Engineering at the University of California at Berkeley (Horne, et al., 2003) contains water quality data for Bridgeport Reservoir from 1989 and 2000. High nutrient levels allowed the growth of significant quantities of blue-green algae (also known as cyanobacteria). Concentrations of chlorophyll a are used as a quantitative indicator of the amount of primary productivity (algae and blue-green algae) in water bodies. Mean concentrations of chlorophyll a were 200-300 μg/L in both years, with peak concentrations up to 1,900 μg/L in 1989 and more than 800 μg/L in 2000. In comparison, other lakes in the watershed without the excessive nutrient levels could be expected to have chlorophyll a concentrations of less than 5 μg/L. Another indicator of the trophic status (or amount of primary productivity) of a lake is visual clarity as measured by the depth at which a Secchi disc (standardized white plate) is no longer visible. The Secchi depth of Bridgeport Reservoir had a mean value of 1.2 m in 1989 and 1.5 m in 2000. Water clarity measured in the same way in other lakes of the watershed could be expected to exceed 8 m (Horne, et al., 2003).

Maximum concentrations (μg/L) of nutrients were found to be very high in both years:

Nutrient	1989	2000
Ammonia	300-500	>600
Total phosphorus	130-820	>500
Soluble phosphorus	>85	>85

In other lakes in the area, ammonia would be expected to be less than 10 μg/L and total phosphorus less than 5 μg/L (Horne, et al., 2003).

Another consequence of eutrophication is depletion of dissolved oxygen, especially near the bottom of the reservoir. Although other lakes in the watershed could be expected to have concentrations of dissolved oxygen greater than 8 mg/L, Bridgeport Reservoir had dissolved oxygen levels below 4 mg/L in 1989 and less than 1 mg/L in 2000 (Horne, et al., 2003).

The primary study of nutrient cycling within Bridgeport Valley has been done by Elkins (2002) (and included in the Horne, et al., 2003 report) using measurements of nutrients, sediment, and fecal coliform in five streams above Bridgeport Reservoir collected by the U.S. Geological Survey between April 2000 and June 2001.

Phosphorus and pathogen concentrations in tributaries to Bridgeport Reservoir, measured in April-June 2000, increased significantly downstream of pastures (Horne, et al., 2003). In a comparison between mean values from samples taken during 2000 in Buckeye Creek above Bridgeport Valley and at Highway 395, total phosphorus was 14 μg/L and 53 μg/L, phosphate was 2 μg/L and 4.3 μg/L, and fecal coliform was 2 colonies/100 mL and 89 colonies/100 mL. Similarly, mean values from samples taken during 2000 in Robinson Creek at the Twin Lakes outlet and at Highway 395 were 4 μg/L and 7 μg/L for total phosphorus, <1 μg/L and 17 μg/L for phosphate, and <1 colony/100mL and 71 colonies/mL for fecal coliform (Horne, et al., 2003). Soil erosion within the Buckeye Creek watershed is another source of total phosphorus (Elkins, 2002).

Despite the roughly 10:1 ratio between nitrogen and phosphorus in cattle excreta, increases in concentrations of nitrogen species across Bridgeport Valley were small compared to those of phosphorus species, presumably because denitrification is occurring in the saturated soils (Horne, et al., 2003). Total inorganic nitrogen (nitrate + nitrite + ammonia) is regarded as the best estimate of bioavailable nitrogen for algae growth. Averaged concentrations of total inorganic nitrogen were 10 μg/L upstream of Bridgeport Valley and 20.4 μg/L near the reservoir. Given the tenfold greater loading of nitrogen compared to phosphorus, the latter value could be expected to be nearly 400 μg/L. This difference suggests that biochemical processes in the wet soils of the pastures are converting and capturing most of the applied nitrogen (Elkins, 2002; Horne, et al., 2003).

There is some observational evidence (e.g., Borrow, 1967; Jewell, et al., 2007) that cattle redistribute phosphorus simply by grazing widely but excreting in geographically-limited areas.

Over time, phosphorus in the soil becomes relatively more concentrated in particular parts of a pasture. Nutrients can be redistributed within or flushed out of soils during unusually intense hydrologic events (e.g., Kaushal, et al., 2010), such as the January 1997 flood.

Waterfowl also contribute to nutrient loading of Bridgeport Reservoir. Bird counts on the reservoir range between 1,000 and 4,000 or about 5 tons of birds (Horne, et al., 2003). Hundreds of Western and Clark's grebes nest among the water smartweed in the reservoir (Ivey, 2004).

Nutrients and pathogens leaching from septic systems upgradient from Twin Lakes were mentioned as potential contributing factors for excessive nutrients in the lakes as well as a potential health threat in a "water body fact sheet" for Twin Lakes (California Regional Water Quality Control Board--Lahontan Region, 1992b).

The Lahontan RWQCB limits annual average nutrient concentrations in the Bridgeport Reservoir (Horne, 2003) to 0.5 mg-N/L and 0.06 mg- P/L. The 90th percentile targets are 0.8 mg-N/L and 0.1 mg-P/L (Creager, et al., 2006).

Grazing Lands

Livestock grazing in the Bridgeport Valley has long been assumed by regulatory agencies to contribute nutrients and fecal coliform to the tributaries of the East Walker River. The Lahontan Regional Water Quality Control Board has had concerns about the East Walker River and Bridgeport Reservoir since the North Lahontan Basin Plan of 1975. Bridgeport Reservoir was listed as impaired for nutrients, sediment, and siltation in 1994 under Section 303(d) of the Clean Water Act. A Total Maximum Daily Load allocation of nutrients has been proposed for several years (California Regional Water Quality Control Board--Lahontan Region, 2003). Both California and Nevada water-quality agencies have considered the East Walker River to be impaired because of excessive levels of fecal coliform bacteria since the 1990s. With about 8,000 to 10,000 head of cattle in the Bridgeport Valley every summer since the 1870s and release of 1 to 100 billion bacteria per cow per day, there is obviously potential for fecal coliform contamination of Bridgeport Reservoir and the East Walker River. Fortunately, only a tiny proportion of these bacteria actually survive and are found in the main water bodies. Nevertheless, fecal coliform counts, expressed as colonies per 100 mL of sampled water, increase as water flows through the pasturelands of Bridgeport Valley. For example, in a comparison between mean values from samples taken during 2000 in Buckeye Creek above Bridgeport Valley and at Highway 395, fecal coliform was 2 colonies/100 mL and 89 colonies/100 mL Similarly, mean values from samples

Figure 9: Bridgeport Valley Grazing Lands (Rick Kattelmann)

taken during 2000 in Robinson Creek at the Twin Lakes outlet and at Highway 395 were <1 colony/100mL and 71 colonies/mL for fecal coliform (Horne, et al., 2003).

The issue is problematic because the agricultural system of the Bridgeport Valley has been developed to be highly productive of forage during the summer and thereby support a large number of cattle. This extensive irrigation network has also augmented the natural wetlands of the valley floor with greater area and connectivity. The seasonal coverage of water throughout much of the valley floor both provides the opportunity for direct transport of nutrients and coliform to Bridgeport Reservoir as well as the possibility of biochemical amelioration of some of the nutrient load. The existence of Bridgeport Reservoir has also eliminated a large wetland that might have further reduced nutrient and coliform loading to the East Walker River.

A recent study in the Bridgeport Valley (Elkins, 2002) provides some indications about nutrient and fecal coliform pollution. Elkins (2002) found that:

(a) more than half of the annual nitrogen and phosphorus loads to Bridgeport Reservoir were delivered by snowmelt runoff,
(b) total inorganic nitrogen (nitrate and ammonia) was removed by biochemical processes in the saturated soils of the Bridgeport Valley,
(c) water that remained in the channels and was not in contact with the soils retained any inorganic nitrogen already present,
(d) dissolved organic nitrogen was the primary form of nitrogen entering Bridgeport Reservoir and was readily leached from manure and irrigated soils,
(e) phosphorus was not retained by the soils and was readily transported on eroded soil particles,
(f) some fecal coliform from livestock manure appears to survive for months even in the cold temperatures of Bridgeport Valley and is readily transported in snowmelt runoff and irrigation return flow.

The Lahontan Regional Water Quality Control Board has established a "conditional waiver" program for the grazing lands of the Bridgeport Valley (http://www.waterboards.ca.gov/rwqcb6/board_decisions/adopted_orders/2007/docs/r6t_2007_0019_grazingwaiverwdr.pdf). The California Water Code (section 13269) authorizes the regional boards to conditionally waive the state's waste discharge requirements if doing so can be considered to be in the public interest. This program is currently focused on monitoring of fecal coliform and grew out of prior negotiations over water quality monitoring. Although most ranches have individual agreements with the Lahontan RWQCB and have prepared individual Ranch Water Quality Management Plans, monitoring and reporting is done as a coalition, as in other parts of the state with agriculture conditional waivers (Lee, 2008). The Lahontan RWQCB recognized that water flows within Bridgeport Valley are complex and probably impossible to track to individual parcels of land. Because cooperation between the landowners would be necessary to make progress, the conditional waiver was judged to be the best approach. Enforcement actions and waste discharge requirements can only be applied to individuals, whereas waivers to waste discharge requirements allow for cooperative multi-party programs. The Bridgeport Ranchers Organization coordinates the water quality monitoring and interaction with the Lahontan RWQCB.

Locations both above and below the pasture lands are monitored. Water samples are collected from spring through autumn at eleven sites in Bridgeport Valley:

Swauger Creek above Huntoon Vallev
Swauger Creek at USFS Boundary
Buckeye Creek at Upper Diversion
Robinson Creek at Upper Diversion
Virginia Creek at Gauging Station
Green Creek at Green Creek Road Crossing
Summers Creek Upper
Buckeye Creek above 395
Buckeve Creek above Reservoir
Robinson Creek above 395
Robinson Creek at Reservoir
East Walker River above Highway 395

Figure 10: Virginia Creek Gauging Station (Rick Kattelmann)

The objectives of this program are (1) determine fecal coliform concentrations in tributaries entering and exiting the irrigated and grazed portions of Bridgeport Valley, (2) identify source and sink areas for these pollutants in Bridgeport Valley, (3) prioritize implementation of water quality management measures to source areas, and (4) serve as a baseline against which to judge the effectiveness of future water quality management measures.

Initial results demonstrate that there are other sources of fecal coliform besides cattle. Kenneth Tate, Department of Plant Sciences at U.C. Davis, is advising the monitoring program and proposing potential mitigation strategies. Best management practices that could reduce the impacts, most of which have already been or are in the process of being implemented, include fencing along natural and artificial channels to limit direct cattle access to waterways, minimizing grazing in riparian pastures, coordinating irrigation applications with cattle presence, construction of hardened channel crossings for livestock, provision of off-stream livestock watering facilities, and physically reshaping wetlands and fencing off those intended for filtering (California Regional Water Quality Control Board--Lahontan Region, 2007; Lee, 2008).

Results from water samples collected downstream of the pastures (that the authors have heard about but are not reported here because they have not been published elsewhere) are well below standards of the United Stated Environmental Protection Agency (USEPA), other states, and most of California. A common standard is 200 colonies (or "colony forming units") per 100 ml.

However, the Lahontan RWQCB has established a standard of 20 colonies per 100 ml as described in resolution number R6T-2007-0019 (full version available at web link below). "The Water Board has set the Region-wide water quality objective for fecal coliform at 20 colonies per 100 ml, ten times more stringent than the Federal standard at 200 colonies per 100 ml and any other Region in California, recognizing that waters in the Lahontan Region are generally pristine, and recreation is the major use of these waters. USEPA finds the Federal standard to be protective of water contact recreational beneficial uses. However, during the Grazing workshop and Triennial Review of the October 11, 2006 Water Board meeting, the Water Board heard public comments regarding revising the fecal coliform standard to be consistent with Federal standards for areas, such as Bridgeport Valley, where beneficial uses have historically been predominantly agricultural." (http://www.waterboards.ca.gov/rwqcb6/board_decisions/adopted_orders/2007/docs/r6t_2007_0019_grazingwaiverwdr.pdf)

The minutes from the Resource Conservation District (RCD) of Mono County on September 7, 2011 indicate that according to a verbal report given by an RCD Board Member, fecal coliform count in Bridgeport Reservoir and downstream of the reservoir was near zero after six years of monitoring (Resource Conservation District of Mono County, 2011).

The U.S. Geological Survey conducted some water quality sampling at 15 sites in the East Walker River watershed from 2000-2003 (Rockwell and Honeywell, 2004). These sites were distributed longitudinally along Buckeye, Robinson, Green, and Virginia Creeks so that samples were collected above and below the actively grazed portions of Bridgeport Valley. In general, the lowest coliform counts (often less than 1 colony/100 ml) were found at the sites farthest upstream and the highest coliform counts (usually around 50, but a few samples exceeded 600 colonies/100ml) were found in samples collected near Bridgeport Reservoir (Rockwell and Honeywell, 2004).

Other Water Quality Issues and Measurements

Narrative material from measurement and monitoring programs was available for only a few categories of the typical water-quality concerns.

Sediment

Excess sediment has been identified as a primary water-quality concern in the East Walker River. Unfortunately, little quantitative information to describe the sediment load of the river or its tributaries was not found. The limited sampling by the U.S. Geological Survey in 2000-2003 found that suspended sediment was usually below 3 mg/l and rarely exceeded 20 mg/l, with just a few samples between 50 and 127 mg/l (Rockwell and Honeywell, 2004). The release of sediment from Bridgeport Reservoir in 1988 caused significant sediment-related damage to the aquatic habitat downstream.

Metals

The Toxic Substances Monitoring Program found elevated levels of silver, zinc, copper, and lead in fish tissue sampled downstream of Bridgeport Reservoir; elevated levels of silver and nickel in Virginia Creek; elevated levels of silver, zinc, and nickel in Robinson Creek; and elevated levels of silver in fish tissue from Lower Twin Lake (California Regional Water Quality Control Board--Lahontan Region, 1994a and 1994b).

Mercury has been a concern in the Walker River basin after elevated concentrations of mercury were found in tui chub and common loons at Walker Lake (Evers et al., 1998; Wiemeyer, 2002). Recent sampling of water, sediment, and aquatic invertebrates suggests that the primary source areas are associated with the Bodie and Aurora mining districts in the Rough Creek watershed. Downstream in Nevada, the East Walker River above the confluence with the West Walker had a total mercury concentration of about 60 ng/L in the water and more than 1,000 ng/g in the sediment. The greatest total-mercury concentration in sediment was found in the bed of Bodie Creek at 13,600 ng/g (Seiler, et al., 2004).

Temperature

The only known systematic temperature measurements of streams in the East Walker River watershed were reported by Blodgett (1971):

Table 19: Temperature Measurements of Streams in the East Walker River Watershed

East Walker near Bridgeport 10-2930 178 days between June 1950 and June 1969												
Month	O	N	D	J	F	M	A	M	J	J	A	S
Max	17	10	6	8	7	8	12	16	19	21	22	20
Mean	13	8	4	4	4	6	8	11	14	18	19	16
Min	8	1	1	0	1	3	1	4	7	14	17	9

Virginia Creek 10-2890 71 days between February 1960 and June 1969												
Month	O	N	D	J	F	M	A	M	J	J	A	S
Max	13	9	3	3	2	4	14	17	17	23	17	16
Mean	8	4	2	1	1	2	7	9	11	17	15	14
Min	6	1	1	1	0	1	2	3	2	12	11	11

Green Creek 10-2895 86 days between February 1960 and June 1969												
Month	O	N	D	J	F	M	A	M	J	J	A	S
Max	9	9	2	1	2	4	9	13	12	22	16	14
Mean	7	3	1	1	1	2	4	7	9	15	14	11
Min	3	0	1	0	0	1	1	2	3	11	13	8

Robinson Creek 10-2905 87 days between February 1960 and June 1969												
Month	O	N	D	J	F	M	A	M	J	J	A	S
Max	16	10	3	3	4	8	10	12	15	19	20	18
Mean	12	6	2	1	2	4	5	9	9	16	18	16
Min	6	1	0	0	0	1	1	2	3	9	17	12

Buckeye Creek 10-2915 83 days between February 1960 and June 1969												
Month	O	N	D	J	F	M	A	M	J	J	A	S
Max	12	8	2	2	2	3	8	10	14	16	17	30
Mean	7	3	1	1	1	2	4	7	9	12	13	13
Min	2	0	0	0	0	1	1	2	4	10	11	8

Swauger Creek 10-2920 90 days between March 1960 and June 1969												
Month	O	N	D	J	F	M	A	M	J	J	A	S
Max	13	9	4	3	4	8	12	19	17	20	18	17
Mean	8	4	2	2	2	4	7	11	12	14	14	14
Min	4	1	1	0	0	2	1	3	3	9	11	11

Dissolved Oxygen

Dissolved oxygen measurements from water samples obtained in the East Walker River just below Bridgeport Reservoir were reported by Humberstone (1999):

Table 20: Dissolved Oxygen in the East Walker River

	1998						1999		
	J	J	A	S	O	N	J	F	M
Dissolved Oxygen (mg/L) Bridgeport Res.	7.8	7.3	7.7	7.1	9.1	9.6	9.8	10.2	9.6
Dissolved Oxygen (percent saturation) Bridgeport Res.	99	97	110	95	104	91	96	99	101

The limited sampling by the U.S. Geological Survey in 2000-2003 found that dissolved oxygen concentration ranged between 6 and 11 mg/l and oxygen saturation was usually between 80 and 120 percent (Rockwell and Honeywell, 2004).

Toxic Substances

With the low population density of the East Walker River watershed, there are relatively few opportunities for introduction of toxic substances into the watershed. One can assume that chemicals such as mercury and cyanide associated with ore processing were released in the mining and milling areas of the Bodie Hills and that toxic materials have been routinely dumped at the county landfill. There are probably also small spills of agricultural, horticultural, and household chemicals at ranches and residences in the Bridgeport Valley. A "water body fact sheet" (California Regional Water Quality Control Board--Lahontan Region, 1992) for the Bridgeport Valley noted "past fuel tank leaks in Bridgeport" but no further details are available. The total quantity of such releases is likely to be tiny compared to more industrial farming operations and cities. Two significant accidents involving tanker trucks transporting petroleum products have occurred near Bridgeport in the past two decades. A modern hazard involves pesticides, herbicides, fertilizers, and other chemicals at marijuana growing sites hidden in the forested areas. A large-scale operation was discovered and disrupted in the summer of 2011 in the Sweetwater Mountains (Inyo Register, 2011).

