# ALTERNATIVE RESERVOIR SITE EVALUATION

# APPRAISAL LEVEL STUDY

# FOR THE

# SAN JUAN WATER CONSERVANCY DISTRICT

October, 1989

By:

Harris Water Engineering
954 Second Avenue
Durango, Colorado 81301
303-259-5322

# HARRIS WATER ENGINEERING

954 Second Avenue
Durango, Colorado 81301
(303) 259-5322

Steven C. Harris, P.E.


October 12, 1989

Mr. Fred Schmidt, Chairman
San Juan Water Conservancy District
P.O. Box 609
Pagosa Springs, CO 81147

Dear Mr. Schmidt:

Attached is the final Report for the appraisal level "Alternative Reservoir Site Evaluation". The comments provided by the SJWCD Board, at the September 21, 1989 meeting, have been incorporated.

It has been a pleasure working with you and the Board in preparing the Report. The involvement of the Board was essential to the successful completion.

Please call if you have any questions.

Sincerely,

Steven C Harris

Steven C. Harris, P.E.

cc: Colorado Water Resources and Power Development Authority
Chuck Lile, Division 7, Water Engineer
Val Valentine, Water Commissioner
Southwest Water Conservation District

# EXECUTIVE SUMMARY

The San Juan Water Conservancy District (SJWCD) was formed in 1987 to assist water users within the District boundaries, to provide future water supplies. The SJWCD Board of Directors determined that the greatest need was a water storage reservoir, to provide a safe supply of water for present and future needs.

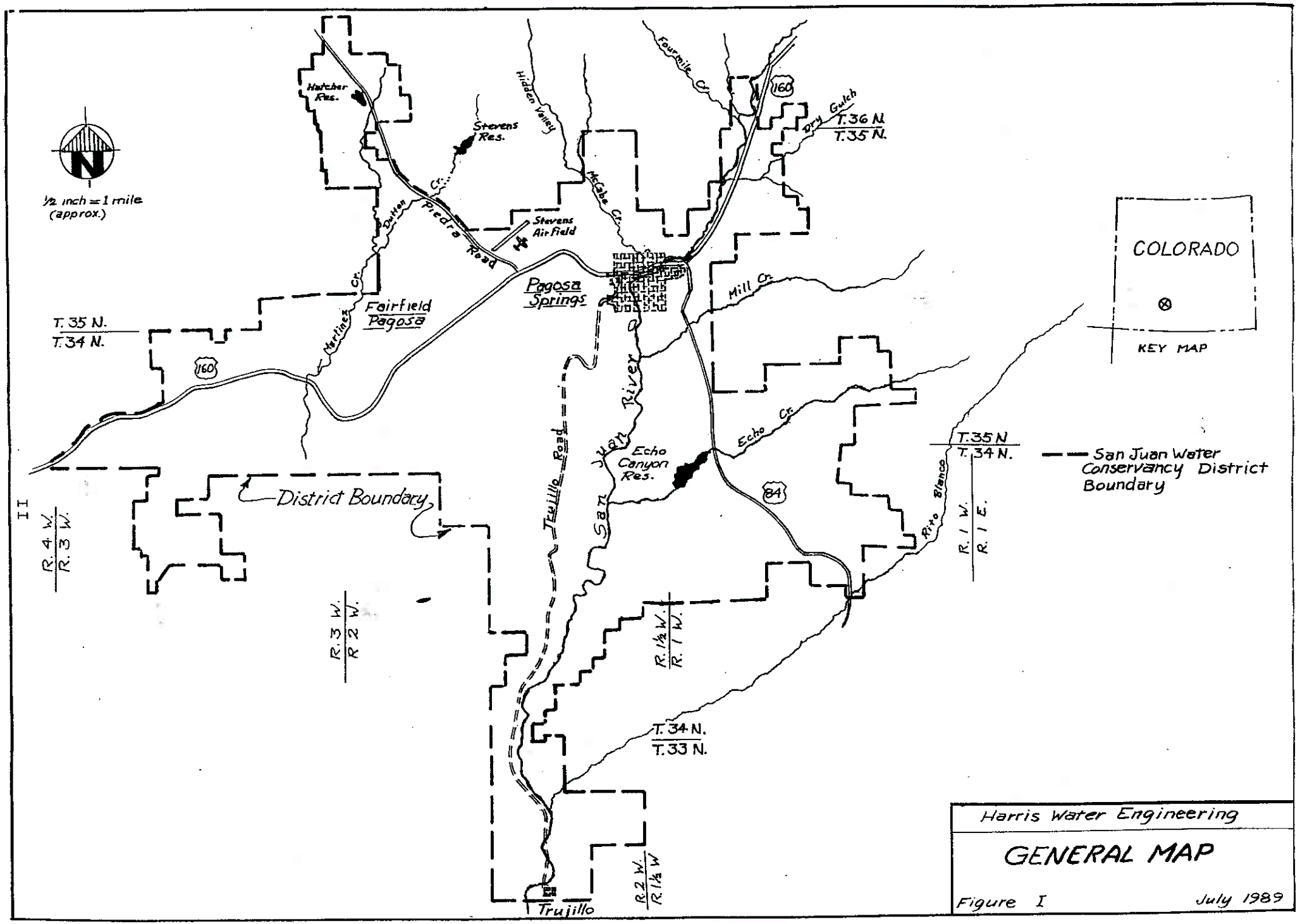
This study was prepared to evaluate alternative reservoir sites that could meet future water demands. The best site for further consideration is recommended. The future water needs are estimated. Figure I shows the SJWCD boundaries.

Based upon the population projections developed by the SJWCD Population Committee, the population growth from 1990 to 2025 is estimated to be about 14,730 persons; of which about two thirds will be in the Pagosa Area Water and Sanitation District (PAWSD) service area. Using a per capita use rate of 200 gallons per person per day, results in an increased yearly water demand in 2025 of 3300 acre-feet. The water demand estimate is believed to be in the moderate to high range to assure that the reservoir will be adequately sized to deliver water through at least the year 2025.

An inventory of eight reservoir sites that could serve the 3300 acre-foot demand, showed that: the Hidden Valley site was the best reservoir to store Four Mile Creek flows through the enlarged Dutton Ditch, the Dry Gulch Reservoir is the best site to store San Juan River flows, and the Echo Reservoir is the only site that can store Rito Blanco flows. The plan that is recommended for future development will be one of the three plans.

The three reservoirs were evaluated at an appraisal level. Center line surveys were available for each dam site. USGS 7.5 minute quad maps were used to estimate reservoir capacity and the related dam height. Existing water supply data was used to estimate yield. Appraisal level cost estimates were prepared on each reservoir and conveyence facilities necessary to deliver water to the present and future water users.

The results showed that Echo Canyon was the most expensive and had the most unreliable water supply and was not recommended for further consideration. Dry Gulch was slightly less costly than Hidden Valley and has a more reliable water supply but is in the wrong location to serve the future water supply. Hidden Valley Reservoir plan is about the same cost and is near the water demand, but the water supply data must be improved significantly. If the Hidden Valley water supply were firm, it would be the recommended plan. Given the present data, both the Hidden Valley and Dry Gulch Reservoir plans must be pursued.




Harris Water Engineering

# GENERAL MAP

Figure I

July 1989

Organizationally, the PAWSD is the only current entity, unless the SJWCD decides to also treat water, that would be in a position to undertake the responsibility of treating the 3300 acre-feet of water that would be developed. Pagosa Springs has an adequate water supply and treatment facilities for their present and future water needs, so it is unlikely that the Town would be interested in developing an enlarged treatment plant. Presently the SJWCD does not plan on treating water. This leaves the PAWSD with the majority of the growth and as the most likely entity to develop the treatment plant. The reservoir should be situated to provide water to the Stevens treatment plant.

The advantages of Hidden Valley Reservoir include: (1) the total cost for the Hidden Valley plan is about the same as for Dry Gulch, and (2) the majority of the future water demand is within the PAWSD service area (north of Highway 160 and west of Piedra Road) which is much closer to Hidden Valley than Dry Gulch.

The primary disadvantage of Hidden Valley Reservoir is that at least two years of data collection is needed to prove or disprove the water supply estimates. An alternate plan is needed in the event that either: (1) additional water must be provided sooner than the Hidden Valley Dam water supply can be proven and the dam constructed or (2) the water supply is proven to not be adequate.

The advantages of Dry Gulch Reservoir include: (1) reliable water supply, (2) less costly dam than Hidden Valley, and (3) the plan could be staged by diverting water directly from the San Juan River to meet near term water demands before a dam can be built, then build the dam to provide a firm water yield.

The primary disadvantage of Dry Gulch Reservoir is the location, which is about 4 times further away from the water demand than Hidden Valley.

The following activities are recommended in 1990 to evaluate the Hidden Valley and Dry Gulch Reservoirs.

1. The gage that was installed on Hidden Valley Creek is essential. Readings from the gage should be continued indefinitely.

2. A flume should be installed on Four Mile Ditch as it enters Hidden Valley to measure imported water.

3. Flows of Four Mile Creek upstream of the Dutton Ditch headgate need to be measured, even if only a staff gage is used that is read once a week.

4. A water right to store water in Hidden Valley Reservoir should be obtained, by purchasing existing storage rights and/or applying for a new right. The total right should be for 10,000 acre-feet of storage capacity.

5. Obtain a topographic survey of the Hidden Valley and Dry Gulch Reservoir basins to prepare an estimate of the reservoir capacity, which can be used to better estimate the height of the dam. The topography should have a 2 foot contour interval and be at a scale of about 1 inch equals 200 feet.

6. Geologic investigations, including bore holes and/or test pits, should be conducted at the Hidden Valley and Dry Gulch Dam sites.

7. The inlet ditches to each reservoir should be further evaluated by holding discussions with: (1) the U.S. Forest Service concerning the environmental issues with enlarging the Dutton Ditch and (2) the Park Ditch Company concerning joint use of the Park Ditch.

The above activities are necessary to further evaluate the Hidden Valley and Dry Gulch plans so that one plan can be chosen, prior to beginning a feasibility study. The Feasibility study will be a costly undertaking and financial assistance from the Colorado Water Resources and Power Development Authority (Authority) or the Colorado Water Conservation Board (CWCB) will probably be necessary. The process to obtain funds for the feasibility study will require 6 to 12 months, possibly more. The feasibility study will require 12 to 18 months and cost about 3% to 5% of the estimated construction cost which would result in a study cost range of $150,000 to $300,000, for the raw water facilities.

It is recommended that the feasibility study not begin until the above work is completed and a definite decision can be made between the two plans.

