Continued Review of the Marlette Lake Water System

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CONTINUED REVIEW OF THE MARLETTE LAKE WATER SYSTEM

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SUMMARY OF RECOMMENDATIONS OF THE ADVISORY COMMITTEE

This summary presents the recommendations approved by the Legislative Commission's Marlette Lake Water System Advisory Committee (*Nevada Revised Statutes* 331.165). The Advisory Committee submits these proposals to the Governor of the State of Nevada and the members of the 71st Session of the Nevada Legislature for their consideration.

The committee recommends:

1. Continuation of the project of the Carson City Water Subconservancy District, including a cost benefit analysis and involvement of all stakeholders.

2. Cooperation of Washoe County and the United States Bureau of Land Management with Storey County officials on reinstatement of original right of way of the waterline from Lakeview to Virginia City.

3. That staff of the committee summarize recommendations of each previous interim Marlette Advisory Committee, and their disposition.

4. Support for the commitment by the Department of Administration to perform additional metering of water transported and sold to Virginia City.

5. Conducting a tour, following the 2001 Session, of the following facilities:

    - Yerington Hatchery
    - Federal Lahontan Hatchery
    - Water Master's House at Lakeview
    - Water Treatment Facilities in Carson City
    - Environmental Improvement Projects in the Marlette/Hobart Watershed

REPORT TO THE 71st SESSION OF THE NEVADA LEGISLATURE BY THE LEGISLATIVE COMMISSION'S MARLETTE LAKE WATER SYSTEM ADVISORY COMMITTEE

The Advisory Committee has attempted, in this report, to present a status report of the various state government programs in the Marlette/Hobart watershed and the provision of water to communities in Western Nevada. The photographs included in this report also provide a visual record of the various facilities, programs, and Advisory Committee activities during the 1999-2001 interim period. All supporting documents and meeting minutes are on file and available from the Research Library of the Legislative Counsel Bureau.

The Advisory Committee wishes to recognize and thank the many individuals who attended and testified at its meetings or participated in its field investigations.

This report is transmitted to the Governor of the State of Nevada and the members of the 71st Session of the Nevada Legislature for their information and consideration.

Respectfully submitted,

Senator Lawrence E. Jacobsen
Chairman, Marlette Lake Water System
Advisory Committee

I. INTRODUCTION

The Nevada Legislature's Marlette Lake Water System Advisory Committee is a permanent committee authorized by *Nevada Revised Statutes* (NRS) 331.165. A copy of NRS 331.165 appears on page 3 of this report.

At its meeting of August 19, 1999, the Legislative Commission appointed three members of the Legislature and one staff member of the Legislative Counsel Bureau (LCB) to serve on the Marlette Lake Water System Advisory Committee. The other four members of the committee were appointed by the executive branch agencies specified in NRS 331.165. The members serving on the Advisory Committee between the 70th and 71st Legislative Sessions were:

Senator Lawrence E. Jacobsen, Chairman
Assemblyman Joseph E. Dini, Jr., Vice Chairman
Senator Mark E. Amodei
Robert E. Erickson, Research Director, LCB (nonvoting member)
Mike Meizel, Chief, Buildings and Grounds Division, Department of Administration
Wayne R. Perock, Administrator, Division of State Parks, State Department of Conservation and Natural Resources
Steve Robinson, State Forester Firewarden, Division of Forestry, State Department of Conservation and Natural Resources (January 17, 2001 meeting)
Roy W. Trenoweth, State Forester Firewarden, Division of Forestry, State Department of Conservation and Natural Resources (October 15, 1999 meeting)
Gene Weller, Deputy Administrator, Division of Wildlife, State Department of Conservation and Natural Resources, State Department of Conservation and Natural Resources

Additional Legislative Counsel Bureau staff services for the Advisory Committee were provided by Brenda J. Erdoes, Legislative Counsel, Legal Division; Kimberly Marsh Guinasso, Principal Deputy Legislative Counsel, Legal Division; and Bruce Daines, Senior Deputy Legislative Counsel, Legal Division; and Nenita Wasserman, Senior Research Secretary, Research Division.

The Advisory Committee held two meetings during the 1999-2001 interim period. The meetings of October 15, 1999, and January 17, 2001, were both conducted at the Legislative Building in Carson City. Additionally, the Advisory Committee conducted three information gathering tours.

Tours conducted by the Marlette Lake Water System Advisory Committee were:

1. October 15, 1999 – Facilities in the Marlette Lake and Hobart Reservoir watersheds, and pipeline and water facilities between Hobart and Lakeview.

2. November 12, 1999 – Water treatment facilities at Virginia City, and pipeline and water facilities between Virginia City and Lakeview.

3. June 13, 2000 – Rainbow trout spawning and egg harvesting program of the Division of Wildlife at Marlette Lake.

During the course of the 1999–2001 interim, extensive expert testimony was received from the agencies represented on the Advisory Committee District and also from:

- Edwin James, Carson Water Subconservancy District

- Pamela B. Wilcox, Division of State Lands

- Greg Hess, Chairman, Storey County Board of County Commissioners

- Richard Bacus, Storey County Public Works Director

- Jay Howard, Nevada-Tahoe Resource Team

The basic function of this committee has been oversight of matters relating to the Marlette Lake Water System. The Advisory Committee may make recommendations to the Legislative Commission, the Interim Finance Committee, the Department of Administration, the State Department of Conservation and Natural Resources, and the Governor concerning any matters relating to the Marlette Lake Water System.

II. STATUTORY AUTHORITY

MARLETTE LAKE WATER SYSTEM

NRS 331.165 Advisory committee: Creation; composition; officers; recommendations.

1. The Marlette Lake water system advisory committee is hereby created to be composed of:

   (a) One member appointed by the Administrator of the Division of Wildlife of the State Department of Conservation and Natural Resources.
   (b) One member appointed by the Administrator of the Division of State Parks.
   (c) Three members from the State Legislature, including at least one member of the Senate and one member of the Assembly, appointed by the Legislative Commission.
   (d) One member from the staff of the Legislative Counsel Bureau appointed by the Legislative Commission. The member so appointed shall serve as a nonvoting member of the advisory committee.
   (e) One member appointed by the State Forester Firewarden.
   (f) One member appointed by the Department of Administration.

2. The voting members of the advisory committee shall select one of the legislative members of the advisory committee as chairman and one as vice chairman. After the initial selection of a chairman and vice chairman, each such officer serves a term of 2 years beginning on July 1 of each odd-numbered year. If a vacancy occurs in the chairmanship or vice chairmanship, the person appointed to succeed that officer shall serve for the remainder of the unexpired term.

3. The director of the Legislative Counsel Bureau shall provide a secretary for the advisory committee.

4. Members of the advisory committee serve at the pleasure of their respective appointing authorities.

5. The advisory committee may make recommendations to the Legislative Commission, the Interim Finance Committee, the Department of Administration, the State Department of Conservation and Natural Resources and the Governor concerning any matters relating to the Marlette Lake water system or any part thereof.

(Added to NRS by 1971, 834; A 1973, 1380; 1975, 1815; 1979, 907; 1985, 415; 1991, 1918; 1993, 1563)

III. HISTORICAL OVERVIEW

A comprehensive discussion of the history of the Marlette Lake Water System is contained in Bulletin No. 79 of the Legislative Counsel Bureau – *The Marlette Lake Water System-A Report on the Feasibility and Desirability of its Retention*, February 1969. The following overview summarizes the historical sections of that report and provides additional information that might be helpful as Nevada enters the 21st Century.

The Comstock Lode, one of the richest mining areas in the world, was discovered in 1859 on the eastern flank of Mount Davidson in the Virginia Range. The Virginia Mining District was the first mining district organized in western Utah Territory. The great mining town Virginia City was established nearby, with its post office dating from December 3, 1859. The nearby mining towns of Gold Hill (1859) and Silver City (1860) were soon established, and all three towns supported large populations in the 1860s, 1870s, and 1880s.

The provision of water to the mining towns on the Comstock posed a serious problem in early Nevada. Originally, several nearby springs and streams fed a series of tunnels, flumes, pipes, ditches, and reservoirs that were constructed. By the early 1870s, these supplies of water had become inadequate. As the area continued to grow, a decision was made by the Virginia and Gold Hill Water Company in August 1871 to develop a water system stretching over 21 miles to the west into the Carson Range, part of the Sierra Nevada Mountains. Surface water was plentiful in the Carson Range, but the key to the system was the inverted siphon, pressure pipeline designed by Hermann Schussler, a German-born engineer from San Francisco.

In August 1873, the first water from Hobart Creek in the Carson Range reached Virginia City and Gold Hill. Wild celebrations by residents of the area reverberated up and down the surrounding canyons and mountainsides. Originally, the system included: (1) a small diversion dam on upper Hobart Creek at Red House; (2) a 4.62-mile wooden flume to a tank that marked the start of the pipeline, at an elevation 351 feet higher than the outlet end of the pipeline in the Virginia Range; 3) a riveted, wrought iron, 11.5-inch, pressure pipeline extending seven miles, down to the lowest point on the system at Lakeview and back up to the high point in the Virginia Range; (4) a 4.04-mile flume to a point where Five-Mile Reservoir was constructed; (5) a 5.66-mile flume to tanks located above Virginia City and Gold Hill. The pipe for the system was made of iron plates bent to a cylindrical shape and then riveted. The pipe was fabricated in San Francisco and shipped by train to Lakeview. The pipe came in 26-foot sections and the thickness of each pipe segment varied depending on where engineering calculations showed differences in internal pressure. The first pipe segments were laid on June 11, 1873, and just six weeks later (July 25, 1873) the last section was in place. There were 1,524 joints in the pipeline as laid, and 1 million rivets and 35 tons of caulking lead were used in its installation.

In 1875, a second flume and pipeline was installed adjacent to the original system to double the original maximum production of 2.2 million gallons per day. However, the flow of water in summer months from the Hobart drainage dwindled to about 700,000 gallons per day.

Lumbering operations on the Lake Tahoe side of the Carson Range on Marlette Creek by Duane L. Bliss and H.M. Yerington started in 1873. They had constructed a small dam across the head of the Marlette depression, thereby forming Marlette Lake. In 1876, the Virginia and Gold Hill Water Company received permission to draw water from Marlette Lake to supplement the water from the Hobart Basin.

The dam at Marlette Lake was then raised to a height of 37 feet and a length of 213 feet. The lake formed by these improvements contained about 2 billion gallons of water (6,100 acre-feet). Unlike the nearby Hobart basin, the flow of water into Marlette Lake is plentiful and more consistent from year-to-year, even during dry periods.

From the dam at Marlette Lake, a covered box flume was constructed some 4.38 miles to the north. At that point a three-quarter mile tunnel was driven through the granite ridge dividing Lake Tahoe drainage from Hobart Creek drainage to the east. Another flume of 8.25 miles in length, known as the "north flume," was constructed north of the tunnel to capture water from many small creeks on the west side of the Carson Range. This flume joined the flume from Marlette Lake at the west portal of the tunnel. The tunnel was completed in May 1877, lined with timber for over half of its length, and measured 7 feet high and 6.5 feet wide on its floor.

From the east portal of the tunnel, a 2.77-mile-long flume was constructed to upper Hobart Creek. A storage reservoir with a capacity of 35 million gallons was built a short distance above Red House. Water from the second pipeline and Marlette Lake did not reach Virginia City and Gold Hill until mid-1877.

In 1887, a third pressure pipe was installed in substantially the same location as the first two pipelines. When completed, the water system included three reservoirs, a total of 21 miles of pressure pipes, approximately 46 miles of covered box flume, several structures and one three-quarter mile tunnel. The total investment at that time was in excess of $3.5 million.

With the decline of the Comstock in the years and decades to come, the fortunes of the water system suffered. In 1933, the water company's name was changed to the "Virginia City Water Company." By 1941, the company started to remove parts of the first (1873) and third (1887) pipelines to replace the flume between Five Mile Reservoir and Virginia City with pipes. Continued failures in the aging pipeline and a lack of funds caused the company to sell the water system to Curtiss-Wright Corporation in 1957. That corporation planned to use water from the system for a proposed missile test site on lands owned by that corporation in Storey County. However, the contract for the missile testing program was never approved. After making certain improvements to the system, Curtiss-Wright subsequently sold it to the Marlette Lake Company. In 1963, the Marlette Lake Company offered to sell the water system to the State of Nevada for $1.65 million of the state's general obligation bonds. Included in the sale, which was approved by the 1963 Legislature, were water rights, over 5,300 acres of land, easements, pipelines, flumes, Red House, the caretaker's house at Lakeview (Lakeview House, 1873), and other water facilities.

A related water project dates to 1903, when the Nevada Legislature appropriated $6,000 to secure additional water in Carson City for the State Capitol and State Orphan's Home. An additional $10,000 was appropriated in 1905 for this same purpose. Over the years that followed, wells were drilled in several locations. In 1959, the Legislature appropriated $15,000 to purchase water rights in Ash Canyon from the Virginia and Truckee Railway after the latter discontinued rail service to Carson City.

The sale was completed in 1961 and was enhanced with the purchase of the Marlette Lake Water System in 1963. For many years following those transactions, the State of Nevada was able to provide water to its Capitol Complex and maximum security prison. Subsequently, the State began selling water to Carson City, particularly during periods of peak demand.

Other notable dates in the history of the Marlette Lake Water System include:

- Tunnel collapsed in 1957. State of Nevada attempts to re-excavate that tunnel were abandoned after spending over $50,000.

- Wooden flume from east portal to Red House replaced with a pipeline in 1968.

- Diesel pump installed at Marlette Lake in 1966, with pipeline to Hobart Reservoir for periodic use during dry water years.

- Marlette Dam raised 15 feet in 1959, thus increasing capacity in Marlette Lake to over 4 billion gallons (11,800 acre-feet).

- A 1974 contract between the State of Nevada and Storey County to ensure the supply of water by the State to Virginia City, Silver City, and Gold Hill on a continuing basis, and to convey the siphon system and rights-of-way relating thereto, located east of Highway 395, from the State to Storey County for $500.

IV. STATUS REPORTS BY STATE AND LOCAL GOVERNMENT ENTITIES

During the October 15, 1999, and January 17, 2001, meetings of the Nevada Legislature's Marlette Lake Water System Advisory Committee, various reports were made by representatives from the Division of Forestry (NDF), the Division of Wildlife, the Division of State Parks, the Division of State Lands, all within the State Department of Conservation and Natural Resources, the Buildings and Grounds Division of the Department of Administration; and interested local government entities regarding the Marlette Lake and Hobart Reservoir Watersheds.

A. Division of Forestry, State Department of Conservation and Natural Resources

At the October 15, 1999, meeting, Rich Harvey, the Nevada Regional Manager of the Division of Forestry, presented information on Nevada Division of Forestry inmate work crew projects, which have been taking place at Marlette Lake and Hobart Reservoir. Crews have been working on several assignments including cutting dead trees, keeping the road open, and collecting seed. The crews work an average of 70 days per year and in 1998, there were 200 crew days for the removal of dead trees.

A commercial harvest was set up in 1994 to remove dead trees killed in the bark beetle epidemic. In 1998, after a large beetle breakout that occurred because of the drought in the Lake Tahoe Basin, the NDF completed an insect and disease survey. The study found Jeffrey Pine beetles in the Spooner North Canyon area and Fern Graver beetles were identified in the Franktown Creek area and above Hobart Reservoir.

The NDF purchased a zigzag yarder with federal grant money. The yarder, which looks like a small ski lift, can be attached to standing trees and can pick up debris and logs, up to eight-foot in length, up to a quarter mile away for firewood. The yarder is used to haul the firewood to the nearest road for collection. There are still remains of the timber harvest in certain areas of the forest, but the trees lose their value after two years due to rotting. Vehicle access is not possible and the expense of helicopter removal is too large to remove the many dead trees remaining in the forest.

At the January 17, 2001, meeting, Pete Anderson, Resource Program Director with the NDF, presented information on several programs taking place in the Marlette Lake and Hobart Reservoir areas, including:

- Utilizing inmate crews to continue to work on problems that have plagued the Carson Range for the last 20 years, including vegetation management and fuels reduction;

- Managing the Hobart/Marlette watershed as a "whole" water resource, recognizing that a wildland fire could be catastrophic to the health of the watershed;

- Addressing the fuel load problems with dead standing and downed timber. (Due to the most recent fire season, the Federal Government has established the National Fire Plan, which has resulted in a significant increase in funding for fire prevention and rehabilitation.)

- Taking a comprehensive look at the watershed and developing a plan to protect it from wildland fire and working to manage the fuel loads that have accumulated over the past 25 to 30 years;

- Planning to utilize mechanical treatments and replanting native vegetation in the Marlette/Hobart watershed before using prescribed fire; and

- Looking into other options for the dead and downed timber that is too old to be marketable for firewood.

B. Division of Wildlife, State Department of Conservation and Natural Resources

At the October 15, 1999, meeting, Dave Sanger, Staff Fisheries Biologist with the Division of Wildlife (DOW), reported on the Brood Stock Program at Marlette Lake. The Brood Stock Program began after the State of Nevada purchased Marlette Lake. The DOW phased out cutthroat trout spawning in 1984. Rainbow trout is the present brood stock established at Marlette Lake. Heenan Lake and Pyramid Lake currently supply cutthroat trout eggs for the fisheries program.

Since 1984, there have been approximately 4.9 million eggs taken from Marlette Lake. Due to weather changes and heavy snowpack, the rainbow trout brood stock has declined over the past four years. The DOW built a new spawning facility which required considerable effort. Further, the DOW is currently looking at rewriting the management plan for the Brood Stock Program at Marlette Lake.

Gene Weller, Deputy Administrator, DOW, addressed concerns regarding the movement by the Federal Government to abandon fish hatchery programs. The DOW recently completed a comprehensive management system study, which recommended stocking more fish, the most frequent request from the public and stakeholders. While a few groups would like to see hatcheries eliminated, it is doubtful due to a likely overwhelming public outcry.

The DOW provided a recap of the new spawning operation at Marlette Lake at the January 17, 2001, meeting. Mason Valley Hatchery personnel, biologists, and summer students manned the spawning station at Marlette Lake. Extensive use of volunteers was used for the spawning activities, including Senator Lawrence E. Jacobsen, and members of the Advisory Committee who assisted in egg harvesting activities in June 2000. Approximately 645 hours of volunteer help was realized over the spawning season. The volunteer program is a valuable and popular program. The monetary value of utilizing volunteers was approximately $18,000 (which mean matching federal program funds and reduce money from licensing fees for hatchery programs are available.)

In mid-May 2000, the road was cleared to permit vehicle passage to Marlette Lake. At this time, installation of the bottom screen on the fish trap took place. On May 31, 2000, the Mason Valley Hatchery crew and volunteers installed the spawning trap and set up the site for use.

In early June 2000, the first spawn took place where 179 female trout produced 189,655 eggs. On June 8, the second spawn took 157,450 eggs from 180 females. The third spawn took place on June 13, 2000, and 260 females produced 193,995 eggs. On June 20, 2000, 243,331 eggs from Tahoe strain rainbow trout were sent to the Gallagher Hatchery, which will be used for Eastern Regional needs. The fourth and final spawn, on June 21, 2000, took 151,747 eggs from 192 females. At that time, the crew and volunteers dismantled the fish trap and egg collection site. On June 22, 2000, the DOW returned the trailer and trap materials to the Mason Valley Hatchery.

In the 2000 spawning operation at Marlette Lake, 811 females produced 692,847 eggs, which made an average take of 854 eggs per female trout. This was the second best take in 15 years. Additionally, there was approximately one male per female ratio. There was not a shortage of males in the 2000 season.

The DOW used the air spawning method, where compressed air is injected into the cavities of the ripe females to strip the eggs, during the 2000 spawning season. By using the air spawning method, there was less physical damage to the female fish. The survival rate for the eggs in the 2000 spawning season was around 75 to 80 percent, an increase from the usual survival rate of 60 to 65 percent. It is unknown if this increase in the survival rate can be attributed to the air spawning method.

Frame nets were also used in the 2000 spawning season. The percentage of ripe females was higher for fish that swam up the creek into the trap. Furthermore, the nets are effective in providing fish earlier in the spawning run. A solar powered electric fence was set around the trap site to deter bears from entering the site. It appears that the fence was effective in deterring the bears, as there were bears near the trap site most evenings.

C. Division of State Parks, State Department of Conservation and Natural Resources

At the October 15, 1999, meeting, Mark Kimbrough, Regional Manager of the Carson City/Lake Tahoe Area in the Division of State Parks, presented information on the Marlette Lake area. The primary recreation use in the Marlette Lake area is hiking and mountain biking. Fishing is prohibited in Marlette Lake because of its value for rainbow trout brood stock. State Parks estimates that approximately 5,000 mountain bikers were counted per month along the Flume Trail with a hidden counter. Additionally, since traffic has increased in the Marlette Lake area, crews have installed a restroom, which is hidden by the trees.

Hobart Reservoir is also popular among recreation enthusiasts. Ash Canyon Road is a primary access route to Hobart Reservoir that needs improvement. State Parks does not maintain the road since the road ends on private property. In addition to the road, a difficult four-mile hike from Lakeview provides access into the area.

The Division of State Parks works with approximately 50 people on improvements for the Tahoe Rim Trail, which passes through the Marlette Lake area. Additionally, the Division is working with the University of Nevada, Reno, Nevada Conservation Corps' program to develop an alternate trail along North Canyon since many hikers no longer use the main trail due to the high volume of mountain bikes. Further, there are no plans to restrict the number of mountain bikers, as there is a restricted amount of parking available for all users.

At the January 17, 2001, meeting, Jay Howard, Resource Ranger, Nevada-Tahoe Resource Team, State Department of Conservation and Natural Resources, presented information on programs and activities in the Marlette/Hobart area. The most significant programs taking place are the Environmental Improvement Projects (EIP). The Federal Government, the State of Nevada, the State of California, local governments, and private partners are preserving Lake Tahoe's unique environment through partnerships. The State of Nevada put together the Nevada-Tahoe Resource Team, which has the goal to protect and enhance the quality of the air and water, as well as protect and restore natural watercourses, wetlands, wildlife habitats, fisheries, vegetation, and the forest. The team is looking at the prevention and control of erosion and the enhancement of recreational and tourism opportunities in the Lake Tahoe Basin.

Environmental Improvement Projects taking place in the Lake Tahoe State Park include:

- Development of the North Canyon alternative hiking trail. The trail will expand four miles from Spooner Lake to Marlette Lake and will be limited to hiker and equestrian users only. The trail is being developed as an alternative to alleviate conflict between hikers, equestrians, and mountain bikers.

- Forest restoration, phases one through five, is a multiphase, multimillion dollar project to reduce the threat of fire and increase health and vigor of forest and state lands. Thinning of overstocked white fir occurred in summer 2000 near the Spooner picnic area. Standing dead timber was removed above Spooner Meadow. A small quantity of wood (450 cords) went to a public fuel wood sale, which removed dead timber from approximately 10 to 15 acres. When conditions are right, another 40 acres will have a small scale logging and thinning operation.

- An archeological study was completed in the North Canyon corridor and areas around Marlette Lake.

- Several wildlife projects are taking place or are in the planning stages. These projects include sugar pine old growth habitat restoration, wildlife habitat enhancement, and North Canyon old growth habitat restoration. These projects involve thinning for habitat health and planning for the benefit of wildlife species.

- Maintenance will take place on the North Canyon road and Tunnel Creek road to assure compliance with minimum standards for reducing sedimentation loss and keeping structural integrity of the roads. In fall 2000, State Parks upgraded a lower canyon culvert crossing.

The planning section of Nevada State Parks is moving forward on EIP projects in the area. Spooner Summit trailhead on Highway 50, Spooner parking lot improvements, and Spooner Lake visitor center are all projects under consideration.

The backcountry of Lake Tahoe Nevada State Park, consisting of approximately 14,000 acres and located from Spooner Lake north to Tunnel Creek, and from Sand Harbor to areas east of Hobart Reservoir and above Washoe Valley, is a highly used and very popular area throughout the year. Some popular portions of the backcountry are the North Rim Trail, the Flume Trail, and the Tahoe Rim Trail. Summertime activities include catch and release fishing at Hobart, equestrian activities, mountain biking, and hiking. Winter activities include cross-country skiing and snowshoeing. There are two primitive unimproved campgrounds in the backcountry area.

The park as a whole receives close to one million visitors per a year, with nearly 150,000 visitors going to the Spooner Lake area. Approximately 60 percent of visitors to Spooner are mountain bikers, and 10 percent are hikers. Many park users go uncounted when they enter the park from Tunnel Creek, the Tahoe Rim Trail, and Ash Canyon.

The Division of State Parks manages the backcountry as a state primitive area, which is "a protected natural environment, managed to prevent damage of the natural conditions and to provide opportunities for solitude or primitive recreation special features." Vehicles are prohibited, with the exception of backcountry permit holders, government vehicles on official business, and emergency traffic. Backcountry permits are available to applicants who meet specific criteria, and on a case-by-case basis.

Additional recreation opportunities exist in the backcountry area under special use permit that allows a concessionaire to operate a cross-country ski area based at Spooner Lake. In the year 2000, the same operator began a mountain bike rental and guide service. The concessionaire also operates two backcountry primitive style cabins in the North Canyon and is permitted to build one more this summer.

The Division of State Parks is considering permanently closing a campground near Franktown Creek due to lack of use. Building another primitive camping area at Hobart Reservoir is under consideration. A slightly improved and controlled camping area would meet the needs of recreationists and reduce illegal camping. State Parks is considering another potential camping area at Twin Lakes. This area is experiencing an increase in visitation from the Tunnel Creek Trail and the Tahoe Rim Trail. Further, the presence of a backcountry seasonal ranger has offered a tremendous opportunity for educating the recreational users in the area as well as assisting in emergencies.

D. Division of State Lands and Nevada-Tahoe Resource Team, State Department of Conservation and Natural Resources

Pamela B. Wilcox, Administrator and State Land Registrar for the Division of State Lands, presented an overview of Interagency Lake Tahoe Programs and how the programs relate to the Marlette Lake Water System. The new programs have resulted from the Tahoe Presidential Forum in 1997. The Forum recognized that to preserve Lake Tahoe, all interested parties would have to contribute. The goal is to evaluate every acre in the Lake Tahoe Basin, so that the entire ecosystem can be healthy.

The 1999 Legislature provided funds for Nevada's portion of the Tahoe Environmental Improvement Program through Assembly Bill 285 (Chapter 514, *Statutes of Nevada 1999*), which establishes a program to protect the Lake Tahoe Basin. Additionally, the 1999 Legislature designated funds to agencies for additional staff to establish the Tahoe Interagency Team. The team will look at the wildlife, vegetative, and water resources together as the whole ecosystem.

Of the nine projects approved by the Legislature during the last session, four will benefit the backcountry around Marlette Lake. These projects include an old growth restoration project, restoration of a hiking trail, an upland wildlife enhancement project, and the first phase of the forest enhancement project.

Ms. Wilcox also presented information on the status of the Nevada-Tahoe Resource Team at the January 17, 2001, meeting. The archeological studies are going well. The first study is complete and more will be done before the other projects are scheduled to begin. The Division of State Lands is working to perform its projects in a high quality manner and treat the individual resources as a total resource, looking at the entire ecosystem.

E. Buildings and Grounds Division, Department of Administration

Mike Meizel, Chief, Buildings and Grounds Division in the Department of Administration, presented information on the management of state property in the Marlette Lake and Hobart Reservoir area. In the past, water was sold to Carson City and Lakeview. The State discontinued using the Ash Creek Water Treatment Plant which was used from the mid-1970s in 1999 because Carson City now has a full water treatment facility.

Currently, the State supplies only raw water to Carson City and Storey County. Storey County treats the water for use in Virginia City and Gold Hill, and for resale to Silver City in

Lyon County. Two projects were funded through the 1999 Legislative Session; an engineering project on a gravity collection system from Marlette Lake for $61,000, and a preliminary engineering project that would design an emergency action plan for both Hobart Reservoir Dam and the dam at Marlette Lake. It is important to have a plan for the water from Marlette Lake, whether it is an emergency backup supply or as a primary supply with the other water.

The Buildings and Grounds Division works with the Division of State Parks and the Division of Forestry to keep the road system in good condition. From Red House down to the diversion tanks, the road is primitive and just open enough to allow a truck to pass. There has been increased bicycle traffic through the Lakeview community. If the traffic continues to increase, the road may be closed.

Pat McInniss, Engineer, Buildings and Grounds Division, presented information on the water rights on Marlette Lake. The State of Nevada has an annual water right of 3,000 acre-feet of water at Marlette Lake, which is predicated only on using three feet of the drawdown because of fisheries protection. If the water level is decreased by more than three feet, the spawning ground of the fish is altered.

The Buildings and Grounds Division plans to rent the historic Lakeview House on a short-term basis until the Division of State Parks is ready to take control of the building. The purpose of keeping the house occupied is to reduce the risk of vandalism. A Lakeview interpretative center, explaining the history and significance of the house, water system and pipeline, is under consideration.

F. Local Governments

Storey County

Greg Hess, Chairman of the Storey County Board of Commissioners, reviewed problems that his county is having with water and the old pipeline. He reported that water users in Storey County have an average monthly water bill of approximately $100 to $130. The county cannot raise the water rates because people cannot afford it. Consequently, Storey County is looking to acquire grants to replace the old pipeline, which is in very poor condition, from Lakeview up to Five Mile Canyon Reservoir.

Additionally, he reported that the old pipeline is engrossed at the surface in many places, making it very easy for access by the public. There have been problems with holes shot into the pipeline and the removal of couplers. Further, it is impossible to access the waterline during the winter due to the elevation, and snow, steep grade where the waterline is located. Storey County would like the water meter moved to its original position, as the County questions some of the data supplied by the State.

Richard Bacus, Public Works Director for Storey County, commented on the status of the Storey County water pipeline. Storey County now has a grant for an engineer to examine the pipeline. The engineer estimates that the pipeline needs approximately $2 million worth of improvements.

Storey County is working with the limited resources available to maintain the pipeline. The county loses an average of 3 million to 4 million gallons a month where there is leakage out of the reservoir. Replacement pipeline is being acquired and the most difficult challenge in upgrading the water system will be the actual replacement of the pipe. Storey County is considering the possibility of purchasing water from Carson City via Mound House, then to Silver City where the water could be sent to a pump station in Virginia City.

Greg Hess, Chairman of the Storey County Commission, presented additional information at the January 17, 2001, meeting. The main concern is that the Marlette Water System currently is Virginia City's only source of water. The pipeline from Five Mile Reservoir is in decrepit shape because it was not maintained properly years ago. Parts of the pipeline have been exposed for 40 to 50 years, and in many places, a pencil can be pushed through the metal pipe. Several preventative measures are taking place to try to eliminate water loss on the pipeline, and Storey County has received a grant to assist in upgrading the water system. However, none of the pipeline is located in Storey County. The pipeline crosses land in Carson City and Washoe County, which is in Washoe, state, federal, and private ownership. Storey County needs easements and rights-of-way to properly repair and maintain the pipeline, which should be relocated to its original alignment.