Box 5: Oil Spill Downstream of Bridgeport Reservoir in 2000

After the release of sediment-laden and oxygen-depleted water from Bridgeport Reservoir in 1998, the oil spill in December 2000 was the main event to impact water quality and aquatic habitat in the East Walker River watershed. A fatal accident involving a tanker truck on State Route 182 released about 3,600 gallons of #6 fuel oil, most of which entered the East Walker River. Up to 70 workers were involved in the clean-up efforts under difficult and hazardous conditions. Where ice covered the stream surface, some floating oil became trapped on the upstream side of the ice dams, enabling manual removal of the oil. Within the first ten days of the initial clean-up operation, more than 1400 gallons of oil were removed from the river. By the middle of January, weather and icing conditions impeded work sufficiently that operations were scaled back until late February. Efforts intensified during the second week of March in anticipation of forthcoming releases for irrigation planned for March 19. The increase in flow mobilized a relatively small amount of oil, much of which was captured downstream. Although the intensive clean-up effort removed most of the oil from the river during the winter and spring of 2001, oil residues were observed throughout the seven miles of river below the spill site within California and for another 3 to 8 miles downstream in Nevada. By May 2001, concentrations of residual aromatic hydrocarbons dropped below levels considered lethal to fish.

A East Walker River Trustee Council was formed from representatives of the California Department of Fish and Game, Nevada Department of Wildlife, Nevada Division of Environmental Protection, and U.S. Fish and Wildlife Service. This Council performed a Natural Resource Damage Assessment (a requirement of federal and state laws relating to oil spills) to evaluate damage from the oil spill and determine activities to restore or replace the equivalent of the damaged natural resources. A settlement agreement reached in 2004 specifies that the trucking company legally responsible for the oil spill pay the California Department of Fish and Game the costs of assessment work ($68,000) and pay the U.S. Department of the Interior for anticipated costs of restoration work ($350,000).

Another fuel spill had occurred in July 1996 on U.S. Highway 395 about 5.5 miles north of Bridgeport (Du Fresne, 1996b). Most of the 3,900 gallons of gasoline and diesel fuel spilled in this tanker truck accident entered the soil adjacent to the highway. About 2,000 cubic yards of contaminated soil was excavated and removed within a few days. An unknown amount of the fuel entered Swauger Creek (Du Fresne, 1996b).

Source: East Walker River Trustee Council, 2008; Padgett, 2001; and Reiter, et al., n.d.

Measurements of Surface Water Quality

The East Walker River at the outlet from Bridgeport Reservoir was sampled in October 1968 and the following analytical results were reported by Glancy (1971):

Temperature (°F)	52
Calcium (mg/l)	28
Magnesium (mg/l)	6
Sodium & Potassium (mg/l)	15
Bicarbonate (mg/l)	134
Sulfate (mg/l)	13
Chloride (mg/l)	1
Conductance (μmhos/cm)	280
pH	7.7

Water samples were obtained by the USGS in 1975, 1976, 1980, and 1981 (Benson and Spencer, 1983).

Water samples were obtained at two sites in the East Walker River watershed: just below Bridgeport Reservoir and on Robinson Creek, upstream of Bridgeport Reservoir (Humberstone, 1999).

Table 21: Miscellaneous Water Quality Data Reported by Humberstone (1999)

	1998						1999		
	J	J	A	S	O	N	J	F	M
Conductance (μmhos/cm)									
Bridgeport Res.	105	87	104	113	124	154	161	151	157
Robinson Creek	-	-	-	-	-	-	-	65	77
Total Dissolved Solids (mg/L)									
Bridgeport Res.	66	54	65	70	78	97	101	95	99
Robinson Creek	-	-	-	-	-	-	-	40	47
Dissolved Oxygen (mg/L)									
Bridgeport Res.	7.8	7.3	7.7	7.1	9.1	9.6	9.8	10.2	9.6
Dissolved Oxygen (percent saturation)									
Bridgeport Res.	99	97	110	95	104	91	96	99	101
Temperature (°C)									
Bridgeport Res.	13	17	21	18	10	3	4	4	7
Robinson Creek	-	-	-	-	-	-	-	0.4	5

The values for Total Dissolved Solids (mg/L) from these samples reported above were well below the threshold values (390 mg/L for higher water quality and 500 mg/L annual average maximum for uses of water supply, irrigation, and livestock) set by the Nevada Administrative Code (NAC 455A.118 to 445A.225) for this reach of the East Walker River (Sharpe, et al., 2007).

During 1999, the Department of Range Science at the University of California at Davis collected water samples from three locations on Buckeye Creek and three locations on Robinson Creek on a biweekly basis from April to October (Centennial Livestock, 2002). The samples from Robinson Creek were analyzed for nitrogen-nitrate, and those samples from Buckeye Creek were analyzed for phosphate. The analytical data were submitted to the Lahontan Regional Water Quality Control Board. For Robinson Creek, seven of the samples at the site near Bridgeport Reservoir were below detection limits (<0.05 mg/L), and the sample collected on 9-11-99 had a nitrogen-nitrate concentration of 0.17 mg/L. On April 16, 1999, samples were collected both upstream and downstream of the bridge where Robinson Creek flows under U.S. Highway 395. Nitrogen-nitrate concentrations were three times higher below the bridge than above the bridge (0.19 mg/L vs. 0.06 mg/L), suggesting that nesting swallows under the bridge may have elevated nitrate levels during the sampling period (Centennial Livestock, 2002). For Buckeye Creek, only 1 of 32 samples was above the 0.05 mg/L detection level, and that was 0.12 mg/L near Bridgeport Reservoir.

The U.S.G.S. sampling program (Rockwell and Honeywell, 2004) between April 2000 and June 2003 measured a variety of constituents at 15 sites, although the limited frequency did not allow the development of a thorough description of variability by season and discharge. Just as an example, specific conductance values were low compared to most streams in California and typically ranged from 30 to 150 at most sites(Rockwell and Honeywell, 2004). The highest values generally occurred during low-flow portions of the year.

As part of the comprehensive studies of the Walker River system conducted by the University of Nevada-Reno in the past few years, water samples from the East Walker River were collected at a site about halfway between the Bridgeport Reservoir dam and the state line (Hershey, et al., 2010).

Analytical results from these seven samplings between April 2007 and September 2008 appear below:

Table 22: Water Quality Parameters for Station EWB

Date	pH	EC (μS/cm)	TDS (mg/L)	TSS (mg/L)	Turbidity
4/26/2007	8.06	199	125	14.6	5.01
8/13/2007	9.33	197	116	5.0	4.09
9/20/2007	9.29	198	13	9.8	7.67
2/13/2008	8.10	250	168	4.2	4.4
4/18/2008	8.24	238	151	7.6	4.01
7/10/2008	8.93	192	129	4.2	3.87
9/11/2008	8.94	202	160	6.7	5.88

(East Walker River below dam) from Hershey, et al., 2010: Table A.6.1

Table 23: Ionic Concentrations for Station EWB

Date	Ca	Mg	Na	K	HCO3	CO3	Cl	SO4	NO3asN	SiO2
4/26/2007	19.4	3.92	15.1	3.23	99.6	NA	2.61	12.6	0.009	15.1
8/13/2007	19.3	4.22	16.8	3.44	73.4	17.8	2.6	9.7	0.103	17.5
9/20/2007	18.7	3.9	17.6	3.56	65.6	18.6	3.0	11.5	0.080	28.7
2/13/2008	24.3	5.06	19.7	4.55	124.0	NA	3.64	23.3	0.097	19.3
4/18/2008	20.6	4.67	20.4	4.01	110.0	NA	4.1	23.0	0.01	17.8
7/10/2008	20.1	4.24	15.0	3.62	86.2	8.6	2.31	12.7	0.117	16.3
9/11/2008	21.1	4.36	15.9	3.84	85.8	11.3	2.49	11.8	0.089	33.0

(East Walker River below dam) from Hershey, et al., 2010: Table A.6.1 (mg/L)

Table 24: Trace-Element Concentrations for Station EWB

Sample Date	Be	Al	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Sr
4/26/2007	<1.0	2.2	1.2	<1.0	17.1	49.7	<1.0	<1.0	<1.0	<1.0	204.2
8/13/2007	<1.0	7.3	3.1	<1.0	11.9	51.1	<1.0	<1.0	<1.0	<1.0	207.5
9/20/2007	<1.0	35.2	4.9	<1.0	17.2	98.5	<1.0	<1.0	<1.0	<1.0	165.1
2/13/2008	<1.0	1.7	<1.0	<1.0	324.1	54.1	<1.0	<1.0	<1.0	<1.0	202.1

Sample Date	Mo	Ag	Cd	Sn	Sb	Ba	Tl	Pb	U	As	Se
4/26/2007	3.9	<1.0	<1.0	NA	<1.0	23.2	<1.0	<1.0	1.8	3.9	<5.0
8/13/2007	5.0	<1.0	<1.0	NA	<1.0	20.8	<1.0	<1.0	2.1	19.5	<5.0
9/20/2007	6.3	<1.0	<1.0	<1.0	<1.0	24.8	<1.0	<1.0	3.7	19.1	<5.0
2/13/2008	5.6	<1.0	<1.0	<1.0	<1.0	33.8	<1.0	<1.0	2.8	3.8	<5.0

(East Walker River below dam) from Hershey, et al., 2010: Table A.6.2 (ppb)

Table 25: Measured Values for Total Dissolved Solids and Electrical Conductivity

This study (Hershey, et al., 2010) found that measured values for total dissolved solids and electrical conductivity were usually much greater in the East Walker River than the West Walker River:

	Total Dissolved Solids (mg/L)		Electrical Conductivity (μS/cm)	
	East	West	East	West
4-26-2007	125	40	199	62
8-13-2007	116	92	197	172
9-20-2007	131	115	198	203
2-13-2008	168	90	250	136
4-18-2008	151	45	238	66
7-10-2008	129	34	192	63
9-11-2008	160	108	202	164

A BLM "Domestic Water Analysis" conducted for an Environment Assessment for grazing permit renewal found good to excellent water quality in Dog, Green, and Virginia Creeks (USDI-Bureau of Land Management, 2011).

In 2002, the Lahontan Regional Water Quality Control Board found that total nitrogen from water sampled at the USGS stream gage on Virginia Creek was 0.12 mg/L, exceeding the agency's standard of 0.05 mg/L. Possible anthropogenic sources for relatively high levels of nitrogen in that watershed are not obvious.

Water sampled from seeps and springs at 22 sites near Paramount Creek near Bodie had conductivity values ranging from 39 to 101 (µmhos/cm), TDS values ranging from 0.007 to 0.073 g/L, dissolved oxygen values ranging from 2.3 to 7.3 mg/L and pH ranging from 5.9 to 7.7 (JBR Environmental Consultants, Inc. 2009).

Biological Indicators

For more than 20 years, benthic macroinvertebrates (aquatic insects living on streambeds) have been used as indicators of water quality and aquatic habitat conditions. Different mixes of species of macroinvertebrates and the number of individuals are associated with natural conditions, disturbance, impaired habitat, different pollutants, etc. For example, the group including mayflies, caddisflies, and stoneflies require high levels of dissolved oxygen and low levels of sediment in the streamwater. Where these insects dominate the species mix, the stream is generally considered to have good water quality and favorable habitat. Several sampling protocols and associated indicators have been developed under the general name of bioassessment (e.g., Ode, 2007; Herbst and Silldorff, 2006).

Streams in the Bridgeport Valley were surveyed with the California Stream Bioassessment Procedure in August 1999 and August 2000 (Tate, et al., 2001). Initial results from this study suggested that the biota present in most cases were consistent with low sediment and high oxygen levels (Tate and Vance, 2001). The study found that stream segments closer to Bridgeport Reservoir and therefore subject to cumulative impacts of grazing and irrigation management tended to have lower indices of habitat quality than upstream segments at higher elevations in the valley (Tate, et al., 2001). The study also concluded that sampling over multiple years and locations was necessary to reduce local and temporal variability and that other physical influences prevent a simple direct relationship between macroinvertebrate indices and other measures of habitat quality and stream impairment (Tate, et al., 2001).

Studies of benthic macroinvertebrate communities at several sites throughout the entire Walker River basin have noted relatively low species richness at the sampling site downstream of Bridgeport Reservoir in the autumn (Acharya and Lodmi, 2010; Sada, et al., 2010). The local benthic macroinvertebrate community is believed to be responding to the relatively high concentrations of total nitrogen and total phosphorus found in water released from Bridgeport Reservoir during late summer and autumn (Acharya and Lodmi, 2010).

Benthic macroinvertebrate communities below Bridgeport Reservoir have been monitored by the California Department of Fish and Game following the oil spill in 2001, but the results have not been released (Montalvo, cited by Sada, et al., 2010).

A survey of macroinvertebrates, conducted in Dog and Green Creeks in association with an Environmental Assessment of renewing grazing permits, found insects generally indicative of good quality water (USDI-Bureau of Land Management, 2011).

A study of attached algae on the bed of the Walker River at a variety of sampling sites throughout the entire basin compared algal biomass in spring and late summer (Davis, et al., 2010). At the site on the East Walker below Bridgeport Reservoir, there was little algae in spring because of low winter temperatures, stream ice, minimal sunlight, and scouring effects of high flows during snowmelt runoff. However, algal biomass in August and September of 2007 at this site were high enough to be considered as nuisance blooms of algae and indicative of high nutrient loading and eutrophic conditions (Davis, et al., 2010). In September 2008, floating colonies of a potentially toxic cyanobacteria, mostly *Microcystis* spp., was observed at the site downstream of Bridgeport Reservoir. These colonies were found to be drift from the reservoir (Davis, et al., 2010).

Groundwater

No useful measurements of groundwater quality for the watershed were located. Some vague summaries were tabulated in a report of the California Department of Water Resources (2004).

The U.S. Geological Survey has been reported to be monitoring water from five or six wells in the Bridgeport Valley, but this work has not been confirmed.

9. Subwatersheds with Detailed Information

Fryingpan Creek, Water Canyon Creek, and Murphy Creek flow in from the east downstream of Bridgeport Reservoir. Boone Canyon Creek and Rock Springs Canyon Creek flow into the reservoir. Before the reservoir was built, Buckeye Creek was the next tributary to join the East Walker. Major tributaries of Buckeye Creek include Swauger Creek (which, in turn, has Long Valley Creek and Harvey Creek as principal tributaries), By-Day Creek, and Eagle Creek. Robinson Creek also flows into Bridgeport Reservoir and may have merged with Buckeye Creek before joining the East Walker in pre-reservoir times. Robinson Creek drains the north slopes of Sawtooth Ridge with main tributaries of Tamarack Creek, Cattle Creek, Horse Creek, and Blacksmith Creek. Upstream of Bridgeport Reservoir, the first tributary of the East Walker River is Aurora Canyon Creek, which includes Clark Canyon Creek. Several tributaries flowing from the south successively join to form the East Walker River as it enters Bridgeport Valley: Clearwater Creek, Virginia Creek, Hot Springs Canyon Creek, Dog Creek, Dunderberg Creek, Green Creek, and Summers Creek. Refer to **Map 22**: Subwatershed Map of East Walker Watershed.

Aurora Canyon Creek

Aurora Canyon Creek flows from east to west out of the Bodie Hills towards Bridgeport. The channel is generally only 1 to 2 feet wide in the lower reaches. One reach below a small meadow was observed to be incised to a depth of up to 20 feet (**Figure 11**). Brush had been placed in the gully to reduce further headcutting. Anecdotally, surface flow in the Aurora Canyon Creek channel is rarely observed to reach the East Walker River (USDI-Bureau of Land Management, 2009).

Figure 11: Gully Erosion along Aurora Canyon Creek (Rick Kattelmann)

Clark Canyon Creek is a tributary to Aurora Canyon Creek that was rehabilitated by the BLM as a riparian demonstration area in the 1980s (Key and Gish, 1989). Flow was described as perennial and "fairly constant" during the summer with a measured discharge of about 0.2 cfs. The stream apparently receives considerable subsurface water inputs throughout its length because of low water temperatures, even during the period when riparian vegetation had been largely denuded (USDI-Bureau of Land Management, 1980s). At the time of measurement in 1979, the average width was 3 feet and average depth was about 1 inch (Key and Gish, 1989). Chemical analyses of water samples from the creek indicated "undesirably high" levels of iron and manganese (Key and Gish, 1989). Algae was observed in meadow reaches of the stream, and the water was visibly turbid in the lower reaches. Clark Canyon Creek supports a reproducing rainbow trout fishery. Beaver were also noted to be present. Vegetation types present in the watershed include montane meadow, Great Basin sagebrush, pinyon-juniper, and deciduous woodland (Key and Gish, 1989).

A stream survey of Clark Canyon Creek conducted by the BLM in 1979 described the stream as "badly damaged by cattle use" and rated the aquatic habitat to be in fair to poor condition (USDI-Bureau of Land Management, 1980s). Gullies were forming in meadows, streambanks were compacted and stripped of vegetation, and the stream was unnaturally wide and shallow. An erosion control project was started in 1982 that included improved grazing management to reduce impacts on the riparian zone and construction of gully control structures. Several wire-mesh, gabion-basket structures, and check dams were built between 1984 and 1987. Monitoring was also initiated, but some of the plots were damaged by sediment deposition soon after the project began (Key and Gish, 1989). Long-term results are unknown. The lower portion of Clark Canyon Creek was observed in October 2011 to support a dense riparian cover of willow and wild rose. The control structures were not found, although little of the channel could be observed through the willow thicket. The author may not have gone far enough upstream to locate the old project area.

Buckeye Creek

Buckeye Creek is one of the principal tributaries to the East Walker River. The headwaters are near Grouse Mountain and Center Mountain. After the North Fork and South Fork join at Buckeye Forks at about 8,400 feet elevation, Buckeye Creek flows between Flatiron Ridge and Buckeye Ridge in a southwest to northeast direction for about 11 miles before entering Bridgeport Valley at about 7,000 feet elevation. Eagle Creek enters from the southwest just upstream of Bridgeport Valley. Buckeye Creek's natural course meandered for another 4 miles across the valley before entering Bridgeport Reservoir. Tributaries Log Cabin Creek, By-Day Creek, and Swauger Creek join in the valley. The reach in the valley has been extensively modified for irrigation purposes.

The U.S. Geological Survey operated a stream gaging station on Buckeye Creek between 1953 and 1979 and again between 1995 and 2008. The contributing area above the gaging station at 6,900 feet near Buckeye Hot Springs is approximately 44.1 square miles. The average annual volume over the period of record has been 43,350 acre-feet. The peak flood of record was 2,750 cfs, occurring on January 2, 1997.

The north facing slopes of the lower portions of Buckeye Ridge and Sawmill Ridge drained by the Eagle Creek tributary were logged in the late 19th century, and a sawmill was located on Buckeye Creek upstream from the hot springs. The lumber was destined for Bodie. Cattle have been grazed in much of the Buckeye Creek watershed for more than a century.

