Mono County
Community Development Department
Planning Division

P.O. Box 347
Mammoth Lakes, CA 93546
(760) 924-1800, fax 924-1801
commdev@mono.ca.gov

P.O. Box 8
Bridgeport, CA 93517
(760) 932-5420, fax 932-5431
www.monocounty.ca.gov

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WEST WALKER RIVER BASIN WATERSHED ASSESSMENT

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1. Introduction

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 in a comprehensive manner.

This report describes how the 410-square mile watershed of the West Walker River above Topaz Reservoir influences the quantity and quality of water that eventually flows into the West Walker River. The West Walker River watershed is designated #631 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 involvement

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 by submitting two proposals to develop watershed assessments and plans. Both proposals were successful, and scopes of work were developed and eventually approved in 2004. Work began on these projects in January 2005.

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." This manual lists the usual components of a watershed assessment as:

- a question or set of questions about watershed condition that puts boundaries on the assessment;
- a collection of relevant information about human and natural processes at the watershed scale;
- the identification of gaps in knowledge;

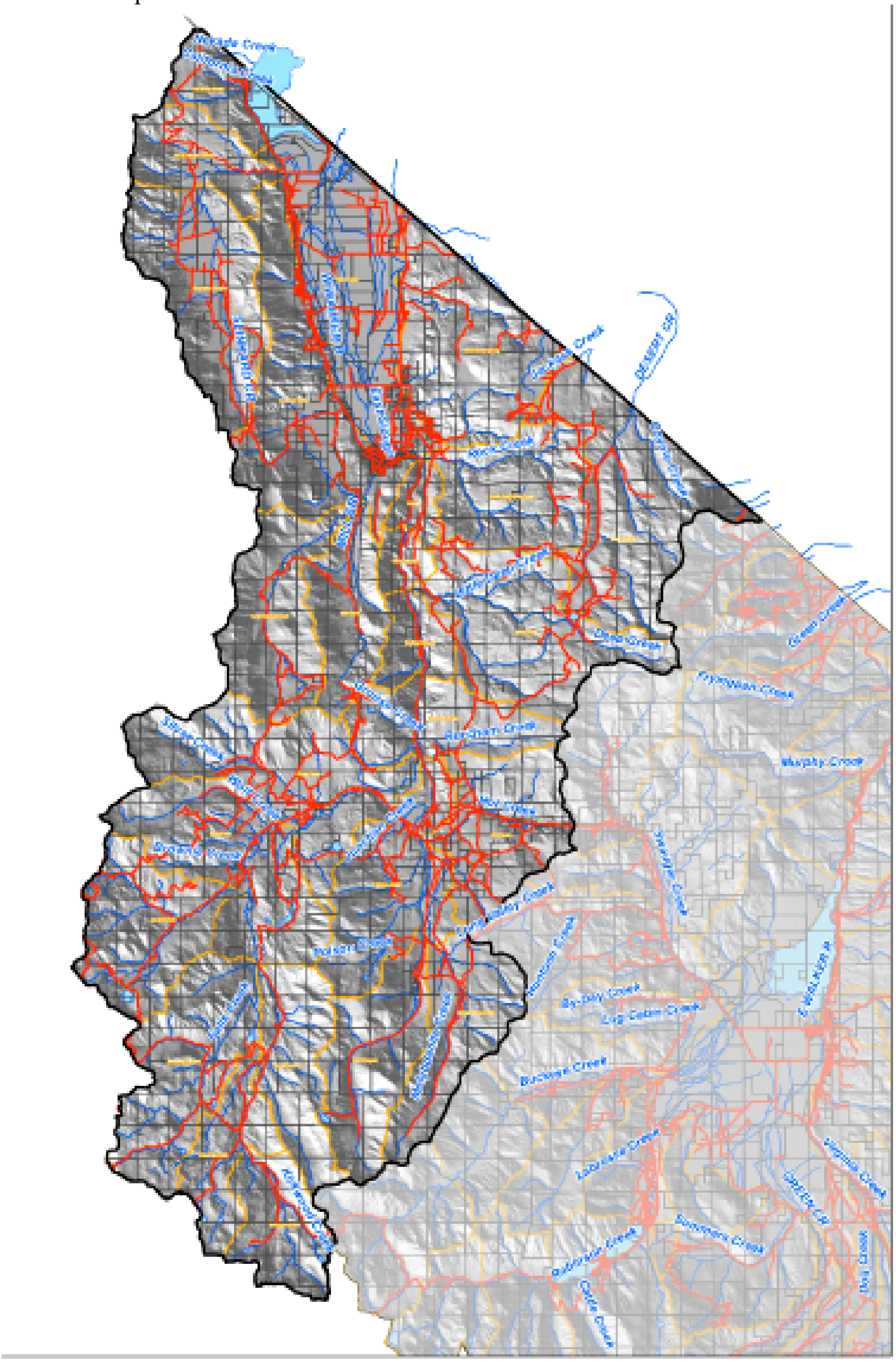
- the combination of information about various processes to reflect the integrated nature of watersheds;
- analysis and synthesis of the information regarding the watershed's condition drawn from data collections, often at various geographic scales;
- a description of how the analysis can assist with decision making in the watershed;
- a design for the collection of future monitoring data; and
- a strategy to evaluate future data and communicate that information via a status-and-trends analysis.

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.

General problems and issues in the West Walker River Basin

The West Walker River contributes more than half of the streamflow in the entire Walker River system that drains to Walker Lake in Nevada. 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. 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 West Walker River was designated as a Category One watershed in the California Unified Watershed Assessment. The Lahontan RWQCB water body fact sheet for the West Walker River lists sedimentation, agricultural drainage, and water diversions as the primary water-quality problems in the West Walker River. The State of Nevada considers the water crossing the state line to not support beneficial uses because of excessive nutrient load. Toxic metals suspected to be leaching from old mine tailings have been found in several tributaries to the West Walker River. Concerns have been expressed by the Lahontan RWQCB about possible groundwater contamination in and near the U.S. Marine Corps facility at Pickel Meadow. Excessive sediment levels have also been noted in tributaries within the basin. Stream channels are continuing to adjust to changes that occurred during a high-magnitude flood in January 1997.

Figure 1. Overview map of West Walker River watershed.



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/). Concentration of salts has increased five-fold over this period (Thomas, 1995). The native Lahontan cutthroat trout and other species in the lake have barely survived this increase in salinity. 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. Some of the snowmelt runoff of 2006 presumably reached Walker Lake. Consumptive use of the West 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). 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 is lacking. 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).

There are not any significant water supply problems within the California portion of the West Walker River watershed. Occasional large-magnitude flooding of the West Walker River is a substantial hazard to homes, agricultural fields, and roadways that are within the floodplain.

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. This funding may have been allocated as part of the 2006 Energy and Appropriations bill.

Water quality

The water body fact sheet for the West Walker River issued by the Lahontan Water Quality Control Board in the mid-1990s listed sedimentation, agricultural drainage, and water diversions as the primary water-quality problems in the watershed. The State of Nevada considers the water crossing the state line to not support beneficial uses because of excessive nutrient load. A Nevada report also mentioned that toxic metals are suspected to be leaching from old mine tailings into the West Walker River. However, such reports may be confused with the East Walker River and Rough Creek in particular. We have been unable to locate any such sources in our study area. Absence of sanitation facilities in areas of high use has created sanitation problems at Little Walker, Leavitt Lake, State Route 108 corridor, Marine ski lift, Marine Leavitt Training Area near Leavitt Lake campground, and Grouse Meadows (USDA-Forest Service, 2004).

Habitat

Riparian habitat quality has declined with the replacement of hardwood species such as aspen, cottonwood, willow, dogwood, and alder with dense conifer stands. Riparian meadow ecosystems have been negatively impacted by conifer invasion, livestock grazing, trails and roads, and motor vehicle use (USDA-Forest Service, 2004).

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. Possibilities to protect and enhance their habitat exist at the current Summit Meadow, Kirkwood Lake, and Koenig Lake 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.

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 West 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 in a few designated aquatic refuges.

Wildfire

As elsewhere in the West, the exclusion of natural wildfire has altered fire regimes throughout the watershed. This change has resulted in denser timber stands, higher fuel loadings, 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. Development at the urban/wildland interface have increased the risk and consequences of wildfire (USDA-Forest Service, 2004).

There have been several major fires in the past decade.

Invasive species

Invasive weeds on National Forest System lands and adjacent federal, state, and private lands can alter natural ecosystems. Native plant communities can be replaced and associated dependent species and uses negatively affected (USDA-Forest Service, 2004). 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 West Walker River watershed to contribute additional water to Walker Lake?

Can sediment delivery to tributaries and the West Walker River be substantially reduced?

Watershed description and boundaries

The West Walker River is the larger of the two forks of the Walker River and provides most of the water for Walker Lake, the terminus of the Walker River. The West Walker River joins the East Walker River about seven river miles upstream from Yerington at the south end of Mason Valley.

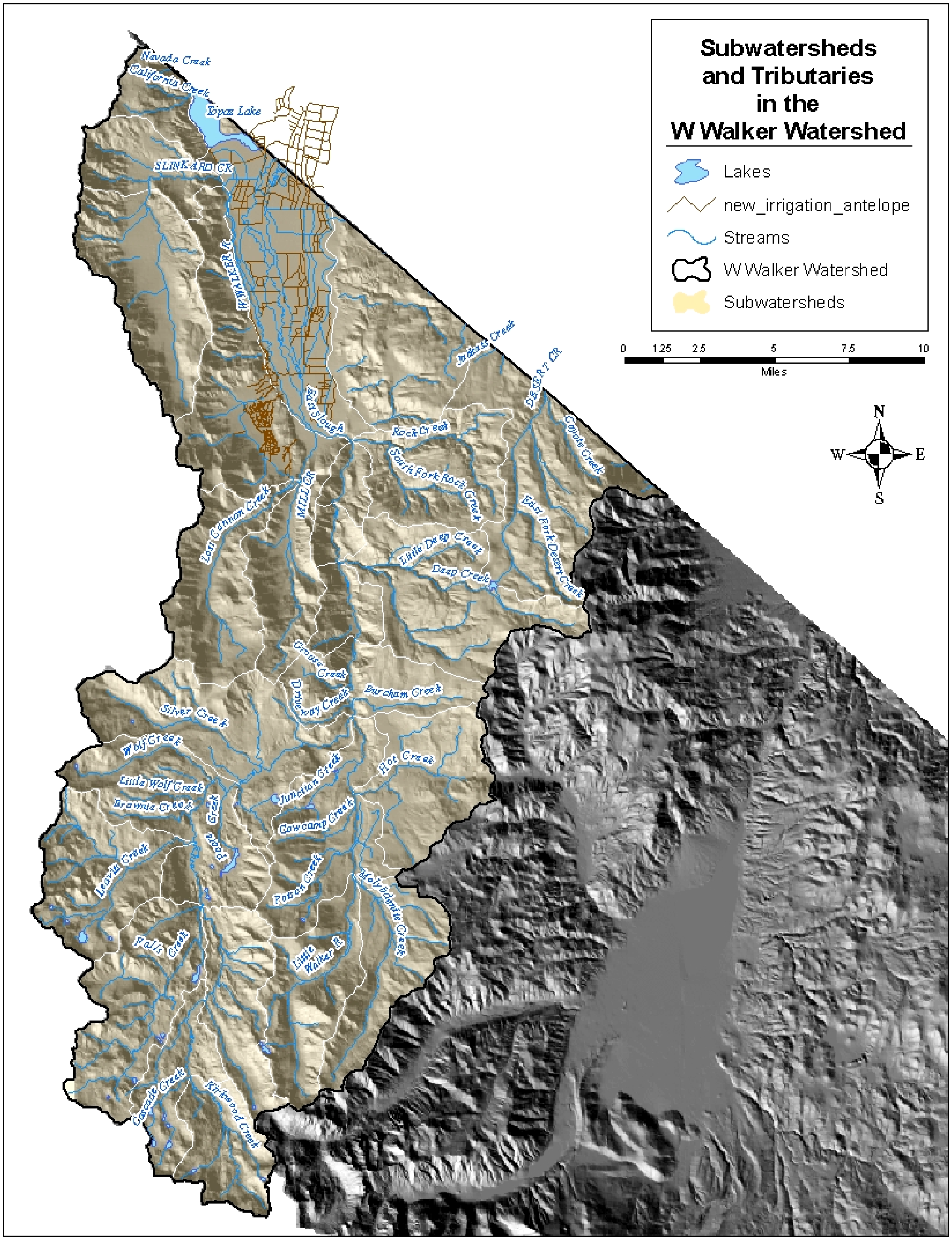
The headwaters of the West Walker River are on the north slopes of the mountains forming the northern boundary of Yosemite National Park. The highest point is Tower Peak (11,755 ft), a long-recognized landmark from the Sonora and Walker Immigrant Route that was originally called Castle Peak.

Beyond the headwater region, the West Walker River travels due north, dropping more than 4,000 feet over 14 miles by the time it enters the southern end of Leavitt Meadow.
Within Leavitt Meadow, the West Walker River adds Leavitt Creek, which drains Leavitt Lake (9,556 feet) and other smaller lakes -- Ski Lake, Koenig Lake, and Latopie Lake -- as well as Sardine Creek. At the north (downstream) side of Leavitt Meadow, the West Walker River picks up Brownie Creek and then turns generally east by northeast and enters Pickel Meadow. Within Pickel Meadow, several small tributaries, including Poore Creek from the south, which drains Poore Lake (7,214 feet), and Little Wolf, Cloudburst, Wolf, and Silver creeks enter the West Walker from the north (California Department of Water Resources, 1992).

Downstream of Pickel Meadow, the West Walker River travels generally east toward U.S. Highway 395 where the Little Walker River joins. After this Sonora Junction confluence, the West Walker River turns due north and flows for ten miles through Walker Canyon before entering the south end of Antelope Valley. Between Sonora Junction and Antelope Valley, Burcham Creek, Driveway Creek, Grouse Creek, and Deep Creek join the West Walker River. Near the southern end of Antelope Valley, Mill Creek (with its major tributary of Lost Cannon Creek) and Rock Creek join the West Walker River.

After flowing through Antelope Valley, the West Walker River adds the remaining waters of Slinkard Creek that have not been diverted for irrigation. The Slinkard Valley runs roughly parallel to and west of Antelope Valley before Slinkard Creek turns east and meet the West Walker. Just downstream of this confluence, most of the water of the West Walker River is diverted into Topaz Reservoir, which serves as the downstream end of the watershed for this study.

Figure 2. Tributary streams of the West Walker River.



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 which 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.

Annual precipitation in the headwater areas of the West Walker River has been estimated to average at least 40 inches and less than 8 inches in Walker Canyon (Mann, 2000).

The average annual precipitation within Antelope Valley has been estimated to range from 8 to 12 inches, with higher amounts in the southern part of the valley (California Department of Water Resources, 1992). The Mono Resource Conservation District (1990) estimated average precipitation in Antelope Valley as 11 inches. Average annual precipitation at Topaz Lake was estimated as 11 inches by Glancy (1971), based on measurements from 1958 to 1968. The average of recorded precipitation at the Topaz Lake gage between 1957 and 2005 was 9.3 inches (Western Regional Climate Center at http://www.wrcc.dri.edu). 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.

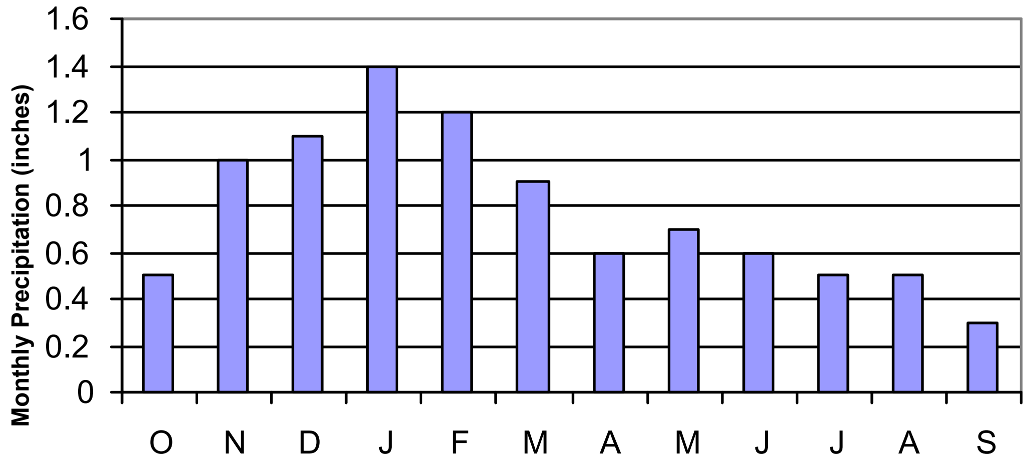


Figure 3. Average monthly precipitation (inches) at Topaz Lake.
Source: Western Regional Climate Center at http://www.wrcc.dri.edu

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. Although Antelope Valley often receives rain during these storms, precipitation in most of the basin falls in the form of snow. Warm winter storms occasionally affect the basin and deposit several inches of rain over most of the basin. The largest such storms on record resulted in flooding of the West Walker River.

Large winter rainfall events
Dec 1937
Nov 1950
Nov 1955
Dec 1963
Jan 1997

Snowpack

The hydrology of West 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. Several snowpack measurement stations have been maintained high in the West Walker River watershed by the California Department of Water Resources and the USDA-Natural Resources Conservation Service:

Courses or sensors	Elevation	period of record	April 1 average
Leavitt Lake	9600	81-07	50.8
Lobdell Lake	9200	64-07	16.9
Summit Meadow	9122	04-07	23.5
Sonora Pass	8750	47-07	24.9
Willow Flat	8260	25-07	9.9
Leavitt Meadows	7200	81-07	7.0

Air temperature

Antelope Valley has a mean temperature in January of 30°F and a mean temperature in July of 69°F (Mono Resource Conservation District, 1990).

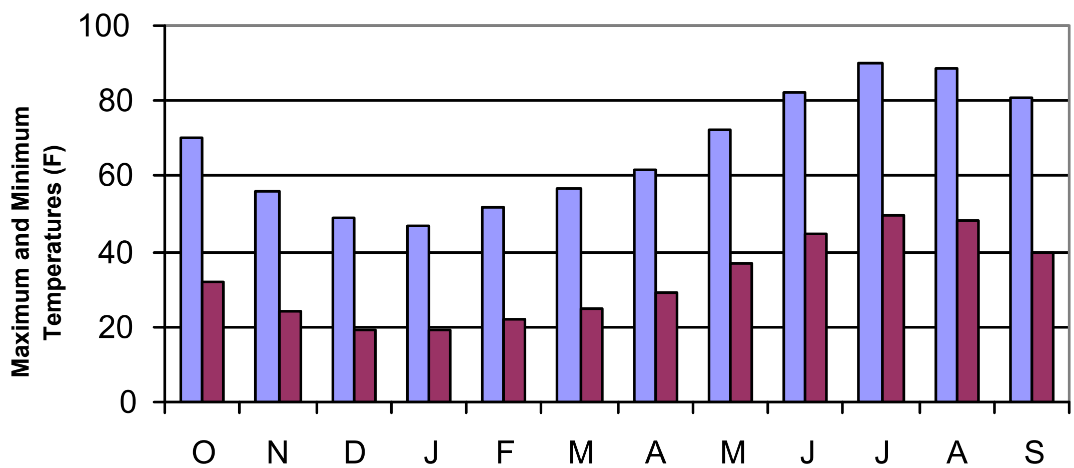


Figure 4. Average monthly maximum and minimum temperatures (°F) at Topaz Lake, representing the low end of the watershed.
Source: Western Regional Climate Center at http://www.wrcc.dri.edu

The frost-free growing season lasts about 105 days in Antelope Valley (Mono Resource Conservation District, 1990) and about 100 days in Little Antelope Valley at 5,500 feet (Thomas, 1984).

Wind

Wind has been measured for a few years at a couple of the NRCS SNOTEL sites. However, there is not enough information to characterize wind patterns for the watershed.

Evaporation

Evaporation has been measured with an evaporation pan (e.g., Dunne and Leopold, 1987:100-103) at Topaz Lake from 1957 through 2002. The average annual total is about 69 inches. Evaporation is zero when the pan is frozen from December through March. However, evaporation continues from the surface of Topaz Lake during these months.

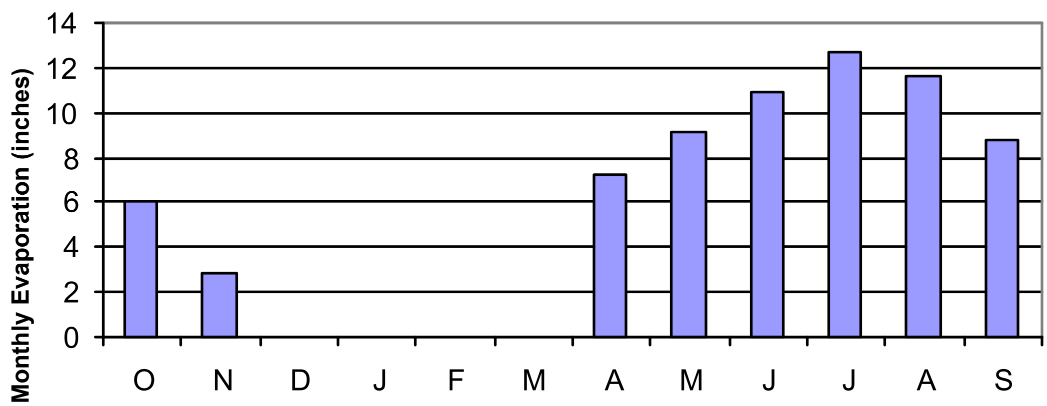


Figure 5. Average monthly pan evaporation at Topaz Lake.
Source: Western Regional Climate Center at http://www.wrcc.dri.edu

Evapotranspiration in the Antelope Valley area was estimated as 33,000 AF from agriculture and 3,600 AF from phreatophytes (Glancy, 1971).

Climate Change

Evidence of severe and persistent drought has been found in the West Walker River channel, indicating periods of 140 to 220 years with very little precipitation (Stine, 1994). Dozens of Jeffrey pine stumps are rooted in the main channel of the Walker River Canyon. 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). 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 Walker River basin. Other dry periods occurred in 1924-25, 1960-61, 1976-77, and 1988-92.

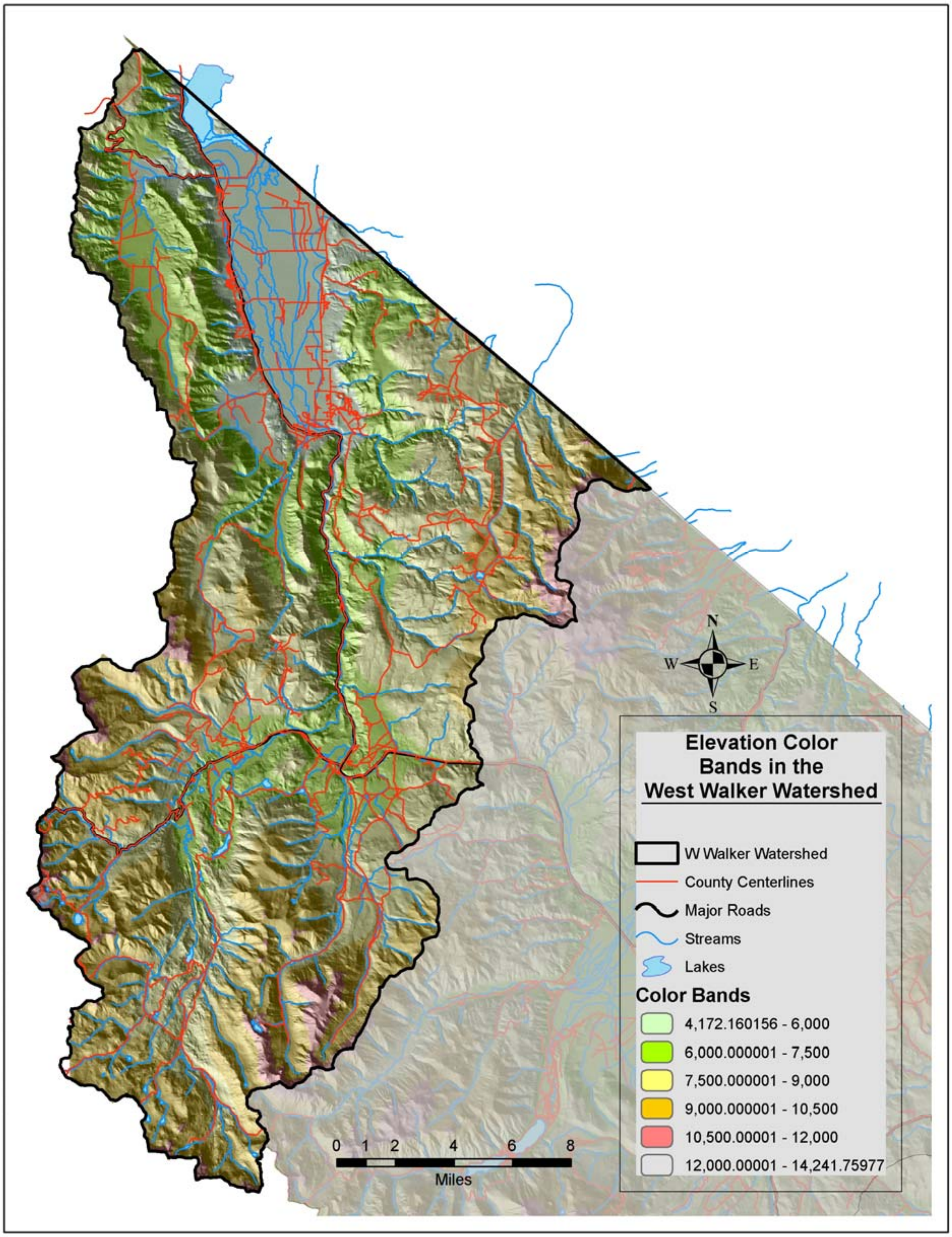
As global temperatures continue to rise as a result of anthropogenic increases in atmospheric carbon dioxide, changes in the climate of the Sierra Nevada can be expected. A wide variety of reports has been issued in the past decade suggesting that regional temperatures will rise, precipitation will decline, 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 just aren't 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. Water managers relying on the West 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 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 10,000 to 11,000 feet. Streams dissect this terrain and initially flow to the northeast or east before joining the main channels.