Storey County does not feel that its problems come from the pipeline, which should be relocated to its original alignment, but from the unfunded mandate to build the new water treatment plant and the discrepancy in the billing for water from the State. The County has not been able to identify where the difference in water usage originates. The County feels as though the difference comes from the metering. Storey County officials would like to see the meter moved east of Five Mile Reservoir since the meter needs a minimum of 10 to 15 feet of straight-line pipe to operate correctly. The discrepancy can be as much as 50 percent, and Storey County only has approximately 400 billable water users.

Virginia City currently is allowing only 12 new residential hookups a year, with no more than 3 per person for Virginia City, Gold Hill, and Silver City. The water filtration plant is operating very efficiently. Additionally, Storey County has discussed the prospect of entering the water business, but the County needs an improved pipeline. The County has considered obtaining water, filtering it and then distributing water all the way to Mound House. If Storey County could obtain the necessary easements, the County would be well on its way to entering the water business.

V. WATER SYSTEM STATUS REPORT, CURRENT PROJECTS, AND SUGGESTED IMPROVEMENTS

A. Water System Status Report

The Carson Water Subconservancy District and the Brown and Caldwell engineering firm prepared a comprehensive review of the water system from Marlette Lake to the Ash Canyon Water Treatment Plant in the "Engineering Report for Upgrading the Marlette Lake Hobart Reservoir Water Delivery System," This report was provided to the Committee on January 17, 2001 (Appendix A). Generally, the East Slope collection system from Marlette Lake to Franktown Creek is in need of repair. With inexpensive and minor repairs to this part of the system, additional water would immediately be placed back into the system.

Hobart Reservoir has lost capacity due to sedimentation and has a current capacity of approximately 100 acre-feet. The Red House diversion structure, which is a concrete diversion dam, discharges water from Hobart Reservoir into an 18 inch steel pipeline above the Red House storage tanks. These structures are in generally good repair and have the capacity to handle the full water right at a constant flow rate.

There are two 8 inch pipelines leaving the storage tanks above Lakeview. One pipeline delivers water to the Ash Canyon Water Treatment Plant of Carson City, while the other delivers water to the Virginia City water system. Both pipes are undersized and incapable of transporting the full amount of water allowed. Both water delivery systems, to Virginia City and the Ash Canyon Water Treatment Plant, need to be upgraded and repaired.

B. Current Projects and Suggested Improvements

Storey County continues to work to maintain the pipeline from Five Mile Reservoir to Virginia City. Storey County has limited available resources to repair and maintain the system. Although it has limited resources and difficulty in accessing the pipeline during the winter, Storey County maintains the water system to the best of its ability.

The engineering report by Brown and Caldwell recommended several improvements to the Marlette Hobart Water System to increase capacity and efficiency. These recommendations are provided in the Executive Summary of the Carson Water Subconservancy District report (page vi, of Appendix A).

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VII. APPENDICES

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APPENDIX A

Carson Water Subconservancy District Report

Engineering Report for Upgrading the Marlette Lake Hobart Reservoir Water Delivery System

December 8, 2000

Prepared For:

Carson Water Subconservancy District
777 East William Street, Suite 100A
Carson City, Nevada 89701

Prepared By:
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Carson City, Nevada

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ABBREVIATIONS, CONVERSION FACTORS, AND DEFINITIONS OF TERMS

(For internal consistency and ease of communication, water volumes in this report are reported as acre-feet (AF), and stream and pipe flow rates in cubic feet per second (cfs). Calculations were generally performed in International (meters, kilograms, seconds) units, and converted to Imperial units)

ACWTP	Ash Canyon Water Treatment Plant, operated by Carson City Utilities
AF	Acre-feet. 1 AF = 43,560 ft^3 = 325,851 gallons = 1223.48 m^3
AFD	Acre-feet per day
CCUD	Carson City Utilities Department
cfs	Cubic feet per second 1 cfs = 448.83 gallons per minute = 0.0283 m^3 per second
CMP	Corrugated Metal Pipe
CPI	Consumer Price Index – a normalized index of the price of goods and services, herein used to update historical cost estimates to the present day.
CWSD	The Carson Water Subconservancy District is an organization created to direct and ensure water supply to Carson City and portions of Lyon, Storey, Douglas, and Washoe Counties, pursuant to NRS 277.060.
ϕ	Greek letter phi - diameter
Firm Yield	The volume of water which is produced by a system with a 95% probability of realization, roughly corresponding to the water produces in the driest year of any 20-year period.
gpm	Gallons per minute. 1gpm = 0.002238 ft^3 per second
GPS	Global Positioning System. A network of satellites operated by the United States Government and others which broadcast their positions continuously. These transmissions are used to locate objects on the earth's surface.
head	The equivalent vertical distance between the free water surface at an initial point and a final point. Head may be derived from elevation, pressure, work performed, or heat added.

Abbreviations, Conversion Factors, And Definitions Of Terms – Continued

hp	horsepower.
meter	System Internationale base unit of length, defined as the length of the path traveled by light in vacuum during a time interval of 1/299,792,458 of a second, with an iodine-stabilized Helium-Neon laser as the preferred light source. 1 meter = 3.2808 feet (Penzes, 2000)
m^3	Cubic meter(s). 1 m^3 = 35.315 ft^3 = 264.17 gallons
MG	million gallons. 1 MG = 133,681 ft^3 = 3.069 acre-feet = 3785.4 m^3
MGD	million gallons per day. 1 MGD = 1.547 cfs = 694.4 gal/min = 3785.4 m^3/day
MHWS	The Marlette Lake – Hobart Reservoir Water System (as defined in NRS 331.160 1) is composed of the water rights, easements, pipelines, flumes and other fixtures and appurtenances used in connection with the collection, transmission, and storage of water in Carson City and Washoe and Storey Counties, Nevada, acquired by the State of Nevada pursuant to law and created by the Statutes of 1973.
MSL	Mean Sea Level (North American Datum of 1927)
NAD 27	The North American Datum of 1927 is the coordinate base used in this report. This choice of datum corresponds to available USGS 7 ½-minute quadrangle maps.
psi	Pounds per square inch.
psig	Pounds per square inch gauge – or relative to atmospheric pressure.
Tanks	The Virginia City siphon inlet and Carson City pipeline inlet tank located at about elevation 7,140 ft MSL in the Carson Range above Lakeview.
Tunnel	The historic Incline Tunnel, constructed to divert waters from the Lake Tahoe drainage basin as a component of the collection and delivery system to the Comstock region of Nevada.
USGS	The United States Geological Survey

EXECUTIVE SUMMARY

As part of Phase II feasibility studies for the Carson Water Subconservancy District, Brown and Caldwell investigated options for increased utilization of the Marlette Lake – Hobart Reservoir Water System (MHWS). The MHWS is a source of high-quality water for municipal, industrial, and commercial use that has been under-utilized in recent decades as the population in the Carson River watershed as grown. The MHWS is an historical system of impoundments, pipelines, tanks and flumes, and has operated continuously since approximately 1870 when it was constructed to deliver water to the Comstock region of Nevada. Since that time, certain components have been replaced or upgraded, and some components are almost non-functional. System components were designed and constructed to be directly usable in an upgraded system, and this study presents a phased approach to improved delivery of MHWS water. A phased approach to upgrading delivery of MHWS water involves both low-cost and high-cost improvements to increase system capacity.

Stream gauge measurements over 22 consecutive years from permanent gauging stations established by the United States Geological Survey were used to refine estimates of available water from the system. The total water available from the MHWS ranges from the dry-year yield (without pumping from Marlette Lake) of 1,878 acre-feet (AF) to the wet year yield of 16,925 AF. Proposed improvements consider this order-of-magnitude variation. Additional considerations include the limitations and requirements for proof of beneficial use of the 12,412 AF that are permitted for the system and projected maximum demands of Carson City, estimated to be 16,800 AF by the year 2050.

This study presents evaluations and preliminary cost estimates for a phased approach to deliver larger volumes of water to Carson City. Specific recommendations include the following:

- The repair of the East Slope Drainage collection system;
- Construction of infiltration basins to the west of Carson City and pipelines to deliver overflow waters to them;
- Construction of a new pipeline from the Tanks to the Ash Canyon Water Treatment Plant; and
- Construction of a permanent pumping station at Marlette Lake to replace the temporary mobile pump OR construction of a subsurface conduit (partially cased borehole) to deliver water from Marlette Lake by gravity flow to the Hobart Creek drainage.

Estimated costs for the phased upgrade of the MHWS are provided in the following table.

Recommendations, Estimated Costs, and Value of Improvements					
(Delivery in Acre-Feet per Year)	MHWS Average Year Delivery	MHWS Dry Year Delivery	MHWS Wet Year Delivery	Total Capital Cost	Total Annual Cost
Existing System	1,873	1,440	1,872	n/a	n/a
Phase I					
Repair Existing East Slope Collection System	2,629	1,605	2,660	$2,751	$2,751
Phase II					
Install West Carson City Aquifer Infiltration Basins and Pipelines	n/a	n/a	n/a	$316,938	$5,000
Install Four Extraction Wells at West Carson City Aquifer Site	n/a	n/a	n/a	$2,150,400	$2,000
Install 10" Pipeline from the Tanks to ACWTP	3,565	1,742	5,378	$2,355,269	$0
Retrofit and Repair existing 8" pipeline	n/a	n/a	n/a	$1,549	$0
Phase III					
Test and Inspect 18" Transmission Main from Red House diversion to the Tanks	3,580	1,742	5,816	$11,504	$0
Phase IV					
Install Permanent Pumping Station at Marlette Lake – Diesel	5,328	2,540	8,122	$531,888	$134,000
Install Permanent Pumping Station at Marlette Lake – Natural Gas	5,328	2,540	8,122	$1,554,140	$134,000
Install Permanent Pumping Station at Marlette Lake – Electric	5,328	2,540	8,122	$10,581,074	$153,301
OR Install 10" borehole from Marlette Lake to Hobart Reservoir	5,632	2,540	8,777	$5,412,400	$2,000
Totals including Marlette Pumping Station - Diesel				**$5,370,299**	**$143,751**
Totals including Marlette Pumping Station – Natural Gas				**$6,392,551**	**$143,751**
Totals including Marlette Pumping Station – Electric				**$15,419,485**	**$163,052**
Totals including Marlette to Hobart Borehole				**$10,250,811**	**$11,751**

SECTION 1.0
INTRODUCTION

Brown and Caldwell prepared this study of the Marlette Lake – Hobart Reservoir Water System (MHWS) for the Carson Water Subconservancy District. The assessment of the MHWS was identified in the Phase I Water Resource Analysis of the Carson River Watershed as a critical component of supply to local municipalities (Brown and Caldwell, 2000). This report analyzes existing conditions on the various elements of this system, and presents feasible alternatives and associated capital and operating cost estimates for upgrading the system to accommodate and utilize seasonal changes in runoff volume for the long-term goal of more complete use of existing water rights. In addition, this study addresses management of additional resources from the MHWS through aquifer recharge for conjunctive use during seasonal and annual variations in water availability and use.

The MHWS is composed of connected drainages and infrastructure components originally used to divert water for use in the Comstock mining era. Currently, the MHWS delivers water to Carson City and surrounding communities including Virginia City, Gold Hill, and Silver City. The system gathers water from three hydrographic sub-basins of the Carson Range between Lake Tahoe and Carson City (Figure 1). The sub-basins, drainages and constructed infrastructure lie entirely within the State of Nevada (Figure 2, enlarged as Plate 1). Water rights associated with the MHWS are all owned by the State of Nevada, and delivered water is sold to various municipal and regional entities.

Documentation and study of the MHWS ranges from popular historical accounts to recent engineering reports (WRC, 1974; 1975; and KJC, 1990). Several sources of data and information have contributed to this analysis of the MHWS. For example, land surface information available from the Nevada Department of Transportation has allowed accurate topographic mapping on the scale of 3-meter contours (10-foot contours are used in this study), as compared to the 40-foot contours previously available from USGS mapping. USGS gauging stations were installed in the early 1970's on Marlette Creek and Franktown Creek, and have monitored streamflow since that time. These data have been partially utilized in previous reports, but the accumulation of a longer period-of-record has provided the basis for this analysis of yield based entirely on measured data.

Due to conflicting historical information on the size, location, and configuration of MHWS components, Brown and Caldwell has inspected the water delivery system from two origin points given limitations of pipe exposure: the exit of the Incline Tunnel (now partially collapsed) and from an inactive pumping station on Marlette Lake, to the final point of delivery to the Ash Canyon Water Treatment facility west of Carson City. The various existing facilities in this system are shown in Figure 2, and more completely described in Section 3.0.

The purpose of this study is to evaluate alternatives that will result in a phased increase of surface water delivered to Carson City, and an upgrade to the capacity of the existing MHWS. Given the preliminary scope of this study, historical cost estimates have been utilized where applicable and no attempt has been made to quantify amortization periods or the effect of costs on existing utility rate structures. The size and capacity of the proposed facilities are based on updated yield information from USGS gauging stations and existing under-utilized water rights held by the State of Nevada. The remainder of this study provides a description of the existing system, specific recommendations for repair of the existing system and recommendations for project implementation. This study evaluates the following potential improvements to the MHWS:

- Repair and maintenance of specific portions of the existing system observed to be in poor or non-functional condition at the time of this report;
- Construction of a parallel pipeline between the Incline Tunnel exit and the Red House Diversion Facility;
- Construction of a borehole from Marlette Lake to Hobart Reservoir to collect, by gravity flow, waters for which the State of Nevada holds certificated rights;
- Construction of a permanent pumping station attached to the existing pipeline from Marlette Lake to the Hobart Creek drainage;

- Increased storage capacity of Marlette Lake and/or Hobart Reservoir;
- Construction of a parallel pipeline between the Tanks and the Ash Canyon Water Treatment facility;
- Construction of higher capacity delivery systems, recharge basins and supply wells on the alluvial fan immediately to the west of Carson City to receive diverted surface water from the expanded system.

SECTION 2.0
EXISTING WATER SUPPLY SYSTEM

The existing supply system of the MHWS is described in this section. The various watersheds (hydrographic sub-basins) are shown in Figure 2, which is enlarged as Plate 1.

2.1 System Background and General Description

The MHWS originated in the 1870s to provide for mining and domestic use in Virginia City as ground and surface water sources became exhausted or were made unavailable by mine dewatering. Currently, the MHWS is the sole water delivery system to Virginia City, via an inverted siphon from the Tanks across Washoe Valley to Five-Mile Reservoir in the Virginia Range (Figure 2). At the time of construction, this siphon was an engineering marvel, achieving 6.8 cfs (3,055 gpm or 4.4 MGD) delivery through two steel pipes which sustained pressures of 744 pounds per square inch to the booming Virginia City area (KJC, 1990). Water has been steadily available to Virginia City to the present time. Water is also delivered to Carson City via a pipeline from the Tanks.

The WRC (1974) report states: "Many of the original facilities of the MHWS are currently in use in some form or another. The original flumes have all deteriorated and been retired, although their routes and alignments still provide access for recently constructed pipelines and possible future facilities". After the state of Nevada purchased the MHWS from the Curtiss-Wright Corporation, the Nevada Legislature enacted a bill in 1973 to enable development of a plan to improve the MHWS.

The legislative act led to the preparation of a detailed engineering report by Montgomery Engineers of Nevada and Wateresource Consulting Engineers (WRC, 1974). Since the 1960s, renewed interest has been generated to reconstruct and improve the remaining portions of the system in order to meet increasing demands for water within the Virginia City area and the growing communities within the Carson River watershed.

2.2 Marlette Lake to Franktown Creek

Marlette Lake, described in detail in Plate 2, was raised three times (1873, 1876 and 1959) to provide increased storage capacity for runoff from precipitation and snowmelt. The degradation of the flume from Marlette Lake to the Incline Tunnel and the partial collapse of that tunnel has required pumping of Marlette Lake water to the Hobart Reservoir system through an 8" pipeline. A temporary diesel pump has been intermittently installed, usually around the first of July, and then operated at a maximum capacity of approximately 1.5 cfs through September. The operation and maintenance (O&M) costs average $806 per million gallons, and steadily increased between 1990 and 1994. Available pumping records are presented in Table 2-1.

Table 2-1 Marlette Lake Pumping Records

Year	Gallons Pumped	Total Cost	Cost per Million Gallons
1988	26,348,000	unknown	unknown
1989	17,576,000	$25,386	$1,444.36
1990	97,734,000	$48,717	$498.47
1991	85,431,000	$48,152	$563.63
1992	45,414,000	$30,355	$668.40
1993	none	none	n/a
1994	55,855,000	$47,640	$852.92

Brown and Caldwell inspected the existing 8" welded steel pipeline from Marlette Lake to the Franktown Creek drainage on October 9, 2000. The exposed pipeline was observed to be generally physically sound, with specific areas in poor repair, as described below:

- The discharge of the 8" pipeline is exposed and no constructed outlet works or energy-dissipating structures exist (Figure 3a Photographs). The pipe discharges into a natural rocky drainage tributary to Franktown Creek above Hobart Reservoir. Immediately above the outlet, a tree approximately 2 feet in diameter has fallen onto the pipe and compressed it approximately 1 inch.

- Approximately 1,175 feet from the outlet the pipe is broken at a surface weld bend, probably as a result of gradual slope movement, creating tension in that portion of pipe.

Because no flow erosion has occurred at this point, the break occurred since the time of last pumping.

- Approximately 2,940 feet from the outlet, a brass hose bib is regulated by a compression valve that is broken and non-functional, creating a potential leak.

- Approximately 3,070 feet from the outlet, the pipe transitions into asphaltic-wrapped, welded 50-foot sections. East of this point, the pipe consists of 20-foot sections with iron victaulic couplings.

- About 6,375 feet from the outlet, a wooden box houses a brass pressure gauge (?). The PVC pipe connecting this gauge to the 8" pipe is broken, and potentially leaking. West of this point, the pipe transitions back to 20-foot sections with iron victaulic couplings.

- Approximately 8,886 feet from the outlet, the pipe originates at a 6-inch flanged fitting for attachment to the temporary pump. A 5-foot long 10" rubber hose connects to a 9" pipe that enters the lake via a 12" perforated, screened inlet tube. The inlet tube is cracked, bent, oxidized and probably unsalvageable. A section of ¾-inch galvanized conduit runs alongside the pipe from the origin for approximately 1,575 feet (its purpose is unknown).

2.3 East Slope to Franktown Creek

The East Slope is defined by several collection systems (drop inlets) intersecting minor drainages to the northwest of Red House. Historically, a flume transported waters from the Incline Tunnel to a diversion structure near Red House. When this flume degraded and could no longer be used, a surface pipeline was installed with six drop inlets at the pipeline's intersections with these minor drainages. The pipeline diameter is 8 inches from the Tunnel to the last of these drop inlets, which is located in the largest of the sub-drainages approximately 2,885 feet northwest of the Red House diversion structure. At this point, the pipe size is increased to 12 inches via a welded intersection.

The drainage areas that contribute to this pipe system total approximately 1,291 acres (Figure 2). The basin has a minimum elevation at the Red House diversion structure of about 7,330 feet above mean sea level (amsl), with a maximum elevation of 8,855 feet amsl. The State of Nevada indicates that about 1.0 cfs is consistently added to the MHWS from the East Slope pipeline system (McInnis, pers. comm., 2000).

The Incline Tunnel was constructed using conventional mining techniques in the 1870s. The flume from Marlette Lake to the inlet of this tunnel degraded beyond usability, and was replaced by a steel pipeline. This pipeline is no longer in usable condition and a portion of the tunnel has collapsed, leaving only a small stream that exits the tunnel and is collected by the East Slope system. This discharge from the collapsed tunnel may be fed by groundwater seepage. The outlet of the tunnel is in a minor drainage at the northwestern end of the East Slope, and is covered by a metal grating with signs that warn against entry (See Figure 3b – Photographs).

Waters from the Incline Tunnel are collected by a concrete and cobble diversion dam about 13 feet wide, which has no functional impoundment capacity. At present, this system component consolidates approximately one-half of the flow from the Tunnel and directs it into an 8" welded steel pipeline with abraded asphaltic wrapping via an 18" corrugated metal pipe with side discharge into the pipeline. Several small springs or streams from the sides of the drainage also flow around the dam. Brown and Caldwell inspected the East Slope pipeline system on September 26, and October 9, 2000, and marked locations summarized in Table 2.2 with a portable GPS instrument.

Table 2-2 East Slope Drainage Collection System Summary

Structure	GPS Location	Approx. Pipe Elevation (ft. MSL)	Comments
Pipe Inlet	N 39.22099° Lat W 119.89299° Long	7,490	Collecting 50% of base flow
Drop Inlet #1	N 39.21902° Lat W 119.89270° Long	7,470	non-functional
Drop Inlet #2	N 39.21567° Lat W 119.89334° Long	7,436	Collecting 70% of base flow
Drop Inlet #3	N 39.21383° Lat W119.89308° Long	7,420	Collecting 100% of base flow
Drop Inlet #4	N 39.20423° Lat W 119.88793° Long	7,430	non-functional
Drop Inlet #5	N 39.20379° Lat W 119.88769° Long	7,414	Collecting 20% of base flow
Drop Inlet #6	N 39.20364° Lat W 119.88005° Long	7,380	Collecting 60% of base flow
Red House Inlet	N 39.20408° Lat W 119.87185° Long	7,330	Standpipe into 18" ϕ Steel Pipeline to Tanks

In addition, Brown and Caldwell made the following observations:

- Approximately 822 feet from the Tunnel exit, the pipeline intersects a 32" corrugated metal settling basin (Drop Inlet #1). This basin received additional minor drainage waters via an approximately 36' long 8" corrugated metal pipe which terminates in a metal flared end section. The flared end section is currently filled with sediment and only a trickle of water is entering the sediment basin from this diversion. A piezometric water surface in this sediment basin was measured to be 3.2 feet above ground level, and the inlet and outlet pipes were about half full.
- Approximately 2,667 feet from the Tunnel exit the pipeline is intersected by an 8" steel pipe (Drop Inlet #2), which is connected upstream in a minor drainage to an 8" corrugated metal pipe (CMP). This CMP intersects a 32" CMP settling basin about 24 feet upstream of the primary pipeline. An 8" CMP inlet is connected to this basin, and this pipe directs waters collected by an 18" CMP with side discharge into the 8" CMP. This 18" CMP terminates in a metal flared end section, which was partially filled with sediment. This drop inlet was functional at the time of observation and was collecting approximately 70% of the flow in the channel. About 1" deep flow was observed in the 8" inlet to the settling basin.
- Approximately 5,169 feet from the Tunnel exit, the pipeline is intersected by an 8" steel pipe (Drop Inlet #3) which is connected upstream in a minor drainage to an 8" corrugated metal pipe. This CMP intersects a 32" CMP settling basin about 95 feet upstream of the primary pipeline. An 8" CMP inlet is connected to this basin, and this pipe directs waters collected by an 18" CMP with side discharge into the 8" CMP. This 18" CMP terminates in a metal flared end section, which was partially filled with sediment. This drop inlet was functional at the time of observation and was collecting all flow in the channel. About 4" deep flow was observed in the 8" inlet to the settling basin.
- Approximately 6,511 feet from the Tunnel exit, the pipeline is intersected by an 8" steel pipe (Drop Inlet #4) which is connected upstream in a minor drainage to an 8" corrugated metal pipe. This CMP intersects a 24" CMP settling basin about 70 feet upstream of the primary pipeline. Two 8" CMP inlets are connected to this basin, which lie directly in minor drainage channels. The 8" CMP inlet pipe to the East is broken about 8' from the settling basin, and no flow was observed in either inlet pipe. A minor flowing stream was observed to bypass this drop inlet.
- Approximately 6,688 feet from the Tunnel exit, the pipeline is intersected by an 8" steel pipe (Drop Inlet #5), which is connected upstream in a minor drainage to an 8" corrugated metal pipe. This CMP intersects a 32" CMP settling basin about 85 feet upstream of the primary pipeline. However, it is broken about 57 feet upstream of the primary pipeline, and only a trickle of water is being conveyed to the water delivery system. An 8" CMP inlet is connected to this basin, and this pipe directs waters collected by an 18" CMP with side discharge into the 8" CMP. This 18" CMP terminates in a metal flared end section. This drop inlet was functional at the time of observation and was collecting approximately 20% of the flow in the channel.

- Approximately 9,667 feet from the Tunnel exit, the pipeline intersects a 12" steel pipe (Drop Inlet #6) that is connected upstream in a minor drainage to an 8" steel pipe. This pipe intersects a 32" CMP settling basin about 103 feet upstream of the primary pipeline. An 8" CMP inlet is connected to this basin, and this pipe directs waters collected by a 32" CMP with side discharge into the 8" CMP. The 32" CMP terminates in a metal flared end section. This drop inlet was functional at the time of observation, and was collecting approximately 60% of the flow in the channel. About 4" deep flow was observed in the 8" inlet to the settling basin.

- Approximately 14,540 feet from the Tunnel exit, the 12" pipeline intersects a 12" bypass pipeline and flow may be directed by two gate valves to drain directly into Franktown Creek below the Red House diversion or (as at the time of observation) to the settling basin and inlet into the 18" steel pipeline running towards the Tanks.

- Approximately 14,570 feet from the Tunnel exit the 12" steel pipeline is connected to a 12" CMP and drops at about 45° for 16 feet to discharge into a 32" CMP settling basin with overflow into an 18" steel standpipe connected vertically to the main 18" steel pipeline running towards the Tanks.

Brown and Caldwell calculated the capacity of each section of the East Slope collection system, and have concluded that the 12" pipeline from Drop Inlet #6 to the Red House inlet limits flow. The existing East Slope collection system is estimated to deliver 1,059 AF, 645 AF, and 1,070 AF in the average, dry, and wet years, respectively. These calculations take into account the maximum flow rate of 1.5 cfs for the 12" pipeline section and the shape of the hydrograph. These potential capture volumes are 61%, 88%, and 26% of the average, firm, and maximum yields, respectively. On the basis of available water rights, the 1,059, 645, and 1,070 AF values represent 11%, 7%, and 11% of the total water right of 9,411 AF for the Incline Tunnel and Franktown Creek and East Slope basins combined.

2.4 Hobart Reservoir and Red House Diversion

Hobart Reservoir is an impoundment created by a small earth-fill dam, originally with a cobble downstream face, constructed in the 1870s. The dam crests approximately 28 feet above the stream bed, and has been repaired several times following its original construction. Hobart Reservoir has gradually lost storage capacity due to sediment accumulation. The reservoir has an estimated capacity of 100 AF.

The Red House diversion structure is a concrete diversion dam 73.3 feet from bank to bank with a tiered emergency overflow of 94.1 ft^2 in total cross sectional area. A small impoundment with its standing surface approximately one inch below the overflow at the lowest tier flows through a knife gate into a concrete box. This discharges directly into the 18" steel pipeline towards the Tanks.

2.5 Red House Diversion to the Tanks

The 18" pipeline leaving the Red House diversion structure is exposed intermittently along approximately 30% of its run to the Tanks. According to the 1974 WRC report, a 24" corrugated segment originated from the Red House diversion structure. However, this segment has probably been replaced with an 18" segment in the following years. The 18" pipeline is in fair to good condition with little exposed damage. It has an asphaltic wrapping which is approximately 98% intact. The pipeline runs generally next to, and occasionally underneath, an access road that begins at a locked gate in the Lakeview community northwest of Carson City and loops past Hobart Reservoir to return to Lakeview (Figure 2). Minor erosion events and historic fires have not significantly impacted the stability or condition of this pipeline. The pipeline then runs up the Franktown Creek drainage to the Red House diversion. Brown and Caldwell observed the alignment of this pipeline on September 26, 2000 (Figure 3d, photographs), and recorded exposed pipe locations using a portable GPS instrument.

The inlet to the Tanks (now a single painted steel tank) is via a 45° downward bend to discharge into the top of the tank. The 18" pipeline is approximately 21,667 feet (4.1 miles) long and has an inlet elevation of approximately 7,330 feet amsl and an outlet elevation at the Tanks of approximately 7,090 feet amsl. Brown and Caldwell calculated that the existing pipeline is capable of conveying 13.9 cfs under pressurized, fully turbulent conditions. However, in order to pass this flow rate through the 18" inlet, a head level of 1.0 feet would be required at the Red House diversion structure.

The existing Red House diversion structure includes an overflow weir with a concrete crest less than 0.1 feet above the water surface on the date of observation (September 26, 2000), limiting the inflow rate to approximately 13.0 cfs. Unused flashboards and a flashboard slot in this lower section of the overflow weir could raise the water level to approximately 4.85 feet above the centerline of the 18" pipe inlet, sufficient to pressurize the pipe and deliver the maximum capacity of 13.9 cfs.

The 1974 WRC report states; "...it is essential that the flow be controlled at the upstream end to prevent imposing a hydrostatic head, or pressure, on the pipeline which might cause leaks". The maximum full-pipe, no-pressure discharge for this pipe is estimated to be 10.2 cfs. However, the welded steel pipeline is in good condition and it appears that a pressurized flow rate of 13.9 cfs could be achievable, pending careful initial observation and testing (see Section 5.5). WRC (1974) recommended that the pipe be lined with cement/mortar to improve its hydraulic characteristics and prolong its life. Our investigation suggests that the reduced pipe diameter and resulting loss of capacity, and initial cost of repairs ($0.6 million adjusted by CPI), would make this an unattractive option.

2.6 Tanks to Ash Canyon Water Treatment Plant

Two 8" pipelines emerge from the steel holding vessel at the Tanks facility, and each flows through a valve and meter system in a small building to the northeast of the tank. (Figure 3 Photographs). One of the nominal 8" pipes leaving this valve system runs underground approximately along the road alignment toward Lakeview, and then through the historic inverted siphon to Virginia City. The other runs underground to the southeast with occasional pipe exposures and some surface features such as valves and junction boxes to the Ash Canyon Water Treatment Plant (ACWTP) in Carson City.

Brown and Caldwell inspected, where possible, the alignment of the pipeline from the Tanks to Ash Canyon on September 26, 2000. Based on visual observation of exposed pipe and the sound of rushing or surging water underground at other locations, the alignment was recorded with a portable GPS instrument. In addition, Brown and Caldwell made the following observations:

- Approximately 2,112 feet from the outlet to the Tanks, the pipe enters a concrete collection box with a sealed 4" pipe protruding in the general direction of Rose Spring, which may have previously been a point of collection for waters from that source. A turbulent water surface was estimated to be approximately 2 feet above ground level in this collection box.

- Approximately 4,087 feet from the outlet to the Tanks, the pipe crosses the bottom of Vicee Canyon and is partially crushed for about 10 feet of length as it crosses the road in the bottom of that canyon.

- Approximately 4,397 feet from the outlet to the Tanks, the pipe enters the top of a junction box with a non-functional 4" pipe protruding from the side of the box.

- Approximately 5,908 feet from the outlet to the Tanks, a flow meter was noted on the primary pipeline at a diversion point with a second pipeline running towards the Vicee Canyon Recharge Basins.

- Approximately 10,912 feet from the outlet to the Tanks, a padlocked concrete junction box was observed on the saddle above the ACWTP.

- Approximately 12,639 feet from the outlet to the Tanks, the 8" pipeline discharges into a square concrete holding pond, which serves as temporary raw water storage for the ACWTP and as a diversion point for overflow waters to be directed into Ash Canyon Creek. This pond was full at the time of observation (September 26, 2000).