An unsurfaced road crosses Buckeye Creek on a major bridge near the historic site of the sawmill. A spur road follows the creek for about a mile and crosses the creek on another bridge, providing access to a Forest Service campground and trailhead. A maintained trail follows Buckeye Creek, with one branch crossing the Sierra Nevada crest into Yosemite National Park and the other entering the headwaters of the West Walker River. Another trail ascends Eagle Creek. The campground had a malfunctioning sewage system suspected of contaminating the creek. That system was replaced with vault toilets in 2003 (USDA-Forest Service, 2004). Dispersed camping is popular in the area near the Buckeye Road and Buckeye Hot Springs, leading to some soil compaction and risk of fecal contamination. Use trails accessing the hot springs have eroded the hillslope above the springs and deliver sediment directly into the creek. Bank erosion along the reach of the creek above Bridgeport Valley was noted in a Forest Service stream survey (USDA-Forest Service, 2004).

Another Forest Service document (USDA-Forest Service, 2000) noted that observed degradation of Buckeye Creek and the South Fork of Buckeye Creek had resulted from intensive grazing in the past, the 1997 flood, and poor location of trails. The document noted that the current permittee was committed to helping restore the channel and riparian vegetation.

The current (2008) section 303(d) list states that 17 miles of Buckeye Creek are impaired due to pathogens. Some water sampling has also indicated high levels of phosphorus in Buckeye Creek.

The lower slopes facing the Bridgeport Valley between Buckeye Creek and Log Cabin Creek burned in the Buckeye Fire of September 2011.

By-Day Creek, a tributary to Buckeye Creek, is about 6 miles long with the upper 2 miles having good habitat conditions for trout. This upper section flows through open coniferous forest, has frequent pools, reasonable cover, and minimum flows of 0.1 to 1 cfs (Dodge, 1992). By-Day Creek is believed to contain the last pure native Lahontan cutthroat trout population in the Walker River basin. By-Day Creek was never stocked with other species of fish, and Lahontan cutthroat trout from the small creek are used as brood stock for attempts at reestablishing the species in other parts of the Walker River basin (Gerstung, 1988). The size of the population in By-Day Creek was estimated from electrofishing at about 1,000 in 1986, but subsequent drought conditions probably reduced the population to about 250 in the early 1990s (Dodge, 1992). Much of the upper watershed of By-Day Creek is owned by the California Department of Fish and Game and managed as a refuge for Lahontan cutthroat trout.

A forest road follows the narrow canyon of By-Day Creek upstream from the Buckeye Road, which crosses By-Day Creek over a large culvert. Portions of the road were carefully constructed, with some high-quality stone work. The road appeared quite stable with no obvious erosion problems. There is much large woody debris in the channel, and a dense riparian cover of willow and cottonwoods surrounds the small channel. Above the narrow canyon, the channel crosses more open terrain on the slopes east of Rickey Peak. In the lowest reaches, between the Buckeye Road and the natural confluence with Buckeye Creek, By-Day Creek's channel has become indistinct after being intercepted by at least two ditches.

Swauger Creek is a principal tributary to Buckeye Creek with the confluence near Bridgeport Reservoir and has a larger watershed area than Buckeye Creek above their respective gaging stations. Long Valley Creek and Harvey Creek are the two named tributaries to Swauger Creek, but small creeks also enter from Mack Canyon, Sario Canyon, Patterson Canyon, and Yaney Canyon. Swauger Creek has an unusual flow regime compared to the other tributaries in the East Walker River basin in that Swauger Creek discharge is relatively consistent from month to month without a pronounced snowmelt runoff pattern. Presumably, the local geology results in subsurface flow that takes several months to move infiltrated water to the stream channel, thereby attenuating most of the snowmelt runoff (Curry, 1992). Swauger Creek had the highest concentrations of soluble reactive phosphous and total phosphorus of any of the tributaries to the East Walker River sampled by the USGS (Elkins, 2002). In 2000, more than 3,000 cattle and sheep grazed in the Swauger Creek subwatershed between June and September (Elkins, 2002). The current (2008) section 303(d) list states that 14 miles of Swauger Creek are impaired due to pathogens.

Figure 12: Swauger Road Erosion (Rick Kattelmann)

Most of valley areas of the Swauger Creek watershed, such as Huntoon Valley, Pimentel Meadows, and the lower portions of Mack Canyon and Harvey Creek are privately owned. Huntoon Valley is used for sheep and cattle grazing. The small community known as Swauger Creek consists of about two dozen homes spread out in Pimentel Meadows and along the forest road following the creek north from U.S. Highway 395. Following thunderstorms in early summer of 2011, this access road was badly eroded with sloughing off into the adjacent creek channel (**Figure 12**). Above the private parcels, the road had captured the stream channel in late 2011.

The U.S. Geological Survey operated a stream gaging station on Swauger Creek between 1953 and 1975 and made a few measurements in 2005 and 2006. The contributing area above the gaging station at 6,620 feet just above the Bridgeport

Valley is approximately 52.8 square miles. The average annual volume over the period of record has been 19,620 acre-feet. The peak flood of record was 585 cfs, occurring on December 23, 1955.

Robinson Creek

Robinson Creek collects water from the picturesque glacial cirques of Sawtooth Ridge and Matterhorn Peak. The more distant headwater area is between Cirque Mountain and Slide Mountain. The glacial geomorphology of the upper portion of the watershed is evident in the cirques, moraines, and tarns, as well as the remnant pocket glaciers and "permanent" snowfields along Sawtooth Ridge east to Twin Peaks. The high-elevation portions of the Robinson Creek watershed are quite popular for backpacking, fishing, off-trail hiking, mountaineering, and spring skiing.

Runoff from the upper parts of the watershed flows into Twin Lakes at about 7,090 feet elevation, which are two glacial lakes that have been raised a few feet by dams. A dam was built at the outlet of Lower Twin Lake in 1888 to increase the volume of the natural lake (East Walker River Trustee Council, 2008). Upper Twin Lake on Robinson Creek has a managed storage capacity of 2,050 acre-feet behind the 14-foot tall dam. The 16-foot tall dam forming Lower Twin Lake impounds 4,050 acre-feet (California Department of Water Resources, 1992). Water rights for storage in Upper Twin Lake have priority dates of 1905 and 1906. Water rights for storage in Lower Twin Lake have priority dates of 1888 and 1906. The decreed place of use for waters managed in both reservoirs is Bridgeport Valley (Horton, 1996).

The Twin Lakes area is perhaps the most popular recreation destination in the East Walker River watershed, and recreational use has been estimated at up to 300,000 visitor-days per year. There are two private communities at Twin Lakes: Rancheria and Twin Lakes with a total of about 180 homes. There are also three recreational resorts: Mono Village, Twin Lakes Resort, and Doc and Al's. Mono Village is the most extensive and occupies a private parcel at the west end of Upper Twin Lake at the end of the road. Boating is quite popular on both lakes. The California Department of Fish and Game stocks the lakes with rainbow trout. Kokanee salmon (*Oncorhynchus nerta*) reportedly inhabit the lakes (or did so in the recent past).

Between the outlet of Lower Twin Lake and the upper margin of the Bridgeport Valley pasturelands, Robinson Creek has created a montane riparian woodland. Trees found along this reach include quaking aspen, black cottonwood, mountain alder, Jeffrey Pine, creek dogwood, and willows (East Walker River Trustee Council, 2008). Cabins at Doc and Al's Resort are adjacent to the creek and within the riparian zone. The Forest Service campgrounds Honeymoon Flat, Robinson, Paha, Crags, and Lower Twin all have campsites within the riparian zone. Several cabins near the outlet of Lower Twin Lake also have outhouses (not necessarily in current use) near the stream. A Forest Service report (USDA-Forest Service, 2000) briefly noted that riparian vegetation has been damaged by recreational use around Twin Lakes and nearby reaches of

Robinson Creek. A considerable amount of construction debris near the lakeshores adjacent to the communities and scattered cabins was visible in autumn 2011.

The U.S. Geological Survey operated a stream gaging station on Robinson Creek between 1953 and 1975 and again between 1994 and 2008. After a lapse during the 2009 water year, the gage may be in operation again. The contributing area above the gaging station at 7,050 feet about 0.2 miles downstream of Lower Twin Lake dam is approximately 39 square miles. The average annual volume over the period of record has been 45,530 acre-feet. The peak flood of record was 1,170 cfs, occurring on January 3, 1997.

Downstream of Lower Twin Lake and the campgrounds, Robinson Creek flows out of the moraine and into Bridgeport Valley. The dominant riparian vegetation changes abruptly from Jeffrey Pine to willow. Willows are extensive in the area where the natural channels of Robinson Creek and Buckeye Creek are parallel. Similar to Buckeye Creek, irrigation diversions have greatly altered the course of Robinson Creek through the pasturelands.

The current (2008) section 303(d) list states that 11 miles of Robinson Creek (Twin Lakes to State Highway 395 and then to Bridgeport Reservoir) are impaired due to pathogens.

Green Creek

The headwaters of Green Creek extend to the part of the Sierra Nevada crest including Camaica Peak. The broad part of the upper watershed contains the Green Lakes. Dams controlling Green Lakes (actually the set of East Lake, West Lake, and Green Lake) were constructed in the 1890s to control water release into Green Creek for hydroelectric generation. The three reservoirs have a total managed storage of 400 acre-feet, a priority date of 1895, and a decreed place of use for the managed water in the Bridgeport Valley (Horton, 1996).

Below the lakes, the watershed is bounded by Monument Ridge and Kavanaugh Ridge. Green Creek continues on a north to northeast course toward the East Walker River and the Bridgeport Valley. Along the way, Dynamo Pond was developed in the 1890s to generate hydroelectric power to supply the Standard Consolidated Mine in Bodie (13 miles away) and the Silverado Mine in the Sweetwater Mountains. Dynamo Pond was created by a timber crib and earth fill dam. It served as the forebay for a dual-wheel powerhouse about half-way down the steep (gradient of 400 feet per mile) canyon of Green Creek (California Department of Fish and Game, n.d.). The Green Creek hydroelectric facility operated until 1941. The watershed above Dynamo Pond has an area of 18.5 square miles.

There was a proposal in the 1980s to install a small hydroelectric facility on Green Creek, including a diversion at the old Dynamo Pond site and a powerhouse downstream of the original structure (California State Water Resources Control Board, 1988). The project would have had about twice the hydraulic head of the historic facility (700 feet vs. 350 feet).

Within the canyon of Green Creek, there is a dense riparian community of willow, aspen, and wild rose with occasional Jeffrey Pine. The canyon provides good habitat for songbirds (California Department of Fish and Game, n.d.). Rainbow trout were routinely planted in the road-accessible meadow reaches of Green Creek near the U.S. Forest Service campground. These areas receive moderate to heavy fishing pressure of 7,500-8,500 angler-days per year (California Department of Fish and Game, n.d.). Streamflow volume measured at a gage downstream of the old powerhouse site (contributing area of 19.5 square miles) averaged 21,000 acre-feet (or 29 cfs) per year (1953-1975) with average daily flows ranging from 60 to 100 cfs between May and July and from 7 to 10 cfs during the winter (California Department of Fish and Game, n.d.). The trout population in lower Green Creek is 80 percent brown trout and 20 percent rainbow trout (California State Water Resources Control Board, 1988). Speckled dace and Paiute sculpin have been found downstream of the Summers Meadow road crossing (USDI-Bureau of Land Management, 1980s).

A Forest Service watershed condition survey of Green Creek in 2002 suggested that the watershed was in healthy condition with scattered soil compaction along the shorelines of the three principal lakes from heavy recreational use (USDA-Forest Service, 2004). The portion of Green Creek adjacent to and within BLM lands is upstream of the culvert-crossing on the road to Summers Meadow. This reach was considered to be in excellent condition and supported an excellent trout fishery in the 1980s (USDI-Bureau of Land Management, 1980s). No impact from sheep grazing was noted at that time, and the few dispersed campsites near the stream were not thought to be detrimental (USDI-Bureau of Land Management, 1980s).

The road that parallels Green Creek is a source of sediment to the creek. The road has both altered the riparian corridor as well as provided easy access for additional disturbance such as clearing for parking spots and campsites. Several summer cabins are located at the end of the road near the trailhead parking area and campground. Remains of two mining and ore processing operations are located near the confluence of the outlet channel from Par Value Lakes and Green Creek in Glines Canyon, but no historical information has been found.

The U.S. Geological Survey operated a stream gaging station on Green Creek between 1953 and 1975 and since 2004. The contributing area above the gaging station at 6,850 feet and about 100 feet downstream of the bridge on the Upper Summers Meadow Road is approximately 19.5 square miles. The average annual volume over the period of record has been 20,780 acre-feet. The peak flood of record was 451 cfs, occurring on June 6, 2010.

Summers Creek

Summers Creek is a principal tributary to Green Creek, collecting runoff from the north slopes of Monument Ridge and the south and east slopes of the Hunewill Hills. After curving around the east side of the Hunewill Hills, Summers Creek runs parallel to Green Creek across the southern part of the Bridgeport Valley. Presumably, the course of the natural channels have been altered to enhance water spreading and irrigation over the past century and a half.

A Forest Service watershed condition survey of Summers Creek in 2002 described several observations of bank erosion along Summers Creek below the diversion from Tamarack Creek, possibly because of the artificially higher flows in this reach (USDA-Forest Service, 2004). The study also found the stream crossings along Forest Road 144 in Deep Canyon were in poor condition. In the worst example, the creek occupied the road for about 50 yards (USDA-Forest Service, 2004).

A gaging station was operated by the U.S. Geological Survey on Summers Creek from 1953 through 1959. The contributing area above the gage was about 8 square miles. The average annual volume over the six years of operation was 4,278 acre-feet.

Virginia Creek

Virginia Creek drains the southern portion of the East Walker River watershed, originating in the alpine terrain above Virginia Lakes. The dozen or so small lakes upstream of and around the Virginia Lakes recreation area range in size from 3 to 25 acres. A paved road extends to about 9,800 feet elevation and provides access to this popular recreation area. The Virginia Lakes Resort and a campground are near the end of the road. A small seasonal community served by a mutual water company is located on a few hundred acres of private land. The Virginia Lakes Pack Station operates under a special use permit on 2.6 acres of USFS land near Virginia Lake. The site includes office and living quarters for staff, tack sheds, and horse corrals.

Water has been diverted out of Virginia Creek and into the Mono Basin at the Conway diversion since 1859 (DeDecker, 1966). Decree C-125 establishes a water right for diversion from Virginia Creek to Conway Ranch in the Mono Basin of 6 cfs or about 1,000 acre-feet per year (California Department of Water Resources, 1992). The point of diversion is in the southwest corner of Section 26, near the Virginia Lakes Road, at about 8,320 feet elevation. The drainage area is about 7.9 square miles above the diversion (Beak Consultants, 1986).

A Forest Service report (USDA-Forest Service, 2000) briefly noted that riparian vegetation has been damaged by recreational use in the headwaters of Virginia Creek (with possible impacts to amphibian habitat) and downstream of Virginia Lakes (with possible impacts to willow flycatcher habitat). A watershed condition survey conducted by the Bridgeport Ranger District in 2002 found that stream bank erosion is prevalent along the reach of Virginia Creek that is paralleled by Forest Road 139 and that has extensive dispersed camp sites. This survey also described erosion problems on Forest Road 020 (Dunderberg Meadow Road) where the road has captured water from the irrigation ditch that diverts water from Dunderberg Creek into Dog Creek. Field observations in 2010 and 2011 found that fishermen's use trails around each of the Virginia Lakes had impacted the lakeside habitat and riparian vegetation. The impacts were typical of popular mountain lakes with nearly vehicular access: intermittent compacted areas, minor erosion, and reduced vegetation density.

Primary land ownership changes from Forest Service to Bureau of Land Management below about 8,900 feet along Virginia Creek. The reach of Virginia Creek between this boundary and about 8,200 feet was considered to have excellent aquatic habitat (USDI-Bureau of Land Management, 1980s). In the 1980s, the meadows and aspen groves west of U.S. Highway 395 on the north side of Conway Summit were private land and actively grazed by both cattle and sheep. Comparison of aerial photos taken in 1955 and 1974 showed extensive clearing of aspens from this parcel during that time period. A network of ditches in this parcel spread water diverted from Virginia Creek. The grazing and water management added sediment, nutrients, and heat to Virginia Creek (USDI-Bureau of Land Management, 1980s). The Trust for Public Land acquired some of the property in the area and transferred it to the public domain. The Bureau of Land Management considers an area of about 3,000 acres around Conway Summit to be a special management area because of its wetlands and scenic aspen groves. Sheep grazing on the public lands downstream of this parcel contributed additional sediment, but the impacts were not considered significant compared to the beaver activity in this reach (between 7,600 and 7,200 feet). A comparison of 1955 and 1974 aerial photos showed that there was little evidence of beaver dams in 1955, but several dams had appeared by 1974 (USDI-Bureau of Land Management, 1980s).

The lower portion of Virginia Creek is on Bureau of Land Management land, which has unofficial campsites constructed in the riparian zone and an estimated 4,000 visitor-days of use per year (U.S. Bureau of Land Management, 1990). Channel crossings of Virginia Creek by dirt roads on BLM land were found to break down stream banks, widen the channel for 10 to 20 feet, create pools, and generate small amounts of suspended sediment (USDI-Bureau of Land Management, 2011).

During the Dogtown mining boom of the 1850s, the portion of Virginia Creek near the confluences with Dog Creek and with Clearwater Creek was dredged. Over time, the tailings have become stable, and riparian vegetation has reestablished (USDI-Bureau of Land Management, 1980s).

The construction and presence of U.S. Highway 395 above Virginia Creek has had negative impacts (U.S. Bureau of Land Management, 1990). Sediment and pollutants from the road surface flow directly into the stream. In the narrow canyon downstream of the confluence with Clearwater Creek, the stream was channelized during highway construction. There are also several houses and other buildings in the floodplain and riparian zone in this reach. Nevertheless, the lower section of Virginia Creek on BLM land has been regarded to have fair to excellent aquatic habitat and the fishery appeared to be in good shape in the 1980s (U.S. Bureau of Land Management, 1990).

The U.S. Geological Survey operated a stream gaging station on Virginia Creek between 1954 and 1975 and since 2004. The contributing area above the gaging station at 6,700 feet just downstream from the Virginia Creek Settlement along U.S. Highway 395 is approximately 63.6 square miles.

The average annual volume over the period of record has been 12,200 acre-feet. The peak flood of record was 1,300 cfs, occurring on December 23, 1955.

Clearwater Creek, a tributary to Virginia Creek, has a watershed area of about 37 square miles. The average gradient of the channel is about 5 percent (Denio and Associates Engineering, 1999). Snowmelt runoff and occasional summer thunderstorms provide surface and shallow subsurface flow to the channel. Groundwater seepage and springs maintain some flow in the main channel throughout the year. Clearwater Creek supports a small population of trout and provides water for terrestrial wildlife (Mono County Community Development Department, 2000).

