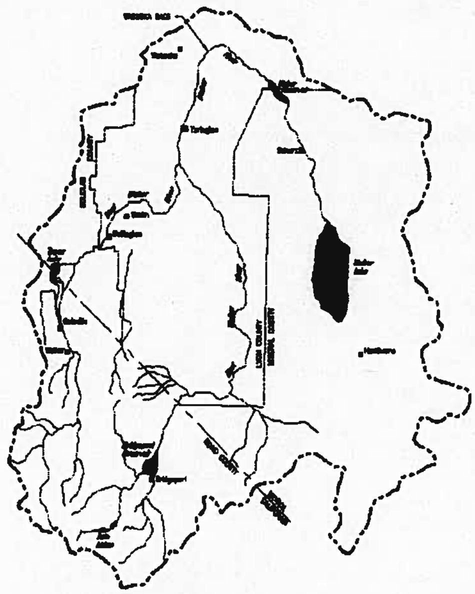
EXHIBIT 82

A REPORT OF FINDINGS: ACTIONS THAT MAY INCREASE FLOWS INTO WALKER LAKE



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Disclaimer

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> "The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Government."

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File Doc: WalkerROF fnl 98612.07cdz-jm2-45Walker

[February 18, 2000]

PROLOGUE

The following extended quote is from a document entitled "*Walker River Chronology: A Chronological History of the Walker River and Related Water Issues*" prepared by the Nevada Division of Water Planning in 1996. This quote provides sharp focus and historical perspective to the subject of the current report.

> "Throughout the century, farming, ranching, and agriculture have been an integral part of the Lyon County economy and a fundamental way of life for the residents of Smith and Mason valleys. It has been the crucial importance of this industry, as well as the rural lifestyle it has fostered, that has made issues pertaining to the protection of existing water rights and the maintenance of a healthy agricultural sector, so sensitive to the local population in these areas.
>
> To some degree, this area has been the victim of vastly changing federal priorities. In the late 1800's and early 1900's, federal homestead and land grant acts were passed to encourage western settlement. In the arid western states, such actions met with limited success except in those areas where water was readily available and the farmers and ranchers developed the storage and irrigation systems necessary to bring life to the desert, thereby increasing the economic productivity and social benefits of the resources of the areas. In the Walker River Basin, these national incentives, combined with determined local efforts to develop the resources of the land, have largely been a success, particularly in California's Bridgeport and Antelope valleys and Nevada's Smith and Mason valleys. By the late 1960's and early 1970's, however, federal legislation with respect to environmental priorities (National Environmental Policy Act), the plight of endangered and threatened species (Endangered Species Act), and a new emphasis on securing the rights of native-Americans, have come to reflect a new mandate for national policies.
>
> More recently, agriculture has come under growing criticism in this and other areas of Nevada for its seemingly disproportionate use of limited water supplies and its adverse affects on habitat. Less well known and recognized is that in addition to its contribution to the Lyon County economy, waters diverted for agriculture in Smith and Mason valleys have, in fact, made important contributions toward habitat creation and preservation in those areas. Nonetheless, since the first white settlements were established in the Walker River Basin, agriculture, more than any other pursuit, has insured the economic viability and sustainability of this region. Only time will tell if a lasting solution can be reached whereby environmental, habitat, recreation, Native American, and agricultural interests can co-exist and share the limited waters of the Walker River Basin."
>
> *(Horton 1996: pages I-20 and I-21)*

Chapter One — INTRODUCTION

Beginning in 1997, the U.S. Congress directed the Bureau of Reclamation (Reclamation) to work with local interests to identify effective water conservation practices applicable to the Walker River Basin, and to assess the contribution conservation could make in providing additional inflow to Walker Lake. On March 27, 1998, Reclamation issued a request for proposals seeking local interests willing to participate in this effort. Authorization and funding for this action was provided in the Energy and Water Development Appropriations Act, of 1998.

Through April and May of 1998, a loose coalition of local Walker River Basin interests began to develop a joint, collaborative proposal. Participants in those early planning efforts included the Walker River Irrigation District, the Antelope Valley Mutual Water Company, Mineral County, the Antelope Valley Water Users Group, the Walker River Basin Water Users Group, the Walker River Paiute Tribe, and the Walker Lake Working Group. Also involved in the discussions were representatives of Lyon County, Mono County, the Bridgeport Ranchers Organization, and the Mason Valley and Smith Valley Conservation districts. The Lyon County Extension Agent was requested to act as liaison by the group

On June 1, 1998, a proposal was submitted to Reclamation representing the participation of most local interests (the Walker Lake Working Group declined to participate, opting instead to submit a separate proposal). The premise of the proposal was that the identification and prioritization of water conservation measures relevant to the Walker River Basin is an activity best carried out by those who live along and rely on the Walker River. The proposed approach met goals and objectives identified in the congressional language and addressed needs listed in Reclamation's request for proposals - the need to identify the most effective water conservation measures, and to quantify contributions that conservation measures can make to solving identified regional issues. The proposal acknowledged that consideration of conservation at the level of the entire Walker River Basin would require the involvement of numerous entities.

In early July, the group of local interests was notified that it had been selected by Reclamation to receive the award. The group was uniquely qualified to conduct the work because it was comprised of a broad spectrum of local interests who live in the Walker River Basin and has first-hand knowledge of the basin's characteristics. Reclamation felt that such knowledge was important in any effort to define practical solutions to water resource problems in the basin. Involvement by local groups increases the chance that the resulting study will have buy-in from people likely to be affected by implementation of identified solutions.

The first task was establishment of the Walker River Basin Advisory Committee (Advisory Committee). By mutual consent, the Advisory Committee was comprised of two representatives from each of four geographic sub-areas within the basin (the upper, middle, and lower Walker River areas, and the Walker Lake area). Ms. Loretta Singletary, the Lyon County Extension Agent, was requested to act as liaison for the Advisory Committee. In that role, Ms. Singletary acted as a facilitator and a central contact person. She was not formally a member of the Advisory Committee and as a result, had no voting privileges.

In keeping with its proposed collaborative approach, the Advisory Committee made a pronounced and ongoing attempt to involve additional stakeholders. Whenever identified, each additional stakeholder was routinely notified of meetings and on-going events. All Advisory Committee meetings have been noticed and held in accordance with applicable open meeting laws and regulations. Additional stakeholders have been offered the opportunity to participate in all aspects of the collaborative planning effort. The success of this effort is evidenced by the number of people who have attended Advisory Committee meetings, and the list of agencies represented. Federal entities included the Bureau of Reclamation, the Bureau of Land Management, the Natural Resource Conservation Service, the U.S. Forest Service, the U.S. Fish and Wildlife Service, the U.S. Army Corps of Engineers, the U.S. Geological Survey, the federal watermaster for the Walker River, and the Mason Valley Conservation District. State entities included the Nevada Division of Water Planning, the Nevada Division of Wildlife, the Nevada Division of Environmental Protection, the Nevada Division of State Lands, the University of Nevada Cooperative Extension, the California Department of Fish and Game, and the University of California Cooperative Extension. Local groups who participated in the program included Public Resource Associates, the Walker Lake Working Group, and the Sierra Club. Representatives of the news media included Staci Emm (Mason Valley News) and Faith Bremner (Reno Gazette Journal). Numerous private individuals also took time to attend Advisory Committee meetings, providing insight from a diversity of perspectives. Hopefully, all of these individuals and groups will see that their concerns are reflected herein.

1.1 Clarification of Study Goals

Funding for this study was authorized in the 1998 Energy and Water Development Appropriations Act. Specifically, the Act states that:

> "The Committee has provided $300,000 for the Bureau of Reclamation to work with local interests to identify the most effective voluntary water conservation practices applicable to the Walker River Basin, and to quantify the contribution that voluntary conservation can make to solving the water resources problems in Walker Lake and the basin as a whole."

This language identifies a matter that Congress wants addressed by Reclamation and local interests. Reference is made to "water resource problems in Walker Lake and the basin as a whole." Since the need for this study revolves around addressing those "problems", it is appropriate that they be clarified.

- Over the century, inflow to Walker Lake has decreased. In 1882, the level of the lake was 4,080 feet. Since then, the level of the lake has dropped by 125 feet to a level of 3,955 feet. The volume and surface area of the lake have declined accordingly. Since Walker Lake is a terminal lake (one from which there is no outflow), this reduction in lake volume has been accompanied by an increase in the concentration of total dissolved solids (TDS). Levels have increased from about 2,500 milligrams per liter in 1882 to a maximum of over 13,000 milligrams per liter in recent years.

- Historically, Walker Lake and the Walker River supported the Lahontan cutthroat trout, a species listed as threatened by the Fish and Wildlife Service. Decreased water volumes have reduced the value of Walker Lake as quality habitat. In addition, the recently established lower Walker River channel exhibits poor fisheries habitat and various structures preclude the upstream movement of fish during spawning runs. These factors have had a pronounced impact on the viability of historic Lahontan cutthroat trout fisheries.

- The lower most segment of the Walker River has experienced significant incisement in response to the pronounced reduction in lake level. For the most part, this represents the establishment of a channel across exposed lake bottom deposits. This down cutting of the river channel is working its way upstream. It is not inconceivable that irrigation structures, highway structures, and railroad structures may be threatened if this process is allowed to continue.

It is these three problems, then, that the Committee viewed as relevant within the context of the Congressional Act. The agreed upon scope of work had as its primary objective the identification of measures that could result in a greater and more consistent inflow of water to Walker Lake. In short, what measures could be undertaken that would enhance the viability of Walker Lake? The Committee's approach was predicated on the assumption that most of the information needed to answer that question was readily available. What was needed was a thorough review of selected data. At its core, this project was intended to conduct that review.

The Congressional language also makes reference to the role that "voluntary conservation" can play in addressing these problems. The 1999 Water Words Dictionary defines "conservation" as the controlled use and systematic protection of a water system in accordance with principles that assure its optimum long-term economic and social benefit. "Voluntary" is taken to mean any action carried out without legal compulsion or obligation. In the present context then, voluntary conservation would include any action taken by a unit of government (local, state or federal), private organizations or groups, or by private individuals the intent of which is the controlled use and systematic protection of some part of the Walker River Basin water system.

1.2 REPORT STRUCTURE

The final product called for in the Advisory Committee's contract with Reclamation was a "report of study results." The present report is intended to serve that requirement. Its design is intended to meet several purposes. First, it documents the process by which conservation measures were identified and by which specific measures were selected for review (Chapters One and Two). Second, it provides some basic contextual information important to the study as a whole (Chapter Three). Third, it documents results of the project team's review of measures selected for specific study (Chapters Four through Eight). Fourth, it presents a series of programs or scenarios that review how the studies measures could be implemented, and the synergistic impacts of their implementation (Chapter Nine). Finally, the report identifies subjects that may deserve further consideration as a part of future planning efforts (Chapter Ten).

Chapter Two —
TOPICS IDENTIFIED FOR INVESTIGATION

Between September and December of 1998, the Advisory Committee discussed a wide variety of conservation measures that may, if implemented, increase flows to Walker Lake. In addition to discussions at committee meetings, the list was discussed at a special public meeting held on October 28, 1998. New measures identified during that public meeting were added to the preliminary list. That list served as the basis of discussion by the Committee on November 10 and again on December 8, 1998. A copy of the completed list is contained in Attachment A.

From the completed list, the Advisory Committee selected six conservation measures as particularly relevant. They are as follows:

- *Review the role of phreatophytes in the overall Walker River Basin water budget.* Evapotranspiration represents a consumptive use of water. There is a generally held assumption that in the Walker River Basin that this loss is substantial in magnitude. The objective will be to quantify the amount and types of phreatophytes present in the Walker River Basin, and to assess the evapotranspiration that occurs due to those phreatophytes. To the extent necessary and practicable, alternative measures will be identified whereby any such impact can be addressed.

- *Review channel and storage management as means of increasing flows to Walker Lake during flood events and reducing TDS levels.* The Committee emphasized the need to take advantage of flood water as a means of increasing flows to Walker Lake. As perceived by the Advisory Committee, this could take the form of moving blocks of flood water that had been storage in the upper basin, and/or channel modifications designed to increase the transmission of flood water. The objective will be to identify and assess means of maximizing the transmittal of flood waters to Walker Lake, and to assess impacts of that transmission to the river system at large.

- *Review the acquisition of existing water rights as a means of increasing flows to Walker Lake.* This review will examine the potential role that the acquisition of water rights can have on increasing in-river flows, and the potential for any such increased flow to enter Walker Lake. The objective will be to estimate a likely "yield" that could be derived, to assess the cumulative benefit of that yield, to identify areas subject to such actions, to prioritize those areas in terms of benefit to Walker Lake, and to assess impacts both on-site and within the river system at large. To the extent necessary and practicable, alternative measures will be identified whereby any such impact can be evaluated. The objective will be to identify areas subject to such actions, to prioritize those areas in terms of benefit to Walker Lake, and to assess impacts of the acquisition on-site and to the river system at large.

- *Review means of reducing evaporative loss from Walker Lake and managing water quality in the lake*. This review will examine means of reducing evaporation losses and TDS levels in Walker Lake, and will assess impacts of those means to other aspects of the lake environment at large. To the extent necessary and practicable, alternative measures will be identified whereby any such impact can be addressed.

- *Examine the degree to which recently exposed delta deposits contribute to Walker Lake TDS levels*. Old delta and lakebed deposits have become exposed due to the lowering of Walker Lake. The Walker River has and continues to down cut through these deposits. A generally held assumption is that these deposits contain heavy concentrations of salt and other dissolvable solids. The objective of this review was to determine the extent to which the delta and lakebed deposits are contributing to elevated TDS levels in Walker Lake. Implementation of this work along the lower Walker River required permission from the Walker River Paiute Tribe. Sampling activities central to this task could occur only with the Tribe's permission. A letter was submitted to the Tribe requesting permission to conduct the identified work and that request was denied. As a result, the Advisory Committee did not conduct this particular task.

- *Review means of enhancing agricultural conservation*. Information provided to the Advisory Committee by members of local conservation organizations indicates that a substantial amount of work has been devoted to the design of projects that may reduce, or make more efficient the use of water by the agricultural community. The objective will be to collect information on those projects, to identify planned improvements that may, if implemented, improve acquisition, distribution, and application systems.

Once the identified reviews had been conducted, the Advisory Committee also requested that the synergistic impact of proposed changes on Walker Lake be assessed. That assessment was to examine the beneficial and adverse impacts that would occur to the Walker River and to Walker Lake.

Chapter Three — ASSUMPTIONS CENTRAL TO THE STUDY

The purpose of this chapter is to provide a review, albeit brief, of water resources in the Walker River Basin. Specific issues addressed include river discharge (sources, volume, and timing), water rights (decreed volume, distribution, and priority), and other water uses. Current water management planning issues also are reviewed.

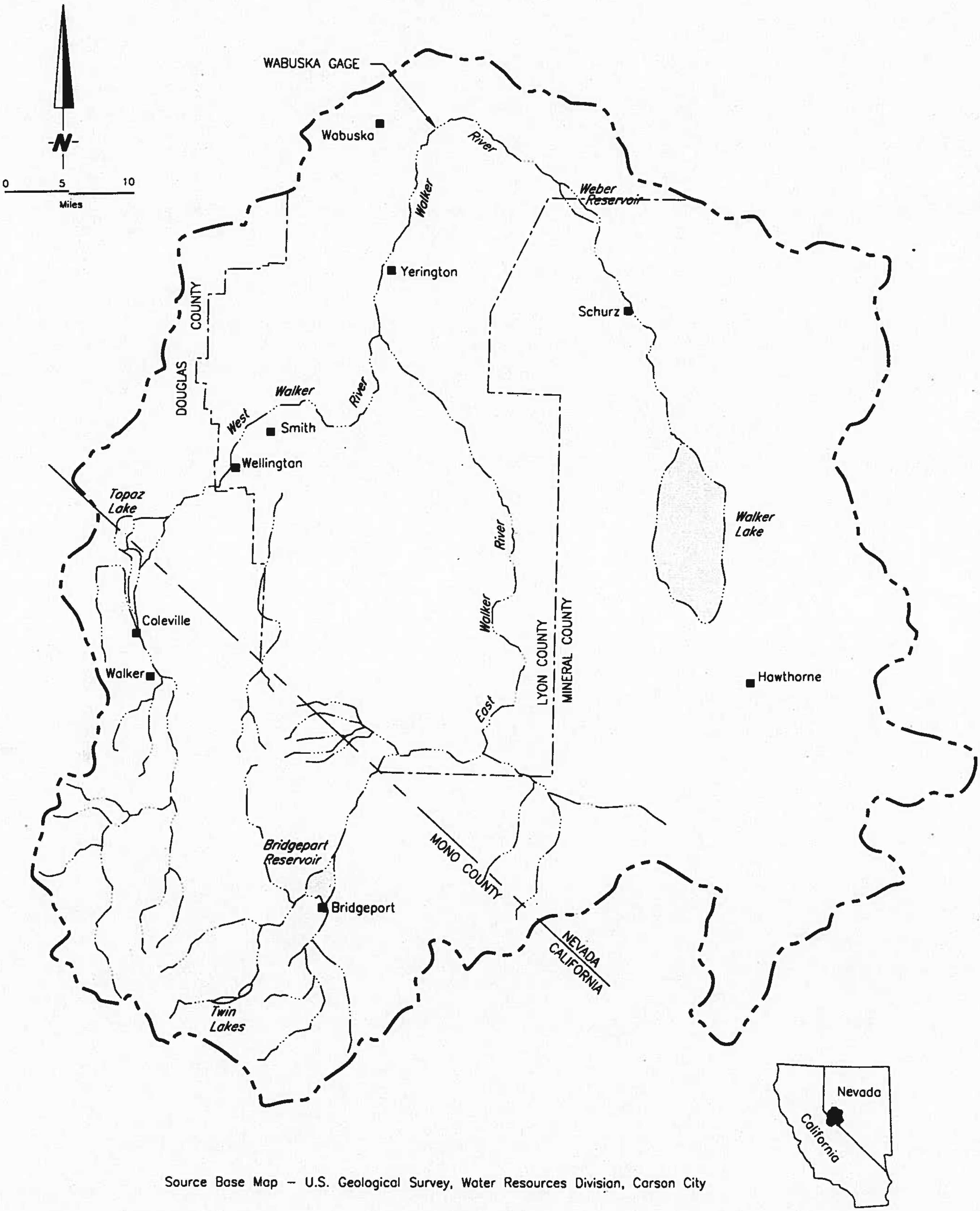
An extensive body of literature exists regarding the Walker River Basin. Materials relied on most heavily during this study are the series of reports prepared by the Mr. Randy Paul and others at the Nevada Division of Water Planning. They include a chronological history of the basin (Horton 1996), a review of water rights and irrigation diversions in the basin (Pahl 1996a, 1996b), gaging station data (Pahl 1997b), a basin surface water budget (Pahl 2000), and a review of ground water rights (Pahl 1997c). Additional information was drawn from U.S. Geological Survey water resource and reconnaissance reports (Everett and Rush, 1967; Huxel and Harris, 1969; Glancy, 1971; Rush and Schroer, 1976), and earlier reports prepared by the Soil Conservation Service (1969) and the Nevada Division of Water Resources (1973).

3.1 WALKER RIVER BASIN HYDROLOGY

The Walker River Basin is located in western Nevada and eastern most California (Figure 3.1). The basin's river system is comprised of the East Walker River with its headwaters near Bridgeport, California, and the West Walker River with its headwaters above Antelope Valley in California. The two forks merge to form the Walker River near Yerington, Nevada. From there, the river flows through Mason Valley and on to Walker Lake, from which there is no outflow aside from evaporation.

Lands within the Walker River Basin fall within Lyon, Mineral, and Douglas counties in Nevada, and Mono County in California. The basin contains some 2.7 million acres, of which 2.1 million acres are in Nevada. Land status within the basin as of the early 1970s is summarized in Table 3.1. Presumably, changes in land status have occurred since that time. However, most of the basin was and continues to be federally administered land.

Major upstream storage facilities include Topaz Lake (built in 1922, modified in 1937), Bridgeport Reservoir (built in 1924), and Weber Reservoir (built in 1934 and currently [1999] scheduled for modification). Other smaller facilities also are present and will be described in a later portion of this report.



Source Base Map – U.S. Geological Survey, Water Resources Division, Carson City

Figure 3.1
Area Map of Walker River Basin

The hydrology of the Walker River Basin is typical of other basins located along the east slope of the Sierran Range. The basin is in the rain shadow of this prominent range and suffers reduced precipitation rates as a result, especially as one goes east across the basin. Precipitation is seasonal, most occurring in the winter as snow. Similarly, stream flows also exhibit pronounced seasonality. For example, approximately 55 percent of the annual runoff along the West Walker River occurs in May and June, while only 4 percent occurs in September and October. Seasonal variations are not as pronounced along the East Walker River. There, 44 percent of the annual runoff occurs in May and June, and 6 percent occurs in September and October (Division of Water Resources 1973:pg 15).

TABLE 3.1 WALKER RIVER BASIN LAND STATUS (IN ACRES)

	California	Nevada	Total	Percent
Private Lands	87,860	213,450	301,310	11.3
State, County Lands	860	30,121	30,981	1.2
Walker River Indian Reservation		256,792	256,792	9.7
Forest Service	380,093	315,647	695,767	26.2
Bureau of Land Management	126,887	1,093,043	1,219,930	45.9
Hawthorne Ammunition Depot		149,769	149,769	5.6
Other Federal Lands		3,871	3,871	0.1
	595,700	**2,062,720**	**2,658,420**	**100.0**

Source: Nevada Division of Water Resources (1973:pg 12, Table 3).

A current estimate of the average annual surface-water budget for the Walker River Basin is provided in Table 3.2. The budget represents averaged values over a number of years (1926-1995) and is not indicative of flows during any given year. The budget is restricted to a consideration of surface water inflows and outflows associated with the major rivers and water bodies in the Walker River Basin. It does not attempt to estimate ground water recharge, consumptive uses, evapotranspiration, or ground water flows between basins.

Between 1926 and 1995, averaged inflow into the uppermost portions of the basin (above Antelope Valley and Bridgeport Valley) has been about 326,300 acre-feet. When other surface inflows and ground water flows are added to this figure, the average total inflow into the basin and its sub-basins (including return flows) has been about 452,400 acre-feet. At the other end of the system, Walker Lake has experienced an average loss in net storage of 76,400 acre-feet per year.

Table 3.2 contains several large values that deserve mention. The first is the amount of water diverted for irrigation use. It must be acknowledged, however, that the amount of water actually consumed by agricultural uses is less than is physically diverted or extracted. Consideration must be given to the amount of return flows from upstream irrigation uses. Based on 1969 data, the Walker River Atlas (1992:pg 77) lists agricultural consumptive use in the Nevada portion of the basis at 133,000 acre-feet, based on diversions and extractions totaling just under 316,000 acre-feet. This suggests that about 42 percent of the diverted water was consumed, while the remaining 58 percent constituted "return flow."

Another large number is the amount of water lost to evaporation from the surface of Walker Lake. The annual average loss is 178,000 acre-feet. This value changes from year to year depending on the surface area of the lake, the average annual temperature, and relative humidity.

TABLE 3.2 AVERAGE ANNUAL SURFACE WATER BUDGET, WALKER RIVER BASIN, 1926-1995 (IN ACRE-FEET)

	Above Antelope Valley	Antelope Valley	Smith Valley	Bridgeport Valley	East Walker River	Mason Valley	Schurz Area	Total Above Walker Lake	Walker Lake
Inflow									
River Inflow	195,700	191,200	176,100	130,600	103,900	235,400	121,200	326,300	69,900
Net Local Inflow		55,800	23,900	28,100	21,800	22,300		126,100	14,000
Precipitation on Lake									17,700
Total	195,700	247,000	200,000	158,700	125,700	257,700	121,200	452,400	101,600
Outflow									
River Outflow	191,200	176,100	130,100	103,900	105,300	121,200	69,900	69,900	-
Irrigation Diversions	4,500	64,700	69,900	50,000	20,400	136,500	23,000	369,000	-
Lake Evaporation		5,800		4,300			2,500	12,600	178,000
Changes in Storage		400		500				900	-76,400
Net Local Outflow							25,800		
Total	195,700	247,000	200,000	158,700	125,700	257,700	121,200	452,400	101,600
River Outflow-River Inflow		-15,100	-46,000	-26,700	1,400	-114,200	-51,300	-256,400	

Source: Pahl (2000:pg 6, Table 1-1).

As noted, the surface-water budget provided in Table 3.2 is an average of flows that occurred between 1926 and 1995. It is intended to provide an approximation of the average condition that has existed historically. It is acknowledged that averages may not provide as representative a picture as some might hope. This is particularly true in the Walker River Basin because of the substantial variability in precipitation that occurs from year to year. Snowfall levels in the Sierra Nevada and other mountain systems in the basin are the primary determinant of the annual water budget.

The extent of year-to-year variability in the basin is illustrated by the gage data summarized in Table 3.3. These data show that during a low water year, flows tend to be about 26 to 30 percent of the average. High flow years are about 210 to 310 percent of the average. Even more pronounced variation is evidenced at the lowest reported gage, the one at Wabuska. During low water years, flows at this gage are as low as 10 percent of the average, while high flows are over five times the average.

TABLE 3.3. SELECTED GAGING STATION FLOWS, WALKER RIVER BASIN, 1926-1999 (IN ACRE FEET)

River	Location	Station	Low Water Year	Average Water Year	High Water Year
West Walker	Above Coleville	10296000	47,280	183,890	388,770
West Walker	Near Coleville	10296500	53,940	195,470	484,340
West Walker	Hoye Bridge	10297500	44,160	173,030	448,860
West Walker	Hudson	10300000	40,830	135,380	296,100
Robinson Cr.	Twin Lakes	10290500	24,470	43,440	72,040
East Walker	Near Bridgeport	10293000	27,150	102,080	320,720
East Walker	Above Strosnider	10293500	28,020	102,080	290,300
Walker River	Wabuska	10301500	9,340	116,560	602,340

Source: Pahl (1996a:pg I-16, Table 6). See notes appended to original table

There has been some discussion among water planners and residents of the Walker River Basin that the concept of an "average" year is misleading. Changes in land use over time, coupled with long-term changes in precipitation patterns are frequently cited reasons for observed variations in stream flow. In an attempt to illustrate this point, annual stream flow data from three locations between 1926 and 1995 were reviewed. Annual flow data were drawn from Pahl (1997b, Table 4). The three locations are near Coleville, near Bridgeport Reservoir, and near Wabuska. In each case, the reported average annual flow over the 70-year study period was accepted as the "average" flow. Flow rates were calculated that represent various percentiles (30 to 50 percent, for example) of the average flow. Then, each year was assigned to a percentile grouping based on the recorded or estimated average flow.

Results of this exercise are reported in Table 3.4. At the near Coleville gage, annual flows during 14 years fell within the 90 to 110 percent of average category. Flows during 32 years were below the 90-percentile mark, while flows during 24 years were above the 110-percentile mark. Data for the near Bridgeport gage are nearly identical. Thirteen years fell within the 90 to 110 percent of average category, 35 years were below the 90-percentile mark, and 22 years were above the 110-percentile mark. In both cases, the annual flow data do appear to reflect a somewhat normal distribution around the calculated annual average flow. The near Wabuska gage data, however, are substantially different. Here, the distribution of annual flows is bimodal. Values are clustered at both ends of the spectrum.

Annual flows during 29 years were below 50 percent of average, while flows during 15 years were in excess of 150 percent of average.

These data suggest that concerns with the validity of the "average" year concepts are relevant within the lower portion of the Walker River Basin, especially in areas located below major diversions. Up stream, annual flows do appear to cluster around an average value. Also, if one looks at the up stream examples, below "average" years tend to outnumber above "average" years by a ratio of approximately 1.4 to 1.0.

TABLE 3.4. VARIATION IN STREAM FLOW AT THREE LOCATIONS, WALKER RIVER BASIN, 1926-1995

	Near Coleville (10296000)		Near Bridgeport (10293000)		Near Wabuska (10301500)	
	Occurrence		Occurrence		Occurrence	
Percent of the Average Flow	Number of Years	Percent	Number of Years	Percent	Number of Years	Percent
< 10%	0	0.0%	0	0.0%	1	1.4%
10-30%	1	1.4%	3	4.3%	20	28.6%
30-50%	7	10.0%	6	8.6%	8	11.4%
50-70%	13	18.6 %	11	15.7%	7	10.0%
70-90%	11	15.7%	15	21.4%	8	11.4%
90-110%	14	20.0%	13	18.6%	4	5.7%
110-130%	9	12.9%	7	10.0%	2	2.9%
130-150%	5	7.1%	4	5.7%	5	7.1%
150-170%	4	5.7%	5	7.1%	0	0.0%
170-190%	2	2.9%	2	2.9%	1	1.4%
>190%	4	5.7%	4	5.7%	14	20.0%

Source of Data: Pahl (1997b, Table 4)

3.2 SURFACE WATER USE IN THE WALKER RIVER BASIN

The use of surface waters in the Walker River Basin is controlled by Nevada and California state water law, and by judicial Decree C-125. Various facets of the decree are described in detail in Chapter 6 of this report. The decree adjudicated the natural flow diversion rights of some 1,575 cfs for use on 110,852 acres. The distribution of irrigated acres and diversion rights by sub-basin are reported in Table 3.5. These data are per the decree as of 1940. Limited changes have occurred since that time. This tabulation also does not list those lands within the Walker River Irrigation District that have no decree rights but are irrigated with storage water from Bridgeport and Topaz reservoirs.

Table 3.6 provides an estimate of consumptive use by area within the basin. For this analysis, consumptive use is estimated by subtracting river outflow from river inflow for each area. Inflow and outflow values were derived from the surface water budget (see Table 3.2 above) which is based on average annual flow data from 1926 through 1995. These data indicate that of the approximately 452,400 acre-feet of water that flows into the Walker River Basin (including return flows), about 431,300 acre-feet or 95.3 percent is consumed. The area of greatest consumptive use occurs at Walker Lake itself, where evaporation removes an average of 178,000 acre-feet per year. The area with the second greatest amount of consumptive use is Mason Valley. There, consumption is attributed to agricultural diversions and use. Based on data reported by Pahl (2000), the Schurz area (that reach of the river between Wabuska and Walker Lake) also is characterized by a pronounced difference between inflow and outflow.

TABLE 3.5. SURFACE WATER RIGHTS BASED ON DECREE C-125

Sub-Basin	Water Source	CFS	Acres
Above Antelope Valley	West Walker River	36.1300	2,089.00
Antelope Valley	West Walker River	256.1900	15,958.00
Smith Valley	West Walker River	154.5137	11,560.25
Bridgeport Valley	East Walker River	419.2900	26,428.50
E. Walker above Sweetwater Cr.	East Walker River	63.9800	4,076.00
E. Walker below Sweetwater Cr.	East Walker River	56.1168	3,519.68
Mason Valley	East and West Walker, and Walker Rivers	562.8164	45,120.54
Walker Lake Valley	Walker River	26.2500	2,100.00
Total		**1,575.2869**	**110,851.97**

Source: Pahl (1996a:pg 12)

TABLE 3.6. CONSUMPTIVE WATER USE BY MAJOR AREA, 1926-1995 (IN ACRE-FEET)

Area	Surface Water Inflow	Surface Water Outflow	Surface Water Consumed	Consumed as a Percentage of Inflow	Percent of Total Consumed
Bridgeport Area	130,600	103,900	26,700	20.4	6.2
Antelope Area	191,200	176,100	15,100	7.9	3.5
Smith Area	176,100	130,100	46,000	26.1	10.7
Mason Area	235,200	121,200	114,200	48.6	26.5
Schurz Area	121,900	69,900	51,300	42.1	11.9
Walker Lake Area	69,900	0	178,000	254.6	41.3
			431,300		**100.0**

Source: Inflow and outflow data are from Pahl (2000:pg. 6, Table 1.1)

By relying only on surface inflow and outflow data, this assessment does not consider in-valley surface flows, or ground water recharge or pumping, but does indirectly account for the summation of inflow-outflow components which are represented in the river outflow amount. Also, the data do no allow for a differentiation between various types of consumptive use – evaporation from the water's surface and from bare soil, agricultural use, or municipal and other uses. Finally, the seventy-year reporting period saw fundamental changes in agricultural practices and resulting return flow characteristics. For all of these reasons, this assessment of consumptive use must be viewed as a worst case analysis.

An alternative approach would be to look at changes that occur over particular periods of the year. By so doing, it may be possible to arrive at a high and a low estimate of changes in surface water flow between set points. The magnitude of the change in surface water flow was first estimated based on a review of selected gage data for the off-season (winter) months. Monthly mean data were assembled and the differences between gage flows were converted to a "percent change" figure. Table 3.7 reflects the results of this effort. That table is based on monthly mean data up to and through the 1996 water year. These data were used so as to exclude the January 1997 flood.

TABLE 3.7. DIFFERENCES IN MONTHLY MEAN FLOWS (1996 WATER YEAR) BETWEEN SELECTED GAGE STATIONS FOR MASON VALLEY (IN ACRE-FEET)

	W. Walker near Hudson [1]	E. Walker above Strosnider [2]	The Two Forks Combined	Walker River at Wabuska [3]	Inflow – Outflow Difference	Percent Change
October	142.2	136.9	279.1	154.9	- 124.2	- 45 %
November	132.7	80.5	213.2	177.3	- 35.9	- 17 %
December	146.6	100.6	247.2	222.1	- 25.1	- 10 %
January	122.4	105.1	227.5	226.1	- 1.4	- 1 %
February	162.8	140.0	302.8	261.8	- 41.0	- 14 %
March	197.2	165.0	362.2	297.5	- 64.7	- 18 %
April	412.6	357.0	769.6	309.4	- 460.2	- 60 %

Source: USGS (1996) Water Resource Data, Nevada, Water Year 1996.

1. *Gage 10300000, West Walker River Near Hudson; 1915-1996 by water year.*
2. *Gage 10293500, East Walker River Above Strosnider Ditch, Near Mason; 1948-1996 by water year.*
3. *Gage 10301500, Walker River Near Wabuska; 1902-1996 by water year.*

This table combines the water coming out of the east and west forks (as measured at the Hudson and Strosnider gages) and compares it to the water that flowed past the Wabuska gage. During January (the coldest month), the data suggest almost no change between the amount of water entering and leaving the reviewed section of the system. In contrast, changes in flow during October and April were high because of irrigation diversions. Between November and March, however, the data suggest a transmission "loss" of between one and 18 percent (an average of 12 percent). That loss may be due to the continuation of stock water flows into ditches, bare soil and water surface evaporation, limited levels of phreatophytic transpiration, and ground water recharge. It must be noted that water "lost" to groundwater recharge is not truly lost; it remains in the overall hydrologic system. The emphasis of the current analysis, however, is short-term surface water flows. As a result, recharge water represents a withdrawal of water that could be making its way to Walker Lake in the short term. This assessment provides an estimate as to the base transmission "loss" (about 12 percent) during the non-irrigation season within the monitored portion of the Walker River.

Another estimate of transmission "loss" is suggested based on comments made by Mr. Roger Bezayiff, the Federal Water Master, before the Advisory Committee.

Mr. Bezayiff stated that during an exceptionally dry year, it was necessary to release 125 cfs from Bridgeport Reservoir to meet the Walker River Paiute Tribe's senior right of 26 cfs at the Wabuska gage. This reflects a transmission "loss" of approximately 79 percent. This estimate reflects worst case conditions; evaporative loss off of the water surface, evapotranspiration by phreatophytes, bare soil evaporation, and ground water recharge were at their highest levels.

3.3 GROUND WATER USE IN THE WALKER RIVER BASIN

Ground water resources are often quantified based on two measures. One is the total amount in storage within a particular valley's ground water reservoir (the upper 100 feet of saturated alluvium). The second is the perennial or system yield. Perennial yield is the maximum amount of ground water that can be withdrawn annually over the long term without depleting the ground water reservoir. In areas where there is a large river system, the concept of system yield is frequently employed. This is the combined amount of surface and ground water that can be consumed annually without continually removing ground water from storage or reducing surface water flows to downstream users.

Table 3.8 provides data on the amount of storage, estimated recharge, perennial or system yield associated with each major reach of the Walker River System. These data suggest that the estimated annual recharge to ground water in the Walker River Basin is about 80,500 acre-feet. The Nevada State Water Plan (Nevada Division of Water Planning, 1999 Part I, page 4-27, Table 4-8) indicates that the perennial yield of that part of the Walker River Basin located in Nevada is about 57,300 acre-feet per year.

Decree C-125 does not address ground water usage. The Nevada Division of Water Resources administers ground water usage in the Nevada portion of the Walker River Basin (except for areas held in trust by the U.S. Government on behalf of recognized tribes). Ground water resources are essentially unregulated in California.

Table 3.9 provides a summary of ground water rights (including supplemental rights) by status. The table summarizes rights committed by the State Engineer in the form of permit and/or certificate (as of August 19, 1999), and those for which applications were pending. It must be noted that the summary is not static; it changes whenever a right is modified by action of the State Engineer. These data clearly indicate that a preponderance of the ground water use occurs in Mason and Smith valleys.

TABLE 3.8. ESTIMATES OF STORED GROUND WATER AND GROUND WATER RECHARGE, WALKER RIVER BASIN (IN ACRE-FEET)

	Stored Water in Upper 100 ft. of Saturated Valley Fill	Estimated Annual Recharge	Perennial (p) or System (s) Yield
Antelope Valley	364,000 [1]	18,000	41,000 (s)
Smith Valley	1,500,000	17,000	62,000 (s)
Mason Valley	2,900,000	8,000 [2]	100,000 (s)
East Walker River	1,000,000 [3]	31,000	17,000 (s)
Walker Lake Valley – Schurz Area	1,500,000	500	110,000 (s)
Walker Lake Valley – Lake Area	100,000	600	700 (p)
Walker Lake Valley – Whiskey Flats Area	900,000	5,400	5,000 (p)
Total		**80,500**	

Sources: USGS Reports 40 and 53, Water Resources Bulletins 38 and 43

1. *This includes 200,000 acre-feet in Nevada and 164,000 acre feet in California (Glancy 1971).*
2. *For this study, the recharge value is estimated at five percent of the average precipitation rate.*
3. *This includes 800,000 acre-feet in Nevada and an estimated 200,000 acre-feet in California (Glancy 1971).*

TABLE 3.9. NEVADA GROUND WATER RIGHTS BY STATUS (IN ACRE FEET)

	Permitted Water Rights			Water Rights Applications		
Basin	**Permit**	**Certificate**	**Total**	**Application**	**Ready for Action**	**Total**
Antelope Valley	1,269.48	5,297.49	6,566.97	0	9,498.10	9,498.10
Smith Valley	5,258.65	54,489.03	59,747.68	79.96	552.40	632.36
Mason Valley	23,111.29	125,759.59	148,870.88	1,120.68	487.41	1,608.09
East Walker Area	15,139.96	6,712.77	21,852.73	0	2,569.67	2,569.67
Schurz Area	603.00	34.40	637.40	0	0	0
Lake Area	2,074.41	29.75	2,104.16	0	0	0
Hawthorne Area	7,487.36	8,210.75	15,698.11	0	0	0
Total	**54,944.15**	**200,533.78**	**255,477.93**	**1,200.64**	**13,107.58**	**14,308.22**

Source: Nevada Division of Water Resources Water Rights Database Abstract (dated 8/19/1999)

3.4 WATER MANAGEMENT PLANNING ISSUES

At the grand level, planning issues associated with the Walker River Basin have been clearly articulated and are fairly well accepted by all involved (see for example Horton, 1996; Public Resource Associates, 1994; Boyle, 1976; Corps of Engineers, 1997). Those issues include the following:

- Walker Lake has been receding since before the turn of the century due to upstream diversions. Declines in the level, volume, and quality of Walker Lake are of particular concern.

- Pronounced variability in stream flows creates a number of management and environmental difficulties. Above average flows are often associated with flooding, erosion and sedimentation, and channel scour. Below average flows jeopardize the maintenance of stream flows, cause the water temperature to increase, impact fish and wildlife populations, and limit agricultural production.

- Maintaining and enhancing the Lahontan cutthroat trout fishery in Walker Lake is of particular concern. Currently, the lake's trout population is totally dependent on restocking. Re-establishment of a viable Lahontan cutthroat trout fishery in the Walker River is an important consideration.

- The agricultural industry represents a major component of the Walker River Basin's economy. Preserving the viability of the agricultural industry in the basin is of particular concern to those involved in the industry, and to the towns and counties that rely, in part, on revenues generated from that sector of the economy.

- The U.S. Government has taken legal action on behalf of federal interests in the Walker River Basin including the Walker River Paiute Tribe. Among other matters, that action presumes to secure additional water rights for the Tribe. That legal action remains unresolved.

- While both Nevada and California have passed legislation adopting a bi-state compact addressing management of water in the Walker River Basin. Congress has yet to ratify that compact. As a result, the interstate allocation of water has not been addressed.

- Recreational water uses are an important consideration. Addressing the viability of stream environment zones along the Walker River, and ensuring minimum flows within the river are important considerations.

But, as the old saying goes, the devil is in the details. Means must be identified that resolve some of these matters without impacting the potential to deal with the remaining issues. Identifying those means has been and remains the planning issue of greatest import.

Chapter Four —
TOPIC ONE: PHREATOPHYTE MANAGEMENT

Evapotranspiration represents a consumptive use of water. Given the physical size of the Walker River Basin, this loss is substantial in magnitude. The goal of this measure is to determine the amount of water loss that occurs due to evapotranspiration by phreatophytic vegetation present in the Walker River Basin. Alternative measures are identified whereby such losses can be addressed. The work plan called for several activities, as described below.

- Sources of information on the distribution of vegetation communities in the Walker River Basin were reviewed.
- The location and extent of phreatophytic vegetation communities were quantified.
- The composition and density of species present in each community were estimated.
- Limited field assessment was conducted to verify community locations, composition, and density.
- Evapotranspiration rates were estimated for each phreatophytic community.
- Volumes of water consumed by phreatophytes were estimated based on the assembled data. Estimates were calculated for an average year.

Before proceeding with a discussion of phreatophytes within the Walker River Basin, it is important to understand what phreatophytes are:

> Phreatophytes are water-loving plants ranging from small grasses to large Cottonwood (*Populus* spp.) trees. These plants habitually obtain their water from ground water sources, either in the zone of saturation or from a high water table (Affleck, 1975; Blaney, 1961; Horton, 1964). Many phreatophytes, termed facultative phreatophytes, utilize unsaturated soil moisture. This ability lets species such as saltcedar (*tamarix* spp.) to survive even after the water table is lowered and in drought conditions (Cleverly et al., 1997). Hydrophytes differ from phreatophytes in that hydrophytes live wholly in water; hydrophytes also have very high evapotranspiration rates. Examples of hydrophytes are tules (*Scirpus* spp.) and cattails (*Typha* spp.). For the purpose of this report, hydrophytes and phreatophytes are classified together. The term phreatophyte was first defined in 1923 by Meinser (Afflect, 1975).

Examples of phreatophytic species common to the Walker River Basin include greasewood (*Sarcobatus vermiculatus*), riparian grasses, saltgrass (*Distichlis spicata*), willows (*Salix* *spp.*), cottonwood (*Populus spp.*), rabbitbrush (*Chrysothamnus spp.*), and wildrose (*Rosa spp.*).

TABLE 4.1. PREVIOUS PHREATOPHYTE SUMMARIES

Plants Present/ Areas Represented	Acres	ET Rate (afy/ac)	ET (afy)
SCS (1969)			
Fremont poplar	1,450	5.00	7,200
Black greasewood	19,750	0.98	19,400
Quailbrush	9,370	0.98	9,200
Silver buffaloberry	5,960	0.98	5,800
Willow	9,220	1.17	10,800
Rose	850	0.94	800
Rubber rabbitbrush	10,720	0.98	10,500
Tamarisk	2,500	1.16	2,900
Saltgrass	5,870	0.49	2,900
Creeping wildrye	13,070	1.48	19,300
Others	6,010	3.12	18,800
Report Total	**83,320**	**1.29**	**107,600**
Nevada Division of Water Resources (1973)			
Upper East Walker			400
Sweetwater Rough Creeks			1,600
Lower East Walker			2,400
Mason Valley			41,500
Schurz			12,100
Whiskey Flat			700
Antelope Valley			2,800
Smith Valley – Desert Cr.			4,400
Walker Lake			4,100
Report Total	**54,260**	**1.29**	**70,000**

4.1 PREVIOUS DISCUSSIONS ABOUT PHREATOPHYTE WATER USAGE AND CONTROL

An extensive literature search was conducted to find information on water use by phreatophytes in the Walker River Basin. Nine reports were identified that contained acreage surveys for phreatophytes and water use estimates. Most of the reports were specific to a region of the Walker River Basin.

4.1.1 Estimates of Phreatophyte Water Usage and Acreage

Two reports provide an estimate of evapotranspiration (ET), or water use, by phreatophytes for the entire basin (SCS, 1969; Nevada Division of Water Resources, 1973). These reports are different in structure. The SCS report summarized ET based on individual plant species (Table 4.1). In contrast, the Nevada Division of Water Resources report summarizes ET by geographic area. These documents report substantially different amount of phreatophytes present and the magnitude of water loss due to ET. Of interest, they result in an identical average ET rate estimate, 1.29 acre-feet per acre per year. It is assumed that the Nevada Division of Water Resources report made use of the estimate arrived at by the SCS.

Results of selected U.S. Geological Survey reconnaissance reports were combined to form a third estimate (Everett and Rush, 1967; Huxel and Harris, 1969; Glancy, 1971). The estimated acreage of phreatophytes (Table 4.2) is higher than either of the previously discussed reports, but estimated water loss due to ET is within the range of the previous estimates. ET rates used in the USGS reports are lower than reflected in either the SCS or the Nevada Division of Water Resources report.

Information contained in the reviewed reports suggests that phreatophytes cover between 54,260 and 98,350 acres of the Walker River Basin (see Tables 4.1 and 4.2), or between 2.0 and 3.7 percent of the total surface area. ET rates reported in these studies range from 0.1 acre-foot per year for sparse rabbitbrush (*Chrysothamnus* spp.) to 3.0 acre-feet per year for some willow (*Salix* spp.) communities. Basin-wide, mean ET rate estimates varied between 0.98 and 1.29 acre-feet per acre. The application of the reported acreages and rates suggest that between 70,000 and 107,600 acre-feet of water is lost during an average year in the Walker River Basin due to ET.

Variations in ET rate estimates can be explained in varying ways. For example, different methods of estimating ET may result in significantly different ET rate estimates. Methods employed might include the development of in-field ET measurements (these methods themselves may vary), relating leaf area indices to published ET rates and scaling individual leaf use to stand-wide water use, or utilizing ET rates measured on plant species in a lab setting that correspond to field species. Another explanation might involve yearly variation in climatic conditions such as precipitation and temperature. Literature reviews conducted on behalf of this study did not yield means to estimate ET during a drought or a very wet year. It is understood, however, that such variations may greatly impact ET rates among years. During years of high soil moisture ET rates will be significantly higher than during years of drought conditions, given the same temperature regime. Specifically, it is important to recognize these types of variations exist. Any estimate of ET use is just that, an estimate with the potential for significant variation in actual results observed.

4.1.2 Information Regarding Phreatophyte Control

Studies on phreatophyte usage in Nevada have been conducted at least since the early 1960s and have demonstrated substantial water loss through evapotranspiration (Robinson, 1970). In Owens Valley, California, not too great a distance from the Walker River Basin, evapotranspiration studies have been ongoing since at least 1911 (Norman et al., 1993). Considerable information is available in the published literature regarding theoretical water savings that can be realized from the eradication or control of phreatophytes. These water saving are achieved by eliminating or reducing transpired and evaporated water used in plant processes (evapotranspiration). In this report we review actual savings that have been realized by previous phreatophyte control projects, and we address potential savings that may be realized in the Walker River Basin.

TABLE 4.2. PREVIOUS PHREATOPHYTE SUMMARY BASED ON USGS REPORTS

Area	Plants Present	Acres	ET Rate (afy/ac)	ET (afy)
USGS Report 38 (Huxel and Harris, 1969)				
Mason Valley	Saltgrass, greasewood, rabbitbrush, buffaloberry	5,960	1.0	6,000
Mason Valley	Saltgrass, greasewood, rabbitbrush, buffaloberry, cottonwood	15,830	1.5	24,200
Mason Valley	Saltgrass, greasewood, rabbitbrush, tule	5,760	3.0	17,000
Mason Valley	Greasewood, shadscale, sagebrush	14,100	0.25	3,500
Mason Valley	Greasewood, shadscale, saltgrass	5,910	0.25-0.5	2,400
Mason Valley	Greasewood, saltgrass	3,200	0.1	400
Mason Valley	Willow, cottonwood, tule	1,960	2.0	4,000
Report Total		**52,720**	**1.1**	**57,500**
USGS Report 40 (Everett and Rush, 1967)				
Schurz Subarea	Meadow grass, willows	6,200	1.5	9,300
Schurz Subarea	Meadow grass, rabbitbrush, greasewood, cottonwood, willow	3,000	2.0	6,000
Schurz Subarea	Greasewood	10,000	0.2	2,000
Schurz Subarea	Bare Soil	1,500	0.1	150
Whiskey Flat	Meadow grass	1,400	2.0	2,800
Whiskey Flat	Meadow grass, rabbitbrush	9,000	0.2	1,800
Lake Subarea	Meadow grass	Trace	1.0	-
Lake Subarea	Meadow grass, rabbitbrush	4,000	0.2	800
Report Total		**35,100**	**0.7**	**22,850**
USGS Report 53 (Glancey, 1971)				
Sweetwater Flat	Willow, wildrose, aspen	360	1.5	540
East Walker Flood Plain	Willow, wildrose, buffaloberry, greasewood, cottonwood	1,100	1.5	1,600
East Walker Flood Plain	Willow, wildrose, buffaloberry, rabbitbrush, cottonwood	860	2.0	1,700
East Walker Flood Plain	Willow, wildrose, buffaloberry, rabbitbrush, greasewood	1,200	1.5	1,800
East Walker Flood Plain	Greasewood	20	0.2	4
East Walker Flood Plain	Willow, wildrose, buffaloberry, aspen	200	1.5	300
Rough Creek Basin	Rabbitbrush, greasewood	370	0.2	70
Rough Creek Basin	Sparse rabbitbrush, greasewood	450	0.1	40
Rough Creek Basin	Swamp grass, tule, grass	10	2.0	20
Upper Bodie Creek	Grass, wildrose, aspen	320	1.0	320
West Walker Flood Plain	Grass, willow, tule	1,500	1.5	2,200
West Walker Flood Plain	Greasewood, rabbitbrush	1,300	0.3	390
West Walker Flood Plain	Greasewood, rabbitbrush	440	0.1	40
Bridgeport Area	Grass, willow, cottonwood	2,400	1.5	3,600
Report Total		**10,530**	**1.2**	**12,624**
Combined Total		**98,350**	**0.9**	**92,974**

Concern has existed in the desert southwest and Great Basin regions for some time regarding water loss to ET. Considerable research in the Southwest during the 1960s was devoted to the definition of species-specific ET rates, water yield, and water harvesting. Literature reviewed in this section deals with the subject of increased water yield through the control of phreatophytic vegetation. The following are representative documents on the subject.

Affleck (1975) evaluated five methods of phreatophyte control in riparian zones. He concluded that while some methods do eliminate phreatophytes, they have ecological impacts that may outweigh the increases in water yield. In his research, Affleck evaluated the conversion of phreatophytic vegetation to another vegetation type that used less water, stream channelization, cottonwood thinning, anti-transpirant use, and biological control methods. He noted that the anti-transpirants and biological controls had not been used on an operational scale, but only at a research level. He felt those two methods had the most promise for increasing water yields.

In an Arizona project, cottonwoods (*Populus* spp.) and willows (*Salix* spp.) were cleared in combination with the lowering of the water table. This resulted in about a 50 percent increase in ground water salvaged for irrigation (Blaney, *no year or publication*). In his report, Blaney also provides statewide estimates of phreatophytic water loss for Nevada. He estimated that 2,801,000 acres of phreatophytes are present in Nevada and that 1,500,000 acre-feet of water are lost through evapotranspiration annually. In a separate article, Blanley (1961) cautions that all the water gained through the application of phreatophytic control measures may not be readily available for use. The limited or non-availability of water occurred for several reasons. First, it may not be economically feasible to conduct control measures at a level sufficient to result in actual water savings. Second, the water saved may not be available in the areas that require the water.

Research has been conducted evaluating water yields that might be derived from the manipulation of vegetation in pinyon-juniper woodlands, desert shrub zones, and riparian zones (Ffolliott and Thorud; 1977). Ffolliott and Throud concluded that vegetation manipulation for increased water yield in these zone habitats could not be justified. The authors concluded that the negative impacts to the environment, wildlife, recreation, and aesthetics from vegetation manipulation out-weighed the positive impacts from any increased water yield that might be obtained. They did note that mixed conifer and ponderosa pine forests, and chaparral vegetation zones offer greater potential for vegetation manipulation to improve water yield. It is important to note that most all of Walker River Basin phreatophytic vegetation falls within the three habitats that Ffolliott and Throud feel should not be manipulated to increase water yield.

In Arizona, Hendricks et al. (1960) evaluated the effectiveness of limited duration defoliation on cottonwood (*Populus* spp). This defoliation treatment eliminated evapotranspiration for about seven or eight days after treatment, or until trees refoliated. This method was shown to be an effective, if short-term means of reducing evapotranspiration.