TABLE OF CONTENTS

## LIST OF TABLES

LIST OF TABLES - Continued

## LIST OF FIGURES

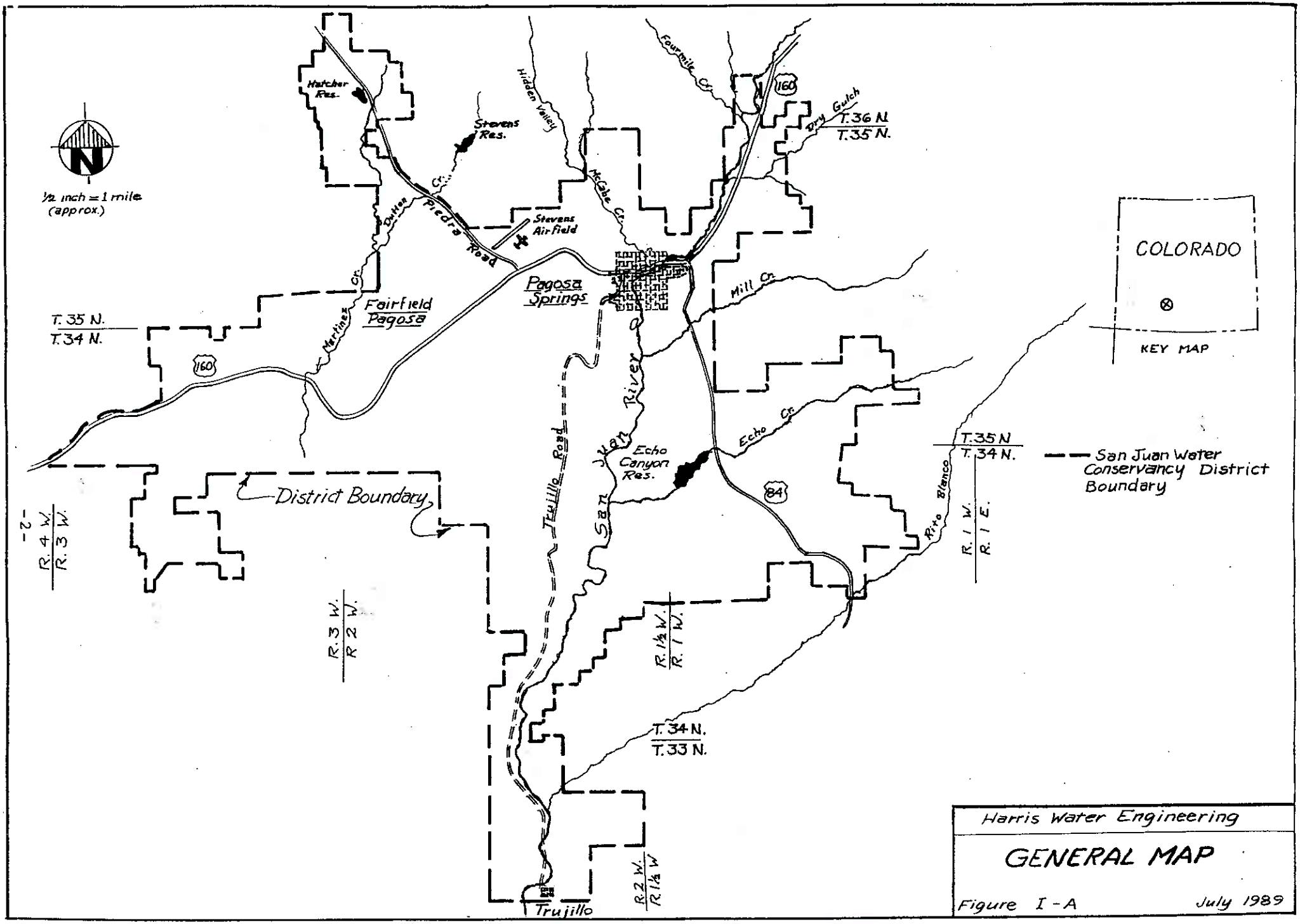
# CHAPTER I
# INTRODUCTION

The San Juan Water Conservancy District (SJWCD) was formed in October of 1987 to conserve and utilize the water resources within the SJWCD boundaries. Specifically, the SJWCD was formed to construct a reservoir to provide for the future water needs of the users within the SJWCD. The existing storage capacity in the study area is minimal with small reservoirs near the Hatcher and Stevens treatment plants but no reservoir for the Pagosa Springs plant. Figure I-A is a general map of the study area and shows the boundaries of the SJWCD.

There are three general steps to the development of a water resources project. The first is evaluation of alternative plans to determine the best plan and an approximate cost. The second step is a feasibility study to specifically address the engineering, environmental, and financial considerations in constructing the plan, selected in step one. The feasibility study is typically used to obtain financing and permits necessary for construction of the project. The project may be stopped in either of the first two steps if the project is infeasible for some reason. The third step is final designs and construction of the project. The distribution of development costs between the three steps is approximately 2% - %5 of the total development cost for step one, 10% - 15% for step two, and 80% - 88% for step three. This study is step one of the process.

The purpose of this study is to evaluate, at an appraisal level, potential reservoir sites that will provide a reliable supply to meet the water demands of the SJWCD and select the best site for further study. This report may also serve as a basis for obtaining funds from other entities in order to begin the feasibility study process, which is much more costly.

Chapters V, VI, VII, and VIII describe and compare alternative plans to provide municipal water to most users within the SJWCD boundaries. Total water systems, from water collection to distribution are described and costed in order to compare the total costs of the three alternative plans. Even though facilities for raw water and treated water are described for comparison purposes, the SJWCD does not anticipate being involved in financing or construction of the treatment plants nor treated water distribution facilities. The SJWCD assumes that individual water user entities will provide the treatment and distribution facilities when those facilities are needed. The SJWCD generally plans to provide for the financing and construction of the raw water collection and storage facilities and the conveyance system to move water from the reservoir to a treatment plant.




Harris Water Engineering

# GENERAL MAP

Figure I - A

July 1989

The cost of a new or expanded treatment plant has not been included in the evaluation. It is assumed that the cost of the treatment plant would be the same regardless of where the plant is located. Where possible, raw water is delivered to an existing treatment plant. The Pagosa Area Water and Sanitation District (PAWCD) has two treatment plants; the Hatcher Plant near Hatcher Reservoir with 1.0 million gallon capacity and the Stevens Plant near Stevens Reservoir with 0.5 million gallon capacity. The Town of Pagosa Springs has a treatment plant with a design capacity of 2 million gallons but has a reliable capacity of only 1.2 million gallons.

Previous studies which were used in the preparation of this report are: (1) the 1988 water supply evaluation of the Hidden Valley Reservoir site, prepared by Harris Water Engineering for the SJWCD, (2) water rights evaluations and dam cross section performed by the Southwestern Water Conservation District for Dry Gulch Dam, (3) work performed by the Soil Conservation Service on Echo Dam, and (4) the Turkey Creek Project Study prepared for the Colorado Water Resources and Power Development Authority.

The Board members of the SJWCD provided invaluable assistance in the preparation of this report by collecting data on population, dams, and land owners, then reviewing the preliminary results. Special acknowlegement goes to Cecil Tackett for his work on evaluation of the dam sites and Fred Ebeling for his work on the population projections.

## CHAPTER II
## WATER DEMANDS

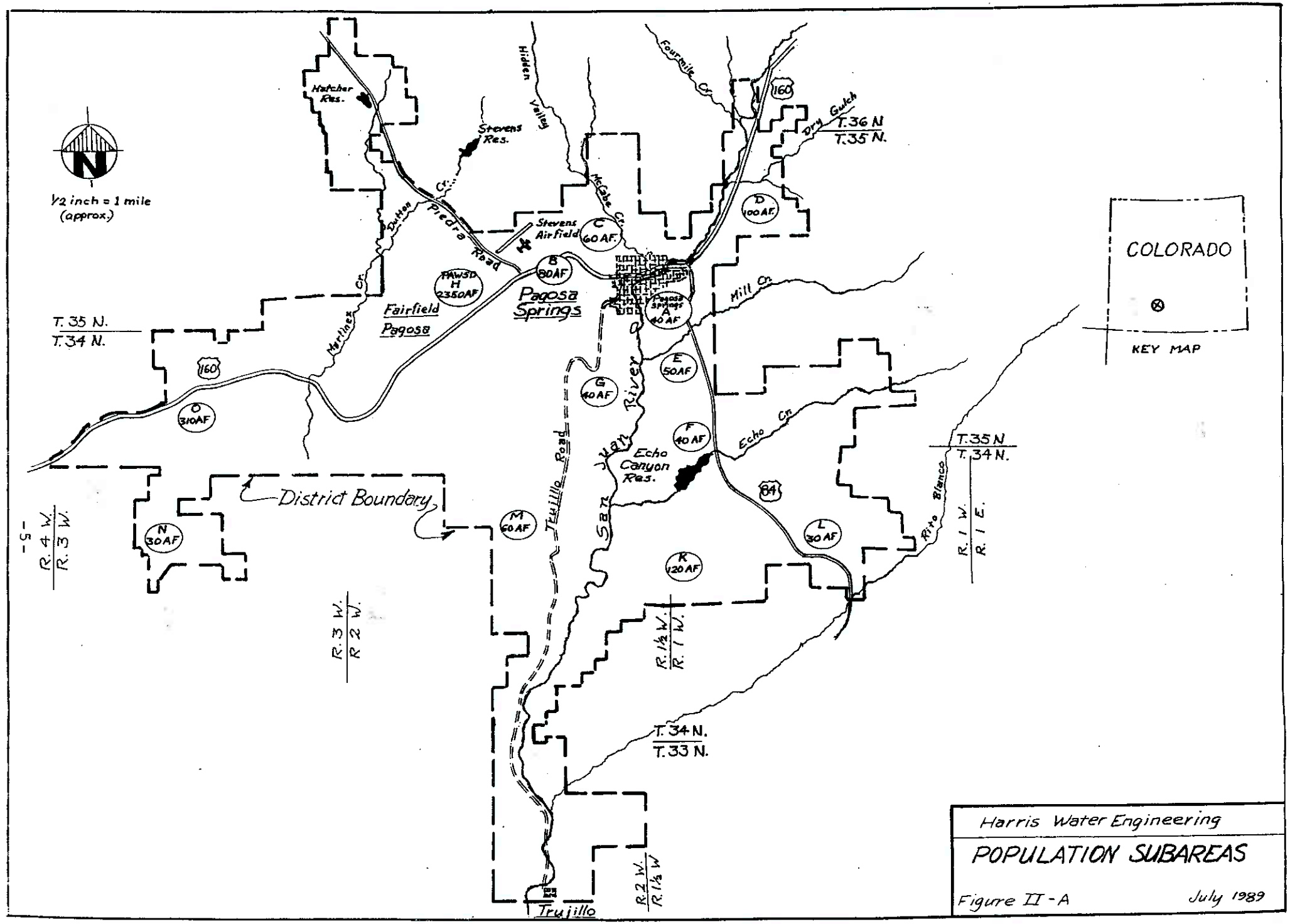
The SJWCD Board formed a Population Committee to estimate the population growth within the District. The Committee was formed of the persons on the Board who are extremely familiar with development patterns in the area, presently and over the last 10 to 20 years. The Committee used their knowledge of past growth patterns, developable land areas, and developers, to estimate population growth.

The Committee determined that a 35 year projection was the most reasonable period for estimation which is long enough to assure that the reservoir would not be undersized. The population estimates that are shown herein were developed with the knowledge that error on the high side would have less impact on the long term use of the reservoir than a low estimate. For instance, an oversized reservoir will allow the water supply to extend longer into the future but an undersized reservoir would require a large cost to construct another reservoir. The result is that population estimates are believed to be in the moderate to high range.

The Committee separated the District into 13 subareas which generally correspond to subareas from a sewer study conducted in of the early 1980's. The approximate location of each subarea, which are titled with a capital letter, are shown on Figure II-A. Each subarea and the estimated acre-foot water requirement is described in following narrative.

Table II-1 shows the population estimate for each subarea beginning in 1990 and for each five year period to the year 2025. The first column of the table is the letter designation for each subarea. The second column is a short desciption of the location of each subarea. The third column is the estimated population of each subarea in 1990. The following columns are the estimated population for each five year period for each subarea. The percent per year growth for each five year period is also shown.

The total population for all subareas is shown in the bottom row. The total population increase is from 8,935 in 1990 to 23,665 in 2025 for a total increase of 14,730 persons. The reservoir must be sized to serve growth from 1990 to 2025. The reservoir will not be constructed until the mid to late 1990's so there will likely be some water shortages before the reservoir is available.