Construction and upgrading of State Highway 270 have channelized portions of Clearwater Creek, removed riparian vegetation, and provided a source of sediment and vehicular pollutants to the stream (USDI-Bureau of Land Management, 1980s). Some streambank erosion from cattle and sheep in the upper elevation lands was noted by BLM personnel. Gully erosion, both active and stabilized, was also noted. Beaver dams and their removal were thought to be a cause of some of the gully problems (USDI-Bureau of Land Management, 1980s). Diversions and ditches in Mormon Meadow spread water throughout the meadow area. Nevertheless, the stream was judged to be in good condition there. Aquatic habitat was judged to be fair, except where impacted by the road and removal of beaver dams (USDI-Bureau of Land Management, 1980s). Clearwater Creek supports a good population of the native sucker species *Catostomus tahoensis* throughout its length, as well as brown trout and rainbow trout in some reaches (USDI-Bureau of Land Management, 1980s).

Clearwater Creek is listed as impaired by sediment under section 303(d) of the Clean Water Act. Data collected in Clearwater Creek document a macroinvertebrate assemblage that indicates impacts of sedimentation (Singer, 2000). Clearwater Creek has a dynamic channel that is becoming wider in several areas in response to past downcutting. The incised and unstable channel of Clearwater Creek will likely continue to widen over time as the channel establishes a functional floodplain (Singer, 2000).

The portion of Clearwater Creek just upstream of the confluence with Virginia Creek was described in an EIR for a proposed recreational-vehicle campground (Mono County Community Development Department, 2000). In this reach, Clearwater Creek flows through a canyon that is 100-400 feet wide and 100-200 feet deep. The stream channel is 4-10 feet deep and 30-60 feet wide (Mono County Community Development Department, 2000). The EIR described Clearwater Creek as "deeply gullied; its banks appear to be unstable, highly erodible and subject to collapse" (Mono County Community Development Department, 2000:I-52). Another report relating to the proposed project noted "significant bank erosion" following the 1996-97 winter (Denio and Associates Engineering, 1999:7). Field observations in 2011 indicated that the channel form and size is highly variable along its course, appears stable in most places because of dense riparian vegetation (mostly willow), is constrained by State Highway 270 in its lower reaches, and does not appear as unstable as the EIR documents might suggest.

The channel of Dog Creek begins on the eastern slopes of Dunderberg Peak and turns north to flow through Sinnamon Meadow, add water from Dunderberg Creek and continue to its confluence with Virginia Creek. Ditches divert water from Dog Creek at about 8,440' and take it northwest to slopes above Sinnamon Meadow and northeast to the meadows north of Conway Summit. Much of the 3.5 mile-long reach on BLM land above the confluence with Virginia Creek was dredged between 1857 and 1859. The tailings are now stable and support riparian vegetation. The reach on BLM land was considered to be in very good condition in the 1980s with excellent aquatic habitat (USDI-Bureau of Land Management, 1980s). No streambank damage was noted with respect to the sheep grazing in the area. The stream supports reproducing populations of brown, rainbow, and eastern brook trout and Paiute sculpin. Beaver have altered portions of the channel (USDI-Bureau of Land Management, 1980s).

Similar to Virginia Creek, channel crossings of Dog Creek by dirt roads on BLM land were found to break down stream banks, widen the channel for 10 to 20 feet, create pools, and generate small amounts of suspended sediment (USDI-Bureau of Land Management, 2011).

Dog Creek contributes a significant amount of water to lower Virginia Creek, estimated to be about half of the total discharge in Virginia Creek at the gaging station (Beak Consultants, 1986).

Riparian vegetation along Virginia Creek from the Conway diversion to the USGS gaging station was mapped by Beak Consultants (1986). After flowing out of a mixed lodgepole pine / aspen forest near the diversion, Virginia Creek enters a wet valley with extensive side channels and seeps that support a diverse riparian zone composed of mature aspen groves, meadows, and shrub thickets. About 1.6 miles downstream of the diversion, the riparian zone becomes thin and confined along the narrow valley. Willows and aspens are the dominant species. Just downstream of the confluence with Dog Creek, there are two small meadows associated with beaver dams. Vegetation in the reach above the gaging station is primarily willow (Beak Consultants, 1986).

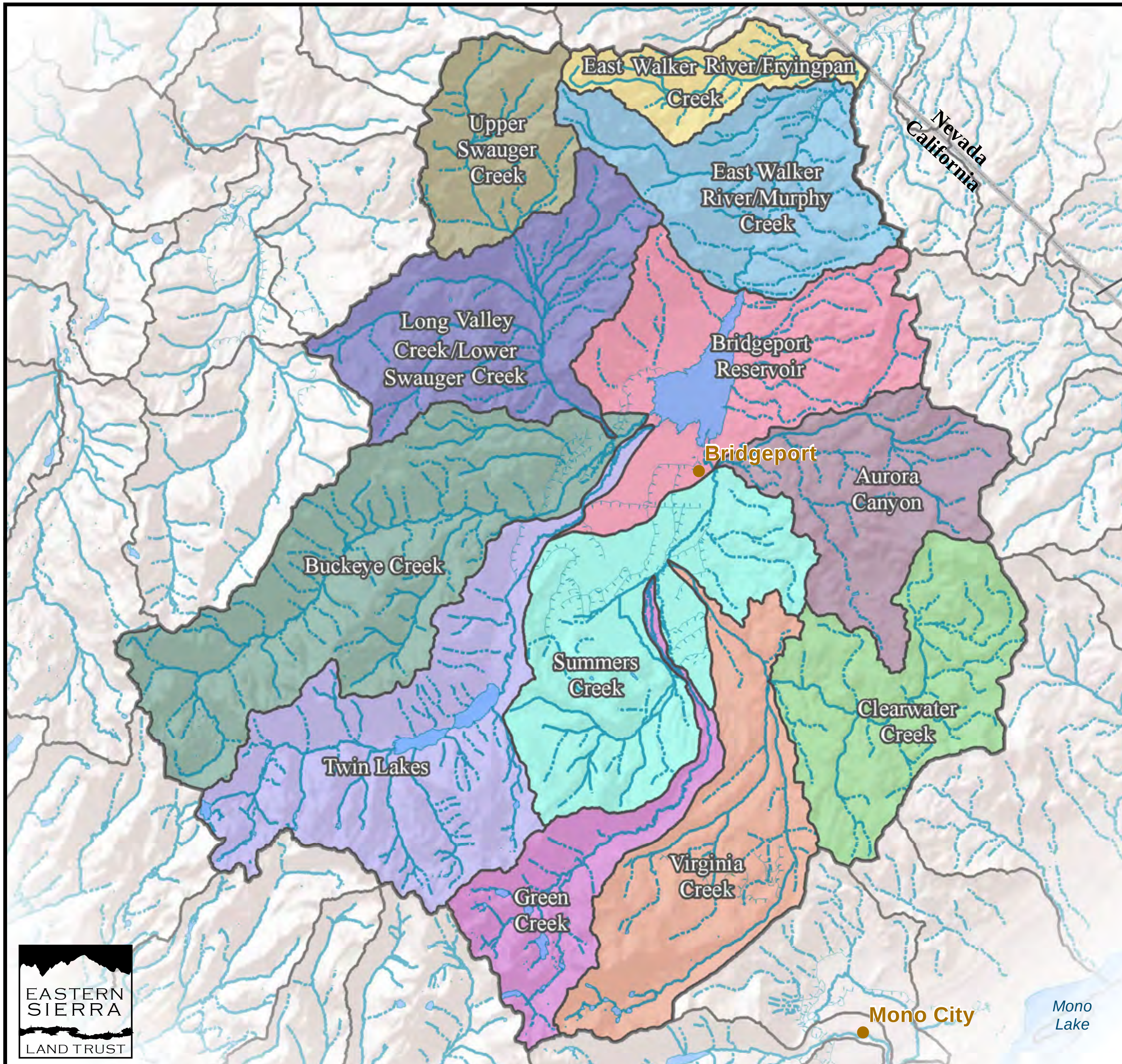
In 1993, a stream assessment of the reaches of Virginia Creek and its tributaries (Dog, Green, and Dunderberg Creeks) that are on BLM land was conducted using the standard BLM "proper functioning condition" protocol. These reaches were classified as "functioning-at-risk", meaning that they were in functional condition though susceptible to degradation. Although a formal assessment has not been repeated, an Environmental Assessment for renewal of grazing permits considered these reaches to still be in the same condition with an upward trend toward proper functioning condition (USDI-Bureau of Land Management, 2011).

Hot Springs Canyon Creek

Hot Springs Canyon Creek would naturally connect to the East Walker River about a mile north of the beginning of the mapped name of the East Walker (confluence of Green Creek and Virginia Creek), between the buildings of the Point Ranch and the town of Bridgeport. However, water spreading east of U.S. Highway 395, the physical influences of the roadway, and irrigation ditches west of the highway have altered the channel as it approaches the Bridgeport Valley.

From the 1940s through the 1980s, Hot Springs Canyon Creek was recognized as a severe erosion problem (USDI-Bureau of Land Management, 1980s). Gullies occupied the entire 1.7 miles of channel on BLM land, ranging from a four-foot deep though wide cross-section at the lower end to sections up to 30 feet deep with vertical sides in the upper reaches. Overgrazing resulted in soil compaction, bank sloughing, loss of riparian vegetation, and headcuts (USDI-Bureau of Land Management, 1980s). The sediment load was heavy, nutrient level high, and water temperature high as a result from the excessive grazing use. Aquatic habitat was rated as poor and riparian habitat as very poor (USDI-Bureau of Land Management, 1980s). The BLM condition assessment recommended drastic reduction in livestock numbers and active rehabilitation of the channel. Portions of the channel are constrained by State Route 270.

Hot Springs Canyon Creek was formerly on the 303(d) list as impaired for sediment, but was de-listed in 2008. Stream surveys conducted by the Bureau of Land Management in 1988 found poor vegetation cover in the portions of the riparian zone and active bank erosion. Grazing management practices were improved after 1993, and the stream channel has recovered. A field survey by Bureau of Land Management and Lahontan RWQCB staff in 2007 found that riparian vegetation and streambank stability had significantly improved over the preceding 20 years and that the stream could no longer be considered impaired. The U.S. Environmental Protection Agency delisted Hot Springs Canyon Creek in 2010.



Subwatershed Map of East Walker Watershed

East Walker Watershed Assessment
March 2012

Legend

Subwatershed (HUC 12)

Area of Subwatershed Contributing to California Portion of East Walker Watershed (Sq. Miles)

Aurora Canyon: 27.9
Bridgeport Reservoir: 38.9
Buckeye Creek: 55.8
Clearwater Creek: 33.2
East Walker River / Fryingpan Creek: 12.5
East Walker River / Murphy Creek: 30.5
Green Creek: 20.3
Long Valley Creek / Lower Swauger Creek: 35.4
Summers Creek: 43.2
Twin Lakes: 48.3
Virginia Creek: 36.0
Upper Swauger Creek: 18.8

0 1.5 3 6
Miles
N

North American Datum of 1983 (NAD 83)
Universal Transverse Mercator, Zone 11

Sources: US Geological Survey

Map 22: Subwatershed Map of East Walker Watershed

10. Evaluation of Problems and Issues

Although the East Walker River watershed appears to be in relatively good condition compared to other watersheds of California and even of Mono County, watershed assessments by their nature focus on problems identified in the evaluation. The Bridgeport Valley is an idyllic ranching location that has been used for summer cattle grazing since the 1850s. Abundant water spread through an extensive network of irrigation ditches produces enough forage to support more than 8,000 cattle each summer. The waste products of all that grazing contain nutrients and coliform bacteria that can pollute the water leaving the pastures and entering Bridgeport Reservoir. One could argue that there might not be a problem if the reservoir did not exist, and it certainly came many decades after the cows. However, the reservoir does exist and is covered by state laws and regulations intended to maintain and enhance water quality. The regional regulatory objective for fecal coliform is an order of magnitude stricter than elsewhere in the state and nation despite the absence of known resources at risk in the affected portion of the East Walker River. The situation makes for lively discussion in the context of environmental ethics. Fortunately, the ranchers of the Bridgeport Valley and the regional water-quality agency are working together to reduce the nutrient and coliform loading to the receiving waters while the numerical standard has not yet been enforced. There is significant potential for creative grazing management to result in measurable decreases in the constituents of concern, although the likelihood of reaching the water-quality agency's current objective for fecal coliform while maintaining economically viable ranching operations in the Bridgeport Valley is not favorable.

Bridgeport Reservoir has additional water quality issues relating to its location and physical nature. As the receiving sump for anything carried by streams through and off of the flatlands of the Bridgeport Valley, the reservoir has accumulated nitrogen and phosphorus compounds in its stored sediments for almost a century. In addition to the high availability of nutrients, intense solar radiation in the summer months powers photosynthesis and warms the water, leading to excessive productivity of algae and blue-green algae. Preliminary limnological studies suggest that both internal and external sources of nutrients contribute to the high productivity. If reducing the productivity of the reservoir were deemed worthwhile, a variety of measures could be employed, but all would be costly and reduce the storage utility of the reservoir.

Localized sources of sediment from human impacts, such as roads, construction, and grazing, could be limited if such reductions were considered worthwhile and sources of funding for small projects became available.

Riparian habitat has been locally impacted by the construction and presence of roads, trails, buildings, and recreational facilities (primarily campgrounds) within the riparian zone.

The risk of catastrophic wildfire (and subsequent risk of erosion and sedimentation) is linked to the accumulation of dead fuels and increases in density of forests, woodlands, and shrublands in the absence of a natural fire regime.

Water availability appears to be adequate for all known demands within the watershed. Water management for irrigation in Bridgeport Valley and in Nevada alters the flow regime of the East Walker River downstream of Bridgeport reservoir and leaves only the required minimum flows in the river during later summer and autumn of some years. There is little opportunity for increasing deliveries of water to either irrigators in Nevada or to Walker Lake.

Quantitative knowledge about hydrologic and biogeochemical processes is limited throughout the East Walker River watershed. There have only been seven stream gages with intermittent operation, five climate stations, seven snow courses or sensors, and minimal chemical and biological sampling to provide data about the hydrology and chemistry of the watershed. The lack of data and information is a limiting factor for identifying trends over time, responses to impacts or remediation, or potential solutions to known problems. Nevertheless, there is considerably more information per unit area than for most of the western United States.

Summary

A watershed assessment is intended to describe the state of knowledge about the set of influences on water quantity and quality within a particular watershed. The set of natural and human factors that produce streamflow and affect its quality are complex and highly variable from place to place and over time. Our knowledge is also quite limited, especially with respect to **quantities** of water and the associated chemical and biological constituents. So, not only is the hydrologic system complicated and variable, but we also just don't know very much about it. The preceding chapters have attempted to summarize what we do know and indicate the limitations and uncertainties of that knowledge. These details and their associated caveats are not readily distilled into a few sound-bites or headlines without losing much of the critical context and qualifications. Nevertheless, such simplifications are required because few people will bother to read the entire document. The following summary remarks are intended to provide overview impressions and should not be used for development of policy or practices.

Although not pristine with respect to human influences, the East Walker River watershed has been spared the more serious impacts afflicting water resources throughout much of the United States. There are simply not many people residing in or visiting the watershed to produce major impacts. The extent and intensity of water-resources engineering is comparatively small and largely focused on the lower end of the watershed (i.e., Bridgeport Valley irrigation and operation of Bridgeport Reservoir). The proportion of watershed area covered by impermeable surfaces is a fraction of one percent. The hydrologic functions of vegetation and soils have not been greatly altered. The stream channels have not been significantly manipulated over much of the watershed.

There are no polluting industries. The extent of mining has been quite limited in extent and severity. Although roads are one of the chief impacts on the watershed, their extent and location with respect to channels do not have nearly as much influence as in most watersheds of the United States.

The watershed of the East Walker River produces large volumes of high-quality water. The headwater areas on the western edge of the watershed receive significant snowfall in most years, and the main tributaries (Buckeye, Robinson, and Green Creeks) produce more than 18 inches of runoff per year, on the average. That figure is substantial compared to almost all other streams of the Great Basin and not too much less than the 24 inch average of river basins on the wetter western slope of the Sierra Nevada (Kattelmann, 1996). The runoff production processes are intact and minimally altered by human activities (at least in comparison to most of California). Only a small proportion of the watershed is significantly disturbed with respect to hydrologic and geomorphic processes – primarily the Bridgeport Valley and the developed area adjacent to Twin Lakes.

One estimate of the amount of water lost to evaporation from irrigation in the Bridgeport Valley is 17,000 acre-feet per year (Lopes and Allander, 2009). About 45 percent of that estimate is derived from diverted streamflow, and the remainder is from direct precipitation on the pasture lands. If the Bridgeport Valley were not artificially irrigated, then at least 7,600 acre-feet (17,000 x 0.45) of water per year, on the average, would not be evaporated and continue east as streamflow. In the absence of irrigation, native vegetation would still transpire a lot of water (potential evapotranspiration [if water supply is not limiting] would still be about 29 inches per year or 17,000 acre-feet over the area of interest). However, there is no adequate means of calculating the relative amounts of water naturally entering the valley from adjacent foothills and runoff flowing off the valley lands in spring and early summer before the opportunity for evaporation. Therefore, we will offer a rough estimate that about 8,000 acre-feet per year (amount of diverted water rounded up) would not be transpired if there were no irrigation in the Bridgeport Valley. That is a crude approximation of the total amount of water that could potentially be available to augment flows to Walker Lake if diversion and irrigation were shut down within the Bridgeport Valley. That amount of water is 7 to 8 percent of the average flow of the East Walker River below Bridgeport Reservoir (about 106,000 acre-feet) and about 6 percent of the average inflow to Walker Lake of about 135,000 acre-feet that would be necessary to stabilize the lake's level. While every increment of additional water would help the Walker Lake ecosystem, there simply is not much available to contribute from even a complete cessation of irrigation within the California portion of the East Walker River watershed.

Evaporation from the surface of Bridgeport Reservoir has also been considered as a potentially-recoverable water loss from the Walker River system. The best available estimate of annual evaporation from the reservoir is 43 inches or about 9,000 acre-feet (Lopes and Alexander, 2009). This quantity is about 8 to 9 percent of the average flow of the East Walker River below Bridgeport Reservoir (about 106,000 acre-feet). If the reservoir was no longer used for storage, potential savings would be less than 9,000 acre-feet because the wetlands that would reoccupy much of the reservoir area would continue to evapotranspire a substantial amount of water. Operating the reservoir at lower storage volumes could greatly reduce the evaporating surface area because of the shallow topography of the reservoir site.

The principal water-quality issue in the watershed is nutrient and pathogens contamination of Bridgeport Reservoir and the East Walker River below the dam. The reservoir is just downstream of the pasture lands of the Bridgeport Valley that are grazed by about 8,000 cattle each summer. The resulting fecal material contains nitrogen and phosphorus compounds and fecal coliform. The issue is quite difficult to resolve because the agricultural system of the Bridgeport Valley has been developed to be highly productive of forage during the summer and thereby support a large number of cattle. The valley has become a significant agricultural resource for summer-seasonal grazing of beef cattle. The extensive irrigation network has also augmented the natural wetlands of the valley floor with greater area and connectivity. The seasonal coverage of water throughout much of the valley floor both provides the opportunity for direct transport of nutrients and coliform to Bridgeport Reservoir as well as the possibility of biochemical amelioration of some of the nutrient load. The existence of Bridgeport Reservoir has also eliminated a large wetland that might have further reduced nutrient and coliform loading to the East Walker River. A further complication is the low-value objective for fecal coliform in water bodies within the Lahontan Region of 20 colonies per 100 ml – ten times more stringent than the standard of 200 colonies per 100 ml adopted by other regions in California, as well as the U.S.E.P.A.