Brown and Caldwell calculated that the existing pipeline system is limited to approximately 3.7 cfs delivery by the previously described partially crushed section of pipe crossing Vicee Canyon. Water delivery records from the State of Nevada indicate that the maximum delivery over the past seven years was 51.8 million gallons in October of 1996. The constant-flow delivery rate for this month was 2.59 cfs. Because of uncertainty in the physical characteristics of the existing 8" pipeline, this recorded flow rate was used in calculations involving existing capacity of the Tanks to ACWP pipeline.

SECTION 3.0
WATER YIELD AND WATER RIGHTS

3.1 General

The major sources of surface water for the MHWS consist of precipitation and runoff in three hydrographic sub-basins: Marlette Lake Basin, Franktown Creek Basin (also referred to historically as the Hobart Creek Basin), and the East Slope Basin. These drainage basins have been synthetically analyzed in previous studies to estimate potential, average, and firm (dry year) yield values. The results of these analyses are summarized in Tables 3-1, 3-2, and 3-3.

The USGS established permanent gauging stations on Marlette Creek below Marlette Lake and on Franktown Creek below Hobart Reservoir in the early 1970s, and has intermittently monitored stream flow in several drainages of the East Slope Basin. The gauged data for Marlette Creek and Franktown Creek consist of daily measurements of instantaneous flow in cubic feet per second (cfs) over a period of twenty-two consecutive years. These data have been used to revise the previous estimates of average basin yield, as presented in Table 3-1. Estimates in the WRC 1974 report utilized only the first year of Marlette Creek data and part of a year for Franktown Creek to estimate average, dry year (firm yield), and wet year runoff volumes (Tables 3-1, 3-2 and 3-3, respectively).

The 22 year period-of-record utilized in this study contains both dry (1977) and wet years (1983) for the basins. These data are used directly to represent firm and maximum yield. Brown and Caldwell generated hydrographs assuming a continuous flow over each 24-hour period. We then totaled this discharge to achieve a total volume of water passing each gauging station in the course of a year to determine annual yield. These data were then used to represent the firm yield and maximum runoff years. Because the "firm yield" is loosely defined as the 95% reliable runoff volume, it should be fairly represented by the driest year in any 20-year period. The runoff summary tables indicate that the recorded average and firm yields from the Marlette Lake drainage basin are considerably lower that those estimated in other reports. Probable reasons for this difference are discussed below in Section 3.2.

Table 3-1 Summary of Historical Average Annual Yield Estimates					
	Yield (acre-feet)				
Source and Date	**Brown and Caldwell (2000)**	**WCE-ME/N (1974)**	**Nevada D.W.R. (1973)**	**Montgomery Engineers (1965)**	**Walter Reid (1964)**
Marlette Lake Basin	1,866	2,800	3,501	2,347	3,000
East Slope Basin including Incline Tunnel	1,722	1,500	1,809	1,569	1,600
Franktown Creek Basin	2,520	2,000	2,770	1,930	2,400
Total	**6,108**	**6,300**	**8,080**	**5,850**	**7,000**

Table 3-2 Summary of Historical Annual Firm Yield Estimates					
	Yield (acre-feet)				
Source and Date	**Brown and Caldwell (2000)**	**WCE-ME/N (1974)**	**Nevada D.W.R. (1973)**	**Montgomery Engineers (1965)**	**Walter Reid (1964)**
Marlette Lake Basin	45	909	n/a	n/a	n/a
East Slope Basin including Incline Tunnel	736	487	n/a	n/a	n/a
Franktown Creek Basin	1,097	649	n/a	n/a	n/a
Total	**1,878**	**2,045**	**n/a**	**n/a**	**n/a**

Table 3-3 Summary of Historical Annual Maximum Yield Estimates					
	Yield (acre-feet)				
Source and Date	**Brown and Caldwell (2000)**	**WCE-ME/N (1974)**	**Nevada D.W.R. (1973)**	**Montgomery Engineers (1965)**	**Walter Reid (1964)**
Marlette Lake Basin	6,843	7,350	n/a	n/a	n/a
East Slope Basin including Incline Tunnel	4,050	3,937	n/a	n/a	n/a
Franktown Creek Basin	6,032	5,250	n/a	n/a	n/a
Total	**16,925**	**16,537**	**n/a**	**n/a**	**n/a**

The drainage basins of the MHWS are located in high, mountainous regions dominated by coniferous trees and high semi-desert shrub and forb undergrowth. Portions of the Franktown Creek and East Slope basins were burned during a forest fire in 1988, and the dominant vegetation in these areas is manzanita with forb and grass understory. The basins all receive most of their precipitation as snow and rain during the winter, and intermittent summer storms. In general, runoff follows a general pattern of snowmelt with occasional peaks at other times during the year. Detailed hydrographs, references to the large volume of USGS stream gauge data, and the analyzed data used in this report are included in Appendix A. Detailed information regarding Marlette Lake is provided in Plate 2).

The State of Nevada holds several certificated and permitted water rights for the MHWS, as summarized in Table 3-4. The total available water under the water rights for the study area is 12,412 AF. However, this total may be limited by environmental issues associated with pumping from Marlette Lake, and the actual available yield from the East Slope and Franktown Creek drainages, as discussed in Sections 3.2, 3.3 and 3.4, respectively. In addition, downstream facilities have not been constructed to store and/or distribute the full water right volume. Therefore, the full permitted amount is unlikely to be realized in an average runoff year.

Brown and Caldwell estimates that a total of 6,108 AF will be available in an average year from all of the drainages within the study area, or 49% of the permitted volume. However, in the estimated wet year (i.e., maximum runoff yield), 16,925 AF would be available from all of the drainages included in the study area, or 136% of the permitted volume. All of the alternatives for improved utilization of the MHWS presented in this report include means of storing high runoff volumes, (i.e., capture of the majority of the maximum runoff volume). This range of available yield suggests that the full permitted value of all water rights be certificated to allow flexibility in source utilization.

Table 3-4 Marlette Lake Water System Water Rights

Source	Amount (per Right)	Amount (AFY)	Status
Marlette Lake	3,000 AF/yr	3,000	Permit No.30896 for municipal and domestic use; Permit No. 24877 is certificated for a lesser amount.
Upper Franktown Tributaries & East Slope	10.0 cfs	7,240	Decreed right for commercial, industrial and domestic use
Incline Tunnel	3.0 cfs	2,172	Permit No.24876 for municipal and domestic use; no means of utilization
		12,412	**Total (Areas Under This Study)**
Upper Rose Spring (Vicee Canyon)	1.0 cfs	724	Permit No.8808 for irrigation and domestic use; Appropriated right.
Upper Rose Spring (Vicee Canyon)	1.0 cfs	724	Permit No.15973 for general domestic use; Appropriated right.
Lower Rose Spring (Vicee Canyon)	2.0 cfs	1,448	Permit No.8807 for irrigation and domestic use; Appropriated right.
Ash Canyon	Amount flowing through a pipe 3½" ϕ at lower end	Unknown	Decreed right in name of V&T Railroad (purchased by State of Nevada) – Not currently utilized.
		2,896	**Total (Other Areas)**

Source: Wateresource, 1974

3.2 Marlette Lake

The Marlette Lake drainage basin is roughly 3 miles long, 1.2 miles wide, and comprises about 1,855 acres. The area of Marlette Lake itself is 376.7 acres. The basin has a minimum elevation of about 7,823 feet at lake level and a maximum elevation of 9,214 feet amsl. A single natural outlet has been modified with an earthfill dam, and outlet waters flow via Marlette Creek to Lake Tahoe (Plate 2).

The USGS established a permanent gauging station on Marlette Creek below the dam in October 1973. This station has measured stream flow continuously since that time, and has recorded a maximum flow rate of 63 cfs and a minimum flow rate of 0 cfs. In a report by KJC (1990), the USGS gauging station data were used to develop a synthetic "drainage basin" of the Marlette-Hobart-Franktown Creek system. This analysis did not attempt to separate the data for the individual sub-basins.

Brown and Caldwell requested pumping records from the State of Nevada Department of Administration because pumping by the State has impacted the net yield from the Marlette Lake drainage basin. These records were presented above in Table 2-2. Based on written correspondence with the State of Nevada Department of Administration, the pump is in place from July through September of each year in which pumping takes place. Review of the USGS gauge data for Marlette Creek shows a dramatic drop in stream flow in early July, and a somewhat less dramatic rise in September or October of the years in which pumping was done (Table 2-2). The total volume pumped during these years was analyzed in this report as a constant pumping rate based on the number of days the pump operated. That rate was added to the Marlette Creek data to estimate the natural runoff rate. This rate was also subtracted from the gauge data for Franktown Creek, as discussed below.

The Marlette Lake drainage is not adjudicated. However, the State of Nevada holds a permitted water right for up to 3,000 AF annually. Based on incomplete record information, no more than 301 AF, or approximately 10% of the total water right, has been removed in any recent year by the State of Nevada. In 1965 the State of Nevada began stocking rainbow trout in Marlette Lake. Since then, the lake has become a breeding stock area for this species. Because of this, the Nevada Division of Wildlife may have concerns about pumping from Marlette Lake.

The average annual yield from Marlette Lake is estimated to be 1,866 AF, or 62% of the total water right. Because Marlette Lake covers an area of approximately 376.7 acres, 753 AF of additional water could conceivably be available in any given year, for a total of 2,619 AF, or 87% of the total water right. However, this physical allowance for the top two feet of the lake is unlikely to be withdrawn on a regular basis because of environmental concerns and the need to replenish the removed waters in years following the drawdown. The maximum flow rate in the average year is estimated to be 6.7 cfs.

The dry year (firm) yield from Marlette Lake is estimated to be 798 AF, or 17% of the total water right. Approximately 45 AF of the firm yield value is from actual stream flow. The remaining yield is an estimate of the volume of water in the top two feet of the lake. The low flow volume is based on actual measurements of stream flow leaving Marlette Lake in 1977, when no pumping operations removed water from the lake. Therefore, this estimate should accurately represent the dry year stream flow yield. Potential reasons for this low volume include higher than expected evaporation from the lake surface and subsurface losses due to permeable soils and fractured rock around the lake. The analysis by James (written comm., 2000), which estimated firm yield value of 760 AF, based solely on the top two feet of the lake, is in general agreement with our firm yield estimate of 798 AF. The maximum flow rate in the dry year was recorded to be 1.0 cfs.

The wet year (maximum) yield from Marlette Lake is estimated to be 6,843 AF, or 228% of the total water right. This estimate is based on streamflow measurements made in 1983, the wettest year in the period of record, and generally agrees with the 1974 WRC estimate. The maximum flow rate in the wet year was recorded to be 41.0 cfs.

3.3 East Slope

The East Slope drainage basin consists of the upper reaches of several drainages geographically tributary to Franktown Creek below Red House. The basin is defined by the existence of collection systems intersecting these drainages, as described in Section 2.3. The drainage area that contributes to the pipe system is roughly 1.8 miles long, 1.1 miles wide, and comprises about 1,291 acres (Figure 4). The basin has a minimum elevation at the Red House diversion structure of about 7,330 feet and a maximum elevation of 8,855 feet amsl. Most of the water that flows from the Marlette Tunnel is likely derived from groundwater seepage within the tunnel. In addition, a minor amount of surface water flows into the drainage intersected by the tunnel from several tributary drainages (Figure 2).

Intermittent monitoring has been performed by the USGS on several of the tributary streams that contribute to the East Slope collection system. The USGS recorded streamflow rates in five of the drainages, including the tunnel exit on August 12, 1977. The sum of these streamflows was 0.47 cfs. On the same day, the recorded streamflow in Franktown Creek upstream of the Red House diversion was 0.70 cfs. Because the East Slope and Franktown Creek drainages are similarly oriented and immediately adjacent, Brown and Caldwell has assumed that streamflow data in Franktown Creek reasonably simulates streamflow from the East Slope.

Based on these data, the East Slope generated 3.64×10^{-4} cfs/acre and the Franktown Creek drainage basin generated 3.41×10^{-4} cfs/acre. Within the statistical accuracy of the measurements, these yields are nearly identical. Because of this similarity, and following map and visual inspection of the geology and surface conditions of these drainages, our assumption that the drainages may be treated similarly seemed reasonable. Therefore, the actual recorded hydrograph information for Franktown Creek was scaled to the size and yield of the East Slope drainage to generate quasi-empirical streamflow data for this basin. The USGS station on Franktown Creek has measured stream flow continuously since 1974, and the sum of streamflows in the East Slope can be correlated continuously, yielding a maximum flow rate of 43.6 cfs and a minimum flow rate of 0.32 cfs.

The East Slope drainages and Franktown Creek drainage share a water right affirmed in 1961 by the Supreme Court of the State of Nevada for 10.0 cfs, or 7,240 AF on a continuous flow basis. Additionally, a permit for 3.0 cfs (2,172 AF) from the Incline tunnel is held by the State of Nevada.

The average annual yield from the East Slope is estimated to be 1,722 AF, or 18% of the total combined water rights for the East Slope and Franktown Creek of 9,412 AF (10 cfs + 3 cfs on a continuous flow basis). This estimate is in general agreement with previous synthetic estimates. The average annual combined yield from Franktown Creek and the East Slope is calculated to be

4,262 AF, or 45% of the total water right. The maximum flow rate in the average year is estimated to be 7.0 cfs.

The dry year (firm) yield from the East Slope is estimated to be 736 AF, or 8% of the total water right. The annual firm combined yield from Franktown Creek and the East Slope is estimated to be 1,833 AF, or 17% of the total water right. This estimate is based on the modification, as discussed above, of streamflow measurements made on Franktown Creek in 1977 and is somewhat higher than the 1974 WRC synthetic firm yield estimate. The maximum flow rate in the dry year is estimated to be 3.7 cfs.

The wet year (maximum) yield from the East Slope is estimated to be 4,050 AF, or 43% of the total water right. The annual maximum combined yield from Franktown Creek and the East Slope is estimated to be 10,082 AF, or 107% of the total water right. This estimate is based on streamflow measurements made in 1983, the wettest year in the period of record, and is in general agreement with the 1974 WRC synthetic estimate. The maximum flow rate in the wet year is estimated to be 27.5 cfs.

3.4 Franktown Creek

The Franktown Creek drainage basin is defined in this study of the MHWS by the naturally captured waters which discharge to the Red House diversion structure. The basin is about 2.6 miles long, 1.3 miles wide, and comprises about 2,054 acres. Approximately 15.6 acres consist of lake surface. The basin has a minimum elevation at the Red House diversion structure of about 7,330 feet and a maximum elevation at Marlette Peak of 8,780 feet amsl.

The USGS established a permanent gauging station on Franktown Creek above the Red House diversion structure in June 1974. This station has measured stream flow continuously since that time, and has recorded a maximum flow rate of 65 cfs and a minimum flow rate of 0.48 cfs. KJC (1990) used USGS gauging station data to develop a synthetic "drainage basin" of the Marlette-Hobart-Franktown Creek system.

Because pumping by the State of Nevada has impacted the net yield from the Marlette Lake drainage basin, pumping records from the State of Nevada Department of Administration were used to provide the basis for our analysis of Franktown Creek. These records are presented above in Table 2-2. As previously described, the pump is in place from July through September of each year in which pumping takes place. Review of the USGS gauge data for Marlette Creek shows a dramatic drop in stream flow in early July, and a somewhat less dramatic rise in September or October of the years indicated in Table 2-2. The total volume pumped during these years was reduced to a constant pumping rate based on the number of pumping days, and this rate was subtracted from the gauge data for Franktown Creek. That rate was also added to the Marlette Creek data to estimate the natural runoff rate, as discussed in that section.

The East Slope drainages and Franktown Creek drainage share a water right affirmed in 1961 by the Supreme Court of the State of Nevada for 10.0 cfs, or 7,240 AF on a constant delivery basis. The average annual yield from Franktown Creek is estimated to be 2,520 AF, or 27% of the total combined water rights for the East Slope and Franktown Creek of 9,412 AF (10 cfs + 3 cfs on a continuous flow basis). This measured yield is somewhat higher than the synthetic yield estimates of earlier reports presented in Table 3-1. The average annual combined yield from Franktown Creek and the East Slope is estimated to be 4,242 AF, or 45% of the total water right. The maximum flow rate in the average year is estimated to be 10.4 cfs.

The dry year (firm) yield from Franktown Creek was measured to be 1,097 AF, or 12% of the total water right. The annual firm combined yield from Franktown Creek and the East Slope is estimated to be 1,833 AF, or 19% of the total water right. This estimate is based on streamflow measurements made in 1991, and is somewhat higher than the 1974 WRC synthetic firm yield estimate. The maximum flow rate in the dry year was measured to be 5.6 cfs.

The wet year (maximum) yield from Franktown Creek was measured to be 6,032 AF, or 64% of the total water right. The annual maximum combined yield from Franktown Creek and the East Slope is estimated to be 10,082, or 107% of the total water right. This estimate is based on streamflow measurements made in 1983, the wettest year in the period of record, and is in general agreement with the 1974 WRC synthetic estimate. The maximum flow rate in the wet year was measured to be 41.0 cfs.

SECTION 4.0
WATER DEMAND

NDWP (1999) estimated the population of Carson City at 50,410 persons in 1997. This figure was based on the rapid population growth between 1950 (4,200 persons) and 1990 (40,950 persons), when average annual growth was between 6.7 and 7.2 percent per year. Population growth slowed in the 1980s to about 2.5 percent per year. The April 2000 census estimate is expected to report a population of approximately 53,000 persons (Brown and Caldwell, 2000).

Carson City has implemented a program of controlled growth, and the physical setting of Carson City will likely limit population growth. The population of Carson City is expected to be 75,000 by the year 2030, and a maximum population of 80,000 may be reached in the period between 2030 and 2050.

NDWP estimated that Carson City consumed approximately 20,932 acre-feet of water in 1995. Approximately 44.8 percent of this total (9,370 acre-feet) was used for municipal, industrial and commercial purposes. Irrigation withdrawals of 10,710 acre-feet accounted for 51 percent of total use. Public use and losses accounted for 4 percent.

Based on the estimated population of 46,770 in 1995, M&I use corresponds to a consumption rate of 0.20 AFY per capita. Consumption rates for M&I use in 1985 and 1990 reported by NDWP were not significantly different than the 1995 withdrawals for a significantly lower population base. The following tables (NDWP, 1999c) show recent water demand information for Carson City:

Table 4-1. Summary of Carson City Water Use

Water Use By Major Category	1985	1990	1995	Percent Of 1995 Total Water Use
Total Water Withdrawals/ Use	13,316	13,405	20,932	n.a.
Domestic Water Withdrawals	7,110	7,244	7,096	33.90%
Commercial Water Withdrawals	1,098	1,243	1,221	5.83%
Industrial Water Withdrawals	952	1,064	1,053	5.03%
Thermoelectric Water Withdrawals	0	0	0	0.00%
Mining Water Withdrawals	0	0	0	0.00%
Livestock Water Withdrawals	67	11	11	0.05%
Irrigation Water Withdrawals	3,260	2,812	10,710	51.17%
Public Use and Losses	829	1,031	840	4.01%
Water Usage Rates By Type/Sector	**1985**	**1990**	**1995**	
Municipal & Industrial Water Use per Person	247	234	198	
Domestic Public Supplied Water Use per Person	179	160	137	
Total Domestic (Residential) Water Use per Person	178	158	136	
Total Commercial & Industrial Water Use per Worker	105	96	78	
Total Domestic Water Use per Household	459	407	349	

Water consumed in Carson City comes from specific groundwater sources in several hydrographic basins, and from surface water sources including the Carson River and its tributaries. Surface water from the Marlette/Hobart system (State water) comes from outside the watershed. Total withdrawals for Carson City have varied in the range between 8,430 and 11,355 acre-feet. Use of surface water was less during the portion of the drought period (1988 to 1994) and greater during the period of relatively high precipitation and run-off (1995 to 1998).

The reported Carson City Utilities Department (CCUD) use of 9,674 acre-feet for 1995 is similar to the NDWP estimate of 9,370 acre-feet, and corresponds to a 0.21 AFY per capita use rate. CCUD has produced the following water use history for the period 1988 to 1998 that includes municipal, industrial and non-agricultural State consumption:

Table 4.2 Carson City Water Usage History (Acre-Feet)

Ground Water	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Eagle Valley	5,590.00	4,252.49	4,710.74	4,066.99	4,642.30	3,339.04	4,845.24	3,204.12	3,033.47	3,248.18	2,975.90
Dayton Valley	1,164.00	1,103.59	1,425.60	1,240.21	1,456.88	1,593.97	1,684.68	1,200.84	1,256.45	1,417.81	847.60
Carson Valley	277.00	478.31	339.11	727.08	829.63	604.14	502.02	325.90	365.58	584.61	425.20
Washoe Valley	7.25	0.80	4.94	3.09	5.32	3.47	2.91	2.04	0.00	0.00	0.00
Sub-Total Groundwater	**7,038.25**	**5,835.19**	**6,480.39**	**6,037.37**	**6,934.13**	**5,540.62**	**7,034.85**	**4,732.90**	**4,655.50**	**5,250.60**	**4,248.70**
Surface Water	**1998**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Carson River	690.00	1,336.37	1,348.05	1,519.01	1,732.44	2,146.24	1,407.44	1,382.88	1,938.22	1,917.43	2,113.46
Kings Canyon	371.00	613.81	542.75	316.16	268.50	711.91	531.34	1,227.68	1,639.94	1,757.63	1,500.06
.h Canyon	0.00	0.00	0.00	0.00	181.50	778.29	699.46	1,162.47	1,263.74	1,457.19	1,890.29
Clear Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
State Water (Marlette/Hobart)	513.00	643.93	1,106.56	1,008.65	774.13	715.41	1,080.28	1,168.47	1,402.64	971.03	717.66
Sub-Total Surface Water	**1,574.00**	**2,594.11**	**2,997.36**	**2,843.82**	**2,956.57**	**4,351.85**	**3,718.52**	**4,941.50**	**6,244.54**	**6,103.28**	**6,221.47**
Total of All Sources	**8,612.25**	**8,429.30**	**9,477.75**	**8,881.19**	**9,890.70**	**9,892.47**	**10,753.37**	**9,674.40**	**10,900.04**	**11,353.88**	**10,470.17**

CCUD has also reported greatest demand for the "peak demand day" in 1998 at 21,827,000 gallons or 67 acre-feet. This value for the "peak demand day" is approximately double that of the average daily use rate of 0.21 AFY.

Based on the average daily use rate of 0.21 AFY, Brown and Caldwell (2000) projected that Carson City would have an average demand of 16,800 AFY. The MHWS average year yield of 6,108 AF is 36% of this amount. With full utilization of the State of Nevada's water rights, the MHWS is capable of supplying 12,412 AFY, or 74% of this amount. CCUD expects that the increased rating of 9.2 MGD (14.2 cfs) for the ACWTP will be approved by January 2001. This rate will enable CCUD to treat and directly deliver MHWS water to its customers.

SECTION 5.0
EVALUATION OF SYSTEM ALTERNATIVES

5.1 General

The purpose of this report is to analyze existing conditions of the various elements of the MHWS, and present phased improvements for upgrading the system to accommodate and utilize seasonal changes in runoff volume for the long-term goal of more complete use of existing water rights and retaining these waters, through aquifer recharge, for seasonal and climatic dry periods. Though there is no specific target of utilization, several logical steps are involved in this analysis of system capacity:

- The East Slope collection system is in a poor state of repair, and minor, inexpensive maintenance on collection facilities could immediately contribute additional water to the MHWS.

- Two 8" pipelines leaving the Tanks for Virginia City via Lakeview and to the Ash Canyon water treatment facility are undersized, and are incapable of conveying the waters that the 18" Red House to the Tanks pipeline can deliver. The pipeline to Virginia City (the historic inverted siphon) has been repaired during its service history, and contains a spliced section of 6" diameter pipe near the Tanks. The 8" pipeline to the ACWTP is the limiting portion of the MHWS, and its replacement or supplementation is of primary importance to better utilization of the MHWS.

- The pump station at Marlette Lake has not been used in the past seven years, and the existing 8" pipeline from the pump station to the Hobart Creek drainage is broken and leaking in several locations. The temporary, portable pump is historically inefficient and unreliable. Utilization of the water rights associated with Marlette Lake would require a more permanent means of conveyance – however, the average and firm yields from Marlette Lake are lower than previously estimated, therefore any approach to Marlette Lake must balance this low yield with the high water quality and storage value of Marlette Lake.

- The Red House diversion structure and 18" pipeline from this structure to the Tanks are in good repair and, to control costs, should be directly utilized in an upgraded system. The pressurized capacity of the 18" pipeline is sufficient to convey the majority of the water right volume in any year, and a parallel pipeline would be rarely utilized and very expensive. Therefore, the full water right constant flow rate of 17.1 cfs (10 cfs + 3 cfs + 3,000 AF on a constant flow basis) has not been evaluated.

Brown and Caldwell has incorporated these system attributes in preparing recommendations for optimization and improved utilization of the MHWS. Specifically, a phased set of recommendations for gradually higher delivery rates are presented.

5.2 Marlette Lake to Franktown Creek

The storage capacity of Marlette Lake is an important resource for the Carson River watershed, and Brown and Caldwell has evaluated several options for increasing the utilization of Marlette Lake water. Capital and operating costs for the following alternatives have also been calculated.

5.2.1 Subsurface Conduit

The prospect of a permanent conduit through a portion of the Carson Range was discussed in detail in the 1974 WRC report. The report described tunneling by drilling and blasting, and the use of a tunnel boring machine: "The smallest practicable size of tunnel to construct using conventional mining equipment is a 6-foot wide by 7-foot high arched tunnel." (WRC, 1974). The report also noted aerial photographic evidence of a fault zone near the Marlette Lake end of the tunnel. However, the geologic report by P.E. Galli in the 1974 report suggested that the generally intact igneous rock of which this geologic region of the Sierra Nevada mountain range is composed would allow a freestanding tunnel with little or no structural support.

The drilling and blasting method was deemed economically preferable at that time, and construction from Hobart Creek to within a short distance of the lake bottom was proposed. A floating drill rig would then be used to construct one or more vertical boreholes to intercept the tunnel, with screened inlet pipes inserted into these holes. Advantages to tunneling referenced in the 1974 report include the lack of surface disturbance, minimal maintenance, and lack of costs associated with exposed and energy consuming equipment. Disadvantages mentioned include the disposal of excavated materials.

The 1974 WRC report included preliminary cost estimates of $1.9 million and $2.7 million for mining by drilling and blasting and by tunnel boring machine, respectively. These costs included construction of the tunnel and temporary facilities for servicing miners and mining equipment.

Based on the CPI of 49.3 for 1974 and 172.0 for 2000 (Woodrow, 2000), the estimated costs for constructing this tunnel in the present day would be \$6.6 million and \$9.4 million, respectively. An additional 20% for engineering, construction inspection, administration, legal and special services was included in the total capital costs.

Advancements in drilling techniques and equipment make the direct drilling of a cased borehole a viable alternative for diverting waters from Marlette Lake. Lang Exploratory Drilling has proposed that the boring of an underground conduit utilizing a flat area immediately above Hobart Reservoir for a drilling pad and location of outlet works is technically feasible. Brown and Caldwell has created a preliminary design for the conduit, which would run from the drilling pad locations to the current pump set-up location on Marlette Lake, a distance of approximately 9,475 feet. The 10" cased borehole is estimated to have sufficient capacity for the full 3000 AF of permitted water rights (the derivation of this maximum flow rate is presented in Appendix B). The 10" borehole is estimated to cost \$325 per foot to drill, with an additional cost of \$75 per foot for installed casing. Additionally, Lang recommended that \$50,000 be assumed for mobilization and demobilization.

Brown and Caldwell assumed lump-sum construction costs for concrete inlet and outlet structures to be \$10,000 and \$6,000, respectively. The total cost for the constructed borehole and support structures is estimated to be approximately \$5.4 million. This cost includes a factor of 20% for engineering, construction inspection, administration, legal and special services, plus an additional factor of 20% for contingency.

5.2.2 Gravity Pipeline along historic Flume Trail

Rehabilitation of the historical gravity pipeline from the dam at Marlette Lake to the western entrance to the Incline Tunnel was discussed in detail in the 1974 WRC report. CES, another consulting engineering firm, is independently investigating rehabilitation of this pipeline.

5.2.3 Permanent Pumping Station and Repaired 8" Pipeline

The alternative of installing a permanent pumping station on Marlette Lake to convey waters from that lake to the Hobart/Franktown Creek drainage basin was discussed in detail in the 1974 WRC report. WRC recommended that two 250-hp vertical diesel turbine pumps and a 14" buried pipeline could accommodate 6.2 cfs from Marlette Lake. The total estimated cost was estimated at $2.0 million with annual O&M costs of $227,000, adjusted by CPI.

Brown and Caldwell has prepared a preliminary cost estimate for this alternative based on a design for a 400-hp pump, utilizing the repaired 8" pipeline, to deliver a maximum flow rate of 4.3 cfs. Calculation of pump horsepower include the loss of efficiency (20% loss) in a diesel turbine due to high elevation. A turbocharged diesel engine may be more efficient, but would require a higher degree of maintenance. As discussed in Section 2.2, existing or potential pipeline leaks must be repaired.

The cost estimate to repair the existing pipeline is based on man-hours and the use of welding equipment and fire safety equipment, as spare pipeline segments are available near the broken segment of pipe. We have also assumed that spigots and meters that currently leak would be decommissioned, and the holes in the pipeline sealed. The total estimated cost for repair of the pipeline is $3,388 and includes a factor of 40% for contingency.

The total estimated cost to install a diesel pump station with a buried concrete bunker, a concrete emergency impoundment pad for an above-ground diesel fuel tank, a lake inlet line and telemetry for remote operation is $528,500. This cost includes a factor of 20% for engineering, construction inspection, administration, legal and special services, and an additional factor of 20% for contingency. Additionally, the fuel consumed by the pump is estimated to cost $118,000 per year at a mechanical efficiency of 80% (for a fuel consumption rate of 10.4 gallons per hour, diesel costs of $1.50 per gallon, and constant operation), and an annual major overhaul and routine maintenance and monitoring of the pump facility estimated to cost $16,000 per year, for a total annual cost of $134,000.

Alternatively, a pump with a natural gas engine may be installed, which may be less environmentally sensitive than a diesel system. A natural gas main (the Paiute 8" Transmission Line) runs parallel to the 18" water pipeline from Red House to the Tanks, and is 3.8 miles from the Marlette pump station along existing roads. Southwest Gas (which owns the pipeline) estimates an installed cost of $35 per foot with an additional $75,000 satellite communication meter at the tap, for a total installed cost (including pump) of $1,550,752. The operation and maintenance costs are likely to be similar to diesel. Additionally, Southwest Gas would require a permanent 10' wide easement across lands administered by the US Forest Service, and a temporary 20' wide easement during construction. The costs to procure these easements and other issues of permitting and regulatory compliance are not addressed in this report.