Antelope Valley, Little Antelope Valley, and Slinkard Valley are the principal semi-flat areas that are suitable for agriculture in the West Walker River basin. These valleys occupy the transition between the Sierra Nevada on the west and the Great Basin to the east. Antelope Valley lies between 5,000 feet at Topaz Lake and 5,800 feet near Walker and covers about 20,100 acres within California (California Department of Water Resources, 1992). At the north end of Antelope Valley, Topaz Reservoir occupies a topographic low point, which formerly contained a small natural lake known as Alkali Lake (California Department of Water Resources, 1992). The altitude of the bottom of the lake at the California-Nevada border is approximately 4,913 feet. The lowest water level practical for diversion is 4,972 feet, the average water level of Topaz Reservoir from 1922 to 1971 was 4,989 feet, and the maximum stage before water leaks around the low dam is about 5,005 feet (Rush and Hill, 1972).

Figure 6. The highest elevation parts of the West Walker River watershed are found in the south, and the lowest elevation parts are found in the north in the Antelope Valley.



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. Talus slopes (piles of rock debris) are also found in much of the watershed (USDA-Forest Service, 2004).

The glaciers of the West Walker River were the largest Pleistocene-age glaciers in the eastern Sierra Nevada (Clark, 1967, cited by Mann, 2000). The most recent glacial advance, called the Tioga, which ended about 10,000 years ago, resulted in a glacier extending from the Sonora Pass area to Sonora Junction (Clark, 1967, cited by Mann, 2000). The terminus of this glacier was about 20 miles from and 3,000 feet below its source area. Leavitt Meadow shows much evidence of glacial activity. The Tioga glaciation produced most of the terminal moraines in Walker Canyon, which is otherwise composed of volcanic rocks (California Department of Water Resources, 1992).

Within the central and eastern part of the West Walker River watershed, the basin and range topography is characterized by north-south trending fault block ranges with exposures of volcanic, metavolcanic, and intrusive (especially quartz monozonite) rocks, separated by narrow valleys. Faulting has dropped the Antelope Valley relative to the surrounding hills, which contribute sediment to the valley (California Department of Water Resources, 1992).

The West Walker River basin contains complex patterns of faults created during the tilting of the Sierra Nevada. Many of the valleys, including the West Walker River Canyon, have been created along these faults (USDA-Forest Service, 2004).

The primary geologic reference maps for the area are those produced by the U.S. Geological Survey (John, et al., 1981, and Dohrenwend, 1982).

Mineral potential has been identified for gold, silver, uranium and molybdenum within the Patterson and West Walker mining districts, where there has been some exploration but no large-scale mining operations. Only nine claims are known to have had any activity. Shafts and adits were dug in Leavitt Meadow and along Molybdenite Creek. The northern part of the West Walker Mining District has been prospected for gold, silver, copper, platinum, zinc, uranium, molybdenite, cadmium, iron ores, barite, marble and building stone. Four mines exist with activity recorded on eight other claims in this area (USDA-Forest Service, 2004).

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 (Thomas, 1984). 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 (Thomas, 1984).

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).

Except for the relatively flat terrain of Antelope Valley, soils within the West 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).

The alluvial fans on the west side of Antelope Valley are generally less than 11,000 years old, and are composed of poorly sorted boulders, cobbles, gravel, and sand. The deposits have little sign of weathering, and soil development tends to be weak on these young surfaces (Kleinfelder, 2003). Trenches for a fault study provided the following description of layers in the upper five feet:
Surface – light brown gravelly silty sand, moist organic layer at surface, many fine and large roots, fine to coarse gravel, loose, occasional lenses of fine to coarse sand, granitic and quartz clasts, occasional charcoal pieces.
Middle – brown silty gravelly sand, moist, medium dense, fine to medium roots, fine gravel 20-30 percent, occasional coarse gravel, granitic and quartz clasts.
Lower – yellow brown silty gravelly sand, moist, slightly more dense than above, diminishing roots, slightly less gravel, occasional coarse gravel, granitic and quartz clasts (Kleinfelder, 2003).

The soil survey portion of the Natural Resources Conservation Service website suggests that detailed soils mapping has not been completed for the West Walker River watershed. However, some preliminary information has been made available to residents in Walker.

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, such as around Leavitt Lake.

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 West Walker River watershed. Dense stands of white fir and Jeffrey pine have taken over the former open stands of large Jeffrey pine that were maintained by relatively frequent low-intensity fires (Lucich, 2004). Conifers have also entered former aspen groves and reduced regeneration of aspen (Lucich, 2004).

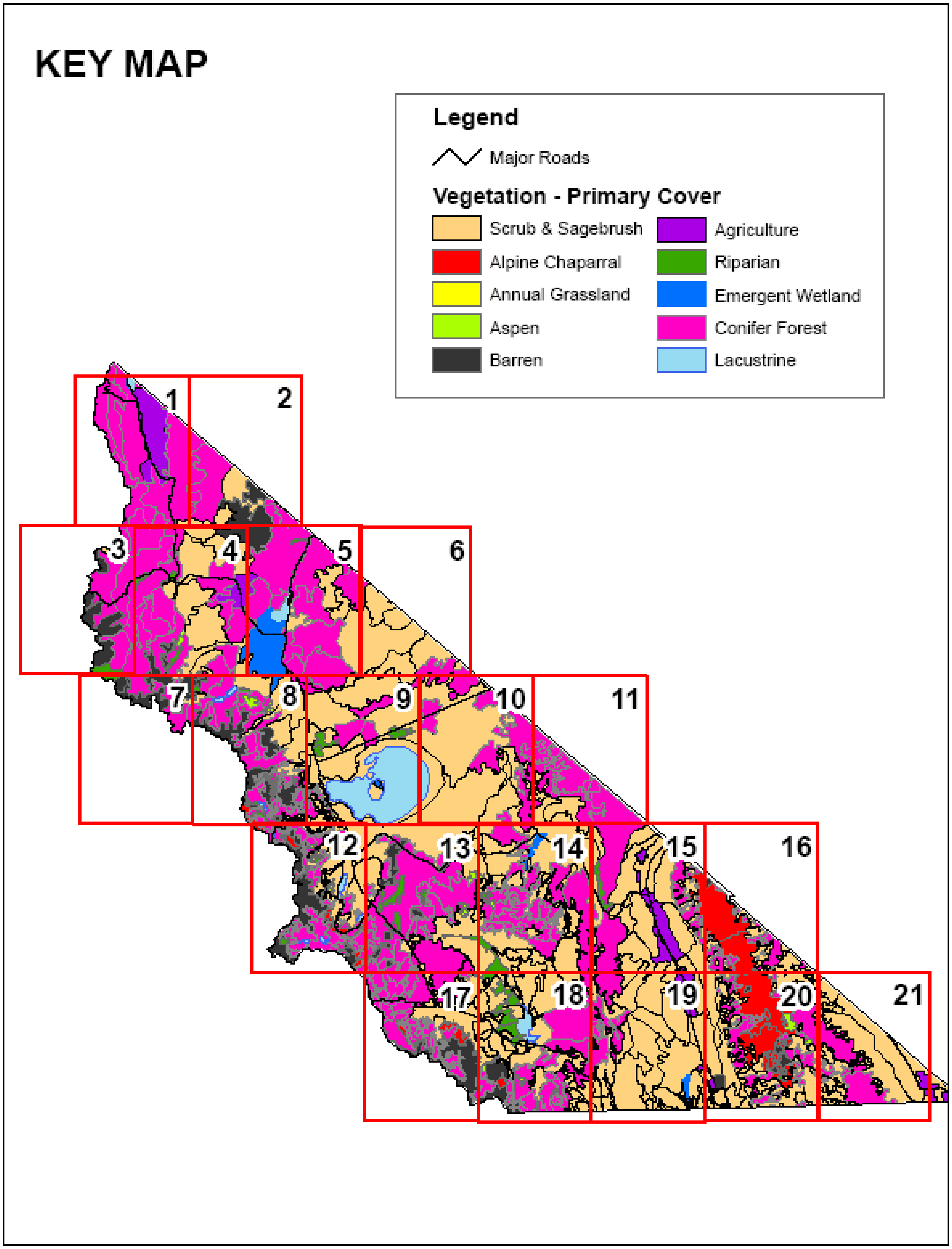
At upper elevations, brushfields are comprised of buckbrush (*Ceanothus velutinus*) and chokecherry (*Prunus emarginatus*). At lower elevations, the brush community is mostly sage (*Artemesia tridentata*), bitterbrush (*Purshia tridentata*), mountain mahogany (*Cercocarpus ledifolius*) and snowberry (*Symphoricarpus albus*) (USDA-Forest Service, 1988). On the north-facing slopes of the Silver and Wolf Creek watersheds, large fields of buckbrush are present (USDA-Forest Service, 1989). The most common riparian vegetation consists of willow (*Salix* sp.) and quaking aspen.

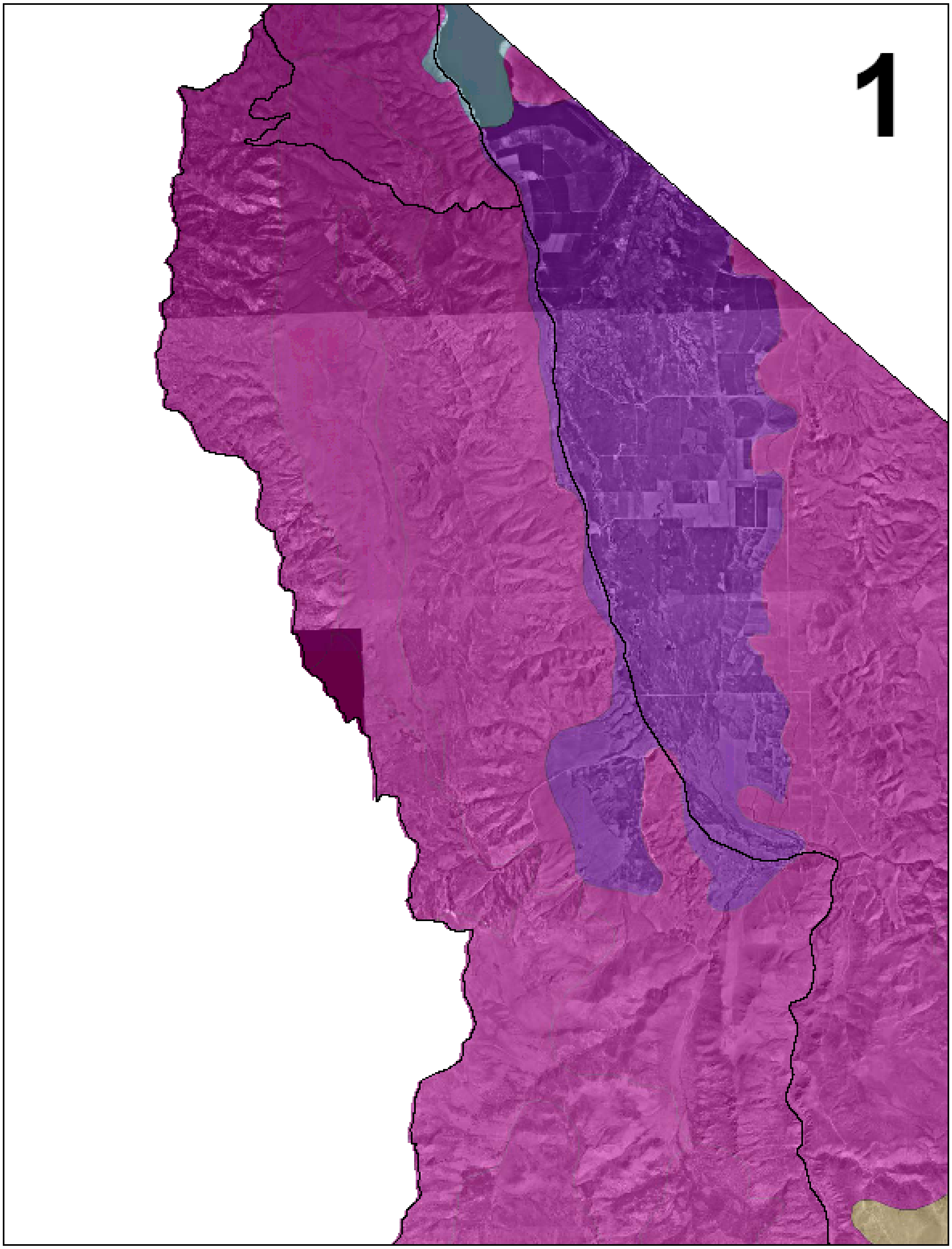
The lower slopes of the Sierra Nevada (below 6,000 feet) are largely covered by a sagebrush (*Artemisia tridentata*) community, intermingled with meadows and some curlleaf mountain mahogany (*Cercocarpus ledifolius*). Typical species of the sagebrush community include bitterbrush (*Purshia tridentata*), rabbitbrush (*Chrysothamnus* spp.), wheatgrass (*Agropyron* spp.), bluegrass (*Poa* spp.), wild-rye (*Elymus glaucus*), needle-grass (*Stipa* spp.), and June grass (*Koelaria cristata*) (Thomas, 1984).

In the Sweetwater Mountains, the main plant community is pinyon-juniper (*Pinus monophylla*, *Juniperus scopulorum*) 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).

The vegetation at the lower elevations of the West Walker River basin (5,000 to 7,000 feet) has changed substantially since the 1860s from bunchgrass range to bitterbrush and sage (e.g., Thomas, 1984). Prior to the arrival of Euroamericans in the mid-19th century, portions of the West 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. Consequently, the bighorn sheep and antelope left the area, and mule deer moved in, taking advantage of the browse species (Thomas, 1984). The native grasses, sedges, and rushes of the meadows were also converted to alfalfa and other forage species.

Figure 7. General vegetation types of the West Walker River watershed.

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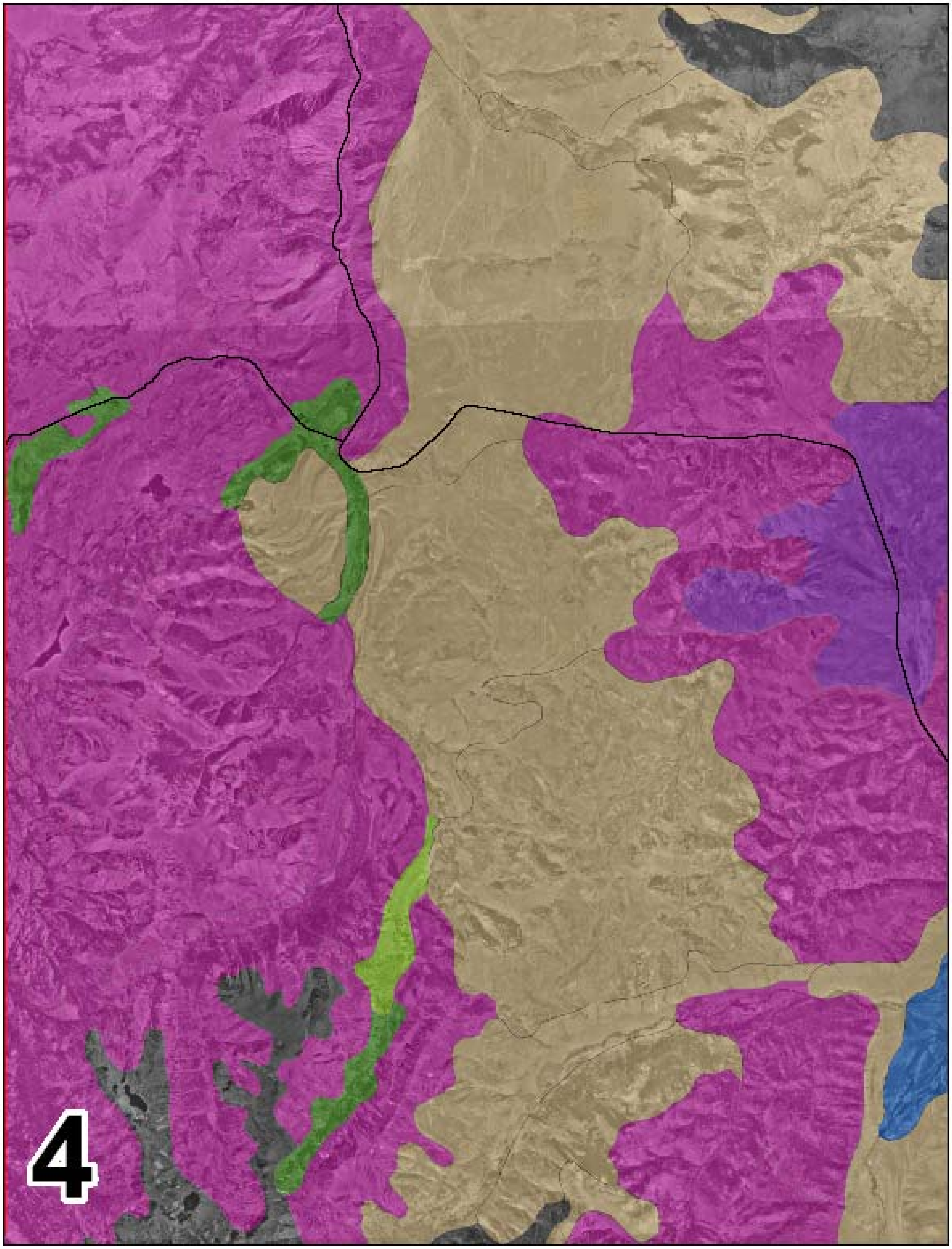
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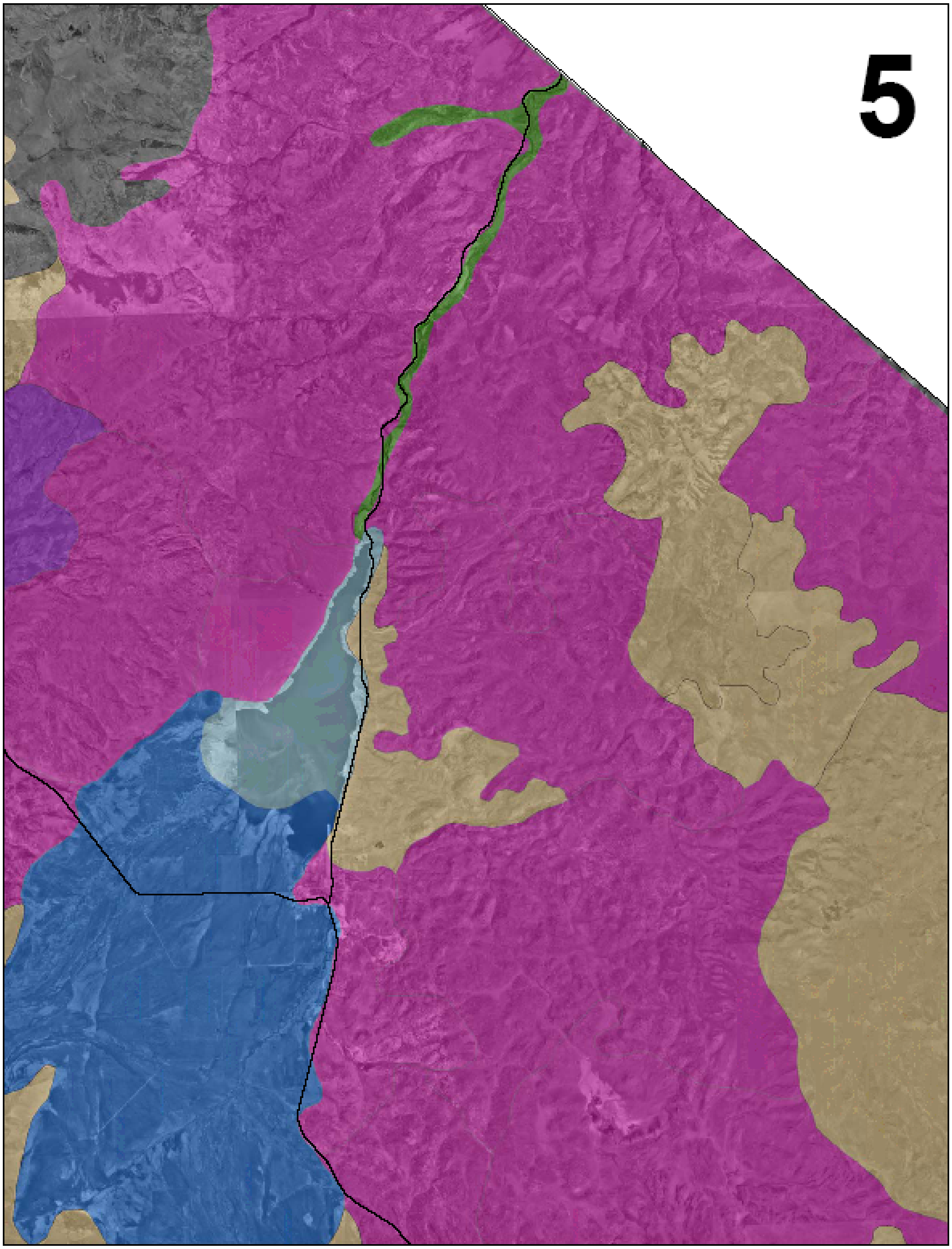
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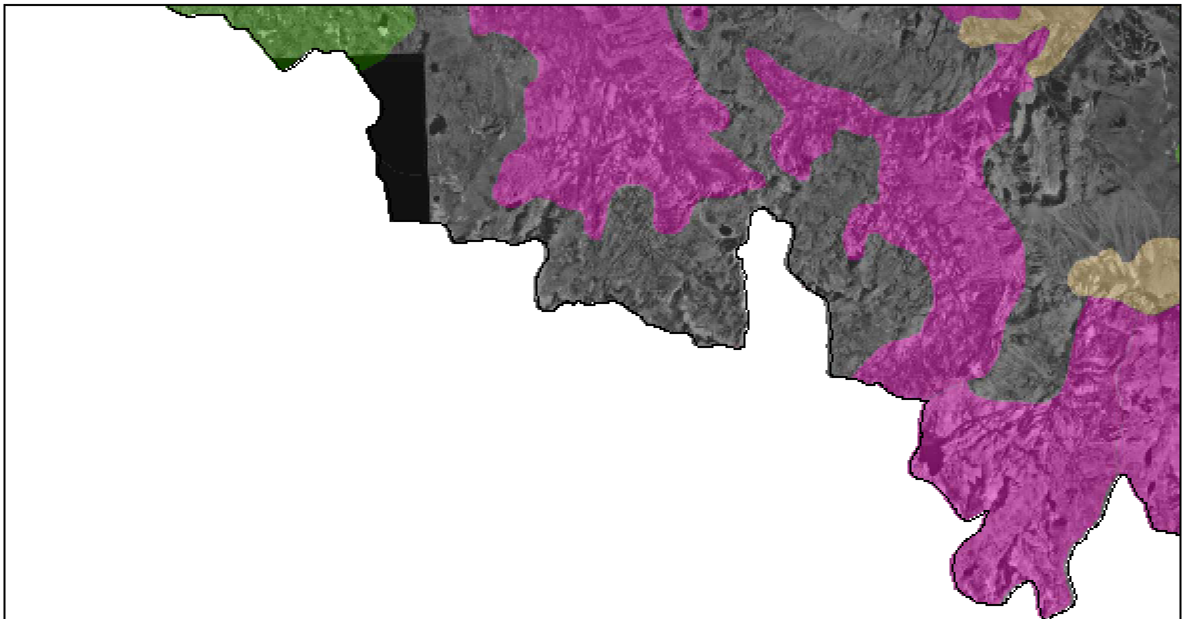