The ranches of the Bridgeport Valley have been operating under an "agricultural waiver" granted by the Lahontan Regional Water Quality Control Board since 2007. Under this waiver, individual members of the Bridgeport Ranchers Organization have followed Rangeland Water Quality Management Plans, implemented grazing Management Practices, and sampled water quality in the streams of the Bridgeport Valley. Over the past five years, coliform counts have generally declined, but some samples have exceeded the 200 colonies per 100 ml provisional standard of the waiver (California Regional Water Quality Control Board--Lahontan Region, 2012). An extension of a more restrictive waiver has been proposed for adoption at the April 2012 meeting of the Lahontan Regional Water Quality Control Board.

By comparison, other water quality issues in the watershed are much less contentious. Some are still largely intractable, such as the long-term eutrophication of Bridgeport Reservoir, which mainly results from the presence of the reservoir itself – a shallow water body that has considerable nitrogen and phosphorus stored in the sediment and that gets quite warm each summer, or the mercury and heavy metals that persist in old mine tailings and the channels downstream in the Bodie Hills. Other water-quality problems are localized and relatively minor.

Several stream segments have become critical to recovery of Lahontan cutthroat trout and are actively managed for that purpose. Other aquatic refuges established by the Humboldt-Toiyabe

National Forest and California Department of Fish and Game may play an important role in maintaining populations of amphibians.

Riparian areas and wetlands have been reduced in extent, complexity, and ecological functions in parts of the East Walker River watershed. Wetland area in the Bridgeport Valley has been greatly expanded by artificial irrigation and the extensive network of ditches. These artificially maintained wetlands are ecologically simple compared to completely natural wetlands, but they do provide some ecological services such as enhancing nutrient cycling. Elsewhere in the watershed, degraded riparian areas have potential to recover somewhat by removing or reducing the intensity of the disturbances. Existing wetlands should be conserved because they are not readily restored to their pre-disturbance condition.

There are a variety of localized impacts to streams and riparian areas that can be largely addressed by measures that detain and/or retain water, sediment, nutrients, and anthropogenic pollutants in the immediate area of the disturbance or activity.

Overall, the watershed of the East Walker River appears to be in comparatively fine shape with only a small degree of manipulation and disturbance relative to most watersheds of California and the nation. The concerns regarding grazing in the Bridgeport Valley and its effects on downstream water quality are the principal water issues within the watershed. Hopefully, continued efforts by the Bridgeport Ranchers Organization and the Lahontan Regional Water Quality Control Board will lead to a reasonable adjustment of the pathogen standard and additional progress on implementing Best Management Practices that reduce pathogens and nutrients in Bridgeport Reservoir and the East Walker River.

Appendix 1. Rough Creek and Bodie Creek Subwatersheds

Rough Creek and its tributary Bodie Creek are minor tributaries to the overall East Walker River. Much less than one percent of the total streamflow in the Walker River system flows out of the Bodie Hills (Lopes and Allander, 2009). Rough Creek joins the East Walker River downstream of the California / Nevada stateline. Because of the State of California funding of this watershed assessment, hydrologic boundaries were secondary to state boundaries, and the Rough Creek subwatershed did not conveniently conform to a constrained delineation of the East Walker River basin as defined as lands upstream of the point where the river leaves California. Nevertheless, the Rough Creek portion of the Bodie Hills has been historically important and a micro-version of a watershed assessment is included here.Refer to **Map 23**: Overview Map of Rough Creek Subwatershed (California Portion).

The vegetation of the Bodie Hills (including both the Rough Creek and Bodie Creek watersheds) has been thoroughly described by Messick (1982). Riparian areas and meadows occur in a wide variety of conditions throughout the Bodie Hills, depending on local moisture regimes (resulting from microclimate, geology, and topography) as well as year-to-year variations in water availability (e.g, Messick, 1982; USDI-Bureau of Land Management, 2009). With much less wildfire than is presumed to be natural, vegetation has become uniform rather than patchy and fuel loads have increased (Provencher, et al., 2009).A variety of management actions have been proposed to return the vegetation of the Bodie Hills to more natural conditions. These possible treatments include prescribed burning, mowing shrubs with low-ground-pressure machinery, hand-cutting shrubs, burning or chipping of cut shrubs and trees, and seeding of native grasses (USDI-Bureau of Land Management, 2011b).

Interpretation of the geology in the Bodie Hills and a water balance for Rough Creek suggests there could be an "appreciable amount" of groundwater movement from the Rough Creek subwatershed into the Mono Lake basin (Glancy, 1971).

Within California, Rough Creek crosses back and forth between private parcels and BLM land. About half the length of the main channel is on federal land. A watershed condition assessment of the BLM portions in 1979 found that the stream was in "fairly good condition despite the heavy cattle use throughout its length" (USDI-Bureau of Land Management, 1980s). The assessment noted that conditions varied greatly along the stream. A few areas were substantially degraded with little riparian vegetation, collapsed banks, and deep gullies. Some wet meadows that were obvious on 1955 aerial photos had been drained by gullying and had dried out. The desiccation of meadows as a result of headcuts, gullying, and lowering water tables was identified as a serious problem in some areas tributary to Rough Creek (USDI-Bureau of Land Management, 1980s). Other reaches were in relatively good condition. The assessment also noted that bank instability and gullying was fairly common within aspen groves throughout the Bodie Hills but was unable to explain the phenomenon.

The area around the Paramount Mine was prospected intermittently, and mining claims were filed from the 1930s through the 1960s. There was an active mercury mine in the area between the 1940s and the 1960s (USDI-Bureau of Land Management, 1990). A variety of road and mine development activities occurred during the 1960s and 1970s (USDI-Bureau of Land Management, 2009: App. A). Prospecting has resumed in the past few years after Cougar Gold LLC / Tigris Financial Ltd. obtained the mining claims to the area. An environmental assessment for the exploration work has been prepared (USDI-Bureau of Land Management, 2009). Political efforts have begun to remove the Wilderness Study Area status of the area to facilitate mining (e.g., Grasseschi, 2011; Scheck, 2011).

Paramount Creek has been evaluated for potential habitat for reintroduction of Lahontan cutthroat trout and found to unsuitable above the usually dry middle reach and possibly suitable in the downstream reach (USDI-Bureau of Land Management, 2009). Rainbow trout were planted in Rough Creek in 1944 and 1946 by the California Department of Fish and Game, but their survival is unknown (USDI-Bureau of Land Management, 1980s).

Rough Creek apparently gains and loses water along its course as subsurface geologic and hydrologic conditions change. In July and August of 1979, measured discharge at different points along the channel varied from zero to 4 cfs (USDI-Bureau of Land Management, 1980s). A significant flood in the winter of 1978 caused severe erosion and gullying in some tributaries, such as Atastra Creek. Water was once diverted from Rough Creek for use in Bodie State Historical Park, but a well is now thought to be the principal water supply (USDI-Bureau of Land Management, 1980s).

Water from a variety of springs and seeps near Paramount Creek was sampled and analyzed a few years ago. Solute concentrations (TDS) ranged from 70 to 84 mg/l and concentrations of major ions were slightly higher than typical concentrations in rainwater (USDI-Bureau of Land Management, 2009). These results suggested that the water in the springs and seeps has a short residence time in the ground and has minimal contact with deep groundwater.

Samples of aquatic invertebrates from four sites in the Rough Creek watershed found elevated mercury concentrations (ranging from 0.26 to 0.86 micrograms/g dry weight).

Rough Creek is classified as a wild river study segment (USDI-Bureau of Land Management, 2009).

Bodie Creek

Bodie Creek has a total length of about 17.4 miles from its source area above Bodie State Historic Park and its confluence with Rough Creek (USDA-Forest Service, 2006). The upper 7.3 miles are within California on lands managed by the State of California and USDI-Bureau of Land Management in addition to several private parcels.

The headwaters of Bodie Creek are the slopes and meadows surrounding the Bodie townsite. Springs and a tributary add water within the first half-mile while flowing east. The channel goes around a large curve and then trends north toward the Nevada border.

The Bodie Mining District was active from 1859 through the 1920s. Gold was initially found by prospector Waterman S. Body in 1859, but yields were small for the following two decades. In 1876, the Standard Company found a deposit of high-grade gold ore, and the boom period began. Discovery of a large ore body in Bodie Bluff in 1878 generated further interest that brought some 10,000 people to Bodie. The peak population at any one time was estimated to range between 5,000 and 7,000. The population had dropped below 700 by 1910 and below 100 by 1920 (California Department of Parks and Recreation, 1979). Total production was about 1.5 million ounces of gold and more than 15 million ounces of silver (USDI-Bureau of Land Management, 1990) with a value of about $30,000,000.

During the active mining period, large amounts of water were pumped out of the mine shafts and released into Bodie Creek. At times, the flow in the creek rose to perhaps 15 times greater than the natural flows (USDI-Bureau of Land Management, 1980s). Several dams were built across Bodie Creek in the first 2 to 3 miles downstream of Bodie. The impoundments stored water for ore processing or hydraulic power and contained mine tailings. The tailings clogged and shifted the channel. More than 10 feet of tailings and debris can still be found in the original channel north of the Bodie townsite (California Department of Parks and Recreation, 1979). When the dams failed, pulses of water and sediment would have scoured the channel immediately downstream and then created sediment piles farther downstream. Gullies and deposition areas are still visible along the course of Bodie Creek (USDI-Bureau of Land Management, 1980s). Cyanide leaching was used to re-process tailings and low-grade ores during the 1890s.

Hybridized Lahontan cutthroat trout were observed in Bodie Creek downstream of the state line in 2006 (USDA-Forest Service, 2006).

Bodie State Historic Park covers about 1,000 acres. The park was 495 acres in size from 1962 until 1997, when the State of California, Bureau of Land Management, and American Land Conservancy were able to purchase another 520 acres and mineral rights from Galactic Resources, Inc., a Canadian firm that had proposed to mine the land in 1990. By the end of 1998, federal funds from the Land and Water Conservation Fund bought out the remaining interest of the American Land Conservancy (Calnan, 1999).

Bodie was designated as a National Historic Landmark in 1961 with an area of 500 acres but no specified boundaries. A study by the National Park Service to delineate a boundary for the Landmark was in progress but no references were found regarding completion. The National Park Service has also studied the area as a potential National Historic Landscape.

More than 16,800 acres of the Bodie Hills were designated as a Wilderness Study Area (WSA) in 1980. In a report prepared for Congress in 1990, the BLM recommended that the area was not suitable for wilderness and that a multiple-use designation should be reinstated (USDI-Bureau of Land Management, 2009). Congressional legislation (HR 6129) to remove the WSA status was introduced in September 2010.

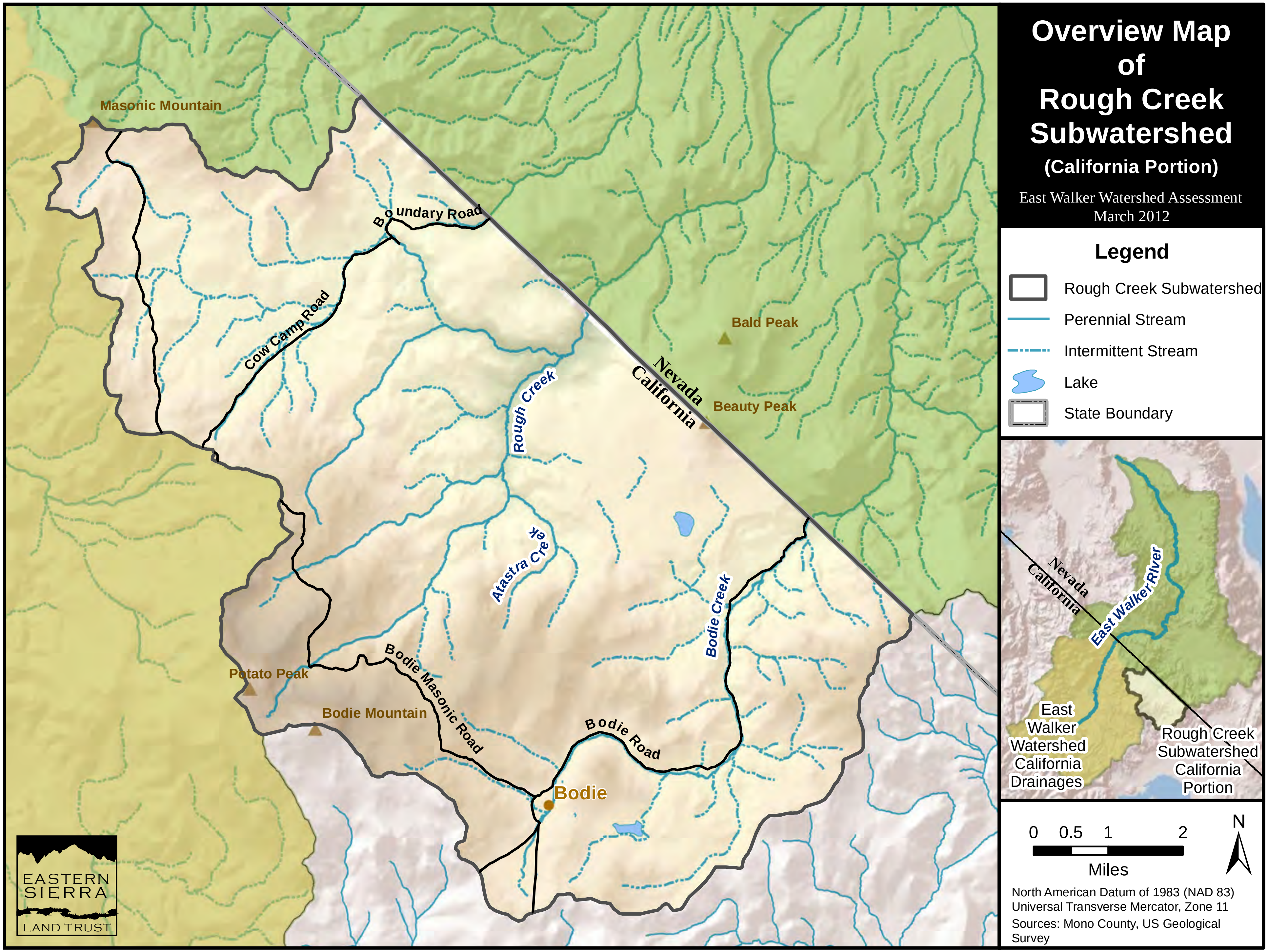
The federal lands surrounding the state park have been designated as an Area of Critical Environmental Concern (ACEC) by the BLM in 1993. This area of special management covers about 5,935 acres. All proposed projects within the Bodie Bowl ACEC must go through both a NEPA review and a "Section 106" process regarding potential impacts to cultural resources. The BLM has a cooperative management agreement with the state park. There are some private parcels downstream of the BLM special area and state park that are managed for grazing. The BLM completed a management plan for the 7,300 acre Bodie Bowl area in 1995.

In the 1990s, there was a proposal for the BLM to withdraw the western portion of the Bodie Bowl from mineral entry that would prohibit filing additional claims in the area. The status of that potential action is unknown. The Resource Management Plan of the BLM states, "While mineral ownership is a right under the 1872 Mining Act, mineral development is a privilege that requires responsible environmental management under FLPMA. Access to and permission to develop a mining claim does not have to be given if it would cause irreparable damage to cultural resources" (USDI-Bureau of Land Management, 1993: 5-7).

The headwaters of Bodie Creek are on the east slopes of Bodie Mountain at about 9,200 feet elevation. Bodie Creek flows northeastward and joins Rough Creek on Nevada side of the border after about 8 miles. Bodie Creek is an ephemeral stream that carries runoff mostly generated from winter rainfall and spring snowmelt. There is rarely any surface flow between a reach about one mile downstream of Bodie State Historic Park and a bedrock outcrop upstream of the state line (California Regional Water Quality Control Board--Lahontan Region, 2002). Bodie Creek was initially listed for impaired water quality from metals in 1991. The Bureau of Land Management 1990 Draft Resource Management Plan and Environmental Impact Report noted high levels of mercury and arsenic in the creek with likely association to historic mining and milling in the watershed. In 1992, data collected for the Toxic Substances Monitoring Program of the State Water Resources Control Board at a point about 2.5 miles downstream of the state park indicated high concentrations of metals (cadmium, chromium, lead, nickel, and silver) in fish tissue (California Regional Water Quality Control Board--Lahontan Region, 1994c and 2002).

A sample of sediment obtained from the bed of Bodie Creek contained 13.6 micrograms of mercury per gram of sediment (Seiler, et al., 2004). The current (2008) section 303(d) list states that Bodie Creek is impaired because of mercury for 11 miles (out of 17.4 miles).

Cattle grazing is the primary current land use in the watershed and the major influence on the stream (USDI-Bureau of Land Management, 1980s). On BLM land where the channel is not constrained by topography, there were localized areas of erosion and sedimentation as well as collapsed streambanks resulting from cattle trampling (USDI-Bureau of Land Management, 1980s). In such areas, aquatic habitat was judged to be poor.



Map 23: Overview Map of Rough Creek Subwatershed (California Portion)

Appendix 2. Overview of Private Agricultural Lands

The East Walker River watershed is unique in the region due to the fact that it is composed of a high percentage of privately owned land (17 percent), which is more than twice the county-wide percentage for Mono County. The majority of this private land is utilized for agricultural purposes, primarily for the grazing of livestock. In fact, 45 percent of the agriculturally designated lands in Mono County occur in this watershed. Despite this designation, due to the limited amount of private land in the region, during times of growth new subdivisions and isolated housing developments are often situated on converted agricultural lands, rather than occurring in closer proximity to existing communities. The unfortunate consequence of such development is the permanent loss or degradation of the economic, cultural, and environmental values that these private agricultural lands provide for the region.

Type of Agricultural Use

The primary agricultural use on private lands in the watershed is grazing of cattle, sheep, and other livestock. The Bridgeport Valley has been identified as one of the largest mountain meadow areas in California (Curry, 1991). The valley, aside from the small town of Bridgeport, is composed primarily of large privately owned parcels of productive pastureland on wet meadows. This land is grazed seasonally, typically from May into November, as part of a number of cow-calf and stocker cattle ranch operations. Many scattered private parcels located at higher elevations throughout the watershed support additional sheep and cattle operations and serve as base properties for adjacent public lands grazing leases.