A third alternative is an electrically powered pump. A new, buried electrical line would encounter similar easement and permitting requirements to a natural gas pipeline, however the only feasible route for new electric service is via Spooner Lake along an existing Forest Service road, a total distance of approximately 6.5 miles. Sierra Pacific Power Company estimates an installed cost of $210 per lineal foot, for a total installed cost (including pump) of $10,577,686. Additionally, the electricity consumed by the pump is estimated to cost $137,301 per year (at operating 400 hp, or 298 kilowatts, unit electricity cost of $.04 per kilowatt-hour, monthly $50 meter charge, $9 per kilowatt-month demand charge, and constant operation), and an annual major overhaul and routine maintenance and monitoring of the pump facility estimated to cost $16,000 per year, for a total annual cost of $153,301.

5.3 East Slope to Franktown Creek

The existing East Slope collection system is capable of conveying 1.5 cfs. This capacity is sufficient to capture the entire annual runoff from 10 of the 22 years of record on a constant-flow basis. Because this rate is sufficient for the average year base flow, except for high runoff periods, the initial recommendation for the East Slope is repair and maintenance of damaged or sediment-choked drop inlets along the pipeline. A map detailing the location of all drop inlets is presented as Figure 4 of this report. The total estimated cost for rehabilitation of the East Slope of $2,751 is based on Nevada standard labor rates (BLS, 2000), and includes a 40% contingency factor. Specific repairs and maintenance items are detailed on Figure 4 and include removal of accumulated sediment in the CMP settling basins, repair of broken or twisted pipes, repair of flared end sections, and manual diversion of minor streams to intercept collections as well as the materials and transportation necessary to conduct this work. As a conservative estimate, Brown and Caldwell assumes that similar repair and maintenance will be required annually to maintain the East Slope collection system.

In order to fully utilize the 3.0 cfs water right for the Incline Tunnel, a parallel welded steel pipeline, 14,570 feet in length and 12 inches in diameter, would be required. The total installed capital cost of this surface pipeline would be approximately $1.1 million, which includes a factor of 20% for engineering, construction inspection, administration, legal and special services and an additional factor of 20% for contingency. The construction of such a pipeline would add additional collection capacity to the existing system because the waters from the Tunnel exit would no longer have to be conveyed. However, the high capital cost and relative impact (the trail next to the existing pipeline would have to be widened to allow continued recreational use) make this option relatively unattractive.

The Incline Tunnel is primarily fed through groundwater seepage, and exhibits an average yield of approximately 0.3 cfs. Brown and Caldwell suggests that this value would not likely increase without considerable rehabilitation of the Tunnel. Given that tunnel rehabilitation would only be justified if the alternative of a gravity flow pipeline from Marlette Lake were utilized, in which case a larger pipeline would have to be installed on the East Slope to convey Marlette Lake water, this option has not been further investigated.

5.4 Hobart Reservoir or Marlette Lake Expansion

The alternative of expanding Hobart Reservoir by supplementing the existing dam or constructing a new dam has received considerable attention in the history of the MHWS. The initial capital expense of such a dam was prohibitive as described by the 1974 WRC report. Dams designed to impound 19,000 AF, 10,000 AF, and 5,000 AF have total initial capital costs of $27.2 million, $11.5 million and $9.0 million, respectively. These costs have been adjusted by CPI, and include a factor of 22% for engineering, construction inspection, administration, legal and special services.

This study, which incorporates conjunctive use of surface water and groundwater recharge in the Eagle Valley of Carson City for day-to-day storage, eliminates the need for larger surface impoundments. However, given that the primary purpose of an expanded Hobart reservoir would be to buffer flow to the 18" transmission pipeline from the Red House diversion to the Tanks during exceptionally wet years, dam construction is considered further. Because the existing 18" pipeline, if determined to be safe under pressurized conditions, is capable of conveying 9,389 AF during the maximum runoff year at a flow rate of 13.9 cfs, an expanded reservoir should be designed to impound 3,023 AF (the remainder of the water right). With this configuration, runoff waters from the Franktown Creek drainage above Hobart Reservoir and waters conveyed from Marlette Lake, which would otherwise exceed the capacity of the existing 18" pipeline, could be retained in the reservoir and discharged at a controlled rate toward the Red House diversion. Expanded Hobart Reservoir capacity would also improve the recreational and conservation value of the reservoir, as discussed in the 1974 WRC Report.

Based on the maximum estimated construction cost in the WRC report per acre-foot of capacity of $1,210, as adjusted for CPI, the smaller reservoir total capital cost is estimated to be $4.4 million, including a factor of 20% for engineering, construction inspection, administration, legal and special services, and an additional 20% for contingency. Because maintenance of the expanded Hobart Reservoir would be similar in scope to that performed presently, no additional annual costs are expected for this alternative.

Utilizing newly available NDOT land surface information, the final reservoir configuration would include a higher dam constructed on the existing dam site, rising an additional 48 feet from the current dam crest to a top elevation of 7,600 feet MSL and allowing approximately 5 feet of freeboard. No detailed design has been prepared for this structure.

Alternatively, because of its bathymetry and surrounding topography, storage in Marlette Lake could easily be increased with the use of flashboards in the existing outlet to Marlette Creek. We have not estimated costs for this improvement, nor calculated the potential increase in lake storage. This system upgrade could be easily managed, and may additionally enhance the trout habitat in the lake.

5.5 Red House Diversion to the Tanks

The existing 18" transmission pipeline from the Red House diversion structure to the Tanks is capable of conveying 13.9 cfs, or 9,389 AF during the maximum yield year. Prior to increasing the capacity of the water system below the Tanks, a test of this pipeline should be conducted. This test should be performed by sealing the entrance to the steel holding vessel and the inlet structures, and pumping compressed air into the pipeline to a maximum pressure of 105 psig (equivalent to the maximum head of 240 feet). The pipeline should be observed for leakage for at least 24 hours and any leaks repaired. If the pipeline is found to be fit to convey water under pressurized conditions, or may be conveniently repaired to the desired state, no further work is needed for this section of the MHWS.

The total estimated cost for testing and minor repair of the 18" Red House diversion to Tanks pipeline of $13,355 is based on Nevada standard labor rates (BLS, 2000) and includes a factor of 20% for contingency.

5.6 Tanks to Ash Canyon Water Treatment Facility

According to Mr. Tom Hoffert of the Carson City Utilities Department, concrete structures on the existing 8" water line become clogged and overflow periodically. Inlet of foreign matter can be controlled at the Tanks through installation of a screen on the inlet valve assembly. Furthermore, the concrete structures should be modified with lockable steel plate covers to inhibit vandalism, and the partially crushed section of the 8" pipe should be manually repaired. The estimated cost for these modifications is $1,092, and includes a factor of 40% for contingency.

Because of the very large change in elevation from the Tanks to the Ash Canyon Water Treatment Facility, a relatively small diameter pipe is required to conduct the target increased flow volumes. The pipeline would be approximately 17,800 feet in length. Brown and Caldwell calculated that a 10" ductile iron pipe would have a maximum capacity of 10.8 cfs, and with continued utilization of the existing 8" pipeline system (maximum capacity 3.7 cfs) would deliver the full amount available from the 18" transmission main from the Red House diversion structure.

Ductile iron pipe with asphaltic wrapping is recommended in preference to PVC pipe because of the high pressure that would be encountered in sections of the pipeline, and to avoid additional complications during excavation and pipeline installation. The estimated installed cost for 10" ductile iron pipe is $94 per lineal foot, for a total installed cost of $2,355,269. This cost includes excavation, bedding, pipe placement and fitting, and the installation of automatic (floating-seal type) air release valves, and includes a factor of 20% for engineering, construction inspection, administration, legal and special services, and an additional 20% for contingency.

Additionally, it should be noted that the calculations of pipe flow in the proposed Tanks to ACWTP Facility pipelines assume the capacity of the existing tank at the Tanks to develop and maintain approximately 7 feet of head. Brown and Caldwell expects that the tank is currently near full capacity, based on observation of overflow from a pipe which connects near the top of the tank, and is designed and constructed to safely store water to its full capacity.

Replacement of the existing 8" steel pipeline was also considered. Through a technique called "pipe splitting" an existing pipe in sufficiently loose material is cut lengthwise and a larger or more hydraulically desirable pipe is pulled through the split pipe by a cable attached to a cone at the front of the new pipe. Mr. Kevin Brazell of Hydro-Tech suggests that this approach may be technically feasible for this pipeline. Advantages to pipe splitting include the decommissioning of an older pipe with indeterminate service life, more ideal HDPE flow characteristics, the need to only access the pipeline at approximately 2,000-foot intervals and corresponding lower disturbance and fewer access and permitting requirement, and potentially lower cost. Additionally, the replaced pipe is bedded by design and jointless, eliminating many construction problems. Disadvantages include the shorter service life of HDPE as compared to ductile iron, and its lower pressure capacity, which necessitates a number of pressure release valves along the pipe alignment. Additionally, the replacement of the existing 8" pipeline removes the advantages of an independent system. Brown and Caldwell were unable to accurately estimate the cost of this procedure, and recommend that interested parties contact Hydro-Tech directly. (See Section 7.0 – References)

Although the Virginia City/Lakeview inverted siphon has traditionally delivered approximately 0.3 cfs from the Tanks facility, this volume may in the future be provided to Virginia City via Carson City and Mound House. Therefore, we have evaluated the delivery system from the Tanks to the ACWTP facility to accommodate the combined flow rates.

5.7 West Carson City Aquifer Infiltration Basins

Brown and Caldwell evaluated the option of aquifer recharge and recovery using infiltration basins and supply wells in the Vicee Canyon area, west of Carson City. This alternative would not require treatment of the surface water because, as the water percolates through the unsaturated zone in the alluvial fan deposits, it is effectively filtered to meet drinking water standards. Surface water from the MHWS has been artificially recharged into existing basins constructed in Vicee Canyon by CCUD with no effect on existing down-gradient supply wells.

To date, recharge of MHWS surface water has not affected down-gradient potable water wells because: 1) the surface water quality exceeds that of the groundwater, and 2) the alluvial fan deposits are generally inert and do not leach constituents into the aquifer. Augmented infiltration in Vicee Canyon was investigated by the USGS (Maurer and Fischer, 1998). Their findings as well as operational data from the Vicee Canyon infiltration basins were used to evaluate the feasibility of using infiltration basins to further increase the aquifer storage in the West Carson City basin.

5.7.1 Infiltration Rates and Aquifer Suitability

The USGS utilized three separate methods to evaluate the infiltration in Vicee Canyon: 1) a water balance approach, 2) a calculated flow through the upper 60 feet of the vadose zone, and 3) calculation of the volume of water required to cause measured groundwater level rises in a network of vadose zone and water table piezometers. In addition, a groundwater model was created to estimate the rise in groundwater levels resulting from increased aquifer recharge.

The data used in estimating the recharge parameters in the Vicee Canyon area were collected from 1983 to 1985. Streamflow in Vicee Canyon was augmented with water from the MHWS for this study via a pipeline outfall to the creek bed at a location approximately one mile upstream from the mouth of the canyon. This outfall remains in place, and is used by the Carson City Utilities Department for delivery of water to the Vicee Canyon infiltration basins.

The USGS found that the average infiltration rate for the Vicee Canyon area is approximately 10 feet per day through clean, non-armored, sandy portions of the streambed. These infiltration conditions are similar to the conditions that would exist in a maintained infiltration basin. Therefore, the USGS findings provide an important benchmark for predicting infiltration basin performance. Based on these infiltration rates, an infiltration basin would transmit approximately 5.0 cfs/acre (10 acre-feet per day per acre), through similar material.

Moderately sloping alluvial fans extend along the Carson Range to the north and south of Vicee Canyon. The alluvial fans are generally composed of fairly coarse, sandy soil, similar to the sands found at the Vicee Canyon infiltration basins. The soil conditions indicate that the alluvial fans would provide suitable sites for infiltration basins that would augment the capacity of the Vicee Canyon infiltration basins. Data from the USGS study and subsequent monitoring activities by CCUD indicates there is adequate storage capacity in the unsaturated (vadose) zone and underlying aquifer in the vicinity of Vicee Canyon to accommodate recharge through additional basins.

5.7.2 Infiltration Basin Design

Several in-stream infiltration basins exist in Vicee Canyon. The Vicee Canyon infiltration basins were first used in 1991, and were utilized yearly until they were damaged in the January 1997 flood. They have since been re-constructed, and Carson City is scheduled to begin infiltration operations again in the fall of 2000. Brown and Caldwell evaluated potential recharge basin sites on the alluvial fan adjacent to Vicee Canyon on September 11, 2000. Topography, surface geology, land ownership, lines of sight to nearby residential areas and ground elevations were considered to minimize the impact of basin locations.

Two locations were identified as potential sites for the proposed recharge facilities that would allow gravity flow from the raw water pond located at the ACWTP (Figures 2 and 5). Each site is screened from view by existing topography and vegetation in all directions except from the east. Diversion from Vicee Canyon to collect surface water via a shorter pipeline from the Tanks was considered. However, this delivery approach would have involved longer pipe runs to the proposed infiltration basins and, due to the potential for floods in Vicee Canyon, could introduce considerable maintenance and periodic structural repairs and reconstruction.

Brown and Caldwell evaluated the construction of two identical basins (South and North Basins) on either side of Vicee Canyon in natural topographic lows (Figure 5). These basins should each have a total floor area of approximately 1.1 acres. The basins are proposed to be directly excavated from existing alluvium with compacted banks at 3:1 slope, and to be incised into the slope. The total earthwork volume is estimated to be 2,700 cy per basin. The basins are proposed to be excavated with a 1.5 cy capacity hydraulic, track mounted backhoe with an excavation rate of 100 cy/hour. The basin walls and pipe outlet area would be rip-rapped to a depth of approximately 12". A 12" ductile iron pipe system would be installed from a valve diversion on the transmission main from the Tanks near the ACWTP. Waters could be diverted to either or both infiltration basins. However, operational plans for the basins should include 3-5 day drying cycles for each basin at regular intervals.

The North and South Basins would be constructed in alluvial materials consisting primarily of decomposed granodiorite with a high permeability and low fines content. Therefore, no lining should be required in these basins to improve hydraulic conductivity. Additionally, the typical low-turbidity water delivered by the MHWS should necessitate only limited maintenance, and the care of these infiltration basins should be limited to annual removal of debris and sediment.

5.7.3 Pipeline Delivery System

In order to supply waters to the infiltration basins discussed above, construction of a new pipeline system to the South and North Basins would be required. The new pipeline must cross Vicee Canyon and should be buried to a depth of at least 5 feet. Air release assemblies would be required on either side of the canyon. A cleanout structure would also be required in the bottom of Vicee Canyon to remove accumulated sediment, as this low portion of the pipe may act as a trap. This structure is proposed to consist of a concrete manhole located at the lowest point on the pipe approximately 20 feet deep and would provide access to a downward-facing gate valve. The valve would periodically be manually discharged to remove sediment.

The total cost for the North and South basins with pipelines, valves and fittings, slope protection, and the Vicee Canyon cleanout structure is estimated to be $316,938. This total cost includes a factor of 20% for engineering, construction inspection, administration, legal and special services, and an additional 20% for contingency. The monitoring and adjustment of these facilities should not require considerable time or effort beyond the requirements for operation of the existing Vicee Canyon infiltration basins and, therefore, a nominal annual maintenance cost of $5,000 is estimated.

5.7.4 Extraction of Infiltrated Water

Extraction of the infiltrated water would be accomplished through higher pumping yields from existing CCUD wells and from new wells placed down-gradient of the recharge facilities. Three CCUD wells, Well #3, Well #6, and Well #10, which are generally located down-gradient from the proposed infiltration basins (Figure 5), experience pumping reductions of about 250 gpm each during the summer peak demand months due to falling water levels in the aquifer. The additional groundwater from the infiltration basins would likely allow the CCUD wells to maintain higher production rates because of higher aquifer water levels. This would result in a potential utilization of about 1.7 cfs (750 gpm) of the stored water per well. However, actual changes in water levels at the individual wells will probably vary, and maintenance of the full 1.7 cfs may not be achievable.

Additional wells should be constructed as needed with increased delivery from the MHWS and increasing demand from the municipalities served by this system. At the maximum delivery rate (as limited by the tested 18" pipeline from Red House to the Tanks) of 13.9 cfs, a total of approximately 7 wells with individual capacity to withdraw 1.7 cfs would be required for the long-term control of the groundwater surface. Remaining water is proposed to be processed directly by the ACWTP. However, the extraction wells are more likely to be constructed in response to demand, because excess available water from the MHWS may be diverted at several points along the delivery system. Based on the average year yield from the MHWS of 6,108 AF, and assuming sufficient buffering capacity in the vadose zone and aquifer recharged by the infiltration basins for higher-yield years, a reasonable target for constant withdrawal is estimated to be 8.4 cfs (6,108 AF on a constant flow basis). With the additional capacity in the existing wells allowed by a controlled water table, this target would require four additional wells. The proposed wells would be housed in underground vaults and be similar in design to recently constructed CCUD extraction wells (Well #47 is the basis for Brown and Caldwell's cost estimate), with total depths of about 500 feet. An exploration borehole converted to a monitoring well is included in the cost estimate for each extraction well.

The total cost per installed well with accompanying monitoring well is estimated to be $384,000 for a total cost of $2,150,400. This total cost is based on contractor's quotes to the CCUD and includes a factor of 20% for engineering, construction inspection, administration, legal and special services, and an additional 20% for contingency.

SECTION 6.0
SUMMARY AND RECOMMENDATIONS

6.1 Summary of Existing System Capacity

The capacity of each component of the existing Marlette Lake Water System is summarized in Table 6-1. This summary assumes that the 18" transmission main from the Red House diversion structure to the Tanks facility is limited to the capacity indicated in the 1974 WRC report.

Table 6-1 Summary of Existing System Capacity

System Component	Capacity (cfs)
Marlette Lake to Hobart Drainage Temporary Pumping Station (pipeline is non-functional)	0.0
East Slope To Red House Diversion Pipeline and Collection System (functioning at approximately 60% of capacity)	0.9
Red House Diversion to the Tanks 18" ϕ Pipeline	10.3
Net Capacity to the Tanks	**10.3**
Tanks to Ash Canyon Water Treatment Facility	2.6
Net Capacity to the Ash Canyon Water Treatment Facility	**2.6**

6.2 Recommendations, Preliminary Costs, and Value of Improvements

The base flow in the average year for all basins in the Marlette Lake Water system is approximately 7.7 cfs. The peak firm yield (dry year) runoff from all basins is 10.2 cfs. Additionally, the existing system is capable of delivering all but the peak flow in the dry year. Therefore, no modification of the existing system to target the firm yield is required. Brown and Caldwell's approach to upgrading the MHWS is to recommend a phased construction and repair or replacement of water system components (Table 6-2).

Table 6-2 Recommendations, Estimated Costs, and Value of Improvements

(Delivery in Acre-Feet per Year)	MHWS Average Year Delivery	MHWS Dry Year Delivery	MHWS Wet Year Delivery	Total Capital Cost	Total Annual Cost
Existing System	1,873	1,440	1,872	n/a	n/a
Phase I					
Repair Existing East Slope Collection System	2,629	1,605	2,660	$2,751	$2,751
Phase II					
Install West Carson City Aquifer Infiltration Basins and Pipelines	n/a	n/a	n/a	$316,938	$5,000
Install Four Extraction Wells at West Carson City Aquifer Site	n/a	n/a	n/a	$2,150,400	$2,000
Install 10"ϕ Pipeline from the Tanks to ACWTP	3,565	1,742	5,378	$2,355,269	$0
Retrofit and Repair existing 8" pipeline	n/a	n/a	n/a	$1,549	$0
Phase III					
Test and Inspect 18" ϕ Transmission Main from Red House diversion to the Tanks	3,580	1,742	5,816	$11,504	$0
Phase IV					
Install Permanent Pumping Station at Marlette Lake – Diesel	5,328	2,540	8,122	$531,888	$134,000
Install Permanent Pumping Station at Marlette Lake – Natural Gas	5,328	2,540	8,122	$1,554,140	$134,000
Install Permanent Pumping Station at Marlette Lake – Electric	5,328	2,540	8,122	$10,581,074	$153,301
OR Install 10" ϕ borehole from Marlette Lake to Hobart Reservoir	5,632	2,540	8,777	$5,412,400	$2,000
Totals including Marlette Pumping Station - Diesel				**$5,370,299**	**$143,751**
Totals including Marlette Pumping Station – Natural Gas				**$6,392,551**	**$143,751**
Totals including Marlette Pumping Station – Electric				**$15,419,85**	**$163,052**
Totals including Marlette to Hobart Borehole				**$10,250,811**	**$11,751**

Because the duration of each phase of construction and the likely delay between phases is not known, no attempt is made to quantify amortization costs or project the effect of capital improvement on the water rate structures for the municipalities served by the MHWS. Table 6-2 summarizes the recommended approach to better utilization of the MHWS. The order of the recommendations (phases) is intended to delay expenditures until they are necessary and to avoid delivering more water from upstream system components than can be handled by downstream system components. Each calculated yield volume takes into account upstream delivery capacity (prior to completion of Phase I, the East Slope collection system is limited to approximately 0.9 cfs, and prior to completion of Phase IV, no water is being delivered from Marlette Lake) and the limiting portion of the system (prior to the completion of Phase II, the system is limited by the existing 8" pipeline from the Tanks to the ACWTP to 2.6 cfs, and following Phase II, the system is limited by the 18" pipeline from the Red House diversion structure to the Tanks to 10.3 cfs until completion of Phase III, when the 18" pipeline has capacity for 13.9 cfs).

6.3 Evaluation of the Alternatives

The decision to implement each or any of the recommended phases for system improvement will be related to many factors that are beyond the scope of this study. These factors include, but are not necessarily limited to, the following:

- The need to maintain existing water rights by proving beneficial use or demonstrating development towards eventual beneficial use of the full water rights.
- A cost-benefit analysis of the additional water available for groundwater recharge and dry-year banking by targeting the higher delivery rate vs. the higher initial capital costs for this rate.
- An analysis of the economics of a phased approach to increasing utilization potential of the MHWS.
- A market analysis of water rates structures, projections, and amortization expenses of each phase of the expansion.
- Detailed engineering design and cost estimating for each phase after preliminary decisions have been made.
- Evaluation of other sources of water, which may change, limit, or delay the requirements from the MHWS (e.g., arsenic in existing groundwater supply wells).
- Investigation of each recommendation for possible unknown liabilities and costs, such as environmental impact analysis or permitting through various agencies involved in the region (e.g., TRPA).
- Evaluation of consistency with the State Engineer's and other regional water plans.

In particular, the decision to increase yield from Marlette Lake via a permanent pumping station or via a subsurface conduit will depend on the longer amortization period of a larger initial capital investment for the latter option and present and predicted annual maintenance costs associated with the former. Additionally, the service life of the borehole is much greater than that of a pump, which will need to be regularly replaced or overhauled, as dictated by operating conditions, and the service life of the existing 8" pipeline from Marlette Lake to the Hobart Creek drainage should be closely investigated; it is an exposed feature that has sustained considerable damage in the past seven years.

In summary, the Marlette Lake – Hobart Reservoir Water System has considerable historical significance and is a source of exceptionally high-quality water for municipal use. As recognized in the WRC report of 1974, its value may best be realized as a primary source of water for municipal and industrial use by Carson City, Virginia City and other municipalities within the Carson River watershed. Upgrades to this system should be evaluated in the context of developing or improving other water resources (e.g., new or replacement wells, or treatment of groundwater high arsenic concentrations).

SECTION 7.0
REFERENCES

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Appendix A

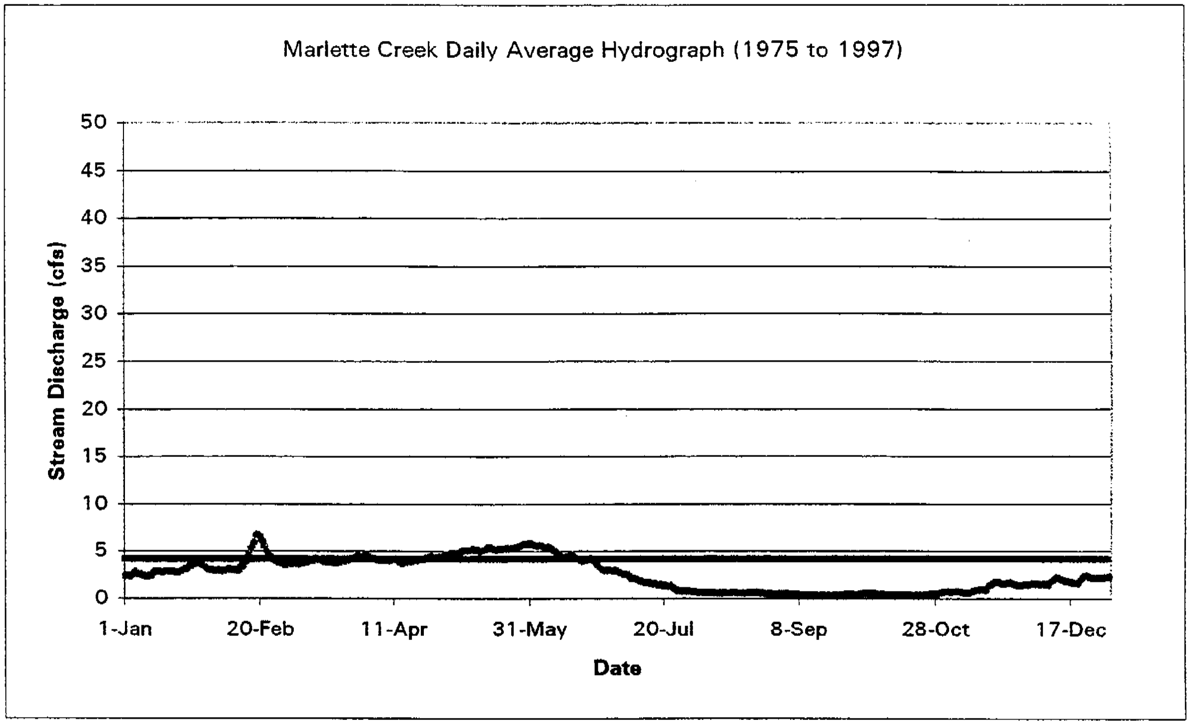
Marlette Lake Water System Hydrology

Sheet No.

APPENDIX A NOTE:

The USGS records of daily streamflow measurements were retrieved from the following URL:
http://waterdata.usgs.gov/nwis-w/NV/search.components/textsearch.cgi?mode=search
Additionally, the data were analyzed by spreadsheet for each basin, and daily capture was computed for each relevant existing or designed pipeline segment. The total data produced in this analysis span several hundred pages, and therefore are not included in this appendix. The data are available from Brown and Caldwell's Reno office at (775) 348-7997 or by contacting Mr. Nathan Earl Robison via e-mail at **nrobison@brwncald.com**

Sheet A- 2



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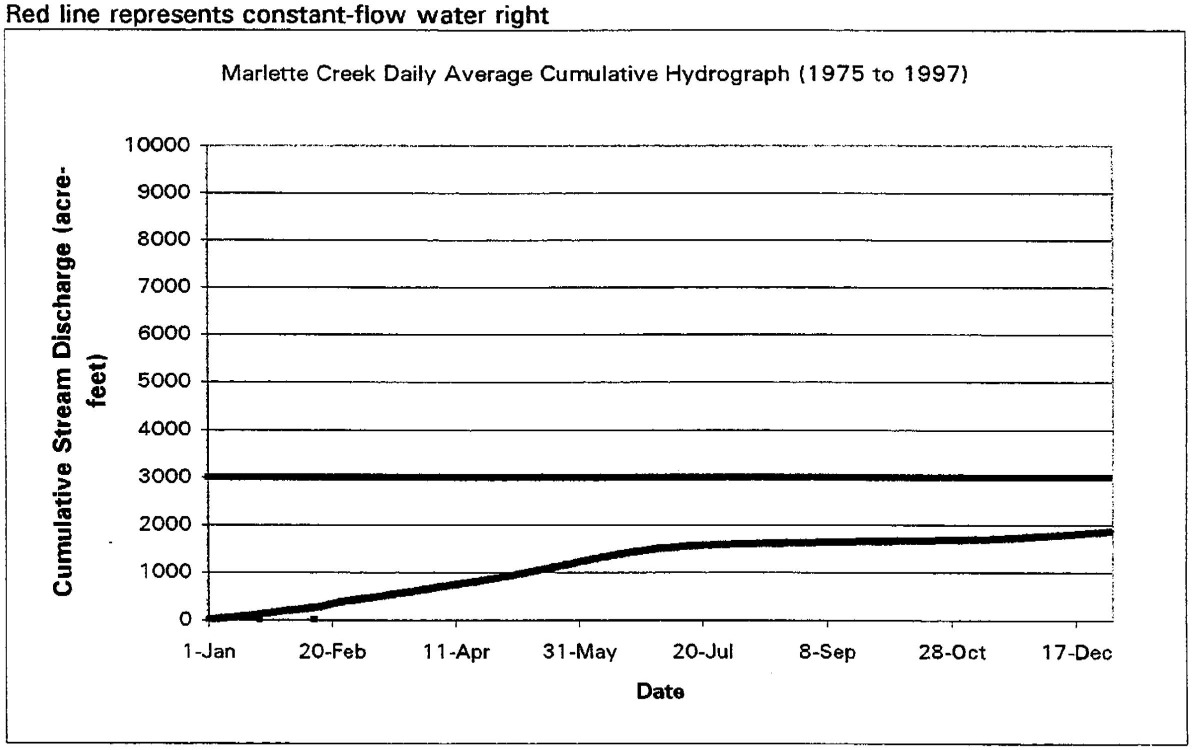