Phreatophyte clearing projects in Arizona produced yearly water savings ranging from 0.8 to nearly 3 acre-feet per acre (Horton, 1972). However, Horton goes on to explain that these types of clearing projects have a tremendous impact on the environment. Compromises must be considered when evaluating the water savings derived from vegetation manipulation. He also notes that many of these phreatophytic zones are a major component in proper functioning flood plains. Replacement with vegetation that has a lower evapotranspiration rate is often not successful because of the lower water table. Horton adds that while water savings can be achieved through phreatophyte control, more work is needed to understand ecological impacts to wildlife and local vegetation communities.

Another interesting study from New Mexico evaluated water saving due to the replacement of 21,500 acres of saltcedar (*Tamarix* spp.) (a phreatophyte) with other vegetation. Calculated water savings were about 10,000 - 20,000 acre-feet annually to the Pecos River. However, these gains were never measured at the stream gage (Weeks et al., 1987). Several explanations are given for why the water savings were not measurable in the river. The expected, but not realized increase in water to the Pecos River may have been the result of masking climatic impacts (precipitation fluctuations during years prior and post vegetation removal), increased ground water pumping near the area, and nearly equivalent ET water use by replacement vegetation (Weeks et al., 1987). The important point is that theoretical water savings associated with vegetation manipulation may not be realized in adjacent or regional streams.

These findings are similar to results noted in ecosystems other than phreatophytic communities. Even the total removal of the above ground biomass has not always greatly increase available water to streams and rivers. An example was a timber site where clear cutting had occurred. Only a three to seven percent increase in water yield occurred (Bent, 1994). Bent noted that increased water yield was probably a combination of decreased evapotranspiration and canopy interception. Again, it is important to realize that increases in water yield come at a potentially high ecological cost; stream hydrology may be altered, runoff may be affected, and water quality may be impacted.

4.2 Current Estimates of Phreatophyte Water Use and Acreage

The Advisory Committee requested that an estimate be developed as to the amount of water consumed by phreatophytes present in the Walker River Basin. To arrive at such an estimate, the amount and type of phreatophyte communities present in the basin must be determined and reasonable evapotranspiration rates must be defined. An inventory of existing phreatophyte communities was obtained by several methods. First, existing phreatophyte surveys were reported in the following documents:

- Water Resources-Reconnaissance Series Report 40 (Everett and Rush, 1967): covers Mineral, Lyon, and Churchill counties.
- Water Resources Bulletin No. 38 (Huxel and Harris, 1969): covers Mason Valley, Lyon and Mineral Counties.
- Water and Related Land Resources, Central Lahonton Basin, Walker River Sub-basin, Nevada and California (SCS 1969): covers the entire Walker River Basin.
- Water Resources-Reconnaissance Series Report 53 (Glancy, 1971): covers Antelope Valley and the East Walker River (California and Nevada).

- Water Resource Bulletin No. 43 (Rush and Schroer, 1976): covers the geo-hydrology of Smith Valley, Nevada, with special reference to the period from 1953 to 1972.

Maps provided in these reports were digitized, allowing for the development of an ArcView GIS database for the Walker River Basin. On that map, phreatophytes were classified as either native stands or agricultural stands. Native stands were further divided into three general plant communities:

- A lower riparian community comprised of willows and grasses;
- An upper riparian community comprised of willows, grasses, cottonwoods, and greasewood; and,
- An upland community comprised of a greasewood shrub complex.

A mean evapotranspiration rate was then selected for each of the three native stand communities. Limited ground and aerial verification was conducted of the mapping.

Prior to finalizing the map, two other sources of information were reviewed. The Gap Analysis Program (GAP) is a USGS coordinated program that seeks to identify gaps in biological information. GAP Vegetation data was obtained for California and Nevada to supplement the existing phreatophyte survey, but proved to be unusable. The GAP data are too coarse in resolution, and incorrect vegetation communities were identified for some areas that had undergone field examination. Also, the Biological Resource Research Center (BRRC) was consulted regarding vegetation mapping. Unfortunately, the BRRC vegetation mapping for the state of Nevada was not complete at the time of this study.

Mapping conducted for this report indicates that native phreatophyte communities cover some 118,000 acres in the Walker River Basin (Figure 4.1). That mapping also indicates that approximately 110,000 acres of irrigated ground are present. Table 4.3 provides information on the distribution of native phreatophyte communities, offers an assumed mean evapotranspiration rate for each community, and presents an estimated water loss due to evapotranspiration. This assessment indicates that on average an estimated 106,400 acre-feet of water loss occurs annually through evapotranspiration in the Walker Basin.

TABLE 4.3. ESTIMATED WALKER RIVER BASIN NATIVE PHREATOPHYTE WATER USE BY VEGETATION COMMUNITY TYPE

Native Phreatophyte Community	Percent of Total Native Phreatophytes	Mean ET rate (ac/ft)	Acres	Total ET (ac/ft)
Lower Riparian – willows and grasses	36	1.5	42,500	63,700
Upper Riparian – willow, grasses, cottonwoods, greasewood	13	2.0	15,300	30,700
Greasewood – shrub complex	51	0.2	60,200	12,000
Totals	100	0.9	118,000	106,400

Several points need to be made concerning this evapotranspiration estimate. First, evapotranspiration rates are controlled by a number of factors. Major factors include the availability of ground water, the depth to ground water, the extent and nature of canopy development, the atmospheric demand, and the degree of advection. These factors vary from one year to another, causing evapotranspiration rates to vary. As a result, mean evapotranspiration rates are employed herein. Also, the acreages employed in this analysis are estimates based on previous surveys. These surveys represent different points in time and some variation may exist due to that fact. Only a limited amount of ground-truthing occurred to rectify mapping inconsistencies. As a result, discretion should be exercised when using the reported acreage figures. Additionally, the January 1997 flood impacted phreatophyte communities along certain reaches of the Walker River. Channel incisement occurred along some upper reaches of the Walker River and in those areas the total acreage of phreatophytes has likely decreased due to reductions in ground water levels. Elsewhere, huge sediment loads were deposited downstream, potentially raising the channel bed and thereby increasing the amount of potential phreatophyte habitat. The redistribution of sediment and changes in channel morphology had the potential to alter the amount, composition, and distribution of exiting phreatophytes within the basin. Any such changes are not represented in Table 4.3. As a result, additional phreatophyte mapping would be necessary should it be determined that the control of phreatophytes is warranted at a regional level. Even if the acreage estimates are correct, only a small percentage of the phreatophyte stands are suitable for control measures. Theoretical water savings through removal of phreatophyte stands may not be realized in area streams or rivers.

4.3 PHREATOPHYTE CONTROL MEASURES

Several methods of phreatophyte control are commonly acknowledged. Some may be used in combination with one another, while others are typically used in isolation. The most common means of phreatophyte control are listed below.

- Mechanical controls (cutting, mowing, fire, dozing).
- Chemical controls (herbicide treatment, short term defoliation).
- Biological controls (typically a species specific form of control; biological control of tamarisk would be an example).
- Biomass harvest on a sustainable level.
- Replacement of phreatophytes with vegetation that has a lower evapotranspiration rate.
- Thinning of woody phreatophytes such as cottonwoods (*Populus* spp.).

- Apply anti-transpirants to leafy phreatophytes such as cottonwoods (*Populus* spp.) as a means of temporarily reducing ET.

- Lowering of water tables through increased ground water pumping. In theory this kills the phreatophytes because they lose access to water. In actuality, some specie's roots will follow the lowering of the water table. For a considerable distance, depending on the rate of decline of the water table.

- Improved management to maintain high value vegetation and prevent phreatophyte invasion.

4.4 PHREATOPHYTE MANAGEMENT ALTERNATIVES

Any number of small-scale or site-specific phreatophyte management programs could be identified. These might include the following:

- The periodic thinning of cottonwoods along the river corridor.

- The periodic clearing or thinning of willows in backwater areas and in the upper riparian community (away from the immediate river corridor).

- The identification and eradication of small pockets of tamarisk.

- The routine removal of phreatophytes from the immediate river channel.

- The routine removal of cottonwoods and willows from along irrigation ditches.

While each of these programs may have merit, none would result in a substantial, quantitative reduction in evapotranspiration when viewed within the perspective of the entire Walker River Basin. Assuming that 200 acres of phreatophytes were removed annually and the ET rate in the treated areas averaged 1.5 acre-feet per acre, then there would be an annual water savings of approximately 300 acre-feet per year. Reductions in water loss would be quite localized and it is unlikely that the reduction would be perceptible in the Walker River.

Two larger programs were selected for more detailed review in this assessment. They deal with tamarisk removal along the lower Walker River and a broad-based, basin-wide phreatophyte reduction program. Each program is described separately.

4.4.1 Tamarisk *(Tamarix ramosissima)* (Saltcedar) Control

Substantial amounts of tamarisk are present along the lower Walker River on the Walker River Indian Reservation. Two species of tamarisk are present. *Tamarix ramosissima* is an invasive form of the species while *Tamarix parviflora* is a non-invasive form (Dr. James

Young, personal communication). Small stands (less than 1 acre) of non-invasive tamarisk were planted as wind breaks and do not pose a threat. These stands are located between U.S. 95 and the river. Far more pervasive along the lower Walker River, however, are stands of *Tamarix ramosissima*. Some of these stands are quite extensive. Vegetation inventories conducted elsewhere in the Walker River Basin have identified numerous young stands of tamarisk that are invading riparian zones.

It is not entirely apparent where some tamarisk stands along the lower Walker River currently obtain their water. Many of the stands are a significant distance from the Walker River, or do not have an obvious irrigation water source. Additionally, down-cutting has occurred along the lower Walker River to such an extent that some stands may now be perched above local ground water levels. These trends have been ongoing since the lake level began to decline substantially (after the turn of the century). Tamarisk stands located on the Walker River Indian Reservation likely obtain soil moisture supplied from other sources, such as small adjacent watersheds.

4.4.1.1 Methods of Tamarisk Control

The past eradication of tamarisk stands by burning, mechanical, chemical, or biological methods have met with varying degrees of success. Reestablishment of some other form of vegetative community in the face of competition by young, re-emergent tamarisk also has been problematic. Research indicates that the success of such reestablishment efforts would be enhanced by a return of natural stream flow and natural water table fluctuations (Sala et al., 1996).

Chemical control on young shoots has proven to be efficient and effective. Use of chemical control must be tempered with concern for the environment, wildlife, and water quality. Chemical treatment often involves individual plant treatment, such as removing the plant and then treating the stump with a product like Garlon® (triclopyr) (Baldwin 1996). Other commonly used herbicides include Arsenal® (imazapyr), Rodeo® (glyphosate), and Roundup® Pro (glyphosate). Garlon® 3A, Garlon® 4, and Arsenal® have had success when applied either to foliar areas, to the cut stump, to the basal bark, or by air. Rodeo® works with all treatment methods except basal bark applications (Jackson 1996).

Rodeo® and Roundup® Pro are broad spectrum, postemergence herbicides with no soil residue problems. However, care must be used when applying Rodeo® because it will kill grass plants as will Garlon® and Arsenal®. Arsenal® is the only product of the four that has soil residue concerns. Garlon® is effective on broadleaf species, offering safety to some grass plants (Jackson, 1996). While Arsenal® has been shown to be effective in tamarisk control, it has several usage problems: it does not have an over-the-water label and it will kill desert saltgrass (*Distichlis spicata*), an important herbaceous species (Young, 1998). Garlon® 4 basal bark applications on plants less than 4 inches in diameter has been shown to be effective (Jorgensen, 1996). Basal bark treatment greatly reduces labor costs: eliminating the need to cut plants for stump treatment is beneficial.

Success of any chemical control plan includes the need to follow-up after the initial application. Retreatment may be required annually for two to three years after the initial treatment (Jackson, 1996). Irrespective of which method of chemical control is selected, extensive labor investments in time and capital will be required. Hand application of herbicide is often required to avoid killing the herbaceous understory.

Burning of live stands can be difficult as tamarisk water content often impedes a killing burn. Successful methods of mechanical control include bulldozing the stands into piles, letting the piles sit for three or more weeks, and then burning the dried tamarisk piles (Jackson, 1996). With either method, some follow-up chemical treatment is required for control of the tamarisk stand. Otherwise, resprouting of tamarisk will usually follow burning (Wiesenborn, 1996). As means of tamarisk control, mechanical and burning methods often cause a substantial amount of site impact that results in additional expenses such as revegetation and rehabilitation costs.

Recently, interest in biological control methods has been increasing. Nineteen insects are currently being tested for release as tamarisk controls (DeLoach, 1996). Biological control of tamarisk in the area might prove feasible over the long term. Research has shown that biological control will keep stands from spreading rapidly and offers the ability to thin stands over a 5 - 10 year period, with final control being a reduction in canopy cover of 75 to 85 percent (DeLoach, 1996). Any use of biological control methods must be evaluated in light of this extended time frame and implications of the control species on other plant and animal species. The Agricultural Research Service (ARS) has plans to begin biological control studies in the Walker River delta area in 1999 (Young, 1998).

4.4.1.2 Suggested Method of Control

Biomass harvest shows promise as a possible renewable resource option for tamarisk. This potentially could occur on a sustained basis. It is also possible that the harvesting of tamarisk for biomass could release understory vegetation. Increased understory vegetation production would offer an increase in forage for summer grazing.

If no beneficial use for the tamarisk can be found, then some measure of, or combination of, chemical, mechanical, or biological control is warranted. Field observations indicate that tamarisk has spread along the Walker River at least as far as Wabuska. It will continue to do so unless some form of control is imposed. As previously mentioned, young tamarisk shoots are found throughout many parts of the system. Research on tamarisk control has resulted in the following hierarchy of control methods (Jorgensen, 1996). The preferred sequence of control would be as follows:

- Direct pulling of seedlings.
- Foliar spraying of seedling beds with Rodeo®.
- Cutting small plants with loppers and spot stump application of Garlon® 4.

- Chain saw large plants, followed by stump treatment with Garlon® 4.
- Basal bark treatment using Garlon® 4.

As stands are reduced through the application of these control measures, it is imperative that the former stand areas be monitored. Efforts will be required to reduce or eliminate the further recruitment of tamarisk. Clearly, tamarisk control is a long-term, continual process.

In addition to the above recommendations, consideration should be given to biological control as a method that may help maintain or reduce stand size. This can occur only as insects are approved for release.

Eradication of adult stands by cutting the trees and treatment of the stumps with Garlon® 4 would cost about $600-$900 per acre, depending upon the size of trees being treated and the hourly wage paid crew persons (Brain Cashore, LADWP, personal communication). This cost estimate is based on an $11 per hour employee wage. Larger trees can be cleared more quickly than dense stands of smaller trees. As noted, maintenance is required to keep tamarisk stands from regenerating. An annual maintenance cost would be required. A full-time position would be required to monitor and maintain control in previously treated areas. The salary for that position is estimated to be $35,000 to $45,000 annually, plus expenses such as part time crews, chemicals, and equipment.

4.4.1.3 Other Considerations

One aspect that cannot be overlooked is that currently tamarisk stands are the only form of bank-stabilization present in some areas along the lower Walker River. Reaches of the river absent tamarisk appear to have more bank sloughing than reaches that have mature tamarisk stands. As a result, tamarisk control or removal near the river's bank might not be appropriate in those reaches of the river where it is providing a stabilizing affect. Tamarisk removal in these areas may need to be more gradual. The tamarisk can be removed as other suitable species are introduced and become established. If other candidate species use as much water as does tamarisk, it may be prudent, in some areas, to leave the slope as is, stabilized by tamarisk. Bank stability along the Walker River is extremely important to reduce sediment load to Walker Lake.

Without some method of control it is possible that the tamarisk stands will continue to expand. Existing stands will produce a seed source available for continued colonization along the Walker River. Control of tamarisk along the Walker River is a basin wide problem and needs to be addressed as such. The following suggestions on tamarisk control are provided:

- Further research needs to be conducted on beneficial uses of tamarisk, including the potential for biomass harvesting.

- Begin research on ground water flow and characteristics as they relate to the establishment, spread, and maintenance of tamarisk stands.
- Establish small tamarisk eradication and control plots, followed by revegetation studies, or understory release processes studies.
- Implement a tamarisk control project, utilizing integrated control (herbicide, mechanical, and biological), while maintaining a belt of tamarisk along the river channel (until suitable replacement species can be found).
- Maintain ongoing tamarisk monitoring programs.
- Begin research to refine the evapotranspiration rate for tamarisk stands along the Walker River (instantaneous stomatal conductance, leaf area index calculations, canopy impacts, etc.).

4.4.2 Multi Specie Phreatophyte Stand Control – Partial Stand Eradication

As shown in Table 4.2, some 118,000 acres of native phreatophytes are present in the Walker River Basin. Those phreatophytes consume an estimated 106,400 acre-feet of water through evapotranspiration. One means of reducing this level of consumption would be to plan and implement a partial phreatophyte eradication program.

The program reviewed here would result in a five percent reduction of phreatophytes in the lower riparian community (about 2,100 acres), a ten percent reduction in the upper riparian community (about 1,500 acres), and a three percent reduction in the greasewood shrub community (about 1,800 acres). A management program would need to be developed that identifies areas in which reductions would occur, and the manner in which they would occur. For discussion purposes, reductions in the lower and upper riparian communities may be in the form of selective thinning conducted throughout the community; reductions in the greasewood shrub community may occur in large blocks (replacement by a substitute form of vegetation).

Based on mean evapotranspiration rates shown in Table 4.2, these eradication efforts would have the potential to reduce water losses by approximately 6,600 acre-feet annually. Assuming that twenty percent of the savings would be consumed by replacement vegetation, some 5,300 acre-feet would theoretically be left in the system. Most of that realized savings would remain in local ground water.

Treatment would likely be labor intensive and site specific. At an estimated cost of $500 per acre, the cost to remove 6,600 acres of phreatophytes would be $3.3 million.

A more realistic assessment may be to assume that a unit of government (Lyon County or NRCS, for example) would institute a program intended to perform this work on an on-going basis. The work would be conducted by agency personnel or by contractors to those agencies. It would be reasonable to assume that the basin-wide implementation of such a program may require an annual budget of $200,000.

4.5 SUMMARY

While many methods have been shown to be effective controls on different species of phreatophytes, it must be recognized that in many instances those controls are not environmentally sound. Thinning or removing cottonwood trees might yield additional water, but the aesthetic and habitat loss may not justify their removal. The same can be said of other comparatively severe forms of treatment (clearing, and mechanical and herbicide methods). In the short term, water yields may increase, but the long term ecological and aesthetic damage may out weigh any theoretical increases in water yield. This would be especially true of vegetation manipulation along the river. The substantial modification of existing of phreatophyte stands may be detrimental to the environment through the loss of wildlife habitat, aesthetic degradation, and the loss of proper functioning flood plains.

If there is an appetite for phreatophyte control, selected program may be worthwhile. First among these is the removal of dense tamarisk stands present on the Walker River Indian Reservation. The removal of willows and other phreatophytes from along irrigation ditches (either by eradication or through concrete lining of ditches) would have the double benefit of reducing ET losses and increasing the operational efficiency of the irrigation ditches. Finally, a basin-wide program of phreatophyte reduction may be justifiable if it is conducted in conjunction with efforts to increase channel capacity.

Chapter Five — TOPIC TWO: FLOOD WATER MANAGEMENT

Public meetings in the fall of 1998 and subsequent Committee meetings resulted in the definition of a series of conservation measures intended to increase the river's flow to Walker Lake. A common point of discussion was the need to take advantage of flood water as a means of accomplishing this task. Flood water almost always reaches Walker Lake, but the question is – are there measures that if implemented would increase yield to the lake as a result of any given flood event regardless of the frequency of flooding? Specific activities called for by the Committee included the following:

- Compile and review information about existing storage facilities. Determine the feasibility of expanding storage capacity to capture and detain flood flows for later release. Evaluate previously proposed facilities for any potential flood control benefits.

- Determine which sections of the Walker River lend themselves to channel modification as a means of containing over-bank flooding. This would provide flood control benefits while enhancing the conveyance of water to Walker Lake.

- Determine if river reaches can be identified where 'out of channel' flood flows can be controlled.

- Estimate stream volume and TDS changes that can be expected throughout the Walker River system as a result of any proposed modifications.

- Qualitatively access impacts that may occur as a result of changes in storage and stream flow.

This chapter provides information relevant to the activities identified above. The scope is constrained to evaluating existing data and interpretations with limited field investigations.

5.1 HYDROLOGIC PLANNING CONSIDERATIONS

This study was designed to evaluate flood management options that if implemented would increase the volume of flood water that flows to Walker Lake. Clearly, flood control benefits would accrue due to such actions, and those benefits are identified.

Two main processes need to be considered. The more passive of the two processes is the *conservation of flow,* or *flow management*. Actions that facilitate this process generally require very little in the way of construction. It must be noted, however that these actions offer almost no benefits for actual flood control. The second process would consist of *storage management*. Proposed reservoirs, existing reservoirs, and river channel segments are reviewed in an attempt to identify reasonable means of increasing the system's overall storage capacity.

Whether one chooses to manage flows or storage, it is important to understand that there are two types of flood water in the Walker River Basin. The first consists of flood water as defined by Decree C-125 (see Section 6.2.4.3 of this report). Decreed flood water is any flow that occurs during the irrigation season that is in excess of the duty required to be delivered via the Decree. Events that result in decreed flood waters occur during spring and early summer as a result of snow melt. Decreed flood waters are distributed to all right holders in proportion to the rights previously established. Priority does not apply in the distribution of decreed flood waters.

The other type of flood water is not defined by the Decree, but consists of flood water that enters the system during the non-irrigation season. It is this type of event were substantial savings can occur due to flood management. Typically, these are rain-on-snow events that can be sizable in magnitude, such as occurred during the January 1997 flood. These mid-winter to early spring flood flows often exceed channel capacity, particularly along the main stem of the Walker River in Mason Valley. As a result, a large area at the north end of the valley becomes saturated. With time, much of the standing water drains back to the river. Some, however, is retained as soil moisture and subsequently is lost to evaporation and transpiration. Undoubtedly, some amount of ground-water recharge takes place due to this over-bank flooding, but the water table is relatively close to the surface in this part of Mason Valley, limiting recharge potential.

Volumes of water generated during any given flood event, even during the irrigation season, can be managed by a combination of water storage and flow conservation methods. On one extreme, sufficient storage could be constructed to retain the entire event. Flow conservation would not be necessary since the release of stored water could be carefully controlled. On the other extreme, storage capacity could be minimized or eliminated. Then far greater emphasis would need to be placed on flow conservation, thereby ensuring that high and uncontrolled channel flows did not cause unwanted damage. Between those two extremes are any number of reasonable system configurations that include some level of storage and some degree of flow conservation.

5.2 Flood Storage Management

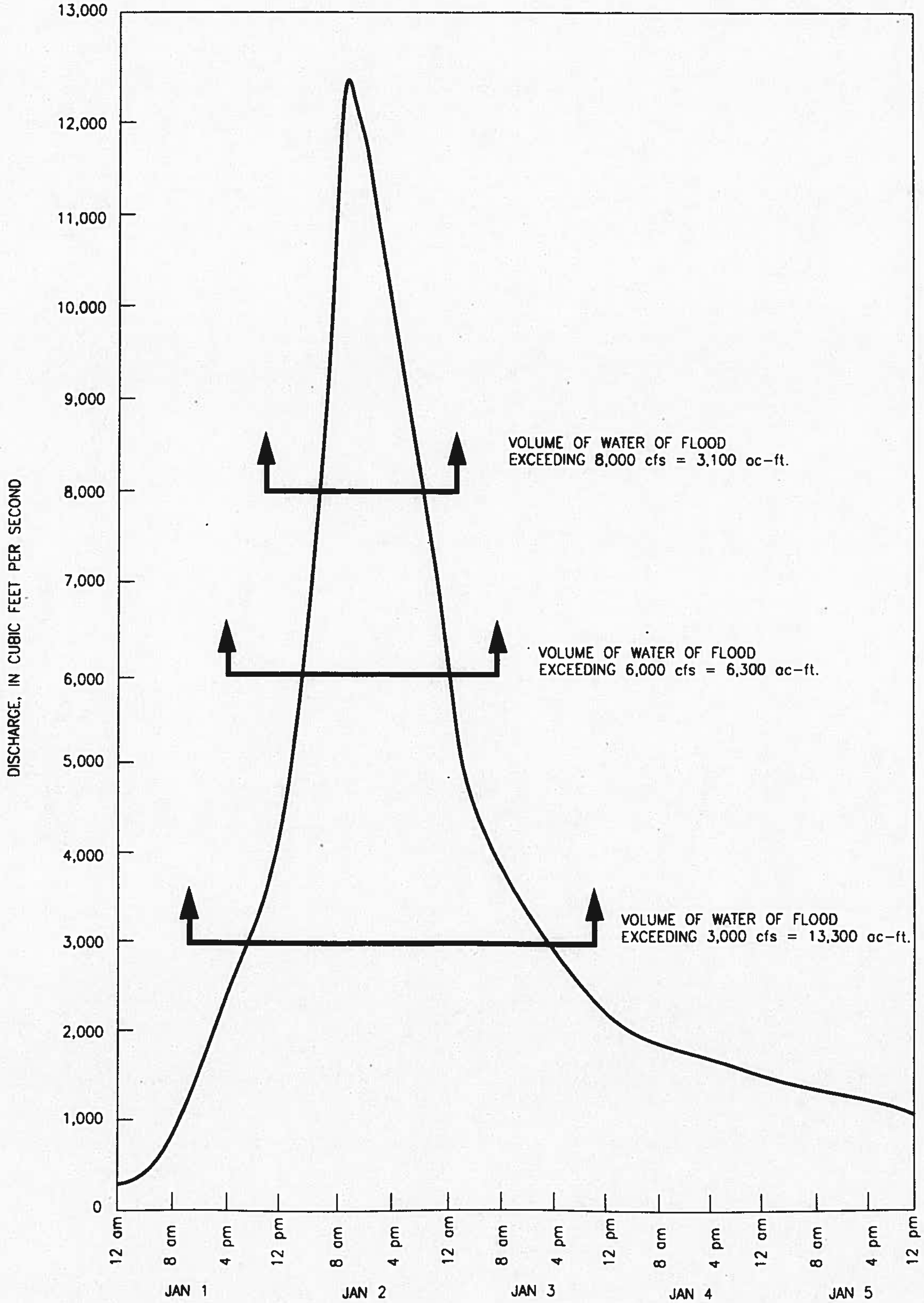
The Walker River Basin encompasses an area of about 4,050 square miles. The East Walker River has a drainage area of approximately 1,100 square miles and an average annual flow of 111,000 acre feet (Bonner et al., 1997) as measured by the U.S. Geological Survey (USGS) below Bridgeport Reservoir. The West Walker River has a drainage area of approximately 970 square miles and an average annual flow of 143,000 acre-feet (Bonner et al., 1997) as measured by the USGS at a site 5 miles southeast of Coleville. Flows of the Walker River are recorded at a site near Wabuska, with an average annual flow of 122,000 acre-feet (Bonner et al., 1997).

Flooding on the Walker River is primarily the result of late spring and early summer snowmelt events, or winter and early spring rain-on-snow events. The largest flood events in the past have been rain-on-snow events. Summer flooding events are smaller in magnitude than snowmelt flooding, are usually quite localized, and are most often contained in existing channels. The most recent and also the most damaging flood recorded along the Walker River was the January 1997 flood. Information gathered during the flood is useful for this study (USGS, 1997; US Army Corps of Engineers, 1997; Nevada Bureau of Mines and Geology [NBMG], 1998).

During the January 1997 event, major flooding took place along the West Fork of the Walker River and along the main stem of the Walker River. The West Walker River crested on January 2 at the south end of Antelope Valley near Coleville at 12,500 cubic feet per second (cfs) and the following ten-day volume of water equaled about 43,000 acre-feet. At the next downstream gage at the Hoye Bridge site, the river peaked at an estimated 11,500 cfs and further downstream in Wilson Canyon the peak was estimated at 11,400 cfs. Travel time of the flood increased as it flowed through Mason Valley and it took 2 ½ days for the peak to travel about 32 miles from the Coleville gage to the Walker River gage near Wabuska, where it was estimated at about 2,600 cfs (USGS, 1999). This attenuation in flow was caused by flood flow exceeding channel capacity and overflowing onto the flood plain. Figure 5.1 shows the flood hydrograph of the January 1997 flood at USGS gaging sites in the Walker River Basin (Nevada Bureau of Mines and Geology, 1998).

The frequency of the January 1997 flood varied with river reach (see Table 5.10). The peak flow on the East Walker River near Bridgeport, California was approximately a 50-year event (see Section 5.4.1 for an explanation of flood frequencies). Storage in Bridgeport Reservoir and flow attenuation reduced the peak flow to about a 25-year event by the time the peak reached the USGS gage near the Strosnider Ditch. The frequencies of the peak flow on the West Walker River were significantly different. The peak flow of the West Walker River near Coleville exceeded a 500-year flood. Storage in Topaz and flow attenuation reduced the downstream peak flow to about a 300-year event. By the time the peak reached the Wabuska gage it had decreased to about a 10-year event. In other words, while flows along the East Walker River were of a magnitude that are somewhat common, flows on the west Walker River were of a magnitude that are uncommonly rare.

Damage caused by the January 1997 flood was pronounced. Over 6 miles of U.S. Highway 395 in Walker Canyon washed out and numerous homes and business near Walker and Coleville, California were severely damaged. In Antelope Valley, California, over 10,000 acres were flooded with up to three feet of sediment. The U.S. Army Corps of Engineers (1998) estimated damages in California at about $3.5 million. In Nevada, the flood damaged several homes and roads in the Hoye Canyon area downstream from Topaz Lake, and large sections of State Route 208 through Wilson Canyon were washed away. The cost to repair damage to the highway in Wilson Canyon was between $726,000 (NBMG, 1998:61) and $1.6 million (U.S. Army Corps of Engineers, 1998). The Walker River overtopped low levees along its east bank and flooded structures and roads in and south of Yerington with



Source: Nevada Bureau of Mines and Geology, 1998.

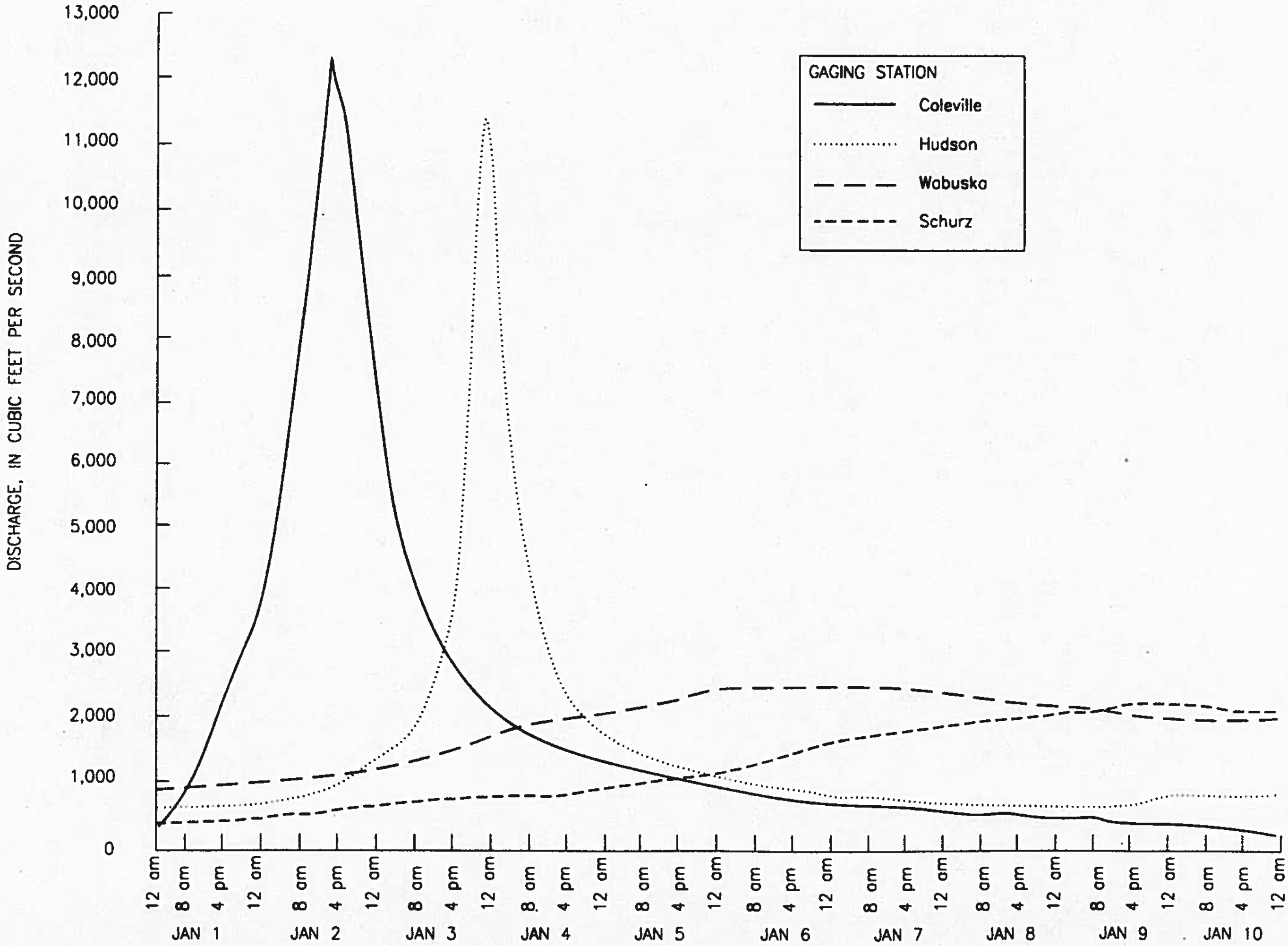
Figure 5.1 West Walker River Hydrograph, January 1st to 5th, 1997 up to 3 feet of water. In Lyon County alone 193 homes and several public buildings were flooded causing over one million dollars in structural damage (U.S. Army Corps of Engineers, 1998); estimated damage to public property in Yerington amounted to more than $81,000. The cost to repair/replace irrigation and related diversion structures in Smith and Mason Valleys was estimated at $26.4 million (NBMG, 1998:63).

The storage of flood waters in existing or new reservoirs could reduce or eliminate river flooding downstream during specific events. As an example, based on USGS gaged data (Figure 5.2), the January 1997 flood had a ten-day volume of 43,000 acre-feet along the West Walker River. It is impractical to consider constructing a reservoir system that could detain this amount of water. As indicated previously the peak flow exceeded 12,000 cfs at the Coleville gage. To reduce that peak by some 4,000 cfs would require about 3,000 acre-feet of additional storage. Reducing the peak to half of its value (about 6,000 cfs) would require about 6,000 acre-feet of additional storage and to further reduce the peak flow to about 3,000 cfs would require about 13,300 acre-feet of additional storage. These flow-storage relationships are shown on Figure 5.2. Thus a flood reservoir system, if in place, and depending on its capacity, could have reduced the 1997 flood peak and any related over-bank flooding considerably. Any water savings that may derive from such activities would occur only during flood events.

Temporary storage of flood waters by existing or new reservoirs could also limit river conveyance losses resulting in more water flowing to Walker Lake. Monthly records indicate that the January 1997 flow volume entering Mason Valley from both forks of the Walker River equaled about 115,000 acre-feet (East Walker River above Strosnider Ditch near Mason, Nevada, was 49,450 acre-feet; West Walker River near Hudson, Nevada, was 65,400 acre-feet). The flow volume of the Walker River near Wabuska, Nevada (northern end of Mason Valley) was about 103,000 acre-feet, indicating a loss of about 12,000 acre-feet. Undoubtedly some of this water eventually returned to the river as ground water, but some of it was lost to the system later in the year due to evapotranspiration. And there are of course errors in the gaged flow that may increase or decrease this amount.

5.2.1 Expand Existing Storage Facilities

Storage facilities are present on both the East Walker River and the West Walker River, however these facilities are operated primarily for the agricultural community. Within the operating criteria there is recognition of the importance of reducing flooding and if possible reservoirs are drawn down in advance of excessive runoff. Existing East Walker River storage facilities include Upper and Lower Twin Lakes, Green Lakes, and Bridgeport Reservoir (Figure 5.3). Topaz Lake is the largest reservoir on the West Walker River. Smaller West Walker reservoirs include Black Reservoir, Lobdell Lake, and Poore Lake. Weber Reservoir, located on the main stem of the Walker River, stores irrigation water for the Walker River Paiute Tribe.



Source: Nevada Bureau of Mines and Geology, 1998.

Figure 5.2 Hydrograph of the 1997 New Year's flood at Selected Sites in the Walker River Basin

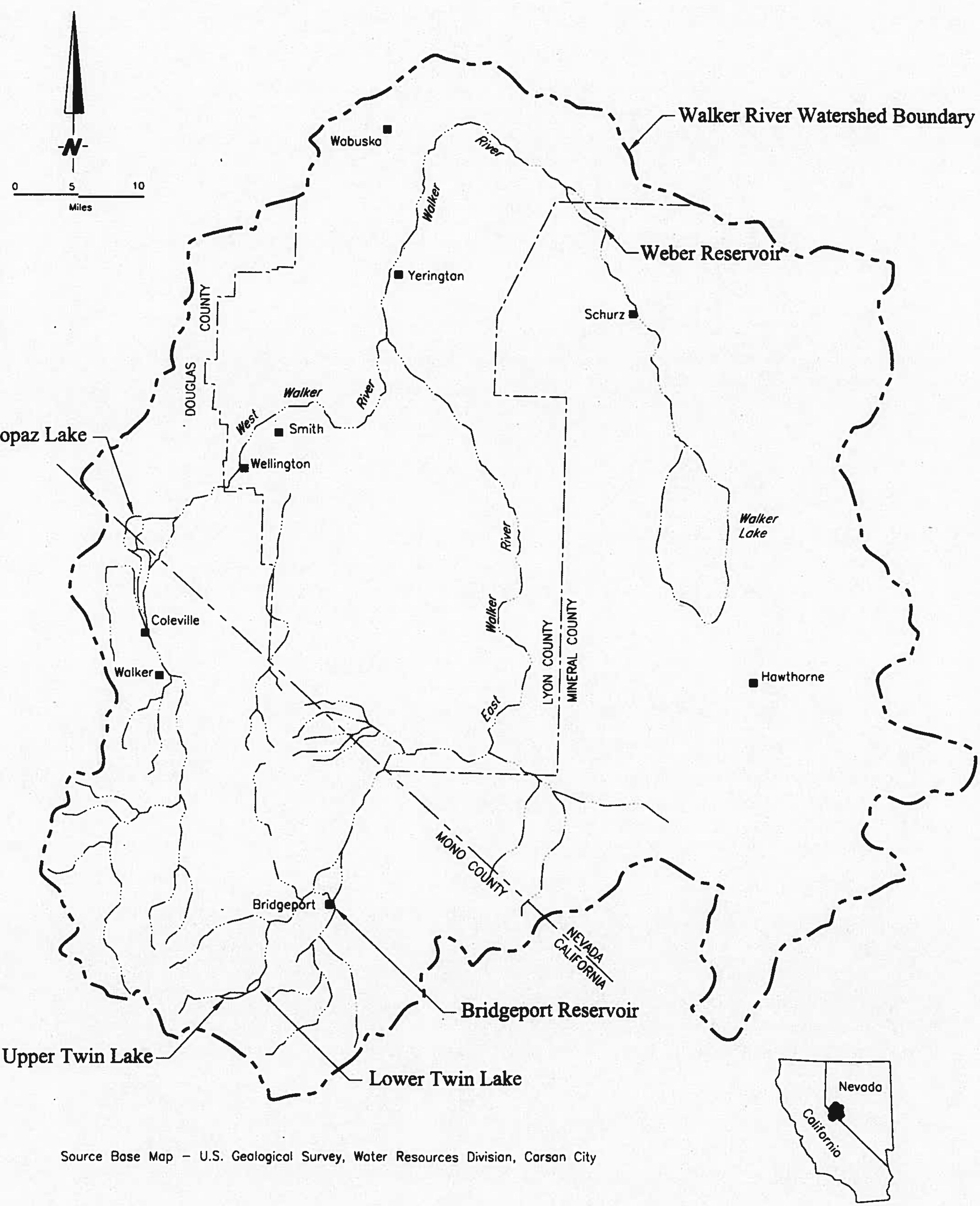


Figure 5.3 Existing Major Storage Reservoir Locations, Walker River Basin

In past events, the prudent operation of larger storage facilities has afforded some flood control benefits to downstream areas. Existing irrigation storage reservoirs are evaluated here to determine their ability to offer flood protection and potential conservation of river flows that could be released directly to Walker Lake. The temporary storage of flood waters in existing reservoirs could substantially reduce flooding during specific events. Due to their limited size and storage capacities, many of the smaller lakes and reservoirs cannot contribute to purposeful flood management. Reservoirs less than 2,000 acre-feet in capacity were not considered in this analysis.

Additional storage on existing reservoirs that would be provided by increasing the height of the dams was estimated by extending USGS stage-capacity data. In determining impacts to shore lines, allowances were made for wave action based on the maximum observed high-water mark during the spring of 1999. Detailed surveys are required should an increase in reservoir storage be determined as a project option.

Another consideration might be the dredging of selected areas within one or more existing reservoirs, thereby increasing storage capacity. For instance, the south end of Bridgeport Reservoir is quite shallow, providing the opportunity for dredging. No attempt was made to estimate the additional capacity that could be gained by such action. Environmental issues such as turbidity, temperature, and water quality would require analysis prior to any such action. Topaz Reservoir also may be a candidate for dredging, particularly on the south side of the reservoir in the area of the diversion dike.

5.2.1.1 Upper and Lower Twin Lakes

Upper Twin Lake's dam, which has a drainage area of 29.5 square miles, provides a useable storage capacity of 2,070 acre-feet between the elevations of 7,200 (natural lake rim) and 7,207 feet (spillway crest). The design storage capacity has been exceeded on at least two occasions (July 7, 1983, elevation 7,209.85 feet at 2,990 acre-feet and June 23, 1997, elevation 7,208.90 feet at 2,680 acre-feet). The elevation/capacity relationship for Upper Twin Lake is provided in Table 5.1.

TABLE 5.1. ELEVATION/CAPACITY RELATIONSHIP FOR UPPER TWIN LAKE

Elevation (ft)	Capacity (af)	Elevation (ft)	Capacity (af)
7,200	0	7,206	1,750
7,201	280	7,207*	2,070
7,202	560	7,208	2,390
7,203	840	7,209	2,710
7,204	1,130	7,210	3,040
7,205	1,440	7,211	3,370

* *Spillway elevation*
Source: USGS rating number 1.

These data indicate that increasing the height of the dam by two feet (to an elevation of 7,209.0 feet) increases the storage capacity by 640 acre-feet. An increase of four feet (to an elevation of 7,211.0 feet) would increase the storage capacity by 1,300 acre-feet. However, increasing storage at Upper Twin Lakes by even two feet would impact homes and businesses along the lakeshore. Additionally, road access to the north end of the lake would be impacted.

Lower Twin Lake's dam, which has a drainage area of 38.9 square miles, provides a usable storage capacity of 4,010 acre-feet between the elevations of 7,190 (natural lake rim) and 7,200 feet (spillway crest). The design capacity of the reservoir has been exceeded on at least two occasions (June 19, 1983, elevation 7,203.58 feet at 5,560 acre-feet and June 23, 1997, elevation 7,202.63 feet at 5,140 acre-feet). The elevation/capacity relationship for Lower Twin Lake is listed in Table 5.2.

TABLE 5.2. ELEVATION/CAPACITY RELATIONSHIP FOR LOWER TWIN LAKE

Elevation (ft)	Capacity (af)	Elevation (ft)	Capacity (af)
7,190	0	7,198	3,200
7,191	400	7,199	3,600
7,192	800	7,200*	4,010
7,193	1,200	7,201	4,430
7,194	1,600	7,202	4,860
7,195	2,000	7,203	5,300
7,196	2,400	7,204	5,750
7,197	2,800		

* *Spillway elevation*
Source: USGS rating number 1.

These data indicate a rise in storage elevation of two feet (to an elevation of 7,202.0 feet) would increase storage capacity by 850 acre-feet. An increase of four feet (to an elevation of 7,204.0 feet) would increase storage capacity by 1,740 acre-feet. Increasing storage at Lower Twin Lake would impact several homes on the north shore of the Lake and road access to the south end of the lake also could be impacted. Additionally, increasing storage could cause dam seepage possibly requiring significant dam modifications.

5.2.1.2 Bridgeport Reservoir

Bridgeport Reservoir is located at the north end of Bridgeport Valley in Mono County, California. The reservoir is formed by an earth-filled, rock faced dam. Storage began on December 8, 1923, just prior to completion of the dam. Capacity of the reservoir is 42,460 acre-feet between the elevations of 6,415 (bottom of the reservoir) and spillway crest elevation of 6,461 feet (Table 5.3). The contributing drainage area upstream of Bridgeport Reservoir is 358 square miles. The maximum capacity of the reservoir was reached on June 16, 1974, at elevation 6,460.78 feet with 44,880 acre-feet of storage. On January 4, 1997, the elevation of the reservoir was 6,460.31 feet (nearly exceeding the previous maximum) with a capacity of 43,400 acre-feet. The elevation/capacity relationship for Bridgeport

Reservoir is listed in Table 5.4. Estimates of increased storage indicate that a rise in the design storage elevation of 2 feet (to an elevation of 4,663.0 feet) would increase storage by 6,390 acre-feet. A rise in elevation of 4 feet (to an elevation of 4,665.0 feet) would increase storage by 13,250 acre-feet.

A two-foot rise in storage elevation could be accomplished without raising the height of the dam. This could be achieved through a change in operational procedures. Preliminary site investigations indicate a two-foot rise in storage elevation would probably have little impact on adjacent land users. One structure on the reservoir's east shore possibly may require mitigation. The airport runway is several feet above the high water line and is probably not at risk with the potential increase in storage. The higher reservoir level would only minimally impact septic systems at homes located on the east shore in close proximity to the high-water line. It is assumed that the proposed flood storage would be temporary in nature. Stored water would be released as soon as possible (typically in a matter of days). A four-foot increase in storage at Bridgeport Reservoir would have more substantial impacts and may require modification of the spillway.

TABLE 5.3. ELEVATION/CAPACITY RELATIONSHIP FOR BRIDGEPORT RESERVOIR

Elevation (ft)	Capacity (af)	Elevation (ft)	Capacity(af)
6,415	0	6,441	7,120
6,417	9	6,443	9,100
6,419	42	6,445	11,380
6,421	115	6,447	13,990
6,423	213	6,449	17,060
6,425	334	6,451	20,620
6,427	539	6,453	24,660
6,429	895	6,455	29,160
6,431	1,400	6,457	34,110
6,433	2,050	6,459	39,540
6,435	2,920	6,461*	45,490
6,437	4,050	6,463	51,880
6,439	5,440	6,465	58,740

* *Spillway elevation*
Source: USGS rating number 1.

5.2.1.3 Topaz Lake

Topaz Lake is an off-channel storage facility formed by diverting water from the West Walker River into an alkali basin. Water is returned to the West Walker River through an outlet tunnel located toward the east end of the lake (the lowest elevation of the outlet tunnel is 4,967.68 feet). Storage began near the end of 1921. Originally, the usable capacity of the lake was 45,000 acre-feet. This was increased to 59,440 acre-feet in 1937. The construction of an earth-filled rock-faced levee at the south end of the lake increased the lake's surface elevation to 5,000.38 feet (three feet below the top of the diversion levee). The contributing drainage area upstream of Topaz Lake is approximately 450 square miles in size. The design capacity of the reservoir has been exceeded on at least one occasion (July 3, 1980, elevation 5,000.92 feet at a releasable capacity of 60,680 acre-feet). The elevation/capacity relationship for Topaz Lake is given in Table 5.4.

These data indicate that increasing storage two feet above the elevation of the spillway (to a gage elevation of 5,002.38 feet) would increase storage capacity of the lake by 4,650 acre-feet. A rise in elevation of four feet (to a gage elevation of 5,004.38 feet) would increase storage capacity by 9,420 acre-feet. Both scenarios would require substantial modification of the existing levee that is over 5,000 feet in length.

TABLE 5.4. ELEVATION/CAPACITY RELATIONSHIP FOR THE CONTROLLED, USEABLE CAPACITY OF TOPAZ LAKE

Elevation (ft)	Capacity (af)	Elevation (ft)	Capacity (af)
4,967.68	0	4,985	28,310
4,968	490	4,990	37,360
4,970	3,580	4,995	47,540
4,975	11,520	5,000.38	59,440
4,980	19,760	5,001	60,870

Source: USGS 1998.

An alternative would be to utilize a portion of the "dead storage" that is present in the lake. Between the outlet elevation of 4,967.68 feet and the bottom of the lake (elevation about 4,913 feet), there is about 65,000 acre-feet of what is considered dead storage according to Rush and Hill (1972). This is water that cannot be released through the outlet works because it occupies that part of the lake that is lower than the outlet works. It may be possible, through an agreement with the Walker River Irrigation District, to use some portion of this dead storage for flood control purposes.

For discussion purposes, it is assumed that 30,000 acre-feet of water, or about half of the dead storage may be available for such purposes. If 30,000 acre-feet of water was removed from the minimum pool, the surface elevation of the lake would be about 4950 feet and the lake would be about 37 feet deep, at its deepest. Management guidelines could vary. Presumably, the accepted strategy would be determined largely on risk tolerance. Two alternate strategies are discussed to illustrate how dead storage management might occur and what benefits might be derived.

<u>*Strategy One – a higher risk management strategy:*</u> At the end of the irrigation season (November 1), begin the controlled release of 30,000 acre-feet of dead storage water. This water would be released through the tunnel from the remaining active storage pool. During a drought, active storage may have been depleted during the irrigation season. In that event, water would be pumped into the outlet tunnel from dead storage. In any event, that release would be completed by December 1 (start of high flood probability season), making available 30,000 acre-feet of flood control storage. The refilling of this dead storage would occur after March 1. At this time, storage over and above releases for irrigation can resume, depending on the magnitude of the snow pack and the runoff predictions. If

conditions are favorable, some, if not all, of the released dead storage can be replenished during the spring runoff period. If conditions are not favorable, then only a part of that storage would be replenished. Depending on the initial lake level, active stored water may be used up before the end of the irrigation season. In this case, water would be pumped from dead storage to meet the unsatisfied portion of the dead irrigation demand. Over a series of drought years this could result in the lake remaining at a very low level. This would have an impact on recreational uses of the reservoir.

Strategy Two – a lower risk management strategy: Four months (November through February) separate the end and the beginning of the irrigation season. At the middle of each of those months, the Water Master would determine the advisability of releasing dead storage waters. That decision would be made based on current lake storage levels, on the magnitude of the snow pack, and runoff predictions. No more than 7,500 acre-feet would be released during any given month. This strategy could result in as much as 30,000 acre-feet of flood control storage. The refilling of this dead storage would occur after March 1. At this time, storage over and above releases for irrigation can resume. If conditions are favorable, 30,000 acre-feet of water would have been released with a fair to excellent chance that it could be replenished during the spring runoff period. If conditions are not favorable, then only some portion of that storage would have been replenished. The amount released would have been predicated on the system's ability to refill the reservoir. Over a series of drought years, little to no dead storage water would be released. Pumping of dead storage water would never be required. No attempt was made to estimate pumping costs or operation and maintenance costs.

Regardless of the strategy employed, a flow routing model needs to be constructed with daily time steps. The model would test the feasibility of the alternate management scenarios against actual river flow values. The model would use different percentages of dead storage and various flow release values for the period of record for gaged river flow. The model would define the risk that a shortage of irrigation water would occur.

5.2.1.4 Weber Reservoir

The Weber Reservoir dam is an earth and gravel-fill structure constructed by the Bureau of Indian Affairs in 1935. It is the only storage facility on the main stem of the Walker River. The reservoir's capacity is 11,100 acre-feet with a surface area of 900 acres. The contributing drainage area upstream of Weber Reservoir is approximately 2,770 square miles in size. The elevation/capacity relationship for the reservoir is shown in Table 5.5.

These data indicate that a rise in storage elevation of two feet (to an elevation of 4,210.0 feet) would increase capacity of the reservoir by 1,200 acre-feet. A rise in the storage elevation of four feet (to an elevation of 4,212.0 feet) would increase storage by 1,900 acre-feet.

Weber Reservoir, because of its location on the lower river and its relatively small storage capacity has limited utility to reduce flooding on a large scale, but can provide some measure of flood protection for Schurz and reduce downstream river-channel erosion from short term, relatively low magnitude runoff events.

TABLE 5.5. ELEVATION/CAPACITY RELATIONSHIP, WEBER RESERVOIR

Elevation (ft)	Capacity (af)	Elevation (ft)	Capacity (af)
4,182	0	4,199	1,750
4,185	66	4,201	5,530
4,187	199	4,203	6,930
4,189	421	4,205	8,500
4,191	866	4,207	10,200
4,193	1,480	4,208*	11,100
4,195	2,250	4,210	12,300
4,197	3,180	4,212	13,000

*Elevation/Capacity from RCI (1999); * Spillway elevation*

5.2.1.5 Existing Reservoirs, A Summary

Five major irrigation reservoirs are present on the Walker River and its tributaries. A summary of the existing storage and potential flood storage of these reservoirs, based upon increasing reservoir elevations (increase dam height or reservoir dike), is provided in Table 5.6.