Economic, Cultural, Environmental Importance

Agricultural businesses in the region contribute to the region's economic, cultural, and environmental values and rural character. In 2010, livestock accounted for 60 percent of all agricultural production in Mono County, or $22 million dollars (Inyo Mono Agriculture, 2010). In fact, according to one past census, Mono County had one of the highest net cash farm returns of the any of counties located in the Sierra Nevada region. Additionally, farms in Mono County have also been determined to be the most valuable within Sierra Nevada counties (Momsen, 1996).

Since the mid-1800s, following the discovery of gold nearby, livestock have thrived on the irrigated pasture lands of the Bridgeport Valley and provided food and economic benefits to the community. Bridgeport became an important supply hub for growing mining towns throughout the region after enterprising ranchers settled the valley and surrounding areas and developed profitable businesses selling livestock and timber to the growing mine towns such as Bodie and Aurora. Although the days of booming mining communities passed long ago, the agricultural lands of the valley have been utilized for livestock production nearly continuously for more than 150 years. As a result, agricultural has become an important portion of the economy and identity of the region.

Private agricultural lands in the watershed can also bring multiple benefits to the public and the environment. As owners of large private acreages, members of the local agricultural community have economic incentives, among other reasons, to manage their lands in a sustainable manner because it maximizes the long-term productivity of their operations. Multiple conservation benefits are met by the protection of ranchland by preserving open land for wildlife, sustainable use of water resources, and the maintenance of scenic rural landscapes that benefit tourism and local economies.

Geographical Description

The watershed contains approximately 36,000 acres of privately owned land used for agricultural purposes. The majority of this land has been given the Agricultural Land Use Designation (LUD) by Mono County; however a number of large parcels with the Resource Management LUD are also utilized by local agricultural operators. Of these private agricultural lands, nearly 23,000 acres occur in a nearly contiguous block on the floor of the Bridgeport Valley, representing almost 30 percent of the county's private working lands.. To the east of the valley, the Bodie Hills portion of the watershed contains significant acreage of private grazing lands scattered in a checkerboard amongst public lands managed by the U.S. Bureau of Land Management. Other significant areas of privately owned agricultural lands occur in the Huntoon Valley, the lower slopes of the Sweetwater Mountains, and the slopes of the Sierra Nevada to the south and west of Bridgeport Valley. The distribution of private lands can be seen clearly on **Map 18**: Land Ownership Map of East Walker Watershed.

Additional Resources on Private Agricultural Lands

Wetlands

Much of the high quality pasture land of the watershed are located on freshwater emergent wetland meadows within the watershed. These wetlands are a combination of naturally occurring, and irrigated wetland complexes resulting from more than 150 years of water spreading and diversion practices. The extensive wet meadows of the Bridgeport Valley includes 15,200 acres of private land that has been designated as wetland by the National Wetlands Inventory, a program of the U.S. Fish & Wildlife Service. To put this figure into perspective, a total approximately 17,000 acres of wetlands occur on private lands within the watershed and more than 24,000 acres (including lakes, reservoirs, and ponds), or nearly 20 percent, of all the wetlands in Mono County occur in this one relatively small watershed. In many respects the agricultural land management practices on these private lands are responsible for the current extent of significant wetlands in the region, particularly in the Bridgeport Valley, where the irrigation practices and infrastructure in use today are essentially the same as they were when the first federal land surveyors visited in the late 1860s (Curry, 1991). Aside from the obvious economic importance of these wetlands as livestock pasture, they also provide important habitat for many wildlife species including several species of special concern. Furthermore, healthy mountain meadows can provide a number of ecosystem services such as flood attenuation and flow reliability, increased late season water flow, reduced erosion, and reductions to summer water temperature (Male, 2010).

Many of the creeks and streams that eventually flow into the Bridgeport Reservoir cross significant portions of private land where that water supports wetlands, riparian habitats, and irrigated grazing lands. According to USGS maps the East Walker River originates on the private lands of the Bridgeport Valley below the confluence of Virginia, Green, and Summers Creeks. In all, 130 miles of rivers, streams, and creeks occur on private agricultural lands in the watershed. As a result, land use practices on these private lands are clearly linked to the overall water quality within the watershed as is described elsewhere in this report. The wetlands and riparian habitats along these waterways are also of great importance to the plant and wildlife species that occur in the region.

Special Status Species

Important habitats for the plant and wildlife species that exist in the watershed occur on much of the privately owned agricultural land in the region. The meadow pastures and upland sagebrush rangelands provide habitat for a number of key species including the greater sage-grouse, mule deer, and at higher elevations, the Sierra Nevada bighorn sheep and red fox. Agricultural fields such as those in the Bridgeport Valley have been documented to be important foraging habitat for a number of raptor species, including bald eagle, which migrate through the region seasonally. Agricultural properties provide important buffer habitat and connectivity to the surrounding public lands and allow for movement across the landscape for migratory species.

Springs, creeks, and ponds on private land provide suitable habitat for various aquatic species including the mountain yellow-legged frog and Yosemite toad. The riparian vegetation that occurs along waterways provides a link between meadows and other wetlands as well as habitat for plant and animal species.

The unique geology and climate that occur in the region also supports a particularly high concentration of rare plant species, several of which are endemic to the region. This includes 13 species that have been identified by the California Native Plant Society as rare and declining, which makes them eligible for State listing (**Table 9**).

Scenic Highway

A 24.5 mile long section of U.S. Route 395, a designated State Scenic Highway, crosses through the watershed. The majority of this length of highway passes by and through privately owned lands, which provide a pastoral viewshed to the dramatic backdrop of high peaks of the Sierra Nevada and Yosemite National Park to the west, and unique and historic Bodie Hills to the east. The route enters the watershed at Conway Summit (8,138 feet), the highest point along the entire length of the highway, where travelers enjoy expansive views that include both public and privately owned aspen groves and mountain meadows. The route then descends north into the Bridgeport Valley passing through green meadow pastures with flowing rivers and herds of cattle, evidence of the rural lifestyle and character of the region. Finally, the route travels back northwest towards the Sierra Nevada and Sweetwater Mountains where the meadows of the valley bottom gradually turn to sagebrush covered slopes and groves of pinyon pine. The undeveloped private agricultural lands that buffer the highway provide public benefit in the form of scenic open space that can be enjoyed by the general public as visible from the roadway.

Opportunities for Long-Term Conservation

The preservation of productive agricultural lands has been identified as a priority by a number of governmental policies:

The Farmland Protection Policy Act, P.L. 97-98, 7 U.S.C. section 4201 et seq., whose purpose is "to minimize the extent to which Federal programs and policies contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses, and to assure that Federal programs are administered in a manner that, to the extent practicable, will be compatible with State, unit of local government and private programs and policies to protect farmland;"

Section 815.1 of the California Civil Code, which defines conservation easements;

California Constitution Article XIII, section 8, California Revenue and Taxation Code, sections 421.5 and 422.5, and California Civil Code section 815.1, under which easements are an enforceable restriction, requiring that the property's tax valuation be consistent with restriction of its use for purposes of food and fiber production and conservation of natural resources;

Section 10200 et seq. of the California Public Resources Code, which creates the California Farmland Conservancy Program within the Department of Conservation;

Section 51220 of the California Government Code, which declares a public interest in the preservation of agricultural lands;

The California General Plan law, section 65300 et seq., and section 65400 et seq. of the California Government Code, and the Mono County General Plan, as amended in 2010, which includes as one of its goals to protect all viable farmlands designated as prime, of statewide importance, unique, or of local importance from conversion to and encroachment of non-agricultural uses.

County Zoning

The Bridgeport Valley and Bodie Hills areas are both covered by a county managed Development Credits Program that allows a certain number of units to be developed per parcel, depending on the size of the parcel.

From Mono County General Plan:

INTENT: The “AG” designation is intended to preserve and encourage agricultural uses, to protect agricultural uses from encroachment from urban uses, and to provide for the orderly growth of activities related to agriculture.

Designate land presently in agricultural use as "Agriculture,” and establish a Development Credits Program, including voluntary Transfer of Development Rights provisions, which will encourage clustering development away from irrigated land.

INTENT: The “RM” designation is intended to recognize and maintain a wide variety of values in the lands outside existing communities. The RM designation indicates the land may be valuable for uses including but not limited to recreation, surface water conservation, groundwater conservation and recharge, wetlands conservation, habitat protection for special status species, wildlife habitat, visual resources, cultural resources, geothermal or mineral resources. The land may also need special management consideration due to the presence of natural hazards in the area; e.g., avalanche-prone areas, earthquake faults, flood hazards, or landslide or rockfall hazards.

Williamson Act

The California Department of Conservation describes the Williamson Act: The California Land Conservation Act of 1965--commonly referred to as the Williamson Act--enables local governments to enter into contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open space use. In return, landowners receive property tax assessments, which are much lower than normal because they are based upon farming and open space uses as opposed to full market value. Local governments receive an annual subvention of forgone property tax revenues from the state via the Open Space Subvention Act of 1971.

Unfortunately, due to funding limitations at the state level, the county is not currently receiving an annual subvention payment. When the program was active, there were 11,500 acres of private agricultural lands in the watershed under Williamson Act contracts, this represents 87% of the total land covered by the Act in Mono County.

Conservation Easements

Voluntary land conservation agreements, known as conservation easements, are an effective tool for preserving important agricultural lands. The process involves a willing landowner, a qualified nonprofit or public agency, and typically several funding agencies. The easement process can take 6-24 months to complete and requires legal and tax advisors for the landowner. When the future plans of the landowner are finalized (reserved building sites, farmstead locations, etc.), an appraisal is completed to determine the value of the conservation easement. This process is based on appraising the value of the property with full development rights and again with the diminished development rights limited by the conservation easement. The value of the easement is the difference between the "before and after" values. If the purpose of the easement is determined to be qualified under Internal Revenue Service code for conservation easements, the value of the easement could be a qualified charitable contribution and significant federal tax benefits may be available. If tax benefits are not of value to the landowner and resources on the property are significant, funding can be sought to purchase the conservation easement.

Federal programs through the Natural Resource Conservation Service such as the Farm and Ranchland Protection Program or the Grasslands Reserve Program are sources of funding for agricultural easements. State programs through the Sierra Nevada Conservancy, Wildlife Conservation Board, California Farmland Conservancy Program, and Environmental Enhancement and Mitigation Program may also be available for protecting agricultural resources.

Easement terms for agricultural easements can restrict roads, water export, subdivision, and disturbance of prime soils. Easements are recorded on the deed of the property and stay permanently with the land through any change of ownership. The holder of the easement, a land trust or other qualified agency, is charged with monitoring the terms of the easement through annual visits and communications, along with legally defending the easement, if necessary.

Appendix 3. Literature Cited

Acharya, K. and A. Lodmi, 2010. Spatial and temporal variability in elemental composition and stoichiometry of benthic macroinvertebrate communities in the Walker River, Nevada and California. in: Collopy, M.W. and J.M. Thomas (eds.). Restoration of a desert lake in a agriculturally dominated watershed: The Walker Lake Basin. Reno: University of Nevada and Desert Research Institute. pp. 311-328.

Acton, R., T. MacDiarmid, E. Miller, and R. Narayanan, 1998. A preliminary study of the potential for water banking within the Walker River basin of Nevada and California. Department of Applied Economics and Statistics, University of Nevada, Reno.

Adams, K. D., 2007. Late Holocene sedimentary environments and lake-level fluctuations at Walker Lake, Nevada, USA. Geological Society of America Bulletin 119(1/2):126-139.

Anchor Point Group, 2009. Community wildfire protection plan, Mono County, California. Boulder, CO: Anchor Point Group.

Bagley, M., 1997. Botanical survey of the proposed Bodie Hills RV park, Mono County, California. prepared for the Mono County Community Development Department, Mammoth Lakes.

Barbier, J. 1995. Angler's Guide to the Eastern Sierra: Bridgeport to Bishop. San Diego: Trade Service Corporation.

Beak Consultants, Inc., 1986. Responses to schedule A: Additional information requested by the Federal Energy Regulatory Commission. FERC Project No. 6549-001. Conway Virginia Creek water power project. prepared for Conway Ranch Partnership.

Becker, D., 1996. Lobdell Lake gill net survey and Desert Creek electroshocking: The search for the elusive Arctic Grayling and Piute Sculpin. DFG Fisheries Files. Bishop: California Department of Fish and Game.

Becker, D., 1997. Silver Creek, Mono County, post-treatment stream evaluation. Memorandum to Fishery files from Dawn Becker. Bishop: California Department of Fish and Game.

Behney, C. and R.W. Niblock, 1993. Water for Walker Lake. OTA-O-584.Washington, D.C.: Office of Technology Assessment, Library of Congress.

Benson, L.V, 1988. Preliminary paleolimnologic data of the Walker Lake sub-basin, California and Nevada. Water Resources Investigations Report 87-4258. Denver: U.S. Geological Survey.

Benson, L.V., P.A. Meyers, and R.J. Spencer, 1991. Change in the size of Walker Lake during the past 5000 years. Palaeogeography, Palaeoclimatology, Palaeoecology 81: 189-214.

Benson, L.V., and R.J. Spencer, 1983. A hydrochemical reconnaissance study of the Walker River basin, California and Nevada. Open File Report 83-740. Carson City: U.S. Geological Survey.

Blodgett, J.C., 1971. Water temperature of California streams: North Lahontan region. Open file report (not numbered). Menlo Park: U.S. Geological Survey.

Borrow, N.J., 1967. Some aspects of the effects of grazing on the nutrition of pastures. Journal of the Australian Institute of Agricultural Science 33:254-262 [cited by Gerrish, J.R., P.R. Peterson, and J.R. Brown, 2010.

Grazing management affects soil phosphorus and potassium levels. University of Missouri, Forage Systems Research Center].

Boyle, D.P., G. Pohll, S. Bassett, T.B. Minor, C. Garner, R. Carroll, D. McGraw, A. Knust, C. Barth, 2010. Development of a decision support tool in support of water right acquisitions in the Walker River basin. in: Collopy, M.W. and J.M. Thomas (eds.). Restoration of a desert lake in a agriculturally dominated watershed: The Walker Lake Basin. Reno: University of Nevada and Desert Research Institute. pp. 763-868.

Bradbury, J.P., R.M. Forester, and R.S. Thompson, 1989. Late Quaternary paleolimnology of Walker Lake, Nevada. Journal of Paleolimnology 1:249-267 [cited by Sharpe, 2010]

Bradford, D.F., 1989. Allotopic distribution of native frogs and introduced fishes in high Sierra Nevada lakes of California: Implication of the negative effect of fish introductions. Copeia 1989: 775-778.

Bradford, D.F., F. Tabatabai, and D.M. Graber, 1993. Isolation of remaining populations of the native frog, Rana muscosa, by introduced fishes in Sequoia and Kings Canyon National Parks, California. Conservation Biology 7:882-888.

Bridgeport Ranger District, 2009. Murphy Creek, Mono County, California: 2009 Lahontan cutthroat trout survey report. Bridgeport: Humboldt-Toiyabe National Forest.

Burton, J.F. and M.M. Farrell, 1992. An archaeological survey and assessment of the Sweetwater Ranch subdivision, Mono County, California. Contributions to Trans-sierran Archaeology No. 32. Appendix in Johnston and Associates, 1992.

California Department of Fish and Game, 1979. West Walker endemic fishes survey. Bishop.

California Department of Fish and Game, 1990. Interim management plan, Pickel Meadow and Little Walker River. Bishop: DFG fisheries files.

California Department of Fish and Game, 2001. Walker River Lahontan cutthroat trout summary 2001. Bishop: DFG fisheries files.

California Department of Fish and Game, 2006. The efficacy of measures to minimize contact between domestic sheep and Sierra Nevada bighorn sheep on the Humboldt-Toiyabe National Forest, Mono County, California. Sacramento. [accessed at: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=27707]

California Department of Fish and Game, n.d. File report on Green Creek small hydroelectric project, FERC #4314. Bishop: DFG fisheries files.

California Department of Parks and Recreation, 1979. Bodie State Historic Park: Resource Management Plan, General Development Plan, and Environmental Impact Report. Sacramento.

California Department of Water Resources, 1960. Report on Bridgeport Valley ground-water investigation. Sacramento.

California Department of Water Resources, 1964. West Walker River investigation. Bulletin 64. Sacramento.

California Department of Water Resources, 1975. California's groundwater. Bulletin 118. Sacramento.

California Department of Water Resources, 1981. June Lake area water assessment study. Sacramento: Department of Water Resources.

California Department of Water Resources, 1992. Walker River Atlas. Sacramento.

California Department of Water Resources, 2004. California's groundwater. Bulletin 118. Sacramento.

California Department of Water Resources, 2009. California Water Plan Update. Bulletin 160-09. Sacramento.

California Native Plant Society. 2011. CNPS Rare Plant Program Website. [accessed at: http://www.cnps.org/cnps/rareplants/ranking.php]

California Natural Diversity Database, Biogeographic Data Branch, Department of Fish and Game. February 7, 2012.

California Regional Water Quality Control Board--Lahontan Region, 1992a. Water body fact sheet for Bridgeport Valley. South Lake Tahoe.

California Regional Water Quality Control Board--Lahontan Region, 1992b. Water body fact sheet for Twin Lakes. South Lake Tahoe.

California Regional Water Quality Control Board--Lahontan Region, 1994a. Water body fact sheet for East Walker River. South Lake Tahoe.

California Regional Water Quality Control Board--Lahontan Region, 1994b. Water body fact sheets for Twin Lake, Upper and Lower. South Lake Tahoe.

California Regional Water Quality Control Board--Lahontan Region, 1994c. Water body fact sheet for Bodie Creek. South Lake Tahoe.

California Regional Water Quality Control Board--Lahontan Region, 1995. Water Quality Control Plan for the Lahontan Region. South Lake Tahoe.

California Regional Water Quality Control Board--Lahontan Region, 2002. Problem statement, Bodie Creek, Total Maximum Daily Load (TMDL) for metals. South Lake Tahoe.

California Regional Water Quality Control Board--Lahontan Region, 2003. Problem statement, Bridgeport Reservoir nutrient TMDL. South Lake Tahoe.

California Regional Water Quality Control Board--Lahontan Region, 2007. Resolution No. R6T-2007-0020, Certifying a negative declaration for a waiver of waste discharge requirements for grazing operators in the Bridgeport Valley and East Walker River watersheds. South Lake Tahoe. (accessed at: http://www.waterboards.ca.gov/rwqcb6/board_decisions/adopted_orders/2007/docs/r6t_2007_0020_grazingwaiver_negdec.pdf)

California Regional Water Quality Control Board--Lahontan Region, 2008. Fact sheet for Hot Springs Canyon Creek de-list. South Lake Tahoe.

California Regional Water Quality Control Board--Lahontan Region, 2012. Renewal of general conditional waiver of waste discharge requirements. Board Order No. R6T-2012-(tentative) for grazing operations in the East Walker River watershed (Bridgeport Valley and tributaries) of the Lahontan Region. South Lake Tahoe.