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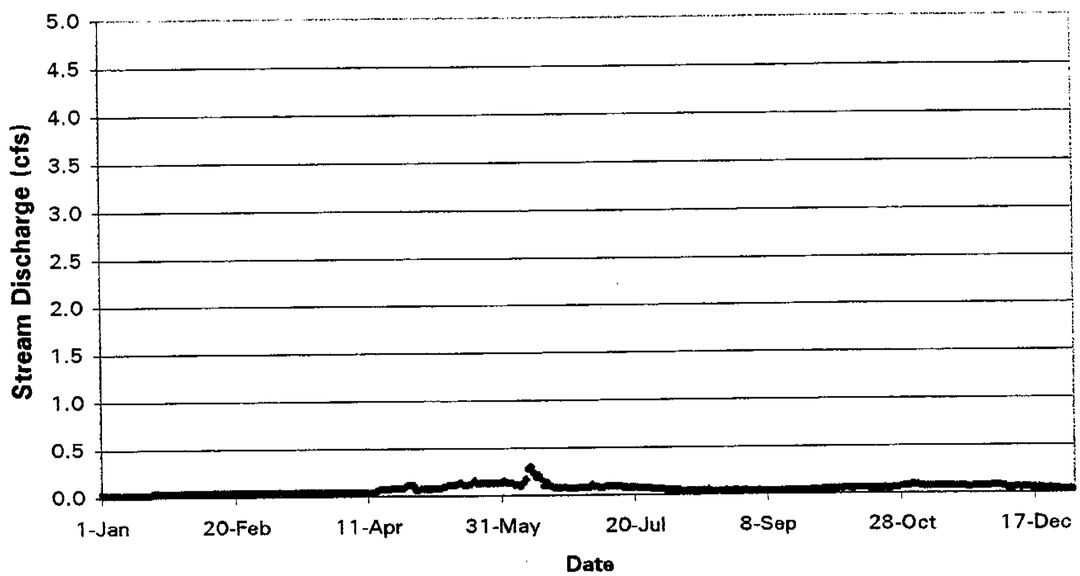
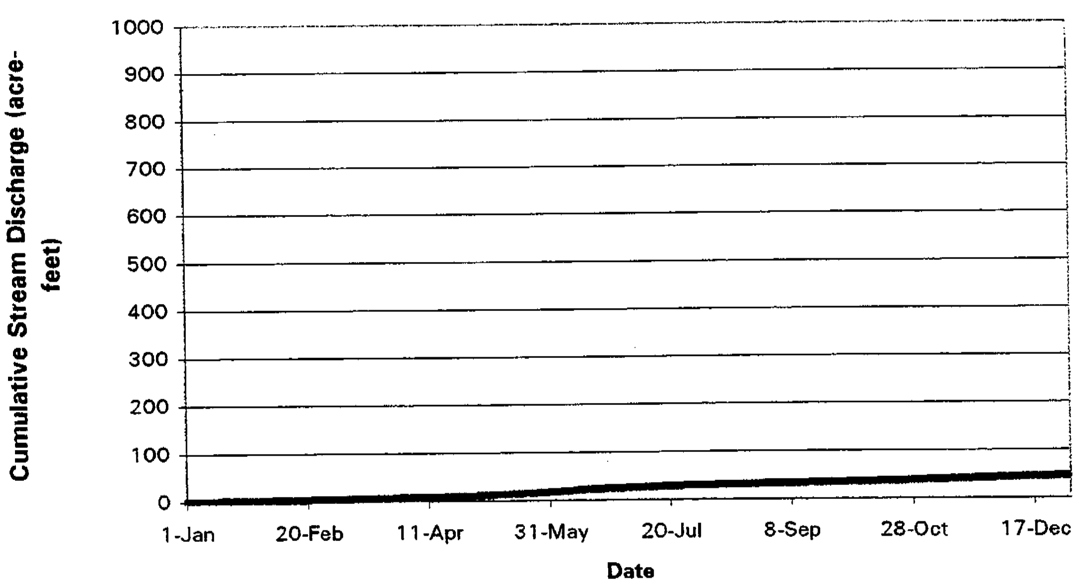
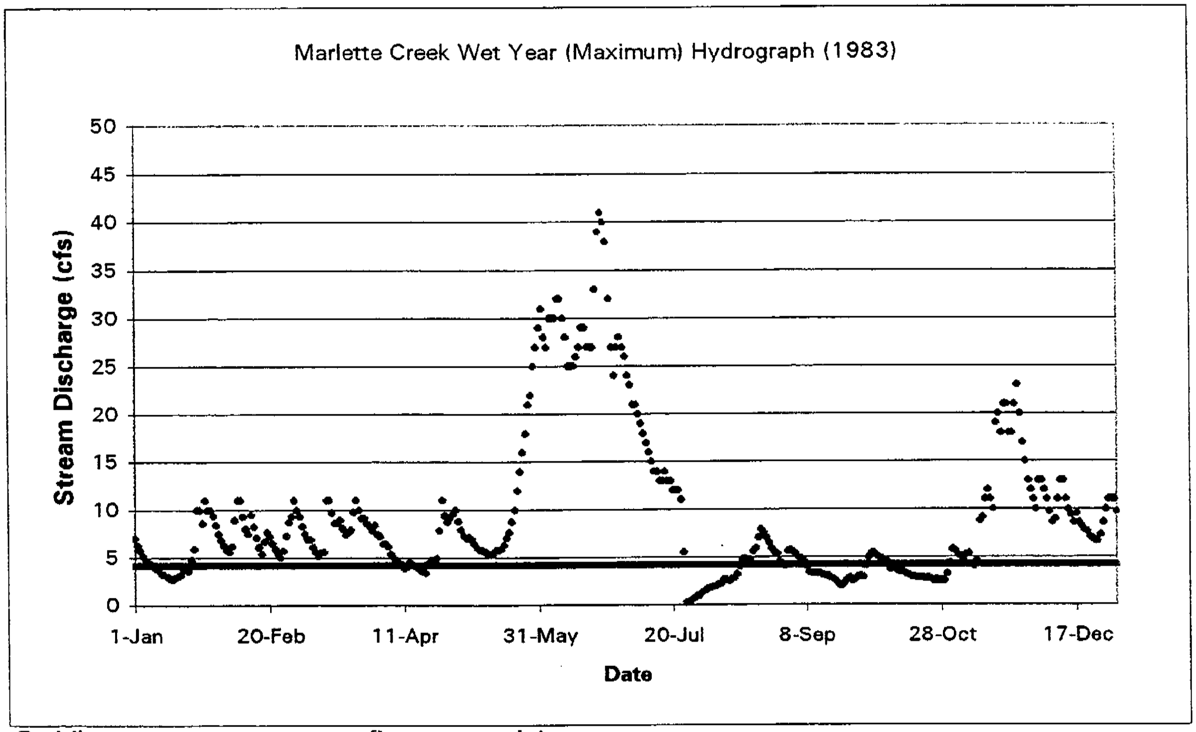
Marlette Creek Dry Year (Firm Yield) Hydrograph (1977)



Marlette Creek Dry Year (Firm Yield) Cumulative Hydrograph (1977)





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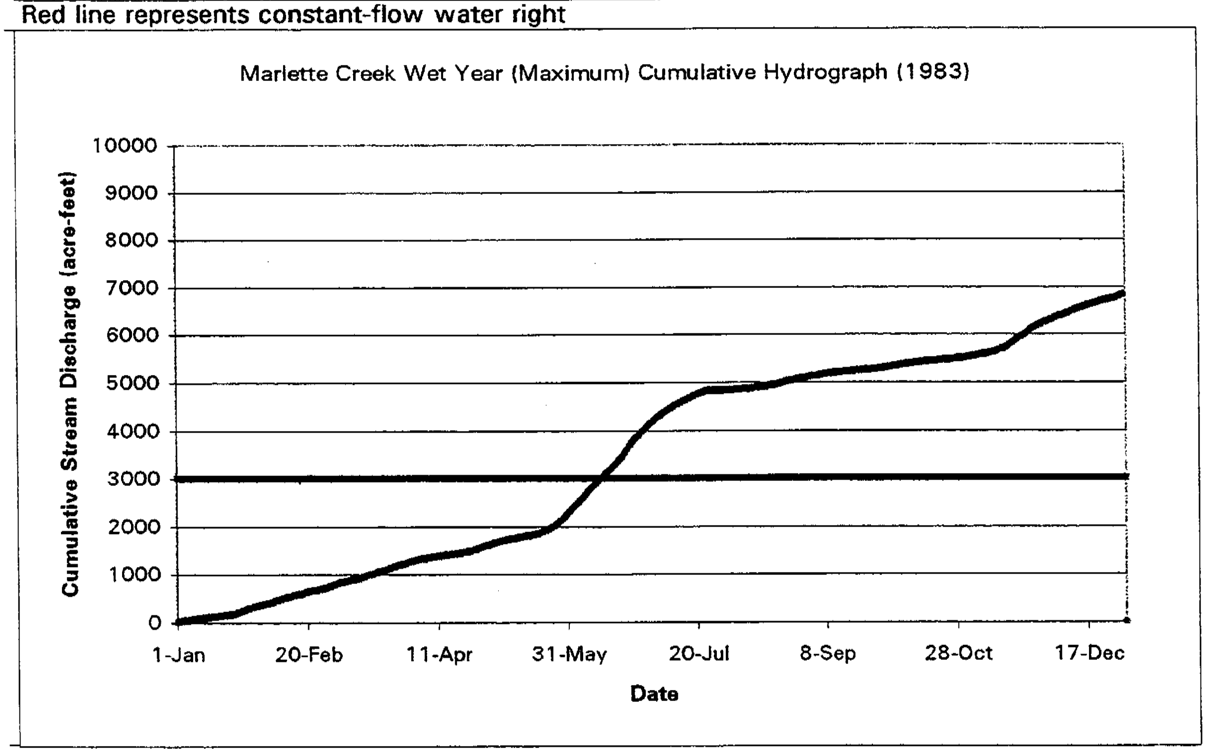

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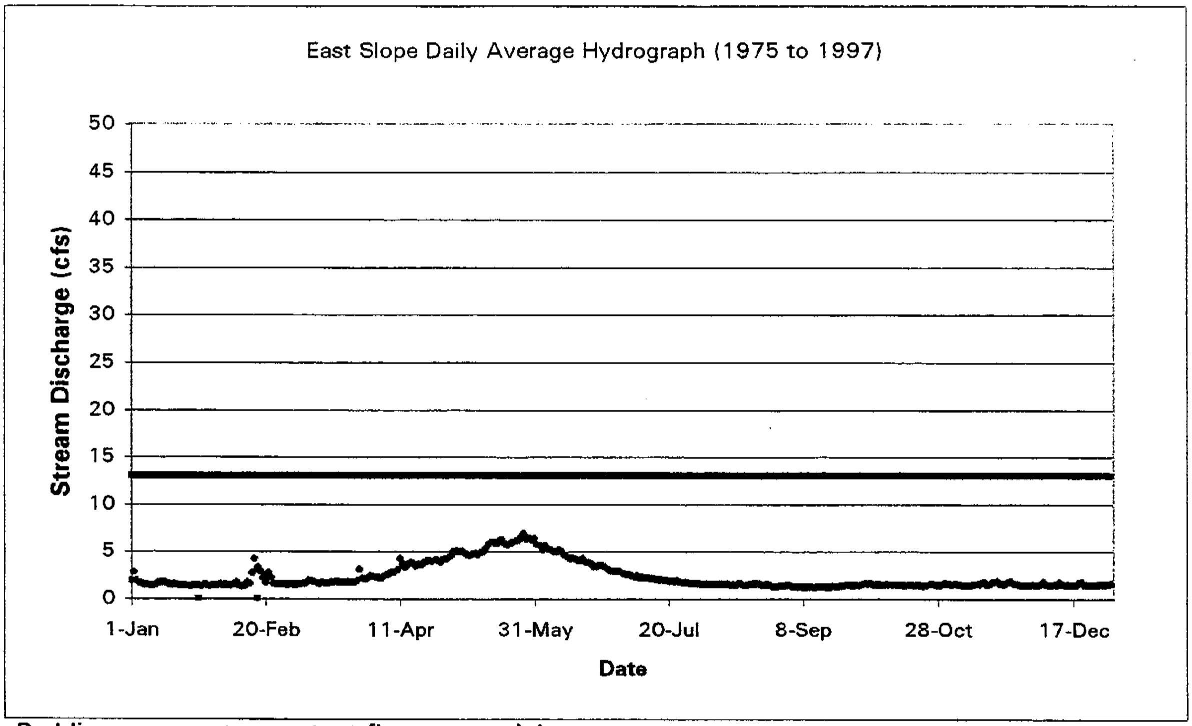

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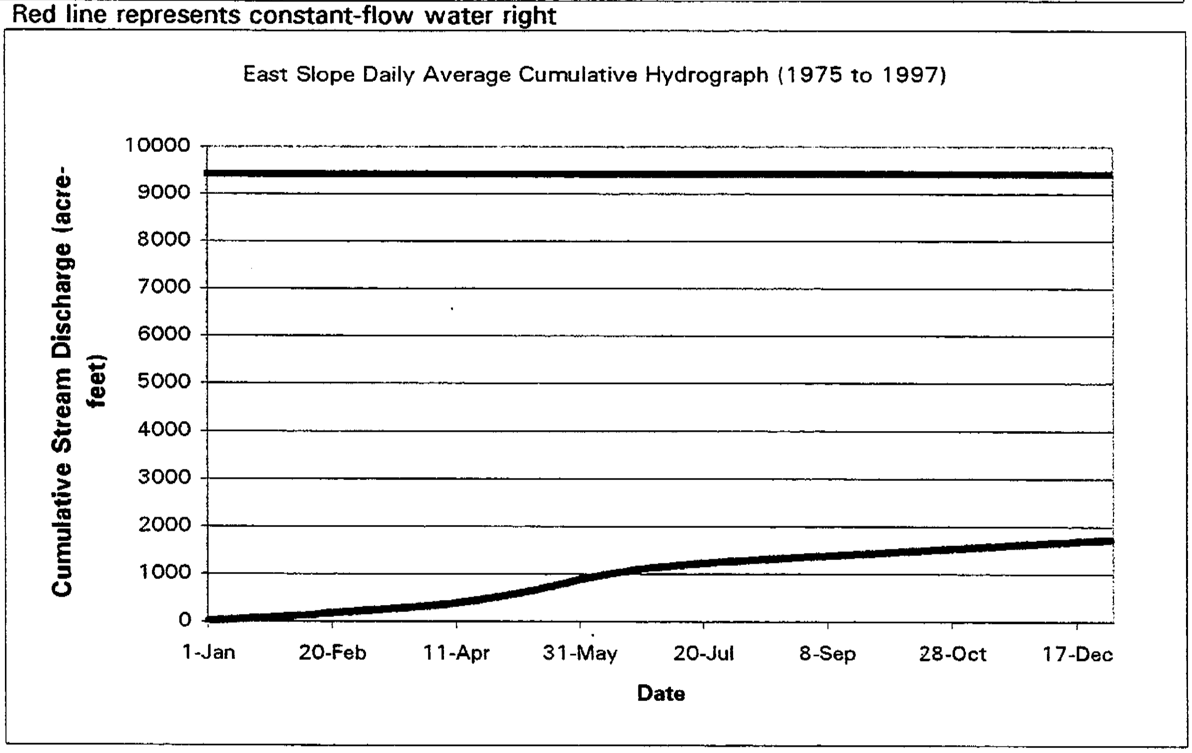

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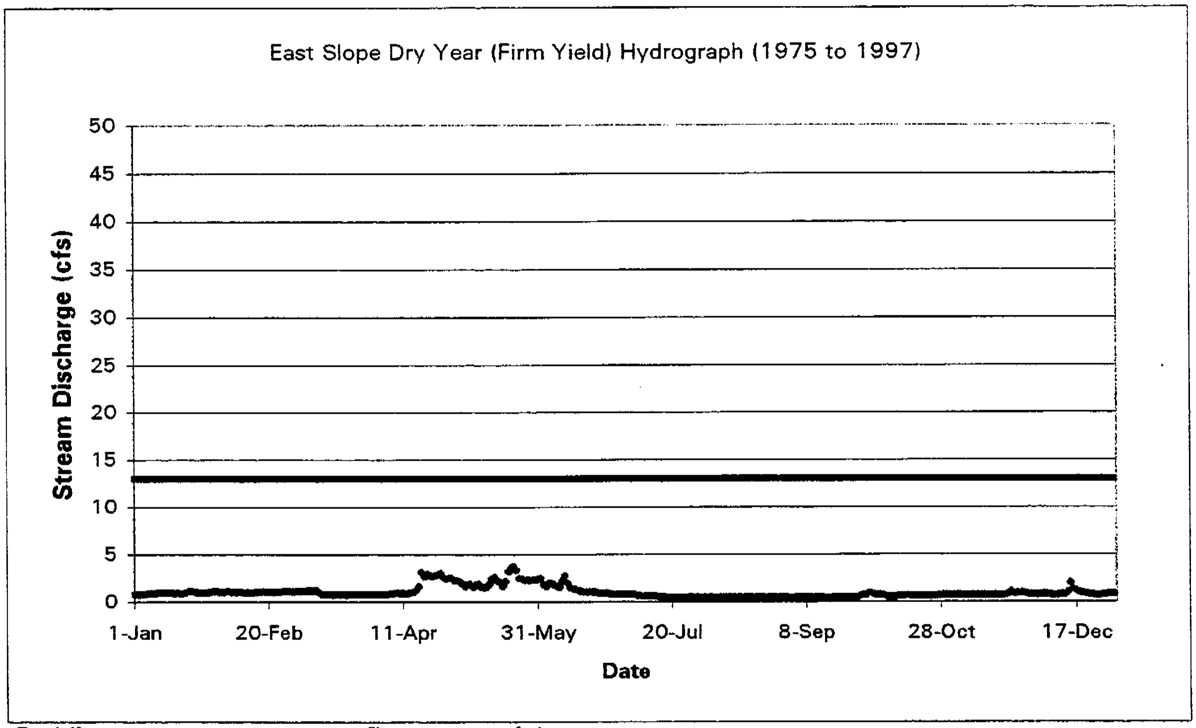

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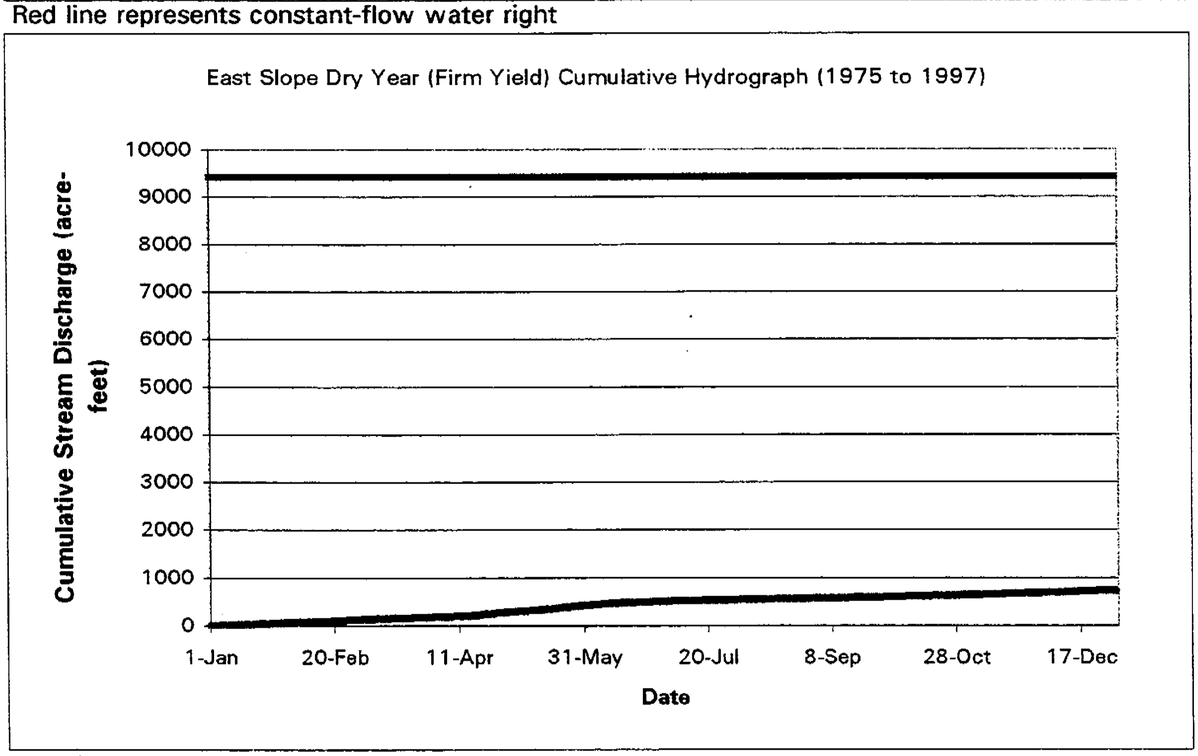

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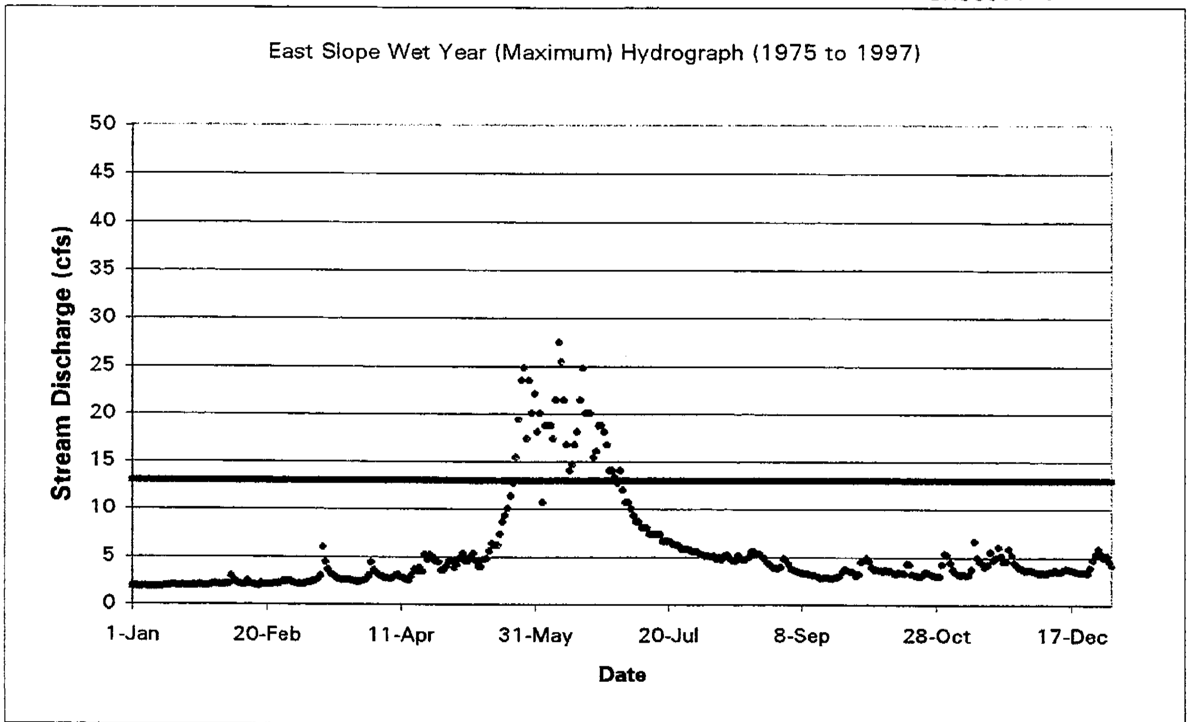

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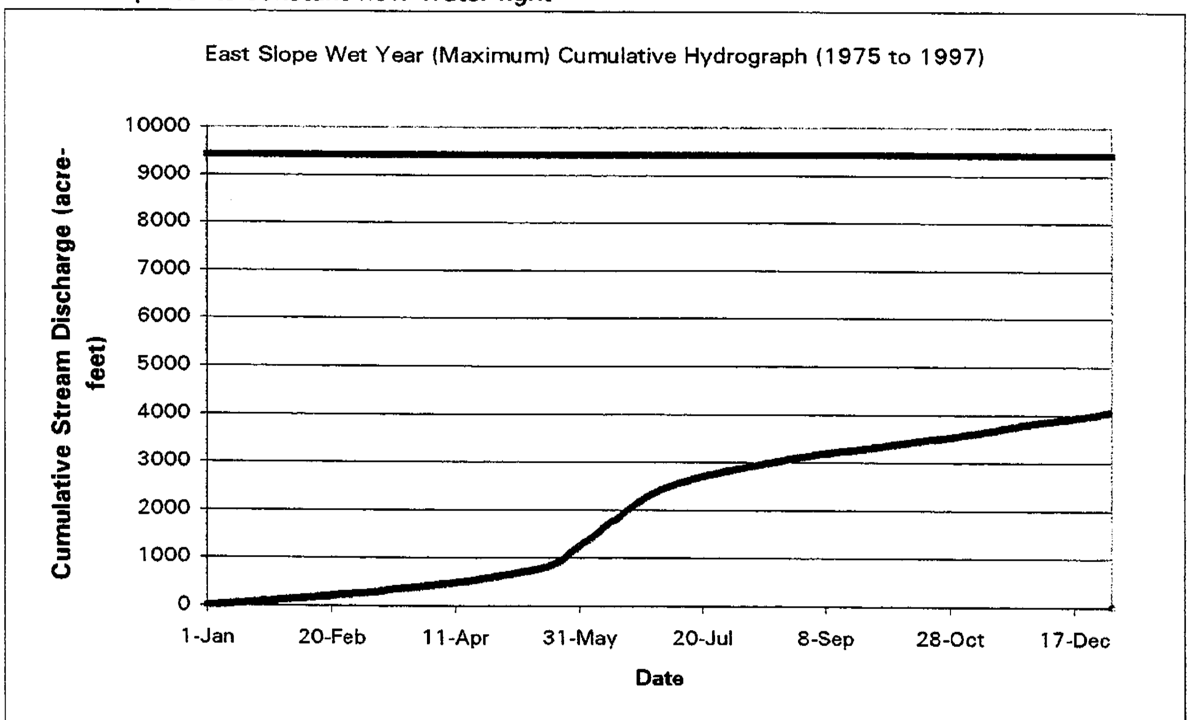

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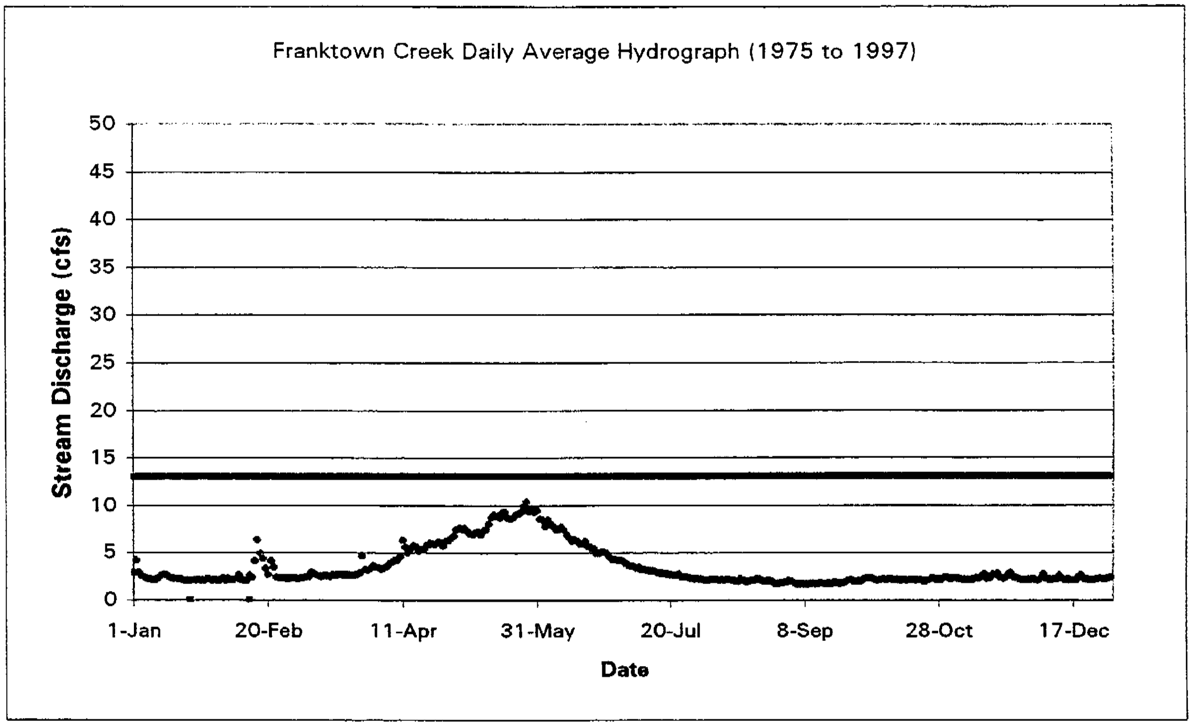

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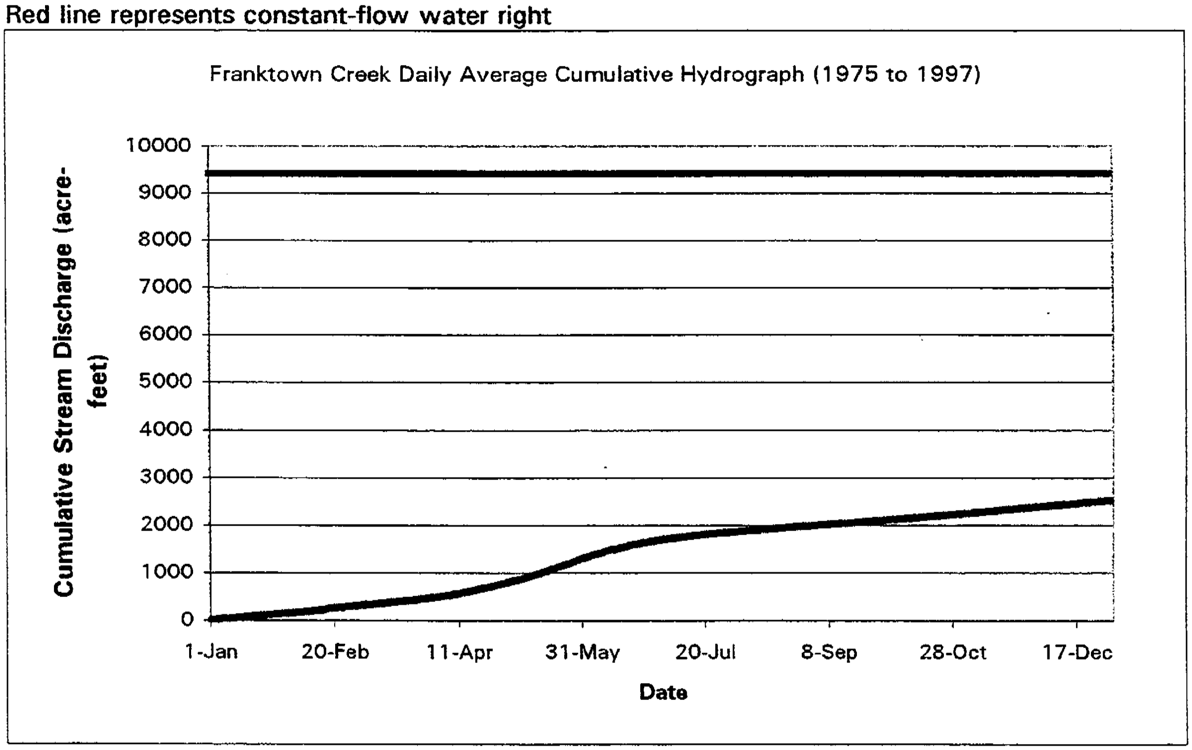