TABLE 5.6. FLOOD STORAGE POTENTIAL OF EXISTING RESERVOIRS

Reservoir	Drainage Area (mi^2)	Irrigation Storage (af)	2-ft Elevation Rise (af)	4-ft Elevation Rise (af)
Bridgeport	358	42,460	6,390	13,250
Upper Twin Lake	29.5	2,070	640	1,300
Lower Twin Lake	38.9	4,010	850	1,740
Topaz Lake	450	59,440	4,650	9,420
Weber Reservoir	2,770	10,700	1,200	1,900

Even the temporary storage of flood flows in Upper and Lower Twin Lake would have an impact on structures and roadways. Weber Reservoir is comparatively small and is located at the wrong end of the river system to offer substantial flood management potential. As a result, the only real potential to provide flood storage at an existing facility would be at Bridgeport and/or Topaz Reservoir. They offer 11,040 acre-feet of flood storage, if reservoir elevations were raised by two feet. As noted above, a four foot increase in elevation at either location is problematic

The West Walker River above Topaz Lake has nearly150 mi^2 more drainage area than the East Walker River drainage above Bridgeport Reservoir. This greater drainage area coupled with the geography of the system is generally responsible for more flood events on the West Walker. Thus, in terms of priority of work for flood control, the greatest benefits can be achieved on the West Walker River. Flood control efforts on either fork will benefit the downstream main stem area.

5.2.2 Previously Proposed Storage Facilities

Over the years, numerous studies have investigated potential reservoir sites throughout the Walker River Basin, typically as means of increasing storage for irrigation. Sites are located along both the East and West Walker Rivers. Their approximate location is shown in Figure 5.4. These sites are reviewed to determine whether any of the proposed reservoirs should be reconsidered as possible flood control or flow conservation facilities that may assist in the enhancement of flows to Walker Lake.

5.2.2.1 Pickel Meadows Dam and Reservoir

Pickel Meadows is located in the upper reach of the West Walker River, approximately 16 miles west-northwest of Bridgeport, California. In 1964, the Bureau of Reclamation prepared a study that explored the possibility of constructing a reservoir in Pickel Meadows. The drainage area contributing to this proposed dam and reservoir site in approximately 100 square miles in size. The reservoir capacity would be 110,000 acre-feet at a surface elevation of 6,824.0 feet. This capacity would provide 10,000 acre-feet of inactive storage to maintain a minimum pool for fishery and recreation, and 100,000 acre-feet of active capacity to regulate irrigation and flood flows.

5.2.2.2 Hoye Bridge Dam Reservoir

The proposed Hoye Bridge Dam site is located on the West Walker River, approximately 5 miles downstream from Topaz Lake and 3.5 miles upstream from Wellington. The Donald Warren Engineering Company originally proposed this dam in 1953 and modified its design in 1961. In 1976, the engineering firm of Sharp, Krater & Associates offered further revisions based on storage capacities and cost estimates for reservoir volumes of 76,800, 40,000 and 20,000 acre-feet. The capacity of the reservoir was dependent on exact dam height and location. The maximum height of the dam with 76,800 acre-feet capacity would be 80 feet, although a majority of the embankment would not exceed 55 feet. The reservoir, as designed, was shallow and would have high rates of evaporation. The reservoir was designed to have the same water surface elevation as Topaz Lake and would therefore encompass the Lake. Separate or combined water regulation of Topaz Lake and Hoye Bridge Reservoir were proposed.

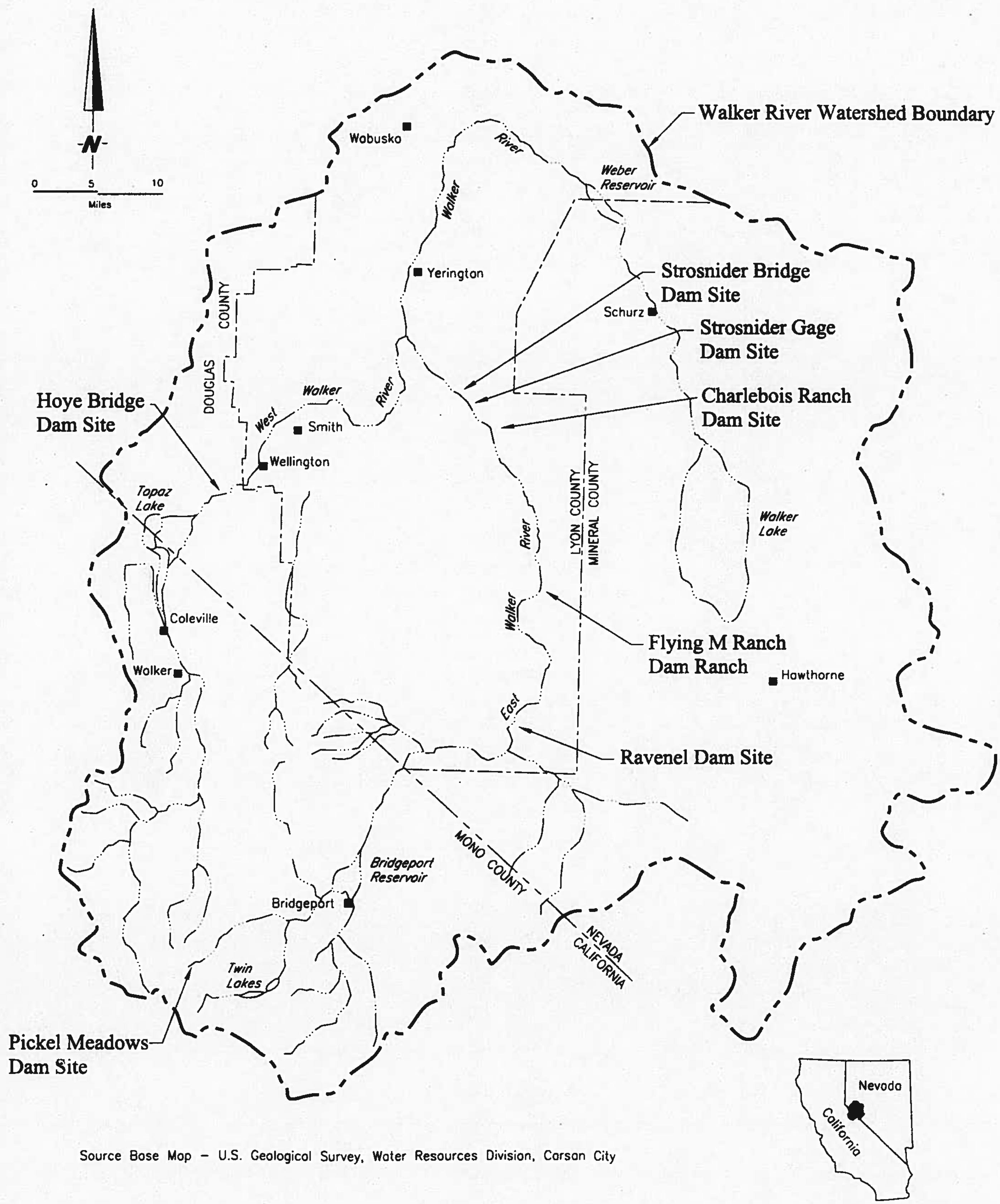


Figure 5.4 Previously Proposed Reservoir Locations, Walker River Basin

The Nevada State Engineer has issued a permit for the Hoye Reservoir. That permit specifically identifies that the reservoir would be used for storage and irrigation purposes. If constructed, this reservoir also could offer substantial flood control along the West Walker in Smith Valley. Because the West Walker has a higher incidence of flooding than the East Walker, the presence of Hoye Reservoir would greatly reduce the flood threat in Mason Valley and further downstream. Flood water detained, by whatever capacity dam, could easily be released to Walker Lake as soon as the threat of flooding was over.

5.2.2.3 Walker River Irrigation District Study

Five dam sites located along the East Walker River were proposed and investigated by Sharp, Krater and Associates, Inc. for the Walker River Irrigation District. Descriptions of these sites follow. For a variety of reasons, none of these reservoirs were constructed.

The Ravenel Reservoir site is located on the East Walker River, approximately 21 miles downstream from Bridgeport Reservoir. Two possible dam sites were identified about a mile apart. A dam at either site would create a reservoir some 6 miles long with a storage capacity of 40,000 to 50,000 acre-feet. The two dams would be approximately 135 to 160 feet in height and 720 to 800 feet in crest length.

The Flying M Ranch Reservoir dam site was located in the NE ¼ of Section 29, T. 9 N., R. 27 E. The reservoir would flood the Flying M ranch with 10,000 to 20,000 acre-feet of water. At the time of the study, it was determined that land acquisition costs would be high and the site was not considered further.

The Old Charlebois Ranch Reservoir dam site was located in the NW ¼ of Section 36, T. 11 N., R. 26 E. The reservoir would flood the Old Charlebois ranch with 10,000 to 20,000 acre-feet of water. It was determined that land acquisition costs would be high and the site was not considered further.

The Strosnider Bridge Reservoir dam site was located in the NE ¼ of Section 9, T. 11 N., R. 26 E. The river elevation at this site is approximately 4,540 feet. A 20,000 acre-foot reservoir would require a dam approximately 66 feet in height, while a 10,000 acre-foot reservoir would require a dam 50 feet in height. Crest lengths would be 1,080 and 925 feet, respectively.

The Strosnider Gage Reservoir dam site would be located in the SW ¼ of Section 14, T. 11 N., R. 26 E. The river elevation at this site is approximately 4,570 feet. A 20,000 acre-foot reservoir would require a dam approximately 68 feet in height and a 10,000 acre-foot reservoir would require a dam 50 feet in height. Crest lengths would be 1,040 and 920 feet respectively.

5.2.2.4 Other Reservoir Sites

Other reservoir sites have been suggested in addition to those described above. The Division of Water Resources (DWR), U.S. Bureau of Reclamation (USBR), and the U.S. Soil Conservation Service (SCS) studied a reservoir at Leavitt Meadows on the West Walker River. The DWR and SCS have also studied a reservoir at the site of existing Roosevelt and Lane Lakes (referred to as the Roolane Reservoir). The enlargement of seven existing small lakes in the upper Walker River watershed was evaluated by DWR. This project is referred to as Mountain Lakes. The WRID has studied a reservoir in Wilson Canyon called Hudson Reservoir. The U.S. Geological Survey studied a reservoir in the Upper Paiute Meadows located in the headwaters of the West Walker River. A reservoir at Willow Flat in the headwaters of the Little Walker River was studied by the SCS. Comparatively little technical information was located regarding these sites.

5.2.2.9 Previously Proposed Reservoirs, A Summary

To provide flood storage on the East Walker River, the proposed Ravenel Reservoir would most likely provide the greatest benefit considering construction costs and land acquisition requirements. This reservoir also has the greatest storage potential of those considered along the East Walker River. To provide flood storage on the West Walker River, the Hoye Bridge Reservoir would probably provide the greatest benefit. The site has a large contributing drainage area and, depending on capacity, could provide significant flood control benefits and conserve river flow for later release to Walker Lake.

TABLE 5.7. PREVIOUSLY PROPOSED STORAGE FACILITIES

Reservoir	River	Flood Storage (af)
Ravenel	East Walker River	40,000 - 50,000
Flying M Ranch	East Walker River	10,000 - 20,000
Old Charlebois Ranch	East Walker River	10,000 - 20,000
Strosnider Bridge	East Walker River	20,000
Strosnider Gage	East Walker River	10,000 - 20,000
Mountain Lakes	-	2,200
Willow Flat	Little Walker River	20,000
Pickel Meadows	West Walker River	110,000
Leavitt Meadows	West Walker River	75,000 - 160,000
Upper Paiute Meadows	West Walker River	50,000
Roolane	West Walker River	25,000 - 40,000
Hoye Bridge	West Walker River	20,000 - 76,800
Hudson	West Walker River	16,000

Source: Horton (1996)

Numerous options are evaluated here, but the most favorable would be to construct a reservoir at the proposed Hoye Canyon site that could, either in part or in whole, provide flood control.

Such a reservoir, depending on its design storage capacity, would nearly flood-proof downstream areas on the West Walker River and, to a large extent, the main stem of the Walker River through Mason Valley. For instance, the January 1997 flood could have been easily stored in the proposed Hoye Canyon Reservoir. Flood waters so retained could have been released in a matter of days after the threat of flooding had passed. A large part of those waters would have flowed directly to Walker Lake, thus conserving large amounts of water that otherwise saturated the flood plain and were subsequently lost by evaporation. Still at risk would be up-stream areas in Antelope Valley. Most of the flood control reservoir sites proposed in the headwaters of the West Walker River are no longer available for consideration.

It is acknowledged, however, that the likelihood that any of the listed reservoirs will be constructed is quite low. This is due to uncertainties regarding Interstate waters, possible environmental constraints including impacts to threatened or endangered species, questionable recreational benefits, unresolved Native American water right issues, and the general belief that there are too many dams on western rivers already. It should be noted that all of these reservoirs originally were considered as potential irrigation storage purposes and not as flood control structures. Nevertheless, these reservoirs were once considered and, depending on the value that is placed on increasing the flow to Walker Lake and associated flood control benefits, one or more of them may now present a unique flood control opportunity.

5.3 FLOOD FLOW MANAGEMENT

In addition to managing floods by storing the water in on-line reservoirs there are the options of diverting the flood flows to off channel areas, increasing the capacity of the river channel, or constructing flood by-pass channels. Many of these options are described in this section.

5.3.1 Out-of-Channel Flood Control Options

Reservoir storage is not the only water conservation and flood control tool available to regulate river flow. There exists on the Walker River system the unique opportunity to utilize one or more out-of-channel storage facilities. These facilities do, however, require diversions from the river and depend on unique processes for returning the flow to the river.

5.3.1.1 Artificial Recharge Ponds

Artificial recharge is becoming an increasingly attractive technique available to water managers to increase their water supply options. It allows water to be taken from one source, such as floodwaters, and put into storage in the ground-water system. The water can be injected using wells, or allowed to infiltrate into the water table from basins. For example, controlled amounts of flood water could be diverted from the West Walker River at the outlet of Wilson Canyon. That water could be placed into basins located in Missouri Flat at the extreme south end of Mason Valley (other areas along the Walker River System also may offer the potential for artificial recharge). An existing canal would need to be enlarged to carry between 500 cfs and 1,000 cfs. This level of diversion would not prompt a substantial reduction in peak flood flows. As a result, the construction of recharge basins would do little to reduce overbank flooding that may occur lower in the system.

The implementation of an artificial recharge project would, however, take that river flow and use it to recharge the ground-water system. Later, that water could be withdrawn from the ground water aquifer and put to some specific use. One such use may be to ensure a minimum flow in the lower reaches of the Walker River during the latter part of the irrigation season. Or, recharged ground waters could be relied on if other activities (water rights acquisition, for example) cause permitted uses to become isolated. Another option may be to substitute the use of recharged ground water for decreed flood water. Under this option, potential flood water users would forego their rights to flood water in exchange for the ability to rely more heavily on ground water. Flood waters would then be allowed to flow to Walker Lake.

Clearly, further study is necessary before any such exchange of ground for surface water occurs. Evidence must be developed that the action would not cause a substantial impact to groundwater, and that there would be some benefit to Walker Lake.

5.3.1.2 Artesia Lake

Artesia Lake is a natural depression located at the north end of Smith Valley, approximately 11 miles north of Wellington, Nevada. Currently, the lake is approximately 3.4 square miles in area at an elevation of 4,547 feet (USGS Smith Valley Topographic map 1:100,000 – 1985). An irrigation ditch delivers West Walker River water to numerous ranches located along the western edge of Smith Valley. The canal terminates about 2 miles south of Artesia Lake. A review of topographic maps indicates that water could flow to Artesia Lake if the existing ditch was modified. Storage of flood water would be limited by the capacity of the delivery system. Depending on the volume of inflow, the lake could be raised to an elevation where it covered approximately 13.2 square miles. Returning water to the river would be expensive as a fairly long channel plus significant pumping would be required.

5.3.1.3 Yerington Mine at Weed Heights

The Yerington Mine, located one mile west of Yerington, is a large open pit. The Anaconda Copper Company operated the mine from 1951 to 1978 and the mine is currently owned by the Arimetco Company but is not in use. A lake has developed in the abandoned pit due to ground water seepage. Consideration has been given to pumping water from this pit lake into the Walker River. Reviews conducted in 1995 (Horton, 1996), however, indicated that water quality issues would preclude pumping the pit water directly into the river.

An alternative action may be to divert flood waters into the pit from the river, allowing for their temporary storage. This would require the construction of a diversion structure and a diversion channel that could be several miles in length depending on how much flood protection is afforded the Yerington area. A pump system would be needed so that flood waters could be returned to the Walker River (when river flows were below channel capacity) and conveyed to Walker Lake with little channel loss. Storage capacity of the pit was estimated based on a 1986 topographic map.

TABLE 5.8. ESTIMATED ELEVATION/CAPACITY RELATIONSHIP, ANACONDA PIT

Elevation (ft)	Depth (ft)	Capacity (af)
4005	0	0
4200	195	22,400
4400	395	66,000

A major consideration would be the technical practicability (and high cost) associated with pumping the water out of the pit and back into the river. This cost could be reduced if it was possible to maintain a high water level in the pit, but a higher water level reduces the potential storage. The temporary storage of large volumes of water in the mine pit may improve the quality of the mine water to a point where it would not represent a contamination risk to Walker River or Walker Lake. Temporary flood storage would reduce downstream over-bank flooding and thus increase the amount of water that may reach Walker Lake.

5.3.1.4 Fish & Wildlife Ponds

The Nevada Division of Wildlife operates the Mason Valley Wildlife Management Area located north of Yerington. The Division has constructed several ponds that are used in conjunction with fish hatchery and wildlife enhancement activities. In terms of flood control these ponds are extremely small (total area about 200 acres) and shallow (about two feet). Water from the hatchery ponds cannot be put into the river due to water quality constraints. Numerous water quality parameters may play a part in this decision (Ammonia, suspended solids, temperature, turbidity, and color to name the most obvious). Currently, the water is used for land application to fields where grains are raised with the specific intent of attracting wildlife. Thus, the ponds offer virtually no opportunity for flood storage.

5.3.1.5 Little Alkali Lake

Little Alkali Lake is located east of Topaz Lake in Nevada. Just as Topaz was created for storage of waters by diverting the river channel, Little Alkali Lake could be similarly developed and used for flood water storage. Detailed surveys are needed to develop accurate elevation/capacity relations, but significant storage appears possible with comparatively little improvement. As the site is a natural depression, a relatively small retention levee or dam would be required with appropriate outlet works. Given existing topography, the lake could store up to 5,500 acre-feet of flood water. Storage capacity of Little Alkali Lake was estimated based on a 1988 USGS topographic map.

TABLE 5.9. ESTIMATED ELEVATION/CAPACITY RELATIONSHIP, LITTLE ALKALI LAKE

Elevation (ft)	Depth (ft)	Capacity (af)
4970	0	0
4980	10	2,000
4990	20	5,500

A diversion channel approximately 3,600 feet in length would be required to convey flood water from the West Walker River to Little Alkali Lake. The width of the channel would depend on the design flow, which could be in the range of 1,000 to 1,500 cfs. A similar length channel would be required to return the flow to the river, but of a much lower capacity than the inlet channel.

5.3.2 River Channel Improvement and By-Pass Channel Construction

Sediment transport data are generally lacking for the Walker River system. A cursory examination of the main channel downstream from the USGS gaging station near Wabuska shows that the channel bed and banks are made up of fine-grained silt and sand to coarse-grained sand. Very little gravel and almost no cobbles are found. Downstream from the junction of the East and West Forks in the southwest part of Mason Valley, the river is probably aggrading. This process contributes to over-bank flooding as the channel bed increases in elevation. According to Roger Bezayiff, Chief Deputy Water Commissioner on the Walker River (oral commun., 1999), the current channel capacity of the river through Mason Valley is about 1,500 cfs, compared to 20 or 30 years ago when the capacity was about 3,000 cfs. This aggrading process is similar to that described by Katzer and Bennet (1979) along the main stem of the Carson River in Carson Valley, Nevada. The significance of aggradation is that as this process continues there is a decrease in channel capacity. Over time, it will take less of a flood peak to top the banks and cause over-bank flooding. This can result in an ever-increasing amount of water being lost to the system, emphasizing the importance of flood control as a conservation tool. Degrading sections of the Walker River system are the main stem of the river downstream from Schurz and probably the two forks of the river in canyon areas where river energy gradients are the highest. In some canyon reaches the underlying bedrock is shallow and will limit the amount of down-cutting.

Improvements to the Walker River channel could provide a delivery means for transporting flood flows to Walker Lake. River channel modifications and levees are currently in use for flood protection. Extensive mapping by the USGS of flooding during the January 1997 flood event shows channel reaches where improvements could restrain future flooding. The

West Walker River exceeded channel capacity in Smith Valley in an eight-mile reach from approximately 2 miles north of Wellington to the historic Hudson site. In Mason Valley the West Walker River exceeded channel capacity from Wilson Canyon to the confluence with the East Walker River with the exceptions of a short reach located approximately 4 miles south of Nordyke Road and at Nordyke Road. The Walker River exceeded channel capacity in Mason Valley with the exception of the reach that has levees located about 1 mile north of the Yerington Municipal Airport.

The construction of additional levees, particularly on the main stem of the Walker River will, undoubtedly provide additional flood control and increase the efficiency of transporting water to Walker Lake. However, unless measures are taken downstream of the levees to accommodate the increased flows, flooding and channel erosion will be increased.

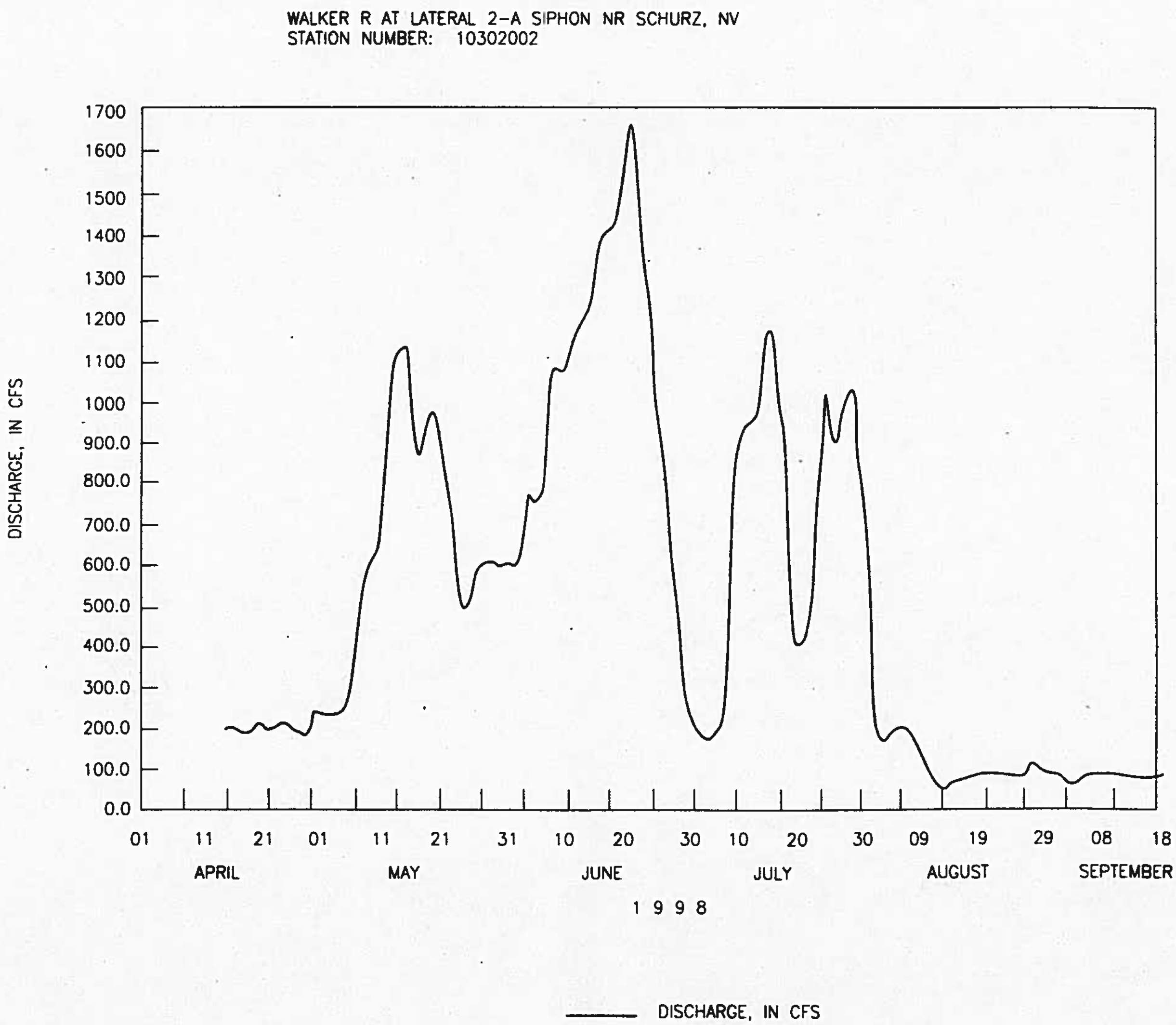
The Walker River channel downstream from Schurz to Walker Lake is unstable. Even average yearly runoff erodes and deposits sediments, and this process is accelerated during high flows. This degradation and aggradation contributes in part to the water quality decline in the river and ultimately the lake because the sediments the river flows through are ancient lake bed deposits high in salt concentration. The river flow dissolves these salts out of the sediments and transports them to the lake. Figure 5.5 is a cross section of the Walker River between Weber Reservoir and Walker Lake surveyed in October, 1998 and April, 1999 and show the complex cut and fill process. The hydrograph, shown in Figure 5.6, shows the flows of the Walker River at Schurz during the time period between river cross-section surveys.

River channel improvements are generally not long-term solutions. Raising the channel banks or levees, allows the river bed to continue to aggrade, decreasing the capacity, and ultimately rising higher than the surrounding valley floor. Rip-rapping the banks increases the velocity of the river flow compounding downstream channel erosion problems.

An alternative to modifying river geometry would be to construct a flood by-pass channel to divert a portion of flood flows from the main stem of the Walker River, starting at a point where the channel capacity decreases below an over-bank flow threshold. This probably would not be feasible on the two forks, but may be possible on the main stem. The capacity, course, and length of the channel have not been evaluated. There are several potential options.

- Design a by-pass channel that would route flood flows around Mason Valley. The diversion would be near the junction of the East and West Forks, and would flow directly to Walker Lake.

- Design a by-pass channel with a diversion near the junction of the East and West forks, but return the flow to the river at the north end of Mason Valley, near the Wabuska gage.



Source: USGS

Figure 5.6 Historical Streamflow Daily Values Graph for Walker River at Later 2-A Sipon Near Schurz, NV (10302002)

- Design a by-pass that would divert flows just upstream from Weber Reservoir and route flood waters to Walker Lake. This alternative would not alleviate flooding in Mason Valley or the loss of water to over-bank flooding, but it would protect the lower Walker River channel.

- Design a by-pass that would divert the releases from Weber Reservoir into a channel that conveys the water directly to Walker Lake. This alternative would not alleviate flooding in Mason Valley or the loss of water to over-bank flooding, but it would protect the lower Walker River channel.

The size of the channel would depend on the option selected, the level of flood protection desired, and the degree of risk accepted.

For discussion purposes, the first option is reviewed. Based on a worst case condition, a combination of 100-year floods occurring simultaneously on both rivers (a very low probability), the resulting peak flow would be about 12,000 cfs. Thus, flood proofing Mason Valley and conveying flood flows to Walker Lake would require a channel capacity of about 10,000 cfs. A more realistic approach would be to select two or three project options that together reduce the peak flow to what water managers consider a reasonable river flow, perhaps in the range of 3,000 to 5,000 cfs. A major benefit of such flood by-pass channels would be the reduction in erosion along the lower Walker River downstream from Schurz, and because salts in the river sediments would not be mobilized, there would be a concomitant reduction in salt loading to the lake.

5.3.3 Operations Management

The Walker River Federal Water Master and the Walker River Irrigation District manage the major reservoirs to provide as much flood control as possible while maximizing storage for the agricultural community. An example is the recent January 1997 flood. Near the end of December 1996, Bridgeport Reservoir was opened when weather forecasts indicated warm precipitation was due. Peaking of East Walker River tributaries above Bridgeport Reservoir occurred late January 1st and January 2nd, 1997. Bridgeport Reservoir's gates were opened (in steps) beginning December 28th, 1996 and by January 2nd, 1997, approximately 3,450 acre-feet of storage space was made available by these early releases. A similar action was taken at Topaz Lake where releases began on December 28th, 1996 and 2,200 acre-feet of storage space were evacuated for flood storage.

Experienced water-managers are able to operate the river system to provide some measure of flood control even though reservoirs were not built for that purpose. A written flood management policy with guide lines to define a relationship between climatic conditions, reservoir storage, and river flow would be useful in predicting downstream flooding and would greatly assist future river managers. Additionally, flood management could be improved with detailed river travel time analyses and models. This would allow predictions of downstream flows at any given point and could serve as a partial early flood warning system. Installation of remote control features on Bridgeport Reservoir and at Topaz Lake would make reservoir operations during flood events more efficient.

5.4 RELATED TOPICS

Two items deserve consideration, but do not fit comfortably within the discussion of either flood storage or flow management. The first is a discussion of flood frequencies and how this matter can affect planning activities. Second, the Advisory Committee asked that there be some discussion of total dissolved solid (TDS) levels in the river. These items are discussed in this section.

5.4.1 Flood Frequencies on the Walker River System

To assist in the decision making process concerning flood management options and to put various peak flows in perspective, flood frequencies for the USGS gaging stations located along the Walker River and its tributaries were calculated using the Log Pearson method (U.S. Water Resources Council, 1976). Results are listed in Table 5.10. Data in this table estimate the frequency of selected peak flows. For instance, the 10-year flood peak for the West Walker River near Coleville is 3,640 cfs and it has a 10 percent chance of occurring during any given year. The 25-year flood peak for the same station is 5,020 cfs and it has a 4 percent chance of occurring during any given year. The 50-year flood for any of the stations has a 2 percent chance of occurring in any given year and the 100-year flood has a 1 percent chance of occurring in any given year. This does not mean the flood peaks will or will not occur with the indicated frequency. Given the right set of conditions, the peaks can occur more than once in any given year or may not occur for several years.

As discussed in Section 5.2, the magnitude of flooding often varies from one place to another in a watershed during the same event. For example, during the January 1997 flood, the peak flow on the East Walker River near Bridgeport was approximately a 50-year event. Storage in Bridgeport Reservoir and flow attenuation reduced the peak flow to about a 25-year event at the Strosnider Ditch. The peak flow of the West Walker River near Coleville exceeded a 500-year flood. Storage in Topaz and flow attenuation reduced the downstream peak flow to about a 300-year event. By the time the peak reached the Wabuska gage it had decreased to about a 10-year event.

Clearly then, the decision as to how much flood protection is desired will depend on the area's location within the overall watershed, its susceptibility to flooding, and what impacts will occur downstream. The more intensive the flood protection sought (protecting against a 50- versus a 25-year event, for example), the greater the need to take these factors into consideration. Also, the methods employed may vary depending on the level of protection sought. For example, expansion of an existing reservoir or the construction of an additional flood control reservoir makes sense if one is seeking protection from a 50- or 100-year flood event. Such measures make less sense if one is only interested in seeking protection from the 10-year flood event.

TABLE 5.10. CALCULATED FLOOD FREQUENCIES AT SELECTED USGS STATIONS ALONG THE WALKER RIVER AND ITS TRIBUTARIES

Station Name	Drainage area (sq. mi)	Record Length	10-Year	25-year	50-year	100-year
East Walker River near Bridgeport	359	1911-1999	1,060	1,480	1,840	2,210
East Walker River above Strosnider Ditch near Mason	1,100	1947-1999	1,010	2,520	3,410	4,510
West Walker River Near Coleville	250	1902-1999	3,640	5,020	6,250	7,680
West Walker River at Hoye Bridge near Wellington	497	1910-1999	2,40	3,860	5,330	7,350
West Walker River near Hudson	964	1914-1999	2,510	3,990	5,470	6,490
Walker River near Wabuska	2,600	1902-1999	2,500	3,900	5,120	6,500

5.4.2 TDS and Stream Flow

Walker River is the primary source of water for Walker Lake, which is the terminus of the Walker River Basin. The only outflow from the lake is by evaporation from the surface of the lake, a process that removes water and leaves behind dissolved solids. This process increased the TDS in Walker Lake more than any other input (Thomas, 1995). Due to an average annual decline in lake volume over the last century, the concentration of total dissolved solids (TDS) has increased from 2,500 milligrams per liter (mg/l) in 1882 to 13,300 mg/l in 1994. Since 1994, above average runoff has diluted the TDS concentration to slightly over 11,000 mg/l (NDEP, 1999 [see Table 7. 2 of this report]). Dissolved solids enter the lake from surface water, wind blown dust falling directly on the lake, ground-water inflow from surrounding alluvial and bedrock aquifers, and salt that dissolves out of the sediments on the bottom of the lake (see Chapter Seven for a further discussion of TDS in Walker Lake).

The U.S. Geological Survey has collected water data along the Walker River and its tributaries for many years. These data include both water quantity and quality at several sites. Total dissolved solids data for the spring runoff of 1995 is shown below in Table 5.11. The data was collected by the USGS and is given in the units tons per acre-feet (T/AF). Conversion from tons per acre-feet to milligrams per liter is one ton per acre-foot is equal to 735 mg/liter.

TABLE 5.11. USGS ANNUAL FLOW AND TDS DATA,
WALKER RIVER BASIN

USGS Site Name	Annual Flow (cfs)	Date	Flow (cfs)	TDS (T/af)[1]	TDS (mg/l)
E. Walker River near Bridgeport, Ca.	105,000	4/25/95	290	0.22	162
E. Walker River above Strosnider Ditch near Mason	111,000	5/1/95	336	0.23	169
W. Walker River below Little Walker River, Ca.	193,000	4/24/95	258	0.11	81
W. Walker River near Coleville, Ca.	202,000	4/24/95	265	0.11	81
W. Walker River at Hoye Bridge near Wellington	175,000	4/26/95	511	0.15	110
W. Walker River near Hudson, Nv.	143,000	5/2/95	492	0.17	125
Walker River near Wabuska, Nv.	122,000	5/3/95	360	0.21	154

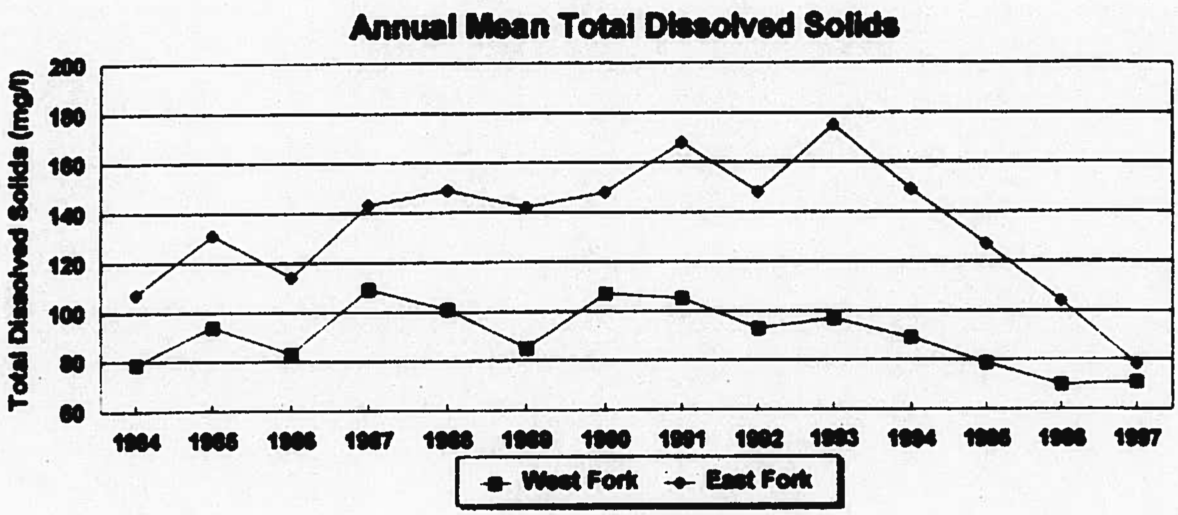
1. Tons/acre-foot.
Source: Bonner et al (1997)

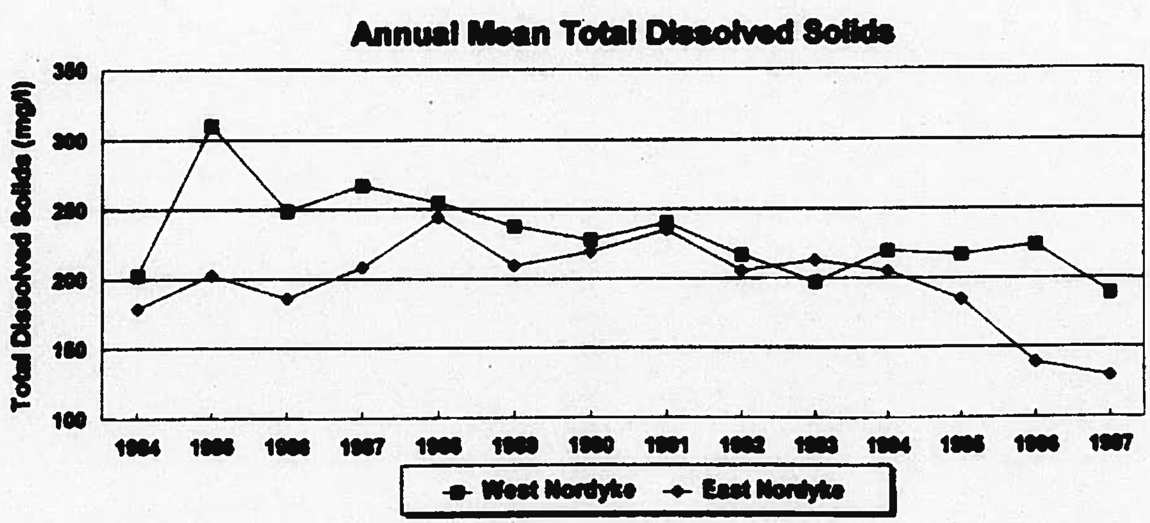
The Nevada Division of Environmental Protection (NDEP), Bureau of Water Quality Planning, has collected data on total dissolved solids in the Walker River for purposes of creating water quality standards for the river. Those data were presented to the Walker River Basin Advisory Committee during a 1999 meeting (Figures 5.7 and 5.8). Those data indicate that TDS levels along the East Fork increased gradually from about 108 to 165 mg/l between 1984 and 1994 and have declined since, reaching a low of 78 mg/l in 1997. TDS levels along the West Fork exhibit less variability, ranging between about 70 and 110 mg/l. The significance of the numbers is uncertain because they may represent a normal range of variability. However, these TDS levels are consistent with those reported by USGS. Figure 5.8 shows that TDS levels along the East and West Forks of the Walker River tend to increase gradually as one moves downstream. A somewhat greater downstream increase is noted along the main stem of the Walker River, especially during drought years (between 1987 and 1994.

Most entities involved in water planning in the Walker River Basin acknowledge that even with a stable lake-surface altitude, dissolved-solids concentration will slowly increase. This is due to the fact that Walker Lake is a terminal sink.

> "It is recognized that even with Walker Lake at its present level, the fishery will continue to decline as the water of Walker Lake become increasingly saline. At some future point in time, the fishery associated with Walker Lake will be lost" (Nevada Division of Water Planning 1973:72).

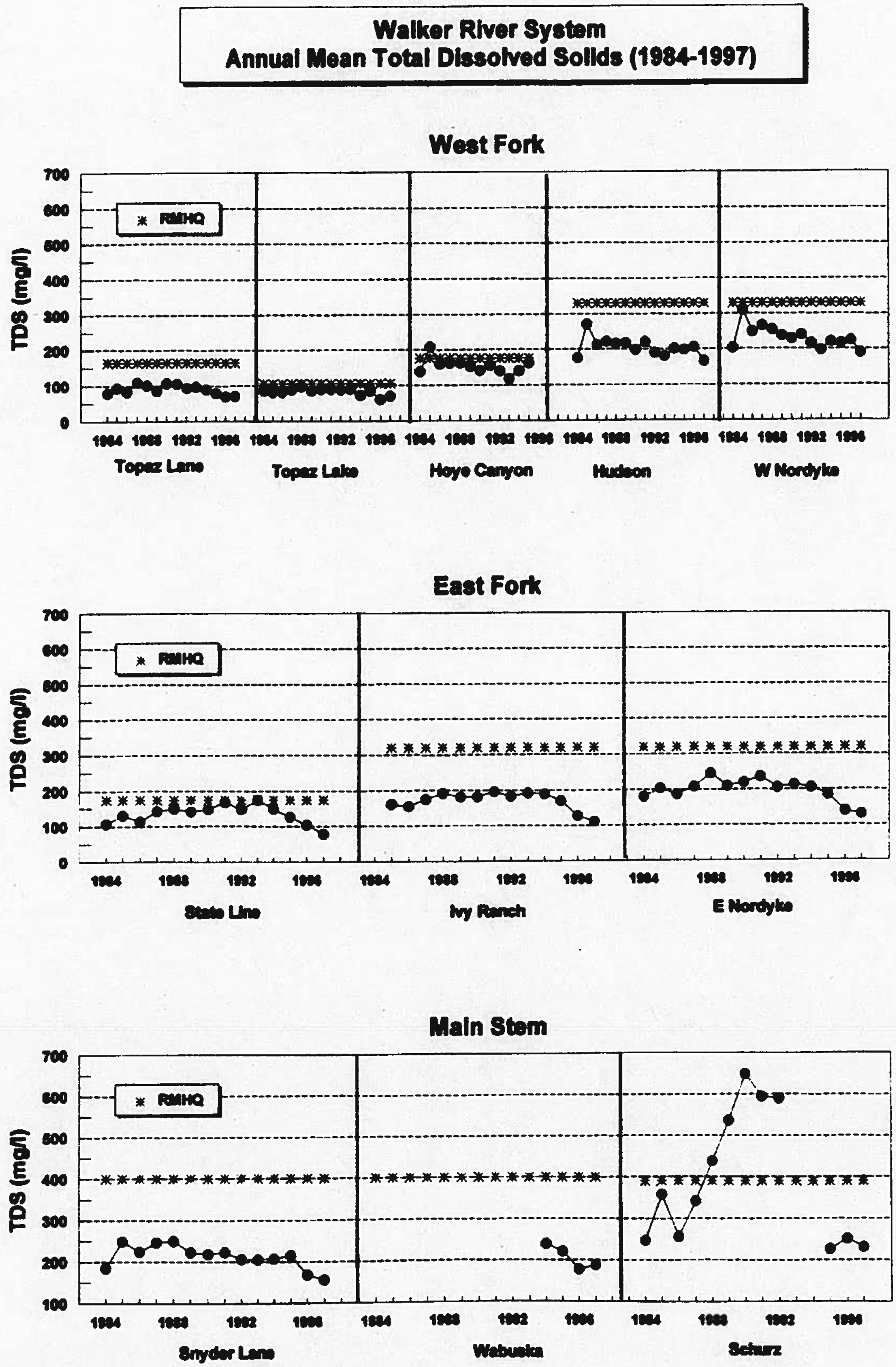
The authors of this study share this conclusion. The question isn't so much will TDS levels increase to such an extent that they affect fisheries, but how quickly that change will occur.





Source: Nevada Division of Environmental Protection.

Figure 5.7 Comparison of TDS Values, East and West Forks Walker River at State Line



Source: Nevada Division of Environmental Protection.

Figure 5.8 TDS values at selected gage stations along the East, West, and Main Walker River

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5.5 CONCLUSIONS

Many legal and administrative constraints must be resolved before any of the options presented above could be implemented. These constraints were not defined or used in this evaluation. Detailed analyses of any preferred option would need to be performed prior to project implementation. The following conclusions are based on analyses of existing data and preliminary field investigations.

Use of dead storage in Topaz Lake: Utilizing a portion of dead storage for flood control has a high potential for success, allowing floods up to and beyond the 100 year flood event to be contained. It will be necessary to provide assurances to existing water users prior to the initiation of any such program. Further consideration of this action is recommended.

Expand existing reservoir capacity: Increasing storage at Bridgeport Reservoir by a two-foot rise in lake level during floods would result in 6,390 acre-feet of additional storage capacity. It is our understanding that this could be accomplished by changing the manner of reservoir operation, allowing the storage of two additional feet of water. Dam safety is a concern and so is minor flooding of septic systems on the shore of the lake. Further consideration of this action is recommended.

Potential new reservoir locations: The Hoye Bridge Dam and Reservoir is the only proposed storage facility that has been permitted by the State of Nevada. Construction of this facility would conserve flood flows and reduce the threat of downstream flooding. This reservoir, depending on its design capacity, could easily have reduced the January 1997 flood peak on the West Walker River to a level that could be accommodated by the existing channel capacity. Then, as river flows dropped, the stored water could have been released at near channel capacity. If managed in this manner, the reservoir would have been emptied within a week or so. Additionally, by storing flood flows for a brief period of time the associated sediment would drop out in the reservoir, thus reducing some of the aggradation in the valley segments of the river channel. We recommend further consideration of this action only if it proves impossible or impracticable to increase storage capacity in Topaz Lake (through the management of dead storage).

Potential out-of-channel flood control options: The most likely out-of-channel flood control options reviewed as part of this report are the construction of Little Alkali Lake in Antelope Valley and the construction of ground water recharge basins in Smith Valley. Flood control benefits derived from these facilities would likely be minimal due to their limited diverting rates. We recommend further consideration of Little Alkali Lake only if it proves impossible or impracticable to increase storage capacity in Topaz Lake (through the management of dead storage). We do however, recommend further consideration of artificial recharge basins, not because of their flood control potential but because of the role they could play in establishing a more conjunctive approach to water use in core agricultural areas such as Smith and Mason valleys.

River channel improvements: River channel improvements have been used on the Walker River in the past and could be expanded in the future. Basin managers must decide on the level of protection desired (10-yr, 25-yr, 50-yr, or 100-yr) for key areas. Specific actions could then be defined to meet those objectives. It is important to recognize that increasing the river flow in one area may simply transfer the flooding problem to a downstream area. As a result, the conservation of flood flows realized in the protected area may be off set by additional flooding problems in the downstream area. We recommend that further consideration be given to protecting Mason Valley from overbank flooding. Such flooding results in a pronounced, short-term loss of flows to Walker Lake.

In general, we feel that by-pass channels would be an expensive means of attempting to flood proof Mason Valley. However, such channels do need to be considered elsewhere in the basin. If measures are taken to stabilize and increase flows in the Walker River, then this will only serve to exacerbate existing problems along the lower Walker River. We strongly encourage that consideration be given to the construction of a by-pass channel that would carry flood flows to Walker Lake. The construction of an additional, or secondary channel would allow for stabilization of the existing channel.

Operations management: Reservoir operations to minimize flood impacts are currently being implemented. A written policy would assist future managers. Flood peak travel time studies would assist in scheduling reservoir releases and could be used as an early warning system for potential downstream flooding. Optimum flood peak management will tend to reduce overbank flooding, thus conserving flood flows for Walker Lake. Further consideration of this action is recommended.

TABLE 5.12. RELATIVE COST OF POTENTIAL FLOOD CONTROL AND WATER CONSERVATION IMPROVEMENTS

Flood Control	Improvements	Relative Cost[1]
Increase Bridgeport Reservoir Storage	Increase existing dam by 2 feet	Low
Increase Topaz Lake Storage	Increase existing levee by 2 feet	Moderate
Utilize Topaz Lake Dead Storage	Depending on management strategy selected, install two or more high capacity pumps and back up power supply	Low to Moderate
Reservoir Operations	Flood modeling	Low
Little Alkali Lake	Land acquisition, dam and diversion channel construction, and permitting	Moderate
Artificial Recharge	Land acquisition, diversion channel, basin construction, and permitting	Moderate to High
River Channel Modification	Levee construction	Moderate to High
By-Pass Channel	Land acquisition, channel construction, and permitting	High
Hoye Canyon Dam and Reservoir	Land acquisition, dam construction	High

1. *Estimates do not include any required environmental analysis or permitting costs.*

Table 5.12 lists the recommended flood control options and provides a relative cost. The range in cost estimates is as follows: a low cost is less than $1,000,000, a moderate cost is between $1,000,000 and $3,000,000, and a high cost is greater than $3,000,000. The development of exact costs will require a detailed analysis of engineering, permitting, and legal requirements.

Examination of these cost estimates indicates that a substantial amount of flow conservation and flood control could be accomplished with limited expenditure. Increasing storage in Topaz and Bridgeport reservoirs could be accomplished through the adoption of modified management procedures. These actions may negate the need for the construction of more costly new reservoirs such as Hoye Canyon or Little Alkali Lake. The only high cost activity we envision as necessary is the construction of a by-pass adjacent to the lower Walker River. Designed to accommodate flood flows, this by-pass would substantially reduce the down-cutting that is currently taking place along the lower Walker River.

Chapter Six —
TOPIC THREE: WATER RIGHTS MANAGEMENT

The goal of this measure is to determine the potential role that the acquisition and management of water rights can have on increasing in-river flows, and the potential for any such increased flow to enter Walker Lake. The study was to consist of several activities, as described below.

- Characterize existing water rights in the Walker River Basin.
- Identify and describe a limited set of alternative water right acquisition scenarios.
- Estimate stream volume changes that can be anticipated as a result of each scenario. Qualitatively assess impacts that may occur as a result of those changes in stream flow.
- Qualitatively assess impacts that may occur to parcels from which water is withdrawn, to related infrastructure, and to institutions dependent upon those lands and infrastructure.

6.1 THE WALKER RIVER DECREE

In 1902 the lawsuit Pacific Livestock Co. vs. Thomas Rickey et. al. was filed in the Federal District Court for Nevada seeking to adjudicate rights to waters of the Walker River system. Subsequent agreements between users provided the basis for a stipulated judgment entered in District Court on March 19, 1919, as Decree 731. This Decree defined river system water rights on the basis of priority (first in historic use is first in priority). Decree 731 included the source, amount, and place of use allowed each claimant.

Due primarily to concerns over the allowance to the Walker River Indian Reservation in Decree 731 (22.93 cfs for 1,906 acres with priorities ranging from 1868 to 1886), the United States initiated an action in Federal District Court in July 1924. This action (U.S.A. vs. Walker River Irrigation District et. al.) resulted in the issuance on April 14, 1936, of Decree C-125, commonly referred to as the Walker River Decree (subsequently amended on April 24, 1940). Decree C-125, as supplemented by various rules and regulations subsequently ordered by the Federal District Court, represents the current operational adjudication of river system rights. Primary provisions of Decree C-125 include the following:

- Rights for the Walker River Indian Reservation are the most senior (1859 priority for 26.25 cfs on 2,100 acres).

- Diversion rates for each adjudicated claim are established, including priority, source, acreage and place of use. Though not specifically defined by Decree C-125, diversion rates were based on either 1.2 cfs or 1.6 cfs per 100 acres, dependent on factors such as location and type of soil.

- The irrigation season is March 1 through September 15 for irrigated acreage in Bridgeport Valley on the East Walker River and for all users above the Coleville Gauging Station on the West Walker River. The Walker River Paiute Tribe is entitled to delivery on 180 consecutive days. For all other users, the irrigation season is March 1 through October 31.

- Decree C-125 stipulates that "reasonable flows" be supplied to users for domestic and stock-watering purposes during the non-irrigation season.

- Decree C-125 defines storage rights on the Walker River system. Primary among these are storage rights for the Topaz and Bridgeport Reservoirs, owned by the Walker River Irrigation District (WRID). The Decree allows 42,000 acre-feet for storage in Bridgeport Reservoir to be diverted from the East Walker River during the non-irrigation season (November 1 through the last day of February). An additional 15,000 acre-feet is allowed to be stored at any time for Bridgeport Reservoir (refill rights) provided that there is sufficient water to serve all stockwater and domestic uses. The Decree allows 50,000 acre-feet of non-irrigation season storage for Topaz Reservoir from the West Walker River. An additional 35,000 acre-feet is allowed for Topaz Reservoir (refill rights).

- A Water Master appointed by the Court apportions and distributes water in both Nevada and California, in accordance with the provisions of Decree C-125.

While Decree C-125 was thorough as to the determination of relative rights on the Walker River system, several currently relevant water rights issues were not addressed. Those include:

- The apportionment of ground water rights.

- No provision was made for storage rights for Weber Reservoir located on the Walker River Indian Reservation.

- No operating flood control rules were provided for Topaz and Bridgeport Reservoirs.

- No provision was made for water rights for Walker Lake or surface water systems tributary to Walker Lake.

The administration of Decree C-125 is the responsibility of the United States Board of Water Commissioners, a six person board appointed pursuant to District Court orders, which acts as the Water Master. The Chief Deputy Water Commissioner has responsibility for operation of the Walker River system in accordance with the Decree, including primarily:

- Determining the daily water right priority to be served.
- Regulating the diversion of water from the Walker River, including coordination with ditch companies and users on delivery.
- Determining and controlling inflow and discharge from Bridgeport and Topaz Reservoirs as it relates to the Decree (not including flood control).
- Monitoring river flow and reservoir storage.
- Maintaining a record of Decree C-125 water rights, including changes to those rights made in accordance with the U.S. Board of Water Commissioners Administrative Rules and Regulations.