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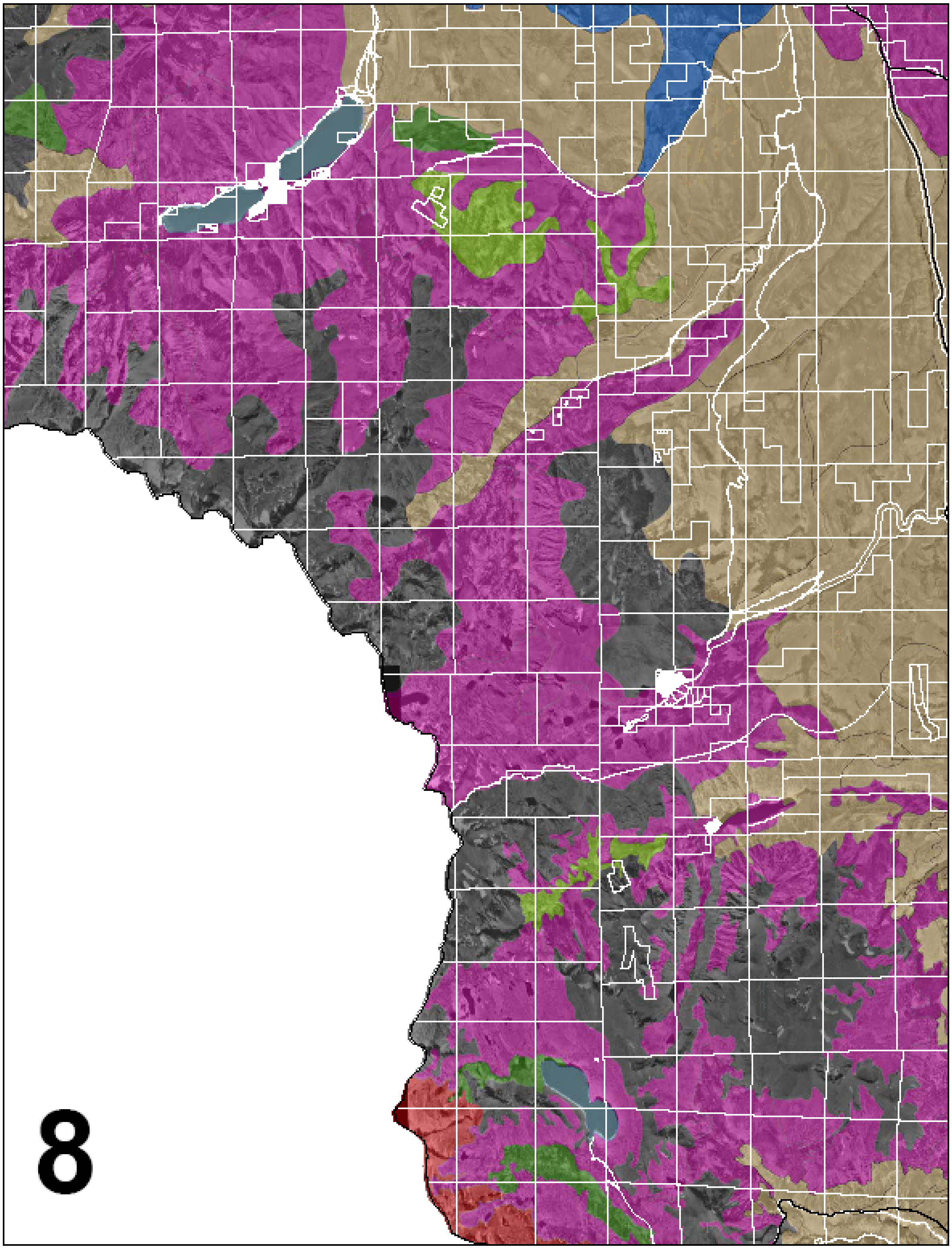
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Invasive Weeds

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).

Curly dock (*Rumex crispus*) has been found near Poore Lake, in Pickel Meadow, at Wheeler Flat, Wolf Creek, and near Lobdell Lake. The size and extent of these weed populations are unknown. These plants are especially common in wet meadows, along ditch banks, and in waste areas. They are not classified by the State of California (USDA-Forest Service, 2004).

Tall whitetop (*Lepidium latifolium*) was found near the Sonora Bridge picnic site. It grows in disturbed areas, wet areas, ditches, roadsides, and cropland. The population was treated in 2000 and 2001 and not found in 2002. Field bindweed (*Convolvulus arvensis*) is located near Rodriquez Flat and in Little Antelope Valley. Canada thistle (*Cirsium arvense*) is limited to isolated plants along the Emigrant trail in Lost Cannon Canyon. Hoary cress (*Cardaria draba*) has been found at the Mountain Warfare Training Center and the mouth of Walker Canyon on county property. Hoary cress is a perennial, common on alkaline, disturbed soils and is highly competitive with other species once it becomes established (USDA-Forest Service, 2004).

Leafy spurge (*Euphorbia esula*) is known to occur at the mouth of Walker Canyon on county land. It displaces many species and is very difficult to control once established. Scotch thistle (*Onopordum acanthium*) is found on private land near Indian Spring. It is an aggressive plant and may become so dense that the stands are impenetrable to livestock (USDA-Forest Service, 2004).

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).

Sensitive plant species

There has been one known sighting of *Orthotrichum spjutii* in the Sonora Pass area. This moss has a very restricted habitat, growing only on continuously misted, shaded granite rock faces. It has a moderate threat listing with threats that include trails/hikers, plant collectors, and hydrologic alteration (SNFP Amendment Appendix R-110, as cited in USDA-Forest Service, 2004).

The Masonic jewel flower (*Strptanthus oliganthus*) has been found in the Grouse Meadow area. 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).

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 West 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).

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 West Walker River watershed. 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).

Some of the wildfires within the West Walker River watershed are listed in the box below and mapped in Figure 8.

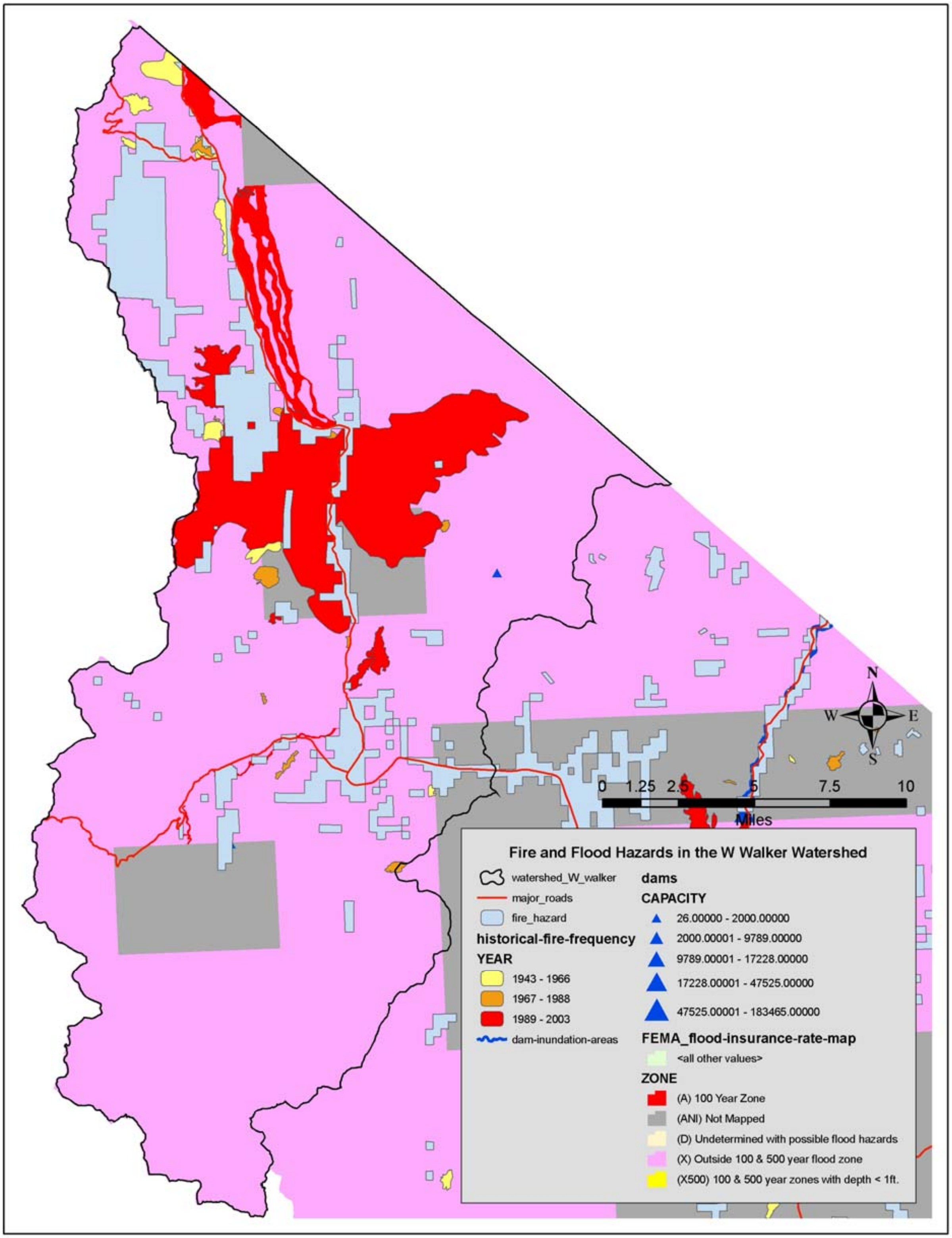
Wildfires between 1964 and 1984 (Thomas, 1984)

name	year	acreage
Rickey Peak	1964	240
Little Antelope	1970	133
Rock Creek	1972	360
Little Antelope	1973	425
Wheeler Bench	1974	120
Golden Gate	1974	650
China Garden	1974	1710

Wildfires after 1984

?	1990	381
?	1994	66
Larsen	1995	80
?	1996	49
Walker Complex	1996	1671
?	1999	246
Golden	2000	1527
Cannon	2002	26683
?	2004	>900
Iana	2004	3161

Figure 8. Map of major wildfires



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

Community or ecosystem	Dominant species	Fire return interval
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

In early June 2002, the Cannon Fire burned public lands of the Humboldt-Toiyabe National Forest, Bureau of Land Management, and California Department of Fish and Game. Within two weeks, the Slinkard Fire burned nearby. These fires burned about 27,000 acres.

A study of aquatic invertebrates in Mill Creek happened to be under way at the time of the 2002 fire, and the researchers were able to examine their study plots a few weeks after the fire (Herbst and Kane, 2004). "Compared to other small control sites, the Mill Creek site showed substantial declines in percent riparian cover, percent stable banks, percent cobble embeddedness, and herbaceous and woody cover, results that would be expected to accompany the loss of vegetation and increased rates of erosion associated with a fire. The Mill Creek site also showed a substantial increase in coarse particulate organic matter and substrate modifiers (i.e., algae, macrophytic vegetation, wood, and moss) and had the highest concentration of total phosphorus and total Kjeldahl nitrogen (i.e., organic forms of nitrogen) compared to all other sites in 2002, but one of the lowest concentrations of nitrate (i.e., inorganic forms of nitrogen)." These observations are indicative of a substantial release of nutrients and increase in stream productivity associated with the fire (Herbst and Kane, 2004).

In 2004, the Bridgeport Ranger District of the Humboldt-Toiyabe National Forest began the environmental assessment work for a proposed fuel-reduction project in the Mill Creek subwatershed to be conducted over six years (Lucich, 2004). In each year, between 0 and 665 acres would be mechanically thinned, and between 275 and 570 acres would be treated with prescribed fire. The goal of these treatments is to create forest stands of lower density that would have much less risk of catastrophic wildfire.

3. Riparian areas and wetlands

Compared to the Upper Owens River watershed and Mono Basin, remarkably little information has been found concerning the wetlands and riparian areas of the West Walker River watershed. 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, overgrazing, 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 through Walker Canyon is the most obvious example. U.S. Highway 395 also follows the course of Hot Creek from Devils Gate to Sonora Junction. State Route 108 is adjacent to portions of Leavitt Creek and Sardine Creek, and State Route 89 is adjacent to the lower portion of Slinkard Creek. Forest roads are within the riparian zone of parts of Silver, Wolf, and Mill creeks and the Little Walker River. Analyses of GIS road and stream layers by Mono County found that there are more than 380 road crossings of streams and more than 38 miles of roads within 100 feet of a stream within the West 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 largest areas of wetlands are flood-irrigated lands adjacent to the West Walker River in Antelope Valley and Little Antelope Valley (Figure 9). Most of these areas would not be classified as wetlands without the artificial application of water for more than a century. The Sonora Junction area also contains a significant area of important wetlands (Figure 10). There are a large number of sites labeled as meadows on Forest Service and U.S. Geological Survey maps (e.g., Upper Piute, Lower Piute, Walker, Sardine, Silver, Leavitt, Pickel, Junction, Grouse, and Cottonwood) 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.

Figure 9. Wetlands in Antelope Valley. [scan Wetlands Antelope]

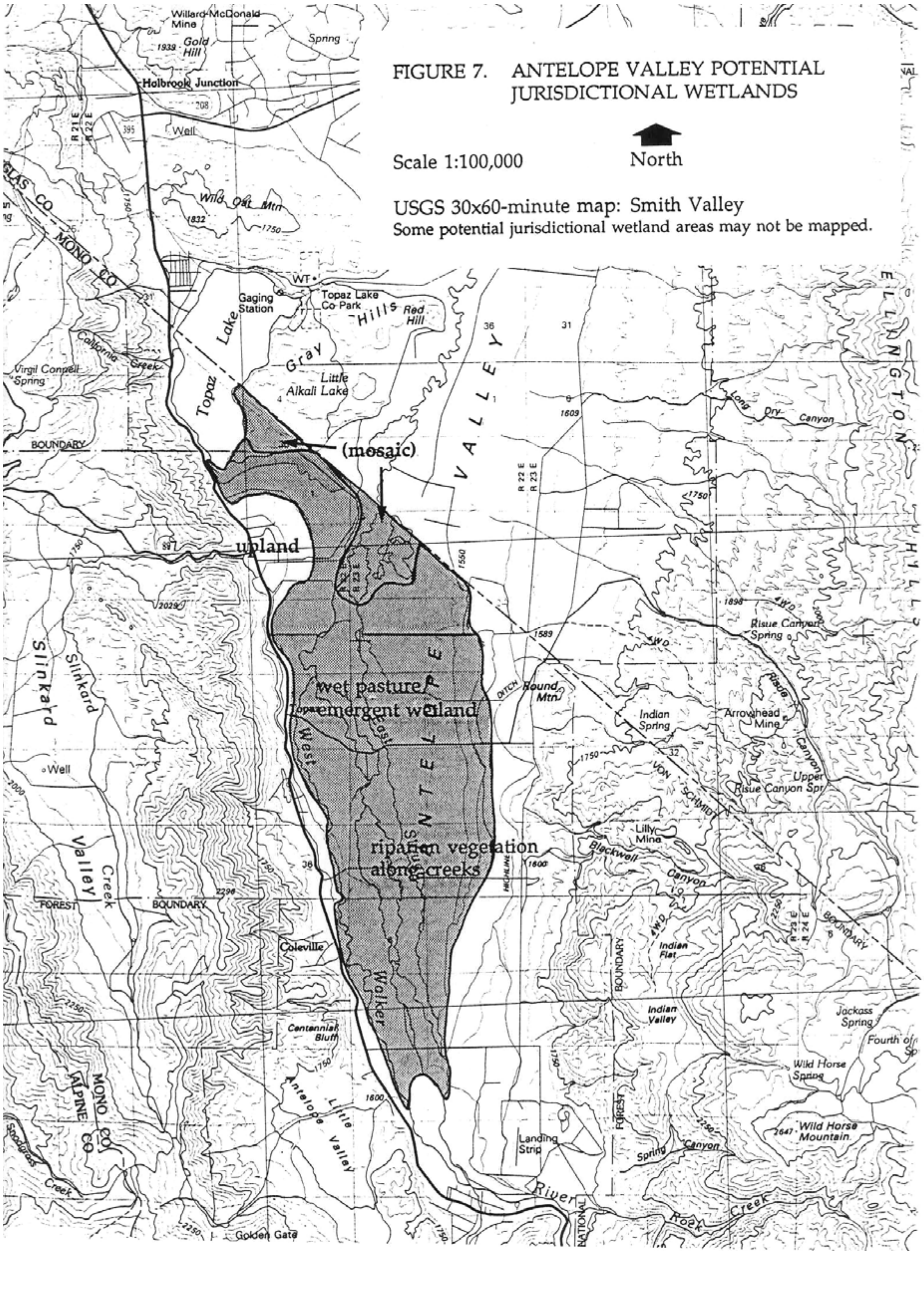
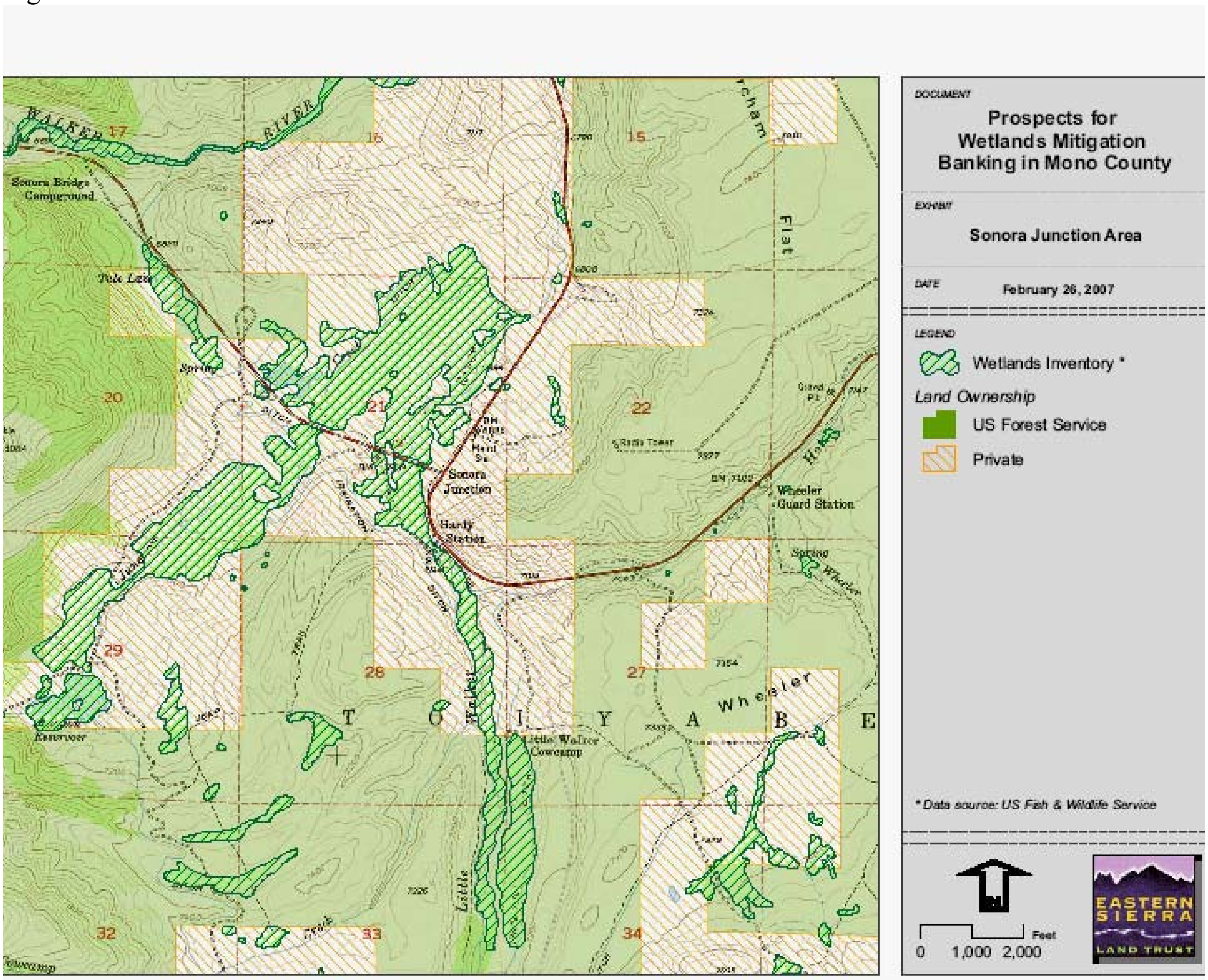


Figure 10. Wetlands in the Sonora Junction area.



A study of recovery of riparian vegetation following rest from grazing found that "Mean riparian cover increased at all small and medium treatment sites, except Poore Creek, between 1999 and 2002, while there was not a substantial change at the large treatment sites" (Herbst and Kane, 2004).

A number of seeps above the east bank of the Little Walker River in the vicinity of Sonora Junction were noted in the application for a small hydroelectric project (North Star Hydro Ltd, 1987). These seeps do not supply much water to the river, but they create wetlands and support riparian vegetation.

The California Department of Fish and Game conducted a project in the 1980s to restore riparian vegetation in Pickel Meadow. Additional restoration work including fencing to keep cattle out of the channel was performed in 1996. As of 2006, the California Department of Fish and Game has a draft restoration plan for Pickel Meadow that should be released soon.

Typically, the riparian vegetation above 7,000 feet consists of willow (*Salix* sp.) and quaking aspen (*Populus tremuloides*) (USDA-Forest Service, 1989).

There is an extensive dry meadow within the lower portion of the Mill Creek watershed (USDA-Forest Service, 1988).

4. Fish and Wildlife

Fish

Lahontan Cutthroat Trout

The Lahontan cutthroat trout (*Oncorhyncus clarki henshawi*) is the prominent species of native fish in the West Walker River basin. 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). 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).

Recovery of Lahontan cutthroat trout in tributaries to the West Walker River

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. 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.

Lahontan cutthroat trout were once native to the West Walker River through Pickel Meadow and the adjoining reaches of Silver and Wolf creeks (Milliron, et al., 2004). Non-native brown, brook, and rainbow trout took over these streams during the 20th century. Beginning in 1992 and 1996, about 4.1 stream miles in the Wolf Creek watershed and about 4.3 miles of stream in the Silver Creek watershed were established as refuges for Lahontan cutthroat trout. The lower portions of these creeks and the West Walker River continue to support other species of trout and are separated by significant fish barriers (Milliron, et al., 2004).

In the mid-1980s, there were 27 self-sustaining populations of Lahontan cutthroat trout in California and Nevada, with two of those in the Walker River drainage, in 3.5 miles of stream (USDA-Forest Service, 1988). The reintroduction of Lahontan cutthroat trout into Mill Creek, Silver Creek, and Wolf Creek during the 1990s added another 17.5 miles of cutthroat stream habitat to the Walker River drainage.

The process for reintroducing a fish to waters inhabited by non-native game fish is always controversial and problematic because it involves removing the existing fish, usually with a powerful poison, and closing the stream to fishing for several years after the species to be recovered is introduced and becomes established. Fisheries biologists in the western states have not found effective alternatives to the use of the fish poison rotenone (Gerstung, 1989; USDA-Forest Service, 1988). For the recovery process to work, fish in the stream reach that could hybridize or compete with the desired fish must be completely eliminated. Poisoning the reach seems to be the only means of accomplishing that step. A physical barrier, such as a waterfall, that prevents movement of the other species back into the managed reach is also necessary.

Wolf Creek was poisoned with rotenone in 1991 and 1992. Surveys in 1993 found an absence of fish but an abundance of aquatic invertebrates (Wong, 1993; Pickard, 1998). Later that year, a total of 289 Lahontan cutthroat trout (117 adults of various year classes, 101 juveniles, and 71 young-of-the-year) were transplanted from Slinkard Creek to Wolf Creek. Annual trout population surveys conducted through 1998 indicate that Lahontan cutthroat trout have greatly expanded their distribution in the stream. Reproductive success was indicated by the presence of multiple year classes and young-of-the-year. Fish appeared to be in excellent condition with a few specimens up to 14 inches in length. Some mortality appears to be linked to illegal angling and the January 1997 flood (Pickard, 1998).

Slinkard Creek was treated with rotenone in August 1987 and June 1988. Lahontan cutthroat trout were transplanted from downstream into this reach where the brook trout had been eradicated (Goldberg, 1988). The California Department of Fish and Game attempted to rear Lahontan cutthroat trout in a makeshift hatchery on Slinkard Creek in the early 1990s, but abandoned the effort. By 2001, the population of Lahontan cutthroat trout in Slinkard Creek was judged to be self-sustaining, and Slinkard Creek was opened to limited angling (California Department of Fish and Game, 2001).