Harris Water Engineering

# POPULATION SUBAREAS

Figure II-A

July 1989

TABLE II-1
SAN JUAN WATER CONSERVANCY DISTRICT
POPULATION PROJECTIONS

| (1) Sub Area | (2) Sub Area Description | (3) 1990 | | (4) 1995 | | (5) 2000 | | (6) 2005 | | (7) 2010 | | (8) 2015 | | (9) 2020 | | (10) 2025 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pop | %/yr | Pop | %/yr | Pop | %/yr | Pop | %/yr | Pop | %/yr | Pop | %/yr | Pop | %/yr | Pop | %/yr |
| A | Town of Pagosa Springs | 1550 | n/a | 1575 | 0.3% | 1600 | 0.3% | 1625 | 0.3% | 1650 | 0.3% | 1675 | 0.3% | 1700 | 0.3% | 1725 | 0.3% |
| B | Hiway 160 West to Piedra Rd | 230 | n/a | 280 | 4.4% | 330 | 3.6% | 380 | 3.0% | 430 | 2.6% | 480 | 2.3% | 530 | 2.1% | 580 | 1.9% |
| C | McCabe Creek-4 Mile Road | 200 | n/a | 250 | 5.0% | 300 | 4.0% | 330 | 2.0% | 360 | 1.8% | 390 | 1.7% | 420 | 1.5% | 450 | 1.4% |
| D | San Juan River NE of Town | 325 | n/a | 385 | 3.7% | 450 | 3.4% | 510 | 2.7% | 570 | 2.4% | 630 | 2.1% | 690 | 1.9% | 750 | 1.7% |
| E | Mill Creek Drainage | 150 | n/a | 200 | 6.7% | 250 | 5.0% | 275 | 2.0% | 300 | 1.8% | 325 | 1.7% | 350 | 1.5% | 375 | 1.4% |
| F | Echo Creek Drainage | 150 | n/a | 175 | 3.3% | 200 | 2.9% | 225 | 2.5% | 250 | 2.2% | 275 | 2.0% | 300 | 1.8% | 325 | 1.7% |
| G | Stinking Springs-SW of Town | 100 | n/a | 125 | 5.0% | 150 | 4.0% | 175 | 3.3% | 200 | 2.9% | 225 | 2.5% | 250 | 2.2% | 275 | 2.0% |
| H | Martinez Creek Drainage | 5000 | n/a | 6500 | 6.0% | 8000 | 4.6% | 9500 | 3.8% | 11000 | 3.2% | 12500 | 2.7% | 14000 | 2.4% | 15500 | 2.1% |
| K | Squaw Ck-No. of 8 Mile Mesa | 100 | n/a | 175 | 15.0% | 250 | 8.6% | 325 | 6.0% | 400 | 4.6% | 475 | 3.8% | 550 | 3.2% | 625 | 2.7% |
| L | Blanco & Rito Blanco Drain. | 110 | n/a | 130 | 3.6% | 150 | 3.1% | 170 | 2.7% | 190 | 2.4% | 210 | 2.1% | 230 | 1.9% | 250 | 1.7% |
| M | Taylor Canyon Drainage | 150 | n/a | 200 | 6.7% | 250 | 5.0% | 280 | 2.4% | 310 | 2.1% | 340 | 1.9% | 370 | 1.8% | 400 | 1.6% |
| N | Burns Canyon & Cat Creek | 70 | n/a | 90 | 5.7% | 110 | 4.4% | 130 | 3.6% | 150 | 3.1% | 170 | 2.7% | 190 | 2.4% | 210 | 2.1% |
| O | Stollsteimer Creek-Hwy. 160 | 800 | n/a | 1000 | 5.0% | 1200 | 4.0% | 1400 | 3.3% | 1600 | 2.9% | 1800 | 2.5% | 2000 | 2.2% | 2200 | 2.0% |
| Total for the SJWCD Service Area | | 8935 | n/a | 11085 | 4.8% | 13240 | 3.9% | 15325 | 3.2% | 17410 | 2.7% | 19495 | 2.4% | 21580 | 2.1% | 23665 | 1.9% |

Note: The population estimates for each of the five year periods were determined by the Population Committe. The estimates were made at a meeting of the Population Committee on February 14, 1989.

This study assumes that the three existing water treatment plants operated by the Town of Pagosa Springs and Pagosa Area Water and Sanitation District (PAWSD) will be able to provide the 1990 water demand. Private wells are assumed to be able to meet the water demand of outlying areas.

As can be seen, about 65% of the water demand is in subarea H, which is the Fairfield-Pagosa Development that is served by the PAWSD. The population estimate for this area is based upon potential capacity rather than the permanent population because there are so many temporary residents in the motel and time shares. The concentration of population growth in one subarea has a major impact upon the feasibility of various plans to provide water because the reservoir closest to the greatest demand will likely be the best alternative.

The second component in estimating water demands is the per capita use rate, which is shown in gallons per capita per day (gpcd). The range of use rates is from 150 gpcd to 250 gpcd. Table II-2, below, shows the volume of water needed in 2025 to serve 14,730 persons for various use rates.

TABLE II-2
2025 WATER DEMAND FOR VARIOUS USE RATES

| gpcd | Million Gallons | Acre-Feet |
|---|---|---|
| 150 | 806 | 2500 |
| 175 | 940 | 2900 |
| 200 | 1075 | 3300 |
| 225 | 1210 | 3700 |
| 250 | 1345 | 4100 |

The use rate of 200 gpcd was selected primarily because it is the middle of the acceptable range which reflects the inclusion of golf courses, parks, and commercial industry. The result is that any reservoir considered as an alternative must be able to provide at least 3300 acre-feet of water per year in 2025.

The final determination for water demand is the distribution of water to each subarea and specifically, the flow requirement in cubic feet per second (cfs), needed to serve each subarea. Table II-3 shows this evaluation. Column 1 is the subarea title. Column 2 is the population increase from 1990 to 2025 for each subarea. Column 3 is the water demand in acre-feet for each subarea based upon 200 gpcd. Column 4 is the water demand in acre-feet for the peak month, which is July, and is about 12% of the total acre-feet. Column 5 is the average flow for the peak month; this flow is used to size facilities from the reservoir to the treatment plant. Column 6 is the peak day flow which is assumed to be 3 times the yearly average flow; this flow is used to size the delivery pipelines to each subarea.

To summarize the water demand. Reservoirs considered as alternatives must be able to supply 3300 acre-feet per year in 2025.

TABLE II-3
SUMMARY OF ESTIMATED 2025 WATER NEEDS

| Area (1) | 1990 to 2025 pop. increase (2) | 200 gpcd Water Demand (AF) (3) | Peak Month (AF) (4) | Peak Month Ave Flow (cfs) (5) | Peak Day Flow 3 x Yr Avg (cfs) (6) |
|---|---|---|---|---|---|
| A | 175 | 40 | 5 | 0.08 | 0.17 |
| B | 350 | 80 | 9 | 0.15 | 0.33 |
| C | 250 | 60 | 7 | 0.11 | 0.25 |
| D | 425 | 100 | 11 | 0.18 | 0.41 |
| E | 225 | 50 | 6 | 0.1 | 0.21 |
| F | 175 | 40 | 5 | 0.08 | 0.17 |
| G | 175 | 40 | 5 | 0.08 | 0.17 |
| H | 10500 | 2350 | 266 | 4.32 | 9.74 |
| K | 525 | 120 | 14 | 0.23 | 0.5 |
| L | 140 | 30 | 3 | 0.05 | 0.12 |
| M | 250 | 60 | 7 | 0.11 | 0.25 |
| N | 140 | 30 | 3 | 0.05 | 0.12 |
| O | 1400 | 310 | 35 | 0.57 | 1.28 |
| Totals | 14730 | 3310 | 376 | 6.11 | 13.72 |

Note: Peak day flow is used to size pipelines.
0.1 cfs is equal to 45 gpm.

## CHAPTER III
## HYDROLOGY AND WATER RIGHTS

The hydrology of various streams in the area and existing senior water rights negatively impacts the availability of the water. The San Juan River runs through the middle of the SJWCD and has adequate water for all users; there would only be a few days in a very dry year when existing water rights would utilize the entire flow of the river.

The Southwestern Water Conservation District (SWWCD) holds conditional water rights on the San Juan River, both storage and direct flow, that could probably be made available to the SJWCD. Over the last few years the SWWCD has transfered water rights to users in the San Juan basin when needed and it is anticipated that rights would also be made available to the SJWCD. The SWWCD rights are junior to most of the present water users including all of the large water users. Development of all the SWWCD water rights would result in many days of no flow in the San Juan River.

Tributaries to the San Juan River, such as Turkey Creek, Four Mile Creek, Hidden Valley, Stollsteimer Creek, Mill Creek, Echo Canyon, Rito Blanco, etc., are generally either appropriated to the point only flood flows in wet years are available or have minimal runoff. The result is that reservoirs on tributaries must have a diversion from another stream and necessary water rights to yield the required water supply of 3300 acre-feet.

An unknown but potentially major issue is in-stream flow water rights. These rights, though junior, to SWWCD rights could establish a minimum stream flow on the San Juan River and tributaries.

## CHAPTER IV
## RESERVOIR INVENTORY

A reservoir inventory of sites that could serve the 3,300 acre-foot water demand was conducted. Reservoir sites on the San Juan River were not considered because of the cost to construct a small dam on a large river. The inventory generally included sites that were within 6 miles of a treatment plant and located high in the basin to minimize pumping. There are very few reservoir sites in the area. The sites were selected from 7.5 minute USGS maps and field reviews by SJWCD Board members. The reservoir sites which are included in the inventory are on small streams and have diversions from the San Juan River or another tributary.

Eight reservoir sites were identified as having reasonable possibility of development and to show tradeoffs between reservoirs at various locations and sources of water. The reservoirs are grouped by source of water. There are 3 sites that utilize San Juan River water. There are 3 sites that utlize Four Mile Creek flood flows through an enlarged Dutton Ditch. One site utilizes Rito Blanco flows by purchasing the Echo Ditch Company. The last site utilizes Turkey Creek flows.

### FOUR MILE CREEK DIVERSION SITES

The 3 Four Mile Creek sites are Hidden Valley, Dutton, and Martinez Reservoirs located on creeks with the same name as the reservoir. Hidden Valley is in the McCabe Creek drainage which is in the San Juan River drainage. The other 2 sites are in the Stollstiemer Creek drainage. The existing Dutton Ditch conveys water from Four Mile Creek into the Stollstiemer Creek drainage, and has a capacity of about 12 cfs. The Dutton Ditch would be enlarged to convey additional water to the reservoirs. The additional flows conveyed through the ditch would be early and late season runoff and excess runoff in wet years, because existing senior water rights have first priority to most of the flow in Four Mile Creek. Water rights for the diversion would include the 20 cfs conditional right held by the PAWSD, which was transfered from the SWWCD, and the 20 cfs conditional right still held by the SWWCD; the rights have identical priorities.

The Hidden Valley site is on a creek which has runoff that can be stored in the reservoir. The Martinez and Dutton sites would have to be filled exclusively by Four Mile Creek diversions because essentially all of the natural runoff is used by senior water users.

The embankments for these 3 sites are assumed to be zoned fills with 3.5:1 upstream slopes and 3:1 downstream slopes. The availability of zone 2 (impervious) material has not been investigated.

Figure IV-1 shows the location of these 3 sites, as well as four other sites, Snowball is not shown. The sites are compared in Table IV-1. The upper 3 reservoirs are the Four Mile Creek Diversion sites. Table IV-1 shows the name of each site in column 1. Column 2 shows the maximum potential capacity of each site. Column 3 shows the required storage capacity to yield 3300 acre-feet a year, with the exception of Snowball Reservoir which yields 2700 acre-feet. The fourth column is the crest elevation and the fifth column is the dam height. The sixth column is the area of the drainage in square miles. Column 7 is the embankment volume. Column 8 is the critical comparison value for selecting the best sites from the inventory and is the ratio of the embankment fill to the reservoir yield; the lower the ratio the better the site. The least embankment volume needed for the reservoir will generally result in the least cost site. Column 9 is the estimated runoff from each drainage area regradless of whether it can be stored or not. The last column is a summary of the water supply for each site.

As can be seen from Table IV-1, Hidden Valley is the best dam site of the 3 Four Mile Creek sites, requiring about 75% of the embankment volume to yield 3300 acre-feet. Hidden Valley is evaluated in greater detail in Chapter V because it is the best of the Four Mile Creek sites.

SAN JUAN RIVER DIVERSION SITES

Three sites were evaluated that used diversions from the San Juan River. The 3 sites are the nearest to the water demand; sites in the upper San Juan River basin were not included because of the cost to convey water to the demands. The 3 sites are Dry Gulch, Mill Creek, and Jackson Creek; again, each are named after the stream they are located on. The site locations are shown on Figure IV-1 and the data for each is on Table IV-1.

The storage capacity required to yield 3300 acre-feet per year is about a third of the capacity needed for the Four Mile Creek Diversion sites. The reason is that the Four Mile sites require carryover from year to year while the San Juan River sites only require carryover from mid-June to September.

Dry Gulch would be filled with diversions from the San Juan River through the existing Park Ditch. An arrangement would have to be made with the Park Ditch Company to allow water to be conveyed through the ditch in off peak times to fill the reservoir.

The Jackson and Mill Creek sites would require pumps, as near to the reservoir site as possible, to convey San Juan River water to each reservoir. The Jackson Creek site would require a 160 foot lift and the Mill Creek site, a 220 foot lift.