Decree C-125 provides that the Federal District Court retains jurisdiction over any changes or modifications to the Decree, including changes to the place of use of the water. Administrative Rules and Regulations, as amended through June 3, 1996, have been adopted for use by the U.S. Board of Water Commissioners under Final Order of the Federal District Court as entered on June 3, 1996. Administrative Rules establish the procedure by which changes are made to the point of diversion, manner of use, or place of use of waters of the Walker River and its tributaries as allowed under Decree C-125, and specifically provide that:

- Applications for changes to rights located within California are made directly to the California State Water Resources Control Board. Applications for changes made within Nevada are filed with the State Engineer of the State of Nevada (administrator of the Nevada Division of Water Resources). The Administrative Rules do not apply to changes to those rights of the Walker River Indian Reservation.
- Changes made to storage waters adjudicated to WRID by Decree C-125 are made per rules and regulations by WRID. However this does not apply to any transfer of storage rights outside of the WRID boundaries.
- All decisions on change applications made by the Nevada State Engineer or the California State Water Resources Control Board are subject to judicial review by the Federal District Court.

Decree C-125 provides for storage in a number of individual small reservoirs on the Walker River system in California. Table 6.1 provides a summary of storage rights and priorities for each. These reservoirs represent a minor portion of the river system storage capacity.

TABLE 6.1. SMALL SIERRA RESERVOIRS LISTED IN DECREE C-125.

Reservoir Name	Water Source	Dam Height (ft)	Decreed Storage Rights (ac-ft)	Priority	Place of Use
Black Reservoir	Black Creek	18	350	1907	Sonora Junction
Green Lakes	Green Creek	N/A	400	1895	Bridgeport
Lobdell Lake	Deep Creek	27	N/A	1864	Smith Valley
Poore Lake	Poore Creek	23	1200	1901	Antelope Valley
Lower Twin Lake	Robinson Creek	16	4050	1888, 1905	Bridgeport Valley
Upper Twin Lake	Robinson Creek	14	2050	1905, 1906	Bridgeport Valley

1.) Green Lakes is a cluster of three small lakes.
2.) Lobdell Lake's diversion right is six cubic feet per second. Actual physical storage is 640 acre-feet.
3.) Subject to conditions in the decree, these reservoirs also have refill rights.
Source: Walker River Atlas (California Department of Water Resources, 1992)

The two primary storage locations are Topaz Reservoir and Bridgeport Reservoir, provided for under Decree C-125 as previously described. Following the issuance in 1919 of Decree 731, in April 1919 the Walker River Irrigation District (WRID) was formed. The District included 260,000 acres within Nevada on the East Walker, West Walker and main Walker Rivers, excluding the Walker River Indian Reservation. A bond of approximately $918,000 was authorized for construction of Bridgeport Reservoir on the East Walker River, and Topaz Reservoir on the West Walker River. Topaz Reservoir was completed and storage began in June 1922. Capacity was originally 45,000 acre-feet, but in 1937 was increased to 59,440 acre-feet. Bridgeport Reservoir was completed and storage began in December 1923, with a 42,460 acre-foot capacity (Boyle, 1976).

Decree C-125 provides for the non-irrigation season storage of 42,000 acre-feet in Bridgeport Reservoir and 50,000 acre-feet in Topaz, with refill rights of 15,000 acre-feet and 35,000 acre-feet respectively. These refill rights can be diverted to storage only when all other adjudicated rights in demand can be served. WRID owns the Topaz and Bridgeport Reservoirs, with delivery of stored water to water right holders coordinated through the federal water master.

Upon completion of the reservoirs, storage rights were apportioned by WRID to acreage within the District. The apportionment was based on an allocated duty of either 3.2 or 4.2 acre-feet per acre, dependent on irrigation requirements of the acreage (soil characteristics, etc.). The apportionment assumed a required irrigation season of 135 days, and that all land allocated water under Decree C-125 with a priority of 1873 or earlier would not have need for storage. Therefore storage was apportioned only to land with a post-1873 priority, with the intent of allowing enough storage water in addition to decreed flow to provide the 3.21 or 4.28 acre-feet per acre duty. Table 6.2 (provided by the federal Water Master's Office) describes the current storage apportionment.

TABLE 6.2. AMOUNT OF STORAGE CAPACITY REQUIRED FOR EACH PRIORITY, 135 DAY SEASON.

Date of Priority	Required Days of Storage	Storage per Acre (duty = 3.2076)	Storage per Acre (duty = 4.2768)	Date of Priority	Required Days of Storage	Storage per Acre (duty = 3.2076)	Storage per Acre (duty = 4.2768)
1859	0	0.0000	0.0000	1885	29	0.6890	0.9187
1861	0	0.0000	0.0000	1886	29	0.6890	0.9817
1862	0	0.0000	0.0000	1887	29	0.6890	0.9817
1863	0	0.0000	0.0000	1888	29	0.6890	0.9817
1864	0	0.0000	0.0000	1889	30	0.7128	0.9504
1865	0	0.0000	0.0000	1890	30	0.7128	0.9504
1866	0	0.0000	0.0000	1891	31	0.7366	0.9821
1867	0	0.0000	0.0000	1892	31	0.7366	0.9821
1868	0	0.0000	0.0000	1893	31	0.7366	0.9821
1869	0	0.0000	0.0000	1894	32	0.7603	1.0138
1870	0	0.0000	0.0000	1895	32	0.7603	1.0138
1871	0	0.0000	0.0000	1896	32	0.7603	1.0138
1872	0	0.0000	0.0000	1897	32	0.7603	1.0138
1873	0	0.0000	0.0000	1898	33	0.7841	1.0454
1874	4	0.0950	0.1267	1899	33	0.7841	1.0454
1875	8	0.1901	0.2534	1900	33	0.7841	1.0454
1876	9	0.2138	0.2851	1901	33	0.7841	1.0454
1877	11	0.2614	0.3485	1902	34	0.8078	1.0771
1878	17	0.4039	0.5386	1903	34	0.8078	1.0771
1879	22	0.5227	0.6970	1904	34	0.8078	1.0771
1880	25	0.5940	0.7920	1905	34	0.8078	1.0771
1881	27	0.6415	0.8554	1906	35	0.8316	1.1088
1882	28	0.6653	0.8870	Excl		0.0000	0.0000
1883	28	0.6653	0.8870	Newl	65	1.5444	2.0592
1884	29	0.6890	0.9187				

Source: Federal Water Master.

Of particular interest is the line in Table 6.2 that relates to irrigated acreage within WRID for which a natural flow water right was not allowed under Decree C-125, categorized as "NEWL" (i.e. "new land"). On such acreage, a storage duty of only 1.54 acre-feet or 2.06 acre-feet is allowed, based on a diversion rate of 0.012 cfs or 0.016 cfs respectively for a total diversion period of 65 days. Given the recognized required annual duty of 3.2076 or 4.2768 acre-feet per acre, storage water as apportioned for new land (at 48% of decreed duty) is insufficient to support normal irrigation demand. A supplemental water source, such as ground water or natural flow flood water, has been the historic means of increasing the new land duty.

WRID currently delivers Topaz and Bridgeport Reservoir storage water to approximately 79,900 acres. Approximately 16,500 acres are served by pre-1874 priority Decree C-125 natural flow rights, approximately 28,930 acres are served by post-1873 Decree rights supplemented by storage, and approximately 34,400 acres are served by straight storage as new land apportionments. Table 6.3, based on information presented by WRID in 1994 at a forum on Walker Lake, provides a breakdown of the acreage served within the District from the various river sections and from storage.

TABLE 6.3. WALKER RIVER IRRIGATION DISTRICT
IRRIGATED ACREAGE SUMMARY (IN ACRES)

River Section	Total Water Rights	Decree Only	Decree and Supplemental Storage	New Land (Storage Only)
East Walker	24,134	4,380	8,380	11,170
West Walker	20,563	3,100	5,790	11,820
Tunnel Section	6,982	1,560	1,570	3,530
Main Walker	28,227	7,440	13,190	7,850
Total	79,906	16,490	28,930	34,370

Source: presented by WRID at a forum hosted by Senator Reid, March 28, 1994.

1.) *All acreage located within boundaries of WRID.*
2.) *River section descriptions:*
East Walker – Nevada state line to confluence with West Walker.
West Walker – Nevada state line to Wilson Canyon.
Tunnel Section – Wilson Canyon to confluence with East Walker.
Main Walker – Below confluence of East Walker and West Walker.
3.) *Storage rights on Main Walker served by approximate proportion of 1/3 from Bridgeport Reservoir and 2/3 from Topaz Reservoir (per Roger Bezayiff, Federal Water Master).*
4.) *Table appears to contain arithmetic differences between "Total Water Rights" acreage and the sum of the three component columns. Due to the limited differential total (116 acres, or 0.1 percent), no attempt was made to rectify the differences.*

6.2 STATE WATER RIGHTS ADMINISTRATION

Water rights in Nevada and California are administered by the Nevada Division of Water Resources and the California State Water Resources Control Board, respectively. However, the administration of rights differs significantly, both as to procedure and doctrine. The following provides a brief summary of the administration within the separate states.

6.2.1 Nevada

Water rights (both ground water and surface water) in Nevada are based on the doctrine of prior appropriation, which generally holds that the first in time to use the water has the first right (priority) to continued use of the water (i.e. first in time, first in right). The doctrine of prior appropriation is generally applied in the administration of water rights in most of the arid western states.

Nevada's water law is administered in accordance with Title 48 of the Nevada Revised Statutes (NRS) by the Nevada State Engineer as the administrator of the Nevada Division of Water Resources (NDWR). NRS Chapter 533 provides the statutory procedure for the adjudication of vested rights (i.e. rights pre-dating Nevada's water law confirmed through judicial process) and appropriative rights (i.e. rights established through permit issued by the Nevada State Engineer).

Water right permits are issued under applications filed with the Nevada State Engineer. The priority of appropriation for any permit is established by the date of filing of the application. NRS 533 provides a specific process of public notice, protest, and judicial appeal for applications. The Nevada State Engineer has wide authority to apply conditions on the beneficial use of water as allowed under approved permits. As a normal rule, a permit is granted as a temporary right (i.e. a specific timeframe is allowed for use, subject to cancellation for non-use) which can be "perfected" through actual beneficial use in accordance with the permit terms.

Upon beneficial use of the water, the permittee files with the Nevada State Engineer proof of that use, up to but not exceeding the original permitted amount, and a certificate is issued. For irrigation permits, proof includes a cultural map prepared by a licensed water right surveyor, delineating specifically the acreage irrigated. From that point forward, the certificate represents a permanent right that can be lost only through statutory forfeiture or abandonment procedures.

Each permit is specific as to the amount of water allowed, and the manner, place, and period of use. There is provision under NRS 533 for changing the point of diversion (well location on an underground permit), manner and/or place of use of all or a portion of a permit or certificate through the filing of an application to change with the State Engineer. An important protection accorded a permit issued as a change to an existing (base) permit is that the new permit retains the priority of the base permit. The filing and public notice process for a change application is the same as that of the original appropriation.

A change to the point of diversion, place, or manner of use of water rights allowed under Decree C-125 can be made under provisions of the Administrative Rules (as amended June 3, 1996) of the United States Board of Water Commissioners. Under these rules, applications to change the Decree are made to the Nevada State Engineer, and are processed in accordance with procedures described in NRS 533. However for all changes to Decree C-125, the decision of the State Engineer does not take effect until the federal District Court approves it and enters an order modifying the Walker River Decree accordingly.

Water rights issued under NRS 533 are considered real property within Nevada, and ownership may be held separately from that of the property on which they are located. Regardless of ownership, however, the water can be used only within the place of use described by the permit or certificate.

An important aspect of rights as issued by the Nevada State Engineer is their characterization as "supplemental" or "non-supplemental," based on whether or not the water right is to be used in combination with another right. The Nevada State Engineer establishes a total duty of water allowed for the approved beneficial use. For example, within the Walker River Basin an annual duty of 4.0 acre-feet per acre per year is normally allowed for irrigation. If more than one source is used to irrigate the same acreage, the cumulative total of the sources cannot exceed 4.0 acre-feet per acre, including supply from both surface and/or underground sources. Permits are not necessarily or specifically designated as supplemental or non-supplemental as a part of the conditions of approval, but do specifically limit the total annual duty from all rights.

If a permit is recognized as supplemental to a surface water right allowed under Decree C-125 (including storage), the permit will normally include the specific condition that ground water can be used only in the event that sufficient water is not available from surface sources to provide the necessary annual duty of 4.0 acre-feet per acre. Thus it is the intent of the Nevada State Engineer that ground water which is supplemental to surface sources be used only as a secondary source rather than as the primary source.

As might be expected, supplemental ground water rights in Nevada have historically become an important source of water for irrigated acreage dependent on storage and/or flood flow to realize a sufficient annual duty. Supplemental ground water is particularly critical to acreage designated "new land" for storage delivery by WRID, which is apportioned only 48% of the normal duty allocation of 3.21 or 4.28 acre-feet per acre (see Table 6.2). During dry hydrologic cycles, this use of supplemental ground water has historically stressed the capacity of producing underground aquifers, particularly in the Smith Valley and Mason Valley hydrologic basins.

The Nevada State Engineer is charged by statute with protection of the state's ground water resources. A specific procedure available is the "designation" process established under the provisions of NRS Chapter 534. In areas where it is the judgment of the Nevada State Engineer that the ground water basin is being depleted, NRS 534.120 allows for making "...such rules, regulations and orders as are deemed essential for the welfare of the area involved." Principal among the authorizations of the designation process is the State Engineer's ability to establish a "preferred use" of water in acting on applications filed for new water right permits. Under this authority, the State Engineer is allowed to approve applications for a new permit for a use (for example, municipal) determined to be preferred to some other use (for example irrigation), even though the preferred use application may have been filed later in time. The designation of a ground water basin also establishes increased controls by the State Engineer over the construction and operation of wells, including the provision that a production well cannot even be drilled until a permit has actually been approved.

The following designation Orders have been issued by the Nevada State Engineer within the Nevada portion of the Walker River Basin:

Smith Valley	Order No. 245 dated June 27, 1960
Mason Valley	Order No. 627 dated January 20, 1977
	Order No. 691 dated September 7, 1977
Antelope Valley	Order No. 714 dated May 25, 1978
Whiskey Flat-Hawthorne Subarea	Order No. 823 dated September 9, 1983

6.2.2 California

The Water Resources Control Board of California administers water rights in California. California's water law recognizes that rights on surface water can be held under a variety of legal doctrines, including both appropriative and riparian. The doctrine of appropriative rights, as previously described, is based on "first in time, first in right". The riparian doctrine on the other hand is based on the concept that the owner of land adjacent to a water system has the right to make reasonable beneficial use of that water. Riparian users share the resource, and the concept of priority is not applied. In the event of water shortage on the system (drought, declining ground water levels, etc.), the riparian users share in the shortages. Riparian rights cannot be sold or transferred for use on non-riparian land. No permit is required for riparian use in California, although such uses require the filing of a "Statement of Water Diversion and Use" with the Water Resources Control Board.

For ground water, there is no statewide system such as Nevada's for administration of water rights. Ground water resources in California within the Walker River Basin are unregulated. The riparian doctrine is applicable, which holds that any property within the basin possesses an overlying ground water right to as much water as can be reasonably placed to beneficial use. Beneficial use is not specifically defined.

Permits are not required for the drilling or production of a ground water source, except as associated with the issuance of a building permit (residential, commercial, etc.). In Mono County, applications for such well permits are filed with the County Department of Health. Permits as issued do not constrain the user to specific limits (for example acre-feet per year). Neither state nor county agencies maintain records as to the annual use of water (per personal communication, Carl Hauge, California Department of Water Resources, Water Conservation Office).

Administrative Rules (as amended June 3, 1996) of the United States Board of Water Commissioners, adopted pursuant to Decree C-125, provide a procedure administered by the California Water Resources Control Board for changes to the Decree, and regarding compliance with California Fish and Game Code Section 5937. The Administrative Rules set down a specific application procedure, which includes provision for public notice and protest, agency decision and judicial review.

6.2.3 California-Nevada Compact

The individual states administer water rights within their own political boundaries. On an interstate system, such as the Walker River Basin, one means by which the water within that system can be allocated between the states is through an interstate compact. A compact represents an agreement negotiated between the states, which must then be adopted by the legislatures of each, and ratified by Congress.

In 1955 both states appointed a California-Nevada Interstate Compact Commission for the negotiation of an agreement over allocation of the waters of the Truckee River, Carson River, and Walker River Basins. Based on results of those negotiations, the legislatures of California and Nevada passed legislation in September 1970 and March 1971, respectively, adopting the Compact (California Chapter 1480, California Statutes 1970 and Nevada NRS 538.600). Compact Article VIII applies to the Walker River Basin. Provisions of the Compact relevant to water rights management issues included primarily:

- Confirmation of those rights held under Decree C-125, subject to constraints on storage in Bridgeport and Topaz reservoirs.
- For use on the Walker River Indian Reservation, provided for 13,000 acre-feet of storage in Weber Reservoir (not addressed by Decree C-125).
- In addition to those natural flow diversions allowed by Decree C-125, allows 9,450 acre-feet per year diversion with a priority date of 1933, at a maximum diversion rate of 60 cfs for the Walker River Indian Reservation.
- So-called "unused water" in the system (i.e. water in excess of that recognized specifically by the Compact) is to be divided 35% to California and 65% to Nevada, with all such unused water to be equal in priority.
- Return flow to the Walker River is deemed natural flow.

Subsequently, bills were introduced before Congress seeking ratification of the Compact. The last such effort was by Nevada Senator Laxalt in 1986. None were passed. The legislation adopted by the two states provides specifically that the Compact, and thus the negotiated allocations, would become effective only when consented to by an act of Congress. However both states recognize its provisions within their respective statutes.

6.3 WATER RIGHTS QUANTIFICATION

Water rights within the Walker River system can be divided into several generalized categories. Each category is described.

6.3.1 Decree C-125 Natural Flow Diversion Rights

Decree C-125 is specific as to the rights of those users allowed to divert water from the yearly natural flow of the Walker River and its tributaries during the irrigation season. This includes the right to divert flow to storage. Each right is described within the body of Decree C-125 by the following details:

- The ownership of the individual rights. Ownership of many rights described under the Decree has changed as properties have been subsequently sold and/or changes to the Decree (i.e. place of use) have been allowed. The federal Water Master's office maintains current assessment records.

- Year of relative priority.

- Amount in cubic feet per second (cfs). Although not specifically stated within the Decree, the diversion rate is established on the basis of either 1.2 or 1.6 cfs per 100 acres, dependent on site conditions. The Decree rate is measured at the point of diversion from the natural channel.

- Number of acres irrigated.

- A legal description of the irrigated acreage, based on an equally divided, 40-acre breakdown. Maps of the location of decreed water rights, including subsequent changes, are maintained by the federal Water Master's office.

In anticipation of the future development of a water management modeling program for the Walker River Basin, the Nevada Division of Water Planning (NDWP) has prepared a series of reports detailing water rights and historic water use on the Walker River system. While currently in draft form, these reports provide information helpful in an analysis of the historic application of Decree C-125 to management of Walker River water rights. Pahl (1996a) provides a database of natural flow diversion rights as provided for by the Decree. A subsequent report (Pahl, 1996b), provides a database of historic measured diversions of water from the Walker River system, as reconstructed primarily from the records of the federal Water Master's office. These reports have not received the specific imprimatur of the U.S. Board of Water Commissioners. However they were developed in close coordination with the Chief Deputy Water Commissioner. With the permission of NDWP, the following database tables are made a part of this report:

- Table 6.4 - NDWP "Table 4. Summary of Natural Flow Diversion Rights (in cfs) Per C-125 (As Amended 4/24/40)"

- Table 6.5 - NDWP "Table 5. Summary of Natural Flow Diversion Rights (in acres) per C-125 (As Amended 4/24/40)"

Table 6.4. Summary of Natural Flow Diversion Rights (in cfs) per C-125 (as amended 4/24/40).

SUB-BASIN	Above Antelope Valley	Antelope Valley		Smith Valley (North)	Smith Valley (South)		Bridgeport Valley	
WATER SOURCE	West Walker R. & Trib.	West Walker R.	Lost Canyon/ Mill/ Rodriquez Cks.	West Walker R.	West Walker R.	Desert Ck.	East Walker R. & Trib.	
							Non-WRID	WRID[1]
Riparian	8.0500							
1859								
1860						4.3400	17.9200	3.8400
1861			5.1200		0.0800		42.4000	4.8000
1862		18.1300			0.1730	5.6600	100.8000	11.5200
1863	7.7600	62.1700	3.1400		18.7180		16.5600	4.8000
1864		74.0900			11.6320	5.3000	60.4000	13.7600
1865	1.2800	3.4000			4.1600			
1866		2.4000			2.5400			
1867							6.4000	
1868		2.2400			2.0180		5.7600	
1869		0.6400			0.3700		1.2800	
1870		1.6000			2.4000	3.2600	7.8400	
1871							3.8400	1.2800
1872	2.5600	2.6800						
1873							7.6800	
1874		2.1600					23.1700	
1875					2.2400	1.0400		
1876		2.4000					8.0000	
1877	4.7200				9.6000		10.2400	
1878	0.6400	33.3800			14.6030			
1879							1.6000	
1880					5.2400		1.2800	
1881	0.6400							
1882		22.6200			1.0500			
1883					1.1300		4.8800	
1884	6.0800				1.7800			
1885		1.0600			3.5200	8.4800	0.6400	
1886	1.2800	2.5600					0.6400	
1887								
1888		0.6400						
1889		1.6800						
1890		2.4000		20.3100	0.7300		26.5600	
1891		0.6400			0.0000			
1892					0.5600		2.2400	
1893							8.9600	
1894							0.6400	1.9200
1895		0.6400		5.6100				
1896		0.6400						
1897	0.2400	3.2000			3.5400		1.9200	
1898								
1899		0.3200					0.6400	
1900		0.6400		0.8000	0.3200		1.6000	
1901							1.6000	
1902	2.8800	5.6000						
1903								
1904								
1905				2.4000				
1906								
1907								
1908								
1909				2.3700				
1910				3.4887			0.8000	
1911								
1912				1.8510				
1913								
1914				3.2000				
1915								
1916							1.2800	
1917								
1918							7.8800	
1919								
1920							1.2800	
1921							0.6400	
TOTAL	36.1300	247.9300	8.2600	40.0297	86.4040	28.0800	377.3700	41.9200

[1]These rights are for lands submerged by Bridgeport Reservoir and are held by the Walker River Irrigation District.

Table 6.4. Summary of Natural Flow Diversion Rights (in cfs) per C-125 (as amended 4/24/40) – Continued.

SUB-BASIN	East Walker River Area (above 10293050)			East Walker River Area (below 10293050)		Mason Valley			Walker Lake Valley	Total	Cumulative Total
WATER SOURCE	East Walker R.	Frying Pan/ Murphy Cks.	Sweetwater Ck.	East Walker R.	Bodie/ Rough Cks.	West Walker R.	East Walker R.	Walker R.	Walker R.		
Riparian										8.0500	8.0500
1859									26.2500	26.2500	34.3000
1860	4.4800		4.1600		6.9600					41.7000	76.0000
1861			11.6800	0.1300		1.6000				65.8100	141.8100
1862	2.0800			5.6000		0.9600		1.2000		146.1230	287.9330
1863						0.9600	1.2800	5.0400		120.4280	408.3610
1864						1.2000		7.5000		173.8820	582.2430
1865	1.6000		5.1200	3.6900			22.1200	4.9200		46.2900	628.5330
1866										4.9400	633.4730
1867				0.1400						6.5400	640.0130
1868						7.3600		9.6000		26.9780	666.9910
1869						1.6800		6.9600		10.9300	677.9210
1870	3.2000		2.5000			0.6400	18.6900	28.8200		68.9500	746.8710
1871							0.8000	3.3400		9.2600	756.1310
1872						9.8400		15.9100		30.9900	787.1210
1873							0.1200	8.7200		16.5200	803.6410
1874				3.7600	6.5000			40.9500		76.5400	880.1810
1875	1.6000			1.8600		0.4800	24.6900	26.8100		58.7200	938.9010
1876							1.2500			11.6500	950.5510
1877				1.7600	1.9200	7.5500	1.4600	7.6800		44.9300	995.4810
1878			3.8400					5.7500		58.2130	1,053.6940
1879				1.5700		2.8800	0.2400	13.3900		19.6800	1,073.3740
1880	3.2000	1.2800	5.1200	2.6400			17.2500	57.1580		93.1680	1,166.5420
1881		4.9600		1.6000				0.4800		7.6800	1,174.2220
1882						2.0800		2.8800		28.6300	1,202.8520
1883						2.7700	2.4000	0.3600		11.5400	1,214.3920
1884								2.0500		9.9100	1,224.3020
1885	1.6000		5.6000	3.2000	0.8000	2.4000	7.1300	26.5000		60.9300	1,285.2320
1886								4.9200		9.4000	1,294.6320
1887				1.2000	3.2000		0.2400	0.7800		5.4200	1,300.0520
1888						0.8000	1.9200	0.9600		4.3200	1,304.3720
1889				0.1600				0.6000		2.4400	1,306.8120
1890	1.9600			3.2000		2.0800	3.8800	13.9800		75.1000	1,381.9120
1891							1.1200	5.7120		7.4720	1,389.3840
1892							2.0100	3.5400		8.3500	1,397.7340
1893				0.6400				0.1800		9.7800	1,407.5140
1894				1.4600		0.5100	4.8000	0.1800		9.5100	1,417.0240
1895				2.2900			6.8900	9.4700		24.9000	1,441.9240
1896							0.4800	1.9200		3.0400	1,444.9640
1897							4.0000	2.1200		15.0200	1,459.9840
1898							0.4800	1.2600		1.7400	1,461.7240
1899						0.1600	3.0400	0.1400		4.3000	1,466.0240
1900				0.6400		1.4900	0.9900	23.0400		29.5200	1,495.5440
1901							0.4000	0.1800		2.1800	1,497.7240
1902							1.8000	0.1100		10.3900	1,508.1140
1903						0.4800	1.4400			1.9200	1,510.0340
1904						0.1200	1.1200	0.9500		2.1900	1,512.2240
1905						1.5200	0.5900	25.2200		29.7300	1,541.9540
1906				0.7200				0.2400		0.9600	1,542.9140
1907							0.3200			0.3200	1,543.2340
1908										0.0000	1,543.2340
1909										2.3700	1,545.6040
1910										4.2887	1,549.8927
1911							5.0952			5.0952	1,554.9879
1912										1.8510	1,556.8389
1913										0.0000	1,556.8389
1914										3.2000	1,560.0389
1915							2.0130			2.0130	1,562.0519
1916				0.4768				0.8782		2.6350	1,564.6869
1917										0.0000	1,564.6869
1918							0.8000			8.6800	1,573.3669
1919										0.0000	1,573.3669
1920										1.2800	1,574.6469
1921										0.6400	1,575.2869
TOTAL	19.7200	6.2400	38.0200	36.7368	19.3800	49.5600	140.8582	372.3982	26.2500	1,575.2869	

Table 6.5. Summary of Natural Flow Diversion Rights (in acres) per C-125 (as amended 4/24/40).

SUB-BASIN	Above Antelope Valley	Antelope Valley		Smith Valley (North)	Smith Valley (South)		Bridgeport Valley	
WATER SOURCE	West Walker R. & Trib.	West Walker R.	Lost Canyon/ Mill/ Rodriquez Cks.	West Walker R.	West Walker R.	Desert Ck.	East Walker R. & Trib.	
							Non-WRID	WRID[1]
Riparian	334.00							
1859								
1860						271.00	1,120.00	240.00
1861			320.00		5.00		2,850.00	320.00
1862		1,134.00			14.68	354.00	6,300.00	720.00
1863	485.00	3,887.00	196.00		1,411.10		1,035.00	320.00
1864		4,572.50			969.00	330.00	3,775.00	860.00
1865	80.00	213.00			260.00			
1866		150.00			159.00			
1867							400.00	
1868		140.00			166.50		360.00	
1869		40.00			31.00		80.00	
1870		100.00			150.00	204.00	490.00	
1871							240.00	80.00
1872	160.00	168.00						
1873							480.00	
1874		135.00					1,448.00	
1875					140.00	65.00		
1876		150.00					500.00	
1877	295.00				600.00		640.00	
1878	40.00	2,088.00			1,110.00			
1879							100.00	
1880					328.00		80.00	
1881	40.00							
1882		1,414.50			66.00			
1883					71.00		305.00	
1884	380.00				112.00			
1885		65.00			260.00	530.00	40.00	
1886	80.00	160.00					40.00	
1887								
1888		40.00						
1889		105.00						
1890		150.00		1,692.50	46.00		1,655.50	
1891		40.00						
1892					47.00		140.00	
1893							560.00	
1894							40.00	120.00
1895		40.00		467.50				
1896		40.00						
1897	15.00	200.00			295.00		120.00	
1898								
1899		20.00					40.00	
1900		40.00		67.00	20.00		100.00	
1901							100.00	
1902	180.00	350.00						
1903								
1904								
1905				200.00				
1906								
1907								
1908								
1909				237.00				
1910				375.87			50.00	
1911								
1912				185.10				
1913								
1914				320.00				
1915								
1916							80.00	
1917								
1918							480.00	
1919								
1920							80.00	
1921							40.00	
TOTAL	2,089.00	15,442.00	516.00	3,544.97	6,261.28	1,754.00	23,768.50	2,660.00

[1]These rights are for lands submerged by Bridgeport Reservoir and are held by the Walker River Irrigation District.

Table 6.5. Summary of Natural Flow Diversion Rights (in acres) per C-125 (as amended 4/24/40) – Continued.

SUB-BASIN	East Walker River Area (above 10293050)			East Walker River Area (below 10293050)		Mason Valley			Walker Lake Valley	Total	Cumulative Total
WATER SOURCE	East Walker R.	Frying Pan/ Murphy Cks.	Sweetwater Ck.	East Walker R.	Bodie/ Rough Cks.	West Walker R.	East Walker R.	Walker R.	Walker R.		
Riparian										334.00	334.00
1859									2,100.00	2,100.00	2,434.00
1860	280.00		260.00		435.00					2,606.00	5,040.00
1861			730.00	8.00		100.00				4,333.00	9,373.00
1862	130.00			350.00		60.00		100.00		9,162.68	18,535.68
1863						60.00	80.00	420.00		7,894.10	26,429.78
1864						75.00		626.00		11,207.50	37,637.28
1865	100.00		320.00	231.00			1,844.00	410.00		3,458.00	41,095.28
1866										309.00	41,404.28
1867				9.00						409.00	41,813.28
1868						460.00		800.00		1,926.50	43,739.78
1869						105.00		580.00		836.00	44,575.78
1870	200.00		156.00			40.00	1,538.00	2,401.00		5,279.00	49,854.78
1871							50.00	278.50		648.50	50,503.28
1872						616.00		1,326.00		2,270.00	52,773.28
1873							10.00	727.50		1,217.50	53,990.78
1874				235.00	400.00			3,416.50		5,634.50	59,625.28
1875	100.00			116.00		30.00	1,965.00	2,233.50		4,649.50	64,274.78
1876							78.00			728.00	65,002.78
1877				110.00	120.00	471.50	91.00	640.00		2,967.50	67,970.28
1878			240.00					479.00		3,957.00	71,927.28
1879				98.00		180.00	15.00	1,116.50		1,509.50	73,436.78
1880	200.00	80.00	360.00	165.00			1,359.00	4,761.50		7,333.50	80,770.28
1881		310.00		100.00				40.00		490.00	81,260.28
1882						130.00		243.00		1,853.50	83,113.78
1883						173.00	150.00	30.00		729.00	83,842.78
1884								171.00		663.00	84,505.78
1885	100.00		390.00	200.00	50.00	150.00	569.00	2,209.00		4,563.00	89,068.78
1886								410.00		690.00	89,758.78
1887				75.00	200.00		15.00	65.00		355.00	90,113.78
1888						50.00	120.00	80.00		290.00	90,403.78
1889				10.00				50.00		165.00	90,568.78
1890	120.00			200.00		130.00	310.00	1,165.00		5,469.00	96,037.78
1891							70.00	476.00		586.00	96,623.78
1892							148.00	295.00		630.00	97,253.78
1893				40.00				15.00		615.00	97,868.78
1894				92.00		32.00	300.00	15.00		599.00	98,467.78
1895				143.00			535.00	788.50		1,974.00	100,441.78
1896							30.00	160.00		230.00	100,671.78
1897							250.00	177.00		1,057.00	101,728.78
1898							30.00	105.00		135.00	101,863.78
1899						10.00	190.00	12.00		272.00	102,135.78
1900				40.00		93.00	68.00	1,921.00		2,349.00	104,484.78
1901							25.00	15.00		140.00	104,624.78
1902							115.00	9.00		654.00	105,278.78
1903						30.00	90.00			120.00	105,398.78
1904						10.00	70.00	79.00		159.00	105,557.78
1905						95.00	39.00	2,101.50		2,435.50	107,993.28
1906				45.00				20.00		65.00	108,058.28
1907							20.00			20.00	108,078.28
1908										0.00	108,078.28
1909										237.00	108,315.28
1910										425.87	108,741.15
1911							509.52			509.52	109,250.67
1912										185.10	109,435.77
1913										0.00	109,435.77
1914										320.00	109,755.77
1915							201.30			201.30	109,957.07
1916				47.68				87.82		215.50	110,172.57
1917										0.00	110,172.57
1918							79.40			559.40	110,731.97
1919										0.00	110,731.97
1920										80.00	110,811.97
1921										40.00	110,851.97
TOTAL	1,230.00	390.00	2,456.00	2,314 68	1,205.00	3,100.50	10,964.22	31,055.82	2,100.00	110,851.97	

Table 6.6. Summary of Annual Diversions from the NDWP Diversion Database (acre-feet).

Year	Antelope Valley - West Walker River	Antelope Valley - Tributaries	Smith Valley - West Walker River	East Walker Area - Above 10293050	East Walker Area - Between 10293050 and 10293500	Mason Valley - West Walker River	Mason Valley - East Walker River	Mason Valley - Walker River	TOTAL
1931			21,520	1,940	5,189	8,502	13,311	13,222	63,684 *
1932			62,304			26,908	50,323	71,058	210,593 *
1934			31,616	1,524	6,889	9,385	23,476	29,924	102,814 *
1935			57,158		12,758	25,026	49,662	60,652	205,256 *
1936			64,540		16,165	29,909	56,346	65,746	232,706 *
1937			62,209			29,738	55,563	66,770	214,280 *
1938			66,497			37,040	56,689	67,054	227,280 *
1939			58,135	2,422	12,581	19,640	42,125	50,034	184,937 *
1940			83,083	4,678	15,526	19,662	53,360	60,696	237,005 *
1941			80,817	1,568	16,209	23,098	57,040	73,151	251,883 *
1942			81,119		17,372	21,815	63,884	76,485	260,675 *
1943	66,328		76,645		17,439	23,890	57,903	68,150	310,355 *
1944	58,650		75,380	6,692	14,889	19,352	45,680	64,983	285,626 *
1945	84,539		74,463		17,052	21,951	55,498	76,870	330,373 *
1946	80,981		77,401		20,622	24,376	60,925	82,923	347,228 *
1947	60,669	334	72,480	3,990	17,436	21,129	44,288	62,901	283,227
1948	45,192	1,009	53,949	5,240	11,709	17,728	35,518	55,565	225,910
1949	54,702	1,966	68,277	4,994	12,384	18,985	39,419	53,745	254,472
1950	55,011	2,741	71,987	5,236	14,534	22,456	46,078	71,211	289,254
1951	70,002	2,826	81,467	6,777	18,735	25,243	58,510	92,546	356,106
1952	98,811	5,426	100,520	3,910	22,341	33,075	74,606	91,673	430,362
1953	72,934	2,613	88,827	8,041	17,949	26,672	60,080	82,590	359,706
1954	57,969	2,504	82,948	6,077	18,086	24,524	53,347	71,353	316,808
1955	56,933	1,214	53,215	4,889	11,268	17,196	34,887	57,554	237,156
1956	88,192	3,333	100,456		14,819	30,394	70,169	92,583	399,946 *
1957	63,000	2,961	82,609	4,704	18,782	26,135	61,199	75,923	335,313
1958	82,991	5,302	103,802	4,067	24,287	33,450	75,631	103,322	432,852
1959	49,586	2,041	62,743	4,515	13,225	17,603	41,663	60,825	252,201
1960	51,319	1,859	30,323	3,747	8,434	10,069	22,795	40,650	169,196
1961	44,743	1,905	19,582	2,872	5,230	6,642	12,677	28,590	122,241
1962	70,043	3,056	80,817	8,024	15,080	20,045	56,548	73,300	326,913
1963	62,683	2,450	82,991	8,284	15,131	20,517	56,177	72,763	320,994
1964	43,062	1,073	62,072	5,683	12,766	16,817	37,640	58,010	237,123
1965	78,076	2,333	92,616	7,974	16,816	26,102	63,819	87,572	375,307
1966	57,769	3,009	73,444	6,207	16,707	19,020	42,641	64,631	283,427
1967	69,017	4,808	90,608	10,196	19,708	28,233	70,047	94,899	387,515
1968	53,331	3,026	65,318	5,637	12,532	18,826	39,277	61,557	259,504
1969	90,633	5,369	105,029	10,498	13,754	31,161	74,964	90,427	421,835
1970	65,353	2,364	89,024	8,314	17,694	23,267	56,127	72,562	334,704
1971	69,220	2,499	93,238	8,214	18,579	24,293	64,517	85,915	366,476
1972	68,513	3,175	70,380	6,152	17,282	20,155	48,967	68,194	302,819
1973	69,976	1,219	98,285	9,087	18,775	24,699	63,825	79,947	365,812
1974	94,375	2,957	119,142	9,296	21,284	28,132	74,081	90,868	440,135
1975	77,638	2,993	101,748	8,611	20,733	26,607	69,790	82,279	390,399
1976	43,361	1,499	43,973	3,334	12,269	12,855	26,493	41,149	184,932
1977	30,506	1,058	16,513	1,847	4,953	5,867	12,307	20,672	93,723
1978	84,442		116,593	9,719	19,836	28,623	80,844	109,945	450,002 *
1979	69,561	200	90,324	6,427	15,401	25,771	63,959	85,403	357,046
1980	86,214		118,584	11,421	25,383	30,779	76,924	99,571	448,876 *
1981	49,377		55,530	6,605	15,435	17,458	39,354	59,395	243,155 *
1982	92,516		117,147	12,354	25,040	27,165	71,521	91,765	437,508 *
1983	84,625		110,890	7,375	23,197	26,420	66,389	83,956	402,852 *
1984	75,587		102,331	9,575	24,232	26,958	65,504	88,144	392,331 *
1985	59,407		59,219	6,925	19,146	19,990	48,169	71,911	284,767 *
1986	88,814		101,163	8,807	23,842	28,451	72,473	102,000	425,550 *
1987	47,011		40,840	4,876	14,219	13,065	31,754	43,474	195,239 *
1988	43,990		22,596	2,371	6,186	7,954	15,044	31,619	129,760 *
1989	66,141		45,992	4,573	8,724	14,211	32,615	57,995	230,251 *
1990	49,710		24,227	2,632	5,696	9,029	14,035	36,217	141,546 *
1991	53,396		29,182	2,667	5,654	9,734	15,015	36,152	151,800 *
1992	38,845		14,400	1,850	4,438	4,510	8,299	23,751	96,093 *
1993	69,313		60,952	5,616	12,856	18,488	48,824	82,218	298,267 *
1994	39,877		29,051	2,500	6,896	8,093	17,500	36,776	140,693 *
1995	88,744		85,100	7,133	16,904	24,262	60,457	95,449	378,049 *
Average	65,541	2,535	71,178	5,901	15,230	21,237	49,352	67,957	284,763

* Data missing for some years

- Table 6.6 - NDWP "Table 4. Summary of Annual Diversions from the NDWP Diversion Database (acre-feet)"

These tables are enlightening as to the C-125 natural flow rights available in the individual sub-basins, including relative priorities.

6.3.2 Storage Rights

Rights to the storage and beneficial use of water on the Walker River system are described by Decree C-125, and confirmed by the California-Nevada Interstate Compact. The two largest reservoirs, which have primary impact on the storage and delivery of water for irrigation are Bridgeport Reservoir on the East Walker River, and Topaz Reservoir on the West Walker River. The Walker River Irrigation District (WRID) owns both reservoirs. Use is limited to within the WRID boundaries, which are located fully within Nevada. Permits for the operation of both reservoirs are within the purview of the Water Resources Control Board of California. Management of the storage and release of water from both reservoirs is the responsibility of the U.S. Board of Water Commissioners, in coordination with WRID.

The primary irrigation beneficiary of flood water is WRID acreage for which additional water is necessary to supplement direct diversion flow and/or storage. This is particularly critical for those users allocated storage on new land at only 48% of the normal annual acre-foot duty. In the absence of the flood water and/or supplemental ground water, new land may be non-productive. The use of flood water would normally be preferred to ground water as a supplemental source due to the cost of development, maintenance, and operation of a production well.

6.3.3 Flood Water Rights

Just as there exist low-flow periods during which insufficient water is present in the Walker River system, there are also periods of high flow during which more water is available than is necessary to fulfill the natural diversion and storage rights allowed under Decree C-125. "Flood water," therefore, occurs not only during flood events, but any time during the irrigation season when the river flow exceeds demand. Such additionally available flow, typically termed flood water, is distributed by the federal Water Master in accordance with the Order Approving Rules and Regulations for Distribution of water on the Walker River Stream System, entered by the US District Court on September 3, 1953. That Order specifies distribution of excess flow as follows:

> "If at any time the Chief Deputy Water Commissioner determines that there is more water available in the stream than is required to fill the rights of all of the vested users including the rights of the Walker River Irrigation District

and others similarly situated to store water, then he shall prorate such excess water to all users in proportion to the rights already established."

In addition to the provision for distribution of flood water by the federal Water Master, the Nevada State Engineer has issued three separate permits for the diversion of flood water, those being described as follows:

- Permit 5528, Certificate 8859 (date of priority June 6, 1919) - Issued to the Walker River Irrigation District for the diversion of 491.2 cfs, not to exceed 89,612 acre-feet per season from the West Walker River for the irrigation of up to 38,617.18 acres. The point of diversion is the point at which the West Walker River crosses the Nevada state line. The period of use is limited to May 1 to July 31 of each year.

- Permit 25017, Certificate 8860 (date of priority April 11, 1969) - Issued to the Walker River Irrigation District for the diversion of 349.1 cfs, not to exceed 63,688 acre-feet per season from the East Walker and Main Walker Rivers for the irrigation of up to 35,000 acres. The point of diversion is the point at which the East Walker River crosses the Nevada state line. The period of use is limited to May 1 to July 31 of each year.

- Permit 25792, Certificate 10860 (date of priority September 17, 1970) - Issued to the Nevada Division of Wildlife for the diversion of 795.2 cfs, not to exceed 575,870 acre-feet per year from the Walker River and tributaries for fish, game and recreation purposes in Walker Lake. The point of diversion is at the terminus of the natural channel of the main Walker River, at which point it flows into Walker Lake. The period of use is January 1 to December 31 of each year.

The U.S. federal district court having jurisdiction under Decree C-125 has never recognized these certificates. The federal Water Master is therefore not constrained by provisions of the state-issued certificates, and he continues to distribute flood water in conformance with the previously cited 1953 Order.

The large diversion rate and acre-foot duty under Permit 25792 are based on a Proof of Beneficial Use form filed with the State Engineer by the Nevada Division of Wildlife after record flows to Walker Lake in the 1982-1983 water year. While Permit 25792 provides for the use of flood water to maintain the level of Walker Lake, its effectiveness is limited by the fact that it is later in priority than WRID Permits 5528 and 25017. Based on the doctrine of prior appropriation as applied under Nevada's water law, those Walker Lake rights represented by Permit 25792 can be served only after the earlier WRID flood water rights. There is however significant value under Permit 25792 in preventing the appropriation by other parties of any flood water on the Walker River in excess of the WRID rights.

The primary irrigation beneficiary of flood water is WRID acreage for which additional water is necessary to supplement direct diversion flow and/or storage. This is particularly critical for those users allocated storage on new land at only 48% of the normal annual acre-foot duty. In the absence of the flood water and/or supplemental ground water, new land may be non-productive. The use of flood water would normally be preferred to ground water as a supplemental source due to the cost of development, maintenance, and operation of a production well.

6.3.4 Ground Water

As previously discussed under Section 6.2, significant differences exist between California and Nevada in the administration of ground water rights. The increased control over ground water exercised by Nevada through its appropriative process carries with it an enhanced quantification of both the existing and future allowable (permitted) use, as well as records of historic actual use. Given these differences, the quantification of ground water rights will be separately reviewed for each state.

6.3.4.1 California

As previously described, ground water rights within California are established primarily under the riparian doctrine, which confirms overlying rights on properties limited only by the amount reasonably necessary for beneficial use. The Water Resources Control Board of California maintains no record of ground water use or rights in the Walker River Basin.

The most definitive reference on ground water use information in California appears to be a cooperative report by the U.S. Soil Conservation Service (SCS) dated June 1969. That report indicates a total of 1,645 acres in Antelope Valley (California portion) to be irrigated by ground water, with 810 of the 1,645 acres supplemented by surface water (presumably natural diversion flow under Decree C-125, although not specifically stated). The report indicates no ground water use in the Bridgeport area for irrigation. A draft report by the Nevada Division of Water Planning summarizing ground water rights in the Walker River Basin (Pahl, 1997c) also relies on the SCS report for its summary of California ground water use.

Based on the USDA report, and assuming a maximum irrigation duty of 4 acre-feet per acre, ground water use within the California portion of the Walker River Basin is projected to be between 3,240 and 6,580 acre-feet per year, depending on the extent of supplemental surface water use.

6.3.4.2 Nevada

Ground water rights in Nevada are based on the doctrine of prior appropriation (first in time is first in right), with administration of rights by the Nevada State Engineer. Water cannot be diverted to use in Nevada without permitted approval.

The Nevada State Engineer maintains a full database of permitted ground water rights within the Walker River Basin. That database is continually updated as changes to the status of water rights take place. This database is available to the public in the form of computerized summary printouts of rights within each hydrographic basin or sub-basin. Those printouts provide the following specific information:

- Application/Permit Number, as assigned consecutively by the Nevada State Engineer's office on the filing of an application, and any subsequent applications filed to change the subject permit.
- Certificate Number, if issued (as assigned by the Nevada State Engineer's office).
- The status of that application/permit (i.e. permitted, certificated, cancelled, ready for action by the State Engineer, etc.).
- The source (in this case underground); the location of the permit point of diversion, by equally divided 40-acre units; and the rate of diversion (cfs) as applied for, or as permitted or certificated.
- The manner of use (i.e. irrigation, commercial, municipal, recreation, stockwatering, etc.)
- Indication (yes or no) of whether or not the application/permit is supplemental to other rights.
- The number of acres irrigated if intended/permitted for irrigation use.
- The annual total duty in acre-feet.
- The county in which the point of diversion is located, and the current owner of record, as reflected by the records of the Nevada State Engineer's office.

In addition to the database of all rights, the Nevada State Engineer maintains a computerized summary of active ground water application/permits within each hydrographic basin or sub-basin on the basis of current status and manner of use. Attached to this report are copies of the summaries for current status (Attachment A) and manner of use (Attachment B) generated by the Nevada State Engineer's database on August 19, 1999.

Table 6.7 provides a tabulated summary of committed ground water uses. The table summarizes only those ground water rights that have been committed by the State Engineer in the form of a permit and/or certificate. It must be noted that the summary is not static; it changes whenever a right is modified by action of the State Engineer. Water rights within the summary have been rectified by the State Engineer to reflect the total duty with other supplemental ground water rights. In other words, where two or more permits are supplemental to each other, the summary reflects only the total duty allowed under those several rights. However, the summary does not reflect surface water rights that are supplemental to ground water rights. This is a significant factor in attempting to establish the total committed rights from all sources within the basin.

TABLE 6.7. COMMITTED NEVADA GROUND WATER RIGHTS BY USE (ACRE FEET/YEAR).

	Antelope Valley	Smith Valley	Mason Valley	East Walker	Walker Lake	Total
Commercial	337.28	2,537.30	195.50	0.00	23.94	3,094.02
Domestic	1.63	227.16	16.23	0.00	5.25	250.27
Environmental	0.00	0.00	218.85	0.00	5.37	224.22
Industrial	0.00	57.84	11,375.82	0.00	72.30	11,505.96
Irrigation (DLE)	0.00	1,184.04	0.00	0.00	0.00	1,184.04
Irrigation	5,202.96	54,183.60	117,179.84	21,129.55	3,742.99	201,438.94
Mining/Milling	0.00	530.95	7,418.94	669.96	37.30	8,657.15
Municipal	0.00	0.00	2,369.43	0.00	6,501.47	8,870.90
Quasi-Municipal	993.10	188.25	1,013.81	0.00	3,359.65	5,554.81
Recreation	32.00	0.00	6,037.57	0.00	0.00	6,069.57
Stock Water	0.00	608.71	402.37	62.39	26.70	1,100.17
Other	0.00	431.39	0.00	0.00	4,664.71	5,096.10
Total	**6,566.97**	**59,949.24**	**146,228.36**	**21,861.90**	**18,439.68**	**253,046.15**

Source: Nevada Division of Water Resources Water Rights Database Abstract (dated 8/19/1999)

It should be recognized that the pumpage of ground water within the Walker Lake hydrologic basin may significantly exceed the permitted total shown in Table 6.7. The abstract indicates 612 acre-feet per year of ground water to be permitted within the Walker Lake-Schurz Subarea, which includes the Walker River Indian Reservation. Of that amount, only about 12 acre-feet are located within the Reservation boundary. However, Pahl (1997c) indicates the use of approximately 1,680 acre-feet per year of ground water diverted by the Walker River Indian Reservation for the irrigation of approximately 420 acres. Estimates of acreage and use reported by Pahl were based on information obtained from the Reservation's water resource director in 1997.

The use of ground water on the Walker River Indian Reservation without benefit of permits issued by the Nevada State Engineer is based on the Paiute Tribe's claim of federal reserved rights. Given the fact that approximately 600 of the 612 acre-feet included on the State Engineer's database is for land outside of the Walker River Indian Reservation, the amount of ground water actually committed to irrigation use is probably closer to 2,500 acre-feet per year. This total (and associated impacts) could increase (or decrease) outside of the permitting authority of the State Engineer, depending on the extent of future ground water development within the Reservation boundaries.

In addition to maintaining a database of water rights within the Walker River Basin, beginning in 1994 the Nevada State Engineer has maintained a record of estimated ground water pumpage within the Smith Valley and Mason Valley hydrologic basins. Although the Nevada State Engineer continues to collect field pumpage data on both basins, reports have been completed and issued only for 1994 through 1996. Table 6.8 provides a compilation of data from the 1996 report relative to agricultural ground water pumpage for the 1994-1996 period.

Table 6.8 is informative as to ground water demands for irrigation within the Smith Valley and Mason Valley hydrologic basins. However, it also makes clear that significant additional study and inventory of water use within the Walker River Basin will be required before a clear quantification of water rights and actual use can be made. For example, issues requiring clarification raised by the pumpage inventory might include:

TABLE 6.8. GROUND WATER PUMPAGE SUMMARY, SMITH AND MASON VALLEYS, 1994 THROUGH 1996

	1994	1995	1996
Smith Valley			
Irrigated Pumpage (af)	32,740	9,900	17,500
Other Pumpage (af)	1,260	1,500	1,500
Total Pumpage (af)	*34,000*	*11,400*	*19,000*
Perennial Yield (af)	17,000	17,000	17,000
Difference	*-17,000*	*5,600*	*-2,000*
Average Ground Water Level Change	-6.58 ft	+11.14 ft	+6.75 ft
Total Mean Percent of Average System Stream Flow	36 %	198 %	166 %
Mason Valley			
Irrigated Pumpage (af)	107,300	25,800	34,500
Other Pumpage (af)	12,200	12,500	10,700
Total Pumpage (af)	*119,500*	*38,300*	*45,200*
Perennial Yield (af)	25,000	25,000	25,000
Difference	*-94,500*	*-13,300*	*-20,200*
Average Ground Water Level Change	-2.76 ft	+5.38 ft	+2.47 ft
Total Mean Percent of Average System Stream Flow	36 %	193 %	166 %

Source: Gallagher (1996)

Note: based on mean percentage of normal flow at four separate gauges for differing long term periods of record, i.e. West Walker at Hoye Bridge (1919-1996), West Walker at Wilson Canyon (1915-1996), East Walker near Mason (1943-1996), and Walker River at Wabuska (1902-1996).

- There is need for a full and accurate inventory of the interrelationship between all water rights, including Decree C-125, WRID storage, floodwater, and ground water (both supplemental and non-supplemental). This need may be particularly acute with respect to a clear definition of the use of ground water to supplement Decree C-125 water. It does not appear from research of the records of the Nevada Division of Water Resources that an accurate mapping is available at that office of the acreage described under the Decree as originally issued. Such a full inventory would provide a much more accurate accounting of actual ground water commitment within the basins

- There may be a significant difference between permitted ground water rights and actual ground water demand. This difference appears particularly large in Smith

Valley. Pumpage to irrigation in 1994 was approximately 32,700 acre-feet while the total stream flow (West Walker River primarily) was only 36% of average. During a year of particularly low surface water availability, it would be anticipated that practically all rights available would be actually used, with high reliance on supplemental ground water. However pumpage in 1994 was still about 22,600 acre-feet less than the permitted total of approximately 55,300 acre-feet of ground water in Smith Valley (see Table 6.7).