The practice that has been adopted for reintroduction of Lahontan cutthroat trout is to select a reach of a stream with suitable habitat characteristics and a natural barrier to migration at the downstream end. Electrofishing and nets are used to capture as many existing fish as possible and then transfer the caught fish to other waters. The stream reach is then poisoned with rotenone in the late summer or autumn and a detoxicant (a chemical, usually potassium permanganate at 2 ppm, that reacts with and breaks down the rotenone) released into the water at the fish barrier, or downstream end of the treated reach. A second treatment a year later is usually done to ensure eradication of the non-native fish. During the year following the second chemical treatment, Lahontan cutthroat trout from a hatchery or other stream are planted in the channel. The reach is closed to angling until the population of Lahontan cutthroat trout is judged sufficient to allow angling to resume.

Besides the targeted fish, other aquatic organisms, such as invertebrates, crustaceans, and larval amphibians, are killed by rotenone. However, studies have shown that sufficient survivors exist to ensure continued existence of each species (USDA-Forest Service, 1988). Amphibians in the susceptible larval stage are unlikely to be affected because the rotenone treatments are done in the fall at low streamflow when the tadpoles and larval salamanders are not in the streams. The decline in aquatic invertebrates and fish affects other animals that feed on the stream organisms for food. The temporary decrease in food availability has not been viewed as significant (USDA-Forest Service, 1988).

In Mill Creek, the refuge for Lahontan cutthroat trout includes the headwaters and about 7.5 miles of channel downstream to a natural barrier falls located 100 feet upstream from the confluence with Lost Cannon Creek. About 3 miles of the refuge are on parcels owned by the California Department of Fish and Game. The channel in the meadow owned by the department has the potential for the highest carrying capacity of Lahontan cutthroat trout (USDA-Forest Service, 1988). In June 2001, 54 Lahontan cutthroat trout measuring more than 5 inches in length were released into the lower section of Mill Creek where few Lahontan cutthroat trout had been observed previously. The Lahontan cutthroat trout were collected from Slinkard Creek (California Department of Fish and Game, 2001).

Silver Creek was chemically treated in 1994, 1995, and 1996. Visual and electrofishing surveys were made of the creek to verify the absence of fish in 1997 (Becker, 1997). The stream was stocked with Lahontan cutthroat trout in 1997 and 1998. A survey in 2001 found 28 Lahontan cutthroat trout ranging in size from 3 to 12 inches and about 250 less than three inches, which indicated successful spawning (California Department of Fish and Game, 2001). About 5 miles of Silver Creek (headwaters to barrier falls) and 5 miles of Wolf Creek (Wolf Lake to barrier falls) have been established as Lahontan cutthroat trout refuges (USDA-Forest Service, 1989).

Other fish present in streams of the West Walker River watershed include several native species found at lower elevations (mountain whitefish, mountain sucker, Tahoe sucker, Piute sculpin, Lahontan tui chub, Lahontan redside, and speckled dace) and introduced rainbow trout, brook trout, and brown trout (Milliron, et al., 2004).

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. Before the artificial stocking, most or all waters in the West Walker River watershed did not contain trout, except for the lower portions of Silver and Wolf creeks, which contained native Lahontan cutthroat trout (Milliron, et al., 2004). Many strains of rainbow trout and brook trout have been planted in lakes and tributaries of the West 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).

Endemic Fishes

Endemic fish surveys of the West 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 West 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*) was found in East Slough, the West Walker River in Antelope Valley, the middle, canyon section of the West Walker River, the Pickel Meadow and Leavitt Meadow section of the West Walker River, Fales Hot Creek, Mill Creek, Poore Lake, and Poore Creek. Particularly high numbers were found near Parsons Bridge on the West Walker River.

Speckled dace (*Rhynicthys osculus robustus*) was found in East Slough, the West Walker River in Antelope Valley, the canyon section of the West Walker River, the Pickel Meadow and Leavitt Meadow section of the West Walker River, and Poore Creek. Particularly high numbers were found in the Antelope Valley section of the West Walker River and in East Slough. Speckled dace has recently been found in Secret Lake. It is thought to have been introduced there, since it is a lotic species and is not typically found in lakes.

Lahontan redside (*Richardsonius egregius*) was found only in East Slough and in the Antelope Valley section of the West Walker River.

Mountain sucker (*Catostomus platyrhynchus)* is a species of special concern because populations in California are thought to be in a general decline (Olson and Erman, 1987). In these surveys it was found in the canyon section of the West Walker River, the Pickel Meadow and Leavitt Meadow section of the West Walker River, Little Walker River, and particularly high numbers were found at Topaz Lane Bridge in the Antelope Valley section of the West Walker River.

Piute sculpin (*Cottus beldingi*) was found in all sections of the West Walker River, the Little Walker River, Poore Creek, Poore Lake, Silver Creek, and Desert Creek.

Mountain whitefish (*Prosopium williamsoni*) was found in the canyon section of the West Walker River, the upper meadows section of the West Walker River, Little Walker River, Poison Creek, Poore Creek, Silver Creek, and Molybdenite Creek.

No endemic fish species were found in the following creeks within the West Walker River watershed; Leavitt Creek, Sardine Creek, Wolf Creek, Junction Creek, Lost Cannon Creek, Cottonwood Creek, Deep Creek, Burcham Creek, and Slinkard Creek.

No surveys of endemic fish in the West Walker River watershed have been conducted since 1978. A detailed table of this information is available in Appendix XX.

Mountain whitefish was the dominant species found in the Little Walker River near Sonora Junction during environmental work for a proposed small hydroelectric project (North Star Ltd, 1987).

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.

When fish surveys were conducted in 2001 by the California Department of Fish and Game, 25 of the 35 named lakes in the upper West Walker River watershed had fish populations that were either self-sustaining or supported through fish stocking by California Department of Fish and Game. The following seven named lakes were fishless: Chango Lake, Hidden Lake, Lower Long Lake, Millie Lake, Mud Lake, Red Top Lake, and Wolf Creek Lake. Twenty-four lakes had allotments for aerial plantings of fingerling trout (Milliron, et al., 2004).

Recreational fishing is popular in the West Walker River along U.S. Highway 395 because of the ease of access. The river is stocked with catchable-size hatchery trout by the California Department of Fish and Game. Topaz Reservoir is also a popular fishery and is heavily stocked (California Department of Water Resources, 1992). Trophy-size trout from Alpers' Ranch hatchery have also been planted since the mid-1990s in selected areas to enhance fishing derbies and other events (Reed, 2005b). Although native Lahontan cutthroat trout have been largely replaced by introduced brown, brook, and rainbow trout, a few remnant groups may be found in some of the more remote tributaries. Other native fish include speckled dace, mountain or Tahoe sucker, sculpin, and mountain whitefish. (USDA-Forest Service, 2004).

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). The absence of public explanations or outreach by the fisheries agencies led to yet another public-relations debacle over fisheries management in Mono County.

Low flows in the West Walker River through the Antelope Valley at the end of the irrigation season subject fish to limited habitat and high water temperatures. Fish are carried into the diversion ditches in the Antelope Valley and become fertilizer (Lahontan Regional Water Quality Control Board, 1975).

The California Department of Fish and Game has used Junction Reservoir (owned by the Junction Cattle Company) for years to maintain the State's sole broodstock of the Kamloops strain rainbow trout. The lake is uniquely suited as a broodstock facility because there are no other strains of trout present in the watershed, it is remote, and yet can be accessed by vehicle during the spring spawning season. Nearby Kirman Lake is a popular trophy brook trout fishery and catch and release lake in the department's Wild Trout Program. Public access by foot to Kirman Lake has been permitted across Junction Ranch (California Department of Fish and Game, 1990).

Amphibians

Amphibian populations are assumed to be declining in the West 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.

The principal amphibians of the West Walker River watershed are Yosemite toad (*Bufo canorus*), mountain yellow-legged frog (*Rana muscosa*), and Pacific tree frog (*Hyla regilla*). Salamanders are presumed to inhabit the watershed as well, but specific references were not located.

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. Yellow-legged frog adults and tadpoles were observed at Wolf Creek Lake in 1993 (Wong, 1993). The species has also been observed within the Cascade Creek, Kirkwood Creek, and Kennedy Canyon subwatersheds (Milliron, et al., 2004).

The most widely dispersed amphibian in the West Walker Management Unit is the Pacific tree frog (Milliron, et al., 2004). Pacific tree frogs are found in all tributaries within the West Walker Management Unit (a California Department of Fish and Game designation) and appear to be relatively stable.

Wildlife

The West Walker deer herd is a significant wildlife resource within the basin and affects many land management decisions. The herd occupies about 200 mi^2 of winter range and 500 mi^2 of summer or intermediate range within the California portion of the West Walker River basin (Thomas, 1984). The West Walker mule deer herd uses winter range in Little Antelope Valley, east side Antelope Valley at base of the Wellington Hills, Slinkard Valley, Gray Hills, and Wild Oat Mountain (Taylor, 1997; Ferranto, 2006). During the spring and fall, the herd migrates to and from summering habitat. Deer wintering in the Wellington Hills migrate south through Indian Valley, Jackass Flat, and the west slope of the Sweetwater Mountains to the Sonora Junction holding area. From there, they move to summer ranges in the central Sierra. The Sonora Junction holding area encompasses approximately 80 square miles at an elevation of about 6,000 feet. It extends from Cottonwood Creek, on the west side of the Sweetwater Mountains, south to Pickel Meadow and east to Bush Mountain. Part of the holding area is dominated by big sagebrush and wet meadow habitats that provide deer with an abundance of succulent forage. Much of this area has been grazed by cattle and has high levels of human disturbance from recreational activity and training maneuvers associated with the Mountain Warfare Training Center (Taylor, 1997).

Bald eagle (*Haliaeetus leucocephalus*) and wolverine (*Gulo gulo*) sightings have been verified on and adjacent in the Pickel Meadow area to the parcels, but the dates were not recorded (California Department of Fish and Game, 1990).

Mono Basin area 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. The birds are found in many parts of Mono County. Active leks have been noted at Burcham Flat and Wheeler Flat (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 California Department of Fish and Game noted where beaver were found in 1967: Little Walker River, West Walker River, Mill Creek, and Lost Cannon Creek (memo in CDFG files in Bishop office, no date).

Refuges and Reserves

The Humboldt-Toiyabe National Forest has established several "critical aquatic refuges" to promote recovery of threatened amphibians. The Kirkwood Lake refuge was established for the mountain yellow-legged frog. It covers 840 acres at the higher elevations of the West Walker River watershed. Surveys in 2000 found a total population of more than 10,000 frogs, among the heaviest concentrations in the Sierra Nevada. In addition to these frogs, Yosemite toad larvae were also found in this refuge in the 2000 survey. The Koenig Lake refuge was established for Yosemite toads. It includes 2000 acres in the Latopie, Koenig and Leavitt lakes subwatersheds. Recent surveys found Yosemite toad tadpoles in the wetlands surrounding Koenig Lake and in unmapped ponds between Koenig and Latopie lakes (USDA-Forest Service, 2004).

Much of Pickel Meadow was purchased by the California Wildlife Conservation Board in 1989 as five noncontiguous parcels totaling 991 acres. The land is managed by the California Department of Fish and Game for deer habitat and migration, fisheries habitat, and recreational angling. The Little Walker parcel consists of 280 acres located on the lower portion of the Little Walker River between the junction of U.S. Highway 395 and State Route 108, upstream of its confluence with the West Walker River. The remaining parcels include Millie Lake, Pickel Meadow, Silver Creek, and “The Bridge” parcel. These parcels are located along or near the West Walker River, near the U.S. Marine Corps Mountain Warfare Training Center. The properties contain portions of Millie Lake, Mud Lake, the West Walker River, Little Walker River, Silver Creek, and Poore Creek. A riparian water right for 8 cfs on the Pickel parcel was conveyed to the State (California Department of Fish and Game, 1990). Much of Slinkard

Valley is owned by the California Department of Fish and Game and is managed largely for deer.

5. Human History and Land Use

Native Americans of the Piute and Washoe tribes lived in the West Walker River basin for at least several hundred years. Their history in this region is not as well known as in areas to the north and south. 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. The Miwok from west central California also used the Sonora Pass area (USDA-Forest Service, 2004).

Trappers including Jedediah Smith and Joseph Walker apparently crossed within the lower Walker River basin in 1827 and 1833. The first Euro-Americans known to have visited the West Walker River basin were in the Bartelson-Bidwell party, who were the first overland emigrants to California. This group came through Antelope Valley in October 1841 and struggled over the Sierra Nevada somewhere north of Sonora Pass. The famous explorer John C. Fremont, with guides Tom Fitzpatric and Kit Carson, passed through Antelope Valley in February 1844.

Antelope Valley was settled in the late 1850s and began to produce hay for Carson City and Virginia City (Mono County Resource Conservation District, 1990). Irrigation ditches were soon constructed to expand the land under cultivation. In addition to hay fields and pastures, farmers in the valley grew beans, melons, corn, tomatoes, and berries and started orchards that produced apples, peaches, and plums. The valley was named for a large antelope (pronghorn) herd, but the last known antelope sighting was in 1872 (Northern Mono County Chamber of Commerce, 2005).

Although gold was discovered near Bodie in 1859 and 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 West Walker River basin and produced heavy demand for agricultural products from the rapidly growing farms of the Antelope Valley. Several small mining communities were established in the Sweetwater Mountains, including Star City, Cameron, Boulder Flat, and Patterson (Smith, 2003). The Sonora-Mono road over Sonora Pass was completed by 1864 and the early road through Walker Canyon was completed in the early 1870s. Sheep herding expanded in the uplands in response to the demand from the mining towns, and continued in large numbers into the early 1900s. The oldest Basque carvings found on aspen in the West Walker River basin date to 1889, while most carvings date to the 1920s and 1930s (USDA-Forest Service, 2004).

Many of the farms and ranches of Antelope Valley were consolidated in the 1880s by cattle baron Thomas B. Rickey. By the turn of the century, Rickey's operations were using enough water that downstream ranchers in Smith and Mason valleys believed that their water rights were being infringed upon. A lawsuit filed in 1902 would eventually be settled in 1919. Meanwhile, Rickey lost most of his cattle to disease and suffered other financial losses that led to the sale of his holdings to the Antelope Valley Land and Cattle Company in 1907. In the 1920s, these holdings were disaggregated, and most of Antelope Valley was again divided into family farms and ranches (Bishop, 1997; Northern Mono Chamber of Commerce, 2005; Smith, 2003; Horton, 1996).

In 1899, work began for Topaz Reservoir on some of Thomas Rickey's land that included Alkali Lake. A levee on the south side, several ditches bringing water in from the West Walker River, and an outlet tunnel at the northeast corner would convert the natural depression into a functional reservoir. With Rickey's financial difficulties, construction stalled but the project was later completed by downstream water interests that formed the Walker River Irrigation District in 1919. Water storage began in 1921, and by May 1924, about 30,000 AF of water were stored in Topaz Reservoir (California Department of Water Resources, 1992; Smith 2003).

The Marine Corps Mountain Warfare Training Center in Pickel Meadow was established in 1951.

Walker River Chronology (quoted verbatim from Horton, 1996)

1827 Jedediah Strong Smith, leader of a party of 15 trappers of the Rocky Mountain Fur Company ... [returning east from the San Joaquin Valley] with two companions crossed the Sierra Nevada Mountains near Ebbetts Pass, crossed the Walker River and skirted Walker Lake to the south.

1833 Joseph Walker, of the Hudson's Bay Company, led a party of explorers and trappers along the Humboldt River, the Humboldt Sink, the Carson Sink, and then up into the Sierra Nevada Mountains by either the Carson River or the Walker River.

1841 The Bartleson-Bidwell emigrant party made the first successful crossing of the Great Basin. Having reached the base of the Sierra Nevada Mountains on the West Walker River in October 1841, the party spent the next two weeks crossing the mountains, most probably near Sonora Pass. Reports of their successful passage would inspire others to attempt the passage.

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 Settlement of Antelope Valley began when pioneer stockman began moving into the valley with herds of cattle.
Comstock silver rush began.

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

1861 Gold discovered at Aurora

1862 Priorities attributed to appropriative water rights indicated that irrigation began in Antelope Valley about this time.

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 on the West Walker River. In 1907 Rickey would suffer financial failure and his extensive ranch holdings and cattle operations would be sold to the Antelope Valley Land and Cattle Company.

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 Thomas Rickey of the Antelope Valley [sic] Land and Cattle Company began to advance his plan to divert the waters of the West Walker River above Smith and Mason valleys into the natural reservoir site occupied by Alkali Lake. Miller et Lux filed suit in federal district court (Miller et Lux v. Rickey) claiming that such waters, according to then-current appropriations, rightfully belonged to Henry Miller's Walker River Ranch in Mason Valley.

1907 Thomas Rickey of the Rickey Land and Cattle Company suffered failure in the panic of 1907 and sold his ranching properties in AV to the Antelope Valley Land and Cattle Company.

1918 Application 1097 and 1098 for storage rights at Pickel Meadow and Leavitt Meadow as future reservoir sites on the West Walker River were filed with the State Water Commission of California by Nevada agricultural interests who would later (1919) form the WRID

1919 The litigation of Pacific Live Stock Company v. Antelope Valley Land and Cattle Company and the issuance of Decree 731 caused a number of farmers in Smith and Mason Valleys to band together and form the WRID.

1922 Waters of the West Walker River were first stored in Topaz Reservoir, a storage facility created from an expansion of the original Alkali Lake, a fault-block basin separated from the West fork by an alluvial fan of Slinkard Creek.

1926 In response of applications 1097 and 1098 filed in 1918 for storage rights in Pickel Meadow and Leavitt Meadow as future reservoir sites on the West Walker River in California, the California Water Rights Board issued permits 2534 and 2535 to WRID.

1928 severe drought through 1935

1937 Topaz Reservoir's capacity was increased from its original 45,000 AF to 59,440 AF.

1945 The original Mono County Soil Conservation District in Antelope Valley was formed.

1950 particularly damaging floods, but limited urbanization minimized property damage

1953 rules adopted by the U.S. Board of Water Commissioners with respect to Decree C-125 for lands above the Topaz Reservoir intake canal on the West Walker River (primarily AV and surrounding areas) were reaffirmed a water duty of 1.6 cfs per 100 acres of land.

1955 particularly severe flooding

1955 After two subnormal flow years, California farmers and ranchers in Antelope and Little Antelope valleys requested CDWR undertake an extensive study of the water resources of the West Walker River.

1957 Based on a request made by farmers and ranchers in 1955, the CDWR issued a preliminary report on water resources of the West Walker River Recommendations called for a more extensive analysis of potential reservoir sites.

1964 USBR published its Walker River Project and CDWR completed its water resources investigation of the West Walker River. An important observation contained within this investigation was the recognition of the variability of West Walker River flows, which over a 35 year period of record encompassing 1920-1955, varied from a minimum of 67,900 AF/year to a maximum of 372,700 AF/year. it was determined that this range of flows greatly limited this river's potential as a stable source of surface water for agriculture. It was also noted that potential water requirements within this portion of the basin exceeded the available water supply.

[1976-1977 drought]

1989 Most of the West Walker River in California was added to the California Wild and Scenic River System under the 1973 California Wild and Scenic Rivers Act.

1987-1994 drought

1994 Walker Lake low point of 3,941 feet; TDS of 13,894 ppm (or mg/l)
water level had dropped about 135 feet since turn of the century.

(Horton, 1996)
Abbreviations used by Horton:
WRID Walker River Irrigation District
CDWR California Department of Water Resources
USBR United States Bureau of Reclamation

1997 Flood of record on West Walker River resulted in major property damage in Antelope Valley and destruction of U.S. Highway 395 within Walker Canyon

2002 Cannon Fire burned much of Mill Creek and Lost Cannon Creek watersheds

Land use

More than 85 percent of the West Walker River watershed is in public ownership by the USDA-Forest Service, USDI-Bureau of Land Management, and the California Department of Fish and Game for resource management purposes (USDA Nevada River Basin Study Staff, 1975). Most of the private land is in Antelope Valley where agriculture, primarily cattle ranching, is the dominant land use. Pasture irrigation is the largest single use of agricultural water in Antelope Valley (California Department of Water Resources, 1992). Other areas of large-parcel private land include Little Antelope Valley and the Sonora Junction area. In the early 1970s, there were approximately 38 farms and ranches operating within the West Walker River watershed with a combined area of about 15,870 acres (USDA Nevada River Basin Study Staff, 1975). Four communities are found in the watershed: Walker, Coleville, Camp Antelope, and Topaz. The population of Antelope Valley was 574 in 1970 and 1187 in 1980.

Figure 11. Land-use designations

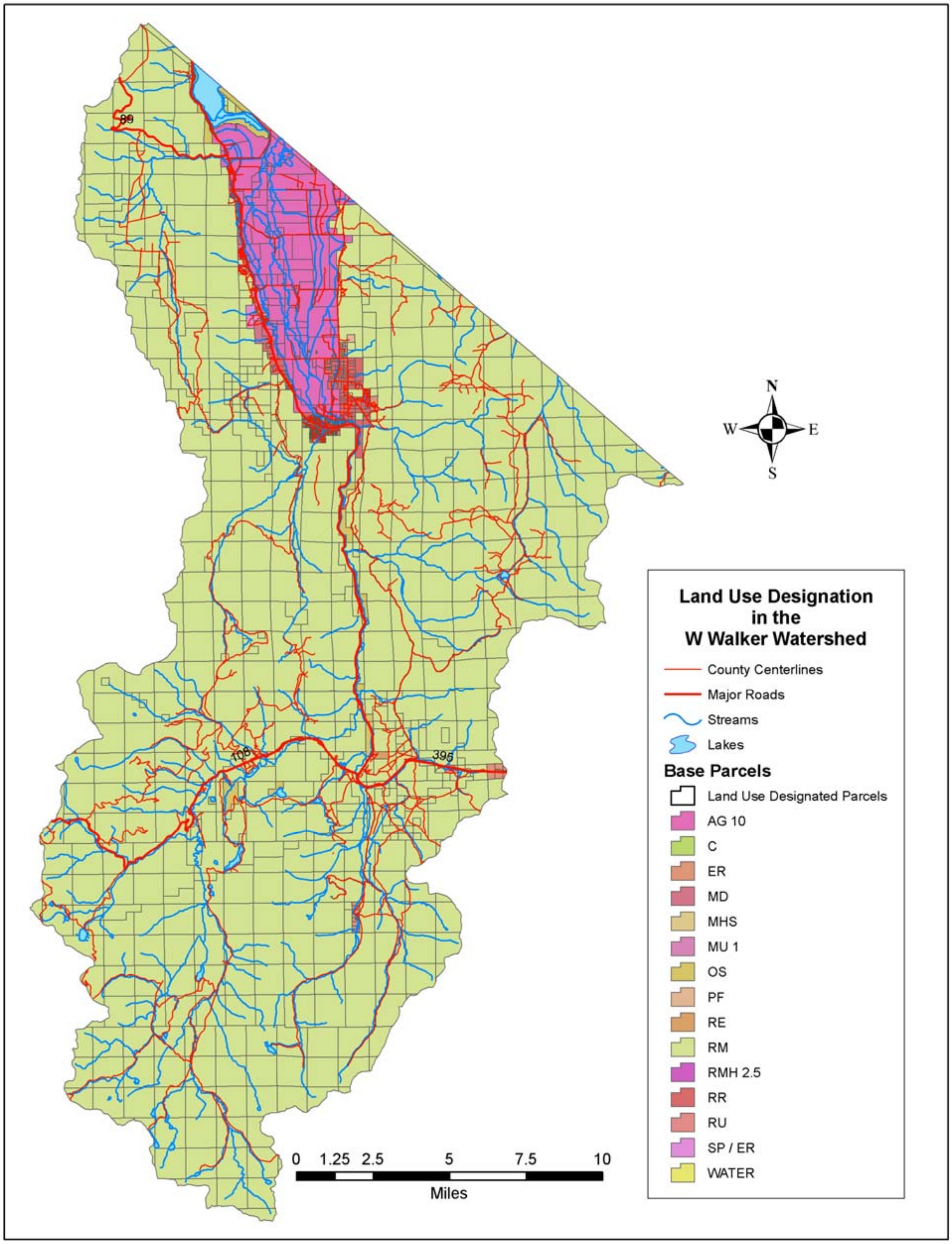


Figure 11. Land-use designations – north end

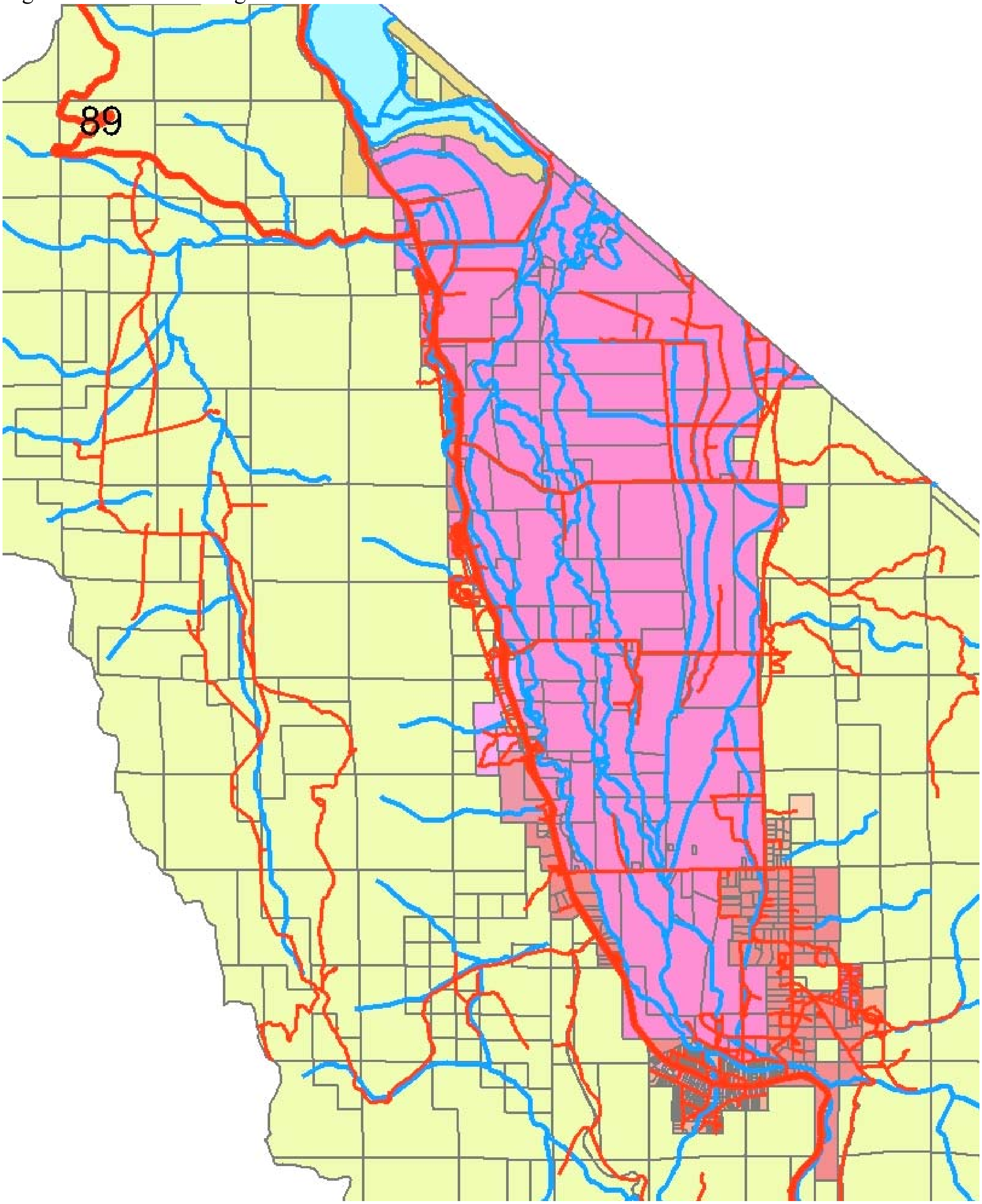


Figure 12. Land ownership [watershed_jpegs W_walker_ownership]