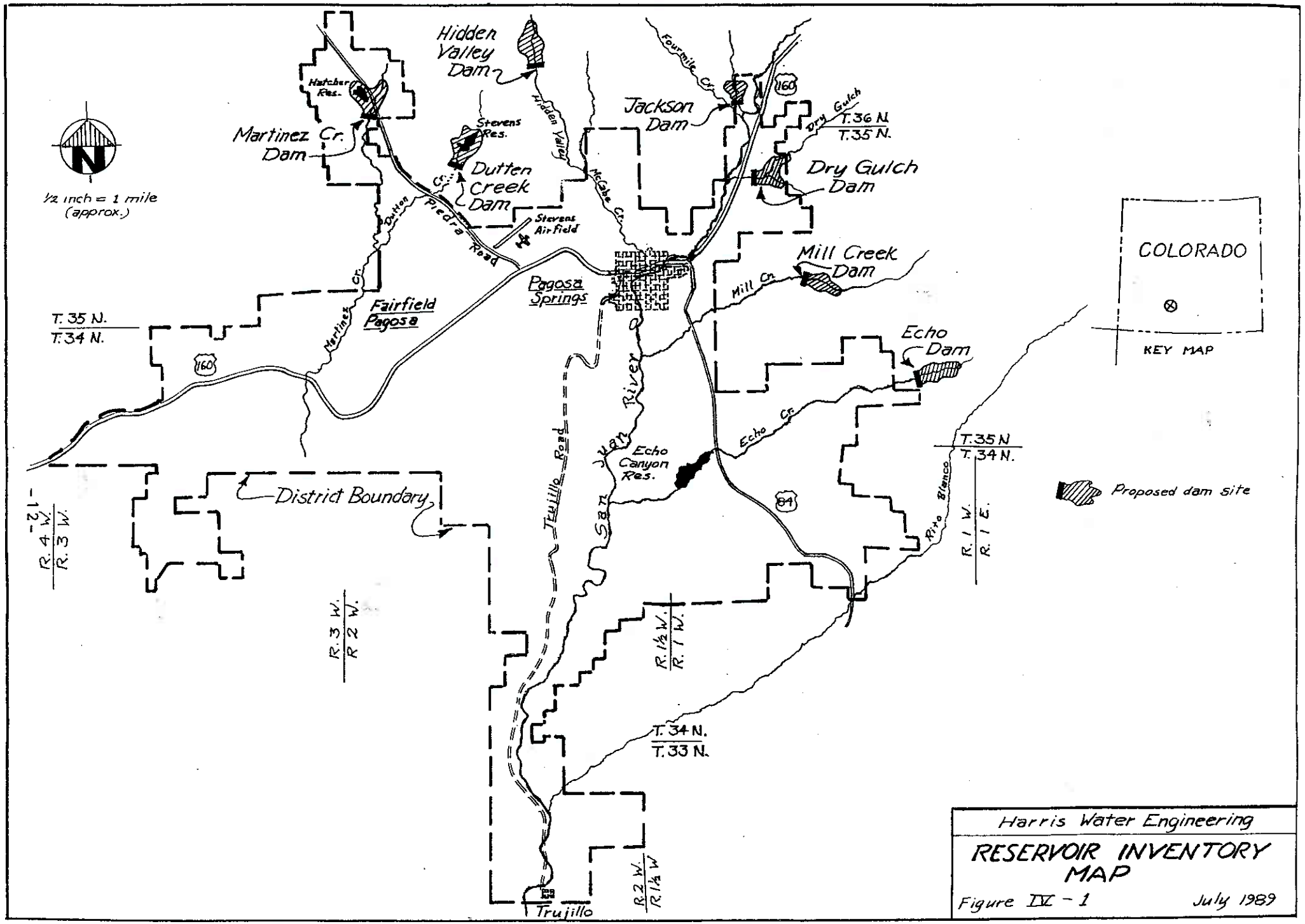

Hidden Valley Dam
Hatcher Res.
Martinez Cr. Dam
Stevens Res.
Dutton Creek Dam
Hidden Valley Cr.
Fourmile Cr.
Jackson Dam
160
Dry Gulch
T. 36 N.
T. 35 N.
Dry Gulch Dam
McCabe Cr.
Dutton Cr.
Piedra Road
Stevens Airfield
Mill Creek Dam
Mill Cr.
Pagosa Springs
Martinez Cr.
Fairfield Pagosa
T. 35 N.
T. 34 N.
160
Echo Dam
Echo Cr.
San Juan River
Trujillo Road
Echo Canyon Res.
T. 35 N
T. 34 N.
84
Rito Blanco
R. 1 W.
R. 1 E.
District Boundary
R. 4 W.
R. 3 W.
R. 3 W.
R. 2 W.
R. 1½ W.
R. 1 W.
T. 34 N.
T. 33 N.
R. 2 W.
R. 1½ W
Trujillo
½ inch = 1 mile
(approx.)
COLORADO
KEY MAP
Proposed dam site
Harris Water Engineering
RESERVOIR INVENTORY MAP
Figure IV - 1
July 1989

TABLE IV-1
COMPARISON OF DAMS AND RESERVOIRS

| Item (1) | Maximum Capacity (Ac-Ft) (2) | Active Capacity for 3300 AF Yield (Ac-Ft) (3) | Crest Elev (feet) (4) | Dam Height (feet) (5) | Drainage Area (sq mi) (6) | Embank. Volume (Cub Yds) (7) | Ratio of Fill to Yield (8) | Approx Average Runoff (Ac-Ft) (9) | Sources of Water (10) |
|---|---|---|---|---|---|---|---|---|---|
| Four Mile Creek Diversions: | | | | | | | | | |
| Hidden Valley | 16000 | 6300 | 7611 | 96 | 5.6 | 505000 | 153 | 1400 | Runoff & enlarged Dutton Ditch |
| Martinez Creek | 8900 | 6300 | 7730 | 100 | 14.5 | 668500 | 203 | 3610 | Enlarged Dutton Ditch |
| Dutton Creek | 21600 | 6300 | 7737 | 107 | 6.1 | 688900 | 209 | 1520 | Enlarged Dutton Ditch |
| San Juan River Diversions: | | | | | | | | | |
| Dry Gulch | 11000 | 2000 | 7314 | 74 | 2.3 | 375400 | 114 | 460 | Arrangement with Park Ditch |
| Mill Creek | 5100 | 2000 | 7340 | 85 | 16 | 591600 | 179 | 3200 | 220 ft Pump lift |
| Jackson Creek | 4300 | 2000 | 7394 | 94 | 2 | 736200 | 223 | 400 | 160 ft pump lift |
| Rito Blanco Diversion: | | | | | | | | | |
| Echo Basin | 3100 | 2249 | 7785 | 91 | 1.7 | 749300 | 227 | 370 | Purchase Echo Ditch and shares |
| Turkey Creek Diversion: | | | | | | | | | |
| Snowball | 4300 | 2900 | 8053 | 123 | n/a | 989000 | 366 | n/a | Enlarged Snowball Ditch |

Note: Snowball Reservoir will only yield 2700 acre-feet.

The ratio of fill to yield shows that the Dry Gulch site would require about half the fill to yield 3300 acre-feet per year as the other two sites. This coupled with the availability of a ditch to convey water to the reservoir by gravity, easily make this the best site to utilize San Juan River water. The Dry Gulch site is evaluated in greater detail in Chapter VI.

RITO BLANCO DIVERSIONS

Only one site was located that could be used to store water from the Rito Blanco, which is the Echo Basin site in Echo Canyon. The site was studied by the Soil Conservation Service (SCS) in the 1970's as an irrigation reservoir to augment the supply of the Echo Basin Ditch. The Echo Basin Ditch diverts water from the Rito Blanco to Echo Canyon for irrigation purposes. In order for Echo Reservoir to yield 3300 acre-feet per year, the Echo Ditch would have to converted to municipal purposes and the present amount of water conveyed through the ditch must be doubled.

The data for the site is shown on Table IV-1. The fill to yield ratio is very high but since this is the only site to utilize Rito Blanco flows it is evaluated in greater detail in Chapter VII.

TURKEY CREEK DIVERSIONS

The Snowball Dam site, which would utilize diversions from Turkey Creek through the Snowball Ditch, was evaluated in a feasibility study conducted in 1986 by the Colorado Water Resources and Power Development Authority for the Town of Pagosa Springs. The study and findings subsequent to the study showed the site to be infeasible because of cost and problems with acquiring rights-of-way for the reservoir. The site is included for comparison purposes but is not evaluated in greater detail. The 1986 study provides details of the plan.

The data for the site is shown on Table IV-1 and shows that the site is the worst site of the 8 sites inventoried.

# CHAPTER V
# HIDDEN VALLEY RESERVOIR PLAN

The Hidden Valley Reservoir plan includes Hidden Valley Reservoir as the storage facility, a pipeline and pump to convey raw water to Stevens Reservoir for temporary storage prior to treatment at the Stevens Treatment Plant, a distribution system to existing water systems, and distribution systems to new areas. The details of the water supply to serve the demands and the necessary facilities are described in the following sections of this chapter.

## WATER SUPPLY

The water supply for the Hidden Valley Reservoir was initially considered in a study commissioned by the SJWCD in 1988. The study was to evaluate the amount of water available from basin runoff and Four Mile Creek diversions through the enlarged Dutton Ditch, in order to provide for future municipal water demands. The study concluded that there was a significant amount of water from basin runoff, Four Mile Creek Diversions, and possibly through the purchase of Four Mile Ditch shares. As a result of the study, a gage was installed on Hidden Valley Creek to measure the basin runoff.

The gage was installed prior to the spring runoff in 1989. The four months of records from the gage were surprising in that the runoff peaked very early, March, and then dropped off to nearly zero by the end of April. The 1989 runoff throughout the basin was generally a month early and the runoff was below average. The gage showed that the runoff estimates in the 1988 study were probably low.

The 1988 runoff estimates are used in this study which should result in conservative yields from basin runoff. The gage on Hidden Valley Creek will remain in place so that the runoff estimates can be updated in future years.

Table V-1 is a Hidden Valley Reservoir operation study utilizing just basin runoff. Later in this section is a description of an operation study utilizing basin runoff and Dutton Ditch diversions. Basin runoff is evaluated initially to determine the amount of yield, available without importing water.

The operation study is an attempt to simulate how much water would have been in the reservoir at the end of each month from January, 1975 through December, 1979. This time period was used