6.4 MANAGEMENT ALTERNATIVES

Before discussing management alternatives, it is important to acknowledge that not all water rights are equal with regard to their ability to be transferred to Walker Lake. It is recognized that some water rights may be acquired that either in whole or in part would not be transferable to Walker Lake. This may occur because the transfer is contested, the right is inactive or its status is questionable, or it is otherwise ineligible for transfer under State law or court action. Although it is unlikely that the purchasing entity would *seek* to acquire such water rights, it should be recognized that depending on the management alternative selected, many such rights may be offered.

Also, it is important to consider *who* might administer the acquisition program. Administration could occur at a number of different levels, or it could be centralized in a single entity. The Bureau of Land Management (BLM) has expressed an interest in playing a central role in the acquisition of water rights with the expectation that those rights would be transferred to Walker Lake. Other existing entities that could play a role include the Natural Resource Conservation Service (NRCS), the States of Nevada and/or California, county governments, the Walker River Irrigation District, the Board of Water Commissioners, non-profit groups such as the Nature Conservancy or the Sierra Club, and private individuals. Each entity brings with it advantages and disadvantages. In Chapter 10 of this document it is recommended that consideration be given to the formation of a water conservancy district in accordance with Section 541 of the Nevada Revised Statutes. A conservancy district would be a locally based and supported, State entity with broad powers to manage water to the benefit of the Walker River Basin at large. Similar conservancy districts currently exist in the Truckee River and Carson River basins. For purposes of the following discussion, it is assumed that a single entity would be responsible for most if not all water rights purchases.

Prior to formulating alternative management plans, it was necessary to consider methods of acquiring water rights. As described below, those methods do not rely solely on acquisition through purchase. It is reasonable to expect that over time, the purchasing entity would acquire water for Walker Lake through application of the following methods.

The direct purchase of water rights: The purchasing entity would acquire water through the direct purchase of water rights. Purchase is a direct means of obtaining fee title to available water rights. All purchases would be on a voluntary, willing seller basis.

The purchase of water rights with land: Some landowners may not sell their water rights unless they can also sell the appurtenant land. In these circumstances, the purchasing entity may consider buying land with water rights and, possibly, could also acquire related interests (houses, buildings and other improvements). Appurtenant lands and related interests would be the management responsibility of the purchasing entity, and may include the possibility of disposal. This might allow for affected land to be rezoned in accordance with local government master plans. This might also prevent undesired land use conversions and unmanageable growth patterns, and could facilitate land exchanges to maintain production on important agricultural lands.

The donation of water rights: An individual, group, or agency may wish to donate or bequest a water right or a portion of a water right (and possibly appurtenant land and related interests) to the purchasing entity to be managed for the benefit of Walker Lake.

The leasing of water rights: The purchasing entity may lease water rights from owners and convey the leased water to Walker Lake. Leases may be recurring, intermittent, or single event acquisitions from willing lessors. The lessor would allow full or specified use of water rights in return for payment. Unless renewed, when a lease expired, the water right would revert back to the owner.

The permanent or conditional transfer of federally held water rights: Agreements could be sought with federal agencies that hold water rights in the Walker River Basin. Those agreements could allow for the transfer of water rights to the purchasing entity to be managed for the benefit of Walker Lake. Transfers of federally held rights might also be conditional in the event of possible future need for the federally held right. For example, the Hawthorne Ammunition Depot holds several permitted water rights (Table 6.9) established through use during periods of high activity. However in peacetime, a substantial portion of those rights may not be required due to diminished depot activity. In fact, some rights may potentially be subject to forfeiture or abandonment due to extended periods of non-use. It may be possible for the purchasing entity and the Depot to identify conditions under which some portion of those water rights could be allowed to enter Walker Lake as a beneficial use, while potentially protecting the active status of the rights.

The permanent or conditional transfer of state held water rights: Agreements might be sought with state agencies that hold water rights in the basin. As in the case of federally held rights, agreements might allow for the permanent or conditional transfer to the purchasing entity of state-owned water rights to be managed for the benefit of Walker Lake. For example, the Nevada Divisions of Wildlife and State Lands hold permitted groundwater rights in support of the Mason Valley Wildlife Management Area (Table 6.10, Basin 108). The quality of water discharged in conjunction with some of those rights (discharged from the operation of the state's fish hatchery) precludes discharge to Walker River. This may represent water available for maintaining the state's wildlife area, while freeing up other water rights now no longer needed. An inventory of state-held rights (both permitted and decreed), and a comparative review of actual demands based on permitted uses, may identify conditions under which some portion of those water rights could be allowed to flow to Walker Lake without negative impact of historic uses. However, the preparation of such inventories is beyond the scope of this review.

TABLE 6.9. PERMITTED WATER RIGHTS HELD BY THE HAWTHORNE AMMUNITION DEPOT.

Number	Source	Use	Diversion (cfs)	Area Irrigated (ac)	Annual Duty (af)
Lake Subarea					
1020	Stream	Irrigation	0.105	10.50	42.00
3979	Stream	Irrigation	0.159	15.91	47.73
5086	Stream	Irrigation	0.370	37.00	111.00
5397	Stream	Irrigation	0.311	31.14	93.42
5596	Spring	Irrigation	0.219	21.87	65.61
7430	Stream	Irrigation	0.027	2.65	14.43
16688	Stream	Municipal	3.810	0.00	2,547.31
16956	Stream	Municipal	0.500	0.00	361.99
Whiskey Flat – Hawthorne Subarea					
2092	Stream	Irrigation	0.384	38.39	153.56
3394	Stream	Irrigation	0.532	53.20	170.00
48043	Groundwater	Industrial	1.337	0.00	72.30

Source: Nevada Division of Water Resources water rights database abstract dated 6/30/99.

The exchange of land and/or water rights: Agreements could be sought between the purchasing entity and private, state, or federal owners of land and/or water rights, whereby land and/or water rights could be exchanged. Such exchanges would be implemented with the intent of furthering goals set by the purchasing entity.

The purchase of water from other purveyors: The purchasing entity could purchase water from various purveyors, such as the Walker River Irrigation District, ditch companies, or municipalities (sewage effluent). For example, water rights issued in the name of the City of Yerington (Permit 52430) provide for the disposal of up to 455 acre-feet per year of treated sewage effluent from the Yerington wastewater plant by land application within the Wildlife Management Area. This permit is the subject of a Cooperative Agreement between the City of Yerington and the Nevada Division of Wildlife. That agreement specifically recognizes the use of effluent for wildlife, and wetlands protection and enhancement. As discussed with regard to state owned rights at the fish hatchery, this effluent may represent water available to replace other rights without diminution of the wildlife management operation.

The purchase and management of ground water rights: For purposes of this discussion, it is assumed that no new ground water appropriations would be approved by the Nevada State Engineer, and that all efforts would relate to existing ground water rights. For the purchasing entity to utilize groundwater, wells would need to be developed that could pump adequate volumes of water, or existing wells would need to be purchased along with water rights. The use of groundwater rights in support of management of flow to Walker Lake would be dependent on many factors, including location, their identification as supplemental or non-supplemental, their priority relative to other rights within each basin, and the availability of less costly water sources. In dry years, ground water pumping might be used to offset surface water shortages. In wet or even normal years, the comparative cost of pumping ground water might suggest its diminished use. The purchasing entity could acquire existing ground water permits and seek to transfer those permits to other, better positioned wells or well locations. Methods available to the purchasing entity for the management of ground water rights (so as to benefit flow to Walker Lake) are limited only by the imagination of the entity, available funding, and the ability of the State Engineer to accommodate those alternatives within limitations of the State's water law.

Of these methods, direct purchase is anticipated to be the most permanent and reliable long-term means of securing additional water for Walker Lake. Other methods of acquisition (such as donation) could reduce costs substantially, but it is not anticipated that these methods will play a major role in any water rights acquisition program that is developed and implemented. Methods such as leasing and conditional transfers offer short-term flexibility and lower costs per acre-foot. For leasing, however, administrative costs and annual lease payments could eventually be higher than costs associated with outright purchase.

Given that water rights would be acquired from locations of varying productivity, an average per acre purchase price would seem reasonable. Information presented by the U.S. Fish and Wildlife Service for the Lahontan Basin provides a means of estimating water rights purchase prices. Market values for water rights were $215 per acre-foot in 1988 and rose to $343 per acre-foot by 1993 (USFWS 1996:3-141). These costs were for the water right only and did not include a cost for the appurtenant land, or any operation and maintenance costs associated with continued exercise of the right.

A more recent appraisal (effective date July 1, 1999) was made of water rights within the Truckee-Carson Irrigation District (TCID). The appraisal, prepared by Western Property Analysts for the Carson Water Subconservancy District (CWSD), was intended to establish a value for water rights to be purchased with funding established by the 1999 Nevada Legislature under AB 380. The appraisal considered water right valuation within two distinct areas: the Truckee Division (Fernley area above Lahontan Reservoir) and below Lahontan Reservoir. The Truckee Division's highest and best use was considered to be agriculture and/or dedication to municipal purposes. Below Lahontan Reservoir, the highest and best use was considered to be agriculture and/or Lahontan Valley wetlands.

Based on a highest and best use, water rights in the Walker River Basin would probably be most comparable to those in the CWSD appraisal within the area below Lahontan Reservoir. The CWSD appraisal concluded that the normal range in market value for that area is $1,500 to $1,800 per water right acre. Based on a normal allocation of 3.5 acre-feet per acre, this would represent a market value between $428 and $514 per acre-foot. This does include the component of the land, but does not include administrative costs.

TABLE 6.10. PERMITTED WATER RIGHTS HELD BY THE NEVADA STATE AGENCIES.

Number	Source	Use	Diversion (cfs)	Area Irrigated (ac)	Annual Duty (af)
DIVISION OF WILDLIFE					
Smith Valley					
28299	Spring	Recreation	0.001	0.00	1.01
31004	Other Surface	Wildlife	10.210	0.00	7,389.94
47450	Other Surface	Wildlife	10.000	0.00	4,746.68
49580	Spring	Wildlife	0.001	0.00	0.80
49581	Spring	Wildlife	0.072	0.00	52.11
49582	Spring	Wildlife	0.000	0.00	0.15
Mason Valley					
18931	Underground	Irrigation	5.400	400.74	1,602.96
18934	Underground	Irrigation	5.400	295.68	1,182.72
20821	Underground	Irrigation	2.700	105.80	423.20
23753	Stream	Irrigation	9.444	786.90	2,524.06
50704	Underground	Wildlife	0.150	0.00	108.60
60557	Underground	Recreation	3.000	0.00	861.50
60558	Underground	Recreation	3.000	0.00	861.50
60559	Underground	Recreation	1.630	0.00	1,180.07
60560	Underground	Recreation	3.000	0.00	844.76
60561	Underground	Recreation	3.000	0.00	844.76
60562	Underground	Recreation	0.185	0.00	138.92
61575	Underground	Wildlife	3.000	0.00	2,171.94
64604	Underground	Recreation	0.980	0.00	181.67
64605	Underground	Quasi-Municipal	0.054	0.00	10.00
64606	Underground	Recreation	0.270	0.00	50.04
64607	Underground	Recreation	0.980	0.00	181.63
64608	Underground	Recreation	0.710	0.00	131.58
64609	Underground	Recreation	1.060	0.00	196.45
64610	Underground	Recreation	0.865	0.00	160.31
64611	Underground	Recreation	0.865	0.00	160.31
64646	Underground	Quasi-Municipal	0.216	0.00	40.00
Walker Lake Valley					
25792	Walker River	Recreation	795.200*	0.00	575,870.00
DIVISION OF STATE LANDS					
Mason Valley					
63179	Underground	Irrigation	1.730	320.00	392.00
63180	Underground	Irrigation	1.060	320.00	240.00
63181	Underground	Irrigation	0.710	320.00	160.00
63182	Underground	Irrigation	1.250	320.00	160.00
63183	Underground	Irrigation	1.250	320.00	160.00

Source: Nevada Division of Water Resources water rights database abstract dated 7/26/99
** Right for Walker Lake after all other rights are satisfied*

The following discussion is predicated on the assumption that there is an interest in developing a water rights acquisition program and that the goal of that program is to increase inflow into Walker Lake. However, the extent of any such program has yet to be defined. For purposes of discussion, the goal would be to acquire sufficient water rights to sustain, on a long-term average, an arbitrarily defined block of 5,000 acre-feet per year of additional flow into Walker Lake. It is assumed that direct purchase would be the method of acquiring most water rights. Alternatives are defined based on how a program of water rights acquisition could be implemented, what the goal of that acquisition effort would be, and what the consequences of that effort would be. Four alternative programs are suggested.

6.4.1 Alternative One – Unstructured Water Rights Acquisition

This first alternative program places an emphasis on the acquisition of any type of water right from any location in the Walker River Basin. Each acquisition would occur on a willing seller, willing buyer basis. Acquisitions would continue on a "first come, first served" basis until program goals are met or until available funds are exhausted. It is assumed that the purchasing entity would conduct most or all of the water right purchasing. The purchasing entity would manage the acquired water rights in accordance with established policies, state law, the decree or applicable court directive, any supplemental arrangement that may be agreed to with the seller, and whatever supplemental plans the entity may establish.

Some water rights may be acquired that either in whole or in part would not be transferable to Walker Lake. Water rights held by a single party will often consist of several separate rights, frequently from different sources (i.e. ground water or surface water), and with different characteristics (i.e. decreed, permitted ground water, supplemental, flood, storage, etc.). All rights in such a package may not actually be of direct benefit to Walker Lake (supplemental ground water, for example). However, it may be necessary that the purchasing entity acquire all of the water rights held by an individual to conclude a purchase. In such situations, the purchasing entity might sell, exchange, or even retire rights as a part of the management process. Water right packages would not be acquired unless the purchasing entity expected that they could be transferred, at least to a substantial degree. Although it is unlikely that the purchasing entity would *seek* to acquire such water rights, it should be recognized that on a first come, first served purchase basis, many such rights will be offered. There is also the potential that changes to existing water rights, and particularly decreed rights, might be limited to a duty less that allowed for the base right. For example, under provisions of the Carson River Decree (USA v Alpine Land and Reservoir, Civil No. D-138 BRT, Final Decree, 1980), changes in the manner of use from irrigation and changes in the place of use are limited to the net consumptive use of the water right. For planning purposes, it is estimated that in this unstructured acquisition alternative, approximately 65 percent of the acquired water rights would be transferable to Walker Lake.

Currently, the U.S. Fish and Wildlife Service is acquiring water rights on the Carson River system in an effort to maintain wetlands in Lahontan Valley. Studies conducted in support of that effort contain information about conveyance efficiencies. Historically, the conveyance efficiency of Newlands Project facilities has varied from a high of 68.1 percent during a full irrigation year to a low of 59.3 percent during shortage years (USFWS 1996, page 4-11). Clearly, there are differences between the Newlands Project and the Walker River system. The Newlands data, however, did provide one regional estimate of relative delivery efficiency. In spite of differences between the two systems, delivery efficiencies in the Walker River Basin are expected to be similar to or even lower than the reported figures. This is due largely to the greater distance the water must be conveyed. For planning purposes, it is estimated that water acquired as a part of this alternative would experience 50 percent delivery efficiency.

Based on the somewhat dated figures from the USFWS analysis, and considering conclusions of the more recent CWSD appraisal, it appears reasonable for project cost projection purposes to assume water rights in the Walker River Basin to have a market value of approximately $500 per acre-foot. Administrative costs would be incurred with the purchase of a water right. These would include analysis of the water right, contract development, costs associated with changes to accommodate management to benefit of Walker Lake, and potential costs associated with the legal defense of such changes. For planning purposes, these costs are estimated at $250 per acre-foot. When combined, purchase and administrative-management costs for Alternative One are estimated to average about $750 per acre-foot.

As previously noted, the management objective has been defined as acquiring sufficient water rights to realize 5,000 acre-feet of additional water to Walker Lake. Based on the planning-level estimates listed above (a 50 percent delivery efficiency and a 65 percent transfer rate), the acquisition of approximately 15,400 acre-feet of water rights would be required. Assuming an average cost of $750 per acre-foot, the total cost of this management alternative would be approximately $11.5 million dollars. Requirements include a willing seller, a willing buyer, and sufficient funds to complete the transaction.

Advantages inherent to the unstructured approach to water rights acquisition include its simplicity and broad applicability. The absence of limiting criteria on water rights qualifying for purchase (i.e. source, priority, location, supplemental/non-supplemental, etc.) would provide a large market available to the purchasing entity. This program would likely result in the earliest success in seeing water rights change hands.

Disadvantages to this management approach result mostly from its lack of structure. The acquisition of water rights would occur with little or no consideration of their type, location, priority, or the impact of their transfer. As a result, there would be less assurance that the acquired water would ultimately result in additional flow to Walker Lake. For example, if the purchasing entity acquisitions included later priority surface rights, supplemental ground water rights, or rights from scattered or remote upper basin locations, there would be a reduced certainty that this expenditure of funds would directly benefit Walker Lake.

The random acquisition of water rights may cause existing irrigation systems to become less efficient and more expensive to operate. Retiring land from irrigation at the beginning or in the middle of a ditch system increases the cost of maintaining that system to those who remain. It also may affect tailwater availability to users who historically have relied on that tailwater as a part of their irrigation system. Since delivery ditch losses (evapotranspiration and seepage) may remain unchanged, the removal of irrigated acreage could increase the proportional inefficiency of the ditch. These types of disadvantages are reflected in the planning estimate that the proposed unstructured purchase program would experience only 50 percent delivery efficiency.

Depending on the type of right, the transfer of water to Walker Lake may require removal of that water from the jurisdiction of current management agencies (WRID, U.S. Board of Water Commissioners, ditch companies). Any attempt to transfer water rights under Decree C-125 would require authorization of the USBWC, and probably amendment to the Decree through the U.S. District Court. In its current configuration, Decree C-125 does not allow for the transfer of water to a place of use beyond defined limits. In the absence of active participation and support by WRID, attempts to transfer jurisdictional water rights outside of the bounds of the District would most likely result in protest and legal action. Even with the active involvement of the District Court and jurisdictional agencies, there will be protest actions by individual parties who feel that they are negatively impacted, or that the public interest is not being protected.

The issue of protest or other legal action against the transfer of water rights to Walker Lake is not limited to the unstructured water rights acquisition alternative. *Any* alternative acquisition program will face these same challenges. However, in the absence of a clear definition by the purchasing entity of those rights that will most effectively fulfill their mandate (which is the definition of "unstructured"), the potential for viable protest is increased. An unstructured system invites the purchase of rights without regard to negative impacts or potential for transferability. This would increase the average administrative cost per acre-foot of acquired water rights, and it may decrease the percentage of those purchased water rights that could be transferred to Walker Lake.

6.4.2 Alternative Two – Structured Water Rights Acquisition

Alternative Two would place an emphasis on the acquisition of specific types of water rights, or water rights from specific locations within the Walker River Basin. Each acquisition would be on a willing seller, willing buyer basis. The exact acquisition target is not identified herein, but would be identified by the purchasing entity under its management program. The emphasis under Alternative Two is the establishment of a planned and structured acquisition strategy. Criteria that might be used to structure the acquisition process may include one or more of the following:

- Early date of priority – acquiring early priority water rights would increase the reliability of water delivery to Walker Lake, even during years marked by less than average precipitation and stream flow.

- Single source water rights – acquiring rights uncomplicated by rights from other sources such as supplemental ground water, WRID storage water or flood water,

- Land productivity – acquiring water rights based on land productivity would remove rights from low productivity lands and lands that contribute to diminished water quality.

- Ground water proximity to the Walker River – acquiring ground water rights located near the Walker River would reduce the cost of delivery to the river.

- High loss ditches – acquiring water rights located along high loss ditches (high infiltration, high evapotranspiration, long distances, etc.) would reduce the amount of water diverted from the Walker River needed to provide required irrigation duties at the place of use.

- Tie to local planning or master planning elements – integrating water rights purchases into local and regional planning efforts would ensure the compatibility of land use planning efforts.

- Substitution of rights – allowing for the substitution of water rights would increase the likelihood that purchased water could be transferred to Walker Lake.

- Purchase flood water rights – acquiring flood water rights would reduce the amount of water taken from the Walker River during high flow periods.

Acquisitions would continue until program goals are met or until available funds are exhausted. It is assumed that the purchasing entity would conduct most or all of the water right purchasing. As with the Alternative One, the purchasing entity would manage the acquired water rights in accordance with established policies, state law, the decree or applicable court directive, any supplemental arrangement that may be agreed to with the seller, and whatever supplemental plans the entity may establish.

Since Alternative Two is based on the structured and selective acquisition of water rights, it is assumed that a higher proportion of the acquired rights could be transferred to Walker Lake. For planning purposes, it is estimated that approximately 70 percent of the acquired water rights would be transferable.

Depending on the selection and management criteria, it may be possible that rights not contributing directly to stream flow could have an indirect beneficial effect. For example, supplemental ground water rights acquired and retired in close proximity to the river may result in a marginal increase in ground water inflow (reduction in ground water outflow) to the river. Or, the transfer of supplemental ground water rights or storage rights to decreed acreage without such alternative sources may reduce the amount of flood water normally diverted. Thus, the selective nature of this alternative would result in an increase in delivery efficiency as compared to Alternative One. For planning purposes, it is estimated that water acquired as a part of the proposed program would experience 55 percent delivery efficiency.

Given that water rights would likely be acquired from locations of higher potential yield, a slightly higher than average purchase price may be expected. For planning purposes, it is estimated that the average market value of water rights purchased under this alternative would be approximately $550 per acre-foot. Administrative costs are also expected to be somewhat higher than in Alternative One due to the greater level of planning that would be required. For planning purposes, these costs are estimated at $300 per acre-foot. When combined, purchase and administrative costs may average about $850 per acre-foot.

As previously noted, the management objective has been defined as acquiring sufficient water rights that 5,000 acre-feet of additional water would enter Walker Lake. Based on the planning estimates indicated above (a 55 percent delivery efficiency and a 70 percent transfer rate), approximately 13,000 acre-feet of water rights would be required. Assuming an average cost of $850 per acre-foot, the total cost under Alternative Two would be approximately $11.0 million dollars.

Advantages inherent to a structured approach to water rights acquisition include an ability to target specifically defined types of water rights or areas. Emphasis on community and/or county planned and targeted goals would increase program benefits. Development of those planning goals by the purchasing entity would likely afford an opportunity for public participation. Depending on the targeted areas, this alternative may encourage the retention of highly productive agricultural lands and optimize the potential of water reaching Walker Lake.

When compared to Alternative One, Alternative Two would require the acquisition of 16 percent fewer water rights to achieve the set goal. This is consistent with studies conducted in the Lahontan Basin. In its consideration of alternative acquisition programs, the U.S. Fish and Wildlife Service noted a 12 percent reduction in the amount of land needed to achieve a goal using a structured versus a random acquisition strategy. Given differences in purchase and administrative costs, Alternatives One and Two would be fairly comparable in terms of cost.

It is also reasonable to expect that Alternative Two would result in a reduced level of legal actions against proposed changes when compared with Alternative One. As previously noted, *any* alternative selected will encounter legal challenges, particularly with regards to the intent to transfer water to Walker Lake from within the administrative boundaries of WRID or the USBWC. However the ability to selectively target water rights that would avoid conflict with other water users (common ditch users or those historically reliant on tailwater for irrigation or wildlife purposes, for example) could be expected to reduce protests

Disadvantages to Alternative Two are associated with the time and cost associated with its greater emphasis on planning. Some level of planning would be required prior to the onset of any acquisitions, which would extend the period necessary for implementation of the purchase and management program. Also, by targeting selected areas and water right characteristics, the purchasing entity would be eliminating others from the opportunity to willingly participate in the program.

6.4.3 Alternative Three – Retention of Core Area(s)

A major concern associated with the acquisition of water rights is the potential that sufficient high quality, irrigated farmland would be taken out of production that the economic viability of the Walker River Basin would be affected. The goal of the third alternative would be to limit impacts to core areas of high value farmlands, thereby better retaining the area's economic viability. That goal would be achieved, in large part, by the acquisition of water rights from locations outside of the core areas. This alternative would need to include the following elements:

- community and local government participation in the definition of core areas;
- coordination with city and county zoning and land use restrictions; and,
- the opportunity for land exchanges.

Acquisitions would occur on a willing seller, willing buyer basis until program goals are met or until available funds are exhausted. It is assumed that the purchasing entity would conduct most or all of the water right purchasing. As with the other alternatives, the purchasing entity would manage the acquired water rights in accordance with established policies, state law, the decree, any supplemental arrangement that may be agreed to with the seller, and whatever supplemental plans the entity may establish.

As noted, the goal of this alternative would be to retain the integrity of core areas comprised of high quality agricultural lands. It is reasonable to assume that, for the most part, core areas would be located in valley bottoms on lands that were put to an agricultural use fairly early in the region's history. Water rights associated with core areas, therefore, are more likely to be decreed rights with comparatively early priorities. Water rights acquired under this alternative would be those located outside of, or along the periphery of these core areas. Acquisition is likely to involve decreed rights with later priorities, storage rights, flood water rights, and ground water rights. When compared with other alternatives, it is assumed that a comparatively low proportion of the acquired rights could be transferred to Walker Lake. For planning purposes, it is estimated that approximately 60 percent of the acquired water rights would be transferable.

Most likely, water rights would be acquired from areas along valley edges, and from smaller agricultural areas that fall outside a core area. When coupled with the comparatively large proportion of rights that would be retired (ground water rights), this alternative would probably exhibit the lowest delivery efficiency of the four alternatives considered. For planning purposes, it is estimated that water acquired as a part of this alternative would experience 45 percent delivery efficiency.

Given that water rights would be acquired from locations of lower potential yield, a slightly lower than average purchase price may be expected. For planning purposes, it is estimated that the average market value of water rights purchased under this alternative would be approximately $450 per acre-foot. Administrative costs are also expected to be somewhat reduced due to the lower potential for protests and legal action. For planning purposes, these costs are estimated at $200 per acre-foot. When combined, purchase and administrative costs would average about $650 per acre-foot.

As noted above, a management objective has been defined; enough water rights would be acquired that 5,000 acre-feet of additional water would enter Walker Lake. Based on the planning estimates listed above (a 45 percent delivery efficiency and a 60 percent transfer rate), some 18,500 acre-feet of water rights would need to be purchased. Assuming an average cost of $650 per acre-foot, then some $12.0 million dollars would be required. When compared with the other alternatives, Alternative Three would require acquisition of the largest amount of water rights to attain the identified goal, but costs per acre-foot would be comparatively low.

Advantages inherent in this alternative include its potential for reducing impacts to local economies and to ensure the continuance of the agricultural character of the region. This alternative also affords the greatest potential for program activities to occur within the context of local and county master plans, and in accordance with regional or state level planning and resource management efforts. As noted, this alternative should include the ability to exchange water rights and lands. This would allow for the willing participation of parties throughout the Walker River Basin. The notion would be that regardless of where the acquisition occurred, an effort would be made to retain agricultural practices with the core areas. This should reduce the disadvantage noted for Alternative Two whereby those located outside target areas may be eliminated from participating in the program.

Disadvantages to the approach include the extended time and cost required to define core areas, and to develop needed plans and administrative procedures and policies. Also, the emphasis on retaining core areas causes the acquisition program to focus on peripheral lands located some distance from the Walker River, and on types of water rights that have a lower probability of being transferable to Walker Lake. As a result, when compared with other alternatives, this alternative would require the acquisition of a larger amount of water rights to achieve a specified goal. It should be acknowledged, however, that legal challenges may decline with an increased emphasis on community planning. As a result, some of the identified disadvantages may be offset by lower than average legal fees and delays.

6.4.4 Alternative Four – Maximize Benefits to Walker Lake

Alternative Four would emphasize the acquisition of all types of water rights from the lower (north) end of Mason Valley. Rights that cannot be transferred would be retired (such as supplemental ground water) or reallocated (such as storage). With the exception of the Walker River Indian Reservation, this area represents the lowest portion of the system in which large scale irrigation occurs. It is therefore nearest in proximity to Walker Lake, reducing conveyance losses. Rights acquired in lower Mason Valley would be more easily managed, and would reduce impacts on (or by) downstream users.

Acquisitions would continue on a willing seller, willing buyer basis until program goals are met or until available funds are exhausted. It is assumed that the purchasing entity would conduct most or all of the water right purchasing. As with the other alternatives, the purchasing entity would manage the acquired water rights in accordance with established policies, state law, Decree C-125 or applicable court directive, any supplemental arrangement that may be agreed to with the seller, and whatever supplemental plans the entity may establish.

Since this alternative would probably be focused on the selective acquisition of early priority decreed rights and ground water rights, and given its location at the lowest end of the basin, it is assumed that a higher proportion of the acquired rights could be transferred to Walker Lake. For planning purposes, it is estimated that approximately 80 percent of the acquired water rights would be transferable.

Given the proximity of the area to the Walker River and to Walker Lake and the reduced impacts of downstream users, Alternative Four is expected to have the highest delivery efficiency of the four alternatives. For planning purposes, it is estimated that water acquired as a part of the proposed program would experience 60 percent delivery efficiency.

Lands near the lower end of Mason Valley vary considerably in terms of their potential agricultural yield. In the aggregate, however, it is estimated that water rights would exhibit a higher than average purchase price. For planning purposes, it is estimated that the average market value of water rights purchased under this alternative would be approximately $600 per acre-foot. Administrative costs are also expected to be low due to the absence of downstream users and issues. For planning purposes, these costs are estimated at $200 per acre-foot. When combined, purchase and administrative costs would average about $800 per acre-foot.

As noted above, a management objective has been defined; enough water rights would be acquired that 5,000 acre-feet of additional water would enter Walker Lake. Based on the planning estimates listed above (a 60 percent delivery efficiency and a 80 percent transfer rate), some 10,400 acre-feet of water rights would need to be acquired. Assuming an average cost of $800 per acre-foot, some $8.3 million dollars would be required. When compared with the other alternatives, Alternative Four would require acquisition of lowest amount of water rights to achieve the set goal and would have the lowest program cost.

Advantages inherent to this alternative focus on the increased assurance that acquired water would be deliverable to Walker Lake. The comparative simplicity of the program would require less time to develop.

Disadvantages to the approach deal mostly with its negative impact on the agricultural community. Much of the area that would be targeted for acquisition is made up of highly productive agricultural lands. Removal of agriculture from these lands would have an increased economic impact on the area. Also, by selecting a specific target area, the purchasing entity would eliminate the potential for others to willingly participate in the program.

6.4.5 A Brief Comparison of Reviewed Alternatives

Four alternative approaches to water rights purchase are discussed above. Table 6.11 contains a comparison of assumptions central to these alternatives. In each case, the goal was to realize 5,000 acre-feet of additional inflow to Walker Lake annually. The water rights purchase totals listed in Table 6.11 represent the amount and cost necessary to achieve that goal.

TABLE 6.11. A SUMMARY OF WATER RIGHTS PURCHASE ALTERNATIVES

	Estimated Cost (per acre-foot)			Estimated Yield Factors		Estimated Need	
Alternative	Purchase	Administration	Total	Transfer Approval	Conveyance Efficiency	Water Rights	Cost
Unstructured Program	$500	$250	$750	65 %	50 %	15,400 af	$11.5m
Structured Program	$550	$300	$850	70 %	55 %	13,000 af	$11.0m
Core Area Retention	$450	$200	$650	60 %	45 %	18,500 af	$12.0m
Maximize Benefit to Walker Lake	$600	$200	$800	80 %	60 %	10,400 af	$8.3m

Review of Table 6.11 indicates that Alternative Four would require purchase of the fewest water rights and would have the lowest cost. Alternative Four would maximize benefits to Walker Lake by purchasing water rights lower in the system.

6.4.6 A Substantial Impact Common to All Alternatives

Because of the aridity of the area, once lands have been disturbed (i.e. cleared and cultivated) re-establishing vegetative cover under natural precipitation conditions is difficult. There is a likelihood that some lands removed from irrigation would be invaded by noxious weed species, which presents a significant management problem for other land remaining in production. In addition land erosion and airborne particulates become issues. Some level of interim irrigation may be required to re-establish a stable vegetative cover on land once removed from cultivation.

- When appurtenant lands are acquired with water rights, the purchasing entity could take one of the following actions: land treatment (conservation tilling or plowing), revegetation, protection of the existing cover crop, or nothing. The appropriate management practice would depend on the size, condition, soil type and location of the parcels. Where revegetation is planned, the purchasing entity could delay transfer of the water rights for one or two years to facilitate establishment of a stable vegetative cover.

- When appurtenant lands are not acquired with the water rights (the lands remain in private ownership), the purchasing entity would have no authority to require or take actions to prevent erosion or weed infestations. In such cases, local government or the NRCS may be able to provide assistance.

Chapter Seven —
TOPIC FOUR: MANAGEMENT OF WALKER LAKE

The goal of this measure is to explore possible means of reducing evaporation losses and improving water quality in Walker Lake, and to assess impacts of those means to other aspects of the lake environment at large. To the extent necessary and practicable, alternative measures will be identified whereby any such impact can be addressed. As established by the Advisory Committee, the work plan will consist of several activities, as described below.

- Review and assess means of reducing evaporation from Walker Lake, particularly during the summer months.
- Review and assess means of lowering alkalinity and TDS concentrations in Walker Lake.
- Identify and describe a limited set of management options.

This chapter provides information relevant to the activities identified above. Five in-basin management options are reviewed as to their capacity to provide relief to the general decline of Walker Lake and its associated water quality. If selected for further consideration, any one of the options would require additional research, bench scale studies, and/or pilot studies to determine actual feasibility and impacts (beneficial and adverse) to Walker Lake. The scope of the present study was limited to an evaluation of existing data and interpretations. No field visits were conducted as a part of this effort.

To understand the potential impact to Walker Lake of each in-basin management option, selected background information on the lake's physical setting, paleolimnologic history, and limnology is provided.

7.1 THE PALEOLIMNOLOGIC AND RECENT HISTORY OF WALKER LAKE

Walker Lake is located at the terminus of the Walker River Drainage and occupies a surface area of approximately 37,931 acres (approx. 60 square miles) (Figure 7.1). The lake is situated between the Wassuk Range to the west and the Gillis Range to the East (maximum elevations are 11,239 feet and 7,888 feet, respectively). The lake lies in both the larger scale rain shadow of the Sierra Nevada Mountains and the more local rain shadow of the Wassuk Range. Surface flows and precipitation within the Walker Lake hydrographic sub-basin is limited to inflow from Walker River, runoff from snow pack along the Gillis Range, runoff from the northern half of the Wassuk Range, and direct precipitation from storm events.

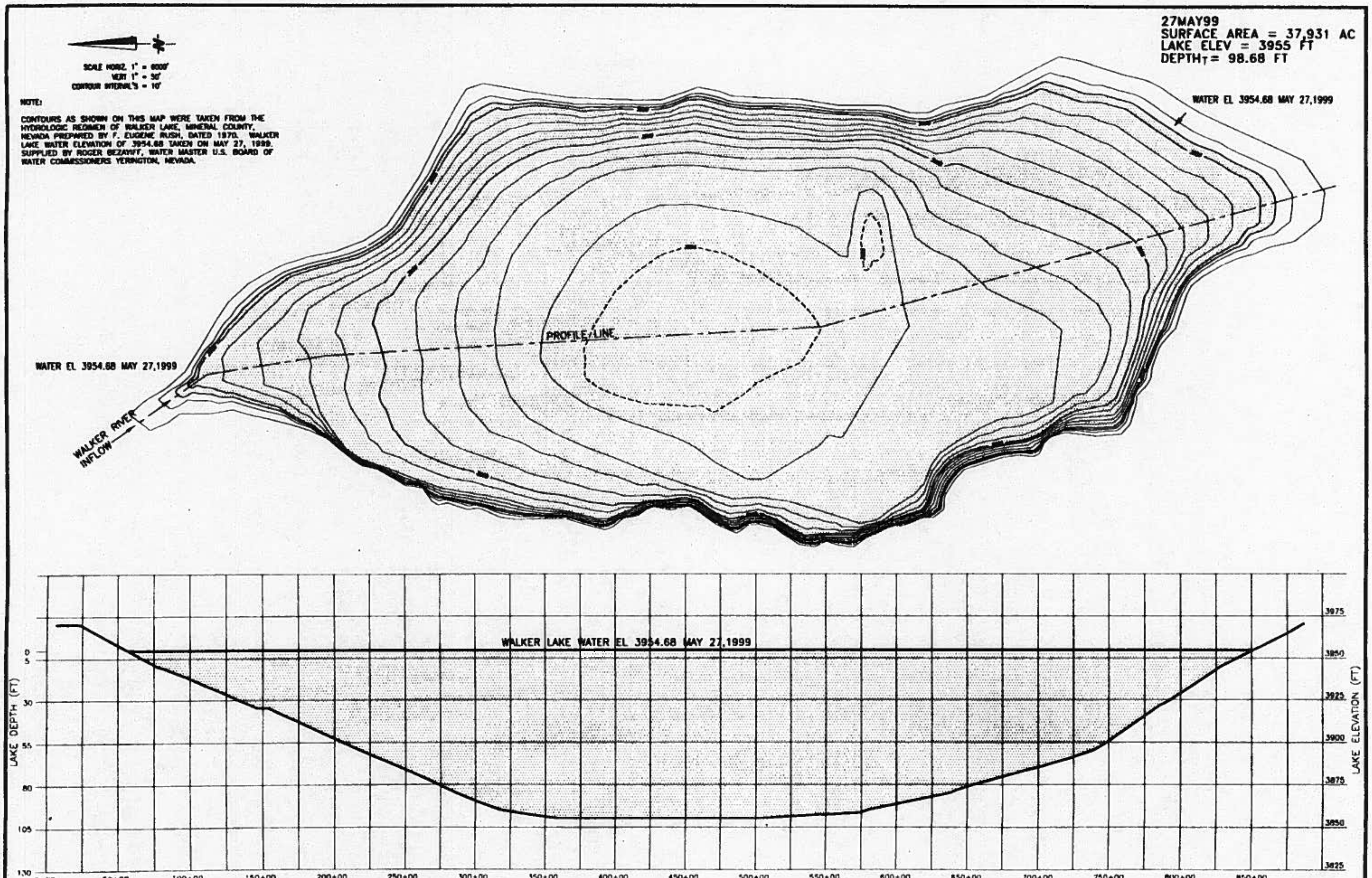


Figure 7.1
Plan and Profile View of Walker Lake
Mineral County, Nevada

Surface runoff from the eastern slope of the southern half of the Wassuk Range is intercepted at various locations along U.S. Highway 95, and is diverted to the Hawthorne Ammunition Depot (Figure 7.2). Only during periods of runoff which exceed the demand of the Depot does water from this portion of the Wassuk Range reach Walker Lake.

The paleolimnologic history of Walker Lake has been fairly well documented, and is characterized by dramatic changes in water elevations. These changes have been in response to both long-term and short-term oscillations in climatic regimes. Long-term oscillations account for the most pronounced extremes in the extent of Walker Lake. While its paleolimnologic history is the subject of ongoing discussion, Benson (1988) has suggested that Walker Lake was shallow or dry during the following periods:

- 360,000 to 130,000 years before present;
- 21,000 to 15,000 years before present;
- about 4,700 years before present; and
- about 2,600 years before present (Benson 1988).

These periods of desiccation are thought to be the result of extended periods of low precipitation throughout the region and/or the diversion of Walker River into the Carson Sink through Adrian Valley (Benson 1988). The Walker Lake strain of the Lahontan cutthroat trout most likely became extinct during one of these periods of desiccation (NDOW 1995).

Long-term oscillations also account for the highest documented water level for Walker Lake. That peak, 4,380 feet, occurred during the existence of pluvial Lake Lahontan (Rush 1974). This maximum elevation was 425 feet above the lake's current elevation of 3,955 ft (as of 27 May 1999), and 297 feet above the 1882 water elevation of 4,083 feet.

Between these extremes, Walker Lake also has experienced short-term changes in lake level due to "high-frequency, low amplitude climatic change on a sub-regional scale" (Benson 1988). The Walker River sub-basin, relative to the other sub-basins within the Lahontan complex, is more easily affected by short-term, extreme variations in climate (Benson 1988). The year 1882 has been used as a common benchmark, prior to which, agricultural development and its impact on the Walker River drainage was minimal. The record indicates that between 1845 and 1868, Walker Lake was experiencing a period of lake level rise (Table 7.1). The water level in 1845 was recorded at 4,035 feet.

Seventeen years later (1862), the water level had risen 47 feet to an elevation of 4,082 feet. Six years later, the lake had risen an additional 7 feet (4,089 feet). Between 1868 and 1882 (a period of 14 years) the lake level receded six feet to an elevation of 4,083 feet. The U.S. Geological Survey first measured the water level of Walker Lake in 1908. That elevation, 4,078 feet, was five feet lower than had been recorded in 1882. The rate of lake level decline for the period from 1882 to 1908 was 0.19 feet per year. By 1927, the lake elevation had receded 23 feet to an elevation of 4,055 feet. The rate of lake level decline for this period had increased to 1.21 feet per year. The increase in rate of lake level decline between 1908 and 1927 was due primarily to the establishment of agricultural diversions (Rush 1974). Since 1927, Walker Lake has receded most years, for a net loss of 100 feet, at a rate of 1.39 feet per year.

TABLE 7.1. SELECTED PERIODS OF LAKE LEVEL DECLINE (1845 – 1999)

Year	Lake Stage (ft)	Change in Stage (ft)	Rate of Change (ft/yr)
1845	4035	*baseline*	*baseline*
1862	4082	47	2.76
1868	4089	7	1.17
1882	4083	-6	-0.43
1908	4078	-5	-0.19
1927	4055	-23	-1.21
1999	3955	-100	-1.39

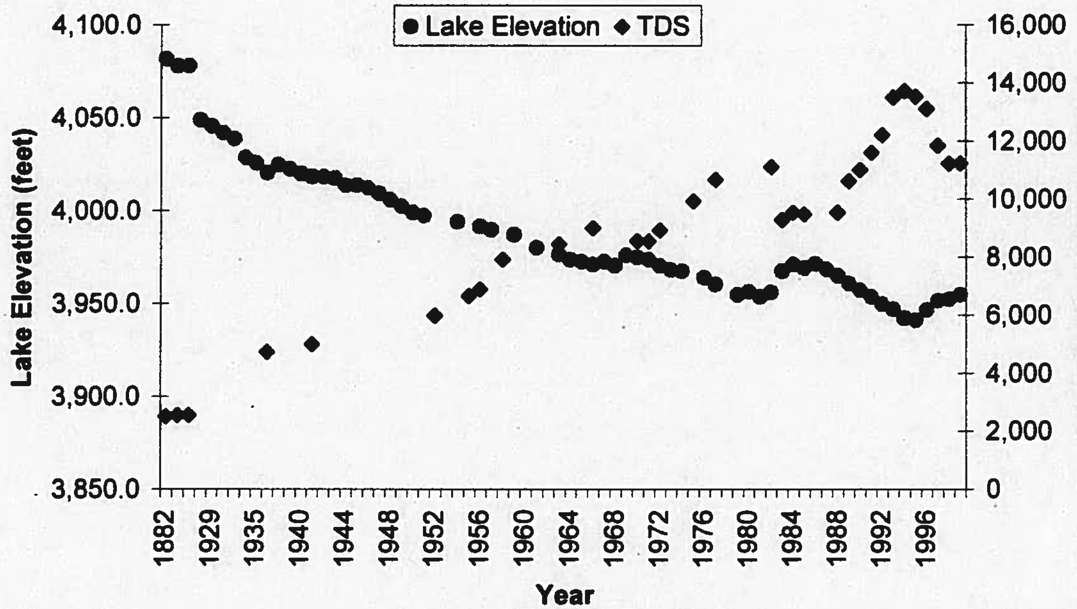
Source: Rush (1974)

Since the early 1900's, there has been a general decline in the level of Walker Lake (Figure 7.3a). However, periods of above normal precipitation and/or additional flows to the lake have demonstrated the ability of Walker Lake to rebound (Rush 1974). This characteristic has been most recently demonstrated between 1979 and 1999 (Figure 7.3b). The lake levels in 1979 and 1999 exhibit the same elevation (3,954.7 feet), with an interim high in 1986 (3,971 feet) and low in 1995 (3,941 feet). This represents a fluctuation of 30 feet over a period of 20 years, and includes the lowest lake level (3,941 feet in 1995) in recorded history (NDOW 1995). During the drought period from 1986 to 1995, the average rate of decline was 3.3 feet per year. During subsequent wet years (1995 to 1999) the average rate of rise in lake level was 3.5 feet per year.

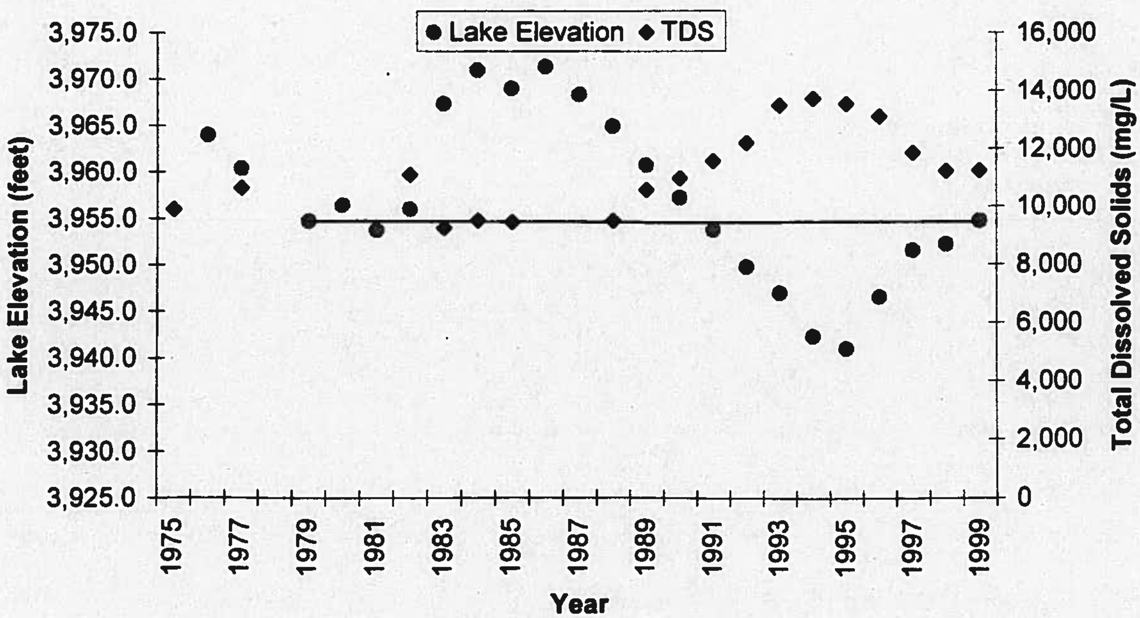
7.2 GENERAL LIMNOLOGIC DESCRIPTION OF WALKER LAKE

Limnological and fisheries information from four reports (Cooper and Koch 1984; NDOW 1988; Horne et al 1994; Beutel and Horne 1997) are summarized in an effort to provide information pertinent to the evaluation of management options listed in Section 7.3.

Figure 7.3
Walker Lake Elevation and Total Dissolved Solids Concentration as a Function of Time
(Sources: USGS, NDEP, NDOW, DRI)



7.3a: 1882 - 1999



7.3b: 1975 - 1999
(Line indicates lake elevation of 3954.7 feet for the period from 1979 to 1999)

Walker Lake exhibits many of the characteristics common to endoreic (areas in which rivers arise but do not reach the sea), terminal lakes found in dry or desertic regions. According to Margalef (1994), these characteristics include an increased response to hydrological changes, such as changes in water levels and salinity. These lakes also exhibit an inverse, temporal relationship between water level and salinity (the lower the water level, the greater the salinity). In addition, lake mixing may be affected by wind action across the lake surface that affects circulation patterns, nutrient dynamics and production, turbidity, and temperatures.

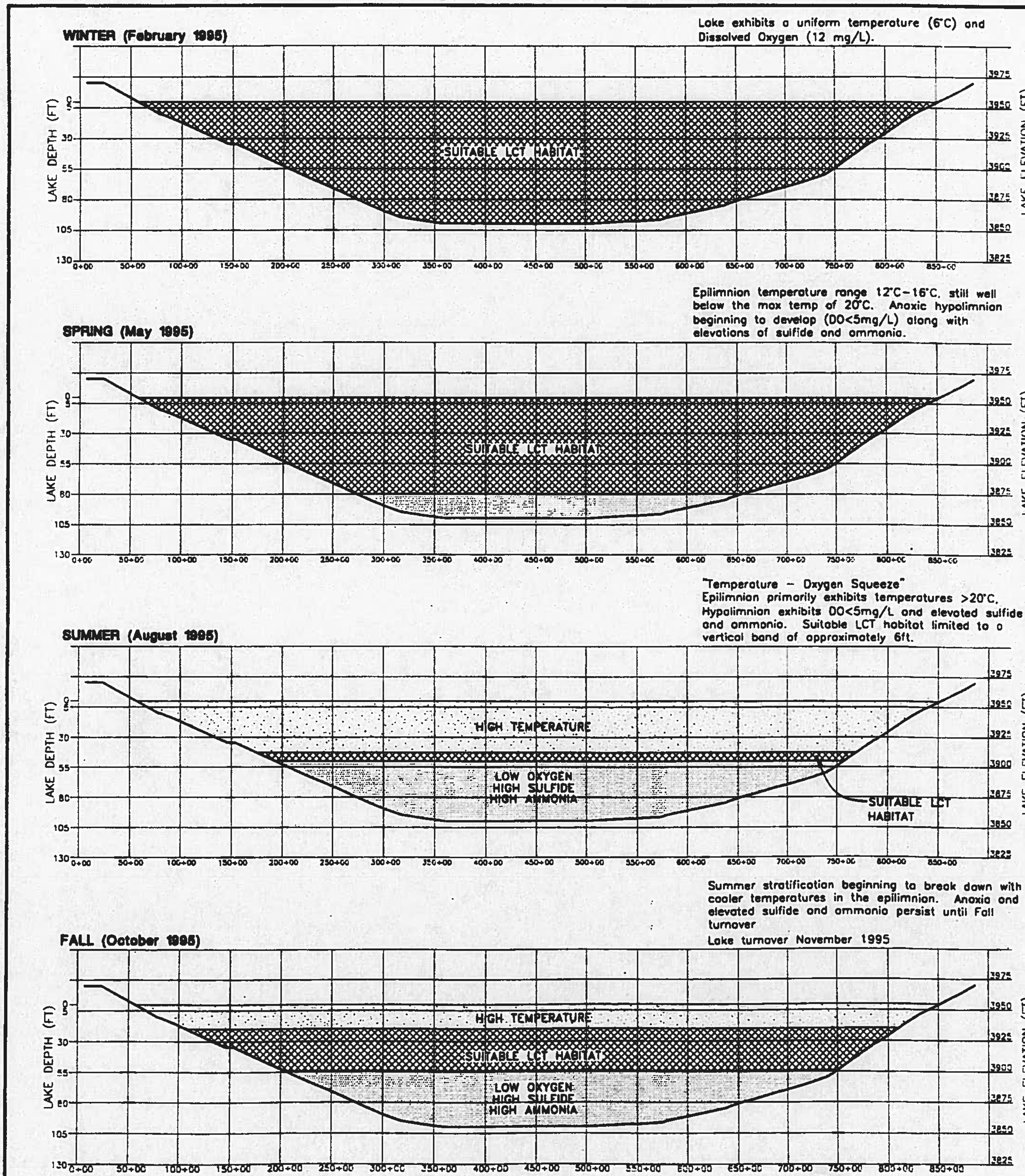
Walker Lake is holomictic – it turns over and mixes from top to bottom once per year, typically in the fall. Walker Lake stratifies in summer as follows (Figure 7.4):

- *Epilimnion* – The upper layer, or epilimnion, exhibits cool temperatures (6°C) in winter and warmer temperatures (22°C) in summer (see Figure 7.4). Temperatures above 20°C may be lethal to Lahontan cutthroat trout.

- *Hypolimnion* – The lower layer, or hypolimnion, exhibits elevated dissolved oxygen (D.O.) concentrations in winter (12 mg/L) and low dissolved oxygen concentrations in summer (0.2 mg/L). Concurrent with depressed dissolved oxygen is an increase in hydrogen sulfide and ammonia (Figure 7.4). During fall turnover, hydrogen sulfide previously confined in the hypolimnion mixes with epilemnetic water and is oxidized to less toxic forms of sulfur. Low D.O. conditions (<5 mg/L), and elevated total sulfide and ammonia concentrations (>700 ppb, and ≥ 0.9 ppm at 12°C, respectively) present toxic, and/or lethal conditions to Lahontan cutthroat trout.

- *Mesolimnion* – The mesolimnion is the transition area between the epilimnion and the hypolimnion. During summer stratification, the mesolimnion typically provides suitable Lahontan cutthroat trout habitat, where temperatures are cool enough and oxygen concentrations are high enough to allow for survivorship through the warm summer months. Summer stratification during periods of lowered lake levels (for example, those experienced in 1993) reduce the mesolimnetic layer to a vertical height of six feet or less (see Figure 7.4). Beutel and Horne (1997) refer to this condition as the "temperature-oxygen squeeze."

Beginning in the fall, air temperatures decrease, cooling the epilemnetic layer. As this layer cools, the vertical temperature regime becomes uniform and upper and lower waters mix. Ammonia and sulfide previously entrained in the hypolimnion, is released throughout the lake (see Figure 7.4).