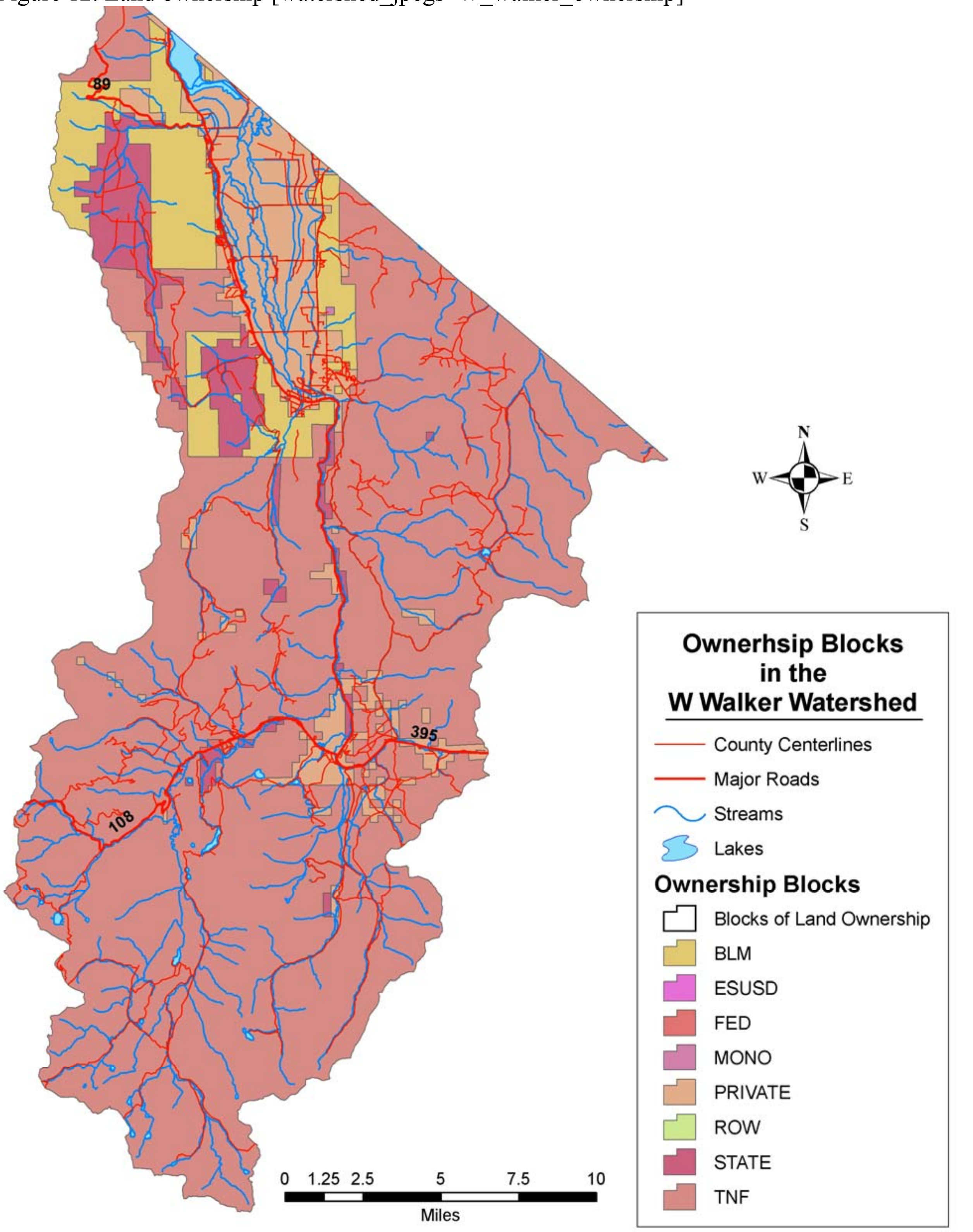
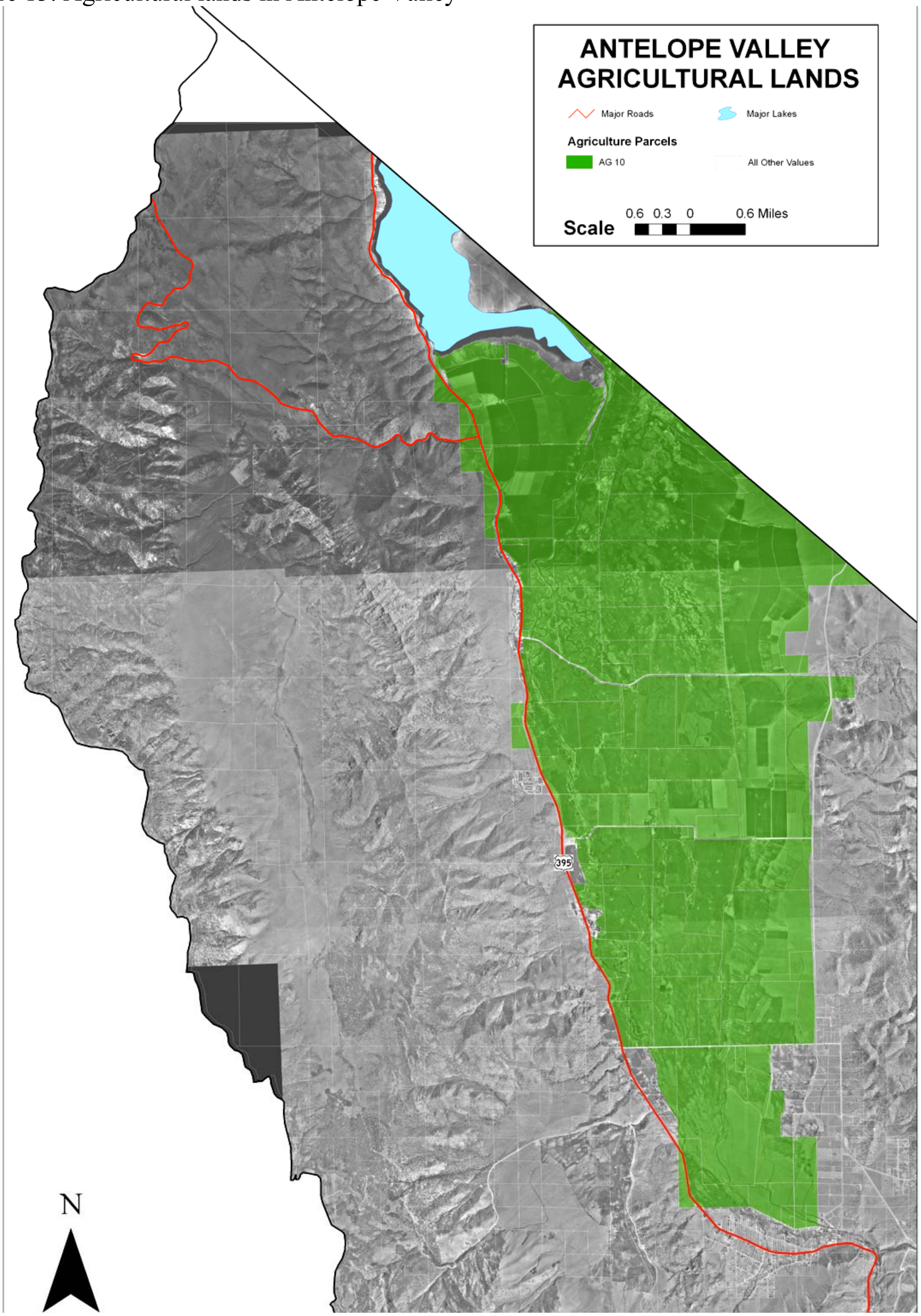


Figure 13. Agricultural lands in Antelope Valley



The community of Walker includes residences, motels and restaurants, a few commercial businesses, county road yard, county park, community center, ballfields, and a county landfill (located on Bureau of Land Management property). Coleville includes private residences, Marine Corps housing, high school, library, and post office. Topaz has residential land use only. Sewer and water services throughout Antelope Valley are provided by individual wells and septic systems (Mono County, 1992). The U.S. Marine Corps Mountain Warfare Training Center at Pickel Meadow is a unique land use with aspects of residential, commercial, and industrial land uses. The facility also utilizes a large amount of adjoining National Forest land for training purposes.

Several isolated parcels of private land exist in the vicinity of Sonora Junction and Burcham Flat. 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.

The U.S. Marine Corps Mountain Warfare Training Center was established in 1951 to provide for cold weather training associated with the Korean War. Use was continued in 1988 by Congress through Public Law 100-693. The Marine base occupies about 500 acres of National Forest land. The Mountain Warfare Training Center has a permanent staff of about 250 military and 90 civilian personnel and up to 1,200 trainees at any given time. Summer training includes 3-5 battalions of about 800 troops each. Winter training includes 4-6 battalions per year, also for 30-day periods. About 9,000 Marines train at the center each year. The base has nine contaminated sites, mostly from fuel spills (USDA-Forest Service, 2004). With the exception of the base camp area, the entire training area is open to multiple use management, including unrestricted public access (USDA-Forest Service, 1989).

One reference was found to a marble quarry that has not been located on a map or visited on the ground: "A quarry, about 4 miles from the town of Topaz in Antelope Valley is a deposit of marble and onyx that comprises all of the famous marbles of the world including two or three that are superior... Walker River Marble. It is a deposit 3 miles in length and some 500 feet in width. It was owned by Mr. W.E. Lindsay of Carson City" (Smith, 2003).

Recreation

Recreation is a major land use within the West Walker River watershed and includes concentrated use areas with some facilities, such as campgrounds, and dispersed recreation.

USFS Campgrounds and day use facilities
Chris Flat [in riparian]
Shingle Mill rest area
Bootleg
Sonora Bridge
Leavitt Meadow
Leavitt Meadow Pack Station and abandoned LM Lodge Resort
Leavitt Falls overlook
dispersed camping along upper 108
(USDA-Forest Service, 2004)

Many of the dispersed camping sites are in riparian conservation areas. One improvement is a pit toilet installed near the Little Walker Road for dispersed campers.

Leavitt Meadow, Obsidian, and Sonora Bridge campgrounds provide 53 family camping sites. Leavitt Meadow has an operable water system, but its toilets are aging. Sonora Bridge has a water system that meets State water quality standards for drinking water, but the taste and color are unacceptable. Campers prefer to use a nearby spring source. Obsidian does not have an operable water system, and its toilets are aging.

Silver Creek, Wolf Creek, Grouse Meadows, Summit Meadows, and Mill Creek are the most-visited day use and dispersed camping spots. A toilet is located along the Mill Creek road, but receives little use. Dispersed camping sites along Silver, Wolf, and Mill creeks are within riparian conservation areas and may not be meeting current standards for soil compaction, riparian vegetation, or water quality.

Shingle Mill day use area was a 90-unit campground before destruction by the 1997 flood.

The Leavitt Meadow Pack Station operates on a special use permit for 14 acres including a horse corral (capacity of 40 horses and mules), house, office, tack shed, and other buildings.

Leavitt Lodge was abandoned in 1999.

Off-highway vehicle use is increasing in Mill Canyon on trails closed to motorized use. In Grouse Meadows, Silver Creek, and Wolf Creek vehicle use of trails is causing some erosion, soil compaction, and loss of riparian vegetation".
(USDA-Forest Service, 2004)

In the early 1990s, a controversy briefly developed between a commercial raft operation and fishermen about whether those recreational uses were compatible (Mammoth Times, 1992).

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 West 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, 2004). The rangelands have been recovering ever since under less intense grazing pressure.

In the southwest portion of the West Walker River watershed, there are five active grazing allotments and one vacant grazing allotment administered by the USDA-Forest Service. Four allotments are for cattle and horse grazing and two are for sheep and goat grazing. About 900 cattle and 1,900 sheep graze in this area from June through September each year. These cattle and sheep numbers equate to about 4,600 animal unit months (USDA-Forest Service, 2004).

In the northwest portion of the watershed, there are three active grazing allotments and one vacant grazing allotment on National Forest land. Two of these are for cattle and horse grazing, and the other two are sheep and goat allotments. Acreage capable of supporting livestock grazing is 1,600. About 200 cattle graze in this unit from May through September each year. About 900 sheep graze during the month of June. These cattle and sheep numbers equate to about 800 animal unit months (USDA-Forest Service, 2004).

There are seven active grazing allotments in the Sweetwater area on the east side of the watershed. Two of these are cattle and horse allotments and five are sheep and goat allotments. About 57,000 acres are capable of supporting livestock grazing. The area supports about 900 cattle grazing the area yearlong. About 4,500 sheep graze from April through September each year. These cattle and sheep numbers equate to about 6,200 animal unit months (USDA-Forest Service, 2004).

A Forest Service grazing permit for the Junction Allotment is held by the Junction Cattle Company for 1,660 AUM. Most of the grazing under this permit occurs on the Pickel Meadow parcel where grazing has been allowed to continue under State ownership (California Department of Fish and Game, 1990).

An agreement states that the administrative responsibility for grazing on California Department of Fish and Game lands has been transferred to the Humboldt-Toiyabe National Forest. This agreement also commits the California Department of Fish and Game to construct 4 miles of range fence on and across lands of mixed ownership within the allotment. The California Department of Fish and Game was also to construct streambank erosion-control structures and plant willow and cottonwood. This agreement also states that a legal trade agreement/contract with Junction Lands, Inc., creating an equal trade of cattle grazing for the use of Junction Reservoir as a brood stock facility for Junction Kamloops Rainbow trout, must be made (Gustafson, 1997).

More than 90 ecological sites in the West Walker River watershed were sampled between 1994 and 1997. This sampling program revealed resource damage in a few of the grazed areas. Several problem areas were identified on the Sardine allotment. The first meadow below Leavitt Lake had some active erosion, unstable banks, and lateral headcuts. Kennedy Canyon had soil disturbance from cattle trampling the meadows. Sardine Creek had some unstable banks and lateral headcuts. However, cattle do not appear to be impacting or contributing to erosion at present grazing levels and use patterns (USDA FS 2210 files 1987-1999). On the Silver Creek sheep and goat allotment, Wolf, Silver, and Cloudburst creeks were noted as areas of concern. This allotment has been vacant since 1993. Past records indicate excess sediment, stream bank deterioration, headcuts, and trampling damage along Silver Creek; headcuts and trampling damage along Cloudburst Creek; and excess bare ground along Wolf Creek (USDA FS 2210 files 1985-1988) (USDA-Forest Service, 2004).

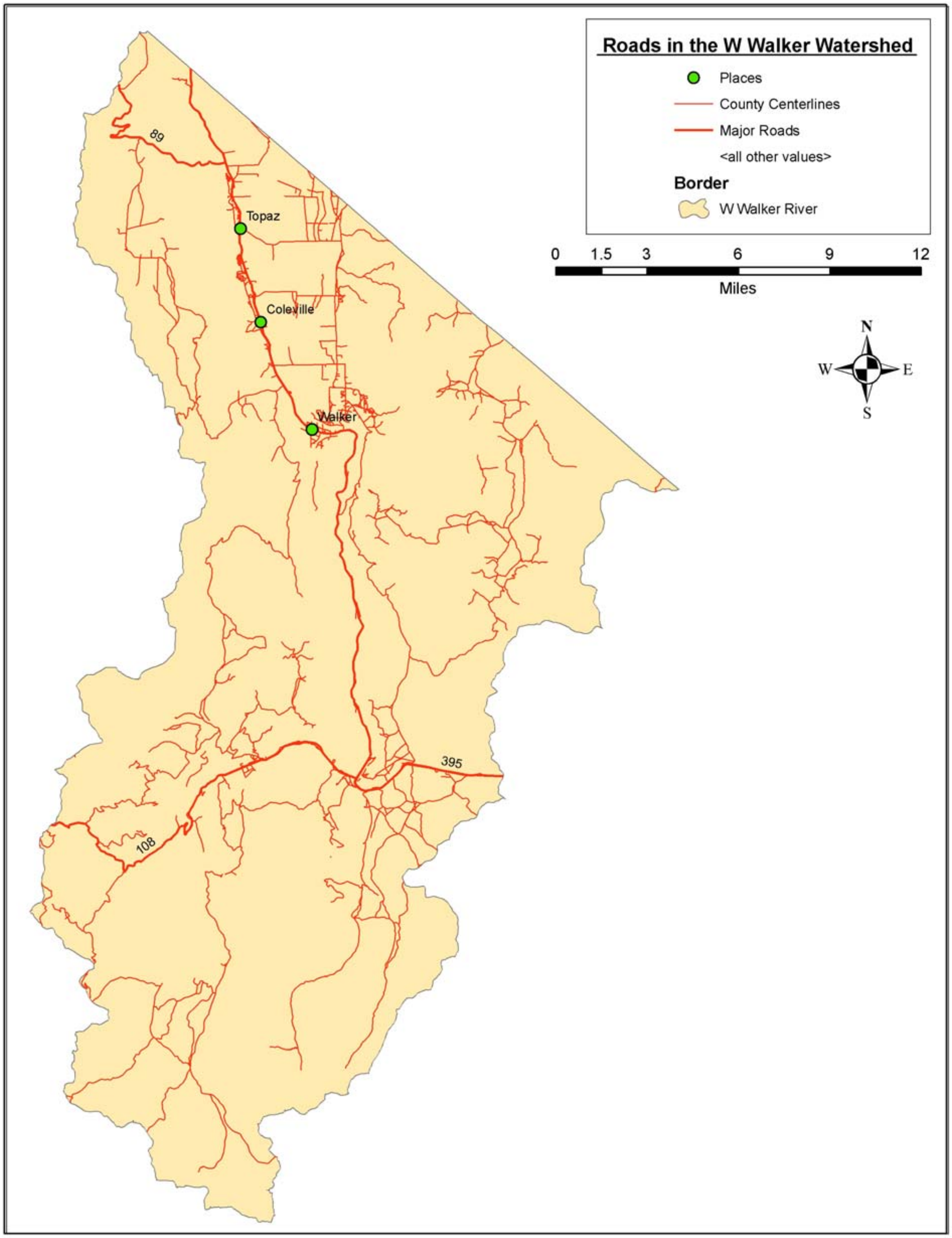
Following the Cannon Fire of June 2002, the burned portions of the Lost Cannon, Mill Canyon, and the Sweetwater allotments were rested for two growing seasons (USDA-Forest Service, 2004).

The California Department of Fish and Game documented grazing-induced resource damage in three parts of the West Walker River watershed: Lost Cannon creek drainage (channel erosion), the Sweetwater range (surface soil erosion in overgrazed areas), and Piute Meadows (degradation of meadows and riparian habitats) (Thomas, 1984).

Roads

Many of the roads in the West 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 U.S. Highway 395 through Walker Canyon. Slopes disturbed by the road placement and construction were long-term sources of sediment to the West Walker River. This section of road was largely destroyed by the flood in January 1997. Portions of other paved roads, such as State Route 108 to Sonora Pass and State Route 89, 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 by Mono County found that the watershed contains more than 490 miles of mapped roads, these roads cross streams in at least 380 places, and more than 38 miles of roads are within 100 feet of a stream.

Figure 14. Major roads in the West Walker River 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:

The Little Walker River Road is a heavily used 6.5-mile road that washes out occasionally.

The Leavitt Lake Road had relatively little use before it was repaired in recent years. The improved access has led to a significant increase in use of the Leavitt Lake area.

The Koenig Lake and Koenig Lake Spur roads are in a critical aquatic refuge and in the proposed addition to the Hoover Wilderness. There has been much trespass in the area by off-highway vehicles that have created new vehicle routes and significant erosion.

The Rodriguez Road to Rodriguez Flat is maintained by Mono County. An evaluation of the road after the Golden Fire of 2000 concluded that resource damage was occurring at one or more stream crossings because the gradients were too flat.

The Mill Canyon road is maintained under Mono County jurisdiction through a special use permit dating back to 1949. The stream crossings on this road appear to be adding sediment into the stream, which is a critical aquatic refuge for Lahontan cutthroat trout (USDA-Forest Service, 2004).

Wild and Scenic River Status

The main channel of the West Walker River from the headwaters near Tower Lake to the confluence with Rock Creek near the town of Walker and Leavitt Creek downstream from Leavitt Falls were added in 1989 to California's Wild and Scenic River System. The designated section includes about 33 river miles of the main stem and about 5 miles of the tributary Leavitt Creek (California Department of Water Resources, 1992).

The California Wild and Scenic Rivers Act of 1972 preserves designated rivers possessing “extraordinary scenic, recreational, fishery, or wildlife values” in their free-flowing condition. The act prohibits construction of dams, reservoirs, and most water diversion facilities on river segments included in the system (California Department of Water Resources, 1992). The major difference between the national and state acts is that if a river is designated wild and scenic under the state act, the Federal Energy Regulatory Agency can still issue a license to build a dam for hydropower generation on that river. Because of this difference, designation under the National Wild and Scenic Rivers Act (1968) affords enhanced protection (Horton, 1996).

A special provision of the California Wild and Scenic Rivers Act applies to the West Walker River because it is an interstate stream and a source of agricultural water and domestic water: "The California Wild & Scenic Rivers Act does not prohibit the replacement of diversions or changes in the purpose of use, place of use, or point of diversion under existing water rights, except that no such replacement or change shall operate to increase the adverse effect, if any, of the preexisting diversion facility or place or purpose of use, upon the free-flowing condition and natural character of the stream, and no new diversion shall be constructed unless and until the Resources Secretary determines that the facility is needed to supply domestic water to the residents of any county through which the river or segment flows and that the facility will not adversely affect the free-flowing condition and natural character of the stream." (http://www.dot.ca.gov/ser/vol1/sec3/special/ch19wsriverschap19.htm#ch19WestWalker)

Aquatic 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).