TABLE V-1
HIDDEN VALLEY RESERVOIR OPERATION STUDY - BASIN RUNOFF ONLY

| Date (1) | Hid Val Ck Flow (Ac-Ft) (2) | 4 Mile Ditch (Ac-Ft) (3) | Irrig Consump (Ac-Ft) (4) | Senior Rights (Ac-Ft) (5) | Storable Flow (Ac-Ft) (6) | Dutton Ditch (Ac-Ft) (7) | M & I Supply (Ac-Ft) (8) | Evap & Misc Loss (Ac-Ft) (9) | E O M Content (Ac-Ft) (10) | Reservoir Spill (Ac-Ft) (11) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 JAN | 28 | 0 | 0 | 0 | 28 | 0 | 66 | 2 | 800 | 0 |
| FEB | 28 | 0 | 0 | 0 | 28 | 0 | 60 | 2 | 766 | 0 |
| MAR | 113 | 0 | 0 | 0 | 113 | 0 | 62 | 2 | 815 | 0 |
| APR | 1032 | 0 | 0 | 0 | 1032 | 0 | 66 | 21 | 1760 | 0 |
| MAY | 356 | 0 | 0 | 45 | 311 | 0 | 76 | 27 | 1968 | 0 |
| JUNE | 56 | 0 | 0 | 137 | 0 | 0 | 98 | 31 | 1839 | 0 |
| JULY | 56 | 0 | 0 | 141 | 0 | 0 | 102 | 33 | 1704 | 0 |
| AUG | 56 | 0 | 0 | 120 | 0 | 0 | 95 | 26 | 1583 | 0 |
| SEPT | 56 | 0 | 0 | 45 | 11 | 0 | 77 | 21 | 1496 | 0 |
| OCT | 38 | 0 | 0 | 0 | 38 | 0 | 64 | 15 | 1455 | 0 |
| NOV | 28 | 0 | 0 | 0 | 28 | 0 | 69 | 2 | 1412 | 0 |
| DEC | 28 | 0 | 0 | 0 | 28 | 0 | 66 | 2 | 1372 | 0 |
| TOTALS | 1875 | 0 | 0 | 488 | 1617 | 2084 | 901 | 184 | | 0 |
| 1976 JAN | 19 | 0 | 0 | 0 | 19 | 0 | 66 | 2 | 1323 | 0 |
| FEB | 19 | 0 | 0 | 0 | 19 | 0 | 60 | 2 | 1280 | 0 |
| MAR | 75 | 0 | 0 | 0 | 75 | 0 | 62 | 2 | 1291 | 0 |
| APR | 685 | 0 | 0 | 0 | 685 | 0 | 66 | 21 | 1889 | 0 |
| MAY | 237 | 0 | 0 | 45 | 192 | 0 | 76 | 27 | 1978 | 0 |
| JUNE | 37 | 0 | 0 | 137 | 0 | 0 | 98 | 31 | 1849 | 0 |
| JULY | 37 | 0 | 0 | 141 | 0 | 0 | 102 | 33 | 1714 | 0 |
| AUG | 37 | 0 | 0 | 120 | 0 | 0 | 95 | 26 | 1593 | 0 |
| SEPT | 37 | 0 | 0 | 45 | 0 | 0 | 77 | 21 | 1495 | 0 |
| OCT | 25 | 0 | 0 | 0 | 25 | 0 | 64 | 15 | 1441 | 0 |
| NOV | 19 | 0 | 0 | 0 | 19 | 0 | 69 | 2 | 1389 | 0 |
| DEC | 19 | 0 | 0 | 0 | 19 | 0 | 66 | 2 | 1340 | 0 |
| TOTALS | 1246 | 0 | 0 | 488 | 1053 | 396 | 901 | 184 | | 0 |
| 1977 JAN | 7 | 0 | 0 | 0 | 7 | 0 | 66 | 2 | 1279 | 0 |
| FEB | 7 | 0 | 0 | 0 | 7 | 0 | 60 | 2 | 1224 | 0 |
| MAR | 28 | 0 | 0 | 0 | 28 | 0 | 62 | 2 | 1188 | 0 |
| APR | 254 | 0 | 0 | 0 | 254 | 0 | 66 | 21 | 1355 | 0 |
| MAY | 88 | 0 | 0 | 45 | 43 | 0 | 76 | 27 | 1295 | 0 |
| JUNE | 14 | 0 | 0 | 137 | 0 | 0 | 98 | 31 | 1166 | 0 |
| JULY | 14 | 0 | 0 | 141 | 0 | 0 | 102 | 33 | 1031 | 0 |
| AUG | 14 | 0 | 0 | 120 | 0 | 0 | 95 | 26 | 910 | 0 |
| SEPT | 14 | 0 | 0 | 45 | 0 | 0 | 77 | 21 | 812 | 0 |
| OCT | 9 | 0 | 0 | 0 | 9 | 0 | 64 | 15 | 742 | 0 |
| NOV | 7 | 0 | 0 | 0 | 7 | 0 | 69 | 2 | 678 | 0 |
| DEC | 7 | 0 | 0 | 0 | 7 | 0 | 66 | 2 | 617 | 0 |
| TOTALS | 463 | 0 | 0 | 488 | 362 | 117 | 901 | 184 | | 0 |
| 1978 JAN | 18 | 0 | 0 | 0 | 18 | 0 | 66 | 2 | 567 | 0 |
| FEB | 18 | 0 | 0 | 0 | 18 | 0 | 60 | 2 | 523 | 0 |
| MAR | 73 | 0 | 0 | 0 | 73 | 0 | 62 | 2 | 532 | 0 |
| APR | 670 | 0 | 0 | 0 | 670 | 0 | 66 | 21 | 1115 | 0 |
| MAY | 231 | 0 | 0 | 45 | 186 | 0 | 76 | 27 | 1198 | 0 |
| JUNE | 37 | 0 | 0 | 137 | 0 | 0 | 98 | 31 | 1069 | 0 |
| JULY | 37 | 0 | 0 | 141 | 0 | 0 | 102 | 33 | 934 | 0 |
| AUG | 37 | 0 | 0 | 120 | 0 | 0 | 95 | 26 | 813 | 0 |
| SEPT | 37 | 0 | 0 | 45 | 0 | 0 | 77 | 21 | 715 | 0 |
| OCT | 24 | 0 | 0 | 0 | 24 | 0 | 64 | 15 | 660 | 0 |
| NOV | 18 | 0 | 0 | 0 | 18 | 0 | 69 | 2 | 607 | 0 |
| DEC | 18 | 0 | 0 | 0 | 18 | 0 | 66 | 2 | 557 | 0 |
| TOTALS | 1218 | 0 | 0 | 488 | 1025 | 1446 | 901 | 184 | | 0 |
| 1979 JAN | 39 | 0 | 0 | 0 | 39 | 0 | 66 | 2 | 528 | 0 |
| FEB | 39 | 0 | 0 | 0 | 39 | 0 | 60 | 2 | 505 | 0 |
| MAR | 156 | 0 | 0 | 0 | 156 | 0 | 62 | 2 | 597 | 0 |
| APR | 1432 | 0 | 0 | 0 | 1432 | 0 | 66 | 21 | 1942 | 0 |
| MAY | 495 | 0 | 0 | 45 | 450 | 0 | 76 | 27 | 2289 | 0 |
| JUNE | 78 | 0 | 0 | 137 | 0 | 0 | 98 | 31 | 2160 | 0 |
| JULY | 78 | 0 | 0 | 141 | 0 | 0 | 102 | 33 | 2025 | 0 |
| AUG | 78 | 0 | 0 | 120 | 0 | 0 | 95 | 26 | 1904 | 0 |
| SEPT | 78 | 0 | 0 | 45 | 33 | 0 | 77 | 21 | 1839 | 0 |
| OCT | 52 | 0 | 0 | 0 | 52 | 0 | 64 | 15 | 1812 | 0 |
| NOV | 39 | 0 | 0 | 0 | 39 | 0 | 69 | 2 | 1780 | 0 |
| DEC | 39 | 0 | 0 | 0 | 39 | 0 | 66 | 2 | 1751 | 0 |
| TOTALS | 2603 | 0 | 0 | 488 | 2279 | 2002 | 901 | 184 | | 0 |

because 1977 was the driest year on record and 1976 was below average. The yield from a reservoir during this time period would be firm; the yield during wetter years would be larger. A drought more severe than any on record, may of course, cause unanticipated shortages from the reservoir.

There are 11 columns in Table V-1, with the first column showing the year and month. Column 2 is the estimated inflow from basin runoff. Column 3 is potential inflow from Four Mile Ditch if shares could be obtained; this inflow is zero for this example. Column 4 is irrigation consumption if irrigation were a user of water from the reservoir; this column is also zero. Column 5 is senior rights below the reservoir that must be bypassed through the reservoir; in many summer months all of the flow of Hidden Valley must be bypassed for these rights. Column 6 is the storable flow in the reservoir.

Column 7 is the inflow from the Dutton Ditch which is zero for this operation study. Column 8 is the municipal and industrial (M & I) water demand as estimated in Chapter II, distributed over 12 months. Column 9 is evaporation and seepage losses in the reservoir. Column 10 is the end-of-month (EOM) content of the reservoir. The last column, 11, is any spills that may occur if the reservoir is full. In the example there are only two spills in 1975 and 1979.

The reservoir size used for this example is 6300 acre-feet active capacity, because that amount is needed when Dutton Ditch flows are included, as described later in this section. As can be seen in this operation study, about half that capacity is needed if only basin runoff is stored. The dam, however, would not be constructed at a smaller size initially and then enlarged in the near future because enlarging dams has proven to not be cost effective.

Table V-1 shows that about 900 acre-feet per year of yield could be obtained by storing basin runoff. This is in a very dry period, so the yield would be greater in an average or wet period. Also, the basin runoff estimates are believed to be conservative, so that as additional data is collected on Hidden Valley Creek, the runoff values may be increased.

Utilizing just basin runoff to fill the reservoir initially will allow the water demand to be supplied until about the year 2000, before enlargement of the Dutton Ditch will be necessary. When the Dutton Ditch is enlarged a minimum of 25 cfs is necessary for inflow to Hidden Valley. There are plans to enlarge the Dutton Ditch by the PAWSD and other entities to about 22.85 cfs for the entire length of the ditch. In order to accommodate Hidden Valley, the ditch would be enlarged to about 48 cfs for about half of the length. It is possible that

environmental contraints required by the U.S. Forest Service may result in a pipeline rather than a ditch. The cost of both is presented in the Dutton Ditch Enlargement section of this chapter.

The estimation of the 25 cfs enlargement is based upon the flows of Four Mile Creek shown on Table V-2. The amounts are a combination of flows recorded by Wheeler and Associates and estimated flows. Some of the flows are recorded which greatly increases the reliability but the estimated values may be off by as much as 25% or more. This potential error should be remembered when evaluating the Hidden Valley plan. The potential amount of water that could be diverted to Hidden Valley from Four Mile Creek should be measured more accurately before the facilities are constructed.

Table V-3 is a large table of numbers used to estimate the water available to the 25 cfs enlargement of the Dutton Ditch after all senior rights have taken their share of water. The time period is the same as used for the operation study in Table V-1, 1975 through 1979. Columns 2 through 8 are the recorded diversions of the ditches that utilize Four Mile Creek flows. Column 9 is the sum of all the ditches; column 10 is a modification of the actual diversions to increase some recorded diversions to provide conservatism to the values. Column 11 is the estimated flow in Four Mile Creek. Column 12 is the historic recorded Dutton Ditch diversions. Column 13 is the additional Dutton Ditch diversions when the ditch is increased from 12 cfs to 22.85 cfs. Column 14 is the water remaining in Four Mile Creek after all of the other diversions; with the 20 cfs conditional right held by the PAWSD and 20 cfs conditional right held by the SWWCD being the being the next in priority.

Column 15 shows how much could be diverted by the Dutton Ditch from Four Mile Creek with 25 cfs of the 40 cfs conditional rights.

Table V-4 is the same Hidden Valley Reservoir operation study as shown in Table V-1 except that inflow from Dutton Ditch, column 7, is included. The reservoir fills in July of 1975 because there is a large amount of inflow from Dutton Ditch, in fact the ditch is estimated to run the full 25 cfs for May, June, and July. In 1976 and 1977 there is almost no inflow to the reservoir from Dutton Ditch causing most of the water demand in 1976 and 1977 to be met from storage. The reservoir is nearly empty in March of 1978; then Dutton Ditch inflow is again available.

Neither the possibility of purchasing Four Mile Ditch shares nor return flow from Four Mile Ditch shares used in Hidden Valley, were included in the evalaution because the amount of water available after purchasing shares and converting them to

TABLE V-2
FOUR MILE CREEK ABOVE DUTTON DITCH
(Values in acre-feet)

| YEAR | JAN | FEB | MARCH | APRIL | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | (150) | (150) | (300) | (1100) | (7800) | 8834 | 6870 | 2270 | 1056 | (170) | (200) | (900) | 29800 |
| 1976 | (110) | (130) | (330) | (1000) | 2066 | 3012 | 474 | 342 | 554 | 766 | 896 | (70) | 9750 |
| 1977 | (60) | (50) | (80) | (300) | (620) | (470) | 338 | 586 | 232 | 162 | 500 | (90) | 3488 |
| 1978 | (130) | (140) | (410) | 2434 | 4284 | 4136 | 496 | 278 | 396 | (180) | (220) | (130) | 13134 |
| 1979 | (150) | (150) | (300) | (1100) | (7800) | (8834) | (6870) | (2270) | (1056) | (170) | (200) | (900) | 29800 |

Notes: The numbers without parenthesis were recorded at a gage installed by W.W. Wheeler and Associates for Fairfield-Pagosa.

The numbers in parenthesis were estimated by Harris Water Engineering.

The flows for 1979 were assumed to be the same as for 1975 because there was no record for 1979 and both were greater than average.