California State Water Resources Control Board, 1988. Dynamo Pond hydroelectric project in Mono County, Application 26627, Decision 1620. Sacramento.

Carson River Basin Council of Governments, 1974. Regional storm drainage plan, Walker River phase I inventory. Carson City.

Centennial Livestock, 2002. Comments on April 2002 staff report: Revision of the Clean Water Act section 303(d) list of water quality limited segments – Lahontan Regional Water Quality Control Board. Letter from William Thomas to Craig Wilson. Coalinga: Centennial Livestock.

Chesterman, C.W., and C.H. Gray, Jr., 1975. Geology of the Bodie quadrangle, Mono County, California. Map Sheet 21, scale 1:48,000. Sacramento: California Division of Mines and Geology.

Clark, M.M., 1967, Pleistocene glaciation of the drainage of the West Walker River, Sierra Nevada, California: Stanford, California, Stanford University, Ph.D. thesis, 130 p.

Coffin, P.D., and W.F. Cowan. 1995. Lahontan cutthroat trout (Oncorhynchus clarki henshawi) recovery plan. U.S. Fish and Wildlife Service, Portand, Oregon.

Collopy, M.W. and J.M. Thomas, 2010. Restoration of a desert lake in a agriculturally dominated watershed: The Walker Lake Basin. Reno: University of Nevada and Desert Research Institute.

Cooper, J.J. and D.L. Koch, 1984. Limnology of a desertic terminal lake, Walker Lake, Nevada. Hydrobiologia 118(3): 275-292.

Creager, C., J. Butcher, E. Welch, G. Wortham, and S. Roy, 2006. Technical approach to develop nutrient numeric endpoints for California. Lafayette: Tetra Tech, Inc.

Curry, R., 2000. Cited by Elkins 2002

Curry, R., 1991. Eastern Sierra Nevada Wetland Assessment: Bridgeport Basin Study Site – Climatic Change, Irrigation, and Wetland Boundaries. WMRS Symposium Volume 4: The History of Water: Eastern Sierra Nevada, Owens Valley, White-Inyo Mountains.

Curry, R.R., 1992. Reasserting riparian rights -- the Walker River case study. in: Hall, C.A., V. Doyle-Jones, and B. Widawski (eds.). The History of Water in the Eastern Sierra Nevada, Owens Valley and White Mountains. Los Angeles: University of California Press, pp. 303-313.

Davis, C., J. Memmott, and C. Fritsen, 2010. Walker River periphyton. in: Collopy, M.W. and J.M. Thomas (eds.). Restoration of a desert lake in a agriculturally dominated watershed: The Walker Lake Basin. Reno: University of Nevada and Desert Research Institute. pp. 229-269.

DeDecker, M., 1966. Mines of the Eastern Sierra. Glendale: La Siesta Press.

Denio and Associates Engineering, 1999. Hydrology and flood plain study for Bodie Hills RV park. [cited by Mono County Community Development Department, 2000]

Dodge, W.B., 1992. Sweetwater subdivision -- environmental impact report -- biological resources. Appendix in Johnston and Associates, 1992.

Dohrenwend, J.C., 1982. Surficial geologic map of the Walker Lake 1 x 2 quadrangle, Nevada-California. Miscellaneous Field Studies Map MF-1382-C. Denver: U.S. Geological Survey.

Dubrovsky, N.M., K.R. Burow, G.M. Clark, J.M. Gronberg, P.A. Hamilton, K.J. Hitt, D.K. Mueller, M.D. Munn, B.T. Nolan, L.J. Puckett, M.G. Rupert, T.M. Short, N.E. Spahr, L.A. Sprague, and W.G. Wilber, 2010, The quality of our Nation's waters—Nutrients in the Nation's streams and groundwater, 1992–2004. Circular 1350, Reston: U.S. Geological Survey, 174 p.

Dunham, J.B., G.L. Vinyard, and B.E. Rieman, 1997. Habitat fragmentation and extinction risk of Lahontan cutthroat trout. North American Journal of Fisheries Management 17(4): 1126-1133.

East Walker River Trustee Council, 2008. Revised draft restoration plan and environmental assessment for the Advanced Fuel Filtration Systems East Walker River oil spill. California Department of Fish and Game, Nevada Department of Wildlife, Nevada Division of Environmental Protection, and U.S. Fish and Wildlife Service.

Elkins, K.A., 2002. Spatial and temporal variability of nutrient and fecal coliform export from East Walker River watershed: Implications for pollutant source areas. M.S. thesis, Civil and Environmental Engineering, University of California, Berkeley.

ESA Planning and Environmental Services, 1987. Tentative Tract Map 32-06 / Van Horn Environmental Impact Report. Mono County Planning Department.

Everett, D.E., and F.E. Rush, 1967. A brief appraisal of the water resources of the Walker Lake area, Mineral, Lyon, and Churchill counties, Nevada. Water Resources Reconnaissance Series Report No. 40. Carson City: Nevada Department of Conservation and Natural Resources.

Evers, D.C., and 7 others, 1998. Geographic trend in mercury measured in common loon feathers and blood. Environmental Toxicology and Chemistry 17(2):173-183.

Ferranto, S.P., 2006. Conservation of mule deer in the eastern Sierra Nevada. M.S. thesis. Reno: University of Nevada.

Gerstung, E.R., 1986. A management plan for Lahontan cutthroat trout populations in California. Sacramento: California Department of Fish and Game, Inland Fisheries Branch.

Gerstung, E., 1988. Status, life history, and management of the Lahontan cutthroat trout. American Fisheries Society Symposium 4:93-106.

Gerstung, E., 1989. Eradication of unwanted fish species using physical removal methods; some case histories. California Department of Fish and Game. Appendix to: Toiyabe National Forest, 1989. Environmental Assessment, Lahontan cutthroat trout restoration project, Silver Creek and Wolf Creek, Mono County. Sparks: Toiyabe National Forest, USDA Forest Service.

Glancy, P.A., 1971. Water resource appraisal of Antelope Valley and East Walker area, Nevada and California. Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series, Report 53. Carson City: U.S. Geological Survey.

Goldberg, J., 1988. Chemical treatment of Slinkard Creek conducted as a follow-up to the August 1987 treatment to remove brook trout prior to re-introduction of Lahontan cutthroat trout. Memorandum to Fisheries Files. Bishop: California Department of Fish and Game.

Gong, P., X. Miao, K. Tate, C. Battaglia, and G.S. Biging, 2004. Water table level in relation to EO-1ALI and ETM+ data over a mountainous meadow in California. Canadian Journal of Remote Sensing 30(5):691-696.

Grinnell, J., and T.I. Storer, 1924. Animal life in the Yosemite. Berkeley: University of California Press.

Gustafson, M., 1997. Memorandum of Understanding between USDA Forest Service and California Department of Fish and Game, Fisheries files. Bishop: California Department of Fish and Game.

Herbst, D.B., and J.M. Kane, 2004. Responses of stream channels, riparian habitat, and aquatic invertebrate community structure to varied livestock grazing exposure and management in the West Walker River watershed (Mono County, California). Final report to Lahontan RWQCB, South Lake Tahoe.

Herbst, D.B., and E.L. Sildorff, 2006. Comparison of the performance of different bioassessment methods: similar evaluations of biotic integrity from separate programs and procedures. Journal of the North American Benthological Society 25(2):513-530.

Hershey, R.L., B. Lyles, T. Mihevc, and S. Sharpe, 2010. Major-ion and trace-element chemistry of Walker River and Walker Lake, Nevada. in Chandra, S. and D.W. Sada, Project A: Instream and lake aquatic health introduction, Part II. Walker River. Reno: University of Nevada.

Horne, A.J., J.C. Roth, and N.J. Barratt, 1994. Walker Lake Nevada: State of the lake, 1992-1994. EEHSL Report 94-2. Report to the Nevada Division of Environmental Protection. Department of Civil and Environmental Engineering, University of California, Berkeley and the Environmental Engineering and Health Sciences Laboratory, Richmond. 85 pp.

Horne, A.J., J.C. Roth, M. Beutel, R. Barth, K. Elkins, S. Stoller, R. Muneepeerakul, J. Berlin, J. Truitt, S. Huang, and J. Kane, 2003. Report on Bridgeport Reservoir beneficial use impairment: Limnology in the summer-fall 2000 and comparisons with 1989. Department of Civil and Environmental Engineering, University of California, Berkeley.

Horton, G., 1996. Walker River chronology: A chronological history of the Walker River and related water issues. A publication in the Nevada Division of Water Planning's Nevada Water Basin Information and Chronology Series, available on the Nevada Division of Water Planning's website: www.water.nv.gov. Carson City: Department of Conservation and Natural Resources,

Horton, G.A., 1997. The Flood of 1997 – Final Report: An Analysis of Snowpack Water Content and Precipitation Changes in the Waterbasins of Western Nevada and the Effect on Runoff and Stream Flows December 16, 1996–January 6, 1997*

Houghton, S.G., 1986. A Trace of Desert Waters: The Great Basin Story. Salt Lake City: Howe Brothers. 287 p.

Howald, A., 2000. Plant communities. in: Sierra East: Edge of the Great Basin. G. Smith, ed. Berkeley: University of California Press. pp. 94-207.

Humberstone, J.A., 1999. Walker River basin water quality modeling. M.S. thesis. Reno, University of Nevada.

ICF International, 2010. Revised draft environmental impact statement Walker River Basin Acquisition Program. prepared for USDI-Bureau of Reclamation.

Inyo Mono Agriculture. 2010. 2010 Crop and Livestock Report. Bishop, CA: Counties of Inyo and Mono Agricultural Commissioner's Office.

Ivey, G.L., 2004. Conservation assessment and management plan for breeding Western and Clark's grebes in California. report prepared for American Trader Trustee Council and National Fish and Wildlife Foundation. Corvalis.

Jackson, L.A., 2010. The Sierra Nevada before History: Ancient Landscapes, Early Peoples. Missoula: Mountain Press Publishing Company, 210 pp.

JBR Environmental Consultants, Inc., 2009. Seep/spring and wetland survey: Paramount Project -- Bodie Hills, California. in Appendix E of U.S. Bureau of Land Management, 2009.

Jennings, M.R., 1996. Status of amphibians. in Sierra Nevada Ecosystem Project: Final report to Congress, vol. 2, chapter 31, pp. 921-944 . Davis: University of California, Centers for Water and Wildland Resources.

Jewell, P.L., D. Kauferle, S. Gusewill, N.R. Berry, M. Kreuzer, and P.J. Edwards, 2007. Redistribution of phosphorus by cattle on a traditional mountain pasture in the Alps. Agriculture, Ecosystems & Environment 122(3):377-386.

John, D.A., and others, 1981. Reconnaissance geologic map of the Topaz Lake 15-minute quadrangle, California-Nevada. Open File Report 81-273. Menlo Park: U.S. Geological Survey.

Johnston [L.K.] and Associates, 1992. Sweetwater Ranch: Draft Environmental Impact Report, SCH 92032035. prepared for County of Mono. Mammoth Lakes: L.K. Johnson and Associates.

Jones and Stokes Associates, 1993. Draft Mono Basin environmental impact report. Sacramento: Jones and Stokes Associates.

Jones, J. and T. Nguyen, 2010. California's drought of 2007-2009. Sacramento: California Department of Water Resources. 116 pp.

Kane, J., 2003. The limnology and restoration of Bridgeport Reservoir: Implications for restoring ecological processes in the Walker Lake Basin. M.S. Thesis, Dept. of Civil and Environmental Engineering. Berkeley: University of California.

Kattelmann, R., 1996. Hydrology and water resources. in Sierra Nevada Ecosystem Project: Final report to Congress, vol. 2, chapter 30, pp. 855-920. Davis: University of California, Centers for Water and Wildland Resources.

Kaushal, S.S., M.L. Pace, P.M. Groffman, L.E. Band, K.T. Belt, P.M. Mayer, and C. Welty, 2010. Land use and climate variability amplify contaminant pulses. Eos, Transactions, American Geophysical Union 91(25):221-222.

Key, J.W. and M.A. Gish, 1989. Clark Canyon (Mono County) riparian demonstration area. in: Abell, D. (ed.), Proceedings of the California Riparian Systems Conference. pp. 127-134, General Technical Report PSW-110, Berkeley: USDA-Forest Service.

Kleinfelder, Inc., 1992. Fault investigation: Proposed Sweetwater Ranch subdivision, Mono County, California. Appendix in Johnston and Associates, 1992. Reno: Kleinfelder, Inc.

Kleinfelder, Inc., 2003. Fault investigation report, Mono County APN 01-060-xx, Coleville, California. Reno: Kleinfelder, Inc.

Kleppe, J.A., 2005. A study of ancient trees rooted 36.5 m (120 feet) below the surface level of Fallen Leaf Lake, California. Journal of the Nevada Water Resources Association 2(1): 29-40.

Knapp, R.A., 1996. Non-native trout in natural lakes of the Sierra Nevada: An analysis of their distribution and impacts on native aquatic biota. in Sierra Nevada Ecosystem Project: Final report to Congress, vol. 3, pp. 363-407. Davis: University of California, Centers for Water and Wildland Resources.

Koenig, J.B., 1963. Geologic map of California: Walker River Sheet, 1:250,000. Sacramento: California Division of Mines and Geology.

Leavesley, G.H., R.W. Lichty, B.M. Troutman, and L.G. Saindon, 1983. Precipitation-Runoff Modeling System: User's Manual. Water Resources Investigations Report 83-4238. Denver: U.S. Geological Survey.

Lopes, T.J. and K.K. Allander, 2009. Water budgets of the Walker River basin and Walker Lake, California and Nevada. Scientific Investigations Report 2009-5157. Carson City: U.S. Geological Survey.

Lopes, T. J. and R.L. Medina, 2007. Precipitation zones of west-central Nevada. Journal of the Nevada Water Resources Association 4(2): 1-19.

Los Angeles Department of Water and Power, 1987. Mono Basin geology and hydrology. Los Angeles.

Lucich, K., 2004. scoping letter regarding Mill Creek habitat improvement project. Bridgeport: USDA-Forest Service.

Male, T., 2010. Business Plan: Sierra Nevada Meadow Restoration: Improving water flows, flood attenuation and wildlife habitat in California. Washington, DC: National Fish & Wildlife Foundation.

Mann, M.P., 2000. Use of geomorphic information in extending the flood record of the West Walker River, California. M.S. thesis. Reno: University of Nevada.

Maule, W.M., 1938. A contribution to the geographic and economic history of the Carson, Walker, and Mono basins in Nevada and California. San Francisco: U.S. Forest Service.

Maurer, D.K., D.L. Berger, M.L. Tumbusch, and M.J. Johnson, 2006. Rates of evapotranspiration, recharge from precipitation beneath selected areas of native vegetation and streamflow gain and loss in carson Valley, Douglas County, Nevada and Alpine County, California. U.S. Geological Survey Scientific Investigations Report 2005-5288.

McGurk, B.J. and D.R. Fong, 1995. Equivalent roaded area as a measure of cumulative effect of logging. Environmental Management 19(4): 609-621.

Mehalick, S. and J. Weaver, 2007. East Walker River summary report, Heritage and Wild Trout Program. Sacramento: California Department of Fish and Game. [cited by Sada, et al., 2010]

Menke, J.W., C. Davis, and P. Beesley, 1996. Rangeland assessment.in Sierra Nevada Ecosystem Project: Final report to Congress, vol. 3, chapter 22, pp. 901-972. Davis: University of California, Centers for Water and Wildland Resources.

Messick, T. 1982. The flora and phytogeography of the Bodie Hills of Mono County, California and Mineral County, Nevada. M.S. thesis. Arcata: Humboldt State University. accessed at http://www.timmessick.com/flora_of_the_bodie_hills.pdf

Milliron, C., P. Kiddoo, M. Lockhart, and R. Ziegler, 2004. Aquatic biodiversity management plan for lakes in the West Walker basin of the Sierra Nevada, Mono County, California, 2004-2014. Bishop: Department of Fish and Game, Eastern Sierra and Inland Deserts Region.

Minnich, R.A., 2007. Climate, paleoclimate, and paleovegetation. in: M.G. Barbour, T. Keeler-Wolf, and A.A. Schoenherr (eds.), Terrestrial Vegetation of California. Chapter 2. pp. 43-70. Berkeley: University of California Press.

Momsen, J., 1996. Agriculture in the Sierra. Sierra Nevada Ecosystem Project: Final report to Congress, vol. II, Ch. 17, Assessments and scientific basis for management options. Davis: University of California, Centers for Water and Wildland Resources, 1996.

Mono County, 1992. Master environmental assessment. Bridgeport.

Mono County, 2003. Master environmental assessment. Bridgeport.

Mono County Board of Supervisors, 2010. letter regarding Walker River Water Leasing Demonstration Program to Walker River Irrigation District. Bridgeport: July 6, 2010.

Mono County Community Development Department, 2000. Bodie Hills RV Park: Revised specific plan and final EIR. County of Mono, Mammoth Lakes.

Mono County Historical Society, 2006. Napoleon. in Mono County Historical Society 2006 Newsletter. Bridgeport.

Mono County Resource Conservation District, 1990. Long range program. Bridgeport.

Mono Resource Conservation District, 2000. The upper East Walker River, California, watershed action plan. Application submitted to the State Water Resources Control Board.

Moyle, P.B., J.A. Israel, and S.E. Purdy. 2008. Salmon, steelhead, and trout in California: Status of an emblematic fauna. Prepared for California Trout. Davis: University of California, Center for Watershed Studies. [accessed at http://watershed.ucdavis.edu/pdf/SOS-Californias-Native-Fish-Crisis-Final-Report.pdf]

Myers, T., 1994? Hydrology of the Walker River basin as related to inflows to Walker Lake. unpublished report to Public Resource Associates.

Nevada Division of Wildlife, 2000. Position statement: Lahontan cutthroat trout management in the Truckee, Carson, and Walker River systems of western Nevada. Carson City: Department of Conservation and Natural Resources, Division of Wildlife.

Nevada Division of Environmental Protection, 2009. Nevada's 303(d) impaired waters list. Carosn City. http://ndep.nv.gov/bwqp/file/303d_list09-att1.pdf

Nevada State Engineer's Office, n.d. Alternative plans for water resource use, Walker River Basin Area 1. Division of Water Resources, Carson City.

North Star Hydro Ltd., 1987. Application for license for a minor water power project. North Star Water Power Project, FERC project no. 8291, Little Walker River, California. Sacramento: North Star Hydro Ltd.

Ode, P., 2007. Standard operating procedures for collecting benthic macroinvertebrate samples and associated physical and chemical data for ambient bioassessments in California. Sacramento: State Water Resources Control Board, Surface Water Ambient Monitoring Program. [accessed at http://swamp.mpsl.mlml.calstate.edu/wp-content/uploads/2009/04/swamp_sop_bioassessment_collection_020107.pdf]

Pacific Consultants, 1993. Draft environmental setting and threshold recommendations for the Bodie Hills area plan. [cited by Mono County Community Development Department, 2000].