6°C = 42.8°F
12°C = 53.6°F
16°C = 60.8°F
20°C = 68°F
LCT – Lahontan Cutthroat Trout

Figure 7.4

Generalized Representation of the Annual Limnetic Cycling of Walker Lake, Nevada. Total Water Depth 99.68ft (30.4m)

Based on: Beutel, M. and A.J. Horne (1997). *Walker Lake Limnological Report, 1995–1996.* Report to the Nevada Division of Environmental Protection. Adapted to water level as of May 27, 1999, 3954.68ft

RESOURCE CONCEPTS, INC.

Walker Lake is a eutrophic (productive), nitrogen-limited lake - nitrogen, as opposed to phosphorus, is the first nutrient depleted by phytoplankton. The two forms of nitrogen predominantly utilized by phytoplankton are ammonia (NH_4^+) and nitrate (NO_3). Collectively, ammonia, nitrate, and nitrite are termed total inorganic nitrogen (TIN). Some blue-green algae are capable of converting (fixing) atmospheric nitrogen (N_2) to ammonia. As a result, these nitrogen-fixing algae are capable of growth even during periods of TIN depletion.

Total Dissolved Solids (TDS) have generally increased as lake level and volume declined. In 1995, the elevation of Walker Lake was at its lowest point in this century (3941 feet), and exhibited a mean TDS concentration of 14,189 mg/L. At its current elevation of 3955 feet, the mean TDS concentration from three NDEP sample events in 1999 is 11,237 mg/L (Table 7.2).

Walker Lake is an alkaline lake, dominated by sodium and chloride ions. Sodium, chloride, sulfates and bicarbonates comprise approximately 97 percent of the total ionic current or content. The LC_{50} for Lahontan cutthroat trout is 8,500 mg/L total alkalinity (LC_{50} is the concentration that results in the death of 50% of the bioassay population [Knoll et al. 1979]). Since 1882, total alkalinity in Walker Lake has increased from 1,340 mg/L to 2,813 mg/L.

TABLE 7.2. NDEP 1999 SPORTSMAN'S BEACH WATER QUALITY DATA

	20 January	9 March	11 May	Mean
TDS (mg/L)	11,320	11,250	11,140	11,237
PH (s.u.)	9.60	9.59	9.61	9.60
Alkalinity (as $CaCO_3$)	2,980	2,680	2,780	2,813
Sulfate (mg/L)	2,280	2,620	2,640	2,513
Chloride (mg/L)	2,560	2,730	2,740	2,677
Total Nitrogen (mg/L)	2.60	1.64	1.51	1.92

Source: Nevada Division of Environmental Protection, 1999

Walker Lake is meromictic, a condition where less dense influent water floats on top of more dense lake water, and resists vertical mixing through the water column (NDOW 1995; Romero and Melack 1996). The density difference is due primarily to the lower concentration of TDS in influent water (about 250 mg/L) versus Walker Lake water (between 10,000 and 12,500 mg/L). This difference is sufficiently pronounced that lake stratification is strengthened. The upper, less dense water in meromictic lakes mixes with deeper water primarily under the influence of wind and wave action. During periods of lower lake levels and decreased inflows, the depth of mixing increases. Should the depth of mixing reach the hypolimnion, a release of nutrients to the upper waters may occur, causing an increase in productivity. Horne et al. (1994) describes this phenomenon as so important to the limnology of Walker and other saline lakes that he coined the term "bathypteromictic eutrophication" (bathyptero = deeper; mixis = mixing). Meromictic lakes tend to have greater annual variability in vertical mixing, a general increase in chemical stability, and variations in annual algal biomass and productivity (Romero and Melack 1996). This description appears consistent with data collected on Walker Lake.

Walker Lake is host to three endemic species of fish: Lahontan cutthroat trout, tui chub, and Tahoe sucker. Lahontan cutthroat trout (*Salmo clarki henshawi)* are anadromous, spending most of their lives in salty water and moving to fresh water to reproduce. Natural spawning runs along the Walker River of native cutthroat trout began to diminish as early as 1860 with the onset of agriculture in Mason and Smith valleys. The construction of structures in the river eventually precluded spawning in the Walker River above Weber Reservoir. The impact of this loss of spawning habitat was evident by the late 1940's and prompted the initiation of stocking efforts in 1949. Today, the Walker Lake trout fishery is maintained solely by hatchery reared cutthroat trout.

Lahontan cutthroat trout have a remarkable tolerance for elevated temperature. Although temperatures above 20°C are generally considered toxic (Vigg and Koch 1980), transitory exposure to temperatures as high as 21.7°C and 24.4°C are tolerated as trout cruise shorezone areas for prey (NDOW 1988). Epilemnetic temperatures in Walker Lake exceed 20°C during the summer months, restricting suitable trout habitat to deeper, cooler waters. As summer stratification progresses, oxygen decreases in the hypolimnion to below 5mg/L, a concentration toxic to Lahontan cutthroat trout. This loss of oxygen also causes an increase in ammonia and sulfide build-up in the hypolimnion. Collectively, increased temperatures in the epilimnion and decreased oxygen and increased ammonia and sulfate in the hypolimnion restricts suitable habitat for Lahontan cutthroat trout to a tolerable area between the two (the "temperature-oxygen squeeze," see Figure 7.4).

Alkalinity in Walker Lake can reach concentrations that may create osmoregulatory problems for aquatic organisms. As described in the NDOW 1988 report, histological examination of kidney tissue from Walker Lake trout suggests that sulfate levels have been high enough to cause kidney degeneration. Other histological alterations identified in Walker Lake trout include gill chloride cell hyperplasia, gill lamellar epithelial separation, kidney glandular swelling and blood congestion in kidneys. Each of these conditions suggested that lake-water chemistry had reached levels that caused cellular damage, and may have accounted for the general decline of the Lahontan cutthroat trout fishery in Walker Lake at that time.

Tui chub (*Gila bicolor* ssp.) are lake spawners that utilize inshore areas for broadcast of demersal (heavier than water) eggs. Most observed tui chub spawning has occurred in the cliff area where the substrate is comprised primarily of large rocks and boulders that are often covered with algae. Invasions of tamarisk along the shoreline have provided added habitat for young-of-the-year schools of tui chub, and may be providing additional spawning habitat. Tui chub are omnivorous. Food materials typically found in their diet include zooplankton, filamentous algae, chironomid larvae, amphipods (*Hyalella* spp.), and other tui chub.

Tahoe suckers (*Catostomus tahoensis)* are both lake and stream spawners. Spawning runs have diminished since the 1950's, and the source of lake recruitment is unknown. Tahoe suckers are benthic (bottom) feeders. During periods of oxygen depletion in the hypolimnion, Tahoe suckers may be adversely impacted by a decrease in the number of bottom dwelling organisms on which to feed.

Warm water fish that once inhabited Walker Lake include Sacramento perch (*Archoplites interruptus*); white crappie (*Pomoxis annularis*); bluegill (*Lepomis machrochirus*); common carp (*Cyprinus carpio*); chinook, silver, and chum salmon (*Oncorhynchus* spp.); rainbow trout (*Salmo gairdneri*); black and largemouth bass (*Micropterus* spp.); channel catfish (*Ictalurus punctatus*); and black bullhead (*I. melas*). Young-of-the-year of several of these species may be found at the mouth of the Walker River, presumably washed down from upstream spawning grounds. However, due to the diminished water quality, they are not able to survive.

Phytoplankton species diversity is very low, dominated primarily by blue-green algae and diatoms. The dominant form of algae is *Nodularia spumigena,* a blue-green algae capable of nitrogen fixation. Summertime blooms of *N. spumigena* may become noxious, and affect the potential Beneficial Uses for Walker Lake such as Aquatic Life and Recreation. Zooplankton species diversity also is very low, dominated primarily by the copepod *Diaptomus sicilis*. A littoral (shoreline) forest of the aquatic grass *Ruppia marina* was identified between 3-6 meters below the lake surface. The *Ruppia* extended approximately 3 meters in height, and was distributed around the lake in varying densities. This forest provides habitat for tui chub and Tahoe suckers, as well as damselfly larvae. *Cladophora* is the primary periphyton, found primarily on submerged rocks.

7.3 Walker Lake Management Options

Over the last several decades, Walker Lake has received attention from regulatory agencies, sport fishermen, and local residents. This attention has focused on the overall decline in lake level and water quality, and subsequent negative impacts on the lake's sport fishery.

Technical and agency planning reports prepared over the past thirty years have reviewed in-basin solutions to the decline of Walker Lake. Some potential solutions have received considerable attention, while others have received only cursory attention. This section focuses on five management options and their capacity to improve the general limnology of Walker Lake. These options include:

- reduction of evaporative losses from the surface of Walker Lake;
- precipitation of calcium carbonate to lower alkalinity in Walker Lake;
- desalination to reduce TDS in Walker Lake;
- cloud seeding to increase the in-basin water supply; and,
- oxygenation to improve oxygen conditions in lower portions of Walker Lake.

Each option is described first in general terms, then in light of its applicability and potential impact to Walker Lake. Finally, a recommendation is provided regarding the option's feasibility for use in improving the general limnology of Walker Lake.

7.3.1 Reducing Evaporation from the Surface of Walker Lake

According to Koch et al. (1979), the average annual evaporation rate at Walker Lake is 4.1 feet per year. Based on an average water surface area of 43,400 acres (for the period from 1926 to 1995), the lake experiences an average annual evaporation loss of approximately 178,000 acre-feet per year. The Advisory Committee requested a review of possible alternatives intended to reduce this rate of evaporation from the lake surface. The following discussion examines the use of an oil-based spray to cover the lake surface, the planting of trees along the shoreline to increase shaded areas, and the use of Bird-Balls™ to cover a portion of the lake surface.

The use of sprays and/or foams to reduce evaporation is confined to industrial vats containing hot, caustic or toxic solutions. These vats are relatively small, confined, and are not subject to turbulence. Several obstacles would have to be overcome in order for such a technology to be successfully adapted for use in lake systems. For example, the material should be non-toxic to a wide variety of organisms (bacteria, algae, zooplankton, fish) and it should be immiscible in water as well as lighter than water. Also, its surface tension should equal that of water to maintain the neuston community (the community living at the water/air interface). Further, the material should be stable under a wide variety of environmental conditions, including varying temperatures, wind speeds and wave action, and it should not be adhesive to wildlife (i.e. birds). Our research failed to find an adaptation of this practice for use in natural lake systems.

The shorezone at Walker Lake is relatively shallow along most of the periphery of the lake, and lends itself to the concept of cooling through the introduction of mesophytic and phreatophytic trees. Assumptions include a static water level, continuous shade during daytime hours, no transpiration, and an effective shade depth towards the center of the lake of 10 feet. Under these conditions, a continuous stand of trees around the periphery of the lake would cover an area of approximately 47 acres and could reduce evaporation from the lake surface by about 0.1 percent. This equates to approximately 178 acre-feet per year. It must be noted however that evapotranspiration from the trees would lessen this apparent savings. Based on an evapotranspiration rate of 2.0 acre-feet per acre (see Table 4.2 and 4.3), some 94 acre-feet would be lost, or over half of the reduction in lake surface evaporation. Also, the environment at Walker Lake includes variable water levels, changes in shade area on a daily and seasonal basis, and wind action creating waves and spray, all of which would reduce the effect provided by the shade. The changing lake level alone would severely inhibit the survivorship of planted trees. This option would not provide a significant decrease in the rate of evaporation from Walker Lake.

Another possible means of providing shade to Walker Lake would be to use Bird Balls™, high-density polyethylene (HDPE) balls ranging in diameter from 0.4 inches to 6 inches. The intended use of these spheres is to float a uniform layer across the entire liquid/air interface, providing an effective barrier to light, heat, evaporation, oxygen, and odors. Bird Balls™ are used primarily in ponds or vats containing harmful solutions (i.e. pregnant ponds at mining sites, plating baths). Not only does the layer of balls prevent wildlife from landing on outdoor ponds, they trap vapors and heat within the water body. Bird Balls™ could be adapted for use at Walker Lake by providing islands that shade the lake surface. Clusters of balls held together with netting could be used to create 50 by 50-foot islands anchored to the lake bottom. Table 7.3 summarizes the number of islands that would be required to provide a 1.0, 2.8, and 10.0 percent reduction in evaporation. These estimates assume use of the largest sphere size commercially available (6 inches in diameter).

TABLE 7.3. THEORETICAL QUANTITIES OF BARRIER ISLANDS REQUIRED TO REDUCE EVAPORATION FROM WALKER LAKE

Percent Reduction of Evaporation	Number of 50' x 50' Islands Required	Approximate Cost (Millions)
1% (1,780 ac-ft)	3,122	$17.6
2.8% (5,000 ac-ft)	8,772	$49.4
10% (17,800 ac-ft)	31,228	$176.0

The use of Bird Balls™ to create islands of shade may prove too costly. Even if more economical construction materials were found, the sheer number of islands required to affect a significant change in evaporation suggests that this may not be a viable option.

7.3.2 Precipitation of Calcium Carbonate to Reduce Alkalinity

Discussions during public meetings of the Walker Lake Advisory Committee identified the possibility of removing total dissolved solids (TDS) from Walker Lake through precipitation. Precipitation is a chemical process whereby some constituent is removed from a solution through the addition of a reagent. In this case the thought was, can some chemical reagent be added to Walker Lake that would cause TDS to drop out of solution and be deposited on the lake bottom?

By definition, *dissolved* solids are particles that pass through a 40-60 micron filter. Total *suspended* solids (TSS) are particles that do not pass through a 40-60 micron filter (Standard Methods 1985). Precipitation applies to the removal of suspended, not dissolved solids. Therefore, TDS levels in Walker Lake cannot be lowered using a precipitation process. Rather, TDS could be treated through the use of reverse osmosis or distillation processes (Tchobanoglous and Schroeder 1987). For example, these are the two primary processes employed in the desalination of sea water. Please refer to section 7.3.2 for a discussion of the possible application of one such process at Walker Lake.

While precipitation may not play a role in reducing TDS levels in Walker Lake, the process may be applied as a possible means of reducing alkalinity. Walker Lake has experienced a general increase in alkalinity as the lake level receded (Table 7.4). This increase in alkalinity has been identified by NDOW (1988) as a "major limiting [water quality] factor" for survival of LCT – "more so than TDS." When compared to TDS, the Lahontan cutthroat trout tolerance range for alkalinity is much narrower. Further, toxicity studies have suggested that alkalinity exerts a synergistic effect on TDS, significantly lowering the TDS threshold. For example, a bioassay study performed by Koch, Mahoney and Knoll (per NDOW 1988) demonstrated 100 percent survivorship by rainbow trout in Walker Lake water that had been treated to remove 71 percent of its alkalinity.

TABLE 7.4. ALKALINITY IN WALKER LAKE, 1882 TO 1999

Year	Lake Stage	pH (s.u.)	Chloride (mg/L)	Alkalinity (mg/L)	Total Dissolved Solids (mg/L)
1882	4083	no data	588	no data	2,560
1937	4020	no data	1,090	1,340	4,730
1956	3992	9.2	1,960	1,742	6,890
1966	3971	9.3	2,020	2,124	8,570
1975	no data	9.3	2,300	2,304	9,918
1984	3971	9.46	2,070	2,136	9,528
1999	3955	9.6	2,677	2,813	11,237

Source: Nevada Division of Wildlife, 1988;
Nevada Division of Environmental Protection, 1999

In 1977, DRI proposed a feasibility study to precipitate calcium carbonate using calcium chloride ($CaCl_2$). Funding for the DRI study was never secured and the feasibility of this option remains uncertain (NDOW 1988). Theoretical quantities of calcium chloride required to reduce alkalinity in Walker Lake were calculated (Table 7.5). These calculations assume that all of the precipitant would be used to reduce calcium carbonate, and that no reactions would occur with other salts.

The alternate use of calcium chloride to reduce alkalinity would have one major draw back. Its use would cause an increase in the base chloride concentration in the lake. This increase would range from 240 to 2,400 mg/L depending on the amount of precipitant added to the lake. When added to the base chloride concentration of 2,677 mg/L, this would increase chloride concentrations to between 2,876 and 4,667 mg/L. Although a water quality standard has not been set for Walker Lake, the recommended EPA criteria for the propagation of wildlife is 1,500 mg/L. Use of calcium chloride to reduce alkalinity may theoretically result in lake water that exceeds this standard. These same negative impacts to Walker Lake would be observed for ferric chloride, another common precipitant.

TABLE 7.5. THEORETICAL QUANTITIES OF CALCIUM CHLORIDE REQUIRED TO REDUCE ALKALINITY IN WALKER LAKE

Percent Reduction	Weight of $CaCl_2$ (Million Tons)	Additional Chloride (mg/L)	Resultant Total Chloride (mg/L)	Resultant Total Alkalinity (mg/L)
Baseline:			2,677	2,813
10	1.05	199	2,876	2,532
25	2.62	498	3,175	2,110
50	5.25	995	3,672	1,407
75	7.88	1,492	4,169	703
100	10.50	1,990	4,667	0

In an effort to eliminate the potential for added chloride, calculations were repeated using calcium oxide as a precipitant. As shown in Table 7.6, a lesser volume of precipitant would be needed to achieve any particular reduction goal and there would be no increase in chloride levels. The use of calcium oxide, however, could result in an increase in pH.

TABLE 7.6. THEORETICAL QUANTITIES OF CALCIUM OXIDE REQUIRED TO REDUCE ALKALINITY IN WALKER LAKE

Percent Reduction	Weight of CaO (Million Tons)	Additional Chloride (mg/L)	Resultant Total Chloride (mg/L)	Resultant Total Alkalinity (mg/L)
Baseline:			2,677	2,813
10	0.53	0	2,677	2,532
25	1.32	0	2,677	2,110
50	2.64	0	2,677	1,407
75	3.97	0	2,677	703
100	5.29	0	2,677	0

In either case, the precipitation process would involve the following steps: introduction of the precipitant (i.e. calcium chloride or calcium oxide), mixing, floc production, and sedimentation. If it were feasible to introduce several million tons of precipitant into Walker Lake, complete mixing would be difficult due to the size of the lake. Portions of the precipitant able to react with lake water would form a white floc, adding to existing lake clarity issues.

Aluminum sulfate (alum) also can be used to precipitate carbonate. However, aluminum ions are soluble above pH 7.8. The pH of Walker Lake (greater than 9.0) is too high for effective use of alum.

The potential to lower the pH of Walker Lake also was investigated. Based on the alkalinity value for 1999, approximately 9.26 million tons of concentrated sulfuric acid would be required to reduce the pH of the lake to 7.0. Additional acid would be required to maintain that pH due to the release of calcium and magnesium carbonates from lakebed sediments. The sulfate concentration would double in value, and overall TDS would increase. Due to the complex nature of the water chemistry of Walker Lake, it is not possible to predict trace mineral reactions without bench scale studies or modeling. Given the current technology, lowering the pH of Walker Lake may not be a viable option.

Further study is necessary before precipitation could be endorsed or fully refuted as a means of reducing alkalinity levels in Walker Lake. Due to the high concentrations of other inorganic compounds in the lake, bench scale studies would have to be performed to determine the actual volume of precipitant to be used, the resultant water chemistry, and the effect on resident aquatic species.

7.3.3 Desalination to Reduce Total Dissolved Solids

Major constituents of total dissolved solids (TDS) include calcium, magnesium, sodium, potassium, carbonate, sulfate, and chloride (Standard Methods 1985). Data gathered at Walker Lake since 1882 (see Figure 7.3a) demonstrate that TDS concentrations are directly affected by lake volume. This is consistent with the behavior of terminal lakes (Margalef 1994). As the volume of Walker Lake has decreased this century, TDS concentrations have increased dramatically. The TDS concentration level in 1882 was estimated at 2,560 mg/L (Rush 1974). In 1956, this value increased to 6,890, and in 1999 the mean TDS level was 11,237 mg/L (USGS 1956; NDEP 1999).

TDS levels have been shown to exert a toxic effect on fish. The demise of Lahontan cutthroat trout in Winnemucca Lake occurred between 1927 and 1931 at a TDS concentration of 14,328 mg/L. NDOW (1988) indicates that the warm water fishery in Walker Lake was lost between the 1940's and the 1960's due primarily to an increase in alkalinity and TDS. Today, young-of-the-year channel catfish, black bullhead, largemouth bass, white crappie, bluegill and Sacramento perch, washed downstream from upstream sources, may be found at the mouth of Walker Lake. However, due to lethal concentrations of alkalinity and TDS, these fish do not survive in the lake.

Several studies describe the toxicity of TDS to Lahontan cutthroat trout (see NDOW 1988). It appears that TDS alone may exert lethal toxicity at a concentration of just over 19,000 mg/L. However, in the presence of high alkalinity, the lethal limit for TDS is lowered to 12,000 - 16,000 mg/L. Signs of TDS toxicity in trout include hyaline degeneration in kidney tubules (kidney degeneration) which reduces the expected life span of planted fish from 8 years to 2-3 years (NDOW 1988).

TDS may be removed from water through the processes of reverse osmosis (RO) and/or distillation, in a method commonly referred to as desalination. Several facilities that employ these processes are listed in Table 7.7. Information is provided on the capacity of the facility (how much useful water it can produce in a day), the TDS level of the product water, and the relative efficiency of the facility. In this context, efficiency is a measure of how much useful water is produced (product, as percent recovery), versus how much is discharged as waste brine.

TABLE 7.7. SELECTED CALIFORNIA DESALINATION FACILITIES

Location	Maximum Volume of Product Water (gpd)	TDS of Product Water (mg/L)	Percent Recovery
Chevron Gaviota Oil and Gas Processing Plant	450,000	50 - 500	35%
City of Morro Bay	600,000	no data	40 - 65%
City of Santa Barbara	7,500	284 - 400	45%
Department of Parks & Recreation, Hearst San Simeon State Historical Monument	40,000	200 - 400	28 - 40%
Monterey Bay Aquarium	43,000	400	No data
Hotel/Conference Sterling Center, Sand City	20,000	no data	no data
SCE, Santa Catalina Island	132,000	no data	27%
PG&E Diablo Canyon Power Plant	576,000	200	45%
PG&E Morro Bay Power Plant	430,000	<1	no data
PG&E Moss Landing Power Plant	475,000	<1	no data
U.S. Navy's San Nicolas Island	24,000	Potable	26%
Walker Lake (1976 Proposed)	***33.3mgd****	***500***	***90%***
*mgd = million gallons per day			

Sources: California Coastal Commission (http:/ceres.ca.gov/coastalcomm/desalrpt), and Boyle (1976)

The reviewed existing facilities treat seawater with a TDS concentration of approximately 35,000 mg/L. The facilities produce water at volumes ranging from thousands to hundreds of thousands of gallons per day, with a resultant TDS concentration in the range of 50 to 500 mg/L. Of the total input water, from 26 to 65 percent is converted to useful drinking water. The remaining water is discharged as waste brine.

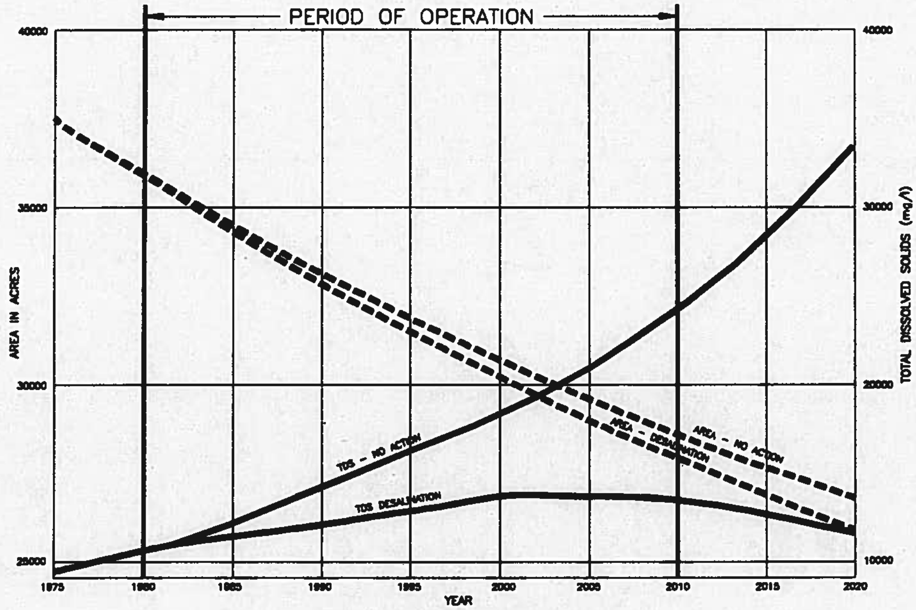
In 1973, the Southwest Research Institute conducted a study "to determine the role of desalting in providing future water supplies for municipal, industrial, and agricultural purposes in Nevada." A portion of that study described installation of a desalination plant along the western edge of Walker Lake. The plant was to supply fresh water to the Hawthorne area. It was to have a processing capacity of 33 million gallon per day (mgd), or 101.3 acre-feet per day. Soon thereafter, the concept was modified to describe desalination of Walker Lake water as a means of reducing TDS (Boyle Engineering 1976). Boyle Engineering proposed the same size plant (33 mgd) operating for a period of 30 years.

Figures 7.5a and 7.5b illustrate that TDS concentrations in Walker Lake were predicted to decline over the long term due to desalination. However, the lake level also was predicted to decline. This was due to the need to separate brine water from product water that would be returned to Walker Lake. Boyle Engineering suggested a brine volume of 3.7 mgd or 11.4 acre-feet per day. The comparatively high recovery rate of about 90 percent was anticipated due to the initial TDS concentration, which is approximately half that of sea water. Typically, brine water is allowed to evaporate, at which time the brine salts are collected and removed. As a result, Boyle Engineering predicted that at the end of the plant's anticipated period of operation (30 years), the TDS concentration in Walker Lake would be about 12,900 mg/L, and the level of Walker Lake would be reduced to about 3913 feet (Figures 7.5a and 7.5b).

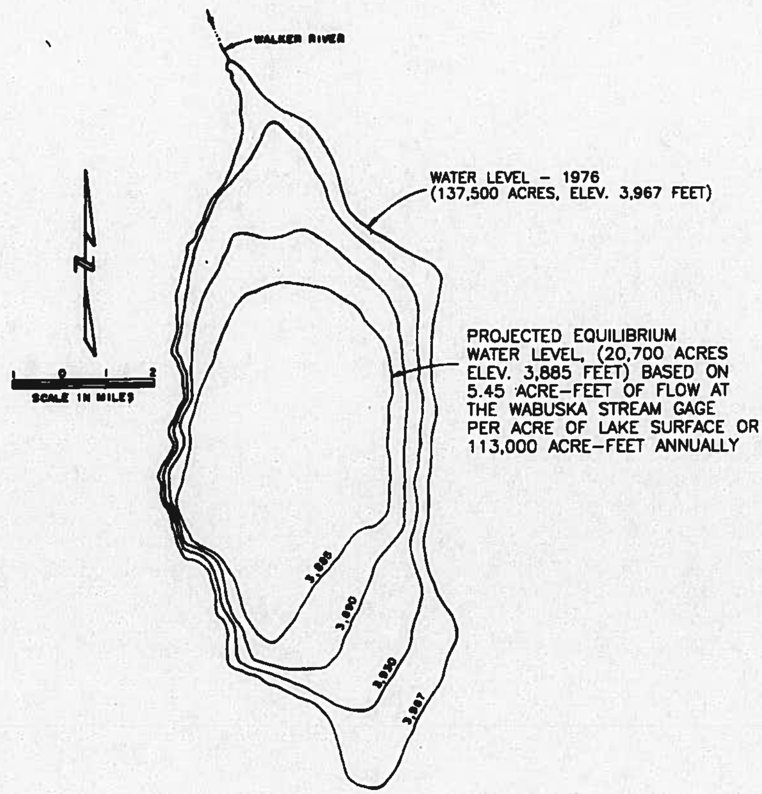
It is recommended that desalination is not a suitable option for Walker Lake. While it may limit TDS build-up over the long term, it would do so at the expense of the lake's volume. Depending on inflow levels, this could cause the lake level to drop below a level at which suitable habitat for Lahontan cutthroat trout could be maintained. The resultant lake would most likely be too warm for trout, and have TDS concentrations too high for a warm water fishery. Capital costs for the desalination plant in 1976 were estimated at $45.8 million, with annual operating expenses of $14.4 million. Given the reduction that would occur in lake volume (due to waste brine management) and the subsequent negative impact to fisheries habitat), it is unlikely that the cost of constructing and operating a desalination plant at Walker Lake, as described in the Boyle report, could be justified.

7.3.4 Cloud Seeding

Cloud seeding is a type of weather modification that consists of introducing artificial nuclei into clouds. The goal is to increase precipitation as either rain or snow. Cloud seeding was first developed in the 1940's and 1950's, and is currently practiced in 43 countries around the world. Seeding agents include silver iodide, dry ice, and liquid propane. Silver iodide remains the most widely used seeding agent for increasing precipitation in orographic winter storms (clouds that form as moist air is lifted and cooled during its passage across mountain ranges, such as the Sierra Nevada). Seeding agents may be dispersed into clouds through ground-based generators, rocket launches, or aircraft over flights.



Mineral County Water Resource Study
FORECAST OF AREA AND TDS OF WALKER LAKE
DESALINIZATION PLANT
OPTION 9



MINERAL COUNTY WATER RESOURCE STUDY

PRESENT AND PROJECTED EQUILIBRIUM WATER LEVELS OF WALKER LAKE

Figure 7.5

Graphic and Illustrative Representation of the Projected Effects of Desalination at Walker Lake.

Source: Boyle Engineering Corp (1976). *Mineral County, Nevada Water Resources Investigation.*

Ground-based generators are typically placed upwind of the target area; the seeding agent is released into the base of the cloud (BAMS 1992; Reynolds 1988; WMA 1997).

One gram of silver iodide may produce as many as 1,000,000,000,000,000 nucleating particles, and in the presence of super-cooled cloud water acts as an effective ice nucleant at around -5°C (23°F) and colder. Environmental effects from silver iodide in rainwater have not been documented. This is due primarily to the low concentration of silver iodide in rainwater - less than 0.1 μg/L (parts per billion). This is well below the acceptable concentration of 50 μg/L (per the U.S. Public Health Service) (WMA 1997). However, due to the extreme sensitivity of aquatic life to silver, residual silver iodide concentrations in aquatic systems may exceed the Beneficial Use Standard of 0.0006 μg/L.

Of particular interest to this study is the seeding of orographic clouds (Figure 7.6). Left unmodified, many orographic clouds may retain as much as 90 percent of their moisture as they form then evaporate on the lee side of mountains. Studies have shown that seeding this type of cloud may increase seasonal target-area precipitation from 5 to 15 percent, with higher localized increases in some storms (BAMS 1992, WMA 1997). Further, Reynolds (1988) suggested that the number of seedable events remains the same whether orographic clouds form in wet or dry years. Cloud seeding may, therefore, be effective during drought periods when it is needed most. Not all clouds will react favorably to seeding. Temperature, abundance of ice nuclei, cloud liquid water and other parameters must be carefully measured to determine whether or not a winter storm will benefit from cloud seeding (WMA 1997).

Cloud seeding has been ongoing in Nevada since the 1960's, and is regulated under Chapter 544 of the Nevada Revised Statute. Cloud seeding operations were developed and are operated by the Nevada State Cloud Seeding Program (NSCSP). The mission of the NSCSP is to augment snowfall in selected mountainous regions, thereby increasing spring runoff. The goal is to provide an increased water supply to municipalities, agricultural regions, recreational lakes, and environmentally sensitive terminal lakes. The NSCSP is currently conducting cloud seeding in the upper Truckee River Basin, the upper Walker-Carson River Basin, the Ruby Mountains, and the Toiyabe Range. An increase of from 4 to 10 percent in seasonal snow pack due to cloud seeding results in the generation of an additional 35,000 to 60,000 acre-feet of water per year (DRI 1999). In past years, cloud seeding operations targeting the mountains of the Carson and Walker River basins provided additional water to agricultural areas of Carson Valley, Mason Valley, and Smith Valley. An estimated 11,345 to 16,527 acre-feet of additional water has been provided to these areas each year through cloud seeding (DRI 1999).

A cloud seeding program that targets the immediate Walker Lake Basin may provide an increase in the flow of surface water and groundwater to the lake. Given that Walker Lake is an environmentally sensitive terminal lake, such a program would be consistent with the mission of the NSCSP. Issues that would need to be addressed when considering such a cloud seeding program include:

- applicability to storm systems characteristic of the Wassuk Range target area;
- ability to control aerial deposition of seeding agents (ground systems versus aircraft over flights; storm patterns);
- potential increase in snow removal operations along public highways (primarily U.S. Route 95);
- ability of storm drainage systems to handle additional runoff;
- possible reduction in precipitation in areas within the rain shadow;
- potential impacts to land, water rights, people, health, safety, or the environment within the affected area; and
- potential impacts to other projects in the area (Colorado weather modification permit program).

The NSCSP has indicated that cloud seeding efforts could be conducted that would result in an increased snow pack in the Wassuk Range. While evaluating the quantitative impacts of cloud seeding operations will require additional research, an initial estimate can be developed based on precipitation and snow pack data available for mountains near the Wassuk Range. Precipitation estimates can be developed based on measurements by the Natural Resource Conservation Service, the National Weather Service, and on model results that take into account orographic enhancement. These data indicate that the high terrain (>7,500 feet) of the Wassuk Range receives 20 to 24 inches of precipitation annually. Based on SNOTEL data from the Sierra Nevada and the Sweetwater Range, about 60 to 70 percent of the total annual precipitation comes as winter snowfall.

The closest SNOTEL site to the Wassuk Range is Lobdell Lake at 9,200 feet in the Sweetwater Range. In the spring, the snow pack at that site has an average water equivelant of about 67 percent of the total annual precipitation. Based on this estimate, the 20 inches of annual precipitation that occurs above 7,500 feet in the Wassuk Range might translate to about 13 inches of total snow water. The area enclosed by the 7,500 foot contour is roughly 98,000 acres. Using the precipitation and snowfall estimates, the annual snow pack of the Wassuk Range can be estimated to contain about 107,000 acre-feet of water. This estimate should be viewed with some uncertainty until actual precipitation and snow core measurements can be obtained from the Wassuk Range. Future studies of cloud seeding enhancement also will need to develop correlations between precipitation and snow pack in the Wassuk Range and elsewhere (upwind or downwind of these mountains).

Because data on storm characteristics are almost non-existent for the Wassuk Range, it may be better to use precipitation data as a means of estimating the extent of snowfall augmentation that could be achieved through cloud seeding. Statistical results from winter cloud seeding programs conducted in mountainous areas of the western United States have indicated that a 5 to 15 percent enhancement of snow pack is feasible. If these results are used with the Wassuk Range snow pack estimate, an enhancement ranging from 5,000 to 15,000 acre-feet might be realized within the region above 7,500 feet. The actual amount of runoff would have to take into account such losses as sublimation and soil intake. These losses could be substantial. Further, to evaluate the potential benefit to Walker Lake, the estimated runoff from the various sub-basins of the Wassuk Range would need to be estimates; not all sub-basins drain directly into the lake or the East Walker River.

It must be noted that many of the streams that would carry any increased flow have been developed and serve as water sources for the city of Hawthorne and the Hawthorne Ammunition Depot (Table 7.8). The Hawthorne Ammunition Depot holds some 3,000 acre-feet of water rights, while the city of Hawthorne holds about 810 acre-feet. Water is diverted from these drainages just upstream of U.S. Highway 95 (see Figure 7.2). Runoff water is allowed to flow into Walker Lake only when flows exceed the needs or limits of the Depot and the city of Hawthorne.

TABLE 7.8. SUMMARY OF SURFACE WATER RESOURCES ALONG THE WASSUK RANGE, EXCLUDING THE WALKER RIVER

Current Owner of Water Rights	Creek Name	Watershed Area (ac)	Average Annual Measured Flow (ac-ft)	Highest Watershed Elevation (ft)
Ammunition Depot	Cottonwood	13,000	672	11,240
Unknown	Dutch	2,000	Variable	11,240
Ammunition Depot	Squaw	2,600	331	11,240
Ammunition Depot	Rose	1,300	643	11,240
	- Reservoir		35mg	
Ammunition Depot	House	2,400	450	10,400
Ammunition Depot	Cat	8,400	270	11,000
	- Reservoir		50mg	
City of Hawthorne	Corey	no information	810	9,500

Source: Boyle Engineering (1976)

A preliminary cost estimate for implementing a cloud seeding program in the Wassuk Range was developed by Mr. Arlen Huggins, NSCSP Program Director (Desert Research Institute [DRI]). Those costs are summarized in Table 7.9. The program would include the following elements:

- monitoring of weather and cloud conditions to verify the number of seedable periods available in a one-year period;
- installation and operation of a DRI microwave radiometer upwind of Walker Lake to document the occurrence of cloud liquid water;
- installation of up to three ground-based generators along the western slope of the Wassuk Range; and
- aircraft seeding flights.

A variety of ground units are available, including manually operated, semi-automated, and fully automated systems operated through the operations center in Reno through cellular communication.

Although there is uncertainty as to the actual amount, cloud seeding would have the potentially beneficial impact of increasing the volume of water available to Walker Lake through spring runoff. An estimate of the magnitude of that impact can be generated using the midpoint of the snow pack augmentation estimates (10,000 acre-feet), and by assuming that 50 percent, or 5,000 acre-feet, would drain off of the east slope and be available to Walker Lake. If that runoff contained no TDS, the addition of 5,000 acre-feet of water would result in a 0.2 percent reduction in TDS (Table 7.10). By itself, cloud seeding would result in an insignificant change in TDS concentration in Walker Lake.

TABLE 7.9. SUMMARY OF COST ESTIMATES FOR EXPANSION OF THE WALKER-CARSON RIVER BASIN CLOUD SEEDING PROGRAM TO INCLUDE THE WASSUK RANGE

	THREE GROUND BASED UNITS		
Cost Element	**Manual-Semi Automated**	**Fully Automated**	**Aircraft Seeding**
Weather Monitoring, Microwave Radiometer	$5,000	$5,000	$5,000
Fabrication	$14,250 - $39,150	$32,850	Cost/flight - $3,000
Installation	$1,560 - $1,973	$1,560	10 flights/yr - $30,000
Operations	$9,160 - $10,750	$9,580	
Maintenance	$378	$378	
Labor	$27,412 - $35,068	$32,252	
Facilities	$5,000	$5,000	
Total Cost – First Year	*$64,350 - $95,729*	*$86,620*	*$35,000*
Estimated Cost/Year – Subsequent Years	*$35,000*	*$35,000*	*$35,000*

Source: DRI (1999).

TABLE 7.10. ESTIMATED REDUCTION OF TDS IN WALKER LAKE AS A RESULT OF CLOUD SEEDING IN THE WASSUK RANGE

Additional Water from Cloud Seeding (acre-feet pre year)	Decrease in TDS (%)	Resultant TDS (mg/L)
Baseline:		*11,237*
5,000	0.2	11,214
10,000	0.4	11,192
15,000	0.6	11,170

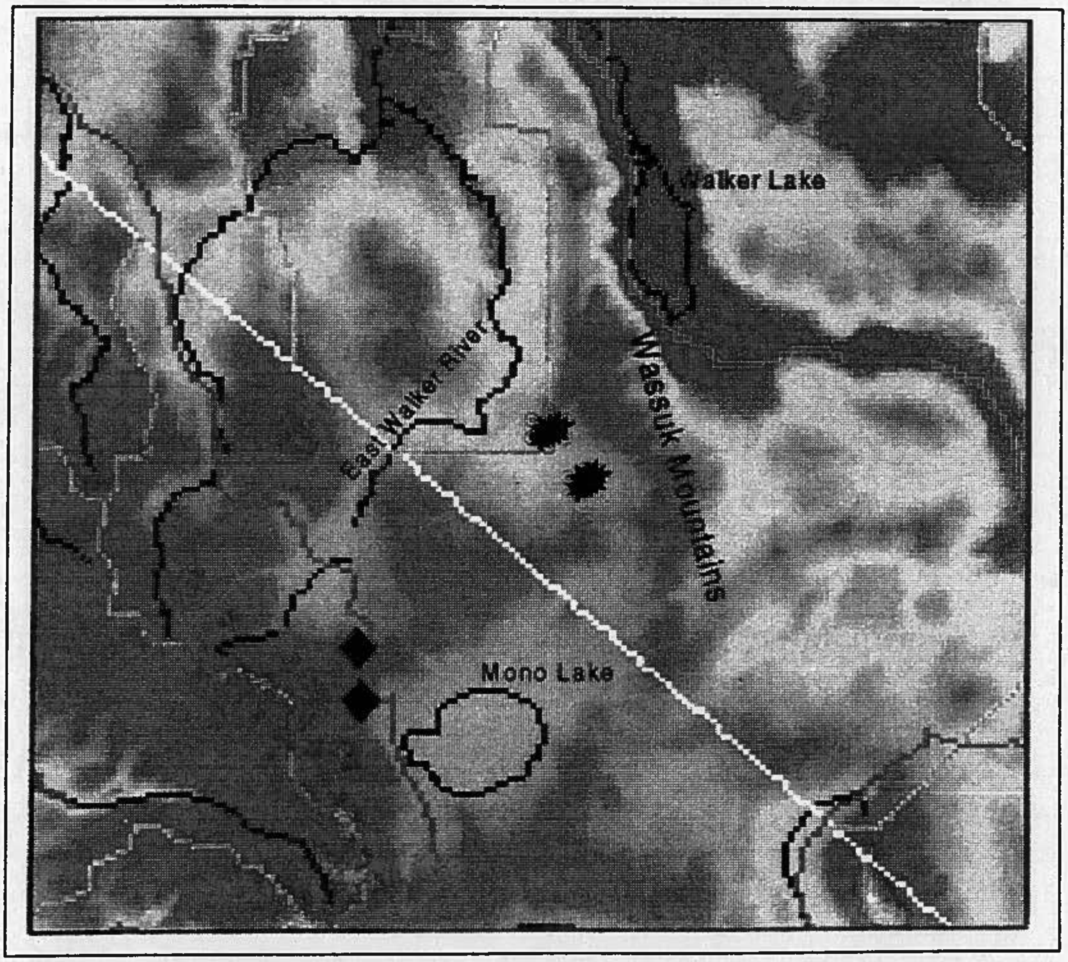
It is recommended that further consideration be given to implementing a cloud seeding program in the Wassuk Range. That program should include an evaluation of storms for their suitability to seeding, and an evaluation of the relationship between snowfall and runoff on the Wassuk Range. These evaluations will allow for a more accurate estimation of the impacts of cloud seeding in the Wassuk Range.

In its June 1999 annual report, the NSCSP describes its plan to install two ground-based generators along the western slopes of the Wassuk Range (Figure 7.7). This was proposed in response to requests from water users in the region. This initial step has two goals: to evaluate the feasibility of conducting seeding operations in this remote region, and to determine the number of cloud seeding opportunities that occur during winter months. Wind and temperature data from prior seasons will be used in a plume dispersion model to optimize the siting of ground generators. Their location will target the higher terrain of the Wassuk Range. This will maximize the benefit of snowmelt and runoff directly into Walker Lake. Flight tracks for seeding aircraft also will be tested in this preliminary study.

If activities proposed by the NSCSP are initiated, it is further recommended that an extensive monitoring program be implemented. Consideration of the following matters will aid in future analyses of the anticipated benefits to Walker Lake derived from the cloud seeding program.

- Review meteorological information to determine the continued applicability of cloud seeding in the Wassuk Range.
- Routinely determine the increased precipitation derived from cloud seeding efforts in the Wassuk Range.
- Through hydrologic modeling and measurements, evaluate impacts to runoff that occur due to increased snowfall from cloud seeding.
- Continued evaluation of the ability of cloud seeding to effectively deposit precipitation along the eastern slope of the Wassuk Range.

Figure 7.7
DRI Siting of Ground-Based Generators Along the Wassuk Range



Map showing topography around the Walker River Basin. Current seeding generator sites are marked by diamonds. Proposed new generator sites near the Wassuk Mountains are shown by snowflakes.

Source: DRI (1999). Report on the Nevada State Cloud Seeding Program. Modified by RCI for presentation in black and white, for the purposes of this report.

- Review of the potential impacts to snow removal operations, urban and agricultural runoff, and areas within the rain shadow.

- Regularly review potential impacts to water rights within the affected area.

- Regularly re-evaluate the ability of cloud seeding to reduce TDS in Walker Lake.

Finally, it is recommended that the city of Hawthorne and the Hawthorne Ammunition Depot develop plans addressing how the increased volumes of runoff would be managed. To the extent possible, agreements should be reached with both entities whereby additional volumes generated as a result of cloud seeding are passed through existing systems and allowed to flow directly into Walker Lake.

7.3.5 Oxygenation of Walker Lake

In 1994, Lahontan cutthroat trout derived from Independence Lake and Catnip Reservoir experienced 95 to 96 percent mortality within six days of planting at Walker Lake (Dickerson and Vinyard, nd.). Fish derived from Pyramid Lake stocks exhibited 58 percent mortality (John Elliott, Nevada Division of Wildlife). It has been assumed that the reduced mortality of the Pyramid Lake stock was due to their increased acclimation to high TDS levels. Although the exact cause of their die-off has yet to be determined, the following limnologic parameters may have contributed to the lake's overall toxicity: TDS, alkalinity, and reduced lake depth.

In 1995, Walker Lake experienced its lowest level this century (3941 feet) at the end of an eight-year drought. At that elevation, the TDS concentration ranged from 14,000 mg/L to 14,977 mg/L, alkalinity was 3,256.7 mg/L, and summer stratification severely limited suitable Lahontan cutthroat trout habitat. Angler surveys suggested that total fish length had decreased, and histological examination of trout indicated gill and kidney damage characteristic of poor water quality.

Sections 7.3.1 and 7.3.2 have discussed possible direct mechanisms to reduce alkalinity and TDS in Walker Lake. This section discusses the possible construction of a system designed to alleviate low oxygen conditions in the hypolimnion during summer stratification. The intended result would be an increase in suitable habitat for Lahontan cutthroat trout. This would be achieved by increasing oxygen concentrations in the cooler, deeper portions of the lake, as well as reducing ammonia and sulfide build-up.

Oxygenation systems are widely used in reservoirs to reduce the toxicity of water discharged from the hypolimnion. For example, an oxygenation system was successfully used to relieve anoxic conditions in the hypolimnion at Camanche

Reservoir in Northern California. Camanche Reservoir is typical of shallow, warm-climate reservoirs, and thermally stratifies in summer months. During the drought of the 1980's, the water level at Camanche Reservoir dropped below its upper outlet causing the release of only anoxic hypolimnetic water into the Mokelumne River. In 1987, the hydrogen sulfide concentration of this water was sufficient to cause significant fish losses at the Mokelumne River Fish Facility (MRFF), located at the base of the dam. Fish losses continued in 1988 and 1989. As a result of these losses, the East Bay Municipal Utility District (EBMUD) developed and implemented short-term strategies to prevent drought conditions from causing fish losses at the MRFF. Supplemental surface aerators were installed at the MRFF and a floating pump station was constructed on Camanche Reservoir, thereby enabling continued discharges from epilimnetic waters. A potassium permanganate treatment system was constructed at the MRFF to remove hydrogen sulfide from intake waters, and releases along the Mokelumne River were managed to prevent early lake turnover.

Following implementation of these short-term strategies, EBMUD selected oxygenation as a long-term solution and installed a system in the hypolimnion to prevent releases of hydrogen sulfide laden water from the reservoir. The oxygenation system consists of a Speece Cone oxygenator set at a depth of 70 feet or more of water. Hypolimnetic water is then withdrawn into the cone, injected with 80 mg/L of dissolved oxygen (DO) at 80 percent efficiency, then discharged back into the hypolimnion via a horizontally directed diffuser (Figure 7.8). The net result of the oxygenation system is a discharge of water with approximately 8 mg/L oxygen at a rate of approximately 300 cfs. Since installation of the oxygenation system, the MRFF has not experienced fish losses due to poor water quality discharged from the hypolimnion at Camanche Reservoir. It should be noted that the oxygenation system is not designed to relieve anoxic conditions throughout the hypolimnion, but is instead designed to prevent the build-up of hydrogen sulfide in the hypolimnion near the dam, thereby protecting downstream fisheries.

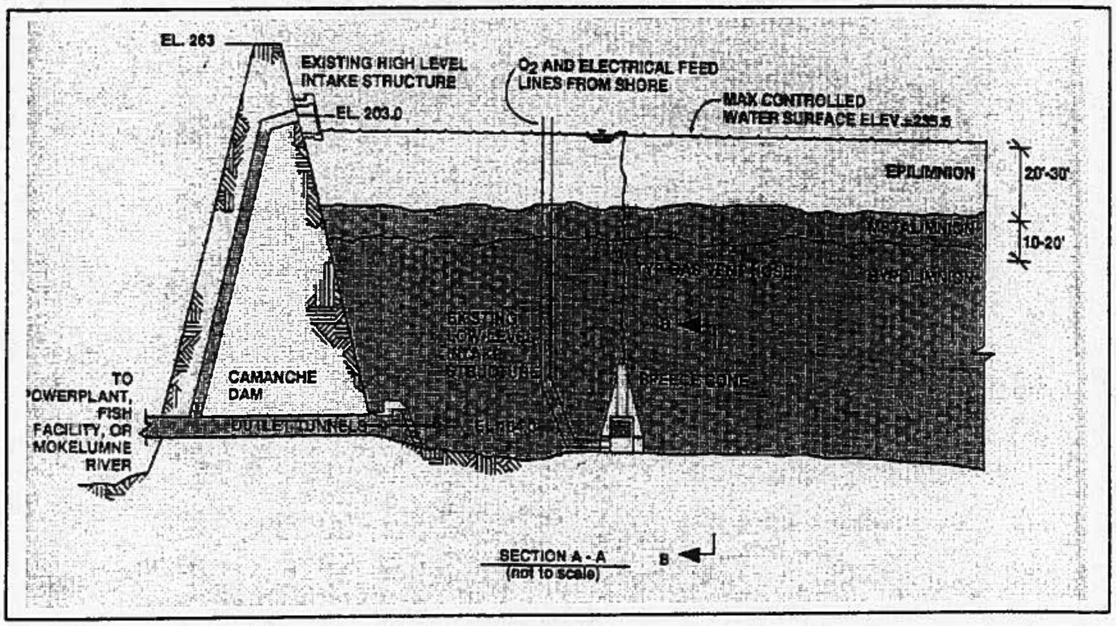
The oxygenation system at Camanche Reservoir requires up to 13,000 pounds of gaseous oxygen per day. The system is turned on and off manually, and is operated for up to six months each year (typically from the onset of thermal stratification in May to fall turnover in November). The oxygen feed rate is set manually to optimize system operation, and system status is remotely monitored via an existing microwave data link. Equipment design, set-up, operation, maintenance and upkeep are leased through an oxygenation system specialty contractor for a fixed monthly fee plus the cost of oxygen used. This approach simplified the ongoing need for operation and maintenance of the system.

EBMUD is currently developing an economic alternative to the Speece Cone called the Soaker Hose. The Soaker Hose design consists of an oxygen injection system attached directly to a diffuser (the "soaker hose") which is located in the hypolimnion. The Speece Cone and the Soaker Hose both affect about the same horizontal area, however, the Soaker Hose may result in more widespread vertical mixing.

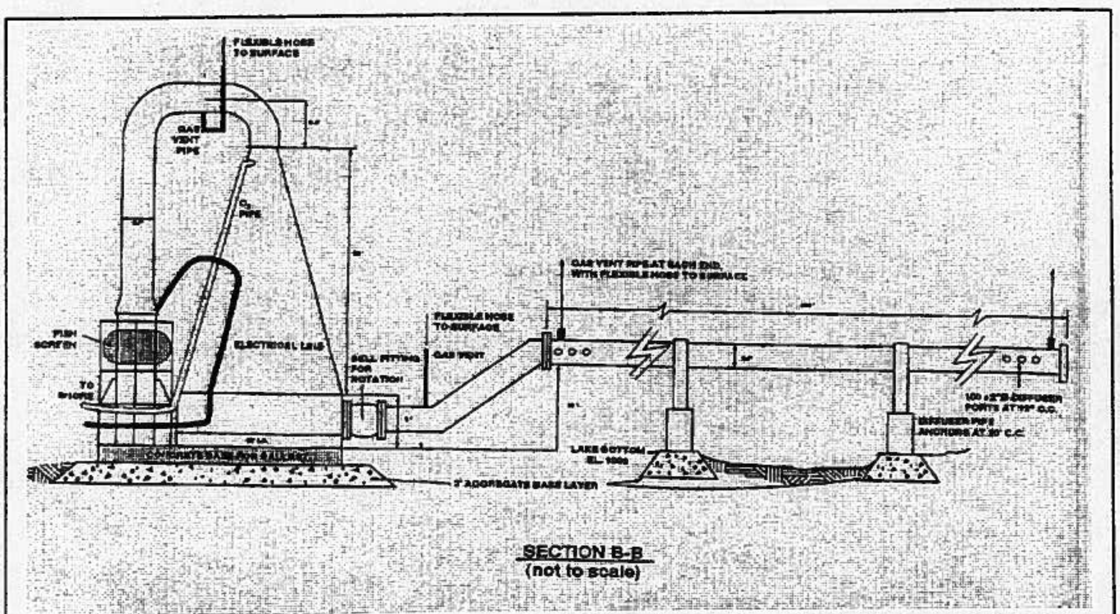
Figure 7.8

Illustration of Speece Cone at Camanche Reservoir (Northern California)

(Source: EBMUD (1999). Initial Study – Camanche Hypolimnetic Oxygenation Demonstration Project).