TABLE V-3
POTENTIAL DIVERSIONS FROM FOUR MILE CREEK TO HIDDEN VALLEY RESERVOIR

| Date (1) | Diversions From State Engineer Records: Parr-Loucks (Ac-Ft) (2) | 4 Mile Ditch (Ac-Ft) (3) | Mesa Ditch (Ac-Ft) (4) | Mtn. Park (Ac-Ft) (5) | Cockrell Ditch (Ac-Ft) (6) | Joe Macht (Ac-Ft) (7) | New Ditch (Ac-Ft) (8) | Total Ditch Diver. (Ac-Ft) (9) | Assumed Ditch Diver. (Ac-Ft) (10) | 4 Mile Flow (Ac-Ft) (11) | Historic Dutton Divers. (Ac-Ft) (12) | Additonal Dutton Diversion @22.85cfs (Ac-Ft) (13) | Remain 4 Mile Flow (Ac-Ft) (14) | Estimated Yield From 25 cfs (Ac-Ft) (15) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 JAN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 150 | 0 | 0 | 150 | 0 |
| FEB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 150 | 0 | 0 | 150 | 0 |
| MAR | 0 | 246 | 0 | 0 | 0 | 0 | 0 | 246 | 246 | 300 | 0 | 54 | 0 | 0 |
| APR | 0 | 238 | 0 | 0 | 0 | 0 | 0 | 238 | 238 | 1100 | 0 | 480 | 382 | 382 |
| MAY | 81 | 198 | 0 | 0 | 0 | 0 | 28 | 307 | 500 | 7800 | 0 | 600 | 6700 | 1488 |
| JUNE | 299 | 1398 | 715 | 0 | 50 | 127 | 83 | 2672 | 3000 | 8834 | 196 | 600 | 5038 | 1488 |
| JULY | 218 | 1232 | 388 | 0 | 61 | 117 | 89 | 2105 | 2500 | 6870 | 236 | 600 | 3534 | 1488 |
| AUG | 123 | 576 | 230 | 0 | 0 | 50 | 36 | 1015 | 1400 | 2270 | 55 | 600 | 215 | 215 |
| SEPT | 30 | 299 | 127 | 0 | 12 | 28 | 79 | 575 | 575 | 1056 | 2 | 600 | 0 | 0 |
| OCT | 24 | 267 | 91 | 0 | 4 | 0 | 42 | 428 | 428 | 170 | 0 | 0 | 0 | 0 |
| NOV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | 0 | 200 | 0 | 0 |
| DEC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 900 | 0 | 0 | 900 | 0 |
| TOTALS | 775 | 4454 | 1551 | 0 | 127 | 322 | 357 | 7586 | 8887 | 29800 | 489 | 3734 | 17069 | 5061 |
| 1976 JAN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 110 | 0 | 0 | 110 | 0 |
| FEB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 130 | 0 | 0 | 130 | 0 |
| MAR | 0 | 368 | 0 | 0 | 0 | 0 | 0 | 368 | 368 | 330 | 0 | 0 | 0 | 0 |
| APR | 0 | 356 | 0 | 0 | 0 | 0 | 16 | 372 | 372 | 1000 | 0 | 480 | 148 | 148 |
| MAY | 131 | 537 | 218 | 0 | 36 | 0 | 93 | 1015 | 1100 | 2066 | 139 | 600 | 227 | 227 |
| JUNE | 232 | 1303 | 602 | 22 | 50 | 101 | 71 | 2381 | 2381 | 3012 | 455 | 600 | 0 | 0 |
| JULY | 30 | 780 | 257 | 32 | 20 | 61 | 32 | 1212 | 1212 | 474 | 0 | 0 | 0 | 0 |
| AUG | 32 | 467 | 208 | 0 | 10 | 109 | 53 | 879 | 879 | 342 | 0 | 0 | 0 | 0 |
| SEPT | 28 | 428 | 57 | 0 | 12 | 38 | 50 | 613 | 613 | 554 | 0 | 0 | 0 | 0 |
| OCT | 22 | 428 | 0 | 0 | 8 | 12 | 20 | 490 | 490 | 766 | 0 | 276 | 0 | 0 |
| NOV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 896 | 0 | 480 | 416 | 416 |
| DEC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 70 | 0 | 0 | 70 | 0 |
| TOTALS | 475 | 4667 | 1342 | 54 | 136 | 321 | 335 | 7330 | 7415 | 9750 | 594 | 2436 | 1101 | 791 |
| 1977 JAN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 60 | 0 | 0 | 60 | 0 |
| FEB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | 0 | 50 | 0 |
| MAR | 0 | 307 | 0 | 0 | 0 | 0 | 0 | 307 | 307 | 80 | 0 | 0 | 0 | 0 |
| APR | 47 | 368 | 40 | 0 | 0 | 0 | 27 | 482 | 482 | 300 | 0 | 0 | 0 | 0 |
| MAY | 122 | 496 | 119 | 7 | 17 | 87 | 61 | 909 | 909 | 620 | 32 | 0 | 0 | 0 |
| JUNE | 51 | 485 | 69 | 3 | 21 | 68 | 71 | 768 | 768 | 470 | 198 | 0 | 0 | 0 |
| JULY | 21 | 333 | 91 | 0 | 5 | 21 | 18 | 489 | 489 | 338 | 0 | 0 | 0 | 0 |
| AUG | 31 | 480 | 119 | 0 | 23 | 73 | 67 | 793 | 793 | 586 | 27 | 0 | 0 | 0 |
| SEPT | 27 | 474 | 81 | 0 | 17 | 118 | 68 | 785 | 785 | 232 | 258 | 0 | 0 | 0 |
| OCT | 40 | 345 | 22 | 0 | 5 | 59 | 3 | 474 | 474 | 162 | 238 | 0 | 0 | 0 |
| NOV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 500 | 267 | 0 | 233 | 233 |
| DEC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 90 | 266 | 0 | 0 | 0 |
| TOTALS | 339 | 3288 | 541 | 10 | 88 | 426 | 315 | 5007 | 5007 | 3488 | 1286 | 0 | 343 | 233 |
| 1978 JAN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 130 | 0 | 0 | 130 | 0 |
| FEB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 140 | 0 | 0 | 140 | 0 |
| MAR | 0 | 338 | 0 | 0 | 0 | 0 | 0 | 338 | 338 | 410 | 0 | 72 | 0 | 0 |
| APR | 0 | 321 | 0 | 0 | 0 | 0 | 0 | 321 | 321 | 2434 | 0 | 480 | 1633 | 1488 |
| MAY | 0 | 109 | 46 | 0 | 0 | 0 | 25 | 180 | 500 | 4284 | 14 | 600 | 3170 | 1488 |
| JUNE | 44 | 1543 | 458 | 50 | 14 | 51 | 91 | 2251 | 2500 | 4136 | 525 | 600 | 511 | 511 |
| JULY | 40 | 853 | 250 | 10 | 22 | 63 | 36 | 1274 | 1274 | 496 | 93 | 0 | 0 | 0 |
| AUG | 19 | 401 | 89 | 0 | 9 | 46 | 9 | 573 | 573 | 278 | 0 | 0 | 0 | 0 |
| SEPT | 0 | 197 | 37 | 0 | 4 | 12 | 11 | 261 | 400 | 396 | 0 | 0 | 0 | 0 |
| OCT | 0 | 203 | 43 | 0 | 0 | 3 | 1 | 250 | 250 | 180 | 71 | 0 | 0 | 0 |
| NOV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 220 | 0 | 220 | 0 | 0 |
| DEC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 130 | 0 | 0 | 130 | 0 |
| TOTALS | 103 | 3965 | 923 | 60 | 49 | 175 | 173 | 5448 | 6156 | 13234 | 703 | 1972 | 5714 | 3487 |
| 1979 JAN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 150 | 0 | 0 | 150 | 0 |
| FEB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 150 | 0 | 0 | 150 | 0 |
| MAR | 0 | 184 | 0 | 0 | 0 | 0 | 0 | 184 | 184 | 300 | 0 | 116 | 0 | 0 |
| APR | 0 | 186 | 0 | 0 | 0 | 0 | 0 | 186 | 186 | 1100 | 0 | 480 | 434 | 434 |
| MAY | 0 | 269 | 0 | 0 | 0 | 0 | 15 | 284 | 600 | 7800 | 0 | 600 | 6600 | 1488 |
| JUNE | 0 | 367 | 493 | 0 | 5 | 0 | 69 | 934 | 1500 | 8834 | 137 | 600 | 6597 | 1488 |
| JULY | 111 | 813 | 508 | 62 | 57 | 75 | 65 | 1691 | 2000 | 6870 | 709 | 600 | 3561 | 1488 |
| AUG | 7 | 1258 | 270 | 1 | 21 | 179 | 40 | 1776 | 2000 | 2270 | 78 | 270 | 0 | 0 |
| SEPT | 0 | 561 | 200 | 0 | 7 | 59 | 24 | 851 | 851 | 1056 | 0 | 205 | 0 | 0 |
| OCT | 0 | 398 | 91 | 0 | 0 | 18 | 0 | 507 | 507 | 170 | 14 | 14 | 0 | 0 |
| NOV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | 0 | 200 | 0 | 0 |
| DEC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 900 | 0 | 0 | 900 | 0 |
| TOTALS | 118 | 4036 | 1562 | 63 | 90 | 331 | 213 | 6413 | 7828 | 29800 | 938 | 3085 | 18392 | 4898 |