Six critical aquatic refuges have been designated in the West Walker River watershed:

Kirkwood Lake refuge (800 acres) has a population of about 10,000 mountain yellow-legged frogs. Yosemite toad larvae have also been found in this area.

Koenig refuge (2,000 acres) has populations of Yosemite toads in the vicinity of Koenig, Latopie, and Leavitt lakes.

Wolf Creek refuge (3,200 acres) including Wolf Creek Lake has a self-sustaining population of Lahontan cutthroat trout following successful reintroduction in the 1990s.

Silver Creek refuge (6,000 acres) including Chango Lake has populations of mountain yellow-legged frog and Lahontan cutthroat trout.

Summit Meadow refuge (5,100 acres) has populations of mountain yellow-legged frog.

Mill Canyon refuge (6,400 acres) has a self-sustaining population of Lahontan cutthroat trout following successful reintroduction in the 1990s.

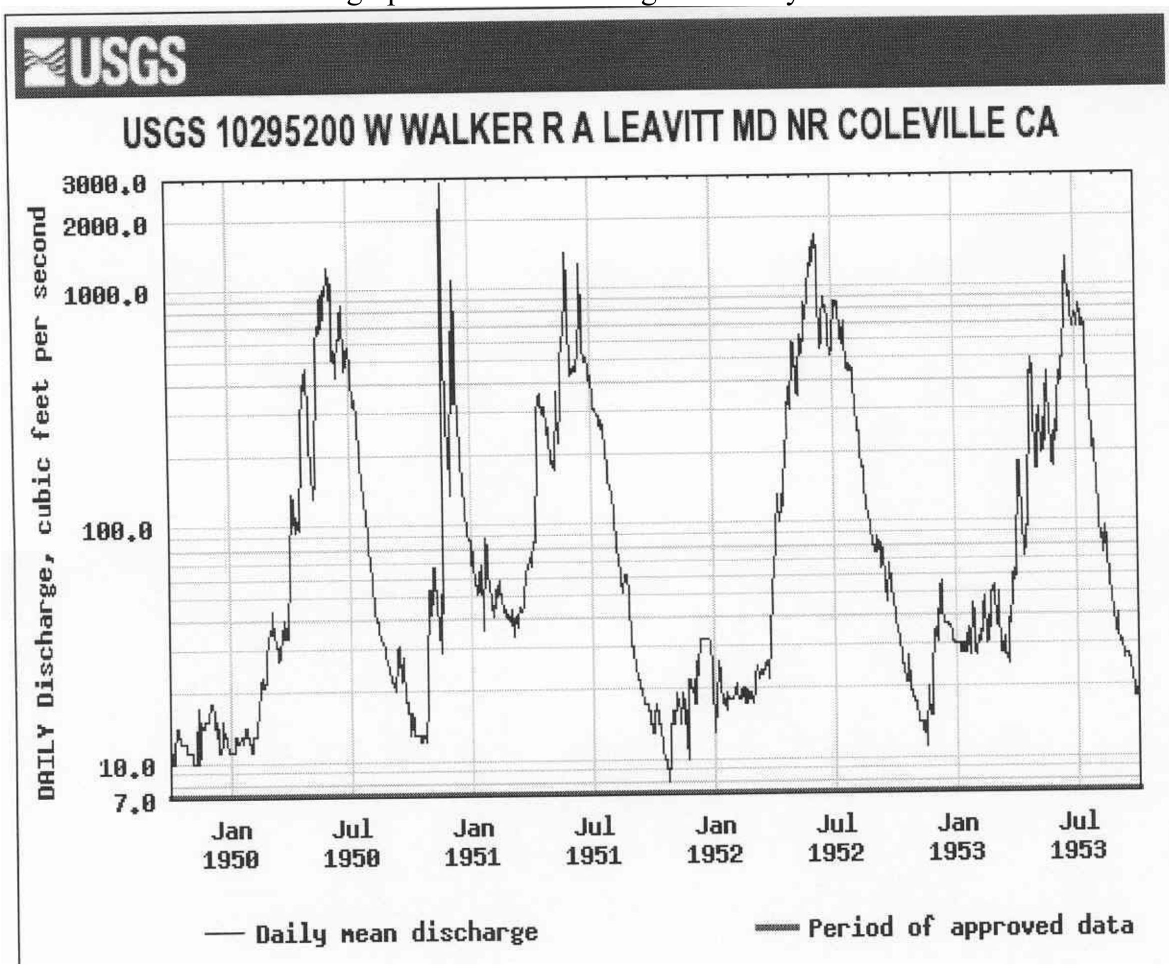
(USDA-Forest Service, 2004; Milliron, et al., 2004)

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).

6. Descriptive hydrology

The West Walker River has a runoff pattern (Figure 15) 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 which have generated the largest floods on record.

Figure 15. Annual pattern of streamflow for four years, including a rainfall-generated flood in November 1950. Data and graph from U.S. Geological Survey.



The West Walker River supplies more than 60 percent of the water that would naturally (in the absence of diversions) enter Walker Lake [195,000 AF / 285,000 AF] (Mono County MEA, 1999).

Runoff generation processes

Most of the runoff volume over the course of a year in the West 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 either 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.

Estimated surface water consumptive use based solely on surface water inflows to and outflows from Antelope Valley 1939 to 1993: inflow (195,000 AF) - outflow (180,000) = surface water consumed (15,000 AF) or about 8 percent of inflow (U.S. Geological Survey, 1995).

A coarse water balance (starting with generated runoff from small tributaries) of the entire Walker River basin estimated that 184,700 AF of runoff enter the upper West Walker River and 1,000 AF evaporate before the river enters Antelope Valley. Within Antelope Valley, another 28,700 AF enter and 38,400 AF are lost to evaporation (31,300 AF from irrigated fields, 2,800 AF from phreatophytes, and 4,300 AF from lake surfaces) for a net export from Topaz Lake of 174,000 AF (Carson River Basin Council of Governments, 1974). Another estimate of evapotranspiration in the Antelope Valley area was 33,000 AF from agriculture and 3,600 AF from phreatophytes (Glancy, 1971).

Streamflow averages and extremes

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

Station	Period of Record	Area (mi^2)	Ave. Volume
West Walker R near Coleville	1902 to present	250	202,000 AF
West Walker R below Little Walker R	1938 to present	181	194,000 AF
West Walker R above Leavitt Mdw	1945 to 1964	73.4	111,000 AF
Little Walker R	1944 to present	63.0	39,000 AF

A U.S. Geological Survey report, issued in 1995, included the following summary statistics for two of these stations:

West Walker River below confluence with Little Walker River, above Coleville CA station 10296000

Average	185,000 AF	(256 cfs)	1939-1993
Low	47,280	(65.3 cfs)	1977
High	388,770 AF	(537 cfs)	1907

West Walker River near Coleville, CA station 10296500

Average	195,000 AF	(269 cfs)	1916-36, 1958-93
Low	53,940	(74.5 cfs)	1977
High	484,340	(669 cfs)	1983

(U.S. Geological Survey, 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.

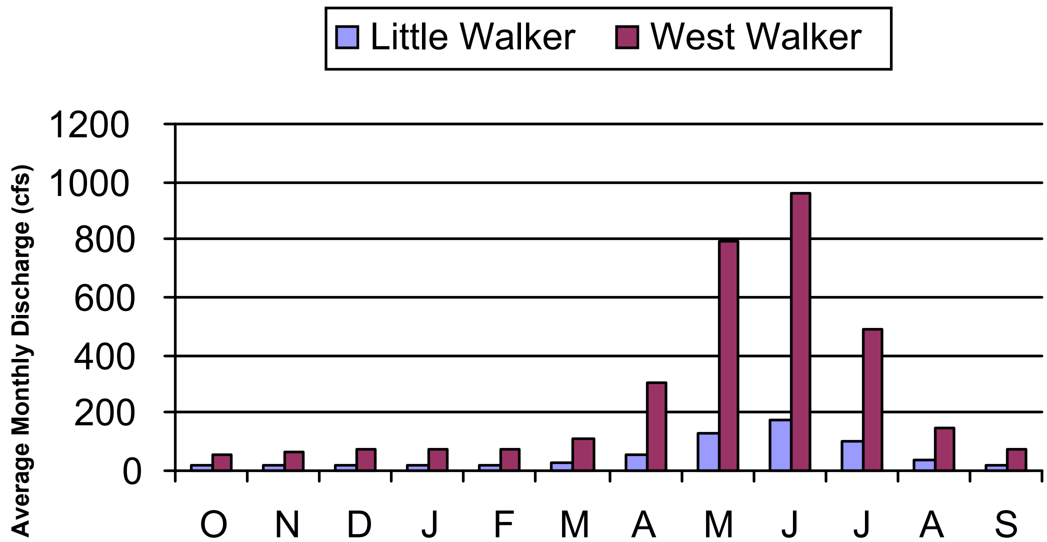
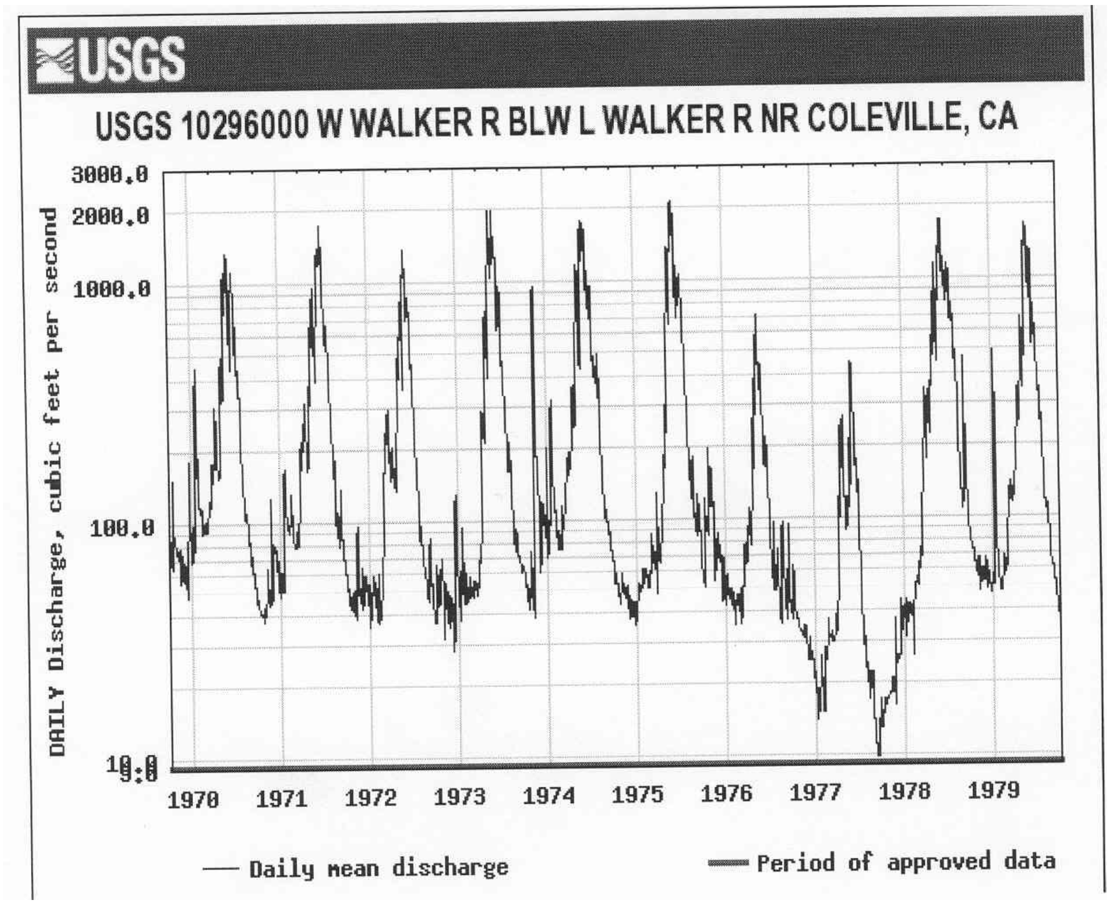
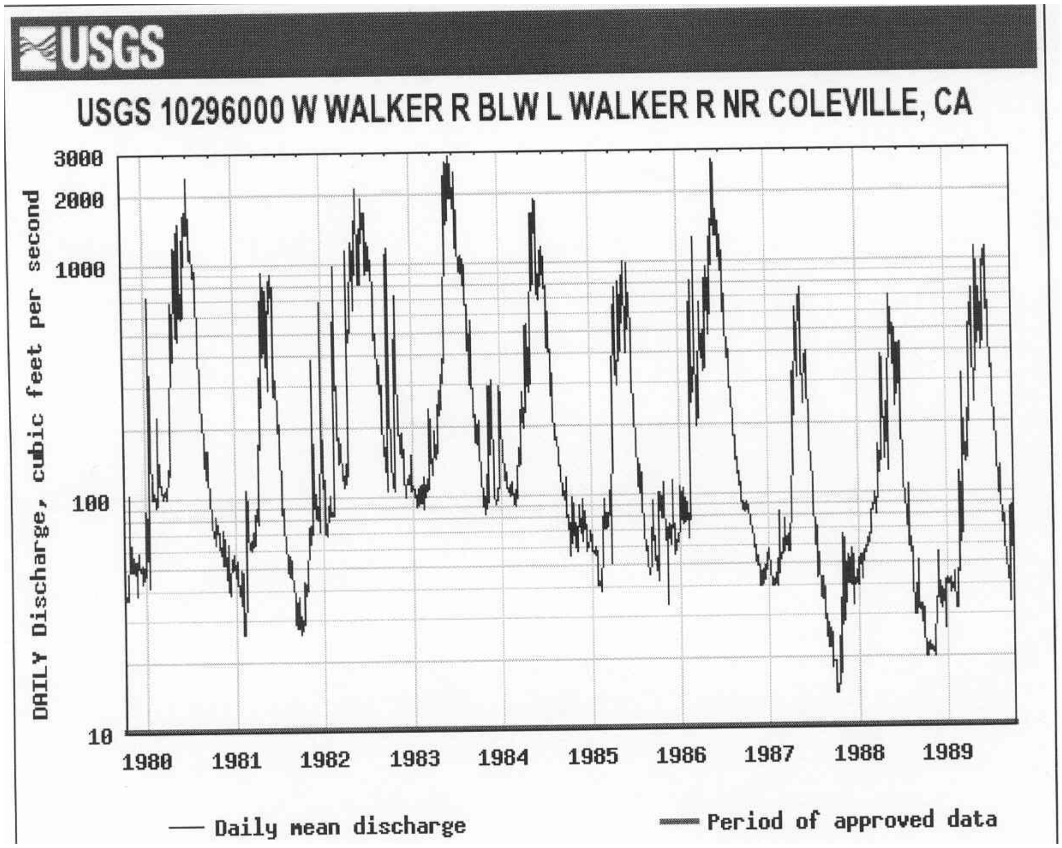
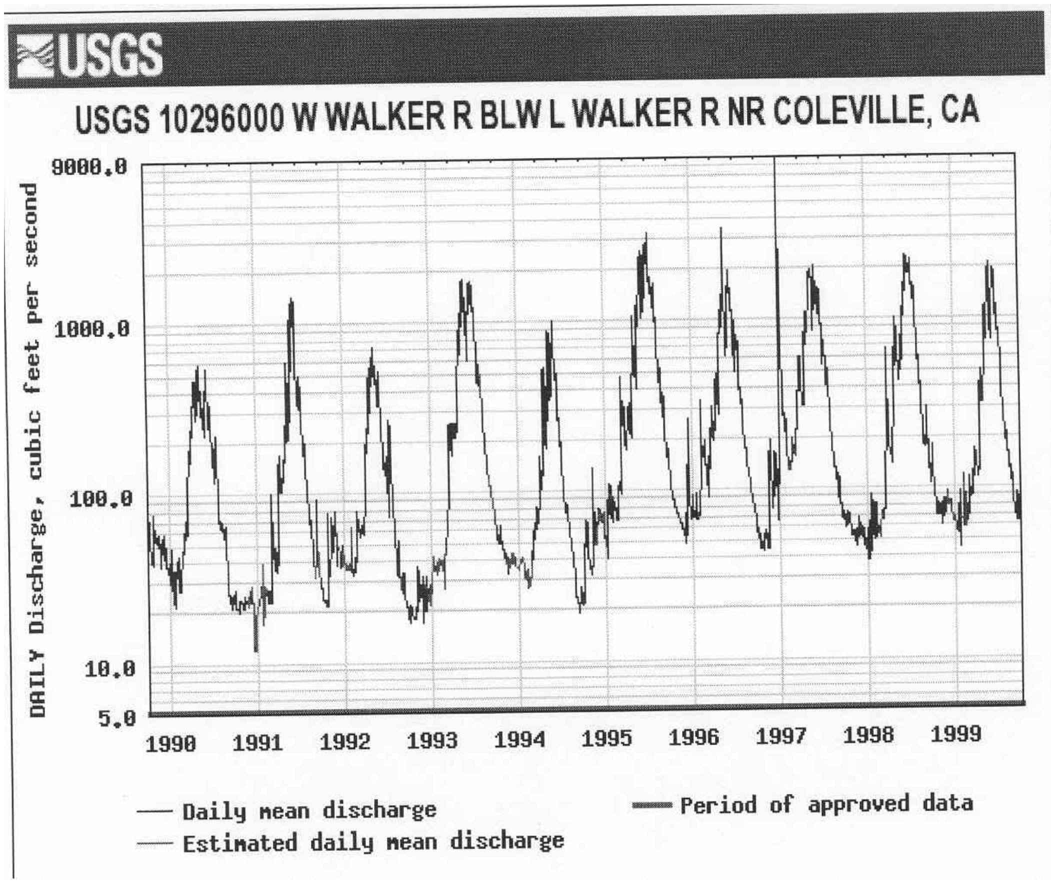


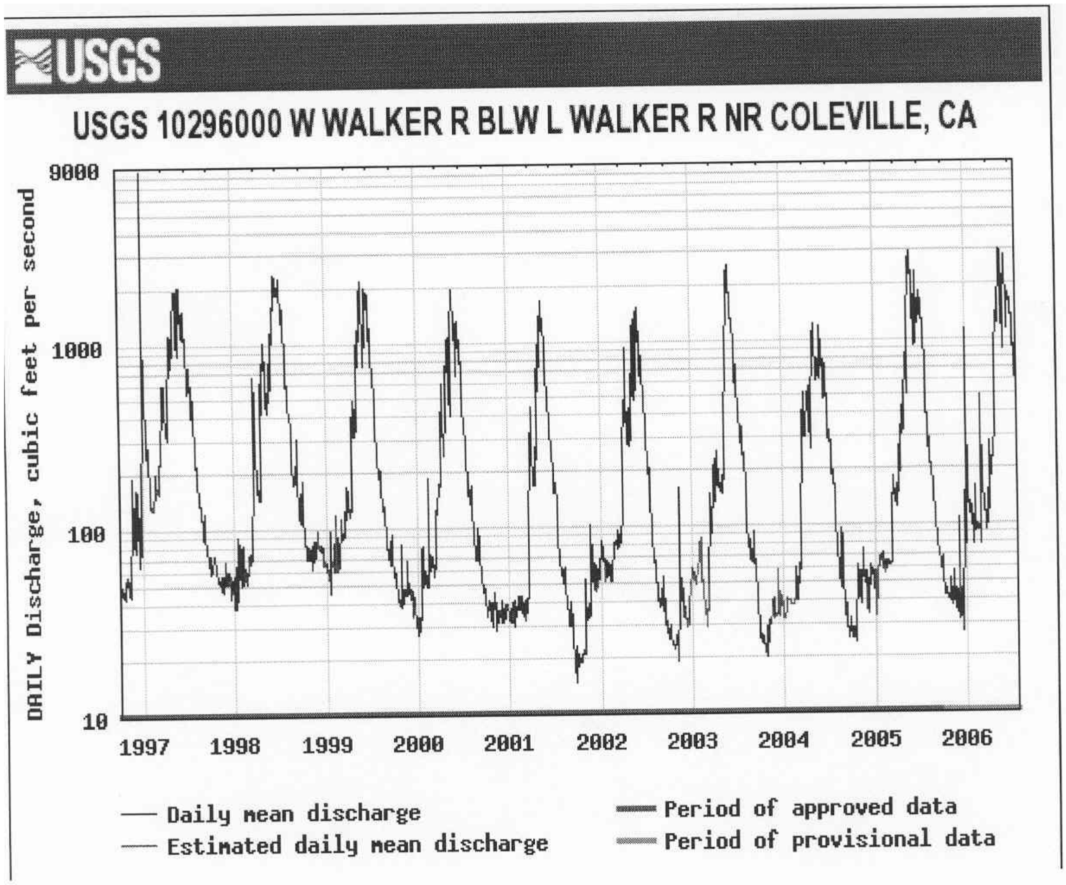
Figure 16. Monthly discharge reaches a maximum in June from snowmelt and remains low from September through March. The West Walker River below the confluence with the Little Walker River has a much larger contributing area and receives greater precipitation than the Little Walker River and has much larger flows as a result.

Figure 17. The hydrograph of the West Walker River below the confluence of the Little Walker River illustrates the variability in flows from year to year over the period of 1970-2006. Note the flood peak of January 1997 is about three times greater than the highest snowmelt peaks. Data and graphs from U.S. Geological Survey.




USGS
USGS 10296000 W WALKER R BLW L WALKER R NR COLEVILLE, CA
DAILY Discharge, cubic feet per second
3000
2000
1000
100
10
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
Daily mean discharge
Period of approved data


USGS
USGS 10296000 W WALKER R BLW L WALKER R NR COLEVILLE, CA
DAILY Discharge, cubic feet per second
9000.0
1000.0
100.0
10.0
5.0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
Daily mean discharge
Estimated daily mean discharge
Period of approved data



Droughts and floods

As noted in the climate section, severe and persistent droughts occurred in the West 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 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, and 1988-92. Topaz reservoir was drained below its operating capacity at times during these dry years. 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 Walker watershed include winter rain floods, spring snowmelt floods, and localized floods often associated with summer thunderstorms.

Flood damage from the winter rainstorms is most significant in Antelope Valley where low-lying lands can be inundated in even relatively small rainstorms (California Department of Water Resources, 1992). Many lots in the community of Walker, especially between North River Lane and Meadow Drive, are within the 100-year flood plain of the West Walker River (Mono County Office of Emergency Services, n.d.; Mono County Department of Public Works, 2002).

As an example of how large rainfall amounts can be during the major flood-producing events, on February 1, 1963, 6.58 inches of rainfall was recorded at Topaz, which has an average annual total of 10.6 inches (Carson COG, 1974).

Snowmelt runoff in 2005 largely filled the channel of the West Walker River within Antelope Valley. In late May, water levels ranged between 8 and 9.2 feet at a gage where 9.0 feet is considered flood stage. Minor flooding was reported between Walker and Topaz (Reed, 2005a). Snowmelt runoff again filled the West Walker River to near flood stage in May 2006.

Prior to the January 2, 1997, peak of about 12,500 cfs, the flood peak of record at the West Walker River near Coleville gage was 6,500 cfs on Dec. 11, 1937 (California Department of Water Resources, 1992).