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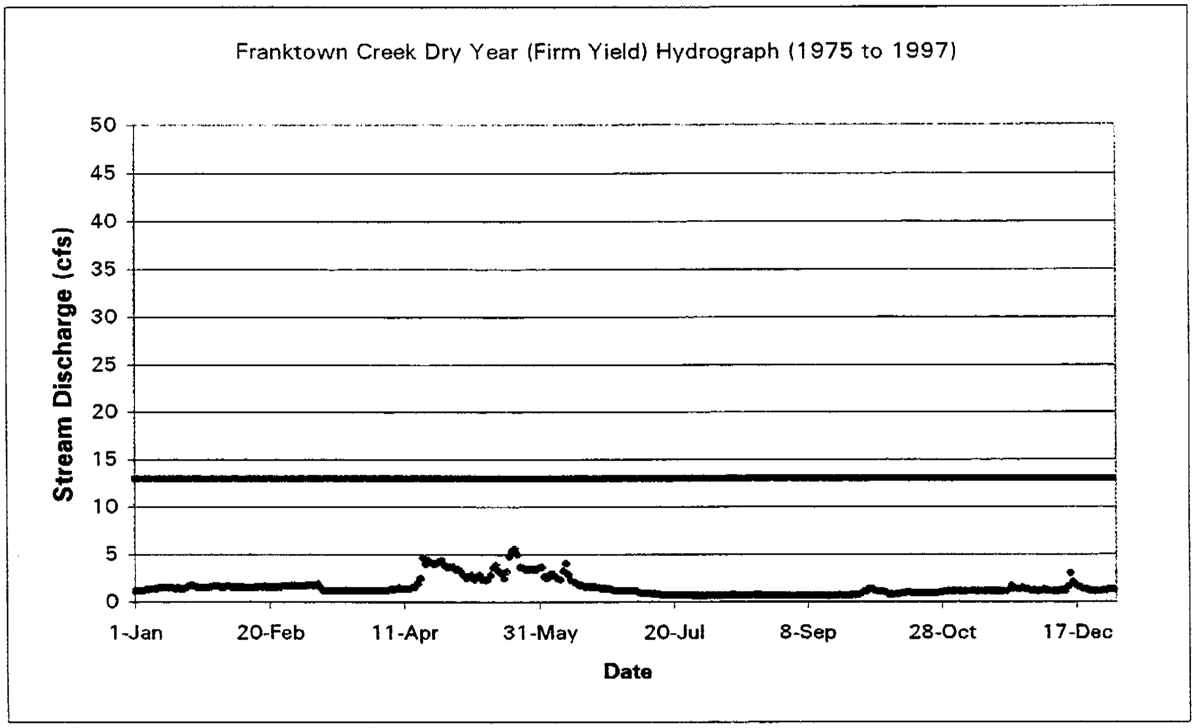

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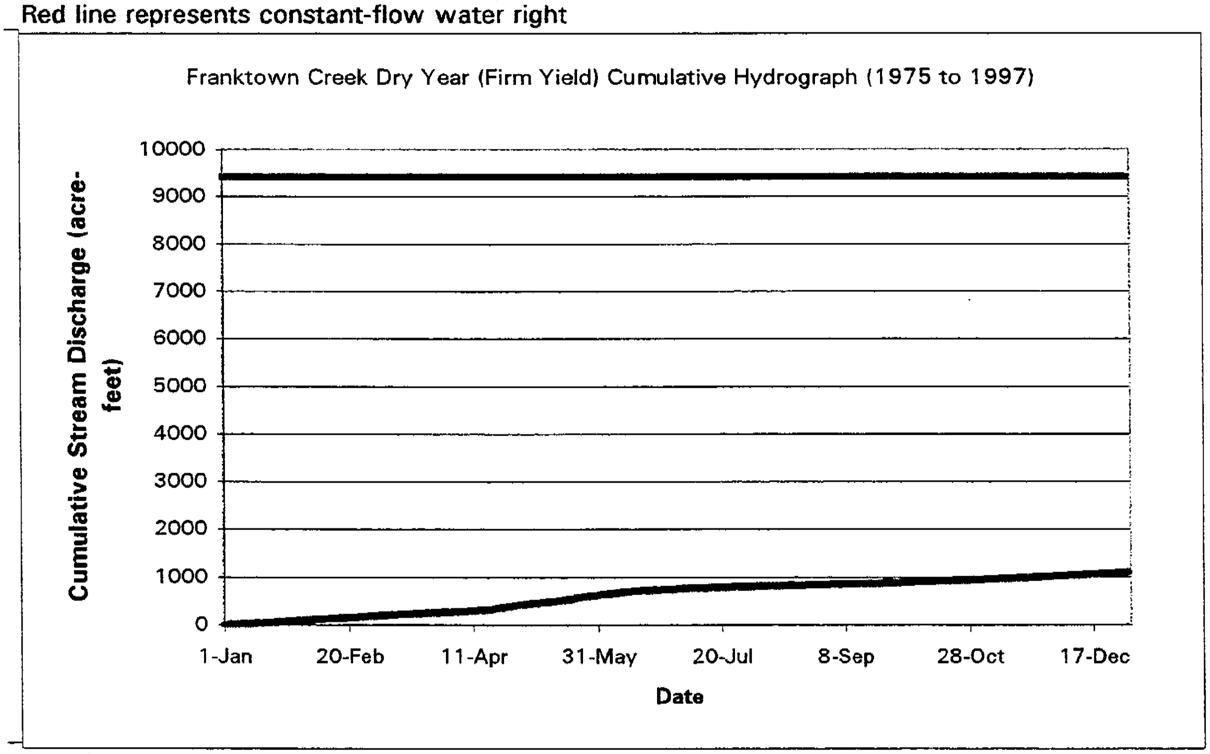

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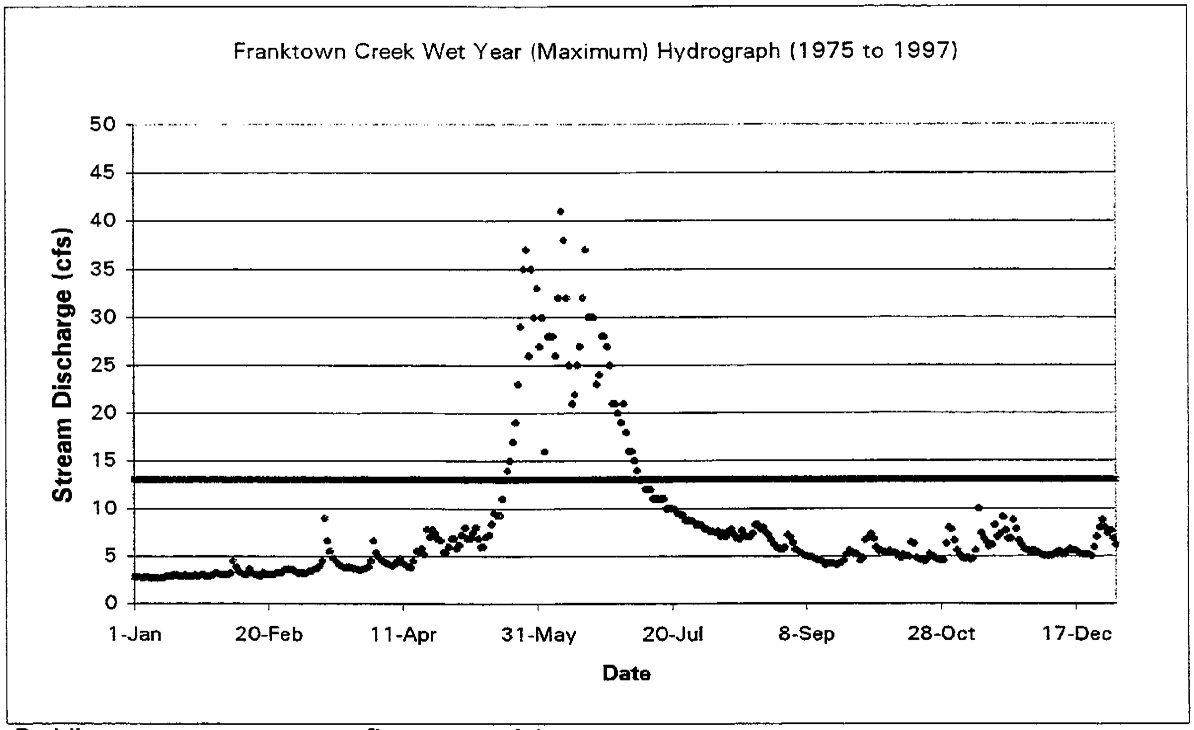

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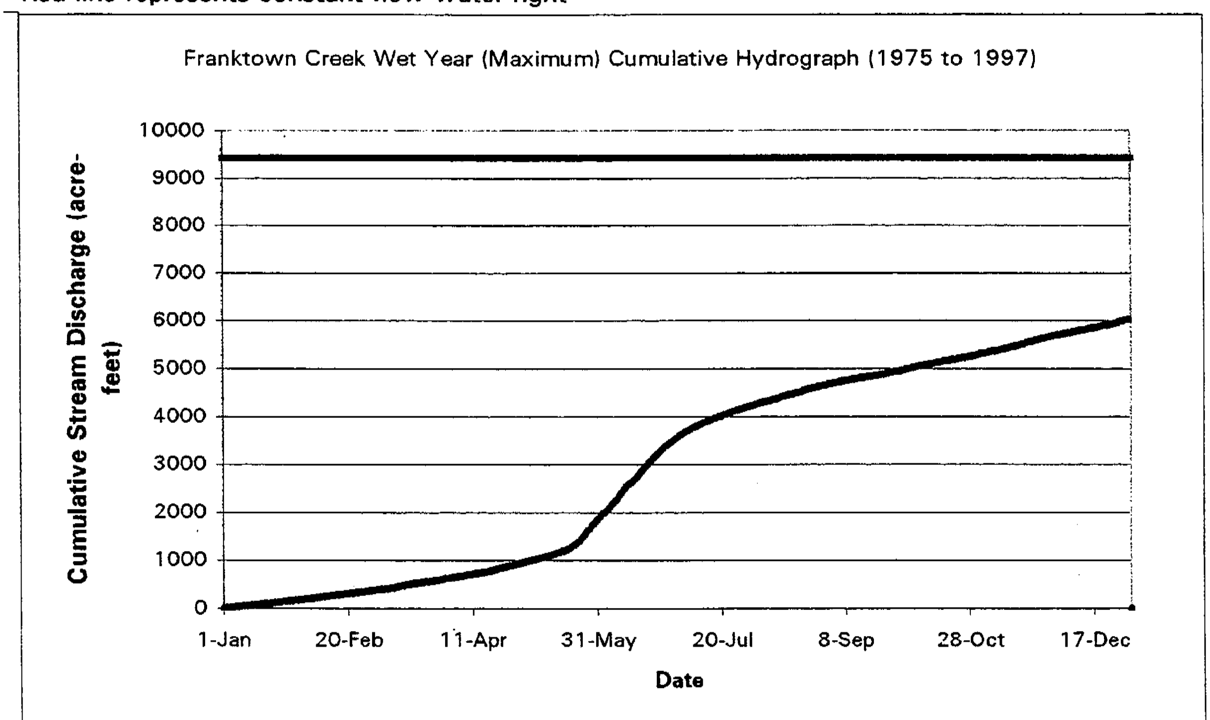

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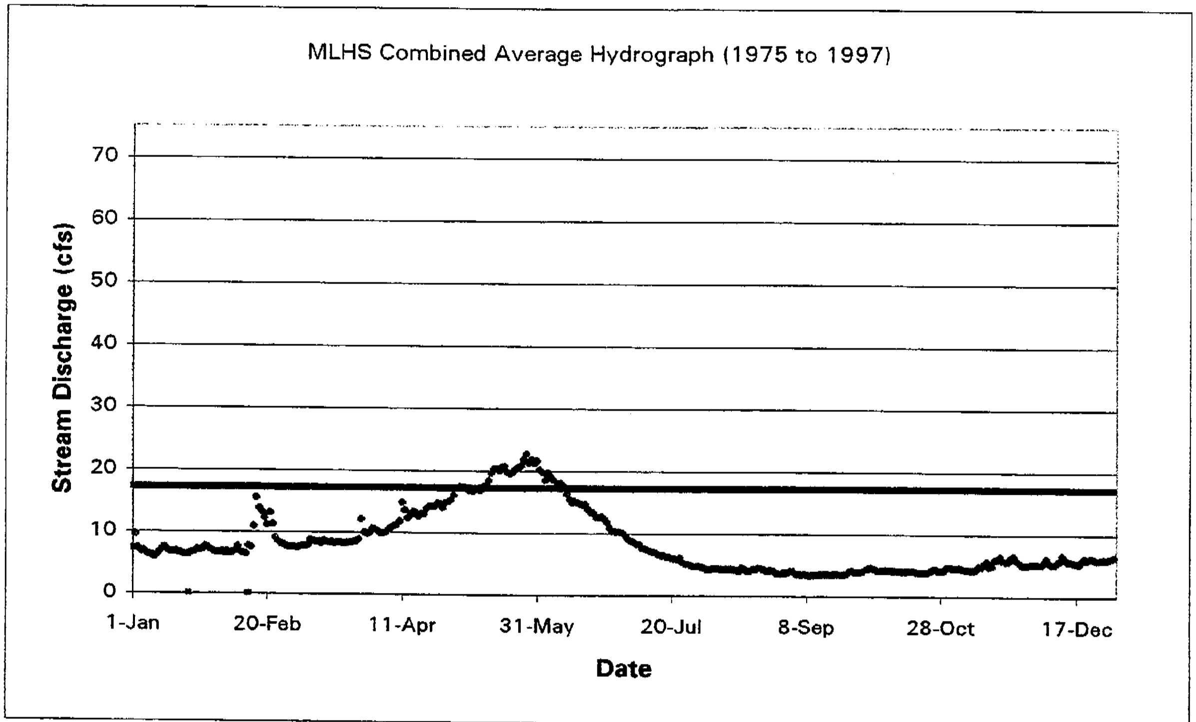
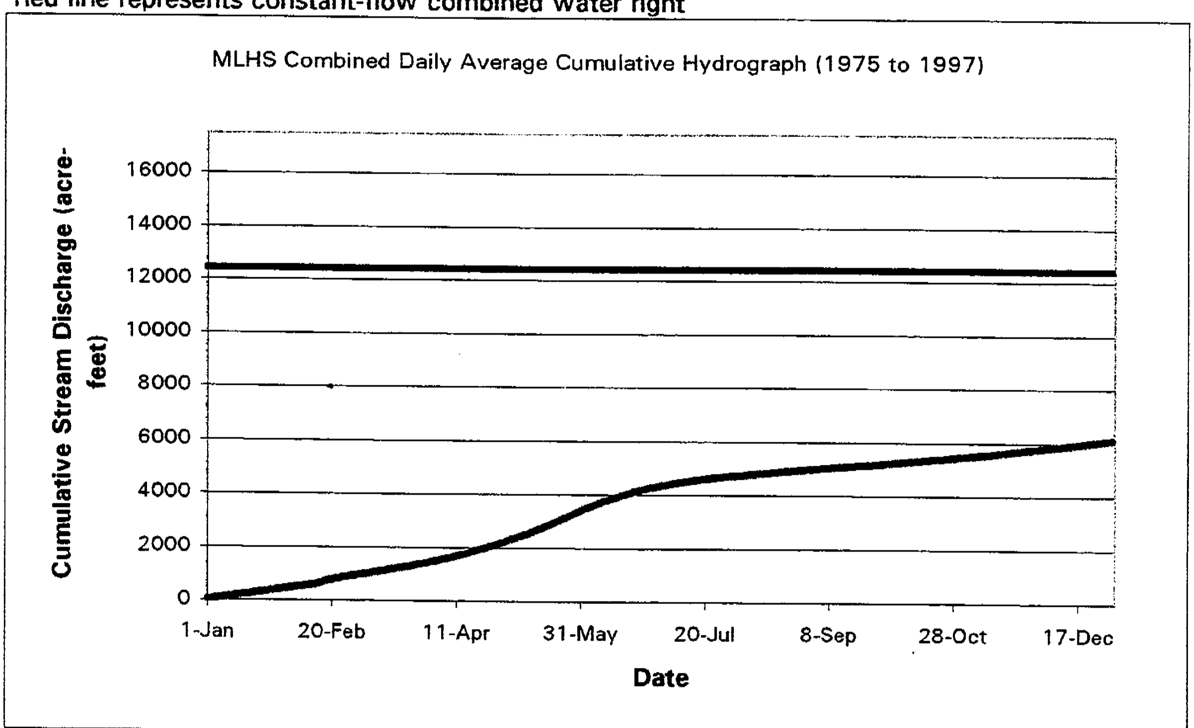
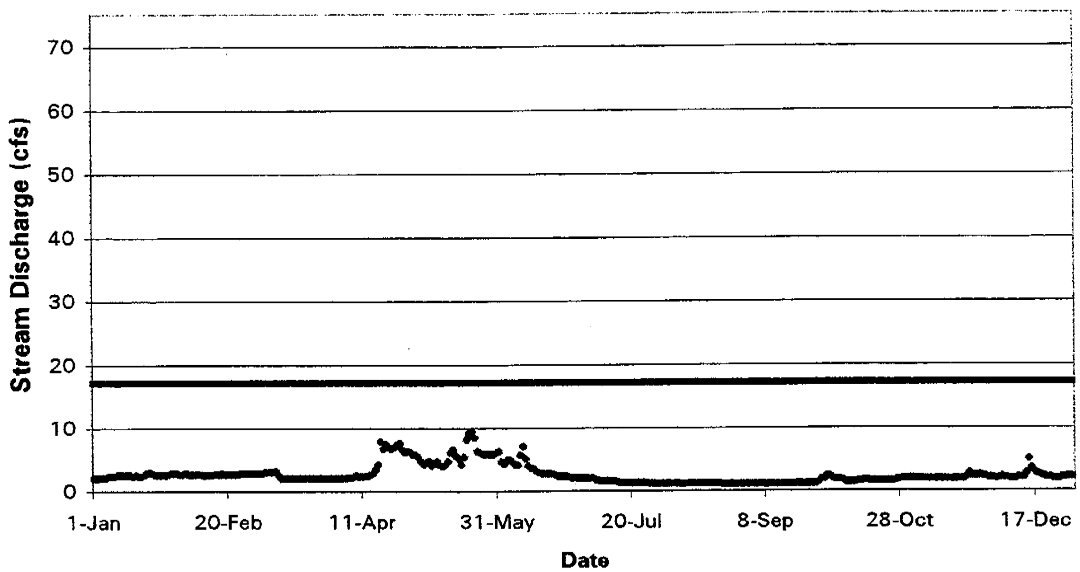


Red line represents constant-flow combined water right



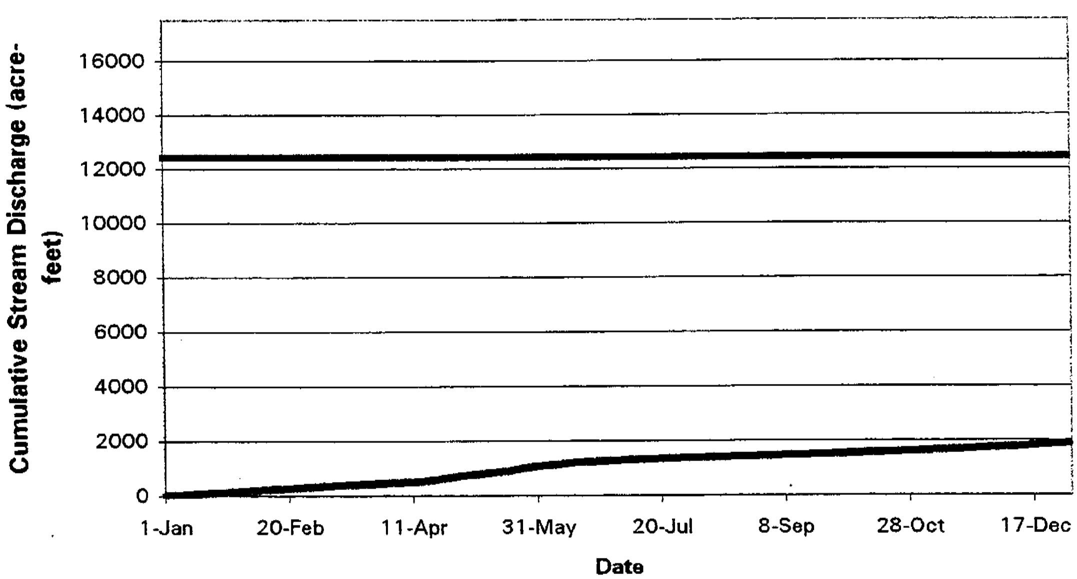
Red line represents full combined water right

MLHS Combined Dry Year (Firm Yield) Hydrograph (1977)



Red line represents constant-flow combined water right

MLHS Combined Dry Year (Firm Yield) Cumulative Hydrograph (1977)



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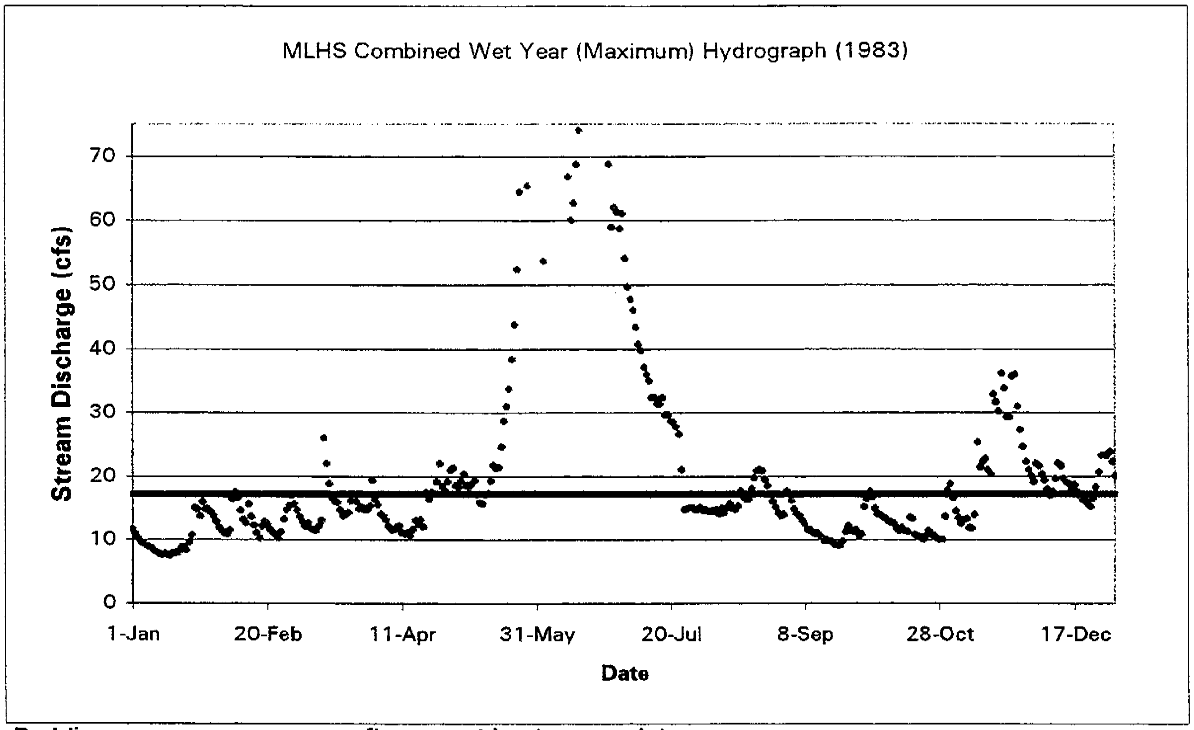

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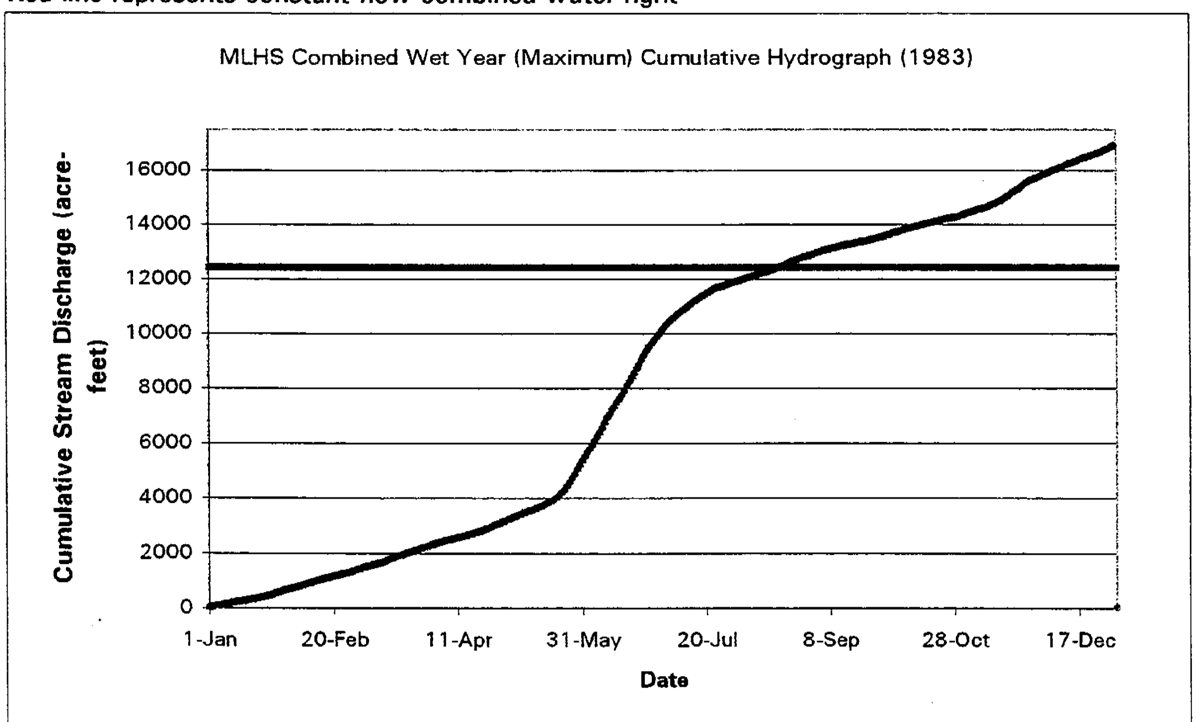

Red line represents full combined water right

Marlette Lake to Hobart Reservoir

10 inch cased borehole

E_i (ft) =	Maximum Water Elevation	7823.00
E_f (ft) =	Minimum Water Elevation	7600.00
h_e (m) =	E_i-E_f (ft > m)	67.97
	υ (m^2/s)	1.01E-06
	μ (kg/m s)	1.00E-03
	g (m/s^2)	9.810
	d (m)	0.343
	L (m)	2887.98
ϑ =	$gd^3h_f/L\upsilon^2$	9.22E+09
	ε (mm)	2.40E+00
R_E =	$-(8\vartheta)^{1/2}\log_{10}[\varepsilon/3.7d+1.775/(\vartheta)^{1/2}]$	738,289
V (m/s) =	$\upsilon R_E/d$	2.16E+00
Q (m^3/s) =	$V(\pi/4)d^2$	2.00E-01

V (ft/s)	7.1
Q (ft^3/s)	7.1
Head Necessary at Orifice (ft)	0.8

Net Average Yield (acre-feet)	2149.1
Net Available Water	2157.8
Percent Capture	99.6%
Net Firm Yield (acre-feet)	798.2
Net Available Water	798.2
Percent Capture	100.0%
Net Maximum Yield (acre-feet)	3000.0
Net Available Water	6843.4
Percent Capture	43.8%

Note: Net available water is the sum available from upstream system capacity and basin yield. Net yield is the portion of this amount captured by the subject system component. - All yields are 365-day integral volumes.

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Marlette Lake to Hobart Reservoir

8 inch existing line, pump head added

E_i (ft) =	Total Pump Head at this flow rate	1096.93
E_f (ft) =	Minimum Water Elevation	437.00
h_e (m) =	E_i-E_f (ft > m)	201.15
	υ (m^2/s)	1.01E-06
	μ (kg/m s)	1.00E-03
	g (m/s^2)	9.810
	d (m)	0.203
	L (m)	2708.45
ϑ =	$gd^3h_f/L\upsilon^2$	6.05E+09
	ε (mm)	2.60E-01
R_E =	$-(8\vartheta)^{1/2}\log_{10}[\varepsilon/3.7d+1.775/(\vartheta)^{1/2}]$	755,476
V (m/s) =	$\upsilon R_E/d$	3.74E+00
Q (m^3/s) =	$V(\pi/4)d^2$	1.21E-01

V (ft/s)	12.3
Q (ft^3/s)	4.3
Necessary Pump Power (kW)	238.6
Necessary Horsepower (80% eff)	400.0

Net Average Yield (acre-feet)	1788.5
Net Available Water	2157.8
Percent Capture	82.9%
Net Firm Yield (acre-feet)	798.2
Net Available Water	798.2
Percent Capture	100.0%
Net Maximum Yield (acre-feet)	2845.5
Net Available Water	6843.4
Percent Capture	41.6%

Note: Net available water is the sum available from upstream system capacity and basin yield. Net yield is the portion of this amount captured by the subject system component. - All yields are 365-day integral volumes.

Sheet B- 2

Drop Inlet No. 1 to Red House Diversion

Existing Condition

E_i (ft) =	Maximum Water Elevation	7402.00
E_f (ft) =	Minimum Water Elevation	7330.00
h_e (m) =	E_i-E_f (ft > m)	21.95
	υ (m^2/s)	1.01E-06
	μ (kg/m s)	1.00E-03
	g (m/s^2)	9.810
	d (m)	0.305
	L (m)	1494.43
ϑ =	$gd^3h_f/L\upsilon^2$	4.04E+09
	ε (mm)	1.20E-01
R_E =	$-(8\vartheta)^{1/2}\log_{10}[\varepsilon/3.7d+1.775/(\vartheta)^{1/2}]$	695,962
V (m/s) =	$\upsilon R_E/d$	2.29E+00
Q (m^3/s) =	$V(\pi/4)d^2$	4.19E-02

V (ft/s)	7.5
Q (ft^3/s)	1.5

	existing	improved
Net Average Yield (acre-feet)	642.1	1059.0
Net Available Water	1721.7	1721.7
Percent Capture	37.3%	61.5%
Net Firm Yield (acre-feet)	541.2	645.1
Net Available Water	736.4	736.4
Percent Capture	73.5%	87.6%
Net Maximum Yield (acre-feet)	642.1	1070.2
Net Available Water	4049.7	4049.7
Percent Capture	15.9%	26.4%

Note: Net available water is the sum available from upstream system capacity and basin yield. Net yield is the portion of this amount captured by the subject system component. - All yields are 365-day integral volumes.

Sheet B- 3

Red House Diversion to Tanks

Existing Condition - Pressurized Pipe

E_i (ft) =	Maximum Water Elevation	7330.00
E_f (ft) =	Minimum Water Elevation	7090.00
h_f (m) =	E_i-E_f (ft > m)	73.15
	υ (m^2/s)	1.01E-06
	μ (kg/m s)	1.00E-03
	g (m/s^2)	9.810
	d (m)	0.457
	L (m)	6604.10
ϑ =	$gd^3h_f/L\upsilon^2$	1.03E+10
	ε (mm)	2.40E-01
R_E =	$-(8\vartheta)^{1/2}\log_{10}[\varepsilon/3.7d+1.775/(\vartheta)^{1/2}]$	1,089,142
V (m/s) =	$\upsilon R_E/d$	2.39E+00
Q (m^3/s) =	$V(\pi/4)d^2$	3.93E-01

V (ft/s)	7.9
Q (ft^3/s)	13.9
Head Necessary at Orifice (ft)	1.0

	w/o Marlette	w/pump	w/borehole
Net Average Yield (acre-feet)	3580.4	5328.4	5631.8
Net Available Water	3580.4	5368.9	5729.5
Percent Capture	100.0%	99.2%	98.3%
Net Firm Yield (acre-feet)	1741.9	2540.0	2540.0
Net Available Water	7101.8	2540.0	2540.0
Percent Capture	24.5%	100.0%	100.0%
Net Maximum Yield (acre-feet)	5816.3	8121.5	8776.5
Net Available Water	7101.8	9947.2	11157.7
Percent Capture	81.9%	81.6%	78.7%

Note: Net available water is the sum available from upstream system capacity and basin yield. Net yield is the portion of this amount captured by the subject system component. - All yields are 365-day integral volumes.