Pahl, R., 1999. Walker River Basin water rights, volume 1. An introduction to natural flow diversion rights defined in Decree C-125. Carson City: Nevada Division of Water Planning.

Pahl, R., 2000. Walker River basin surface water budget. Summary of basin surface water inflows and outflows (1926-95). Carson City: Nevada Division of Water Planning.

Paulus, J. 1998. Supplemental botanical survey for the proposed Bodie Hills RV park. [cited by Mono County Community Development Department, 2000].

Payne, T.R. and Associates, 1988. Supplemental electrofishing survey of Little Walker River, Mono County, California, North Star Hydroelectric Project, FERC No. 8291-003.

Pickard, A. 1998. Completed rotenone projects and restored beneficial uses. Memorandum to fisheries files. Bishop: California Department of Fish and Game.

Pisani, D.J., 1978. The strange death of the California-Nevada Compact: a study in interstate water negotiations. Pacific Historical Review 47(4):637-658.

Powell, D., and H. Klieforth, 2000. weather and climate. In: Sierra East: Edge of the Great Basin, Genny Smith, editor. California Natural History Guides 60. Berkeley: University of California Press. pp. 70-93.

Provencher, L., G. Low, and S.L. Abele, 2009. Bodie Hills conservation action planning: Final report to the Bureau of Land Management Bishop field office. Reno: The Nature Conservancy.

Public Resource Associates, 1994. Water resources in the Walker River basin: A search for water to save Walker Lake. Reno: Public Resource Associates.

Reade, N., 2010. Email interview with the Program Coordinator of the Eastern Sierra Weed Management Area on October 19, 2010. Bishop: Agricultural Commissioner's Office of Inyo and Mono Counties.

Reade, N., 2012. Email interview with the Program Coordinator of the Eastern Sierra Weed Management Area on February 15, 2012. Bishop: Agricultural Commissioner's Office of Inyo and Mono Counties.

Reiter, G.A., K. McCleneghan, P. McGovern, and J. Hardewick, 2001?. The East Walker River spill: Cleanup in a severe winter environment.

Resource Conservation District of Mono County, 2011. Minutes of meeting on Septermber 7, 2011. [accessed at monorcd.org]

Rockwell, G.L., and P.D. Honeywell, 2004. Water-quality data for selected stream sites in Bridgeport Valley, Mono County, California, April 2000 to June 2003. USGS Data Series 89. Reston, VA: U.S. Geological Survey. [accessed at http://pubs.usgs.gov/ds/ds89/CA-3049.pdf]

Rush, F.E., 1970. Hydrologic regimen of Walker Lake, Mineral County, Nevada. USGS Hydrologic Investigations Atlas HA-415. also published as Water Resources – Information Series Report 21. Carson City: Nevada Division of Water Resources.

Rush, F.E., 1974. Hydrologic regimen of Walker Lake, Mineral County, Nevada.

Rush, F.E., and V.R. Hill, 1972. Bathymetric reconnaissance of Topaz Lake, Nevada and California. Water Resources Information Series, Report 12. Carson City: U.S. Geological Survey.

Sada, D., 2000. Native fishes. in: Sierra East: Edge of the Great Basin. G. Smith, ed. Berkeley: University of California Press. pp. 246-264.

Sada, D., C. Rosamond, D. Henneberry, and J. Dillon, 2010. Relationships between aquatic environments and Walker River benthic macroinvertebrate communities, Nevada and California. in: Collopy, M.W. and J.M. Thomas (eds.). Restoration of a desert lake in a agriculturally dominated watershed: The Walker Lake Basin. Reno: University of Nevada and Desert Research Institute. pp. 271-310.

Seiler, R.L., M.S. Lico, S.N. Wiemeyer, and D.C. Evers, 2004. Mercury in the Walker River basin, Nevada and California--Sources, distribution, and potential effects on the ecosystem. Scientific Investigations Report 2004-5147. Carson City: U.S. Geological Survey.

Sharpe, S., 2010. Past elevations and ecosystems of Walker Lake provide a context for future management decisions. in: Collopy, M.W. and J.M. Thomas (eds.). Restoration of a desert lake in a agriculturally dominated watershed: The Walker Lake Basin. Reno: University of Nevada and Desert Research Institute. pp. 23-46.

Sharpe, S., M.E. Cablk, and J.M. Thomas, 2008. The Walker Basin, Nevada and California: Physical environment, hydrology, and biology. Desert Research Institute Technical Report #41231, Rev. 01. Reno: Desert Research Institute. 63 pp.

Shumway, M., 1985. A summary of water diversions in the East and West Walker River drainages. California Department of Fish and Game, Inland Fisheries.

Silver, L.H., 2007. Legal analysis of water rights and transfers in the Walker River Basin, Nevada - California. Appendix E in Yardas, 2007

Singer, H.J., 2000. Letter to Scott Burns regarding Bodie Hills RV Park specific plan and final environmental impact report, Mono County (SCH#97012031). South Lake Tahoe: California Regional Water Quality Control Board Lahontan Region.

Smith, 2003. [History of Mono County].

Sollberger, P. and M. Sevon, 1997. Draft: Topaz Lake Proposal for release of smallmouth bass (Micropterus dolomieui). Reno: Nevada Division of Wildlife, Department of Conservation and Natural Resources.

Stanford Law School Environmental Law Clinic, 2005. Status review and petition to list the Mono Basin area sage grouse (*Centrocercus urophasianus*) as a distinct population segment of greater sage-grouse as threatened or endangered under the Endangered Species Act. Palo Alto: Stanford University.

Stine, S., 1994. Extreme and persistent drought in California and Patagonia during mediaeval time. Nature 369:546-549.

Stockwell, C., 1994. The biology of Walker Lake. Reno: University of Nevada Reno, Biological Resources Research Center. [cited by Sharpe, et al., 2008]

Tate, K.W., and L.K. Vance, 2001. Habitat features and aquatic health: Evaluating California's stream bioassessment procedure in natural and artificial streams in grazed eastern Sierra valley. California Water Resources Center 2000-2001 Annual Report, pp. 40-41. Davis: Water Resources Center.

Tate, K.W., L.K. Vance, and C. Battaglia, 2001. Habitat features and aquatic health: Evaluating California's stream bioassessment procedure in natural and artificial streams in a grazed eastern Sierra valley. Technical Completion Report California Water Resources Center Project W-925. Davis: Water Resources Center.

Taylor, T.J., 1992. Sweetwater Ranch deer migration study. Appendix in Johnston and Associates, 1992.

Theobald, D.M., D.M. Merritt, and J.B. Norman III, 2010. Assessment of threats to riparian ecosystems in the western U.S. Prepared for the Western Environmental Threats Assessment Center, Pineville, OR. 56 pp.

Thomas, J.M., 1995. Water budget and salinity of Walker Lake, western Nevada. Fact Sheet FS-115-95. Carson City: U.S. Geological Survey.

Thomas, R., 1984. The West Walker deer herd management plan. Bishop: California Department of Fish and Game.

Timmer, K., M. Suarez-Brand, J. Cohen, and J. Clayburgh, 2006. State of Sierra Waters: A Sierra Nevada Watersheds Index. South Lake Tahoe: Sierra Nevada Alliance. 170 pp.

U.S. Bureau of Reclamation, 1964. Walker River Project, Nevada-California.

USDA Nevada River Basin Survey Staff, 1969/1975. Water and related land resources - central Lahontan basin-Walker River subbasin - Nevada ... California. U.S. Dept of Agriculture.

USDA-Forest Service, 1947. Ranger district management plan, Bridgeport Ranger District, Toiyabe National Forest. [cited by Menke, et al., 1996].

USDA-Forest Service, 1985. Land and resource management plan. Sparks: Toiyabe National Forest.

USDA-Forest Service, 1988. Environmental Assessment, Lahontan Cutthroat Trout Restoration Project, Mill Creek, Mono County, California. Sparks: Toiyabe National Forest.

USDA-Forest Service, 1989. Environmental Assessment, Lahontan cutthroat trout restoration project, Silver Creek and Wolf Creek, Mono County. Sparks: Toiyabe National Forest.

USDA-Forest Service, 1994. Decision Notice- Finding of no significant impact- Piute/Lost Cannon cattle allotments. Bridgeport: Toiyabe National Forest.

USDA-Forest Service, 1997. Letter to Department of Fish and Game, Bishop, update for threatened trout meeting. Bridgeport: Toiyabe National Forest.

USDA-Forest Service, 2000. Upper Walker River watershed assessment/restoration proposal. Bridgeport: Humboldt-Toiyabe National Forest.

USDA-Forest Service, 2004. Upper East Walker landscape strategy. Bridgeport: Humboldt-Toiyabe National Forest.

USDA-Forest Service, 2006. Bodie Creek, Mineral County, Nevada: 2006 stream habitat survey report. Bridgeport: Humboldt-Toiyabe National Forest.

USDA-Forest Service, 2009. Draft environmental impact statement: Bridgeport travel management project. Bridgeport: Humboldt-Toiyabe National Forest.

USDA-Forest Service, 2010. Final environmental impact statement: Bridgeport travel management project. Bridgeport: Humboldt-Toiyabe National Forest.

USDA-Forest Service, 2010b. Annual operating instructions letter for Robinson Creek allotment. June 8, 2010. Bridgeport: Humboldt-Toiyabe National Forest.

USDA-Forest Service, 2010c. Sierra Nevada Red Fox fact sheet. prepared by the Sierra Nevada Red Fox Interagency Working Group. accessed April 2011 at http://www.fs.fed.us/r5/news/2010/snrf-factsheet.pdf

USDA-Forest Service, 2011. Humboldt-Toiyabe National Forest climate change vulnerability report. Bridgeport: Humboldt-Toiyabe National Forest. [accessed at http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5294901.pdf]

USDA-Forest Service, 2011b. Twin Lakes fuels reduction project: Notice of proposed action / scoping information. Bridgeport: Humboldt-Toiyabe National Forest. [accessed at http://a123.g.akamai.net/7/123/11558/abc123/forestservic.download.akamai.com/11558/www/nepa/72379_FSPLT2_048757.pdf -- unfortunately containing a photograph of Twin Lakes in the Mammoth Lakes basin as figure 1]

USDA Nevada River Basin Study Staff, 1975. USDA report on water and related land resources: Central Lahontan Basin. Carson City: USDA.

USDA-Soil Conservation Service, 1989. Final watershed plan and environmental impact statement: East Walker watershed, Lyon County, Nevada. Reno: USDA-SCS.

USDI-Bureau of Land Management, 1980s. Watershed condition reports, BLM form 6671-5.Bishop Field Office. Dates unknown, but after 1979.

USDI-Bureau of Land Management, 1982. Draft environmental impact statement, proposed livestock grazing management, Bodie-Coleville unit. Carson City.

USDI-Bureau of Land Management, 1990. Bodie Wilderness Study Area (WSA) (CA-010-100).

USDI-Bureau of Land Management, 1993. Bishop Resource Management Plan and Record of Decision. Bishop Field Office.

USDI-Bureau of Land Management, 1995. Travertine Hot Springs ACEC Final Plan and environmental assessment. Bishop Field Office. [accessed at http://www.travertinehotsprings.info/Travertine%20Hot%20Springs%20ACEC%20Plan_small.pdf]

USDI-Bureau of Land Management, [2002?]. draft Walker River Basin EIS, BLM Carson City Field Office.

USDI-Bureau of Land Management, 2009. Cougar Gold Paramount exploration proposal environmental assessment. Bishop Field Office. [accessed at http://www.blm.gov/ca/st/en/fo/bishop/cougar_gold.html]

USDI-Bureau of Land Management, 2010. Environmental assessment for Kirkwood Meadow irrigation ditch maintenance. Bishop Field Office. [accessed at http://www.blm.gov/pgdata/etc/medialib/blm/ca/pdf/bishop/eadocs/fy10.Par.90801.File.dat/doi-blm-cac-070-2010-12-ea.pdf]

USDI-Bureau of Land Management, 2011. Environmental assessment: Livestock grazing authorization Dog Creek [and] Green Creek. Bishop Field Office. [accessed at http://www.blm.gov/pgdata/etc/medialib/blm/ca/pdf/bishop/eadocs/fy11.Par.53026.File.tmp/ea_ca170_09_0002_3_7_11.pdf]

USDI-Bureau of Land Management, 2011b. Bodie Hills upland vegetation restoration project: Proposed action. Bishop Field Office.

USDI-Bureau of Reclamation, 2010. Environmental assessment for the Walker River Basin cloud seeding project. Carson City: Lahontan Basin Area Office, Bureau of Reclamation.

USDI-Bureau of Reclamation, 2011. Desert terminal lakes program [accessed at http://www.usbr.gov/mp/lbao/desert_terminal/desert.html]

U.S. Environmental Protection Agency, 1988. Guidance for the reregistration of pesticide products containing rotenone and associated resins as the active ingredient. OPP Chemical No. 071003, 071004, and 071001, case no. 1255, CAS (Docket) number: 83-79-4, October 1988. Washington, D.C.: Office of Pesticide Programs, Environmental Protection Agency.

U.S. Fish and Wildlife Service, 2007. Recovery plan for the Sierra Nevada bighorn sheep. Sacramento.

U.S. Fish and Wildlife Service, 2010. News release: Fish and Wildlife Service will add bi-state population of greater sage-grouse to list of candidates for Endangered Species Act protection. March 5, 2010. Washington, D.C. http://www.fws.gov/news/NewsReleases/showNews.cfm?newsId=2F9AA4D1-FD83-F411-2FCF93F1E1A780A1

U.S. Geological Survey, 2010. Water-Data Report for 10292500 Bridgeport Reservoir Near Bridgeport, CA. http://wdr.water.usgs.gov/wy2010/pdfs/10292500.2010.pdf

Umek, J. and S. Chandra, 2010. Fishes of Walker River: Present composition and basic ecology. in: Collopy, M.W. and J.M. Thomas (eds.). Restoration of a desert lake in a agriculturally dominated watershed: The Walker Lake Basin. Reno: University of Nevada and Desert Research Institute. pp. 329-331.

Vance, L. 2000. http://www.waterboards.ca.gov/water_issues/programs/tmdl/records/region_6/2006/ref182.pdf

Walker River Basin Recovery Implementation Team, 2003. Short-term action plan for Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) in the Walker River Basin. Reno: U.S. Fish and Wildlife Service.

Walker River Irrigation District, 1998. Bridgeport Reservoir water quality compliance assessment. Yerington: Walker River Irrigation District. [cited by Singer, 2000]

Wiemeyer, S.N., 2002. Mercury in biota and sediment in the Walker River basin, Nevada and California. Reno: U.S. Fish and Wildlife Service.

Wong, D., 1993. CT-L Introduction to Wolf Creek, Mono County. Memorandum to fisheries files. Bishop: California Department of Fish and Game.

Wong, D., 2000. Silver Creek, Mono County, Sept. 13 1999 Survey. Memorandum to fisheries files from Darrell Wong. Bishop: California Department of Fish and Game.

Yardas, D., 2007. Great Basin Land and Water Study: Issue and opportunities for acquiring water from willing sellers to increase Walker Lake inflows. prepared for USDA-Natural Resources Conservation Service, Reno.

Yuan, F., B.K. Linsley, S.P. Lund, and J.P. McGeehin, 2004. A 1200 year record of hydrologic variability in the Sierra Nevada from sediments in Walker Lake, Nevada. Geochemistry, Geophysics, Geosystems 5(3) [electronic journal of American Geophysical Union]

Yuan, F., B.K. Linsley, S.S. Howe, S.P. Lund, and J.P. McGeehin, 2006. Late Holocene lake-level fluctuations in Walker Lake, Nevada, USA. Palaeogeography, Palaeoclimatology, Palaeoecology 240: 497-507.

Legal Advisory Letters and Opinions

DePaoli, G.H. and D. E. Ferguson, 2010. letter regarding Walker River Irrigation District lease of water program / demonstration phase to Mono County Board of Supervisors. Reno: July 6, 2010.

Mineral County v. State, Department of Conservation, 2001. 117 Nev. Adv. Op. No. 23 in the Supreme Court of the State of Nevada, no. 36352. April 11, 2001.

News Articles

Adams, K., 1997. Funds assist flood victims. Mammoth Times, January 30, 1997.

California Trout, 1994. East Walker acquisition complete. Streamkeepers Log, California Trout newsletter, November 1994, p. 9.

California Trout, 1996. Eastern Sierra: East Walker victory. Streamkeepers Log, California Trout newsletter, summer 1996, p. 8.

Calnan, S., 1999. Bodie Park land deal OK'd in BLM buyout. Review-Herald, January 7, 1999.

Clifford, F., 1994. Study reveals 100-year droughts here. Los Angeles Times, June, 1994.

Du Fresne, K., 1994. East Walker River land deal funded. Review-Herald, July 17, 1994.

Du Fresne, K., 1996a. Green Creek land swap between TPL and BLM is final. Review-Herald, January 14, 1996.

Du Fresne, K., 1996b. Missing pin cause of fuel spill. Review-Herald, July 25, 1996.

Geisel, 2010. Born to be idle? The Sheet News, November 6, 2010, page 6.

Grasseschi, W., 2011. What happens next with the Bodie Hills? Mammoth Times, August 12, 2011.

Gregory, G., 2011. Re-watering Walker Lake. High Country News 43(13):7, 21. August 8, 2011.

Inyo Register, 2011. Agencies seize $67 million in marijuana plants. Inyo Register, August 27, 2011:A-3.

KMMT, 1997. local news broadcast, KMMT radio, January 18, 1997.

Lee, C., 2008. California's water quality: Farmers take active role in protecting environment. Ag Alert, June 25, 2008. California Farm Bureau Federation. accessed at http://www.agalert.com/story/?id=1076.

Lewis, M., 1994. River goes public: State aims to restore East Walker's glory. Modesto Bee, October 8, 1994: B1-2.

Mammoth Times, 1992. West fork of the Walker River beyond limits? Mammoth Times, March 26, 1992, pg. 26.

Mammoth Times, 1998. County allocates $3.75 million for flood mitigation project. Mammoth Times, April 16, 1998.

Mammoth Times, 2005. Highway accidents. Mammoth Times, August 31, 2005.

Montiel, J. 1993. East Walker flush to occur this week. Mammoth Review-Herald, October 17, 1993.

Padgett, D., 2001. East Walker oil spill. Streamkeeper's Log, California Trout.

Reed, C., 2005a. Warm temperatures bring flood warnings. Mammoth Times, May 26, 2005.

Reed, C., 2005b. Mono County citizens and officials look into DFG fishing policies. Mammoth Times, June 23, 2005: 3.

Review-Herald, 1996. Fire burns 1,000+ acres near Bridgeport.Review-Herald, August 22, 1996.

Review-Herald, 1997. Clearing of Walker River under way. Review-Herald, January 16, 1997.

Scheck, J., 2011. Gold fever stirs ghost town. Wall Street Journal. August 18, 2011.