Floods listed by Mann, 2000:
winter rainfall
- 12-11-37
- 11-20-50
- 12-23-55
- 1-2-97

spring snowmelt
- 1907
- 1967
- 1969
- 1995
- 1996

Floods listed by Carson Council of Governments 1974:
wet-mantle floods
- 3-19-07
- 6-xx-14
- 6-6-22
- 12-10-37
- 11-18-50
- 12-23-55

dry-mantle floods
- 7-52
- 7-28-60
- 7-30/31-65
- 8-16-65

Peak flows (Carson COG 1974)

gage	DA(mi^2)	ave Q	peak Q	per mi^2	date	record began
WW near Leavitt Mdw	73	--	1440	19.7	7-19-71	1946
WW below Little Walker	180	259	6220	34.6	11-20-50	1938
WW near Coleville	271	275	6500	24.0	12-11-37	1903
Little Walker	63	51	1510	24.0	1-31-63	1944
Slinkard Creek trib	0.14	---	5.0	35.7	8-18-71	1963
Desert Creek	50.4	---	262	5.2	6-5-69	1965

Annual peak flows for West Walker River near Coleville

Date	Peak Discharge (cfs)
1903-06-01	2030
1904-05-25	2100
1905-06-13	1160
1906-07-03	3300
1907-07-03	4170
1908-06-13	1050
1909-06-04	2220
1910-05-25	1680
1916-06-17	1830
1917-06-17	2400
1918-06-14	2280
1919-05-29	2180
1920-05-18	1500
1921-06-12	2710
1922-06-05	2640
1923-06-11	1770
1924-05-09	856
1925-05-27	1660
1926-05-20	1430
1927-06-16	2350
1928-05-26	1480
1929-06-16	1370
1930-06-12	1450
1931-05-07	870
1932-06-26	2020
1933-06-14	2120
1934-06-18	750
1935-06-13	1950
1936-06-23	1540
1937-05-29	2200
1937-12-11	6500
1957-06-04	2000
1958-06-24	2230
1959-05-13	884
1960-06-02	1270
1961-05-26	869
1962-06-22	1500

1963-02-01	2510
1964-05-20	1030
1964-12-23	2710
1966-05-22	1100
1967-07-02	2840
1968-06-03	1330
1969-06-04	3220
1970-06-04	1540
1971-06-27	1990
1972-06-01	1650
1973-05-19	2200
1974-06-07	1980
1975-06-02	2450
1976-05-14	865
1977-06-02	584
1978-06-14	1910
1979-05-27	2250
1980-07-01	2650
1981-06-06	1170
1982-05-27	2240
1983-05-30	3540
1984-05-14	2070
1985-06-08	1230
1986-06-01	3300
1987-05-17	1020
1988-05-16	767
1989-05-09	1150
1990-05-06	619
1991-06-11	1800
1992-05-08	794
1993-05-19	2010
1994-05-31	1250
1995-07-09	4420
1996-05-16	4040
1997-01-02	12500
1998-06-22	2730
1999-05-29	2750
2000-05-28	1940
2001-05-17	1720
2002-06-01	1470
2003-05-29	3400
2004-05-28	1400

January 1997 Flood

The January 1997 flood is the highest flood on record in the West Walker River and caused extensive damage within Walker Canyon and Antelope Valley. 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 West Walker River and its tributaries.

The peak discharge of about 12,300 cfs at the USGS gage below the confluence with the Little Walker River on January 2, 1997, was twice as great as the previous flood of record (6,200 cfs on November 20, 1950). The third largest flood on record had an estimated peak of 5,800 cfs on December 11, 1937 (Bonner, et al., 1998, cited by Mann, 2000). Flood peaks on the Truckee and Carson rivers to the north in 1997 were less than historic peaks in 1950 and 1955. The watermaster for the West Walker River estimated a flood peak of about 14,000 cfs within the Antelope Valley (KMMT, 1997). The Little Walker River was estimated by the USGS to have contributed about 20 percent of the 1997 peak flow (Mann, 2000). This tributary accounts for about 25 percent of the drainage area above the mouth of the Walker Canyon, but much of its area is at higher elevations that would have been expected to yield less water on a unit-area basis.
Many homes at Mountain Gate and in Antelope Valley were destroyed or damaged by the flood waters. Preliminary accounts included 34 homes destroyed, 55 homes with major damage, and 14 homes with minor damage (Review-Herald, 1997). By late January, 32 people had received housing payments from the Federal Emergency Management Agency (Adams, 1997). Mono County received about $5 million in 1998 from the Hazard Mitigation Grant Program of the Federal Emergency Management Agency. Part of this grant went to raising about 20 homes at least one foot above the local base flood elevation, and the remainder of the funds went to acquiring parcels within the floodplain (Mammoth Times, 1998). Large areas of agricultural fields adjacent to the river were covered with sand, gravel, and other debris deposited by the flood waters.

Nine miles of U.S. Highway 395 within Walker Canyon was damaged by the flood. The road was rebuilt and opened about seven months after the flood, on June 28, 1997. The reconfigured river channel and adjacent roadbed were designed to accommodate future large flows. About two million tons of earthwork was involved in the construction project (Juneau, 1997). The $30 million cost of the project was largely funded by the Federal Emergency Management Agency.

Baseflow

The recorded low flows in the Little Walker River generally ranged from 15 to 25 cfs (or about 0.2 to 0.4 cfs per square mile -- typical values for upper-elevation Sierra Nevada streams). Similarly, the recorded low flows at the West Walker River near Coleville gage generally ranged from 20 to 50 cfs (or about 0.1 to 0.2 cfs per square mile). The much greater contributing area of the West Walker River near Coleville (250 mi^2 vs. 63 mi^2) that includes a large fraction of land that receives much less precipitation than the Little Walker River watershed accounts for the smaller values of baseflow on a unit-area basis. During dry years such as 1977, baseflow discharges dipped to about half the average values

Lakes

Detailed descriptions of most of the lakes in the higher-elevation portions of the watershed can be found in Milliron, et al., 2004. Hydrologically, the small lakes of the West 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.

Groundwater

Within the West 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 one of the three groundwater basins. 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 basins of Antelope Valley, Little Antelope Valley, or Slinkard Valley. Alluvial sediments have accumulated to depths of dozens to hundreds of feet within these structural basins and have vast storage space in the pores between the particles. The estimated storage capacities of the groundwater basins of Antelope and Slinkard valleys are 160,000-170,000 and 72,000 AF, respectively (California Department of Water Resources, 1964). These estimates were based on a storage interval between 10 and 100 feet and a specific yield of 5 percent to 15 percent.

The Antelope Valley groundwater basin is composed of a sequence of interbedded alluvial fans, floodplain and stream channel deposits, and lake sediments. The main water-bearing formations are sediments of Recent age. Additional groundwater occurs within fractures and joints of volcanic, granitic, or metamorphic rocks. Groundwater in Antelope Valley is found in both unconfined and artesian zones. Depths to the uppermost groundwater vary from 160 feet in the southeastern portion of Antelope Valley to less than two feet in many places in the center of the valley (California Department of Water Resources, 1964).

The valley fill consists of unconsolidated brown or bluish sandy silty gravel with occasional boulders. This material, originally derived from glacial erosion in the higher terrain to the southwest, was transported in large quantities by streams flowing from the glacial areas and deposited in the Antelope Valley area. The thickness of these deposits is unknown, but it is assumed that similar 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, 1964).

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 (California Department of Water Resources, 1964).

A recent report by the California Department of Water Resources contained a little information on groundwater levels within the Antelope Valley. Based on 76 domestic well completion reports, depths ranged from 48-415 feet with an average of 184 feet. Based on nine irrigation well completion reports, depths ranged from 130-365 with an average of 253 feet. There is no routine monitoring of well levels reported to the state (California Department of Water Resources, 2004).

Within the West Walker River basin, most domestic water supply comes from groundwater. 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 Antelope Valley. Water infiltrates from the canals, and a lot of applied water infiltrates below the root zone of crops (California Department of Water Resources, 1992).

Boron, fluoride, and arsenic have been found in water from artesian wells near the center of Antelope Valley. Five wells were sampled in Antelope Valley, and one had a concentration above a Maximum Contaminant Level for inorganics-primary, and two had a concentration above a Maximum Contaminant Level for radiological (California Department of Water Resources, 2004).

Diversions and storage

The largest diversions from the West Walker River occur at the lower end of our state-boundary-defined watershed. In the northern portion of the Antelope Valley, water from the West Walker River is diverted into Topaz Reservoir, where it is stored for controlled release to irrigators downstream in Nevada. Topaz Reservoir occupies a topographic depression, which formerly contained a small natural lake known as Alkali Lake. The Walker River Irrigation District created Topaz Lake by constructing a diversion and three-mile-long canal from the West Walker River into this closed basin. Topaz Reservoir began to store water in 1921. A tunnel and canal release water back into the river via a tunnel and canal on the Nevada side (California Department of Water Resources, 1992).

Smaller-scale water development began in the West 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. The most recent of these small reservoirs dates to about 1910. Water rights associated with these reservoirs were incorporated in Decree C-125 in 1936, which is the primary basis for water rights in the watershed (California Department of Water Resources, 1992).

Four privately owned reservoirs are included in Decree C-125:

Black Reservoir (also known as Junction Reservoir) is located where Black Creek is impounded by a 18-foot-tall dam. Black Reservoir occupies a topographic low point at the edge of a meadow and provides a head of water for irrigating adjacent pasturelands in Sonora Junction area. The 350 AF storage right dates to 1907.

Lobdell Lake on Deep Creek has a 27-foot-tall dam, a physical capacity of 640 AF, and a diversion right of 6 cfs dating from 1864. The stored water is to be used in the south end of Smith Valley. The high elevation of the reservoir site (over 9,200') facilitates delivery of water down steep-gradient Desert Creek to Smith Valley.

Poore Lake on Poore Creek is contained by a 23-foot-tall dam. The reservoir has a 1,200 AF storage right dating to 1901. The stored water is to be used in Antelope Valley (California Department of Water Resources, 1992).

Topaz Reservoir is owned and operated by the Walker River Irrigation District. It was completed in 1922 and has a usable storage capacity of 59,439 AF (decreed rights are for 50,000 AF and 35,000 AF refill for a total water right of 85,000 AF). The reservoir has an outlet tunnel of 1,200 feet plus an open canal. Dead storage below the level of the tunnel's inlet totals approximately 65,000 AF, providing a total lake capacity of almost 125,000 AF (Horton, 1996).

Within Antelope Valley, the West Walker River has been diverted into canals for local irrigation for more than a century. About 11 miles of the 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 Antelope Valley total about 64,700 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.

The Reclamation Service (later U.S. Bureau of Reclamation) studied a few potential reservoir sites in the early part of the 20th century, but abandoned its efforts after failing to find agreement

among potential water users. The following quotation, taken from the Fourth Annual Report of the Reclamation Service, 1904-05, describes these attempts by the Reclamation Service:
"At the insistance of the farmers in the valley of Walker River, who are involved in litigation over their water rights on account of the insufficiency of the supply for irrigation in the latter part of the season, the Secretary authorized an investigation of the feasibility of storing enough of the flood waters to provide an ample supply to all lands now under cultivation and irrigation. A reservoir site for this purpose was carefully examined and found to be economical of construction, but the land owners have thus far failed to organize a water-users' association, and take the other necessary steps in compliance with the terms of the reclamation act, which are a condition requisite to the commencement of construction. In the meantime, in cooperation with the State engineer, all the irrigated and irrigable lands, together with the two other reservoir sites, are being surveyed and mapped..."
(California Department of Water Resources, 1992)

Efforts by the federal government to obtain an irrigation supply for the Walker River Indian Reservation eventually led to issuance of Decree C-125 in 1936 (California Department of Water Resources, 1992).

Water rights, use and management

Details about the water rights in the West Walker River watershed may be found in the appendix on water rights that contains material directly quoted from the original sources.

Most of the water that is diverted for agricultural use is removed from the channel of the West Walker River. Water is also diverted from Slinkard, Lost Cannon, Deep, and Molybdenite creeks and the Little Walker River for agricultural use. Silver Creek has a small diversion for domestic use by the USMC Mountain Warfare Training Center (Mono County, 1992). Depending on whose figures are used, between 17,000 and 20,000 acres of land within the California portion of the watershed have rights to water from the West Walker River or its tributaries.

Decree C-125 is the primary legal document that determines water rights within the West Walker River watershed. This decree assigned priorities and amounts of water for irrigating specified lands of the parties and allowed incidental domestic and stock-watering uses to be served under the irrigation rights (California Department of Water Resources, 1992). Although the decree encompasses water rights in both California and Nevada, it is not an interstate allocation of the waters of the Walker River. Neither state was a party to the decree. The decree is administered in the field by a watermaster service and board of commissioners under jurisdiction of the federal district court in Reno (California Department of Water Resources, 1992). For most of the Antelope Valley, the Antelope Valley Mutual Water Company distributes water to its shareholders. In a year with average streamflow, only 85 percent of the water right entitlements in the Antelope Valley can be satisfied after the snowmelt flows have receded (USDA Nevada River Basin Study Staff, 1975; Weisshaupt, 1987; cited by Mono County, 1993). There have been occasional conflicts between property owners, irrigators, and the Antelope Valley Mutual Water Company over the use and maintenance of the irrigation ditches throughout the Antelope Valley.

During the brief frenzy of interest in small hydroelectric facilities in California in the 1980s, a few projects in the West Walker River watershed were proposed. These proposals included

Sonora Peak Project on Silver Creek:	diversion at about 8,400 ft	powerhouse near MWTC
North Star Project on Little Walker R	diversion N of Sonora Jct	powerhouse above

confluence (North Star Hydro Ltd., 1987).

Urban runoff and stormwater management

Despite the erroneous mention of "high urban density" and "urban runoff" as probable sources of water quality impairment in the West Walker River in the US EPA 303(d) listing, the watershed does not contain anything approaching an urban area. Perhaps, the largest areas of impermeable surfaces would be the Marine Corps MWTC in Pickel Meadow and the Marine Corps family housing area in Coleville.

Wastewater treatment and disposal

Residences and businesses in Coleville and Walker rely on septic tanks and leach fields for sewage disposal. There are concerns about effectiveness of some of these systems in areas with high water tables. The USMC Mountain Warfare Training Center has a 100,000 GPD package waste treatment plant and leach fields (Mono County, 1992).

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 West Walker River watershed, so this section of the assessment is particularly weak.

Glacial remnants

Most of the landforms in the Sierra Nevada portion of the West 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. The Sonora Junction area and Antelope Valley are 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 glaciers of the West Walker River were the largest Pleistocene-age glaciers in the eastern Sierra Nevada (Clark, 1967 cited by Mann, 2000). The most recent glacial advance, called the Tioga, which ended about 10,000 years ago, resulted in a glacier extending from the Sonora Pass area to Sonora Junction (Clark, 1967 cited by Mann, 2000). The terminus of this glacier was about 20 miles from and 3,000 feet below its source area. Leavitt Meadow shows much evidence of glacial activity. Much of the Mountain Warfare Training Center is located on a lateral moraine informally called Pickel Bench. The Tioga glaciation produced most of the terminal moraines in Walker Canyon, which is otherwise composed of volcanic rocks (California Department of Water Resources, 1992).

Channel processes

In forested mountain areas like the West 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).

The Humboldt-Toiyabe National Forest described the streams of the west side of the watershed as follows: “The upper, high relief areas of the watershed have streams that are steep, entrenched, cascading step/pool streams with high energy/debris transport and very stable, being dominated by bedrock or boulders. Streams where the relief is reduced, for example near Sonora Bridge, have moderate entrenchment, moderate gradient, riffle-dominated channels, infrequently spaced pools, stable profile and banks and colluvial deposition. Streams of the Antelope Valley have lower gradients, meandering, point-bars, riffle/pools, and alluvial channels with broad, well defined floodplains, terraces, and alluvial soils" (USDA-Forest Service, 2004).

Catastrophic flooding can cause major erosion of stream channels, such as in Walker Canyon 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). In the geologic past, the West Walker River within Walker Canyon was probably dammed several times by landslides, which were later breached. These temporary dams and their collapse led to massive flooding and scour of Walker Canyon. A series of debris flow deposits separated by well-developed soils have been identified by Stine (personal communication, 2000, cited by Mann, 2000). The seven events identified by Stine ranged in age from 2,760 years ago to 290 years ago. These events were probably significantly larger than the 1997 flood.

A channel survey by the Bureau of Land Management in the early 1980s found that channel incision or gullying was occurring on about a quarter mile of each of Little Lost Canyon Creek, Lost Cannon Ditch, and an unnamed creek along Golden Gate Mine Road (USDI-Bureau of Land Management, 1982). This survey also found gullying along about three-quarters of a mile of tributary #1 to Slinkard Creek.

Surface erosion

There are no known studies or measurements of surficial erosion within the West 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.

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 West 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). The same report estimated yield from Antelope Valley and some areas on the east side of the watershed as 0.1 to 0.2 acre-feet per square mile. 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).

Sedimentation of one reservoir downstream in the Nevada portion of the West Walker River basin has been measured by the U.S. Geological Survey. Weber Reservoir had a capacity in 1935 of about 13,000 acre-feet. By 1972, the U.S. Geological Survey estimated that sedimentation had reduced storage capacity to 10,700 acre-feet (California Department of Water Resources, 1992).

Human influences

Besides the detailed study by the Humboldt-Toiyabe National Forest, which is excerpted below, few studies are known to have examined human influences on erosion and sediment delivery within the West 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. A study being conducted by UC Santa Cruz has identified a number of stream reaches being used as reference sites along the West Walker River, Poore Creek, Silver Creek, and the Little Walker River (USDA-Forest Service, 2004). 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).

The reach of the Little Walker River near Sonora Junction has been leased for cattle grazing for many years, and the banks show some degradation from trampling (North Star Hydro Ltd, 1987).

A research study compared conditions between grazed treatment sites and ungrazed control sites within the West Walker River watershed and followed recovery of some of the grazed areas when rested (Herbst and Kane, 2004). Some of the study’s results are quoted below:
"At the start of the study, each size class of the control sites had three to ten times more riparian cover, 11 to 24 percent more stable banks, and 7 to 11 percent more undercut banks than corresponding size classes of treatment sites. Consistent differences were not found for vegetated banks, fine materials and sand, D50 particle size, cobble embeddedness, channel width, depth, velocity, or discharge between treatment and control sites.

“In general, most small treatment sites showed a recovery response for most of the recovery parameters (such as riparian cover, bank stability and cover, and channel substrate) while most small control sites did not, indicating that management actions at small treatment sites were effective in inducing improved channel and riparian conditions over the three-year period. Most large and medium treatment sites showed a recovery response for most parameters as well, but so did large and medium control sites, such that recovery of medium and large treatment sites cannot necessarily be attributed to management actions for this three-year period.

“Grazing impacts and potential for recovery are likely to be conditional on the intrinsic resistance conferred by such features as bank armor, substrate size, gradient, flows, and other geomorphic and ecological attributes of each stream." (Herbst and Kane, 2004).

Excerpts from the evaluation of erosion problems by the Humboldt-Toiyabe National Forest

During 2001 and 2002, the Humboldt-Toiyabe National Forest conducted an extensive survey of erosion and hydrologic conditions and a road inventory on National Forest lands within the West Walker River watershed (USDA-Forest Service, 2004). Because the original text is thorough and would not benefit from any reinterpretation here, much of the relevant material from the Forest Service report is abstracted below without editorial modification. However, only portions that were judged to be most relevant to the Mono County assessment are quoted below. The original report (USDA-Forest Service, 2004) should be read for the complete context. The text is organized geographically by Forest Service management unit: Piute (west of U.S. Highway 395 / south of State Route 108), Mill (west of U.S. Highway 395 / north of State Route 108), Sweetwater (east of U.S. Highway 395).

Piute Unit

This survey identified road related erosion problems, such as gullying, rilling, and stream bank erosion on the Leavitt Lake Forest Road and the user created road leading to Koenig Lake. These roads are in the Koenig Lake critical aquatic refuge. Bridgeport RD staff have identified road related erosion problems and impacts to riparian vegetation in a number of other locations, including the Kirman Lake Road and the Poore Lake road.

The Piute Unit is a very popular recreation area. Camping, hiking, OHV use, and pack stock can all result in soil compaction, loss of riparian vegetation, and surface and channel erosion. Poor sanitation facilities can cause water quality degradation.

There are 110 miles of trails in the Piute Unit. Many of these are near streams and lakeshores. The trail up the West Walker River is of particular concern due to its heavy use.
Dispersed camping sites are concentrated along the West Walker River and at Leavitt Lake. These sites were mapped in 2001 (Recreation sites and special uses map). Many of these camping sites are in riparian conservation areas and the Koenig Lake critical aquatic refuge.
A number of developed recreation sites are located in riparian conservation areas, including Leavitt Campground, Leavitt Lodge, and Leavitt Pack Station.

Livestock grazing was unregulated on the Sierra Nevada rangelands for many years. Past overuse of the rangelands in the West Walker country has contributed to less than satisfactory hydrological conditions.

Several areas of concern were identified on the Sardine C&H allotment. Kennedy Canyon has soil disturbance from cattle trampling the meadows. Meadows in the Leavitt Lake drainage show signs of damage from cattle trampling. This has caused active erosion in the NW corner of the meadow. It has unstable banks and lateral headcuts (USDA FS, 2210 files, 1988, 1989). While it is unclear if livestock grazing is the sole cause of these problems, historic livestock grazing is likely a contributing factor.

The Piute C&H allotment is not currently stocked. Grazing related damage is historical. Past cattle use in Upper Piute Meadows caused poor stream bank conditions, including dry washes and bank sloughing. Middle Piute Meadows have evidence of past bank sloughing. Middle Piute Meadows have evidence of past bank sloughing, but they appear to be healing and are now covered with perennial grasses. Lower Piute Meadows also show signs of bank sloughing (USDA FS 2210 files, 1987, 1991).

The Junction C&H allotment includes portions of Poore Creek and the West Walker River. Livestock utilization monitoring studies, including stream bank disturbance, were conducted in Poore Creek in 2001. They indicated that the creek was at 60 percent of its potential and had a rating of fair. Other studies in this allotment are being conducted by UC Santa Cruz along the West Walker River. They include aquatic macroinvertebrate studies, water chemistry, water temperature and photographic reference points.

Mill Unit

The Mill Unit is drained by the tributaries of the West Walker River north of Highway 108 above Walker Canyon. These include Brownie, Wolf, Cloudburst, and Silver creeks. This unit also includes Mill and Lost Cannon creeks, which flow north and join the West Walker River near the town of Walker below Walker Canyon. There are 90 miles of perennial and 75 miles of intermittent streams in this area. The Wolf Creek, Silver Creek, Summit Meadow and Mill Canyon subwatersheds are all designated as critical aquatic refuges. Wolf Creek, Silver Creek and Mill Creek have all been channel-typed using the Rosgen stream classification method. Most of the upper reaches on these streams are type A - steep, entrenched, cascading step/pool streams with high energy/debris transport and very stable, being dominated by bedrock or boulders. Type B stream reaches are also common in this area. They have moderate entrenchment, moderate gradient, riffle-dominated channels, infrequently spaced pools, stable profile and banks and colluvial deposition. A few reaches are Type C - streams have lower gradients, meandering, point-bars, riffle/pools, and alluvial channels with broad well defined floodplains, terraces and alluvial soils. Maps and reports generated from the classification are available for review in the Bridgeport RD office.

The Cannon and Slinkard fires burned within this unit in the summer of 2002. About 43% of the Mill Creek watershed and 21% of Lost Cannon watershed burned. A burn area emergency rehabilitation assessment was conducted on the Cannon fire and erosion control measures were implemented in September of 2002. Almost 1,000 log erosion barriers were installed in Terry Canyon. This subwatershed is a tributary to Mill Creek and burned with high intensity. About 100 acres on both sides of Mill Creek were treated with lop and scatter of junipers. Several small rainstorms during the summer have already resulted in sediment flowing across the road.

Accelerated erosion is anticipated for several years until vegetation becomes established. The riparian vegetation along Mill Creek is making a rapid recovery.

Tollhouse Canyon was nearly all burned. Sediment flowed out of this canyon, across U.S. Highway 395 and into the West Walker River during a summer rainstorm. This canyon is very steep and erosive and will likely produce more sediment during the next few years in response to storm events. Most of the canyon is in private ownership.

There are 1,415 miles of roads in the Mill Unit. About 90 of these miles are on Forest roads. Many of these roads are used and maintained for mountain warfare training by the Marines. The Riparian Area Roads map displays the stream system and road network. Thirty-nine miles of roads are in the riparian conservation areas designated in the Sierra Framework Amendment. Roads in these riparian areas have a high potential for water quality impacts on the adjacent stream channels. In addition there are 50 road/stream crossings.

A hydrologic survey of the West Walker watershed was conducted in 2001. It identified meadow erosion occurring near the Finley Mine Road near Cloudburst Meadow.

A road maintenance inventory for the Mill Unit was completed in 2002. It also identified problems in the Cloudburst drainage, including the culvert on the Cloudburst access road because it is causing some erosion.

The analysis identified unarmored low-water crossings within the Mill Canyon critical aquatic refuge. Minor erosion is occurring on the Lost Cannon Road just above the bridge over Lost Cannon Creek.

The Mill Unit is a popular recreation area, though not nearly as heavily used as the Piute Unit. Camping, hiking, OHV use, and pack stock can all result in soil compaction, loss of riparian vegetation and surface and channel erosion. Poor sanitation facilities can cause water quality degradation.

A primary area of concern is the dispersed camping near the end of the Mill Canyon road. These camping spots are encroaching on the stream. There has been a loss of riparian vegetation and erosion of the streambanks. This area is in the Mill Canyon critical aquatic refuge.

The Sardine C&H allotment is currently stocked. Past studies identified livestock trampling damage, severe headcuts, and many unvegetated banks in the Brownie Creek drainage bottom (USDA FS 2210 Files, 1988, 1999).

The Silver Creek S&G allotment is not currently stocked. Any damage from livestock grazing is historical. Studies conducted from 1985 to 1988 found problems in the Cloudburst and Silver Creek areas. This included unstable streambanks, active headcuts, and trampling damage in the Cloudburst Creek drainage. Grazing-induced silt and deteriorated streambanks in meadows were identified at Silver Creek (USDA FS 2210 Files, 1985-1988). More recent studies conducted in 2001 found improving conditions. These included stream bank stability, which is recorded in observed and references categories. These data are compared to obtain a rating of overall stream bank condition. Silver Creek was well within the 20 percent disturbance threshold from the Sierra Framework Amendment. It was rated good at 75 percent of potential.