Sheet B- 4

Red House Diversion to Tanks

Existing Condition - Manning's Open Channel Flow

E_i (ft) =	Maximum Water Elevation	7330.00
E_f (ft) =	Minimum Water Elevation	7090.00
h_f (m) =	E_i-E_f (ft > m)	73.15
	L (m)	6604.10
Slope =	$(h_f)/L$ (%)	1.11%
	Manning's n	0.014
	d (m)	0.457
R_h =	d/4	0.114
V (m/s) =	$(R_h^{2/3}S^{1/2})/n$	1.77
Q (m^3/s) =	$V(\pi/4)d^2$	2.91E-01

V (ft/s)	5.8
Q (ft^3/s)	10.3

Net Average Yield (acre-feet)	3564.9
Net Available Water	3580.4
Percent Capture	99.6%
Net Firm Yield (acre-feet)	1741.9
Net Available Water	1741.9
Percent Capture	100.0%
Net Maximum Yield (acre-feet)	5377.7
Net Available Water	7101.8
Percent Capture	75.7%

Note: Net available water is the sum available from upstream system capacity and basin yield. Net yield is the portion of this amount captured by the subject system component. - All yields are 365-day integral volumes.

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Tanks to Ash Canyon Water Treatment Plant

Existing - Junction Box 1 to Junction Box 2

E_i (ft) =	Maximum Water Elevation	6448.00
E_f (ft) =	Minimum Water Elevation	5887.00
h_f (m) =	E_i-E_f (ft > m)	170.99
	υ (m^2/s)	1.01E-06
	μ (kg/m s)	1.00E-03
	g (m/s^2)	9.810
	d (m)	0.152
	L (m)	696.47
ϑ =	$gd^3h_f/L\upsilon^2$	8.37E+09
	ε (mm)	2.40E-01
R_E =	$-(8\vartheta)^{1/2}\log_{10}[\varepsilon/3.7d+1.775/(\vartheta)^{1/2}]$	867,223
V (m/s) =	$\upsilon R_E/d$	5.73E+00
Q (m^3/s) =	$V(\pi/4)d^2$	1.04E-01

V (ft/s)	18.8
Q (ft^3/s)	3.7
Head Necessary at Orifice (ft)	5.5

Note: 2.587 cfs is maximum delivery in past 7 years and is used for calculation of existing system capacity

	existing East Slope	improved East Slope
Net Average Yield (acre-feet)	1872.9	2628.6
Net Available Water	3163.5	3591.5
Percent Capture	59.2%	73.2%
Net Firm Yield (acre-feet)	1439.8	1605.3
Net Available Water	1637.9	1741.9
Percent Capture	87.9%	92.2%
Net Maximum Yield (acre-feet)	1872.9	2660.1
Net Available Water	6673.7	7101.8
Percent Capture	28.1%	37.5%

Note: Net available water is the sum available from upstream system capacity and basin yield. Net yield is the portion of this amount captured by the subject system component. - All yields are 365-day integral volumes.

Sheet B- 6

Tanks to Ash Canyon Water Treatment Plant

Proposed 10" pipeline

E_i (ft) =	Maximum Water Elevation	7050.00
E_f (ft) =	Minimum Water Elevation	5226.00
h_f (m) =	E_i-E_f (ft > m)	555.96
	υ (m^2/s)	1.01E-06
	μ (kg/m s)	1.00E-03
	g (m/s^2)	9.810
	d (m)	0.254
	L (m)	3852.37
ϑ =	$gd^3h_f/L\upsilon^2$	2.30E+10
	ε (mm)	2.40E-01
R_E =	$-(8\vartheta)^{1/2}\log_{10}[\varepsilon/3.7d+1.775/(\vartheta)^{1/2}]$	1,531,777
V (m/s) =	$\upsilon R_E/d$	6.06E+00
Q (m^3/s) =	$V(\pi/4)d^2$	3.07E-01

V (ft/s)	19.9
Q (ft^3/s)	10.8
Head Necessary at Orifice (ft)	6.1

Note: Net available water is the sum available from upstream system capacity and basin yield. Net yield is the portion of this amount captured by the subject system component. - All yields are 365-day integral volumes.

Sheet B- 7

Ash Canyon Water Treatment Plant to Infiltration Basins

ACWTP to South Basin

E_i (ft) =	Maximum Water Elevation	5213.00
E_f (ft) =	Minimum Water Elevation	5120.00
h_f (m) =	E_i-E_f (ft > m)	28.35
	υ (m^2/s)	1.01E-06
	μ (kg/m s)	1.00E-03
	g (m/s^2)	9.810
	d (m)	0.305
	L (m)	600.76
ϑ =	$gd^3h_f/L\upsilon^2$	1.30E+10
	ε (mm)	1.50E-03
R_E =	$-(8\vartheta)^{1/2}\log_{10}[\varepsilon/3.7d+1.775/(\vartheta)^{1/2}]$	1,537,510
V (m/s) =	$\upsilon R_E/d$	5.07E+00
Q (m^3/s) =	$V(\pi/4)d^2$	3.70E-01

V (ft/s)	16.6
Q (ft^3/s)	13.1
Q (MGD)	8.4
Head Necessary at Orifice (ft)	4.3

Note: Net available water is the sum available from upstream system capacity and basin yield. Net yield is the portion of this amount captured by the subject system component. - All yields are 365-day integral volumes.

Sheet B- 8

Ash Canyon Water Treatment Plant to Infiltration Basins

South Basin to North Basin

E_i (ft) =	Maximum Water Elevation	5120.00
E_f (ft) =	Minimum Water Elevation	5055.00
h_f (m) =	E_i-E_f (ft > m)	19.81
	υ (m^2/s)	1.01E-06
	μ (kg/m s)	1.00E-03
	g (m/s^2)	9.810
	d (m)	0.305
	L (m)	483.72
ϑ =	$gd^3h_f/L\upsilon^2$	1.13E+10
	ε (mm)	1.50E-03
R_E =	$-(8\vartheta)^{1/2}\log_{10}[\varepsilon/3.7d+1.775/(\vartheta)^{1/2}]$	1,423,951
V (m/s) =	$\upsilon R_E/d$	4.70E+00
Q (m^3/s) =	$V(\pi/4)d^2$	3.43E-01

V (ft/s)	15.4
Q (ft^3/s)	12.1
Q (MGD)	7.8
Head Necessary at Orifice (ft)	3.7

Note: Net available water is the sum available from upstream system capacity and basin yield. Net yield is the portion of this amount captured by the subject system component. - All yields are 365-day integral volumes.

Sheet B- 9

	East Slope Collection System Repair				
	Item	**Unit Cost**	**No.**	**Units**	**Total Cost**
1	Repair Existing Flared End Sections	$16.64	16	hours	$266.24
2	Manual Stream Diversion/Channeling	$16.64	16	hours	$266.24
3	Repair Damaged Pipe	$16.64	16	hours	$266.24
4	Remove Sediment from Basins	$16.64	16	hours	$266.24
5	Transportation	$100.00	4	days	$400.00
6	Pipe Repair Materials	$500.00	1	lump sum	$500.00
7				**Total:**	**$1,965**
8				**Contingency (40%):**	**$786**
9				**Total Estimated Cost:**	**$2,751**

Sources:

BLS, 2000

Assumptions

1) 2 Forestry and Conservation Laborers w/hand tools
2) Nevada Standard Labor Rates

Sheet C- 2

	West Carson City Infiltration Basins Construction				
	Item	**Unit Cost**	**No.**	**Units**	**Total Cost**
1	North Basin Earthwork	$1.76	2706	cubic yards	$4,762.56
2	Rip-rap slopes and pipe outlet	$12.00	2007	square feet	$24,084.00
3	South Basin Earthwork	$1.76	2706	cubic yards	$4,762.56
4	Rip-rap slopes and pipe outlet	$12.00	2007	square feet	$24,084.00
5	Ash Canyon to South Basin 12" Pipeline	$44.00	1971	lineal feet	$86,724.00
6	South Basin to North Basin 12" Pipeline	$44.00	1588	lineal feet	$69,872.00
7	Air Release Assembly	$2,000.00	2	lump sum	$4,000.00
8	12" Gate Valve	$1,219.00	5	lump sum	$6,095.00
9	Vicee Canyon Cleanout Structure	$2,000.00	1	lump sum	$2,000.00
10				**Net Total:**	**$226,384**
11				**Contingency (20%):**	**$45,277**
12				**Engineering (20%)**	**$45,277**
13				**Total Estimated Cost:**	**$316,938**

Sources:

BLS, 2000

Brethauer, Mark, 2000

Means, 1996

***Client:* Carson Water Subconservancy District**
Marlette Lake Water System Optimization
North and South Infiltration Basins

Pond Dimensions		***Balanced Cut and Fill Calculations***	
Bottom Width (ft)	220	Bottom Elevation	1.45
Bottom Length (ft)	220	Fill Shrinkage Factor (%)	0%
Total Depth (ft)	6		
Interior Slope (X:1)	3		
Top Width (ft)	256	Cut Volume (cy)	2,703
Top Length (ft)	256	Fill Volume (cy)	2,706
Top Area (sf)	65,536		
Bottom Area (sf)	48,400		
Volume (cf)	340,512	ML Width (ft)	229
Volume (gal)	2,547,030	ML Length (ft)	229
Volume (af)	7.82	ML Area (sf)	52,304
Crest Dimensions		Fill Height	4.55
		Centerline Length (ft)	1026
Width	2		
Exterior Slope (x:1)	3	Slope Surface Area:	2007

Permanent Pipeline from Tanks to Ash Canyon Water Treatment Plant

	Item	Unit Cost	No.	Units	Total Cost
1	10" Pipeline	$94.00	17,787	lineal feet	$1,671,978.00
2	Air Release Assemblies	$2,000.00	3	lump sum	$6,000.00
3	Gate Valves	$1,219.00	3	lump sum	$3,657.00
4	Inlet to Raw Water Pond	$700.00	1	lump sum	$700.00
5				**Net Total:**	**$1,682,335**
6				**Contingency (20%):**	**$336,467**
7				**Engineering (20%)**	**$336,467**
8				**Total Estimated Cost:**	**$2,355,269**

Sources:

Brethauer, Mark, 2000

Retrofit and Repair Existing 8" Pipeline from the Tanks to ACWTP

	Item	Unit Cost	No.	Units	Total Cost
1	Straighten Crushed Section	$16.64	16	hours	$266.24
2	Bury Exposed Section	$1.76	100	cubic yards	$176.00
3	Install Lockable Steel Lids	$20.50	8	hours	$164.00
4	Materials	$500.00	1	lump sum	$500.00
5				**Net Total:**	**$1,106**
6				**Contingency (20%):**	**$221**
7				**Engineering (20%)**	**$221**
8				**Total Estimated Cost:**	**$1,549**

Sources:

BLS, 2000

	Red House Transmission Main Inspection and Testing				
	Item	**Unit Cost**	**No.**	**Units**	**Total Cost**
1	Pressurize Pipeline	$16.64	144	hours	$2,396.16
2	Testing Supervisor	$70.00	36	hours	$2,520.00
3	Testing Technicians	$16.64	72	hours	$1,198.08
4	800-cfm compressor	$225.00	3	days	$675.00
5	Leakage and Fittings Repair	$20.50	16	hours	$328.00
6	Transportation	$200.00	3	days	$600.00
7	Materials	$500.00	1	lump sum	$500.00
8				**Total:**	**$8,217**
9				**Contingency (40%):**	**$3,287**
10				**Total Estimated Cost:**	**$11,504**

Sources:

BLS, 2000

United Rentals, 2000

Assumptions

1) 1 Union welder/pipefitter
2) 2 Forestry and Conservation workers with hand tools
3) 1 Supervisor/Engineer
4) Nevada Standard Labor Rates

Repair Existing 8" Pipeline from Marlette Lake to Hobart

	Item	Unit Cost	No.	Units	Total Cost
1	Leakage and Fittings Repair	$20.50	40	hours	$820.00
2	Materials and equipment	$1,000.00	1	lump sum	$1,000.00
3	Safety Equipment Rental	$100.00	2	lump sum	$200.00
4	Transportation	$200.00	2	days	$400.00
5				**Net Total:**	**$2,420**
6				**Contingency (40%):**	**$968**
7				**Total Estimated Cost:**	**$3,388**

Sources:

BLS, 2000

United Rentals, 2000

Assumptions

1) 1 Union welder/pipefitter
2) Nevada Standard Labor Rates

Permanent Diesel Pumping Station at Marlette Lake

	Item	Unit Cost	No.	Units	Total Cost
1	400-hp Pump & Motor	$200,000.00	1	lump sum	$200,000.00
2	Wet Well	$6,000.00	1	lump sum	$6,000.00
3	Pump Building	$150.00	400	square feet	$60,000.00
4	HVAC	$20.00	400	square feet	$8,000.00
5	Misc. Electric	$20.00	400	square feet	$8,000.00
6	Lake Inlet	$500.00	1	lump sum	$500.00
7	Piping/Valves	$20,000.00	1	lump sum	$20,000.00
8	Telemetry	$15,000.00	1	lump sum	$15,000.00
9	Fuel Tank	$1.00	50,000	gallons	$50,000.00
10	Site Work	$10,000.00	1	lump sum	$10,000.00
11				**Net Total:**	**$377,500**
12				**Contingency (20%):**	**$75,500**
13				**Engineering (20%)**	**$75,500**
14				**Total Estimated Cost:**	**$528,500**

Sources:

Brethauer, Mark, 2000

	Permanent Natural Gas Pumping Station at Marlette Lake				
	Item	**Unit Cost**	**No.**	**Units**	**Total Cost**
1	400-hp Pump & Motor	$200,000.00	1	lump sum	$200,000.00
2	Wet Well	$6,000.00	1	lump sum	$6,000.00
3	Pump Building	$150.00	400	square feet	$60,000.00
4	HVAC	$20.00	400	square feet	$8,000.00
5	Misc. Electric	$20.00	400	square feet	$8,000.00
6	Lake Inlet	$500.00	1	lump sum	$500.00
7	Piping/Valves	$20,000.00	1	lump sum	$20,000.00
8	Telemetry	$15,000.00	1	lump sum	$15,000.00
9	Installed Natural Gas Pipeline	$35.00	20,148	lineal feet	$705,180.00
10	Satellite Communication Meter	$75,000.00	1	lump sum	$75,000.00
11	Site Work	$10,000.00	1	lump sum	$10,000.00
12				**Net Total:**	**$1,107,680**
13				**Contingency (20%):**	**$221,536**
14				**Engineering (20%)**	**$221,536**
15				**Total Estimated Cost:**	**$1,550,752**

Sources:

Brethauer, Mark, 2000
Svensson, Bruce, 2000

	Permanent Electric Pumping Station at Marlette Lake				
	Item	**Unit Cost**	**No.**	**Units**	**Total Cost**
1	400-hp Pump & Motor	$200,000.00	1	lump sum	$200,000.00
2	Wet Well	$6,000.00	1	lump sum	$6,000.00
3	Pump Building	$150.00	400	square feet	$60,000.00
4	HVAC	$20.00	400	square feet	$8,000.00
5	Misc. Electric	$20.00	400	square feet	$8,000.00
6	Lake Inlet	$500.00	1	lump sum	$500.00
7	Piping/Valves	$20,000.00	1	lump sum	$20,000.00
8	Telemetry	$15,000.00	1	lump sum	$15,000.00
9	Installed Buried Electric Line	$210.00	34,419	lineal feet	$7,227,990.00
10	Site Work	$10,000.00	1	lump sum	$10,000.00
11				**Net Total:**	**$7,555,490**
12				**Contingency (20%):**	**$1,511,098**
13				**Engineering (20%)**	**$1,511,098**
14				**Total Estimated Cost:**	**$10,577,686**

Sources:

Brethauer, Mark, 2000
Svensson, Bruce, 2000

10" Borehole From Marlette Lake to Hobart					
	Item	Unit Cost	No.	Units	Total Cost
1	10" Borehole	$325.00	9,475	lineal feet	$3,079,375.00
2	10" Casing	$75.00	9,475	lineal feet	$710,625.00
3	Mobilization/Demobilization	$50,000.00	1	lump sum	$50,000.00
4	Concrete Bunker/Inlet Assembly	$10,000.00	1	lump sum	$10,000.00
5	Concrete Outlet Works	$6,000.00	1	lump sum	$6,000.00
6	Site Work	$10,000.00	1	square feet	$10,000.00
7				**Net Total:**	**$3,866,000**
8				**Contingency (20%):**	**$773,200**
9				**Engineering (20%)**	**$773,200**
10				**Total Estimated Cost:**	**$5,412,400**

Sources:

Tweidt, Darryl, 2000

	West Carson City Extraction Wells				
	Item	Unit Cost	No.	Units	Total Cost
1	500-ft Cased Extraction Well	$187,000.00	4	lump sum	$748,000.00
2	Well Outfitting for Water Production	$153,000.00	4	lump sum	$612,000.00
3	Converted Exploration Borehole/Monitoring Well	$44,000.00	4	lump sum	$176,000.00
4				Net Total:	$1,536,000
5				Contingency (20%):	$307,200
6				Engineering (20%)	$307,200
7				Total Estimated Cost:	$2,150,400

Sources:

Brethauer, Mark, 2000

	Hobart Reservoir Expansion				
	Item	**Unit Cost**	**No.**	**Units**	**Total Cost**
1	3000 acre-foot Reservoir	$75,614.75	48	per vertical ft.	$3,629,508.00
2				**Net Total:**	**$3,629,508**
3				**Contingency (20%):**	**$725,902**
4				**Engineering (20%)**	**$725,902**
5				**Total Estimated Cost:**	**$5,081,311**

Sources:

Wateresource, 1974

Assumptions

1) High Cost per Acre-Foot in WRC Report of 1974, modified to reflect vertical feet of dam height

Appendix D

Selected Nevada Revised Statutes

1) NRS 277.060
2) NRS 331.160

NRS 277.060 **Cooperative agreements concerning water and sewerage between political subdivisions in certain counties.**

1. In any county having a population of 100,000 or more, any county, city, town, water district, sewer or sanitation district or other political subdivision of the state authorized by law to acquire, operate and maintain water or sewage facilities, or both, or to improve a governmental service in connection therewith, may contract with one or more of these political subdivisions if the contract is authorized by each party thereto with the approval of its legislative body or other authority having the power to enter into or approve the contract.

2. Any such contract must set forth fully the purposes, powers, rights, obligations and responsibilities, financial and otherwise, of the contracting parties.

3. The contract may:

(a) Include, among other things, the renting of machinery and equipment, mobile or otherwise.

(b) Provide for the payment for water facilities, sewer facilities, lands, rights in land and water rights sold, leased or otherwise alienated, the payment to be made within a period of time not exceeding 30 years from the date of the contract from the rates, fees, tolls or charges derived from the operation of the water or sewer facilities, or both, upon such terms and conditions as may be specified in the contract, without the obligation being authorized by any qualified electors of any political subdivision which is a party to the contract.

4. The equipment and employees of any such political subdivision, while engaged in performing any governmental service, activity or undertaking under the contract, have and retain all the rights, privileges and immunities of, and shall be deemed to be engaged in the service and employment of, that political subdivision, notwithstanding that the governmental service, activity or undertaking is being performed in or for another political subdivision.

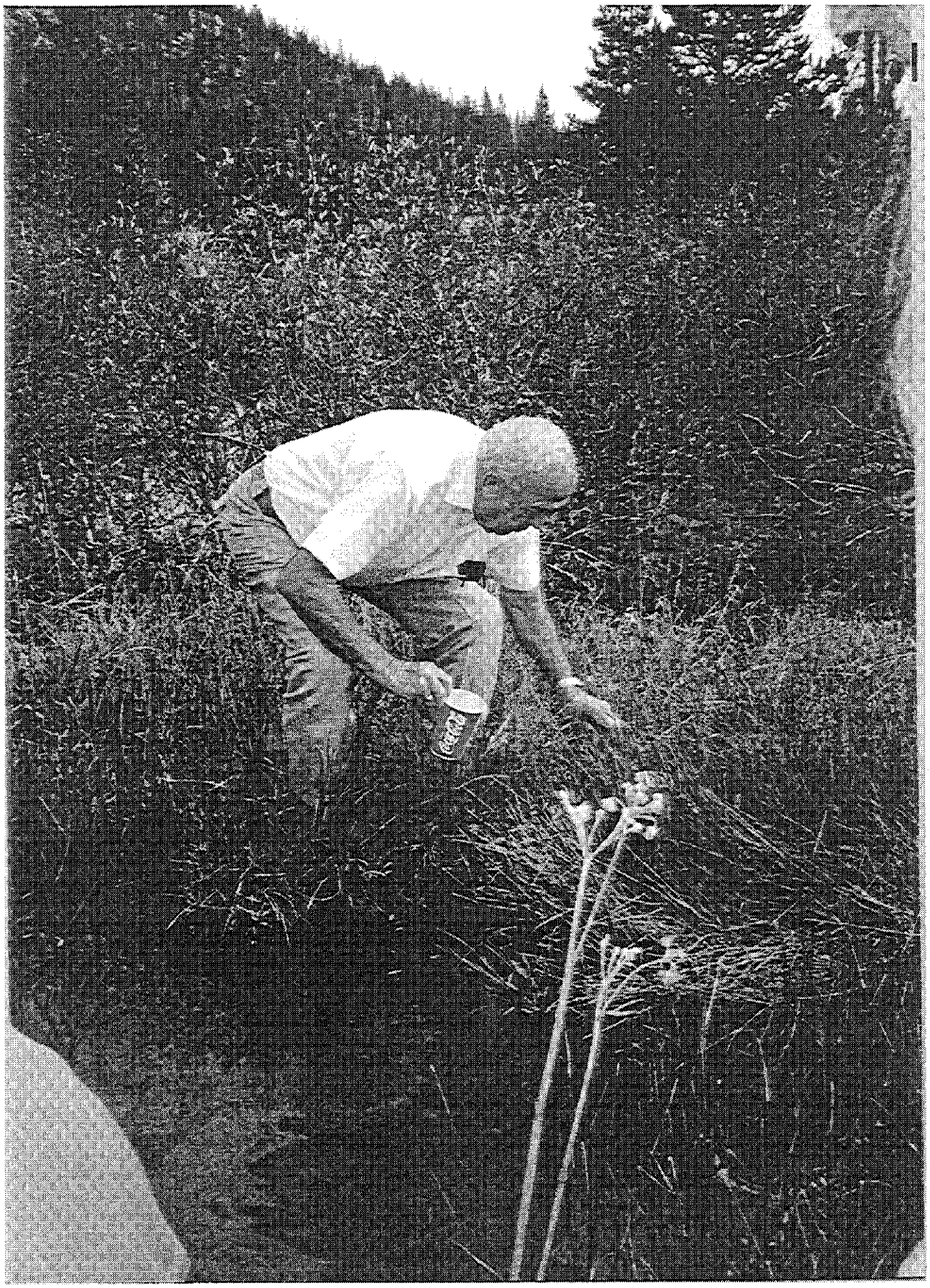
5. The powers conferred by this section are in addition and supplemental to, and not in substitution for, and the limitations imposed by this section do not affect the powers conferred by, any other law. No part of this section repeals or affects any other law or any part thereof, it being intended that this section provide a separate method of accomplishing its objectives, and not an exclusive one.

6. This section, being necessary to secure and preserve the public health, safety and convenience and welfare, must be liberally construed to effect its purpose.

(Added to NRS by 1957, 657; A 1969, 1539; 1979, 528; 1983, 127)

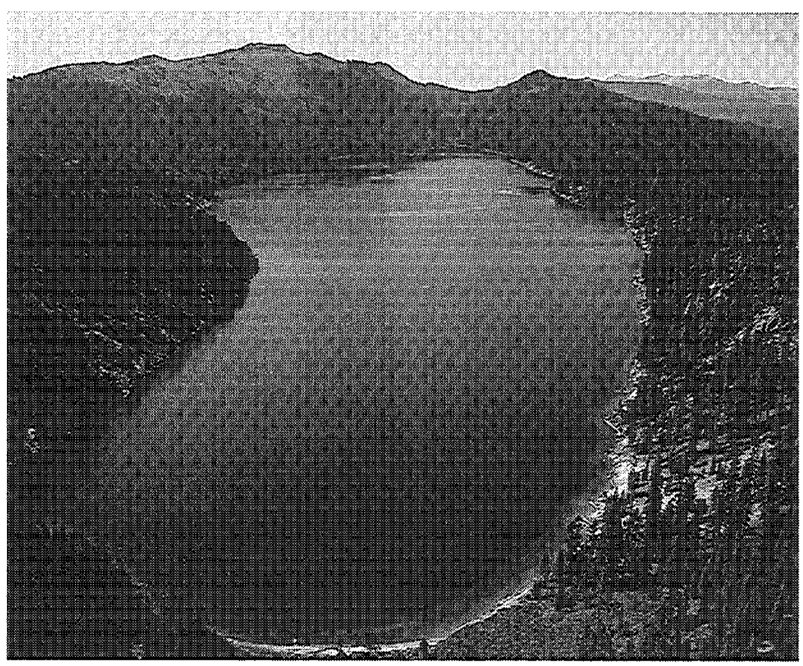
APPENDIX B

Photographs of Areas Toured

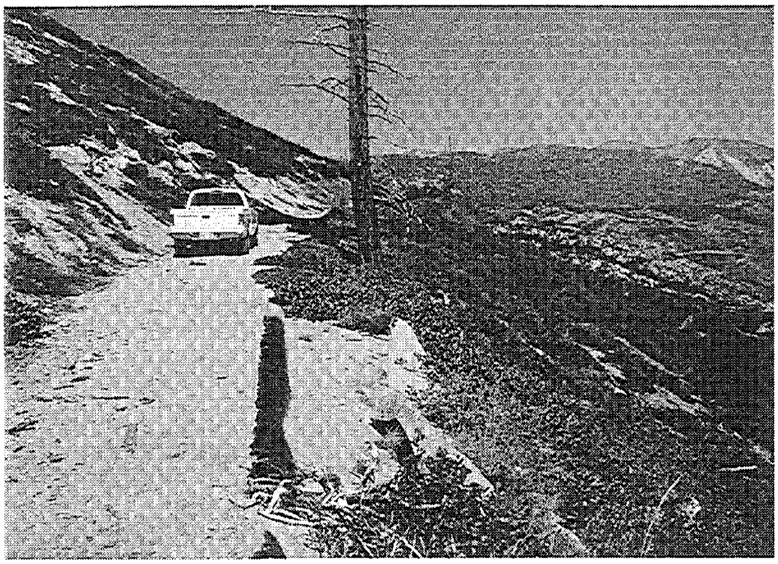


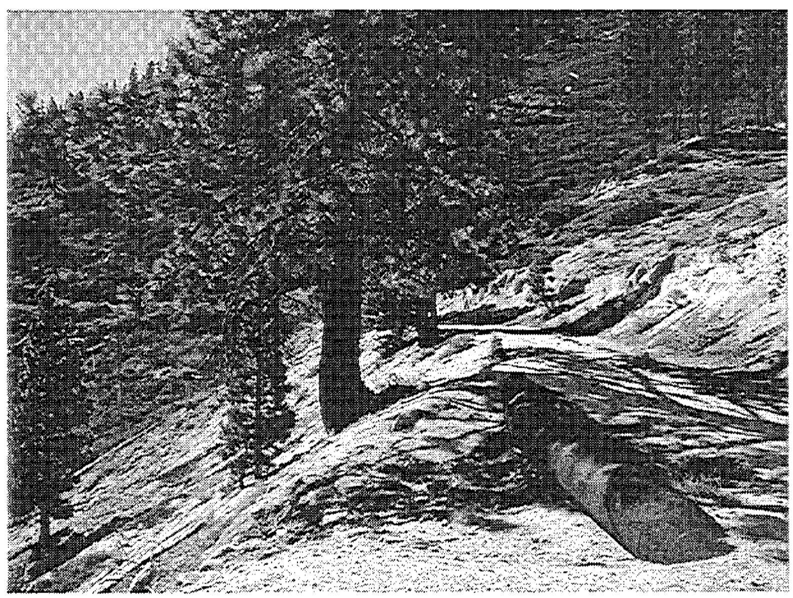
Senator Lawrence E. Jacobsen examining water quality at Jacobsen Springs.

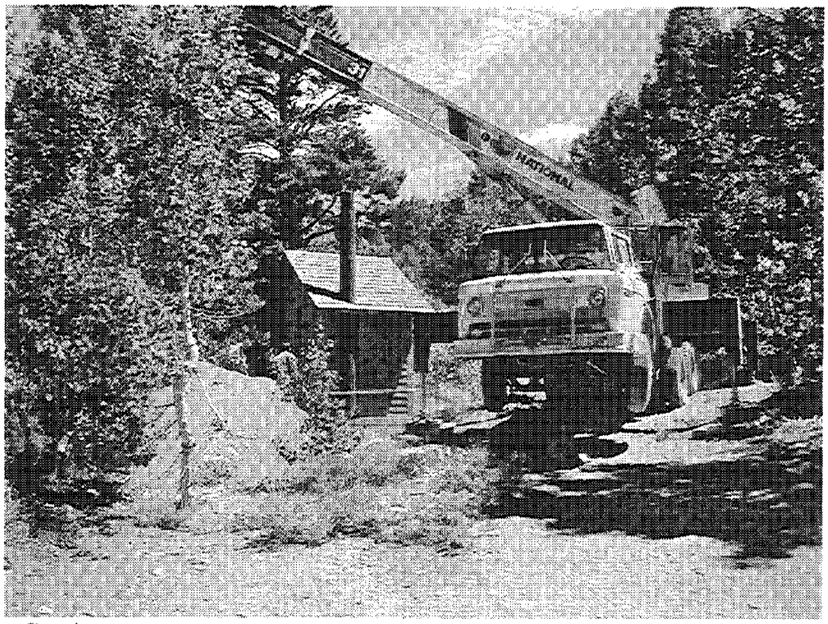
Marlette Lake with view of Lake Tahoe in background.



Aerial view of Marlette Lake.