Orientation of Speece Cone at Camanche Reservoir.



Detail of Speece Cone and Diffuser at Camanche Reservoir.

Currents generated by the soaker hose system may in fact cause disruption of the separation of cooler deeper waters from upper warmer waters. This system, therefore, should be used only in lakes that exhibit strong thermal stratification. Refer to Section 10.5 for a discussion of applying an oxygenation system at Walker Lake.

Camanche Reservoir covers an area of approximately 12 square miles, has a maximum storage capacity of 417,120 acre-feet, and a depth of 135 feet at spill elevation. At its current elevation, Walker Lake is substantially larger in area than Camanche Reservoir. At a depth of approximately 100 feet, Walker Lake remains deep enough to accommodate either a Speece Cone or Soaker Hose oxygenation system.

Capital costs for construction of the oxygenation system at Camanche Reservoir were approximately $1.2 million, and the annual operating costs are about $125,000. Capital and operating costs for the Soaker Hose system were not available since it is still in the preliminary design phase. However, due to the lack of an underwater pump in the Soaker Hose design, there would be a cost saving for design, construction and operation.

The Speece Cone design at Camanche Reservoir is capable of elevating D.O. concentrations above 5 mg/L over a horizontal distance of 10,000 feet upstream. The surface area of the upper limit of the hypolimnion in Walker Lake may extend a distance of up to 24,000 feet (see Figure 7.1), and several oxygenations systems may be required to effectively extend the lower limits of suitable Lahontan cutthroat trout habitat.

It is recommended that installation of an oxygenation system in Walker Lake should be considered more fully. This recommendation is consistent with that given by Horne et al. (1994). The installation of such a system would provide relief to reduced Lahontan cutthroat trout habitat due to oxygen deprivation during periods of summer stratification and periods of extended drought. The system would accomplish this by maintaining dissolved oxygen concentrations within tolerable limits in the deeper, cooler waters of the hypolimnion.

Chapter Eight — TOPIC FIVE: AGRICULTURAL CONSERVATION

Members of several local and regional conservation organizations participated in the development of a list of potential conservation measures reviewed by the Committee (see Chapter Two and Attachment A of this document). Those organizations indicated that a substantial amount of work has been devoted to the design of projects that may reduce the amount of water used by the agricultural community. The goal of this measure is to collect information on those projects, and to assess their merits as conservation measures. The work plan consists of several activities, as described below.

- Meet with local and regional land management and conservation agencies to identify potential projects that are available "on the shelf."
- Compile and review information regarding those projects with the goal of determining their relevance, feasibility, and cost.
- Estimate stream volume changes that can be anticipated as a result of the projects. Qualitatively assess impacts that may occur as a result of those changes in stream flow.
- Qualitatively assess impacts that may occur due to changes in infrastructure, and to institutions dependent upon that infrastructure.

8.1 Planning Considerations

Two general approaches were used to locate pre-existing agriculture or other water conservation plans for the Walker River Basin. First, an extensive literature search was conducted in an effort to locate existing reports on water agricultural water conservation in the basin. This included detailed searches of the following sources:

- the internet;
- the UNR Library and the Nevada State Division of Water Planning library;
- USGS report database (included California, Nevada, and California's Water Division database); the NRCS database (California, Nevada, and national database searches); and the University of California -Davis watershed projects inventory database; and,
- Nevada and California GAP data (the Gap Analysis Program [GAP] is a USGS coordinated program that seeks to identify gaps in biological information).

Two bibliographies were identified as a result of this review. The Nevada State Division of Water Planning has compiled a bibliography of water-related documents that address the Walker River Basin. Also, the *"Basin Resources Outline Report"* prepared by the U.S. Army Corps of Engineers contains a bibliography that lists completed reports, ongoing projects, and proposed projects in the Walker Basin. Two other bibliographies also were reviewed. They are the USGS document titled *Selected Water-Resources Publications on Nevada by the U.S. Geological Survey 1885-1995*, and *Water for Nevada*, a Nevada State Water Planning Document. Both bibliographies contain statewide water publications, but also list some Walker River Basin documents.

Second, personal interviews were held with various groups and individuals. People from the agriculture community, government agencies, and the general public were interviewed regarding water conservation measures and their recollection of existing or planned conservation plans.

8.2 INTERVIEW SUMMARIES

Resource Concepts, Inc (RCI) staff met with the Yerington National Resource Conservation Service office staff (both retired and current employees); Bridgeport, Smith Valley, and Antelope Valley ranchers and farmers; and several other knowledgeable individuals. Follow-up telephone conversations were held with several agency and farming community representatives.

8.2.1 NRCS Meeting in Yerington, Nevada

On February 1, 1999, John McLain and Rob Pearce from RCI went to the Yerington NRCS office to interview current and past NRCS employees about past water conservation planning efforts. Present at the meeting were Gary Cooke (retired from the Agriculture Stabilization and Conservation Service), Rex Ricketts (retired Soil Conservation Service), and Paul Ragland and Ed Biggs (National Resource Conservation Service). These individuals have current and historical knowledge of Walker River Basin issues.

Several points dominated the discussions. It was questioned whether something could be done about the lake only having a "flood right" (see Section 6.3.3 of this report). Concern exists that if people promote efficient irrigation as a way to save water that there may not be sufficient ground water recharge. It was suggested that no matter how much water is added to the lake that the lake will continue to have increasing salt concentrations. An important process regarding water conservation is the timing and amount of water releases from Weber Reservoir. It was mentioned that there is a need for an active flood plain for ground water recharge. Also noted was that there is not enough water storage in the basin system. The idea of making Walker Lake smaller was discussed. In the past (see Boyle 1976), consideration was given to building a dam near

Pelican Point, effectively dividing Walker Lake into two parts. The upper portion of the lake would be smaller but would have a lower TDS concentration. Use of discharge water from the Ft. Churchill Power Plant by the Mason Valley Wildlife Management Area also was discussed. Since the water is too warm to be discharged to the river, it is piped under the river to wetlands in the wildlife area. There was some discussion of what would need to happen before the water could go to Walker Lake. Finally, it was suggested that pump back systems could be used to put irrigation tailwater back into the irrigation system, or possibly the river system.

The Colony Canal in Smith Valley was discussed and it was mentioned that the agriculture fields in the valley were previously flood irrigated. Now, many are sprinkle irrigated. The change from flood to sprinklers has impacted Artesia Lake. It was noted that farmers still have productive agricultural ground utilizing sprinklers, but irrigation-related ground water recharge has declined substantially.

The possibility of reducing evaporation on Walker Lake as a future conservation measure was discussed. The hope was that evaporation might eventually be controlled through some technology that doesn't exist today.

NRCS personnel indicated that the agriculture community feels water is in short supply. They have heard that ranchers are afraid of losing their water rights. Some ranchers state that they are also concerned that water banking is illegal. Several made comments that it is important to point out that there are many agriculture related measures already in effect, including cement lined ditches, laser leveling, sprinklers, and related management practices. It was also noted that the Walker River Paiute Tribe wants a fish hatchery at the lake.

During the meeting several reports related to Walker River water resources were mentioned and it was suggested that RCI review them. The reports included:

- A 1939 Soil Conservation Service report on ditch consolidation in Mason Valley. Rex Ricketts mentioned this report, but RCI was never able to find a copy. Mark Twyeffort, a civil engineer with the State Office of the National Resource Conservation Service remembered seeing plans from the report, but could not find a copy. The existence of the report does illustrate that water conservation efforts in the Walker Basin have been considered for quite some time, at least since 1939.

- Final Watershed Plan and Environmental Impact Statement. East Walker Watershed. Lyon County, Nevada (SCS 1989).

- Gary Cooke mentioned a plan that suggested a dike be put along the outer edge of the flood plain through Mason Valley (a copy of this report was never located).

8.2.2 Smith Valley, Nevada Meeting

On Tuesday March 9, 1999, John McLain and Rob Pearce (RCI) met with Jeff Hunnewill, Stan Hunnewill, Devere Dressler, and Richard Fulstone. These individuals have extensive current and historical understanding of ranching and water use in the Bridgeport and Smith Valley areas. During opening statements, RCI noted that it was seeking information regarding water conservation in the Walker River Basin.

It was noted that in the process of attempting to save Walker Lake, care must be taken not to dry up the rest of the region. Efforts such as sprinkler irrigation and concrete lining of ditches, can save surface water, but will reduce the amount of ground water recharge. Such changes would have an impact on the entire basin. The group was concerned about who will pay for conservation measures. It was stated that conservation measures that might be implemented should be associated with a monitoring program to evaluate their impacts.

There was a general discussion about the effectiveness of different conservation measures. It was agreed that many measures are available and may work, but are not economically feasible for individual ranchers. The group felt that, if the public wants to save the lake, and such efforts are expensive, then it is the responsibility of the same public to help with the cost of conservation and not to place the entire cost on the agriculture community.

There were some general comments on the Mason Valley Ditch Consolidation Report (East Walker Watershed Project [SCS 1989]). It was felt that even if the consolidation was to occur, there may not be a water surplus as suggested in the report. If the consolidation creates a water surplus, ranchers may want to use the water generated through the surplus, because they currently are forced to use supplemental ground water. The Saroni Canal also was discussed (irrigates about 3,900 acres). The canal was built for 110 cfs but never delivers more than 80 cfs. The canal is too large and results in water loss.

Richard Fulstone stated that he believes he has the only lined concrete canal (in the Smith area) all the way from the point of diversion and continuing with concrete ditches through his fields. He no longer experiences water loss, whereas, the previous earthen canals had about a 20 percent water loss. There was a discussion about lining all the canals and it was noted that by so doing there is a loss to ground water recharge. All agreed that when canals are lined with concrete adjacent willow populations are lost and so is their associated wildlife habitat. Concern existed that ground water recharge would need to be part of any conservation system.

The Decree was discussed and it was stated that by mid-July in drought years all Bridgeport water must go to the Walker Lake Paiute Reservation. Perhaps there would be a way to get water delivered to the Reservation from a closer source (maybe ground water pumping). As it is now, some 80 cfs of Bridgeport water must be sent down river to provide the 25 cfs needed to satisfy the Reservation its Decree right. It was suggested that some storage system might be more efficient, one that allowed a larger quantity of water to be delivered at an opportune time in a shorter period, thereby reducing transmission losses.

There was a general discussion regarding proposed reservoir sites and delivering water at critical times for fisheries needs. Several individuals questioned the possibility of storing water downstream for late season release to improve fisheries. It was pointed out how Bridgeport Valley acts like a sponge for subsurface water storage, and how irrigation may conserve water in the long run. Water is stored in an underground system for delivery late in the season, as opposed to a reservoir where there are losses to evaporation. The proposed Whiskey Flat wells and other potential basin water transfers to Walker Lake were discussed. Stan Hunnewill remembered a report on the draw down of ground water and recharge in Smith Valley, but couldn't remember the author.

It was suggested that automated head gates be installed along the river. The river level fluctuates on a daily and hourly basis. Where manual gates are employed, this results in an ever-fluctuating delivery to irrigation canals. Automated gates would maintain a constant flow, reducing overall water use through improved efficiency. The use of underground pipelines as opposed to earthen and concrete lined canals was discussed; these systems offer substantial water savings and less maintenance.

A discussion followed on the possibility of farm land being acquired so that water rights can be transferred to Walker Lake. Concern was expressed as to how piecemeal acquisitions could negatively impact ditch maintenance and water delivery. There was then a discussion that if land acquisition occurred, it should be conducted according to a plan, one in which the acquisitions make sense. A possibility discussed was the acquisition of lands less suitable for agriculture (with good water).

It was asked how one could reconcile the free enterprise aspect of land acquisition. That is, if the public wants to acquire areas for their water rights, that they should not have the right to stop land owners from development if that is what the owners desire. Some thought it would greatly help water conservation efforts if the existing water law could be changed. It was noted that any proposed changes should be considered carefully.

Meeting participants felt that ranchers need to get their message out. They need to let the public know what ranchers need; also the public needs to be informed that newly implemented irrigation efficiencies will also impact the environment.

During the meeting, two reports related to Walker River water resources were identified. Those reports include:

- Klienfelder, Inc. February 1995. Preliminary Walker River Basin Analysis, Walker River Indian Reservation, Schurz, Nevada. Prepared for Public Resource Associates. This report evaluates the hydrology of the Walker River Indian

Reservation. The report states that if pumping occurred on Reservation lands continuously at 3450 gal/minute for 80 years using two wells, it would take 80 years for the cone of depression to reach Walker Lake (this is about 5500 acre feet of water). Kleinfelder did not evaluate how this pumping would impact Walker River flows or existing ground water flows into Walker Lake.

- A report on Smith Valley ground water recharge. No additional information regarding this report (age or the name of the author) was identified.

8.2.3 Walker, California Meeting

On March 24, 1999, Rob Pearce met with a work group attending a University of California, Davis Water Quality Workshop. Rhonda Gildersleeve, Inyo/Mono County Farm Advisor, invited RCI to the workshop to discuss water conservation with the attendants. Present at the meeting were Rhonda Gildersleeve, UCCE; Mike Compston, Bently Agridynamics; Jacquie Compston, Smith Valley, Nevada; Bret Emery; Mike Curti, rancher; Hal Curti, rancher and Board member of the Mutual Antelope Water Company; Al Lapp, California Fish and Game; and Jerry Johnson, rancher.

The major topic discussed by the group was the Sustainable Agriculture Research Education (SARE) project. This is a cooperative program between the University of Nevada Reno, Desert Research Institute, Bently Agridynamics, and other ranchers and farmers. The program is addressing the importance of agriculture, evaluating water use conservation measures, the feasibility of water conservation, and the impact of waste water used for irrigation. One purpose of the project is to educate the public and the agriculture community on the feasibility of water conservation and different uses based on the best available science. Corporations like Bently are providing their water quality records and information they have on water conservation measures. The group felt that information gained through the SARE project might be beneficial to the water conservation efforts for the Walker Basin.

There was a general discussion about selling water rights. It was generally concluded that ranchers would sell as the value of their water increase. Areas like South Park, Colorado, were pointed out as examples of places where negative environmental impacts occurred due to water transfers. Water transfer issues were discussed and it was suggested that the current California State law is good, and will facilitate such transfers.

There was a lengthy conversation about the trade off between water conservation and phreatophyte eradication, and what those types of actions have on ground water recharge, wildlife habitats, and the environment. It was pointed out that conservation measures come with a price, something must give if water conservation is to be achieved.

The conversation then changed to a discussion on water quality monitoring. The Bridgeport Ranchers Organization has implemented a water quality monitoring system on a proprietary basis. The agriculture community in Coleville area is planning to begin a systematic water-quality monitoring program. Bently Agridynamics has a monitoring system in place at this time. Preliminary water quality sampling in the Bridgeport area during the summer of 1998 showed that the sampled waters were within EPA standards, and that phosphorous levels were higher upstream than down stream. The filtering process of irrigated meadow was discussed. Finally, everyone discussed the protocol for water quality sampling and the importance of a third party to do the actual sampling. Questions were raised about what constituents should be monitored and the possibility of archiving sample results.

The final conversation revolved around the state of knowledge about agriculture water conservation measures. It was agreed that the technology exists for highly efficient irrigation practices, but that some of the practices have a high cost and come with a price to the environment. One new report was mentioned at this meeting:

- Mike Compston said that at his home in Smith Valley they have a 1940's vintage report and plans for a ditch consolidation of the Smith Valley Irrigation system. A copy of this report was not found or reviewed as a part of the current study.

8.3 SUMMARIES OF EXISTING CONSERVATION REPORTS

Literature searches and personal interviews revealed several existing reports on water conservation measures for the Walker River Basin. The following are summaries of those reports. Only portions of the report pertaining to agriculture are presented. Seven "conservation" reports were reviewed in detail; five reports containing sections relating to agriculture. Where estimated costs are given, a table is provided summarizing projects costs at the time of the report. A current estimated cost is provided based on the Gross Demand Product (GDP) Index for the year of each report; 1992 is used as the base year (Survey of Current Business, 1999). What the index does not consider is changes in technology since the reports were written. Technology improvements might reduce project expenses.

8.3.1 Report 1, East Walker Watershed Plan

The East Walker Watershed Plan is described in an environmental impact statement (EIS) prepared by the SCS (1989). The purpose of this proposed project is to improve water management and reduce sediment deposition in existing irrigation systems serving 13,460 acres of irrigated land along the East Walker River. Benefits of the project would be water conservation and a reduction in ground water pumping. The project was initiated because inadequate or non-existent water control structures caused a loss of irrigation water, preventing irrigators from managing water efficiently. Sediment deposition was occurring in irrigation ditches and on croplands. The delivery of irrigation water was often interrupted due to the failure of existing irrigation structures. Elements of the proposed project include a new consolidated river diversion structure, construction of settling basins, installation of 94 new headgates, installation of measuring devices, and the preservation of existing wetlands.

Several alternatives were considered during project planning and development of the project's environmental impact statement. A brief description of each alternative is provided. Table 8.1 provides cost data by alternative.

Alternative 1: Consolidate three existing diversions into one ditch located along the High Ditch Diversion. Sand and gravel would be allowed to settle out and would be sluiced back into the river. Measured flows would be allowed into the High, Greenwood-Hall, and Fox Mickey ditch systems. Multiple new headgates and measuring devices would be installed through out the system.

Alternative 2: Includes all of Alternative 1, plus ditch consolidation.

Alternative 3: Includes complete reorganization of the system.

Alternative 4: Same as Alternative 1 except for the settling basin. This alternative would have an earthen settling basin. Sediment would be stockpiled.

Alternative 5: Same as alternatives 1 and 4 except no settling basin.

TABLE 8.1. EAST WALKER WATERSHED PROJECT, ESTIMATED COST BY ALTERNATIVE (1992 BASE YEAR)

Alternative	Project Cost	Base Year Value Project Cost (GDP index = 89.72)	Annual Cost	Base Year Value Annual Cost (GDP index = 89.72)
1	$1,658,000	$1,847,971	$137,000	$152,697
2	$3,600,000	$4,012,483	Annual cost estimated to exceed annual benefit	
3	$7,200,000	$8,024,966	Annual cost estimated to exceed annual benefit	
4	$1,574,000	$1,749,888	$192,900	$215,002
5	$1,290,000	$1,437,806	$96,800	$107,891

Source: SCS (1989)

In the EIS, Alternative 1 was identified as the preferred alternative. Estimated conservation impacts associated with Alternative 1 include the following:

- 5,890 acre feet of water would be saved annually by the improved diversion system, and 2,510 acre feet of water would be saved annually from reductions in irrigation water lost to ground water. These volumes reflect the amount of ground water that would not need to be pumped if the project was implemented.

- Reduction of $82,500 in ground water pumping costs, and a saving of $6,000 per year in reduced labor costs (irrigation system maintenance).
- Eradication of irrigation disruptions as a result of flooding.
- Reduction of 44,600 cubic yards of sediment deposition in irrigation ditches. However, Walker River sedimentation in the Walker River would increase by 57,000 tons in an average runoff year. This increased sediment translates to about an additional one foot of sediment in Weber Reservoir over a 50-year life.

Of all the existing projects reviewed this has the most potential for water savings. This project has a completed EIS and it would be prudent to review its feasibility in light of current conditions and needs (Table 8.2). It is out understanding that the only reason the project was not constructed was the lack of funding.

TABLE 8.2. EAST WALKER WATERSHED PROJECT,
ECONOMIC BENEFITS BY ALTERNATIVE (1992 BASE YEAR)

Alternative	Economic Benefit	Base Year Value Annual Cost (GDP index = 89.72)
1	$173,000	$192,822
2	$270,000	$300,936
3	$510,000	$568,435
4	$173,000	$192,822
5	$133,000	$148,239

Source: SCS (1989)

8.3.2 Report 2, Nevada Division of Water Resources "Alternatives" Report

In the early 1970s, the Nevada Division of Water Resources (1973) prepared a report for the Walker River Basin that discussed alternative uses of water resources. That report evaluates four alternatives. Alternative 1 included a variety of elements oriented toward improving the water supply for agriculture and enhancing upstream recreation opportunities and sport fisheries. Components included the construction of several new storage facilities (Pickel, Hudson, and Strosnider reservoirs) and two enhancement projects (Bridgeport and Pumpkin Hollow projects). Alternative 2 focused on the reallocation of water, thereby allowing for increased levels of mining. Components included new storage facilities (Pickel, Hudson, and Strosnider reservoirs) and the Bridgeport Project. Alternative 3 placed an emphasis on the maintenance of Walker Lake. Land and water rights sufficient to provide approximately 60,000 acre-feet of water to Walker Lake would be acquired. No new reservoirs or projects were proposed.

Alternative 4 placed an emphasis on enhancing the Walker River system without placing an emphasis on Walker Lake. A new dam was proposed near Pelican Point. Sufficient water rights would be acquired to maintain minimum flows within the Walker River.

Of immediate relevance to the present discussion are the proposed Bridgeport and Pumpkin Hollow projects. The Bridgeport project was designed to improve flood channels, water distribution for agricultural lands, and drainage facilities on agriculture lands, all near Bridgeport. The goal of the project was to reduce flood hazards to Bridgeport and to increase agricultural production for agricultural lands in Bridgeport Valley. No estimated annual water saving was given in the report.

TABLE 8.3. BRIDGEPORT PROJECT, ESTIMATED PROJECT COSTS (1992 BASE YEAR)

	Benefits (1973 dollars)	Benefits in Dollars (Base year value, GDP index =35.3	Costs (1973 dollars)	Costs in Dollars (Base year value, GDP index = 35.3)
Flood Protection Portion	$6,300	$17,847		
Irrigation Portion	$217,000	$614,730		
Total	$223,300	$632,577	$52,400	$148,441

Source: SCS (1989)

The pumpkin Hollow project was a proposal for a new diversion dam on the East Walker River, 2.5 miles of channel improvements, 45 miles of new irrigation canals and laterals, concrete lining of over 5 miles of the High Ditch, and about 200 irrigation structures. The effect of the project would have been to decrease flooding, and to eliminate 100 miles of existing low efficiency irrigation canals. Estimated annual water savings were 7,900 acre-feet.

TABLE 8.4. PUMPKIN HOLLOW PROJECT, ESTIMATED COSTS (1992 BASE YEAR)

	Benefits (1973 dollars)	Benefits in Dollars (Base year value, GDP index =35.3	Costs (1973 dollars)	Costs in Dollars (Base year value, GDP index = 35.3)
Flood Protection Portion	<$27,500[1]>	$77,903		
Irrigation Portion	$201,200	$569,971		
Total	$174,200	$493,484	$90,000	$254,957

[1] The negative flood protection benefit was a net figure after considering primary and secondary effects.
Source: SCS (1989)

It is likely that portions of both the Bridgeport and Pumpkin Hollow projects have been completed. There have been ongoing efforts by the agriculture community to increase irrigation efficiency through such efforts as concrete lining of irrigation canals and improved diversion structures for irrigation. A thorough survey of the existing irrigation systems in each area would be required to determine the extent to which these projects have been completed. An analysis could then be conducted to determine whether further improvements are warranted.

8.3.3 Report 3, Public Resource Associates

This report summarizes the water history and current water resources in Walker Basin, primarily focusing on the lower Walker River. The report contains suggestions as to how water could be conserved for Walker Lake. Suggestions specific to agriculture included ditch consolidation, the lining of ditches, the stabilization of ditch and canal flows by automation, the removal of vegetation in or along ditches and canals, and the improvement of measuring devices. The report also discussed the establishment of incentives for shifting to crops that require less water, and shifting to subsurface irrigation systems, pipe canal systems. Detailed analyses, water saving estimates, and cost estimates were not presented in this report.

8.3.4 Report 4, U.S. Department of Agriculture Flood Control Report

In 1940, a preliminary report was prepared that examined runoff and soil erosion prevention (U.S. Department of Agriculture, 1940). The report deals mainly with flood control measures, but does mention several agricultural water conservation efforts. In the report it is stated that:

- Soil Conservation Districts constructed irrigation canal overpasses, promoted improved range management, promoted structural measures to improve water spreading and reduce gully formation, implemented canal improvements, and improved irrigation practices on pastures and cropland to conserve water and reduce erosion.

- The report included a *Water Facilities Area Plan* that recommended ditch consolidation, improved diversion structures from the river, and improvement in ditch headings.

In general, this report suggests that upstream water detention areas (in the Sierras), ditch consolidation, irrigation canal improvements, are required for flood control. As a side note, it was mentioned that some of these measures would help with water conservation.

8.3.5 Summary of Information Present During Interviews and in Reviewed Reports

It is evident that water conservation has been a subject of considerable discussion in the Walker River Basin since at least the late 1930's and probably much earlier than that. The following is a consolidation of the major water conservation efforts (includes agriculture and non-agriculture efforts) suggested in the reviewed documents and interviews:

- Continue with efforts to improve irrigation efficiency through the concrete lining of ditches and canals; the use of underground pipes for water transmission; the laser leveling of fields; the use of sprinkle instead of flood irrigate; and the improvement of diversion structures (both from the river and within irrigation systems).
- Place an increased emphasis on water metering to ensure fair use of the available resource.
- Shift to crops that use less water.
- Consolidate the Mason and Smith Valley irrigation canal systems.
- Transfer water to Walker Lake from other areas through the utilization of ground water.
- Develop additional reservoir storage or water impoundments, and store water for late season releases.
- Implement phreatophyte control measures.

Many alternatives for water conservation have been advanced over the years. The major obstacle to project implementation, however, often seems to be one of cost. There does not appear to be a need for further study for conservation measures, barring some new advanced technological solution. Most measures have been suggested repeatedly for 60 years. Each series of new reports has their answer to agricultural water conservation efforts; however, most of these new solutions have been on the table for years.

8.4 Other Potential Conservation Programs

8.4.1 NRCS EQIP Programs

The Environmental Quality Improvement Program (EQIP) is a cost-sharing program for ranchers and farmers administered by the Natural Resource Conservation Service. Programs are developed to improve soil, water, air, plant, animal, and related natural resource concerns. Each project requires a conservation plan developed by the rancher or farmer with help from NRCS.

Contracts range from 5 to 10 years and NRCS may pay 50-75 percent of the project cost. Water quality projects in the Walker Basin qualify for 60-75 % cost share. Currently, the EQIP program has a budget of $1.3 billion, prorated at $200 million per year through the year 2002. It is unknown what funding is available to those within the Walker River Basin. Potential water savings are unknown and site specific, but projects could be developed that would increase agricultural irrigation efficiency. Rankings for project acceptance are based on set of criteria developed for the Walker Basin. Wetlands, restoration and protection of habitat, and water sources all receive high priority.

Beneficial and adverse impacts would be site specific. However, speaking in general terms this program has the potential to help the agricultural community become more efficient in its use of water. The only adverse impacts are that ranchers and farmers are required to fund part of the projects, and that there are more applicants than there is funding.

It would be beneficial to seek out possible increased funding for this or a similar program, and to evaluate the possibility of obtaining 100 percent funding for water quality and water conservation projects.

8.4.4 Assembly Bill 237

In 1999, the Nevada State Legislature set aside $50 million that will be available state wide for grants to small water systems, water conservation projects, and linking domestic well users to regional water systems. The amount of funding available for each of the programs was not specified, but at this time some $25 million have been awarded to small water systems. This leaves the remaining $25 million for the other two programs. Water conservation projects that may qualify for this program include water piping, lining of irrigation canals, recovery or recycling of tailwater, scheduling of irrigation, measurement of metering of water, improving irrigation efficiency, and improving irrigation water diversion. Funds would be available on a competitive basis.

As with EQIP, beneficial and adverse impacts associated with any given project would be site specific. The AB 237 funding does have the potential to help the Walker River Basin agricultural community develop projects to increase the efficiency of water use.

Chapter Nine — A HOLISTIC ASSESSMENT OF THE ACTIONS

Repeatedly, the Advisory Committee has noted that there is no single cure-all measure. Rather, ensuring a more reliable inflow of water to Walker Lake will require "a little of this, and a little of that." The goal of this chapter is to review several combinations of recommended activities. Benefits of each set of activities to stream flow and lake inflow are discussed, as are apparent disadvantages.

9.1 Recent Developments

Before proceeding with the identification of alternative programs, certain recent developments require discussion. As noted in Section 7.3.4 of this report, the Nevada State Cloud Seeding Program (NSCSP) states in its 1999 Annual Report that it will soon initiate cloud seeding in the Wassuk Range. It appears that costs associated with effort will be borne by the NSCSP. NSCSP estimates that their cloud seeding program may result in an additional 5,000 to 15,000 acre-feet of run-off during wet years. It is estimated herein that this increase could occur evenly on the west-facing and east-facing slopes of the Wassuk Range. Additional runoff along the west-facing slope could serve to recharge ground water and, to a lesser extent, increase flows along the East Walker River. Any such flows would be subject to diversion. Additional runoff along the east-facing slope of the range may have the potential to enter Walker Lake, assuming arrangements can be made with the city of Hawthorne and the Hawthorne Ammunition Depot. At issue is whether or not these entities would allow the increased flow to bypass diversion and storage structures. For planning purposes (see Section 7.3.4 of this document), it is assumed that implementation of cloud seeding by the NSCSP may result in an average of 10,000 acre-feet of additional run-off annually. It is further assumed that half of that amount (or about 5,000 acre-feet) would occur on the east flank of the Wassuk Range. Evaporation and percolation would reduce the amount that actually enters Walker Lake by approximately one half, or to about 2,500 acre-feet. However, it is uncertain how these inflows could be measured.

9.2 Sample Management Programs

Rather than review all possible combinations of the reviewed activities, activities were combined into programs that seem likely when viewed from the perspective of economics and practicability. The programs presented below derive from ideas routinely discussed at Advisory Committee meetings. Each program is constructed around a particular theme or objective. Some activities are common to two or more programs. Clearly, other programs could be developed around other themes, or additional activities could be placed into consideration. As appropriate, results of this exercise could be compared against readily available goals established by state or federal agencies. Four sample programs are presented.

9.2.1 Program One – No More Studies, Do Something Now

Some are of the opinion that additional studies will only defer action and that something needs to occur soon if Walker Lake is to be saved. Hence, the name of this program. Each study element was reviewed to determine whether or not it contained specific activities that could be implemented immediately. Several activities were identified and without exception they share a common characteristic. Funding is required. In some cases, a sponsoring agency or entity also would need to be identified.

Floodwater Management: Prepare written flood management policies and guidelines to be implemented by the federal water master (see Section 5.3.3 of this document). Integrate results of detailed river travel time analyses and models into the flood management guidelines. While these activities could increase operational efficiency over the long term, it is uncertain whether they would result in the regular delivery of increased flows to Walker Lake. Most likely, they could result in the enhanced delivery of water during flood events or high spring flows.

Agricultural Conservation: Construct the East Walker Watershed project. As described in Section 8.3.1 of this document, this extensive project could result in water savings up to 8,000 acre-feet per year. Those savings would arise from improvements to diversion systems and reductions in irrigation water lost to ground water. These savings would be realized during the irrigation season and, as a result, would be available for downstream diversion. For planning purposes, it is estimated that none of the water savings would be realized at Walker Lake.

Agricultural Conservation: Increase funding of the EQIP program as a means of increasing general system efficiencies (see Section 8.4.1 of this document). For planning purposes, it is assumed that funding would be increased by $200,000 per year for five years, for a total cost of $1,000,000. It is difficult to estimate water savings that may occur due to increased EQIP program funding. For planning purposes, it is estimated that there may be a yield of about 0.5 acre-feet for each $1,000 spent. Based on this estimate, water savings may be approximately 500 acre-feet. These savings would be realized during the irrigation season but may not be readily apparent in measurements of stream flow. Advantages inherent to this program are not tied to an increase in stream flows that may be realized due to one project, but rather an improvement in the general irrigation infrastructure. Their implementation will result in a better controlled and efficient system that offers a greater potential for creative water management. For planning purposes, it is estimated that only none of the water savings would be realized at Walker Lake.

Phreatophyte Management: Remove 1,400 acres of tamarisk from along the lower Walker River (see Section 4.4.1 of this document). Until other bank stabilization plans can be developed and implemented, tamarisk located within a 50 to 100 foot wide band along the river should not be removed. Assuming water savings of two acre-foot for each acre of mature tamarisk removed (based on the ET rate for the upper riparian phreatophyte community as identified in Table 4.3 of this document), this action may result in a reduction in water use of 2,800 acre-feet. Replacement vegetation would consume some of this "saved" water and most of the residual would remain in ground water. Conceivably, some portion of that increase in available ground water may flow into the Walker River or Walker Lake. For planning purposes, it is estimated that 25 percent of the water saving may enter the lake or river. Also, assumed costs associated with tamarisk removal do not include any secondary use of the harvested biomass. The tamarisk stands under discussion are on the Walker River Indian Reservation. Funding to carry out this activity could be provided to the Walker River Paiute Tribe. If some other entity performs the work, there would be a need for close coordination with the Tribe.

Water Rights Acquisition: An unstructured program of water rights acquisition could be initiated. This program could be carried out by one or more entities. Each acquisition would be on a first come-first served basis. As discussed in Section 6.4.1 of this document, it is anticipated that this form of an acquisition program would result in the purchase of various types of water rights. Of those rights, it is estimated that 65 percent could be transferable to Walker Lake. Given the diversity in water right types and the variety of locations from which they would be purchased, it is estimated that 50 percent of the transferable water may be delivered to Walker Lake. The estimated purchase price is $500 per acre-foot (water right only) and administrative fees are estimated at $250 per acre-foot. Based on these estimates, 15,400 acre-feet of water rights would need to be purchased to ensure the delivery of 5,000 acre-feet of water to Walker Lake.

Estimated costs and water savings associated with Program One are summarized in Table 9.1. When combined, Program One activities may cost $15,255,000 to construct or implement, and an additional $198,000 per year to continue or maintain. System-wide water savings associated with these activities are estimated to be about 36,700 acre-feet per year. Of that amount, approximately 8,200 acre-feet of additional water may flow into Walker Lake.

Estimated flows to Walker Lake may represent approximately 22 percent of the system wide water savings realized as a result of Program One. Of the remainder, it is estimated that;

- approximately 11,400 acre-feet could recharge local ground water reserves (DRI cloud seeding - 5,000 acre-feet; East Walker Project - 1,000 acre-feet; tamarisk removal - 2,100 acre-feet; water rights - 3,300 acre-feet);

- approximately 11,700 acre-feet could be made available for diversion or other agricultural uses, or could be lost to evaporation (DRI cloud seeding - 2,500 acre-feet; East Walker Project - 7,000 acre-feet; EQIP - 500 acre-feet; water rights - 1,700 acre-feet); and,

- approximately 5,400 acre-feet would be water rights that could not be transferred (35 percent of the total amount purchased).

TABLE 9.1. SAMPLE PROGRAM ONE, DO SOMETHING NOW, ESTIMATED COST AND WATER YIELD ESTIMATES

Activity	Initial Costs	Annual Costs	System Wide Water Saving (acre-feet)	Benefit to Walker Lake (acre-feet)
DRI cloud seeding program.	---	---	10,000	2,500
Prepare flood management policies and guidelines, and travel time analyses.	$25,000	---	Negligible	Negligible
Construct the East Walker Project.	$1,850,000	$153,000	8,000	Negligible
Increase EQIP Funding.	$1,000,000	---	500	Negligible
Remove tamarisk from 1,400 acres along the lower Walker River.	$840,000	$45,000	2,800	700*
Conduct an unstructured program of water rights purchase. Acquire 15,400 acre-feet of water rights.	$11,540,000	---	15,400	5,000
Summary	**$15,255,000**	**$198,000**	**36,700**	**8,200**

** Assumes a 75 percent reduction in surface flow between the place of saving and Walker Lake*

9.2.2 Program Two - Place an Emphasis on Delivering Flood Flows

Comparatively little can be done to increase system flows during drought years. This highlights the need to take full advantage of years when precipitation levels are above normal. Of particular importance to Walker Lake are flood flows. Enhancing the efficient transmission of flood flows would ensure maximum benefit to the lake during years when precipitation levels are normal to above normal. This is the goal of Program Two.

As pointed out in Chapter 5, two types of flood flows are recognized in the Walker River Basin. The goal of Program Two would be to increase the amount of water generated during a mid-winter event that flows into Walker Lake. Records indicate that six major, mid-winter, wet-mantle floods occurred in the Walker River Basin between 1928 and 1967, or an average of once every seven years (SCS 1969:114-115). This program is intended to take advantage of these years. Winter precipitation in substantial excess of the average (130 percent or greater) occurred during six out of the 17 years between 1980 and 1996 (Horton 1996, Table 8; also see Table 3.4 in this document). These years result in above average spring runoff. The activities implemented to increase the delivery of mid-winter flood flows to Walker Lake would also be of use during the management of the resulting irrigation season flood flows. This would be especially true if the water rights acquisition program placed an emphasis on the purchase of flood water rights.

Floodwater Management: Several improvements are recommended. First, prepare written flood management policies and guidelines to be implemented by the federal water master (see Section 5.3.3 of this document). Integrate results of detailed river travel time analyses and models into the flood management guidelines. While these activities could increase operational efficiency over the long term, it is unlikely that they would result in the regular delivery of increased flows to Walker Lake.

Floodwater Management: Establish procedures that would allow for the use of some part of the dead storage present in Topaz Reservoir (see Section 5.2.1.3 of this document) and for an increase in the storage capacity of Bridgeport Reservoir (see Section 5.2.1.2 of this document). This stored water could be released during the non-irrigation season. Given the season of its release, it would not be reduced markedly by downstream agricultural diversion, or by losses to evapotranspiration. For planning purposes, it is estimated that 75 percent of the released water may be realized at Walker Lake. It is anticipated that this floodwater would be available, on an average, once every three years.

Floodwater Management: Construct channel modifications. A design event would be selected and limited channel modification could be constructed (see Section 5.3.2 of this document). Those modifications would focus on limiting out-of-channel flooding. Water savings would occur primarily from decreased infiltration along modified sections of the channel and reduced out of channel flooding. Also, the modified channels would be transmitting increased flows during the non-irrigation season and water savings would not be reduced markedly by downstream agricultural diversion, or by losses to evapotranspiration. For planning purposes, it is estimated that 75 percent of the released storage water may be realized at Walker Lake. It is anticipated that this floodwater benefit would be available, on an average once every three years. The ultimate cost and water savings associated with this activity will depend on the design event that is selected. The planning estimates reflect a limited number of activities in selected areas.

Agricultural Conservation: Program activities are intended to increase flood flows mostly during portions of the year when agricultural diversions are not occurring. As a result, agricultural conservation measures are not included in this program.

Phreatophyte Management: Since program activities are intended to increase flows during the winter months when loss to evapotranspiration is limited, wide-scale phreatophyte control is not included as a major element of Program Two. Rather, a limited program of phreatophyte management is included, with an emphasis on the maintenance of channel capacity. The management program would need to be carefully implemented, ensuring that negative impacts do not occur to riparian and wildlife values. Conduct a limited phreatophyte management program in the lower riparian community (5 percent reduction, or 2,100 acres) (see Section 4.4.2 of this document). Assuming water savings of 1.5 acre-feet for each managed acre, this action could result in a reduction in water use of approximately 3,200 acre-feet. Replacement vegetation would consume some of this "saved" water and most of the residual would remain in ground water. Conceivably, some portion of that increase in available ground water would flow into the Walker River or Walker Lake. For planning purposes, it is estimated that 25 percent of the water saving may enter the lake or river.

Water Rights: Initiate a structured program of water rights acquisition. While this program would focus on the acquisition of storage and flood water rights, it is acknowledged that other types of water rights also would be purchased. Each acquisition would be on a willing seller-willing buyer basis. The acquisition of storage rights would increase the amount of stored water that could be transmitted to Walker Lake during winter months. The acquisition of flood water rights would increase the amount of decreed flood water that could be transmitted to Walker Lake during the spring runoff period. As discussed in Section 6.4.2 of this document, it is estimated that 70 percent of the water rights could be transferable to Walker Lake. Given the focused nature of the purchase program, it is estimated that 55 percent of the transferable water may be delivered to Walker Lake. The estimated purchase price is $550 per acre-foot (water right only) and administrative fees are estimated at $300 per acre-foot. Based on these estimates, 13,000 acre-feet of water rights would need to be purchased to ensure the delivery of 5,000 acre-feet of water to Walker Lake.

Costs and water savings associated with Program Two are summarized in Table 9.2. When combined, Program Two activities may cost $17,175,000 to construct or implement, and an additional $60,000 per year to continue or maintain. System-wide water savings associated with these activities are estimated to be 32,600 acre-feet per year. Of that amount, approximately 13,200 acre-feet of additional water may flow into Walker Lake. For purposes of comparison with other programs, these figures represent an annual average. Since this program places an emphasis on flood events, most benefits would be derived during years that experience mid-winter flood events or above average flood flows. Benefits during these years would be substantially greater than those reported in Table 9.2.

Estimated flows to Walker Lake may represent approximately 40 percent of the system wide water savings realized as a result of Program Two. Of the remainder, it is estimated that;

- approximately 11,600 acre-feet could recharge local ground water reserves (DRI cloud seeding - 5,000 acre-feet; Topaz - 800 acre-feet; Bridgeport - 500 acre-feet; river channel improvements - 200 acre-feet; phreatophyte management - 2,400 acre-feet; water rights - 2,700 acre-feet);

- approximately 3,900 acre-feet could be made available for diversion or other agricultural uses, or could be lost to evaporation (DRI cloud seeding - 2,500 acre-feet; water rights - 1,400 acre-feet); and,

- approximately 3,900 acre-feet could be water rights that could not be transferred (30 percent of the total amount purchased).

TABLE 9.2. SAMPLE PROGRAM TWO, FLOOD FLOW MANAGEMENT, ESTIMATED COST AND WATER YIELD ESTIMATES

Activity	Initial Costs	Annual Costs	System Wide Water Saving (acre-feet)	Benefit to Walker Lake (acre-feet)
DRI cloud seeding program.	---	---	10,000	2,500
Manage dead storage at Topaz Reservoir.	$25,000*	---	10,000 max 3,300 annual	2,500**
Increase storage capacity at Bridgeport Reservoir.	$25,000	---	6,390 max 2,100 annual	1,600**
Prepare flood management policies and guidelines, and travel time analyses.	$25,000	---	Negligible	Negligible
Construct river channel improvements in Smith and Mason Valleys.	$5,000,000	---	3,000 max 1,000 annual	800**
Conduct limited phreatophyte removal from 2,100 acres within the lower riparian community	$1,050,000	$60,000	3,200	800***
Conduct a structured program of water rights purchase. Acquire 13,000 acre-feet of water rights. Focus on purchase of storage and flood water rights.	$11,050,000	---	13,000	5,000
Summary	**$17,175,000**	**$60,000**	**32,600 annual**	**13,200**

* *Assumes that a minimal, low risk policy would be employed; no pumping would occur.*

** *Assumes that the savings would occur on average once every three years (one-third of the savings is credited to any given year) and that a 25 percent reduction in surface flow between the place of saving and Walker Lake.*

*** *Assumes a 75 percent reduction in surface flow between the place of saving and Walker Lake.*

9.2.3 Program Three: Place Emphasis on Integration with Land Use Planning

The acquisition of water rights on a willing seller and willing buyer basis may result in an increasingly disjointed irrigation distribution system. Land use patterns may become more complex. One option would be prepare land use or master plans for each major agricultural area in the Walker River Basin. These plans would focus on the identification of core areas in which agricultural pursuits would be retained. The goal of Program Three is to provide increased inflow to Walker Lake while ensuring that agriculture retains its economic viability.

Planning Activities: Prepare an agricultural element to the Lyon County Master Plan (and, perhaps, the Mono County Master Plan). This effort would focus on the definition of core areas and programs designed to allow for their implementation. While these activities could increase operational efficiency over the long term, it is unlikely that they would result in the regular delivery of increased flows to Walker Lake.

Floodwater Management: Construct channel modifications. A design event would be selected and limited channel modification would be constructed (see Section 5.3.2 of this document). Those modifications would focus on protecting key areas from out-of-channel flooding. Water savings would occur primarily from decreased infiltration along the modified section of the channel and reduced out of channel flooding. The planning estimates reflect a limited number of activities in selected areas. For planning purposes, it is estimated that 50 percent of the released water may be realized at Walker Lake. The ultimate cost and water savings associated with this activity will depend on the design event that is selected.

Floodwater Management: Construct artificial recharge ponds in Smith and Mason valleys (see Section 5.3.1.1). Ponds would be designed and located so as to offset some impacts that may occur due to ground water pumping. If diversion into ponds occurred during winter months, losses to evapotranspiration would be minimized. For planning purposes, it is estimated that none of the water diverted to recharge ponds would directly benefit Walker Lake.

Agricultural Conservation: If within a defined core area, construct the East Walker Watershed project. As described in Sections 8.3.1 and 9.2.1 of this document, this activity would result in water saving of up to 8,000 acre-feet per year. For planning purposes, it is estimated that 25 percent of the water savings may be realized at Walker Lake. This assumes that greater efficiencies elsewhere in the core area would allow some of the saved water to pass out of the system.

Agricultural Conservation: Increase funding of the EQIP program as a means of increasing general system efficiencies in defined core areas. As described in Sections 8.4.1 and 9.2.1 of this document, this activity could result in water savings of approximately 500 acre-feet. For planning purposes, it is estimated that none of the water savings would be realized at Walker Lake.

Phreatophyte Management: Wide-scale phreatophyte control is not included as a major element of Program Three. Rather, a limited program of phreatophyte management is included, with an emphasis on the maintenance of channel capacity. The management program would need to be carefully implemented, ensuring that negative impacts do not occur to riparian and wildlife values. Conduct a limited phreatophyte management program in the lower riparian community (5 percent reduction, or 2,100 acres). As described in Sections 4.4.2 and 9.2.2 of this document, this activity could result in water saving of approximately 3,200 acre-feet. It is estimated that 25 percent of the water saving may enter the lake or river.

Water Rights: Initiate a structured water rights acquisition program designed around the identification of core areas in which agricultural practices would be retained. Emphasis would be placed on the acquisition of all types of water rights from agricultural lands located outside the core areas. Mechanisms would be developed where by farming interests could be transferred onto vacated core areas from the surrounding non-core area. Each acquisition would be on a willing seller-willing buyer basis. Also, selected water rights may be transferred into core areas. The transfer of ground water rights may prove beneficial in that their use in the core area may free up other types of water rights for transfer to Walker Lake. As discussed in Section 6.4.3 of this document, it is estimated that 60 percent of the water rights could be transferable to Walker Lake. Given the focused nature of the purchase program, it is estimated that 45 percent of the transferable water may be delivered to Walker Lake. The estimated purchase price is $450 per acre-foot (water right only) and administrative fees are estimated at $200 per acre-foot. Based on these estimates, 18,500 acre-feet of water rights may need to be purchased to ensure the delivery of 5,000 acre-feet of water to Walker Lake.

Costs and water savings associated with Program Three are summarized in Table 9.3. When combined, Program Three activities may cost $19,675,000 to construct or implement, and an additional $213,000 per year to continue or maintain. System-wide water savings associated with these activities are estimated to be 43,700 acre-feet per year. Of that amount, approximately 10,100 acre-feet of additional water may flow into Walker Lake.

TABLE 9.3. SAMPLE PROGRAM THREE, INTEGRATION WITH LAND USE PLANNING, ESTIMATED COST AND WATER YIELD ESTIMATES

Activity	Initial Costs	Annual Costs	System Wide Water Saving (acre-feet)	Benefit to Walker Lake (acre-feet)
DRI cloud seeding program.	---	---	10,000	2,500
Prepare local and regional management plans.	$500,000	---	Negligible	Negligible
Construct limited river channel improvements in Smith and Mason valleys.	$2,500,000	---	1,500	800*
Construct recharge ponds	$750,000	---	2,000	0
Construct the East Walker Project.	$1,850,000	$153,000	8,000	1,000**
Increase EQIP Funding.	$1,000,000	---	500	Negligible
Conduct limited phreatophyte removal from 2,100 acres within the lower riparian community.	$1,050,000	$60,000	3,200	800**
Conduct a structured program of water rights purchase. Acquire 15,400 acre-feet of water rights.	$12,025,000	---	18,500	5,000
Summary	**$19,675,000**	**$213,000**	**43,700**	**10,100**

* *Assumes a 50 percent reduction in surface flow between the place of saving and Walker Lake.*
** *Assumes a 75 percent reduction in surface flow between the place of saving and Walker Lake.*

Estimated flows to Walker Lake could represent approximately 23 percent of the system wide water savings realized as a result of Program Three. Of the remainder, it is estimated that;

- approximately 16,000 acre-feet could recharge local ground water reserves (DRI cloud seeding - 5,000 acre-feet; river channel improvements - 500 acre-feet;

recharge ponds - 2,000 acre-feet; East Walker Project - 2,000 acre-feet; phreatophyte management - 2,400 acre-feet; water rights - 4,100 acre-feet);

- approximately 10,200 acre-feet could be made available for diversion or other agricultural uses, or could be lost to evaporation (DRI cloud seeding - 2,500 acre-feet; river channel improvements - 200 acre-feet; East Walker Project - 5,000 acre-feet; EQIP - 500 acre-feet; water rights - 2,000 acre-feet); and,

- approximately 7,400 acre-feet could be water rights that could not be transferred (40 percent of the total amount purchased).

9.2.4 Program Four: Place Emphasis on the Lower End of the System

Water savings that occur in the lower end of the system are far more likely to make it to Walker Lake than similar savings realized higher in the system. For discussion purposes, the northern portion of Mason Valley is considered to be the lower end of the system. The goal of Program Four would be to place an emphasis on realizing water savings in this lower portion of the system.

Floodwater Management: Improvements would be limited to channel modifications in Mason Valley. A design event would be selected and appropriate channel modification would occur. Those modifications would focus on limiting out-of-channel flooding.

Agricultural Conservation: Increase funding of the EQIP program as a means of increasing general system efficiencies in Mason Valley (see Section 8.4.1 of this document). Funding priority would be assigned to activities or areas (northern end of the valley) that would result in a substantial reduction in water use. As described in Sections 8.4.1 and 9.2.1 of this document, this activity could result in water savings of approximately 500 acre-feet. For planning purposes, it is estimated that 25 percent of the water savings may be realized at Walker Lake.

Phreatophyte Management: Remove 1,400 acres of tamarisk from along the lower Walker River. As describe in Sections 4.4.1 and 9.2.1 of this document, this action could result in a reduction in water use of 2,800 acre-feet. For planning purposes, it is estimated that 25 percent of the water saving may enter the lake or river. Also, assumed costs associated with tamarisk removal do not include any secondary use of the harvested biomass.

Phreatophyte Management: A wide-scale phreatophyte control is not included as a major element of Program Four. Rather, a limited program of phreatophyte management within Mason Valley is included, with an emphasis on the maintenance of channel capacity. Conduct a limited phreatophyte management program within the lower and upper riparian zones (see Chapter 4.4.2) along the reach of the river between Wabuska and Weber Reservoir. The management program would need to be carefully implemented, ensuring that negative impacts do not occur to riparian and wildlife values. Assuming the management program encompasses 200 acres and there are water savings of 2.5 acre-feet for each managed acre (Katzer et al, 1999), this action could result in a reduction in water use of approximately 500 acre-feet. Replacement vegetation would consume some of this "saved" water and most of the residual would remain in ground water. Conceivably, some portion of that increase in available ground water would flow into the Walker River or Walker Lake. For planning purposes, it is estimated that 25 percent of the water saving may enter Walker Lake. The vegetation under discussion is located on the Walker River Indian Reservation. Funding to carry out this activity could be provided to the Walker River Paiute Tribe. If some other entity performs the work, there would be a need for close coordination with the Tribe.

Initiate a structured water rights acquisition: This program could be carried out by one or more federal, state, or local agencies; the Walker River Irrigation District; or a private foundation or entity. The program would focus on the acquisition of early priority water rights in the central and northern ends of Mason Valley. To the extent possible, flood rights and supplemental ground water rights would also be acquired from the same area. All acquired rights would be assigned to Walker Lake. Each acquisition would be on a willing seller-willing buyer basis. As discussed in Section 6.4.4 of this document, it is estimated that 80 percent of the water rights could be transferable to Walker Lake. Given the focused nature of the purchase program, it is estimated that 60 percent of the transferable water could be delivered to Walker Lake. The estimated purchase price is $600 per acre-foot (water right only) and administrative fees are estimated at $200 per acre-foot. Based on these estimates, 10,400 acre-feet of water rights may need to be purchased to ensure the delivery of 5,000 acre-feet of water to Walker Lake.

Costs and water savings associated with Program Four are summarized in Table 9.4. When combined, Program Four activities may cost $12,735,000 to construct or implement, and an additional $65,000 per year to continue or maintain. System-wide water savings associated with these activities are estimated to be 25,700 acre-feet per year. Of that amount, approximately 9,200 acre-feet of additional water may flow into Walker Lake.