TABLE V-4
HIDDEN VALLEY RESERVOIR OPERATION STUDY - BASIN RUNOFF PLUS 25 CFS DUTTON DITCH

| Date (1) | Hid Val Ck Flow (Ac-Ft) (2) | 4 Mile Ditch (Ac-Ft) (3) | Irrig Consump (Ac-Ft) (4) | Senior Rights (Ac-Ft) (5) | Storable Flow (Ac-Ft) (6) | Dutton Ditch (Ac-Ft) (7) | M & I Supply (Ac-Ft) (8) | Evap & Misc Loss (Ac-Ft) (9) | E O M Content (Ac-Ft) (10) | Reservoir Spill (Ac-Ft) (11) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 JAN | 28 | 0 | 0 | 0 | 28 | 0 | 241 | 2 | 2000 | 0 |
| FEB | 28 | 0 | 0 | 0 | 28 | 0 | 221 | 2 | 1805 | 0 |
| MAR | 113 | 0 | 0 | 0 | 113 | 0 | 228 | 2 | 1688 | 0 |
| APR | 1032 | 0 | 0 | 0 | 1032 | 382 | 241 | 21 | 2840 | 0 |
| MAY | 356 | 0 | 0 | 45 | 311 | 1488 | 277 | 27 | 4335 | 0 |
| JUNE | 56 | 0 | 0 | 137 | 0 | 1488 | 360 | 31 | 5432 | 0 |
| JULY | 56 | 0 | 0 | 141 | 0 | 1488 | 373 | 33 | 6300 | 214 |
| AUG | 56 | 0 | 0 | 120 | 0 | 215 | 350 | 26 | 6139 | 0 |
| SEPT | 56 | 0 | 0 | 45 | 11 | 0 | 284 | 21 | 5845 | 0 |
| OCT | 38 | 0 | 0 | 0 | 38 | 0 | 234 | 15 | 5634 | 0 |
| NOV | 28 | 0 | 0 | 0 | 28 | 0 | 254 | 2 | 5406 | 0 |
| DEC | 28 | 0 | 0 | 0 | 28 | 0 | 241 | 2 | 5191 | 0 |
| TOTALS | 1875 | 0 | 0 | 488 | 1617 | 5061 | 3304 | 184 | | 214 |
| 1976 JAN | 19 | 0 | 0 | 0 | 19 | 0 | 241 | 2 | 4967 | 0 |
| FEB | 19 | 0 | 0 | 0 | 19 | 0 | 221 | 2 | 4763 | 0 |
| MAR | 75 | 0 | 0 | 0 | 75 | 0 | 228 | 2 | 4608 | 0 |
| APR | 685 | 0 | 0 | 0 | 685 | 148 | 241 | 21 | 5179 | 0 |
| MAY | 237 | 0 | 0 | 45 | 192 | 227 | 277 | 27 | 5294 | 0 |
| JUNE | 37 | 0 | 0 | 137 | 0 | 0 | 360 | 31 | 4903 | 0 |
| JULY | 37 | 0 | 0 | 141 | 0 | 0 | 373 | 33 | 4497 | 0 |
| AUG | 37 | 0 | 0 | 120 | 0 | 0 | 350 | 26 | 4121 | 0 |
| SEPT | 37 | 0 | 0 | 45 | 0 | 0 | 284 | 21 | 3816 | 0 |
| OCT | 25 | 0 | 0 | 0 | 25 | 0 | 234 | 15 | 3592 | 0 |
| NOV | 19 | 0 | 0 | 0 | 19 | 416 | 254 | 2 | 3771 | 0 |
| DEC | 19 | 0 | 0 | 0 | 19 | 0 | 241 | 2 | 3547 | 0 |
| TOTALS | 1246 | 0 | 0 | 488 | 1053 | 791 | 3304 | 184 | | 0 |
| 1977 JAN | 7 | 0 | 0 | 0 | 7 | 0 | 241 | 2 | 3311 | 0 |
| FEB | 7 | 0 | 0 | 0 | 7 | 0 | 221 | 2 | 3095 | 0 |
| MAR | 28 | 0 | 0 | 0 | 28 | 0 | 228 | 2 | 2893 | 0 |
| APR | 254 | 0 | 0 | 0 | 254 | 0 | 241 | 21 | 2885 | 0 |
| MAY | 88 | 0 | 0 | 45 | 43 | 0 | 277 | 27 | 2624 | 0 |
| JUNE | 14 | 0 | 0 | 137 | 0 | 0 | 360 | 31 | 2233 | 0 |
| JULY | 14 | 0 | 0 | 141 | 0 | 0 | 373 | 33 | 1827 | 0 |
| AUG | 14 | 0 | 0 | 120 | 0 | 0 | 350 | 26 | 1451 | 0 |
| SEPT | 14 | 0 | 0 | 45 | 0 | 0 | 284 | 21 | 1146 | 0 |
| OCT | 9 | 0 | 0 | 0 | 9 | 0 | 234 | 15 | 906 | 0 |
| NOV | 7 | 0 | 0 | 0 | 7 | 233 | 254 | 2 | 890 | 0 |
| DEC | 7 | 0 | 0 | 0 | 7 | 0 | 241 | 2 | 654 | 0 |
| TOTALS | 463 | 0 | 0 | 488 | 362 | 233 | 3304 | 184 | | 0 |
| 1978 JAN | 18 | 0 | 0 | 0 | 18 | 0 | 241 | 2 | 429 | 0 |
| FEB | 18 | 0 | 0 | 0 | 18 | 0 | 221 | 2 | 224 | 0 |
| MAR | 73 | 0 | 0 | 0 | 73 | 0 | 228 | 2 | 67 | 0 |
| APR | 670 | 0 | 0 | 0 | 670 | 1488 | 241 | 21 | 1963 | 0 |
| MAY | 231 | 0 | 0 | 45 | 186 | 1488 | 277 | 27 | 3333 | 0 |
| JUNE | 37 | 0 | 0 | 137 | 0 | 511 | 360 | 31 | 3453 | 0 |
| JULY | 37 | 0 | 0 | 141 | 0 | 0 | 373 | 33 | 3047 | 0 |
| AUG | 37 | 0 | 0 | 120 | 0 | 0 | 350 | 26 | 2671 | 0 |
| SEPT | 37 | 0 | 0 | 45 | 0 | 0 | 284 | 21 | 2366 | 0 |
| OCT | 24 | 0 | 0 | 0 | 24 | 0 | 234 | 15 | 2141 | 0 |
| NOV | 18 | 0 | 0 | 0 | 18 | 0 | 254 | 2 | 1903 | 0 |
| DEC | 18 | 0 | 0 | 0 | 18 | 0 | 241 | 2 | 1678 | 0 |
| TOTALS | 1218 | 0 | 0 | 488 | 1025 | 3487 | 3304 | 184 | | 0 |
| 1979 JAN | 39 | 0 | 0 | 0 | 39 | 0 | 241 | 2 | 1474 | 0 |
| FEB | 39 | 0 | 0 | 0 | 39 | 0 | 221 | 2 | 1290 | 0 |
| MAR | 156 | 0 | 0 | 0 | 156 | 0 | 228 | 2 | 1216 | 0 |
| APR | 1432 | 0 | 0 | 0 | 1432 | 434 | 241 | 21 | 2820 | 0 |
| MAY | 495 | 0 | 0 | 45 | 450 | 1488 | 277 | 27 | 4454 | 0 |
| JUNE | 78 | 0 | 0 | 137 | 0 | 1488 | 360 | 31 | 5551 | 0 |
| JULY | 78 | 0 | 0 | 141 | 0 | 1488 | 373 | 33 | 6300 | 333 |
| AUG | 78 | 0 | 0 | 120 | 0 | 0 | 350 | 26 | 5924 | 0 |
| SEPT | 78 | 0 | 0 | 45 | 33 | 0 | 284 | 21 | 5652 | 0 |
| OCT | 52 | 0 | 0 | 0 | 52 | 0 | 234 | 15 | 5455 | 0 |
| NOV | 39 | 0 | 0 | 0 | 39 | 0 | 254 | 2 | 5238 | 0 |
| DEC | 39 | 0 | 0 | 0 | 39 | 0 | 241 | 2 | 5034 | 0 |
| TOTALS | 2603 | 0 | 0 | 488 | 2279 | 4898 | 3304 | 184 | | 333 |

municipal use is presently difficult to estimate. The price of the shares is also not known. Return flow is not included because the shares are not always used in Hidden Valley. A Parshall Flume with a staff gage will be installed on Four Mile Ditch as it enters Hidden Valley so that the inflow can be monitored.

The yield of 3300 acre-feet per year from Hidden Valley and Dutton Ditch enlargement is maybe stretching the capability of these water sources. There is not much room for error if the estimate of flows in Four Mile Creek is actually less or the yearly total is the same but the runoff pattern is different which could reduce the potential diversions.

On the other hand the flows could be greater, resulting in more water than estimated. Also, there is the possibility of purchasing a large amount of senior rights on Four Mile Creek and diverting them through the Dutton Ditch. Purchasing the rights could be costly and time consuming but it does give some degree of protection for the large investment in the dam and reservoir, if Four Mile Creek flows are less than estimated.

DAM AND RESERVOIR

Hidden Valley Reservoir is located in Hidden Valley, about 3.5 miles north of Pagosa Springs. The dam site would be located in the southeast quarter section of Section 27, Range 2 West, Township 36 North. The dam site and reservoir basin are shown on Figure V-1. The area-capacity values at various elevations in the reservoir are shown on Table V-5.

The active capacity of the reservoir, necessary to yield 3300 acre-feet per year was established in Table V-4 as 6300 acre-feet for Hidden Valley Reservoir. In addition to the active capacity there must also be a small amount of inactive capacity to allow for sedimentation. If a minimum fishery pool were to be included in the reservoir, that pool would also be considered part of the inactive capacity. An amount of 204 acre-feet is included for inactive capacity for Hidden Valley Reservoir, for sediment only. A larger inactive pool for a fishery may be included if funds can be found.

Flood surcharge capacity is also required to provide flood storage to reduce damage downstream and reduce the size of the spillway. The inflow design flood at the reservoir, resulting from a severe thunderstorm in the 5.6 square mile drainage area would have a peak of about 10,000 cfs but a volume of only about 1500 acre-feet. Rather than construct a large spillway to pass the flood, 8 feet is added to the height of the dam which will provide 1640 acre-feet of capacity to store the entire flood. A small spillway, 150 cfs, will be installed to drain the flood surcharge within a 5 day period.

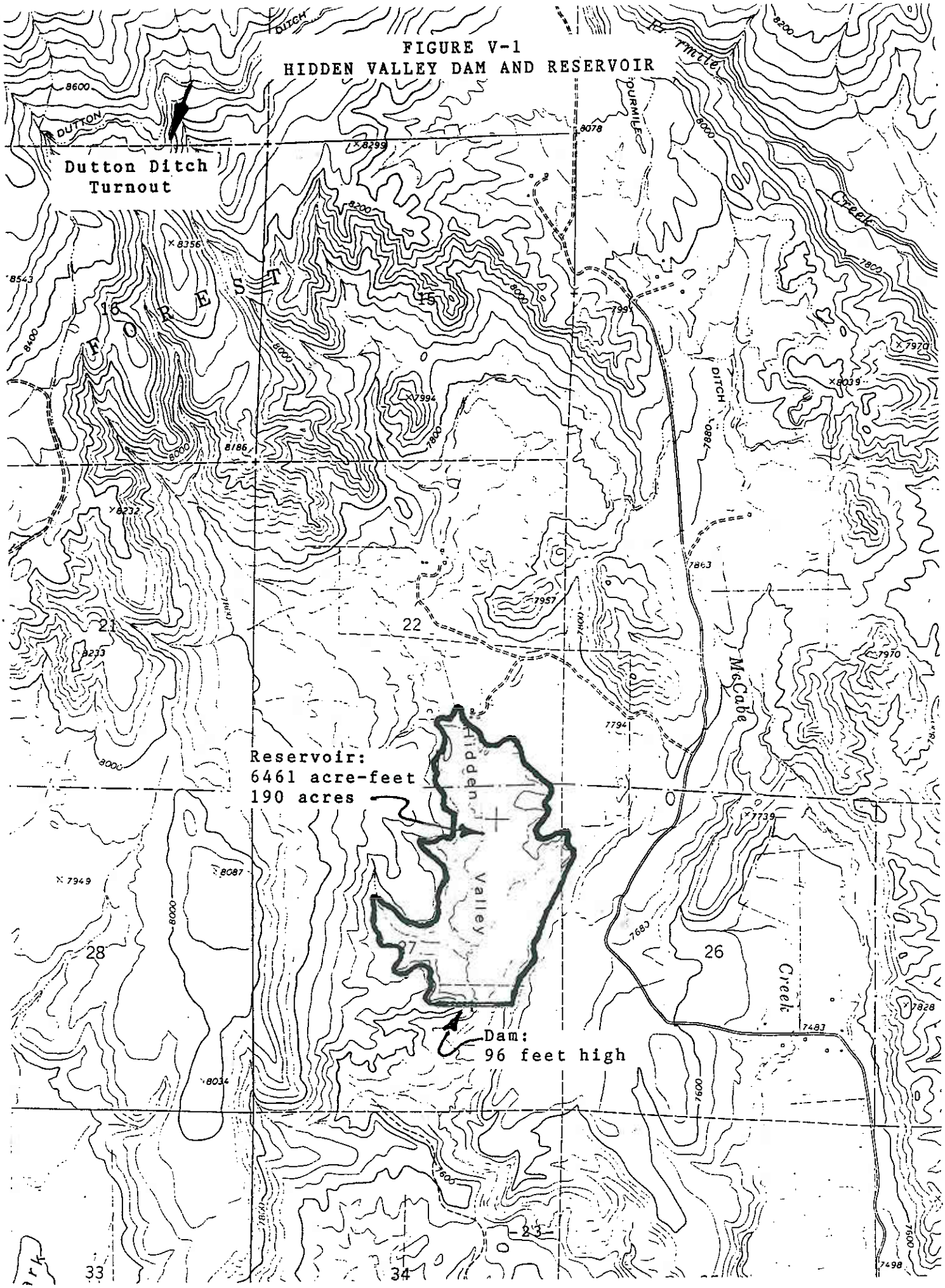


FIGURE V-1
HIDDEN VALLEY DAM AND RESERVOIR
Dutton Ditch
Turnout
DUTTON
DITCH
FOREST
Reservoir:
6461 acre-feet
190 acres
Hidden Valley
Dam:
96 feet high
McCabe Creek
DURMILE
Creek
DITCH
16
15
21
22
27
28
26
23
33
34