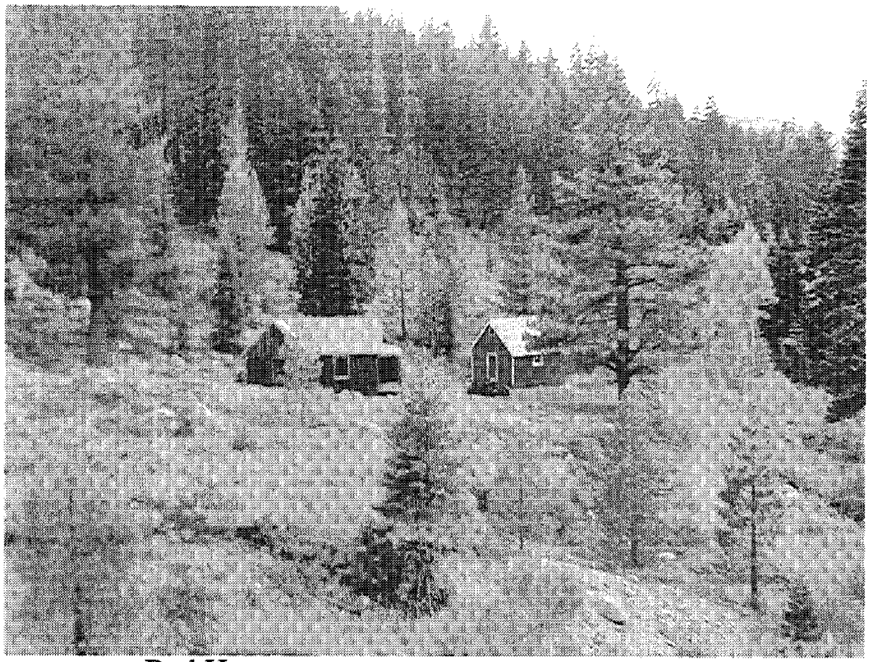

Pipeline on east slope of Carson Range.

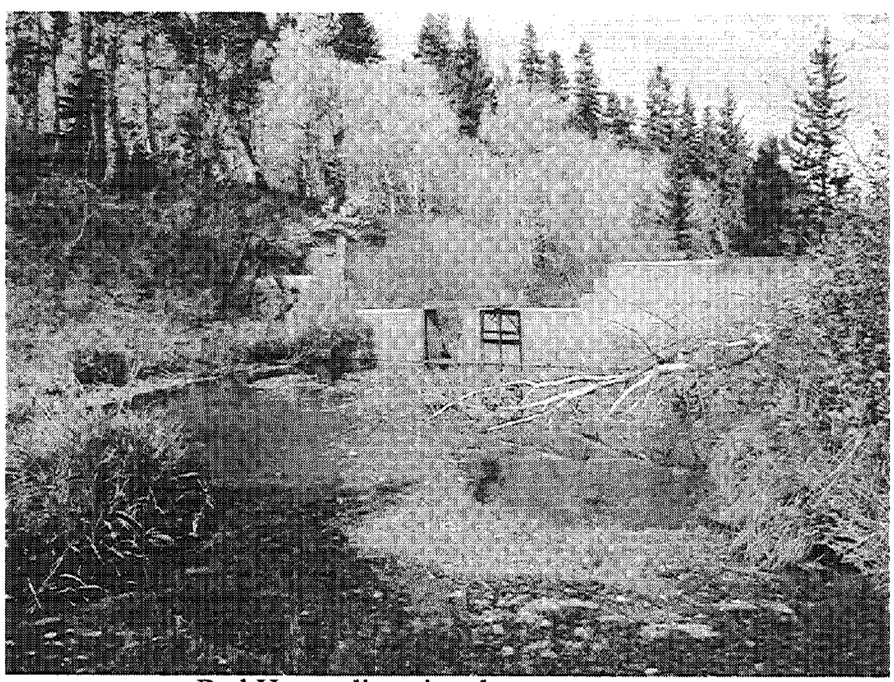

Pipeline east slope of Carson Range.

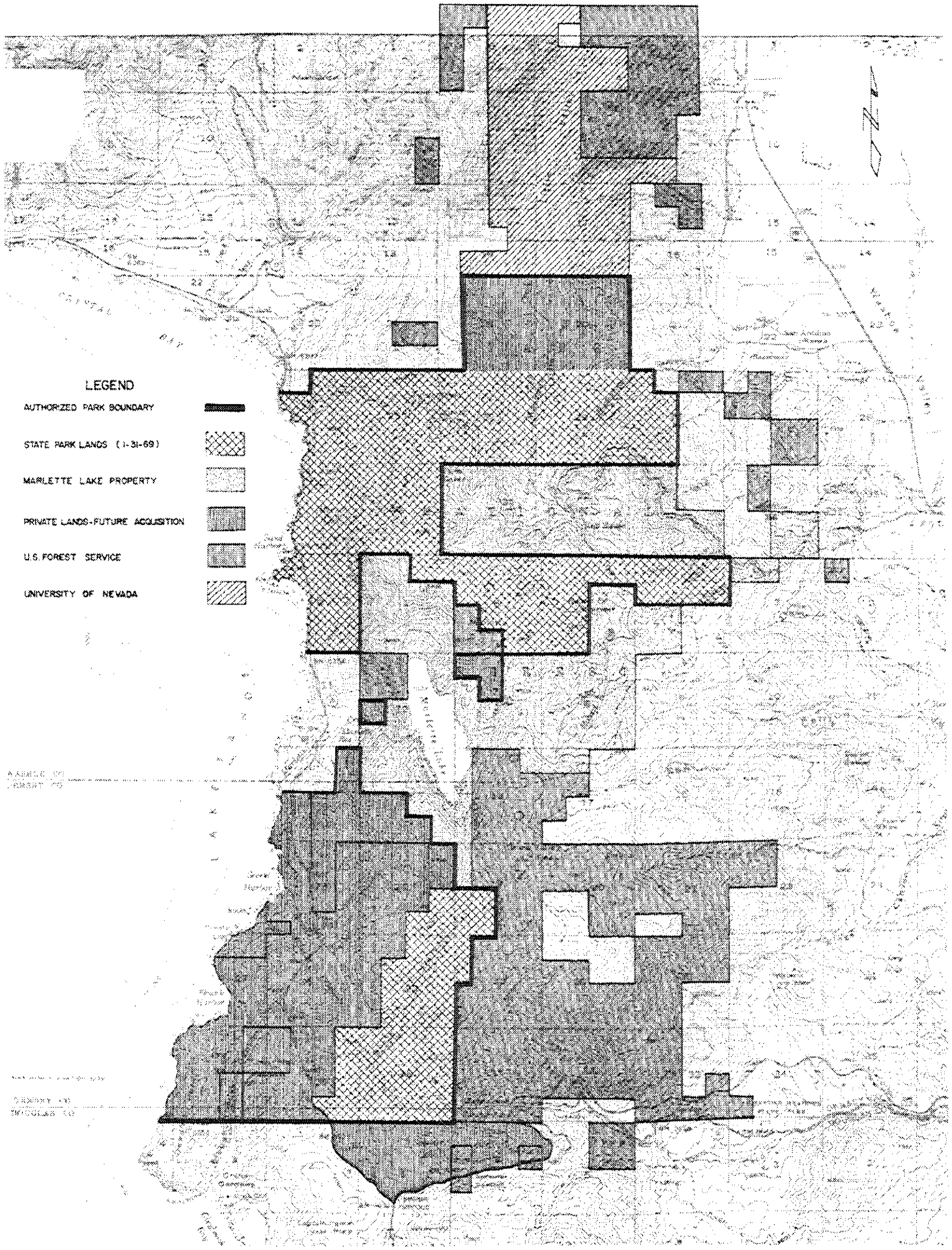


Setting new restroom near Marlette Lake.

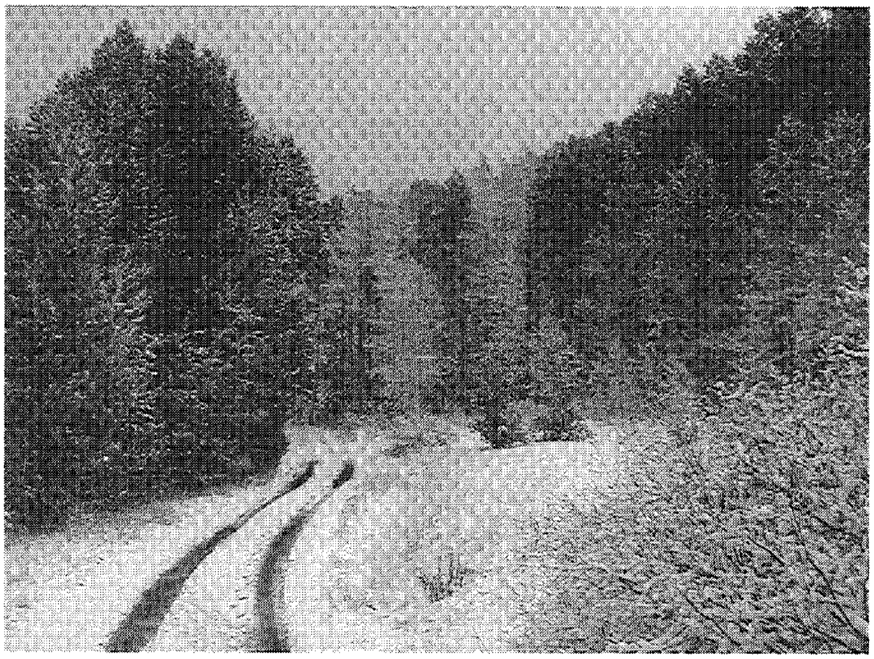
Marlette landscape.


Red House.

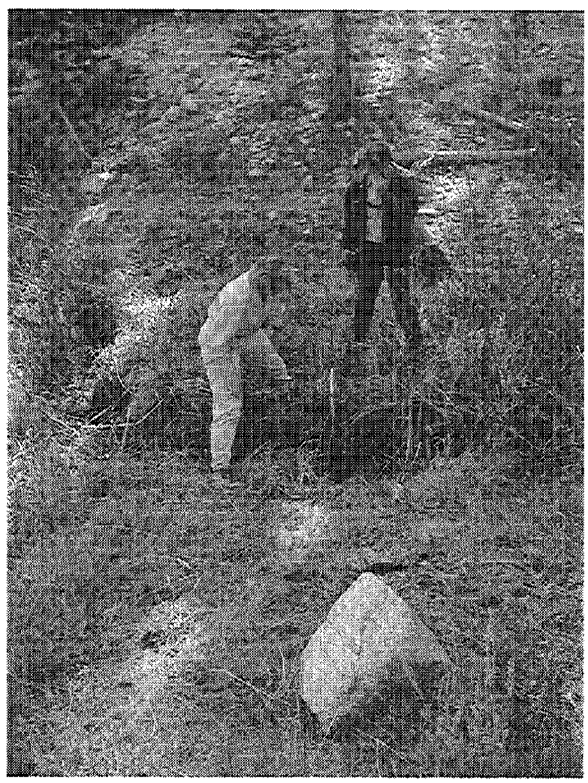

Red House diversion downstream.



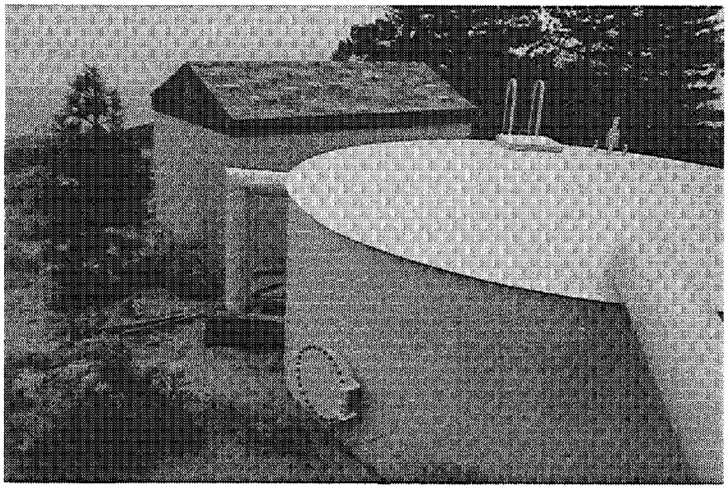
Land Ownership in the Marlette and Hobart Reservoir Areas



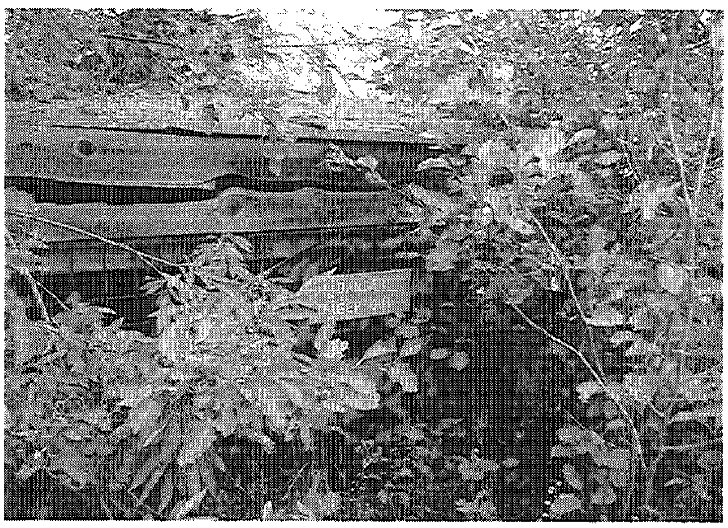
A look at North Road after first snowfall.



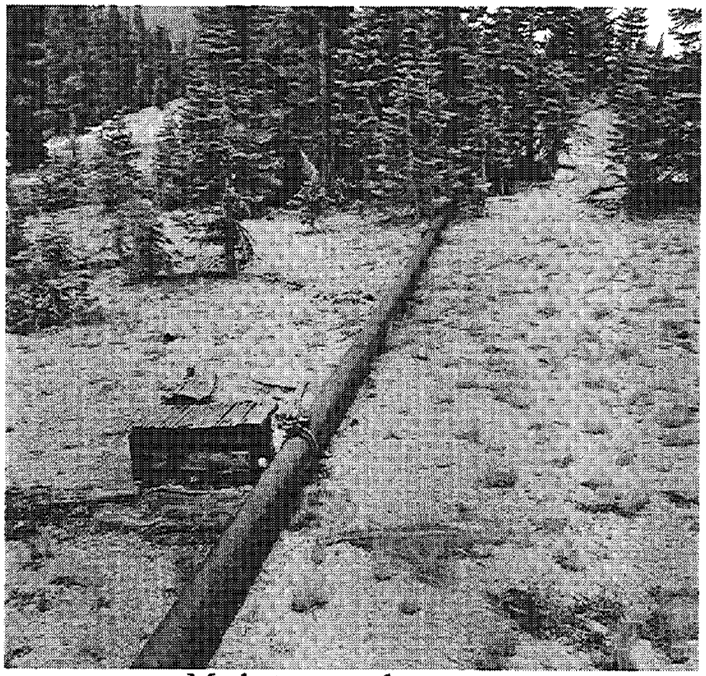
North Canyon hiking trail (EIP Projects).



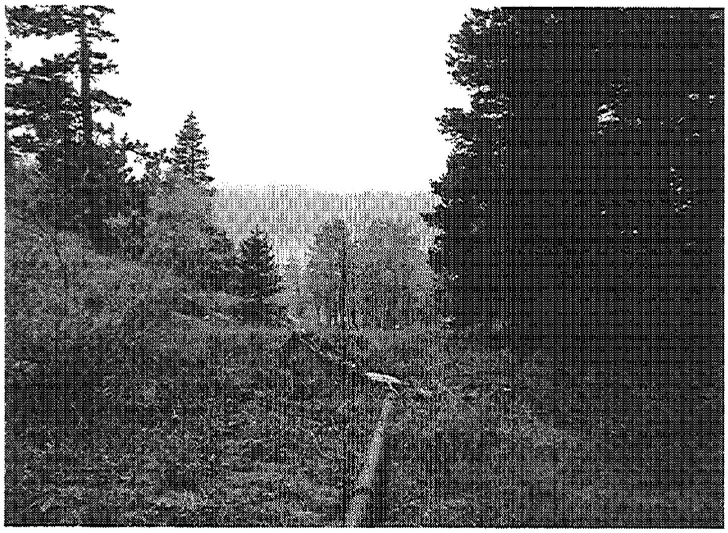
Tanks view.

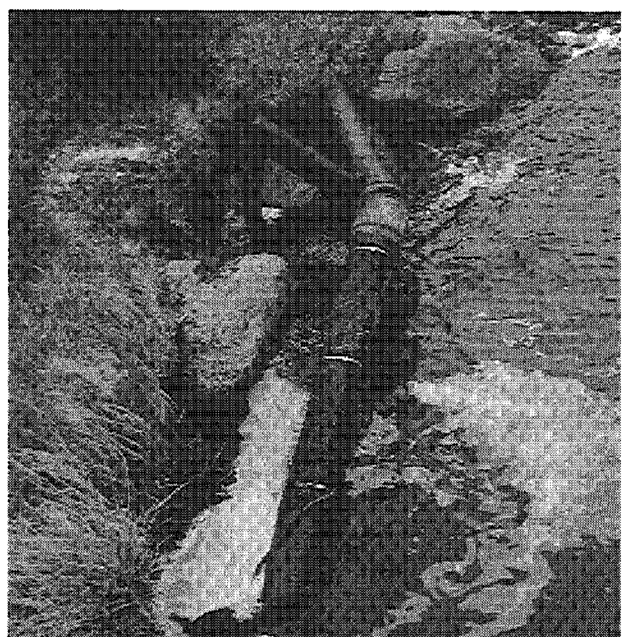


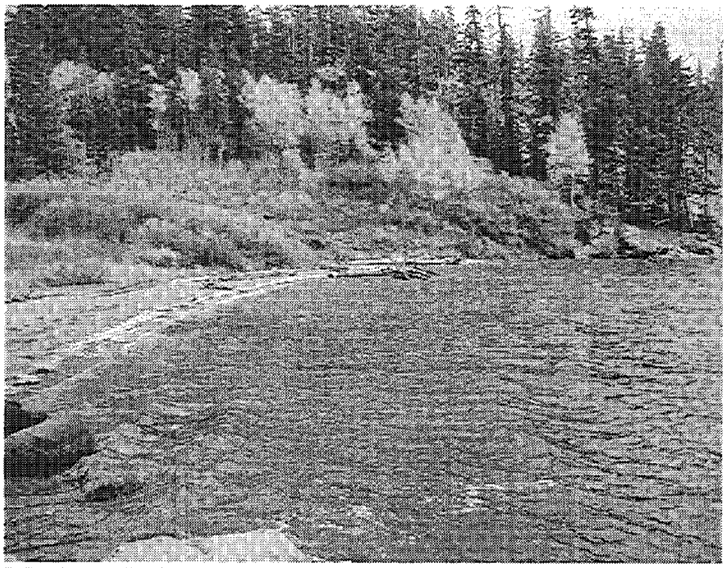
Tunnel outlet warning sign.


Marlette meter box.


Marlette pipe break.

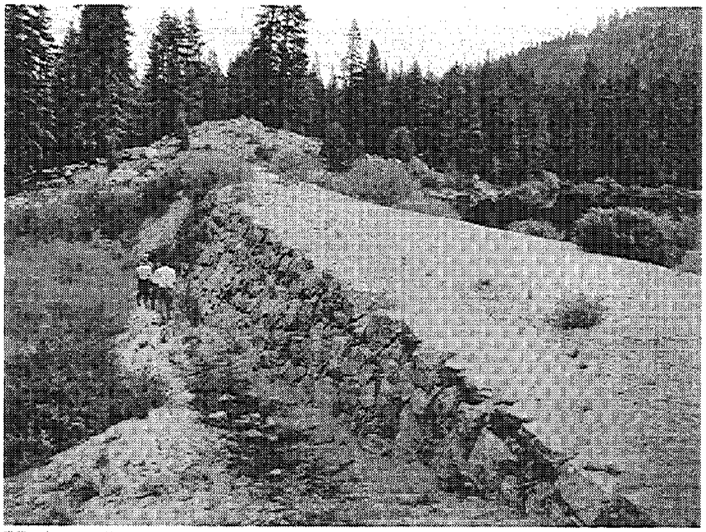

Pipe above Marlette Lake.


Marlette – pipe intake.

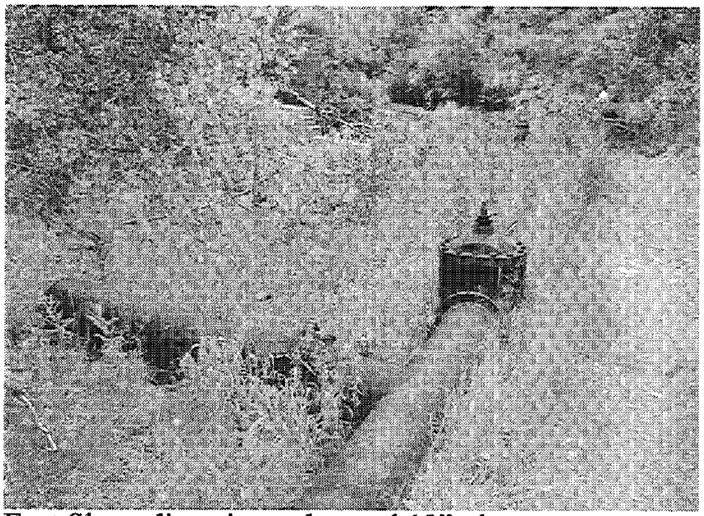


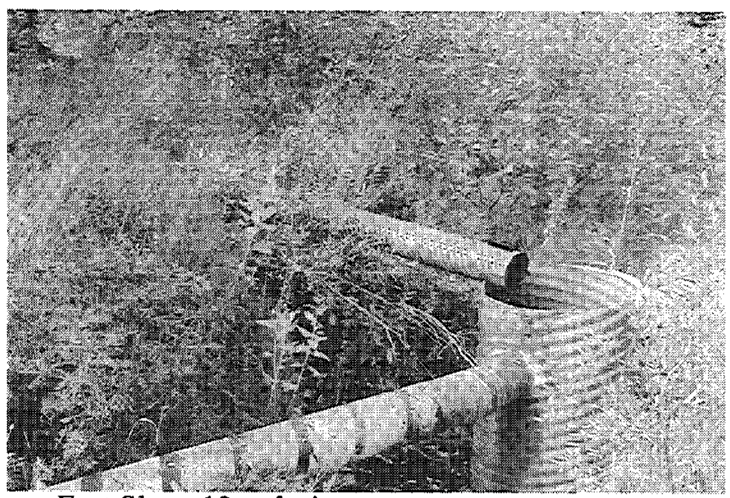
Marlette Lake

Marlette Lake


Hobart Dam (rock face).


Hobart drainage view.

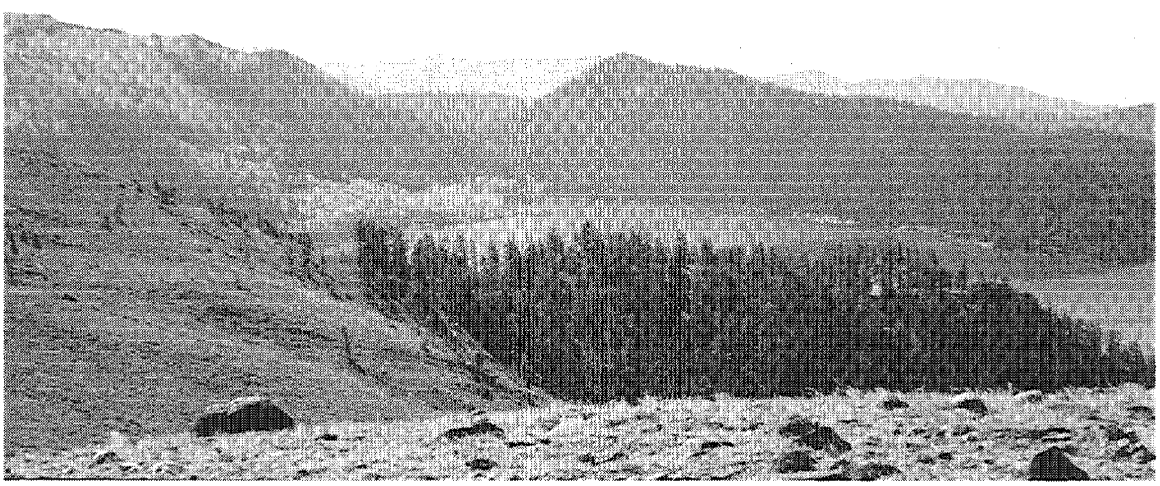

East Slope diversion valve and 12" pipe.


East Slope 12 sed-pipe.


Red House.

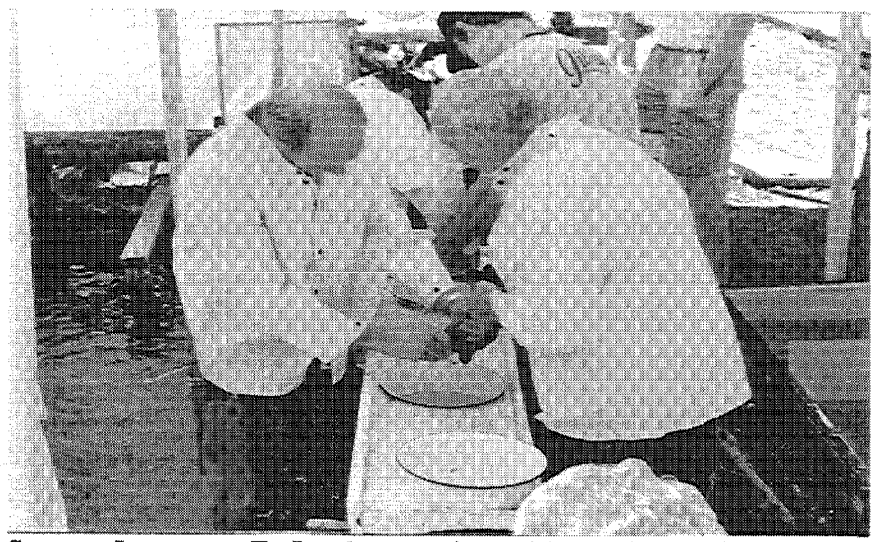

Members of Marlette Lake Advisory Committee.

Fish traps along Marlette Creek,
with egg harvesting area under tent.

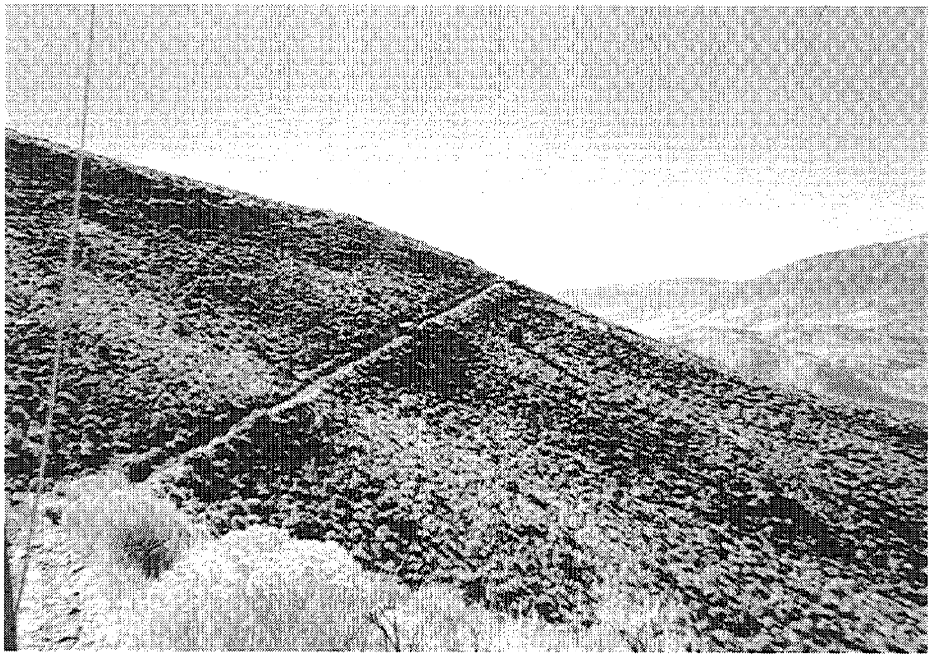


View of Marlette Lake

Egg harvesting at Marlette Lake, June 13, 2000.

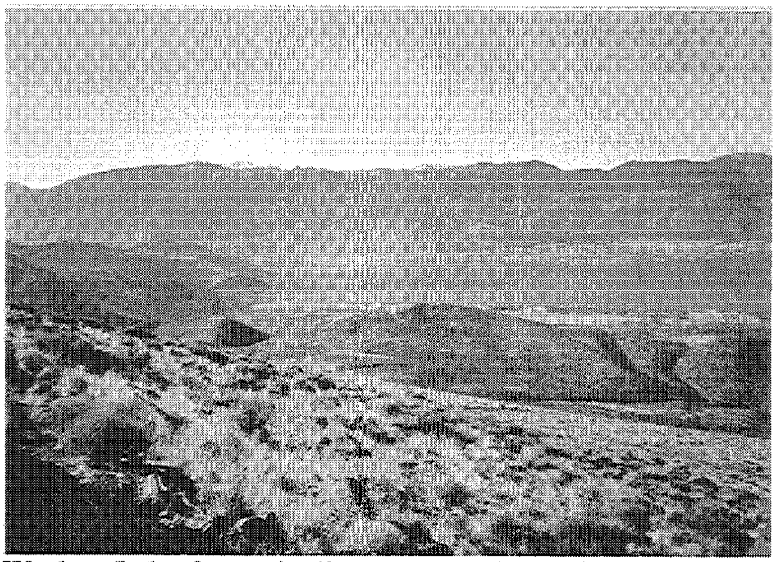


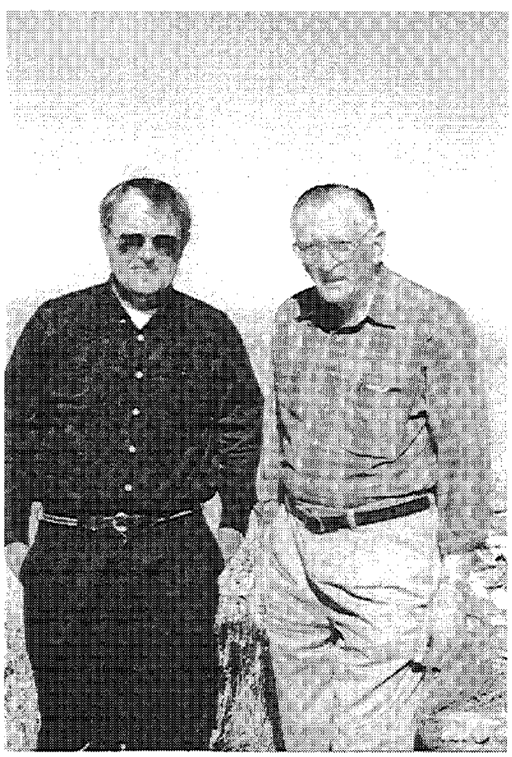
Senator Lawrence E. Jacobsen assists with egg harvesting project.



Traversing steep roads on west slope of Virginia Range.

Senator Mark Amodei inspecting pipeline on west slope of Virginia Range.


Washoe Lake from pipeline on west slope of Virginia Range.


Wayne Perock, Administrator, State Parks and
Assembly Speaker Joseph (Joe) E. Dini, Jr.