Estimated flows to Walker Lake could represent approximately 36 percent of the system wide water savings realized as a result of Program Four. Of the remainder, it is estimated that;

- approximately 10,200 acre-feet could recharge local ground water reserves (DRI cloud seeding - 10,000 acre-feet; river channel improvements – 500 acre-feet; tamarisk removal – 2,100 acre-feet; phreatophyte management – 400 acre-feet; water rights – 2,200 acre-feet);

- approximately 4,200 acre-feet could be made available for diversion or other agricultural uses, or could be lost to evaporation (DRI cloud seeding – 2,500 acre-feet; river channel improvements – 200 acre-feet; EQIP – 400 acre-feet; water rights – 1,100 acre-feet); and,

TABLE 9.4. SAMPLE PROGRAM FOUR, MANAGE LOWER END OF SYSTEM, ESTIMATED COST AND WATER YIELD ESTIMATES

Activity	Initial Costs	Annual Costs	System Wide Water Saving (acre-feet)	Benefit to Walker Lake (acre-feet)
DRI cloud seeding program.	---	---	10,000	2,500
Construct channel modifications in Mason Valley	$2,500,000	---	1,500	800*
Increase EQIP Funding.	$1,000,000	---	500	100**
Remove tamarisk from 1,400 acres along the lower Walker River.	$840,000	$45,000	2,800	700**
Conduct limited phreatophyte removal from 150 acres within selected lower riparian communities	$75,000	$20,000	500	100**
Conduct a structured program of water rights purchase. Acquire 10,400 acre-feet of water rights.	$8,320,000	---	10,400	5,000
Summary	**$12,735,000**	**$65,000**	**25,700**	**9,200**

* *Assumes a 50 percent reduction in surface flow between the place of saving and Walker Lake.*
** *Assumes a 75 percent reduction in surface flow between the place of saving and Walker Lake.*

- approximately 2,100 acre-feet could be water rights that could not be transferred (20 percent of the total amount purchased).

9.3 PROGRAM COMPARISON

A brief comparison of the four reviewed programs is provided in Table 9.5. The estimated cost of each program is provided as is the estimated system-wide water saving. Then, the assumed distribution of that water saving is identified.

Program One would be moderately expensive to implement but would result in the least benefit to Walker Lake. This program would make the greatest amount of additional water available for subsequent diversion (due in large part to inclusion of the East Walker Project). Also, disadvantages associated with the water rights acquisition aspect may limit the program's short-term and long-term effectiveness. Program Two also would be moderately expensive to implement but would likely have the greatest potential to aid Walker Lake. This program would make the least amount of additional water available for subsequent diversion. Program Three would be the most expensive to implement and would likely yield a modest benefit to Walker Lake. It must be noted that, depending on its definition, this program could exhibit considerable management flexibility that may result in far greater water savings (and benefits to Walker Lake) than are reflected herein. Program Four would be the least expensive to implement and would likely produce the lowest system-wide water saving. In spite of this, the program could still provide a moderate benefit to Walker Lake. This is due to the emphasis it places on the lower end of the system.

TABLE 9.5 COMPARISON OF THE REVIEWED PROGRAMS.

	Initial Cost	System Wide Water Saving (acre-feet)	Ground Water Recharge (acre-feet)	Available for Use, Diversion (acre-feet)	Relinquished Water Rights (acre-feet)	Benefit to Walker Lake (acre-feet)
Program One – No More Studies	$15,255,000	36,700	11,400	11,700	5,400	8,200
Program Two – Flood Flow Management	$17,175,000	32,600	11,600	3,900	3,900	13,200
Program Three – Planning Integration	$19,675,000	43,700	16,000	10,200	7,400	10,100
Program Four – Lower End	$12,735,000	25,700	10,200	4,200	2,100	9,200

The four programs discussed in Section 9.2 of this document are not intended to be mutually exclusive. Nor are they the only combinations of alternative actions that can be devised. Other programs could easily be developed based on different objectives, or a different suite of alternative conservation measures. Also, one could combine some of the reviewed programs. For example, elements of Programs Two and Four could be combined, thereby providing improved flood management and an emphasis on reducing irrigation activities at the lower end of the system.

Chapter Ten — RETROSPECTIVES, A POSTMORTEM

Over the course of this study, team members have had the opportunity to review a tremendous amount of material and to participate in numerous conversations about the Walker River Basin. Based on this experience, a wide variety of ideas have been discussed. Specific activities assigned to RCI by the Advisory Committee offered a context in which to explore most of those thoughts. In this chapter, we would like to discuss some of our remaining thoughts.

10.1 A Fundamental Need

At the north end of Walker Lake, the lower Walker River is becoming increasingly incised and bank loss is occurring at a rapid rate, especially during high spring flows. This has been ongoing since the latter part of the nineteenth century when the level of Walker Lake began to decline. Incisement occurs as the river adjusts to the new gradient leading to the lake. The absence of stream-side vegetation and the presence of loosely textured soils that are highly erodible contribute to an unstable channel that is highly erosive. Over the course of a normal runoff season, the riverbed was lowered by as much as six feet in some areas and moved laterally as much as 70 feet in other areas. These changes occurred between April and November of 1998 and are discussed in Section 5.3.2 of this document.

These ongoing processes have had an impact on the quality of fisheries habitat along the lower Walker River. Re-establishment of that habitat will require that steps be taken to physically stabilize the channel and reduce stream bank erosion. These conditions will only be exacerbated if efforts to increase flows to Walker Lake are successful. Increasing flows at any time of the year will cause accelerated erosion and re-deposition, and lateral channel movement.

It is recommended that the existing channel should be stabilized to accommodate an agreed upon, acceptable flow, and that a by-pass channel should be constructed to accommodate any additional flow. Further study would be needed to determine the most reasonable point of diversion for the by-pass channel, and the desired characteristics of the stabilized main channel and the by-pass channel. Addressing this matter will require a considerable expenditure of time and money. Design and construction costs could easily be in the vicinity of $15,000,000. The expenditure is necessary, however, to stabilize the lower Walker River, to provide for viable fisheries in that lower reach of the river, and to reduce sediment loads to Walker Lake.

This reach of the river is located on the Walker River Indian Reservation. Funding to address this matter could be provided to the Walker River Paiute Tribe. If some other entity performs all or part of the work, there would be a need for permission from and close coordination with the Tribe.

10.2 EXPLORE INTER-BASIN TRANSFERS

One way to affect the depth, volume, and surface area of Walker Lake is to increase inflow by importing ground water from adjacent basins. This proposal is not new. It was discussed over thirty years ago in a feasibility study prepared by Boyle Engineering Corporation (1976). That evaluation of water resources in Mineral County focused on the ability of local resources to meet two needs: provide a water supply for the city of Hawthorne, and mitigate the decline of Walker Lake. Among other recommendations, the Boyle study concluded that Mineral County did not have sufficient water resources or economic means to implement a meaningful ground water importation program.

RCI suggests that earlier appraisals deserve re-examination. Several points need clarification, mostly due to the fact that much of the data relied on by the Boyle study is now over 30 years old. For instance, do more recent data indicate that water quality in any given valley is better than indicated previously? Are ground water systems unconfined or confined, and how much water can reasonably be expected for each foot of drawdown? What is the depth to water and what are the expected well yields and pumping levels?

More recent information may help address some of these issues. For example, the work by Welch and Williams (1987) provides a regional appraisal of ground water quality, and work by Robinson and Kister (1986) may provide additional geochemical insight into the geologic framework of some of the selected ground water systems.

An assumption central to the Boyle study is that the amount of water available as perennial yield is fixed. Ongoing studies by the USGS suggest that water budgets in many Nevada valleys may have been under-estimated; the discharge is greater than originally estimated. If that is the case, potential recharge also is greater. This means that there is potentially more water available for use than previously thought. A major variable in this discussion is the annual amount of precipitation that any given area receives. The main source of precipitation data for past USGS studies has been the Hardman Map (1936, revised 1965, modified by the Nevada Division of Water Resources, 1971). Recently, a new precipitation map was released for the western United States. Known as the PRISM Map (Daly et al., 1994 and 1997), it uses a period of record from 1961 - 1990 and generally shows greater amounts of precipitation than the Hardman map, particularly above 8,000 feet altitude. This translates into greater recharge than previously estimated. For any given mountain range, both precipitation maps should be compared and the ground water budgets of adjacent valleys revised accordingly.

Several nearby basins are a potential source of ground water supply for Walker Lake. Most of the basins were evaluated in the Boyle (1976) report. Some additional basins are proposed for consideration - Fairview-Dixie Valley, Garfield Flat, and the Whiskey Flat Sub-area (Table 10.1). The western part of Gabbs Valley is particularly attractive, simply because of its proximity to Walker Lake. The Fairview-Dixie Valley ground water system (Cohen and Everett 1963; Bell and Katzer 1987) is of high potential in terms of available water, but is a long distance away, perhaps 50-100 miles. The main discharge process in this valley system is by ET and a large amount of this could be salvaged. The valley is largely under the control of the U. S. Department of Defense; it is unknown whether ground water is still being used for irrigation and questions concerning available water rights have not been researched.

TABLE 10.1. POTENTIALLY AVAILABLE GROUND WATER FOR EXPORT TO WALKER LAKE.

Basin	Perennial Yield (AF)	Basin Over Appropriated	Direction of Ground Water Flow	Potential Total Dissolved Solids (mg/l)
Gabbs Valley[1]	5,000	Yes	Internal	1,250[2]
Soda Springs Valley, West[1]	1,000	Yes	Walker Lake	1,000[2]
Rhodes Marsh[1]	1,000	Probably Not	Internal	3,000[2]
Teels Marsh[1]	1,000	No	Adobe Valley	1,250[2]
Fairview Valley[1]	Minor	Probably Not	Dixie Valley	300-1,000[3]
Dixie Valley	15,000	Probably	Internal	300-1000[3]
Garfield Flat	Minor	No	Internal	432[4]
Whiskey Flat Subarea	5,000	Probably Not	Walker Lake	370[4]

1. *NDWR (1971)*
2. *Boyle report (1976, Table 6.3, p. VI – 20).*
3. *Cohen and Everett (1963, Table 6)*
4. *Everett and Rush (1967, Table 8*

Two other likely areas, Soda Springs Valley West and the Whiskey Flat Sub-area are tributary to Walker Lake Valley. This raises the question of what impact will occur to the ground water system if ground water flow to Walker Lake is intercepted? The answer depends on a variety of hydro-geologic factors, but the distances and amount of water in storage are particularly important. Conceivably, pumping from the south end of Whiskey Flat at a high rate for a limited time would not cause lake water to infiltrate or flow back into the ground water system.

The reconsideration of inter-basin ground water transfers as a means of augmenting inflow directly to Walker Lake seems worthwhile. Such a transfer should not be relied on in lieu of other conservation measures. Rather, an inter-basin transfer could represent one component of a larger program. The advantage to including an inter-basin transfer in such a program would be its ability to provide water to Walker Lake during years and/or seasons when other sources could not. One alternative, for example, may be to transfer water into Walker Lake only during drought periods (summer months?) when other water uses diminish inflow to the lake. Other management strategies could be explored during the reconsideration of this matter.

10.3 MINERAL COUNTY ACTIONS

There may exist within the Walker River Basin the potential for the consolidation of water systems to the benefit of current users as well as flow to the Walker Lake. A specific example may be the separate existing water systems that currently serve Hawthorne and the Army Ammunition Depot.

The City of Hawthorne has historically been served by its own publicly owned water system. For reasons related mainly to water quality, the primary sources of water are wells located in the Whiskey Flat area at a distance of approximately 10 miles south of town, conveyed by buried pipeline.

The Army Ammunition Depot is likewise served by its own government-owned system. This system has historically relied on both ground water sources within the depot itself, as well as surface water collected as runoff from adjacent the Wassuk Range. Collected surface water has been accumulated in elevated storage reservoirs, and conveyed for use within the depot. Because of ground water quality issues, the collected surface water has historically been the primary source for domestic consumption. Surface water collected from the Wassuk Range is from sources naturally tributary to Walker Lake.

In recent years the Army Ammunition Depot has seen substantially reduced levels of employment, and the coincidental reduction in water service demand. In fact, one of the largest users of water originally served by the system was the government housing area of Babbitt and adjacent irrigated areas. That use no longer exists. However, the water rights established by the federal government for those uses remain in good standing.

The existence of the two adjacent systems, along with a demand that has diminished from historic requirements, may offer a reasonable basis for consolidating the two systems while benefiting Walker Lake. If, for example, the ammunition depot can be served by connection to the Hawthorne system, then surface water previously collected from the Wassuk Range could be allowed to flow directly to the lake.

This latter point is particularly relevant to Cottonwood Creek. Aside from the Walker River, the Cottonwood Creek watershed is one of the few major tributaries that historically flowed directly into Walker Lake (see Table 7.8). Dutch, Squaw, Rose and House creeks also flowed into the lake, but none have as large a watershed as does Cottonwood Creek. Cat Creek has almost as large a watershed, but it historically discharged onto the alluvial plain south of Walker Lake and was absorbed before reaching the lake. It is reasonable to expect that most of the increased snow pack that would result from cloud seeding efforts in the Wassuk Range would occur in the Mt. Grant area. During spring months, much of that additional runoff would flow along Cottonwood Creek. The consolidation of water systems may allow the Hawthorne Ammunition Depot to relinquish rights to Cottonwood Creek. If so, then water now diverted from that stream for use by the Depot and additional runoff generated by cloud seeding could be allowed to flow to Walker Lake.

Also, anecdotal information suggests that planted Lahontan cutthroat trout have been seen attempting to swim up Cottonwood Creek, presumably in an effort to spawn. When coupled with the potential for increased flows along Cottonwood Creek to Walker Lake, this raises the question of whether Cottonwood Creek could be developed to a point where it would provide suitable habitat for natural spawning of Lahontan cutthroat trout. If so, Mineral County and the Hawthorne Ammunition Depot could work together to remove obstacles to fish movement along the stream, and as necessary improve habitat conditions with the reach of Cottonwood Creek most suitable for use by Lahontan cutthroat trout. Any such effort may be comprised of the following steps:

- Conduct a literature and regulatory review to determine what efforts have been made to date regarding the potential use of Cottonwood Creek as a spawning habitat for Lahontan cutthroat trout.

- Gather and review information on the annual and seasonal flows on Cottonwood Creek.

- Gather and review information regarding implementation of existing water rights on Cottonwood Creek and discuss options that may enhance the opportunity for habitat development within the creek.

- Survey reaches of Cottonwood Creek to determine existing habitat, including an evaluation of cover, substrate, pools, forage, and the presence of competitive species.

- As necessary, develop in-stream improvements to provide for continuous access by fish from Walker Lake to the stream.

- As necessary, develop in-stream improvements to provide suitable habitat for spawning, rearing, and foraging.

If the various aspects of this activity prove feasible, existing water uses in the greater Hawthorne area would have been consolidated, a more regular inflow of water to Walker Lake would have been facilitated, and, potentially, spawning habitat may have been re-established for the Lahontan cutthroat trout. These are worthy goals that Mineral County can actively pursue in its own back yard. RCI encourages Mineral County to explore these matters.

10.4 VERIFY EXISTING USES

To this point, there has been no attempt to relate water rights to existing or current use. The irrigation of land without the benefit of water rights, or in excess of existing water rights could have a significant impact on overall system characteristics and performance. While the verification of existing uses of water may fall outside the definition of "voluntary conservation" measures as employed herein, this matter should be given due consideration.

10.5 Consider Oxygenation of Walker Lake

This report discusses several options for the management of Walker Lake. One of those options, oxygenation, would result in an increase in suitable habitat for Lahontan cutthroat trout. As discussed in Section 7.3.5 of this document, that increased habitat potential would occur under all inflow conditions. RCI encourages that a pilot study be conducted. That study should be directed toward the definition of a practical oxygenation system for Walker Lake. The study should include the following elements:

- Determining the strength of summer stratification;
- Determining the preferred design and locations for an oxygenation system;
- Conducting preliminary designs;
- Installation of the pilot system;
- Operation of pilot system to determine field effectiveness and impacts to water quality and limnology;
- Evaluation to determine needs during periods of lower lake levels.

The installation of such a system would provide relief to reduced Lahontan cutthroat trout habitat during periods of summer stratification and periods of extended drought. The system would accomplish this by maintaining dissolved oxygen concentrations within tolerable limits in the deeper, cooler waters of the hypolimnion.

10.6 The "Who" and "When" Questions

For the most part, this report deals with the issues of "what" and "where." What types of actions are viable and where is their application the most relevant? Some may contend, however, that it is time to address two other equally critical issues. These are the issues of "who" will oversee the development and implementation of activities needed to conserve water resources in the Walker River Basin, and "when" will those activities occur. These issues are of particular importance now, as the Advisory Committee considers its future and the big-picture water planning matters that lay before the community at large in the Walker River Basin.

- The Advisory Committee could decide to fade away. The original intent of the Committee was to participate in the opportunity presented by the Bureau of Reclamation to address water conservation possibilities. With that contract nearing completion, the Committee could decide that its job has been completed.

- The Advisory Committee could decide to explore additional "what" and "where" issues in an effort to further define how water resources in the Walker River Basin could best be conserved. Without question these are critical issues. If the Advisory Committee or some other entity wants to continue the pursuit of things to do and places to do them, then the issues of what and where remain relevant.

- The Advisory Committee could decide to delve into the "who" and "when" issues. If it did so, the goal could be to provide definition to the entity or entities best suited to implement conservation programs in the Walker River Basin. Also, the Committee could develop purposes and goals that would help structure the basin-wide conservation program. The Committee could serve as an intermediary between the Basin's past and its future.

RCI encourages the Advisory Committee to give serious consideration to the third option. If the basin-wide community at large believes that steps should be taken to aid Walker Lake, then it is time to address the questions of "who" and "when." We encourage the Committee to serve this important and timely function. The Committee is the only existing, basin-wide, public entity that can serve in this capacity. Participation by all affected county governments and water right users makes the Committee a logical entity to consider these questions. In the following sections, RCI offers a few thoughts on the questions of "when" and "who."

10.6.1 The "When" Issue

Over the last year, we have heard a wide variety of opinions as to "when" it would be appropriate to implement some of the conservation measures discussed in this and other reports. Some would wait until resolution of the lawsuit brought by the U.S. Government on behalf of federal interests, including the Walker River Paiute Tribe. Until that legal matter is resolved, they say, any action that might change the status quo is premature. From this perspective, conservation measures such as those discussed herein may ultimately need to be implemented, but only as determined necessary by results of legal proceedings. For those at this end of the spectrum, the implementation of conservation measures is viewed as "Plan B."

At the other end of the continuum, are those who would proceed with activities as soon as administrative entities and/or funds are identified. From their perspective, assisting in the restoration (or at least maintenance) of Walker Lake is in the interest of the basin-wide community at large and should not be delayed. The best opportunity for local entities to retain decision-making authority is to take steps now to address this call for action. For those at this end of the spectrum, the pending lawsuit isn't as critical as the declining state of Walker Lake.

RCI would encourage the Advisory Committee and the basin-wide community at large to consider the second perspective. While a federal assessment team has been established to identify issues central to the lawsuit, it is unclear how long it may take before the matter is resolved. Resolution may not be realized until one or more drought cycles have occurred. Whether the lake and its fisheries can withstand such impacts is uncertain. Also, numerous viable activities could be conducted that may offer a win-win opportunity. Additional flows could be made available to Walker Lake without decimating the economic viability of any part of the basin. These are the options that should be explored now.

10.6.2 The "Who" Issue

If there is consensus that activities should be implemented in the near term, then the "who" issue becomes critical. As discussed in Chapter Six, administration could occur at a number of different levels, or it could be centralized in a single entity. Existing federal entities that could play a primary role include the Bureau of Land Management (BLM), the Natural Resource Conservation Service (NRCS), the Bureau of Reclamation (BOR), or the U. S. Board of Water Commissioners. States and local entities include various state agencies (the Division of Water Planning or the Division of Wildlife), county governments, or Walker River Irrigation District. Non-profit groups such as the Nature Conservancy or the Sierra Club, or private individuals also could play a major role. Each entity brings with it advantages and disadvantages.

It is suggested herein that consideration be given to the legal formation of a water conservancy district in accordance with Section 541 of the Nevada Revised Statutes. It is further suggested that the boundaries of the district take in that portion of the Walker River Basin contained in the State of Nevada (an alternative would be to form a bi-state conservancy district that encompassed all of the Walker River Basin). Formation of such a conservancy district would require the submission of a petition to district court. That petition would identify the purposes and goals of the conservancy district and would require the approval of all affected counties. Protests and objections to the conservancy district petition may be filed with the district court. A decision by the district court can be appealed to the Nevada State Supreme Court. Once organized, the Governor would appoint a board of directors, including representatives of each county represented in the conservancy district. Powers of a conservancy district that are of immediate relevance include the following:

- The ability to adopt plans that would direct the work for which the district was organized;
- The ability to appropriate monies and to levy and collect taxes and special assessments;

- The ability to accept grants or bequests;

- The ability to contract with the federal government (or any agency there of) and the State of Nevada (or any of its cities, counties or other sub-governmental subdivisions);

- The ability to purchase, lease, and to own water, waterworks, water rights, sources of water supply, and any and all real and personal property;

- The ability to sell, lease or otherwise dispose of water, waterworks, water rights and sources of water supply, and real and personal property; and,

- The ability to construct and maintain works.

The establishment of a conservancy district is encouraged because it would be a locally based and supported, State entity with broad powers to manage water to the benefit of the Walker River Basin at large. A Walker River Conservancy District could play the central integrating role that serves to tie together all parts of the basin, and offers a smooth conduit that allows participation by all levels of government – local, state, and federal. Similar conservancy districts currently exist in the Truckee River and Carson River basins.

10.7 SUMMARY

The relationship between Walker Lake and upstream development has been a subject of discussion for some time. In their 1881 history of Nevada, Thompson and West state that:

> "The waters of the lake [Walker Lake] have been gradually decreasing, owing probably to the supply being largely used for irrigating the ranches along the coarse of the river." (Thompson and West 1881:406)

Elsewhere in their history Thompson and West (1881:135, 141) noted that at that time there were 10 irrigation ditches in Lyon County serving 5,260 acres of land. Some 1,670 acres were cultivated; the remainder was used as pasture. By any standard, that level of use was minimal, yet it still evoked a skeptical assessment. A lot has changed in the Walker River Basin over the last 120 years, but the sense of friction inherent to the use of water and the plight of Walker Lake has not. As water use has increased, so has the intensity of the call for action to protect the lake. What was once a local issue increasingly has become a matter of national concern.

The purpose of this report was to review selected measures that if implemented could result in a more reliable inflow of water to Walker Lake. Most of the reviewed measures have been looked at before. Updated information and additional insights are provided, and certain measures are identified as the most appropriate. Considerable discussion is provided that may help structure future conservation activities in the Walker River Basin. We would contend, however, that the technical merit of various conservation measures is not the central issue. While they garner much of the attention, a more pressing matter quietly occupies center stage. That matter is the identification of when actions will be taken and by whom. It is the answers to these questions that will determine what measures are implemented and who will be impacted. Means are at hand to answer these questions, and to define and achieve a win-win solution. Required now is the resolve to do so.

Chapter Eleven — A LIST OF CONTRIBUTORS

The following is a list of individuals who were actively involved in the preparation of this document. Although not listed individually, all of those who attended Advisory Committee meetings have had an impact of the content and character of the document. Their participation and contribution is hereby acknowledged.

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Attachments

ATTACHMENT A

A PRELIMINARY LISTING OF WATER MEASURES THAT MAY INCREASE FLOWS TO WALKER LAKE

A PRELIMINARY LISTING OF WATER MEASURES THAT MAY INCREASE FLOWS TO WALKER LAKE

(major categories are listed alphabetically, their order of presentation does not reflect any form of ranking)

Measure	Advantages	Disadvantages	Relative Contribution	Relative Cost	Legal Considerations
Agricultural Conservation					
Change Manner of Distribution: change the manner in which irrigation waters are distributed to fields, placing a greater emphasis on lined ditches and pipelines.	Will reduce water conveyance loss	Will reduce level of ground water recharge; salvaged water can be used elsewhere or by others	Moderate	Moderate	May require changes to the decree
Change Manner of Application: shift emphasis on how water is applied to fields, placing a greater emphasis on sprinkler and drip systems, or placing a greater emphasis on the leveling of fields.	Will reduce level of water use	May reduce level of ground water recharge; salvaged water can be used elsewhere or by others	Moderate	Moderate	May require changes to the decree
Change Timing of Use: adjust the season of use to when irrigation waters would be most effective.	Will reduce level of water use	Salvaged water can be used elsewhere or by others	Low	Low	May require changes to the decree
Conjunctive Use of Ground Water: shift emphasis to the greater use of ground waters.	Will reduce emphasis on use of surface water; may reduce evaporative losses	May cause draw down of aquifers	Moderate	Moderate	May require changes to State water law and the decree

Measure	Advantages	Disadvantages	Relative Contribution	Relative Cost	Legal Considerations
Shift to Alternate Crops: shift emphasis to crops that require less water.	Will reduce level of water use	Salvaged water can be used elsewhere or by others	Low	Low	
Shift Priority Rights to Most Productive Soils: shift senior rights to the most productive farmlands.	Will reduce level of water use	Salvaged water can be used elsewhere or by others	Low	Low	May require changes to State water law and the decree
Reduce Winter Flows in Ditches: shift away from keeping water in ditches during the winter for livestock use.	Will reduce level of water use	Will require alternate means of stock watering; may reduce ground water recharge	Low	Low	May require changes to the decree
End-user Conservation					
Residential Water Conservation: implement increased water conservation in homes.	Will reduce level of water use	May reduce ground water recharge	Low	Low	May require changes to city and county ordinances
Municipal Water Conservation: implement increased water conservation in communities.	Will reduce level of water use	May reduce ground water recharge	Low	Moderate	May require changes to city and county ordinances
Commercial Water Conservation: encourage increased water conservation by local industry.	Will reduce level of water use	May limit potential for economic growth	Low	Moderate	May require changes to city and county ordinances
Ground Water Management					
Increase Infiltration: increase recharge to ground water through the greater use of basins, ditches, and surface treatments.	Will increase rate of ground water recharge; will decrease rate of evaporation	Will reduce surface water runoff; water quality may be a concern; will increase evaporative loss	Low	Moderate	

Measure	Advantages	Disadvantages	Relative Contribution	Relative Cost	Legal Considerations
Inject Excess Flood Waters: during flood events, or during seasonal high flows, inject surface water into ground water aquifers.	Will increase rate of ground water recharge; will decrease rate of evaporation	Will reduce surface water flows; water quality may be a concern	Moderate, if conjunctive use of stored water is allowed	Moderate	May require changes to State water law
In-stream Flood Management					
Water Spreading: intentionally spread flood flows onto large surfaces with the intent of increasing local infiltration.	Will increase rate of ground water recharge	Will reduce surface water runoff and stream flows	Low		May require changes to State water law
Dike or Levee Construction: build features in key areas where lateral dispersion of flood flows is not wanted.	Will increase down stream delivery of water; will afford flood protection	Will impact other resources in levee or dike area; may reduce ground water recharge	High	High	
Direct Routing of Flood Waters via Canals or Pipelines: build features that would convey flood flows directly to the Lake, around sensitive areas, or to reservoirs.	Will increase down stream delivery of water; will afford flood protection	Will impact other resources in canal or pipeline area; may reduce ground water recharge	High	High	May require changes to State water law
Temporary Backflow Storage: build areas into which flood waters could flow during high stage, and from which waters would flow back to the river as the flow subsided.	Will decrease the peak flood flow; will increase the duration of down stream flows; will afford flood protection	Will impact other resources in backflow storage area; will reduce surface water flows	Moderate	High	May require changes to State water law

Measure	Advantages	Disadvantages	Relative Contribution	Relative Cost	Legal Considerations
Lake Amendment					
Evaporation Control: apply a treatment to the Lake surface that would reduce the rate of evaporation.	Will reduce evaporation losses	May impact aesthetics, water quality	High	Moderate	
Treat Lake Water: construct a facility that would treat either river water or lake water, removing TDS and/or other pollutants.	Will improve Lake's water quality	Will impact other resources in treatment plant area; by-products may be an issue	Moderate	High	
Source Development					
Cloud Seeding: seasonally, chemically treat clouds in an attempt to increase the rate of precipitation.	Will increase surface water availability	Results questionable	Low	Moderate	
Inter Basin Transfer: build facilities that would pump, pipe, and deliver water to the Lake from outside the Walker River Basin.	Will increase direct inflow of water to the Lake; would not affect existing in-basin uses	May deplete ground water resources elsewhere	Moderate	High	May require changes to the State water law and the decree
Tributary Development: build small dams in tributaries near the Lake and pipe captured waters directly to the Lake.	Will increase direct inflow of water to the Lake; would not affect existing in-basin uses	Will reduce ground water recharge	Low, if tributaries flow into the Lake	Moderate	

Measure	Advantages	Disadvantages	Relative Contribution	Relative Cost	Legal Considerations
Vegetation Management					
Phreatophyte Control: routinely manage willows, cottonwoods, tamarisk, and other phreatopytes along the river channel.	Will reduce water lost due to transpiration	Will reduce or limit riparian vegetation along the river corridor	Low	Moderate	
Apply Anti-transpirants: spray plants with a chemical that reduces the rate at which transpiration occurs.	Will reduce water lost due to transpiration	Chemicals may have unwanted affects	Low	Low	
Forest Clearing: reduce the density of pinyon or juniper stands as a means of increasing surface runoff.	Will increase surface runoff in upper portions of watersheds	Increases in surface water may not enter the river	Low	Moderate	
Water Harvesting					
Treat Soils to Increase Runoff: chemically or physically treat soil surfaces to reduce infiltration, thereby increasing runoff.	Will increase surface runoff in selected watersheds	Will decrease ground water recharge; may increase erosion; increases in surface water may not enter the river	Low	Moderate	
Water Rights Acquisition / Change Place of Use					
Buy Storage Rights: purchase storage rights from willing sellers with the intent that purchased rights could be allocated to the Lake.	Will reduce level of water use; source of income to storage right seller	Salvaged water can be used by others; will reduce recharge in areas previously irrigated; will require regular funding	High, if salvaged water can be moved to the Lake	Moderate	

Measure	Advantages	Disadvantages	Relative Contribution	Relative Cost	Legal Considerations
Buy Decreed Rights: purchase decreed rights from willing sellers with the intent that purchased rights would be allocated to the Lake	Will reduce level of water use; source of income to decreed right seller	Salvaged water can be used by others; will reduce recharge in areas previously irrigated; will require regular funding	High, if salvaged water can be moved to the Lake	Moderate	May require changes to the decree
Buy Ground Water Rights: purchase ground water rights from willing sellers with the intent that the purchased rights would be credited to the aquifer or allocated to the Lake.	Will reduce level of water use; source of income to ground water right seller	Will require regular funding	High, if salvaged water can be moved to the Lake	Moderate	
Water Rights Leasing					
Annual Leasing of Rights: lease part or all of a right for the year from willing lessees with the intent that the leased right would be allocated to the Lake.	Will reduce level of water use; source of income to the lessee	Salvaged water can be used by others; will reduce recharge in areas previously irrigated; will require regular funding	High, if salvaged water can be moved to the Lake	Moderate	May require changes to State water law and decree
Seasonal Leasing of Rights: lease part or all of a right for some part of a year from willing lessees with the intent that the leased right would be allocated to the Lake.	Will reduce level of water use; source of income to the lessee	Salvaged water can be used by others; will require regular funding	High, if salvaged water can be moved to the Lake	Moderate	May require changes to State water law and decree

Measure	Advantages	Disadvantages	Relative Contribution	Relative Cost	Legal Considerations
Long Term Leasing of Rights: lease part or all of a right for more than a year from willing lessees with the intent that the leased right would be allocated to the Lake.	Will reduce level of water use: source of income to the lessee	Salvaged water can be used by others; will reduce recharge in areas previously irrigated; will require regular funding	High, if salvaged water can be moved to the Lake	Moderate	May require changes to State water law and decree
Water Salvaging					
Tail Water Collection: tail waters from agricultural, municipal, and commercial uses could be collected and reapplied, injected, or put into the river.	Will increase surface water flows	May degrade water quality of the river; may reduce ground water recharge	Low	Moderate	
Increase Effluent Use: Municipalities could make greater use of effluent as a means of reducing water needs.	Will reduce level of fresh water use	May increase treatment costs; may impact water quality	Low	Low	
Water Storage Management					
Increase Upstream Reservoir Capacity: additional stored water could be moved to the Lake during seasons when other uses would be limited and evaporation low.	Will allow for greater storage and allow timed releases; will provide greater flood control	Will impact adjacent land uses; may increase loss due to evaporation	High, if stored water can be moved to the Lake	High	May require changes to the decree

Measure	Advantages	Disadvantages	Relative Contribution	Relative Cost	Legal Considerations
Construct Additional Reservoirs: additional stored water could be moved to the Lake during seasons when other uses would be limited and evaporation low.	Will allow for greater storage and allow timed releases; will provide greater flood control	Will impact other resources in reservoir area; may increase loss due to evaporation	High, if stored water can be moved to the Lake	High	May require changes to the decree
Injection to Ground Water: actively use ground water aquifers as storage basins. The addition and removal of water from those basins would be via injection and pumping.	Will increase rate of ground water recharge	Will reduce surface flows; may impact water quality	Moderate, if conjunctive use of stored water is allowed	Moderate	May require changes to State water law
Remove Weber Reservoir: sedimentation has reduced the reservoir's capacity and dam safety is an issue.	Will reduce loss due to evaporation; will increase direct inflow to Walker Lake	Will reduce available storage; will impact Tribe's ability to store irrigation water; may increase in-channel erosion	Low	Moderate	

ATTACHMENT B

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE
HYDROGRAPHIC BASIN SUMMARY
BY STATUS FOR ACTIVE GROUNDWATER SOURCES
DATED 8/19/1999

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY STATUS FOR ACTIVE GROUNDWATER SOURCES

RUN DATE: 08/19/1999

HYDROGRAPHIC BASIN: 106 ANTELOPE VALLEY

HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

STATUS	ANNUAL DUTY UNDERGROUND		ANNUAL DUTY GEOTHERMAL		ANNUAL DUTY OTHER GROUNDWATER		ANNUAL DUTY TOTAL	
	AF	MG	AF	MG	AF	MG	AF	MG
VESTED RIGHT	.00	.00	.00	.00	.00	.00	.00	.00
RESERVED RIGHT	.00	.00	.00	.00	.00	.00	.00	.00
APPLICATION	.00	.00	.00	.00	.00	.00	.00	.00
READY FOR ACTION	9,498.10	3,094.97	.00	.00	.00	.00	9,498.10	3,094.97
PERMIT	1,269.48	413.66	.00	.00	.00	.00	1,269.48	413.66
RELINQUISH PORTION	.00	.00	.00	.00	.00	.00	.00	.00
REVOCABLE PERMIT	.00	.00	.00	.00	.00	.00	.00	.00
CERTIFICATE	5,297.49	1,726.19	.00	.00	.00	.00	5,297.49	1,726.19
DECREED	.00	.00	.00	.00	.00	.00	.00	.00

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY STATUS FOR ACTIVE GROUNDWATER SOURCES

RUN DATE: 08/19/1999

HYDROGRAPHIC BASIN: 107 SMITH VALLEY

HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

STATUS	ANNUAL DUTY UNDERGROUND AF	ANNUAL DUTY UNDERGROUND MG	ANNUAL DUTY GEOTHERMAL AF	ANNUAL DUTY GEOTHERMAL MG	ANNUAL DUTY OTHER GROUNDWATER AF	ANNUAL DUTY OTHER GROUNDWATER MG	ANNUAL DUTY TOTAL AF	ANNUAL DUTY TOTAL MG
VESTED RIGHT	1.23	.40	.00	.00	.00	.00	1.23	.40
RESERVED RIGHT	.00	.00	.00	.00	.00	.00	.00	.00
APPLICATION	79.96	26.06	.00	.00	.00	.00	79.96	26.06
READY FOR ACTION	552.40	180.00	.00	.00	.00	.00	552.40	180.00
PERMIT	5,258.65	1,713.54	.00	.00	.00	.00	5,258.65	1,713.54
RELINQUISH PORTION	200.34	65.28	.00	.00	.00	.00	200.34	65.28
REVOCABLE PERMIT	.00	.00	.00	.00	.00	.00	.00	.00
CERTIFICATE	54,354.20	17,711.37	.00	.00	134.83	43.93	54,489.03	17,755.31
DECREED	.00	.00	.00	.00	.00	.00	.00	.00

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY STATUS FOR ACTIVE GROUNDWATER SOURCES

RUN DATE: 08/19/1999

HYDROGRAPHIC BASIN: 108 MASON VALLEY

HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

STATUS	ANNUAL DUTY UNDERGROUND		ANNUAL DUTY GEOTHERMAL		ANNUAL DUTY OTHER GROUNDWATER		ANNUAL DUTY TOTAL	
	AF	MG	AF	MG	AF	MG	AF	MG
VESTED RIGHT	.00	.00	.00	.00	.00	.00	.00	.00
RESERVED RIGHT	.00	.00	.00	.00	.00	.00	.00	.00
APPLICATION	1,120.68	365.17	.00	.00	.00	.00	1,120.68	365.17
READY FOR ACTION	487.41	158.82	.00	.00	.00	.00	487.41	158.82
PERMIT	23,111.29	7,530.84	.00	.00	.00	.00	23,111.29	7,530.84
RELINQUISH PORTION	.00	.00	.00	.00	.00	.00	.00	.00
REVOCABLE PERMIT	.00	.00	.00	.00	.00	.00	.00	.00
CERTIFICATE	121,201.30	39,493.56	1,257.53	409.77	3,300.76	1,075.56	125,759.59	40,978.89
DECREED	.00	.00	.00	.00	.00	.00	.00	.00

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY STATUS FOR ACTIVE GROUNDWATER SOURCES

RUN DATE: 08/19/1999

HYDROGRAPHIC BASIN: 109 EAST WALKER AREA

HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

STATUS	ANNUAL DUTY UNDERGROUND AF	ANNUAL DUTY UNDERGROUND MG	ANNUAL DUTY GEOTHERMAL AF	ANNUAL DUTY GEOTHERMAL MG	ANNUAL DUTY OTHER GROUNDWATER AF	ANNUAL DUTY OTHER GROUNDWATER MG	ANNUAL DUTY TOTAL AF	ANNUAL DUTY TOTAL MG
VESTED RIGHT	9.18	2.99	.00	.00	.00	.00	9.18	2.99
RESERVED RIGHT	.00	.00	.00	.00	.00	.00	.00	.00
APPLICATION	.00	.00	.00	.00	.00	.00	.00	.00
READY FOR ACTION	2,569.67	837.33	.00	.00	.00	.00	2,569.67	837.33
PERMIT	15,139.96	4,933.37	.00	.00	.00	.00	15,139.96	4,933.37
RELINQUISH PORTION	.00	.00	.00	.00	.00	.00	.00	.00
REVOCABLE PERMIT	.00	.00	.00	.00	.00	.00	.00	.00
CERTIFICATE	6,712.77	2,187.36	.00	.00	.00	.00	6,712.77	2,187.36
DECREED	.00	.00	.00	.00	.00	.00	.00	.00

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY STATUS FOR ACTIVE GROUNDWATER SOURCES

RUN DATE: 08/19/1999

HYDROGRAPHIC BASIN: 110A WALKER LAKE VALLEY-SCHURZ SUBAREA

HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

STATUS	ANNUAL DUTY UNDERGROUND		ANNUAL DUTY GEOTHERMAL		ANNUAL DUTY OTHER GROUNDWATER		ANNUAL DUTY TOTAL	
	AF	MG	AF	MG	AF	MG	AF	MG
VESTED RIGHT	.00	.00	.00	.00	.00	.00	.00	.00
RESERVED RIGHT	.00	.00	.00	.00	.00	.00	.00	.00
APPLICATION	.00	.00	.00	.00	.00	.00	.00	.00
READY FOR ACTION	.00	.00	.00	.00	.00	.00	.00	.00
PERMIT	603.00	196.49	.00	.00	.00	.00	603.00	196.49
RELINQUISH PORTION	.00	.00	.00	.00	.00	.00	.00	.00
REVOCABLE PERMIT	.00	.00	.00	.00	.00	.00	.00	.00
CERTIFICATE	34.40	11.21	.00	.00	.00	.00	34.40	11.21
DECREED	.00	.00	.00	.00	.00	.00	.00	.00

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY STATUS FOR ACTIVE GROUNDWATER SOURCES

RUN DATE: 08/19/1999

HYDROGRAPHIC BASIN: 110B WALKER LAKE VALLEY-LAKE SUBAREA

HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

STATUS	ANNUAL DUTY UNDERGROUND		ANNUAL DUTY GEOTHERMAL		ANNUAL DUTY OTHER GROUNDWATER		ANNUAL DUTY TOTAL	
	AF	MG	AF	MG	AF	MG	AF	MG
VESTED RIGHT	.00	.00	.00	.00	.00	.00	.00	.00
RESERVED RIGHT	.00	.00	.00	.00	.00	.00	.00	.00
APPLICATION	.00	.00	.00	.00	.00	.00	.00	.00
READY FOR ACTION	.00	.00	.00	.00	.00	.00	.00	.00
PERMIT	2,074.41	675.95	.00	.00	.00	.00	2,074.41	675.95
RELINQUISH PORTION	.00	.00	.00	.00	.00	.00	.00	.00
REVOCABLE PERMIT	.00	.00	.00	.00	.00	.00	.00	.00
CERTIFICATE	29.75	9.70	.00	.00	.00	.00	29.75	9.70
DECREED	.00	.00	.00	.00	.00	.00	.00	.00

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY STATUS FOR ACTIVE GROUNDWATER SOURCES

RUN DATE: 08/19/1999

HYDROGRAPHIC BASIN: 110C WALKER LAKE VALLEY-WHISKEY FLAT-HAWTHORNE SUBAREA   HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

STATUS	ANNUAL DUTY UNDERGROUND		ANNUAL DUTY GEOTHERMAL		ANNUAL DUTY OTHER GROUNDWATER		ANNUAL DUTY TOTAL	
	AF	MG	AF	MG	AF	MG	AF	MG
VESTED RIGHT	.00	.00	.00	.00	.00	.00	.00	.00
RESERVED RIGHT	.00	.00	.00	.00	.00	.00	.00	.00
APPLICATION	.00	.00	.00	.00	.00	.00	.00	.00
READY FOR ACTION	.00	.00	.00	.00	.00	.00	.00	.00
PERMIT	2,822.65	919.76	4,664.71	1,520.00	.00	.00	7,487.36	2,439.76
RELINQUISH PORTION	.00	.00	.00	.00	.00	.00	.00	.00
REVOCABLE PERMIT	.00	.00	.00	.00	.00	.00	.00	.00
CERTIFICATE	8,208.75	2,674.83	.00	.00	1.99	.65	8,210.75	2,675.48
DECREED	.00	.00	.00	.00	.00	.00	.00	.00

ATTACHMENT C

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE
HYDROGRAPHIC BASIN SUMMARY
BY MANNER OF USE GROUNDWATER SOURCES
DATED 8/19/1999

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY MANNER OF USE FOR GROUNDWATER SOURCES

RUN DATE: 08/19/99

HYDROGRAPHIC BASIN: 106 ANTELOPE VALLEY

HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

MANNER OF USE	----- ACTIVE ANNUAL DUTY -----		----- PENDING ANNUAL DUTY * --	
	ACRE FEET	MILL GALLONS	ACRE FEET	MILL GALLONS
COMMERCIAL	337.28	109.90	528.52	172.22
CONSTRUCTION	.00	.00	.00	.00
DOMESTIC	1.63	.53	.00	.00
ENVIRONMENTAL	.00	.00	.00	.00
INDUSTRIAL	.00	.00	.00	.00
IRRIGATION (CAREY ACT)	.00	.00	640.00	208.54
IRRIGATION (DLE)	.00	.00	.00	.00
IRRIGATION	5,202.96	1,695.39	.00	.00
MINING & MILLING/DEWATERING	.00	.00	.00	.00
MUNICIPAL	.00	.00	.00	.00
POWER GENERATION	.00	.00	.00	.00
QUASI-MUNICIPAL	993.10	323.60	8,329.58	2,714.20
RECREATION	32.00	10.43	.00	.00
STOCK WATER	.00	.00	.00	.00
STORAGE	.00	.00	.00	.00
WILD LIFE	.00	.00	.00	.00
OTHER/DECREED	.00	.00	.00	.00

TOTAL NUMBER OF RECORDS WITH UNDEFINED ANNUAL DUTY: 0
* May include supplemental duties as well as duties associated with applications to change.

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY MANNER OF USE FOR GROUNDWATER SOURCES

RUN DATE: 08/19/99

HYDROGRAPHIC BASIN: 107 SMITH VALLEY

HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

MANNER OF USE	----- ACTIVE ANNUAL DUTY -----		----- PENDING ANNUAL DUTY * --	
	ACRE FEET	MILL GALLONS	ACRE FEET	MILL GALLONS
COMMERCIAL	2,537.30	826.78	.00	.00
CONSTRUCTION	.00	.00	.00	.00
DOMESTIC	227.16	74.02	.00	.00
ENVIRONMENTAL	.00	.00	.00	.00
INDUSTRIAL	57.84	18.85	.00	.00
IRRIGATION (CAREY ACT)	.00	.00	.00	.00
IRRIGATION (DLE)	1,184.04	385.82	.00	.00
IRRIGATION	54,183.60	17,655.78	632.36	206.06
MINING & MILLING/DEWATERING	530.95	173.01	.00	.00
MUNICIPAL	.00	.00	.00	.00
POWER GENERATION	.00	.00	.00	.00
QUASI-MUNICIPAL	188.25	61.34	.00	.00
RECREATION	.00	.00	.00	.00
STOCK WATER	608.71	198.35	.00	.00
STORAGE	.00	.00	.00	.00
WILD LIFE	.00	.00	.00	.00
OTHER/DECREED	431.39	140.57	.00	.00

TOTAL NUMBER OF RECORDS WITH UNDEFINED ANNUAL DUTY: 1
* May include supplemental duties as well as duties associated with applications to change.

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY MANNER OF USE FOR GROUNDWATER SOURCES

RUN DATE: 08/19/99

HYDROGRAPHIC BASIN: 108 MASON VALLEY

HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

MANNER OF USE	----- ACTIVE ANNUAL DUTY -----		----- PENDING ANNUAL DUTY * --	
	ACRE FEET	MILL GALLONS	ACRE FEET	MILL GALLONS
COMMERCIAL	195.50	63.70	.00	.00
CONSTRUCTION	.00	.00	.00	.00
DOMESTIC	16.23	5.29	.00	.00
ENVIRONMENTAL	218.85	71.31	.00	.00
INDUSTRIAL	11,375.82	3,706.82	.00	.00
IRRIGATION (CAREY ACT)	.00	.00	.00	.00
IRRIGATION (DLE)	.00	.00	.00	.00
IRRIGATION	117,179.84	38,183.17	522.13	170.14
MINING & MILLING/DEWATERING	7,418.94	2,417.47	.00	.00
MUNICIPAL	2,369.43	772.08	1,085.96	353.86
POWER GENERATION	.00	.00	.00	.00
QUASI-MUNICIPAL	1,013.81	330.35	.00	.00
RECREATION	6,037.57	1,967.35	.00	.00
STOCK WATER	402.37	131.11	.00	.00
STORAGE	.00	.00	.00	.00
WILD LIFE	2,642.52	861.07	.00	.00
OTHER/DECREED	.00	.00	.00	.00

TOTAL NUMBER OF RECORDS WITH UNDEFINED ANNUAL DUTY: 4
* May include supplemental duties as well as duties associated with applications to change.

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY MANNER OF USE FOR GROUNDWATER SOURCES

RUN DATE: 08/19/99

HYDROGRAPHIC BASIN: 109 EAST WALKER AREA

HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

MANNER OF USE	----- ACTIVE ANNUAL DUTY -----		----- PENDING ANNUAL DUTY * --	
	ACRE FEET	MILL GALLONS	ACRE FEET	MILL GALLONS
COMMERCIAL	.00	.00	.00	.00
CONSTRUCTION	.00	.00	.00	.00
DOMESTIC	.00	.00	.00	.00
ENVIRONMENTAL	.00	.00	.00	.00
INDUSTRIAL	.00	.00	.00	.00
IRRIGATION (CAREY ACT)	.00	.00	2,560.00	834.18
IRRIGATION (DLE)	.00	.00	.00	.00
IRRIGATION	21,129.55	6,885.08	.00	.00
MINING & MILLING/DEWATERING	669.96	218.31	.00	.00
MUNICIPAL	.00	.00	.00	.00
POWER GENERATION	.00	.00	.00	.00
QUASI-MUNICIPAL	.00	.00	.00	.00
RECREATION	.00	.00	.00	.00
STOCK WATER	62.39	20.33	9.67	3.15
STORAGE	.00	.00	.00	.00
WILD LIFE	.00	.00	.00	.00
OTHER/DECREED	.00	.00	.00	.00

TOTAL NUMBER OF RECORDS WITH UNDEFINED ANNUAL DUTY: 0
* May include supplemental duties as well as duties associated with applications to change.

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY MANNER OF USE FOR GROUNDWATER SOURCES

RUN DATE: 08/19/99

HYDROGRAPHIC BASIN: 110A WALKER LAKE VALLEY-SCHURZ SUBAREA

HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

MANNER OF USE	----- ACTIVE ANNUAL DUTY -----		----- PENDING ANNUAL DUTY * --	
	ACRE FEET	MILL GALLONS	ACRE FEET	MILL GALLONS
COMMERCIAL	.00	.00	.00	.00
CONSTRUCTION	.00	.00	.00	.00
DOMESTIC	1.63	.53	.00	.00
ENVIRONMENTAL	.00	.00	.00	.00
INDUSTRIAL	.00	.00	.00	.00
IRRIGATION (CAREY ACT)	.00	.00	.00	.00
IRRIGATION (DLE)	.00	.00	.00	.00
IRRIGATION	612.00	199.42	.00	.00
MINING & MILLING/DEWATERING	.00	.00	.00	.00
MUNICIPAL	.00	.00	.00	.00
POWER GENERATION	.00	.00	.00	.00
QUASI-MUNICIPAL	3.00	.98	.00	.00
RECREATION	.00	.00	.00	.00
STOCK WATER	20.78	6.77	.00	.00
STORAGE	.00	.00	.00	.00
WILD LIFE	.00	.00	.00	.00
OTHER/DECREED	.00	.00	.00	.00

TOTAL NUMBER OF RECORDS WITH UNDEFINED ANNUAL DUTY: 0
* May include supplemental duties as well as duties associated with applications to change.

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY MANNER OF USE FOR GROUNDWATER SOURCES

RUN DATE: 08/19/99

HYDROGRAPHIC BASIN: 110B WALKER LAKE VALLEY-LAKE SUBAREA

HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

MANNER OF USE	ACTIVE ANNUAL DUTY		PENDING ANNUAL DUTY *	
	ACRE FEET	MILL GALLONS	ACRE FEET	MILL GALLONS
COMMERCIAL	23.94	7.80	.00	.00
CONSTRUCTION	.00	.00	.00	.00
DOMESTIC	1.63	.53	.00	.00
ENVIRONMENTAL	.00	.00	.00	.00
INDUSTRIAL	.00	.00	.00	.00
IRRIGATION (CAREY ACT)	.00	.00	.00	.00
IRRIGATION (DLE)	.00	.00	.00	.00
IRRIGATION	4.19	1.37	.00	.00
MINING & MILLING/DEWATERING	.00	.00	.00	.00
MUNICIPAL	.00	.00	.00	.00
POWER GENERATION	.00	.00	.00	.00
QUASI-MUNICIPAL	2,074.41	675.95	.00	.00
RECREATION	.00	.00	.00	.00
STOCK WATER	.00	.00	.00	.00
STORAGE	.00	.00	.00	.00
WILD LIFE	.00	.00	.00	.00
OTHER/DECREED	.00	.00	.00	.00

TOTAL NUMBER OF RECORDS WITH UNDEFINED ANNUAL DUTY: 0
* May include supplemental duties as well as duties associated with applications to change.

NEVADA DIVISION OF WATER RESOURCES
WATER RIGHTS DATABASE

HYDROGRAPHIC BASIN SUMMARY - BY MANNER OF USE FOR GROUNDWATER SOURCES

RUN DATE: 08/19/99

HYDROGRAPHIC BASIN: 110C WALKER LAKE VALLEY-WHISKEY FLAT-HAWTHORNE SUBAREA

HYDROGRAPHIC REGION: 09 WALKER RIVER BASIN

MANNER OF USE	----- ACTIVE ANNUAL DUTY -----		----- PENDING ANNUAL DUTY * --	
	ACRE FEET	MILL GALLONS	ACRE FEET	MILL GALLONS
COMMERCIAL	.00	.00	.00	.00
CONSTRUCTION	.00	.00	.00	.00
DOMESTIC	1.99	.65	.00	.00
ENVIRONMENTAL	5.37	1.75	.00	.00
INDUSTRIAL	72.30	23.56	.00	.00
IRRIGATION (CAREY ACT)	.00	.00	.00	.00
IRRIGATION (DLE)	.00	.00	.00	.00
IRRIGATION	3,126.80	1,018.87	.00	.00
MINING & MILLING/DEWATERING	37.30	12.15	.00	.00
MUNICIPAL	6,501.47	2,118.51	.00	.00
POWER GENERATION	.00	.00	.00	.00
QUASI-MUNICIPAL	1,282.24	417.82	.00	.00
RECREATION	.00	.00	.00	.00
STOCK WATER	5.92	1.93	.00	.00
STORAGE	.00	.00	.00	.00
WILD LIFE	.00	.00	.00	.00
OTHER/DECREED	4,664.71	1,520.00	.00	.00

TOTAL NUMBER OF RECORDS WITH UNDEFINED ANNUAL DUTY: 0
* May include supplemental duties as well as duties associated with applications to change.