Identical studies conducted in the Lost Cannon C7H allotment also found good conditions. Disturbance was well with the Sierra Framework Amendment threshold. The overall rating was excellent at 93 percent of potential.

Sweetwater Unit

The Wellington Hills and Sweetwater Mountain portions of the watershed are characterized by pinyon and juniper species. The density and cover of these woodlands are increasing and causing a decline in understory biomass, cover, and diversity. One of the concerns related to these changes is increased soil erosion.

This unit is drained by a large network of ephemeral channels that rarely reach the West Walker River. The West Walker River from Sonora Junction to Highway 338 is included in this unit. Other perennial streams include Rock Creek, Deep Creek and Cottonwood Creek. There are 140 miles of perennial stream and 435 miles of intermittent channels in this unit.

During the summer of 2002, the Cannon fire burned 6,400 acres in the Rock Creek and Deep Creek watersheds. A burn area emergency rehabilitation assessment was conducted after the fire. About 640 acres of these watersheds were seeded with native grasses in the fall of 2002.

There are 370 miles of roads in the Sweetwater Unit. About 164 of these are on Forest roads. The Riparian Area Roads Map displays the road network in relation to the stream system. There are 97 miles of roads near stream channels in this unit. In addition there are 44 road/stream crossings.

The West Walker interdisciplinary team analyzed several of these roads in September 2002. The analysis identified portions of the roads in Rickey and Blackwell Canyon in the bottom of dry washes. These flood occasionally and deliver sediment to Eastside Road in Antelope Valley. There are also some user-created roads that have some minor erosion associated with them. Rilling was identified on the road from U.S. Highway 395 to Wild Oat Mountain.

8. Description of water quality

The Lahontan RWQCB water body fact sheet for the West Walker River lists sedimentation, agricultural drainage, and water diversions as the primary water-quality problems in the West Walker River. The State of Nevada considers the water crossing the state line to not support beneficial uses because of excessive nutrient load.

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 West Walker River. Unfortunately, there is little available quantitative information to describe the sediment load of the river or its tributaries.

Metals

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, which is part of the East Walker basin. Samples from the West Walker River had total mercury concentrations within the range of natural background amounts: 0.62 ng/L in the water and 8 to 44 ng/g in the sediment (Seiler, et al., 2004). By contrast, 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). The absence of major mining and milling operations in the West Walker watershed appears to have minimized mercury contamination in marked contrast to the adjacent Carson and East Walker rivers.

Temperature

Herbst and Kane (2004) found that summer stream temperatures rarely exceeded 59°F in the control streams of their study within the West Walker River watershed. Summer temperatures of some of their treatment streams that had comparatively little riparian vegetation were well above 59°F. Maximum temperatures in their Poore Creek site exceeded 80°F in 2002.

Water temperature was measured intermittently in the 1950s and 1960s at the USGS stream gages on the West Walker River. These records, compiled by Blodgett (1971), show that winter stream temperatures ranged from 0°F to 39°F and summer temperatures ranged from 46°F to 72°F.

Dissolved oxygen

Limited sampling above and below Topaz Reservoir suggested that stratification of the stored water behind the dam results in less dissolved oxygen downstream of the reservoir than is present in the West Walker River upstream (Humberstone, 1999).

The Rotenone Story

Rotenone has been an important tool in fisheries management, particularly for removing non-native fish prior to reintroduction of Lahontan cutthroat trout. Rotenone is the common/commercial name for the chemical (2R, 6aS, 12aS)-1,2,6,6a,12,12a-hexahydro-2-isopropenyl-8, 9dimethoxychromeno[3,4-b] furo [2,3-h] chromen-6-one, which is poisonous to most fish (U.S. Environmental Protection Agency, 1988). It is derived from the roots of several plants, including *Tephrosia virginiana*, which grows as far north as Wisconsin and was used by Native Americans as a fish poison in the southern and southwestern United States. It is also a common insecticide used on horticultural and agricultural plants.

A review by the U.S. Environmental Protection Agency in the early 1980s noted that rotenone products registered for use as piscicides (fish poisons) have a high enough toxicity to fish to exceed special review criterion, which was designed to protect against unintended adverse effects to wildlife. However, the EPA concluded, "A pesticide should not be presumed against because it performs its intended effect by preventing, destroying, controlling, or mitigating target organisms." Since toxicity of rotenone to fish is considered an intended effect, the provision should not be invoked against rotenone by reason of this acute toxicity to fish (U.S. Environmental Protection Agency, 1988).

Rotenone treatments appear to cause temporary reductions in overall invertebrate populations until they are replenished by migration into the treated areas and by the gradual repopulation by survivors. The treatments can cause a permanent local loss of certain species or genera of aquatic invertebrates. Hazards to endangered species can be effectively prevented by requiring each proposed treatment site to be evaluated by state or federal fish and wildlife biologists as already required by label statements (U.S. Environmental Protection Agency, 1988).

isoning of birds, mammals, or humans is of negligible risk at the treatment rate of 2-mg/liter rotenone formulation. An occupation intake of 0.7-mg/kg/d rotenone is safe for humans, and the no effect level for dogs is 0.4 mg/kg/d. A person would have to drink 60,000 to 120,000 liters of treated water to receive a lethal dose (USDA-Forest Service, 1988).

etoxification of rotenone with potassium permanganate at the downstream end of the treatment zone and dilution by other streams joining in downstream minimizes if not prevents downstream impacts on other aquatic organisms (USDA-Forest Service, 1988). The decomposition of fish and invertebrates killed by the rotenone would increase nutrient concentration in the treated stream for days to weeks.

The EPA concluded that the available data did not show that the criterion for oncogenicity or reproductive effects was met or exceeded for rotenone in its various forms. However, there was sufficient cause for concern to support a requirement for additional testing. The chemical apparently decomposes rapidly when exposed to light and air.

In a Federal Register Notice published July 15, 1981, it was concluded that available data did not indicate that rotenone presented a risk of unreasonable adverse effects to man or the environment. The agency therefore removed rotenone from its list of suspect chemicals (U.S. Environmental Protection Agency, 1988).

Measurements of surface water quality

West Walker

The West Walker River was sampled twice in October 1968 and the following analytical results were reported by Glancy (1971):

Temperature (°F)	46	55
Calcium (mg/l)	13	20
Magnesium (mg/l)	3	5
Bicarbonate (mg/l)	76	107
Sulfate (mg/l)	11	16
Chloride (mg/l)	4	11
Conductance (micromhos/cm)	160	250
pH	7.7	7.6

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

Water samples were obtained at sites near Walker and Coleville in 1998 and 1999 (Humberstone, 1999).

				1998				1999		
	M	J	J	A	S	O	N	J	F	M
Conductance (micro-mhos)										
W	79	40	34	80	82	117	157	135	131	132
C	97	45	48	93	111	226	184	138	152	133
Total Dissolved Solids (mg/L)										
W	49	24	29	49	51	73	99	85	82	83
C	61	27	29	58	69	143	116	86	95	84
Dissolved Oxygen (mg/L)										
W	-	9.1	9.3	10.1	9.6	10.0	12.9	10.7	10.5	10.2
C	-	9.3	9.0	8.5	9.1	13.7	12.7	10.8	10.0	10.2
Dissolved Oxygen (percent saturation)										
W	-	99	100	118	104	104	121	102	102	102
C	-	98	101	101	103	149	111	105	99	103
Temperature (^{o}C)										
W	5.5	6.5	9.5	12.0	9.7	7.9	0	4.5	4.6	5.4
C	8.0	7.0	10.5	13.0	11.7	9.3	1.8	5.3	5.7	6.5

Results from water samples collected from the West Walker River on a single day (August 30, 1955) were reported in the application for a small hydroelectric project (North Star Hydro Ltd., 1987):

Discharge	15 cfs
Water temperature	67°F
Turbidity	0 ppm SiO_2
Conductivity at 77°F	203 micromhos/cm
pH	8.5
Total alkalinity	80 mg/l
Total hardness	38 mg/l
Calcium	11 mg/l
Magnesium	2.5 mg/l
Sodium	27 mg/l
Chloride	2 mg/l
Sulfate	16 mg/l
Fluoride	0.2 mg/l
Silica	18 mg/l
Boron	0.4 mg/l
Nitrate	0.5 mg/l

Conductivity in the Little Walker River was also measured twice during environmental work in regard to the North Star Hydro proposal. On June 10, 1988, with an estimated discharge of 60 cfs, conductivity was 190 micromhos/cm, and on September 16, 1988, with an estimated discharge of 15 cfs, conductivity was 350 micromhos/cm (Payne, 1988).

Water quality records from the stream gaging stations in the West Walker River watersheds indicted that water quality objectives for total dissolved solids, chloride, sodium, boron, and total phosphorus were exceeded on occasion (Team Engineering, 2006).

Topaz Lake

Analysis of sample taken from Topaz Reservoir 8-19-75 (Benson and Spencer 1983):

T (°F)	64
pH	7.9
EC	113
Total alkalinity (ppm HCO_3)	64
Cl	2.4 ppm
SO_4	4.8
F	0.17
Na	7.4
K	1.5

Ca	12
Mg	2.3
SiO_2	10
Al	0.03
Sr	0.11
Li	0.02
B	0.14
U	1.6+/-0.2 ppb
As	5.2+/-0.7 ppb
Br	5.8+/-0.5 ppb

Upper tributaries

Measurements in 1999 and 2002 (est from figs 18-28 in Herbst and Kane, 2004):

Attribute	Large West Walker	Medium Silver & LitWalk	Small CowCamp, Poore, Kirman, Cottonwood
pH	7.4-8.5	7.5-8.5	7.5-8.9
alkalinity HCO_3/L	24-58	36-65	36-125
hardness mg/L	14-21	20-40	22-120
conductivity microS	11-80	45-140	50-290
DO mg/L	7-10	7-10.5	6.5-10
turbidity ntu	<0.2-2.7	<0.2-6.8	0.3-3.2
total Phos mg/L	<0.05-0.01	0.01-0.04	0.01-0.14
silica mg/L	2-3	3-10	4-18
sulfate mg/L	<2-4	<2-7	<2-42
nitrate mg/L	0.003-0.005	0.004-0.007	0.002-0.045
TotKjeldahl N mg/L	0.04-0.08	0.05-.12	0.12-0.25

Very few 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). One of five public water supply wells tested in Antelope Valley exceeded the maximum contaminant level for one or more constituent in the "inorganics primary" category (antimony, arsenic, asbestos, barium, beryllium, cadmium, chromium, copper, cyanide, fluoride, lead, mercury, nitrate, nitrite, selenium, or thallium). Two of five public water supply wells tested in Antelope Valley exceeded the maximum contaminant level for radiological contaminants.

Biological indicators

Macroinvertebrates

A study of grazing impacts and recovery within the West Walker River watershed used macroinvertbrates as an indicator of stream health (Herbst and Kane, 2004). This study found that grazing impacts depend in part on stream size. The biota of medium to large-size streams appeared to be more resilient to the long-term effects of livestock grazing. In contrast, the invertebrate community of small streams appeared to be consistently impaired by greater exposure to livestock grazing, and did not respond to reduced grazing pressure over the short-term three-year period of the study (Herbst and Kane, 2004). Small grazed streams examined in the study tended to be less diverse and more productive than minimally grazed controls, suggesting that adapted organisms were thriving under disturbed conditions. “Enrichment and algal growth in these streams did not compensate for habitat degradation, and losses occurred in total diversity and among sensitive taxa, and the functional organization of food webs were altered (more algae grazers and reduced diversity within groups of taxa with overlapping resource utilization" (Herbst and Kane, 2004).

Human sources of pollutants

This section includes some anecdotal accounts of water pollution within the West Walker River watershed.

A water quality modeling study demonstrated that reducing diversions from the West Walker River would improve water quality in the river as well as Walker River, largely by providing additional water for dilution of dissolved salts (Humberstone, 1999).

In October and November 2003, "substantial" amounts of untreated sewage from the Mountain Warfare Training Center were discharged to on-site leachfields bypassing the sewage treatment plant because of a faulty pump. Lahontan RWQCB noted major violations in the last quarter of 2003. (LRWQCB XO report March 15, 2004).

Occasional spills of hazardous materials constitute another source of pollution. For example, on August 10, 2005, a tanker truck ran off Highway 89 and released hundreds of gallons of both gasoline and diesel fuel onto soil adjacent to Slinkard Creek. Hazard materials crews from both U.S. EPA and California Department of Fish and Game worked to contain the spill (Mammoth Times, 2005). A marine helicopter crashed about 30 feet from Wolf Creek in July 1996. Dikes were built with absorptive materials to prevent fuel from flowing into the creek (USDA-Forest Service, 1997).

A recent study in the Bridgeport Valley (Elkins, 2002) may provide some indications about nutrient and fecal coliform pollution in Antelope Valley. Although the two valleys have many

differences, Bridgeport Valley appears to be the best analogue to Antelope Valley that has been the subject of study of non-point-source 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) 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.

9. Subwatersheds with detailed information

Relatively few of the subwatersheds within the West Walker River watershed had information available relevant to this assessment.

Little Walker River

The watershed of the Little Walker River is composed of two semi-parallel watersheds of the main stem and Molybdenite Creek that are oriented from south to north and an east-west watershed of Hot Creek that begins near Devil's Gate. The area upstream from the confluence of the upper Little Walker River and Molybdenite Creek near the Obsidian campground is mostly forested and closed to vehicles. Below the confluence, a road parallels the Little Walker River and extends to the west in Poison Creek /Stockade Flat area. Grazing and recreation are the main land uses in this part of the watershed south of U.S. Highway 395. The Hot Creek tributary watershed contains several large parcels of private land: in the area of Fales Hot Springs, in the Wheeler Creek / Wheeler Flat area on the south side, and along the Burcham Creek /Cottonwood Creek road going north from Hot Creek. Wet meadows are found near Fales Hot Springs and along the Burcham Creek / Cottonwood Creek road. Although there are only a few structures at present, these parcels are likely to be developed in the future. U.S. Highway 395 parallels Hot Creek for much of its length, road construction has modified the stream channel. In the Sonora Junction area, there are about three square miles of private land that are mainly used for summer pasture. U.S. Highway 395 and State Route 108 pass through this area, and a dirt road follows Junction Creek to Junction Reservoir. A Caltrans highway maintenance station is located at Sonora Junction. The streams in this area are heavily used by anglers and other recreationists.

A stream gauging station on the Little Walker River just upstream from the confluence with the West Walker River has been operated by the U.S. Geological Survey since 1944. The watershed produces about 12 inches of runoff per year over its 63 mi^2 area, on the average.

West Walker River above Sonora Junction

Below a small alpine zone, the headwaters of the West Walker River are covered by largely undisturbed forest of lodgepole pine at higher elevations and Jeffrey pine and juniper down to about 7,000 feet. North of Tower Peak, the West Walker River drops more than 4,000 feet over 14 miles where it enters the southern end of Leavitt Meadow. Roads do not extend south of Leavitt Meadow and Poore Lake at about 7,200 feet. Within Leavitt Meadow, the West Walker River is joined by Leavitt Creek, which drains Leavitt Lake (9,556 feet) and other smaller lakes -- Ski Lake, Koenig Lake, and Latopie Lake -- as well as Sardine Creek. At the north (downstream) side of Leavitt Meadow, the West Walker River picks up Brownie Creek and then turns generally east by northeast and enters Pickel Meadow. Within Pickel Meadow, several small tributaries, including Poore Creek from the south, which drains Poore Lake (7,214 feet). Little Wolf, Cloudburst, Wolf, and Silver creeks enter the West Walker from the north in the Pickel Meadow area. The U.S. Marine Corps' Mountain Warfare Training Center is the principal developed area of the upper West Walker River watershed. State Route 108 climbs above Leavitt Meadow and follows Sardine Creek much of the way enroute to Sonora Pass. Forest roads follow Poore Creek, Leavitt Creek, and Silver Creek. The Silver Creek road forks at about 8,400 feet, with branches continuing to Silver Creek meadow and four private 40-acre parcels along the creek, Summit meadow, Grouse meadows, and a high route to the southwest that eventually connects with State Route 108. The four parcels along upper Silver Creek were considered for public acquisition several years ago, but whether the sale was completed is unknown.

Silver Creek has average daily flows ranging from 20-60 cfs during spring snowmelt to 5-10 cfs during the remainder of the year. Flows in Wolf Creek average about 4 to 10 cfs during summer months. Water temperatures, dissolved oxygen, food availability, cover, and spawning areas are all suitable for trout (California Department of Fish and Game, 2001). Beginning in 1992 and 1996, about 4.1 stream miles in the Wolf Creek watershed and about 4.3 miles of stream in the Silver Creek watershed were established as refuges for Lahontan cutthroat trout. A marine helicopter crashed about 30 feet from Wolf Creek in July 1996. Dikes were built with absorptive materials to prevent fuel from flowing into the creek (USDA-Forest Service, 1997). A recently-constructed dirt road that connects the Silver and Chango roads may contribute to future sedimentation problems and increase recreational use in the area (California Department of Fish and Game, 2001). The Silver Creek / Wolf Creek area has been grazed as part of the Forest Service's Silver Creek Sheep and Goat Allotment, which allows about 1,000 ewes and lambs during the summer and early fall (USDA-Forest Service, 1989). The area was rested after the permit was canceled in 1993 (California Department of Fish and Game, 2001), but the recent grazing status is unknown. Recreational use of the area is dispersed and includes hunting, fishing, hiking and primitive camping.

West Walker River below Sonora Junction

Downstream of the confluence with the Little Walker River, the West Walker River flows due north for ten miles through Walker Canyon before entering the south end of Antelope Valley. Between Sonora Junction and Antelope Valley, Burcham Creek, Driveway Creek, Grouse Creek, and Deep Creek join the West Walker River. The channel through Walker Canyon is relatively unstable following the January 1997 flood and extensive construction to rebuild U.S. Highway 395 through the canyon. There are also some canyon walls that shed soil and rocks into the river each year. The sediment load of the West Walker River can be expected to be relatively high as the river continues to adjust to reconfigured channel.

Deep Creek (with its tributary Cottonwood Creek) drains the largest area on the east side of Walker Canyon, but has modest runoff production compared to the watersheds on the west side of the basin that receive substantially greater precipitation. Deep Creek is partially diverted at Lobdell Lake with the water going down Desert Creek and not returning to the West Walker River until downstream of the study area. Rock Creek is the next important tributary to the north that also enters from the east.

Near the southern end of Antelope Valley, Mill Creek (with its major tributary of Lost Cannon Creek) joins the West Walker River. Mill Creek flows for about 10.5 miles in a northerly direction from its headwaters at about 9,400 feet to 6,600 feet near the town of Walker. Flows in the stream average 2 to 4 cfs during summer months. Water temperatures, dissolved oxygen, food availability, cover, and spawning areas are all good for trout (USDA-Forest Service, 1988). A refuge for Lahontan cutthroat trout in the Mill Creek watershed includes the headwaters and about 7.5 miles of channel downstream to a natural barrier falls located 100 feet upstream from the confluence with Lost Cannon Creek. About three stream-miles of the refuge are on parcels owned by the California Department of Fish and Game. The channel in the meadow owned by the department has the potential for the highest carrying capacity of Lahontan cutthroat trout (USDA-Forest Service, 1988).

Vegetation of the Mill Creek watershed includes forests of lodgepole pine and white fir at higher elevations and Jeffrey pine at lower elevations. Brushfields at upper elevations are comprised mostly of buckbrush and chokecherry. At lower elevations, the brush community is predominantly sage, bitterbrush, mountain mahogany and snowberry. There is an extensive dry meadow within the lower portion of the watershed (USDA-Forest Service, 1988). Much of the Mill Creek watershed burned in June 2002, and a fuel-reduction project in unburned portions was proposed by the Humboldt-Toiyabe National Forest in 2004 (Lucich, 2004). Burned portions of the watershed were rested from grazing for at least two growing seasons (USDA-Forest Service, 2004). Recreation use in the area is mostly dispersed with a few areas of concentrated use. The majority of use in the area is by deer hunters. Road crossings and areas where the road comes close to the creek appear to contribute sediment to the creek (USDA-Forest Service, 1997; California Department of Fish and Game, 2001).

After flowing through Antelope Valley, the West Walker River adds the remaining waters of Slinkard Creek that have not been diverted for irrigation. Much of the Slinkard Valley has been purchased by the California Department of Fish and Game for conservation of deer habitat. The Slinkard Valley runs roughly parallel to and west of Antelope Valley before Slinkard Creek turns east and meet the West Walker. Just downstream of this confluence, most of the water of the West Walker River is diverted into Topaz Reservoir, which serves as the downstream end of the watershed for this study.

Topaz Lake

Historically, Topaz Lake was a small, natural lake called Alkali Lake and was probably connected to the West Walker River (Horton, 1996). Ranchers and farmers downstream recognized the potential of Alkali Lake for water storage, and the upper Topaz Canal was built in 1921 to divert water from the West Walker River to the lake. The Walker River Irrigation District was created in 1919 to use Topaz Lake as a means of water storage and delivery to agricultural lands downstream. Water was first stored into Topaz Lake in 1922, and capacity was increased in 1937 (Horton, 1996). When the reservoir is full, the maximum depth is about 92 feet, mean depth is about 52 feet, and the surface area is about 2,410 acres. The reservoir has a total water capacity of 125,000 acre-feet, but usable storage above the depth of the outlet is 59,400 acre-feet.

If all the usable water is released for irrigation, then the remaining volume is about 65,000 acre-feet and the minimum water depth is 59 feet (Rush and Hill, 1972). This water volume and depth are sufficient for fish survival. During the summers of 1990-92, water levels were drawn down to the minimum and fish survived during seasonal low water (Sollberger and Sevon, 1997).

High nutrient loading from the West Walker River increases overall productivity in Topaz Lake. The Nevada Division of Environmental Protection collected nutrient and algal biomass data in 1992 and 1993 and classified Topaz Lake as mesotrophic to eutrophic. During late summer, the reservoir usually becomes nitrogen limited, and nitrogen fixing algae concentrate near the surface (Sollberger and Sevon, 1997).

The Nevada Division of Wildlife and California Department of Fish and Game have established a major fishery in Topaz Lake. The earliest record of stocking by Nevada was in 1930 with black bass (Sollberger and Sevon, 1997). Since then, the lake has been stocked abundantly with rainbow trout, brown trout, kokanee salmon, Lahontan cutthroat trout, cutbows (a hybrid between cutthroat and rainbow trout), tiger trout (a hybrid between brown trout and Eastern brook trout, and black bullheads (Sollberger and Sevon, 1997).

10. Evaluation of problems and issues

Water quantity and associated aquatic/riparian habitat

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

Agricultural water use leaves little water in the West Walker River during late summer.

Water quality

Some amount of accelerated erosion and sedimentation appears related to forest roads.

Microbial contamination of streams is assumed to be caused by careless disposal of human waste. There is some uncertainty about the long-term effectiveness of household septic systems.

There is potential, but no direct evidence, for contamination from excessive use of chemical fertilizers on fields, gardens, lawns, and parks. Nutrients from fertilizers that are not incorporated in plant tissue can be leached from soils and enter local streams. Excessive use of pesticides has potential to add toxic materials to waterways.

Vegetation change

The risk of catastrophic wildfire 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.

Potential watershed problems

Much of the agricultural land in Antelope Valley could be converted to residential land use.

Extensive clearing of vegetation and leaf litter for fire safety may lead to accelerated erosion.

Small areas of wetlands remain at risk of drainage and conversion to other land uses.

Knowledge and information gaps

Documented knowledge of the condition of riparian corridors and the location and condition of wetlands within the watershed is minimal.

Few water quality data exist anywhere in the watershed.

The source of the high nutrient loads observed in Topaz Lake is not known to be from natural sources or from agricultural runoff within Antelope Valley.

There is little quantitative information about natural and human-accelerated sediment delivery.

Summary and [over]simplifications

A watershed assessment inevitably illustrates the complexities of interactions between the hydrologic cycle, the landscape, and human activities. These complexities and associated uncertainties 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. So, the following summary remarks are intended to provide overview impressions and should not be used for development of policy or practices.

The watershed of the West Walker River produces large volumes of high-quality water. Estimates of the amount of water lost to evaporation from irrigation in the Antelope Valley range from 15,000 acre-feet to 33,000 acre-feet or 8 percent to 17 percent of the average flow of the West Walker River in the Antelope Valley (about 200,000 acre-feet). Any potential reductions in the consumptive use could contribute additional water to Walker Lake.

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 Walker Canyon, Antelope Valley, and the Mountain Warfare Training Center.

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 may play an important role in maintaining populations of amphibians.

Riparian areas and wetlands have been reduced in extent, complexity, and ecological functions. 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.

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