TABLE V-5
HIDDEN VALLEY RESERVOIR
AREA-CAPACITY TABLE

| Elev. (feet) | Area (Acres) | Volume (Ac-Ft) | Elev. (feet) | Area (Acres) | Volume (Ac-Ft) | Elev. (feet) | Area (Acres) | Volume (Ac-Ft) |
|---|---|---|---|---|---|---|---|---|
| 7515 | 0 | 0 | 7559 | 61.95 | 1245 | 7603 | 195.25 | 6859 |
| 7516 | 0.4 | 0 | 7560 | 63.5 | 1308 | 7604 | 198.5 | 7056 |
| 7517 | 0.8 | 1 | 7561 | 66.55 | 1373 | 7605 | 201.75 | 7256 |
| 7518 | 1.2 | 2 | 7562 | 69.6 | 1441 | 7606 | 205 | 7459 |
| 7519 | 1.6 | 3 | 7563 | 72.65 | 1512 | 7607 | 208.25 | 7666 |
| 7520 | 2 | 5 | 7564 | 75.7 | 1586 | 7608 | 211.5 | 7876 |
| 7521 | 3.5 | 8 | 7565 | 78.75 | 1663 | 7609 | 214.75 | 8089 |
| 7522 | 5 | 12 | 7566 | 81.8 | 1743 | 7610 | 218 | 8305 |
| 7523 | 6.5 | 18 | 7567 | 84.85 | 1826 | 7611 | 221.25 | 8525 |
| 7524 | 8 | 25 | 7568 | 87.9 | 1912 | 7612 | 224.5 | 8748 |
| 7525 | 9.5 | 34 | 7569 | 90.95 | 2001 | 7613 | 227.75 | 8974 |
| 7526 | 11 | 44 | 7570 | 94 | 2093 | 7614 | 231 | 9203 |
| 7527 | 12.5 | 56 | 7571 | 97.05 | 2189 | 7615 | 234.25 | 9436 |
| 7528 | 14 | 69 | 7572 | 100.1 | 2288 | 7616 | 237.5 | 9672 |
| 7529 | 15.5 | 84 | 7573 | 103.15 | 2390 | 7617 | 240.75 | 9911 |
| 7530 | 17 | 100 | 7574 | 106.2 | 2495 | 7618 | 244 | 10153 |
| 7531 | 18.55 | 118 | 7575 | 109.25 | 2603 | 7619 | 247.25 | 10399 |
| 7532 | 20.1 | 137 | 7576 | 112.3 | 2714 | 7620 | 250.5 | 10648 |
| 7533 | 21.65 | 158 | 7577 | 115.35 | 2828 | 7621 | 253.75 | 10900 |
| 7534 | 23.2 | 180 | 7578 | 118.4 | 2945 | 7622 | 257 | 11155 |
| 7535 | 24.75 | 204 | 7579 | 121.45 | 3065 | 7623 | 260.25 | 11414 |
| 7536 | 26.3 | 230 | 7580 | 124.5 | 3188 | 7624 | 263.5 | 11676 |
| 7537 | 27.85 | 257 | 7581 | 127.55 | 3314 | 7625 | 266.75 | 11941 |
| 7538 | 29.4 | 286 | 7582 | 130.6 | 3443 | 7626 | 270 | 12209 |
| 7539 | 30.95 | 316 | 7583 | 133.65 | 3575 | 7627 | 273.25 | 12481 |
| 7540 | 32.5 | 348 | 7584 | 136.7 | 3710 | 7628 | 276.5 | 12756 |
| 7541 | 34.05 | 381 | 7585 | 139.75 | 3848 | 7629 | 279.75 | 13034 |
| 7542 | 35.6 | 416 | 7586 | 142.8 | 3989 | 7630 | 283 | 13315 |
| 7543 | 37.15 | 452 | 7587 | 145.85 | 4133 | 7631 | 286.25 | 13600 |
| 7544 | 38.7 | 490 | 7588 | 148.9 | 4280 | 7632 | 289.5 | 13888 |
| 7545 | 40.25 | 529 | 7589 | 151.95 | 4430 | 7633 | 292.75 | 14179 |
| 7546 | 41.8 | 570 | 7590 | 155 | 4583 | 7634 | 296 | 14473 |
| 7547 | 43.35 | 613 | 7591 | 158.05 | 4740 | 7635 | 299.25 | 14771 |
| 7548 | 44.9 | 657 | 7592 | 161.1 | 4900 | 7636 | 302.5 | 15072 |
| 7549 | 46.45 | 703 | 7593 | 164.15 | 5063 | 7637 | 305.75 | 15376 |
| 7550 | 48 | 750 | 7594 | 167.2 | 5229 | 7638 | 309 | 15683 |
| 7551 | 49.55 | 799 | 7595 | 170.25 | 5398 | 7639 | 312.25 | 15994 |
| 7552 | 51.1 | 849 | 7596 | 173.3 | 5570 | 7640 | 315.5 | 16308 |
| 7553 | 52.65 | 901 | 7597 | 176.35 | 5745 | | | |
| 7554 | 54.2 | 954 | 7598 | 179.4 | 5923 | | | |
| 7555 | 55.75 | 1009 | 7599 | 182.45 | 6104 | | | |
| 7556 | 57.3 | 1066 | 7600 | 185.5 | 6288 | | | |
| 7557 | 58.85 | 1124 | 7601 | 188.75 | 6475 | | | |
| 7558 | 60.4 | 1184 | 7602 | 192 | 6665 | | | |

Note: The areas were taken from 1 inch = 2000 foot USGS Quad maps by interpolating between 40 foot contours. The areas and capacity could be off by plus or minus 15% because of the inaccuracy of the maps.

Table V-6, below, summarizes the elevations and capacities at various levels in the reservoir.

TABLE V-6
HIDDEN VALLEY RESERVOIR DATA

| Reservoir Level | Elevation (feet) | Capacity (ac-ft) | Incremental Capacity |
|---|---|---|---|
| Streambed | 7515 | 0 | 0 |
| Inactive | 7535 | 204 | 204 |
| Active | 7602 | 6665 | 6461 |
| Flood Storage | 7610 | 8305 | 1640 |
| Dam Crest | 7611 | n/a | n/a |

The height of the dam above streambed would be 96 feet. The embankment is presently planned to be a zoned earthfill with 3.5:1 upstream slope and 3.0:1 downstream slope. The crest would be 20 feet wide. The stripping depth would be 3 feet to remove all loose material and plants. The foundation is estimated to be 10 feet to bedrock. The key trench would have a 30 foot wide base, be 10 feet deep, and 1:1 sideslopes. Based upon the data the embankment and foundation would have 440,000 cubic yards of zone 1 material (impervious) and 71,800 cubic yards of zone 2 (pervious) material. A total of 505,000 cubic yards of material would be placed assuming a 20% compaction factor.

The outlet works would be installed in the dam to provide water to the pipe and pump system to Stevens Treatment Plant and for safety purposes to drain the reservoir. The Colorado State Engineer presently requires that the outlet works drain the top 5 feet of the reservoir in 5 days which will result in a 95 cfs outlet. The municipal demand is 7 cfs so the safety requirement sizes the outlet. A 2.5 foot diameter outlet pipe is included in the dam. At the downstream end of the outlet pipe there would be one branch to the treatment plant and on branch to the stream.

The spillway will be a 5.5 foot diameter pipe placed on the east abutment to drain the surcharge capacity in 5 days. The pipe would discharge to the east channel which is about 25 feet higher in elevation than the main channel; this will reduce the length of the spillway pipe.

A one mile access road will be required from the Four Mile Road to the downstream side of the dam. About 300 acres of land would be purchased for the reservoir.

DUTTON DITCH

In order to fill the Hidden Valley Reservoir, the Dutton Ditch, from the diversion point on Four Mile Creek to the first stream in Hidden Valley (shown on Figure V-1), would be enlarged. The total distance is about 18,100 feet measured from USGS Quad maps. The enlarged ditch is assumed to be an unlined section with a base width of about 6 feet, 2.5 feet depth of water, 2:1 side slopes, and .5 feet of freeboard. The excavated material would be placed on the downhill side of the ditch to form a rough access road.

Most of the route would be on U.S. Forest Service administered lands which would require that environmental clearances to enlarge the ditch be obtained. If a pipeline were constructed, the cost would be approximately 3 to 4 times the cost of enlarging the ditch.

PUMP & PIPELINE TO TREATMENT PLANT

The raw water in the reservoir must be treated before it can be used for municipal purposes. If possible, the enlargement of an existing treatment plant would be the least costly way to treat the water, as opposed to a new plant. Also, an existing plant would be connected to existing distributions systems. The nearest treatment plant is the Stevens Treatment Plant, operated by the PAWSD, on Dutton Creek. The plant is just downstream from Stevens Reservoir, which provides a small amount of storage.

The use of Stevens Treatment Plant is also advantageous because most of the future water demand is in the PAWSD service area and the Stevens Plant is the closest plant to the area.

Hidden Valley Reservoir is located about 2 miles northeast of the plant, as shown on Figure V-2. The Hidden Valley Reservoir is at elevation 7535 (top of inactive) and the ridge between the reservoir and the plant is at elevation 7950 feet. A total pump lift of 450 feet is estimated, including an elevation difference of 415 feet and 35 feet of friction losses. An 18 inch diameter, 5600 foot long pipe would convey water to the top of the ridge. The pipe would carry up to 7.0 cfs which is about the peak month average flow demand; the daily flow peaks are assumed to be met from Stevens Reservoir. Once over the ridge the pipe diameter would be reduced to 12 inch and be 2000 feet along, which would end at Dutton Creek. Dutton Creek would provide the conveyance system into Stevens Reservoir.

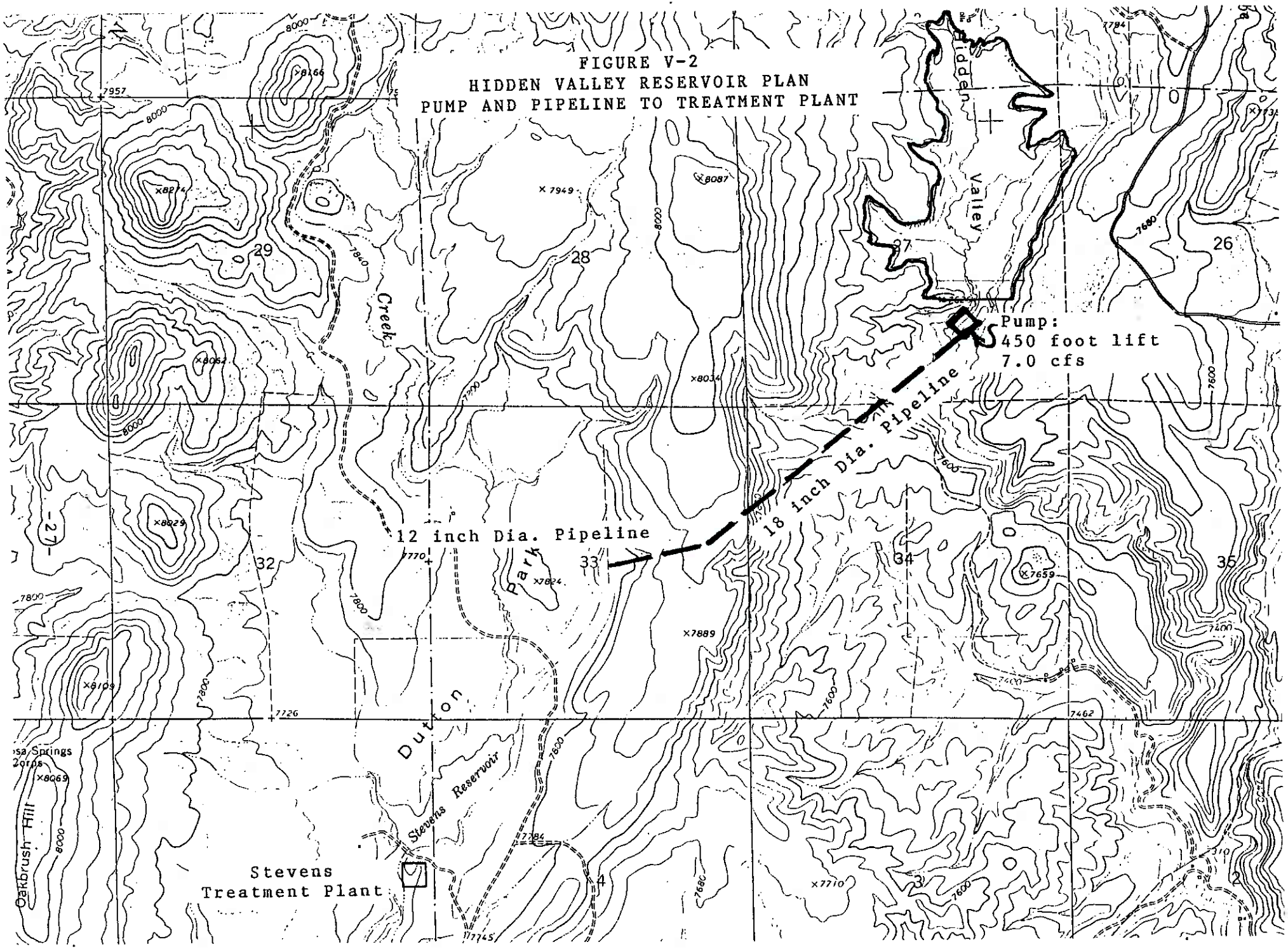


FIGURE V-2
HIDDEN VALLEY RESERVOIR PLAN
PUMP AND PIPELINE TO TREATMENT PLANT
Pump:
450 foot lift
7.0 cfs
18 inch Dia. Pipeline
12 inch Dia. Pipeline
Hidden Valley
Creek
Dutton
Park
Stevens Reservoir
Stevens
Treatment Plant
Oakbrush Hill
29
28
27
26
32
33
34
35
4
3
2

A pumping plant to lift up to 7.0 cfs of water 450 feet would be required near the dam. The plant would have multiple pump units to allow a wide range of pump flows.

## DISTRIBUTION TO EXISTING WATER SYSTEMS

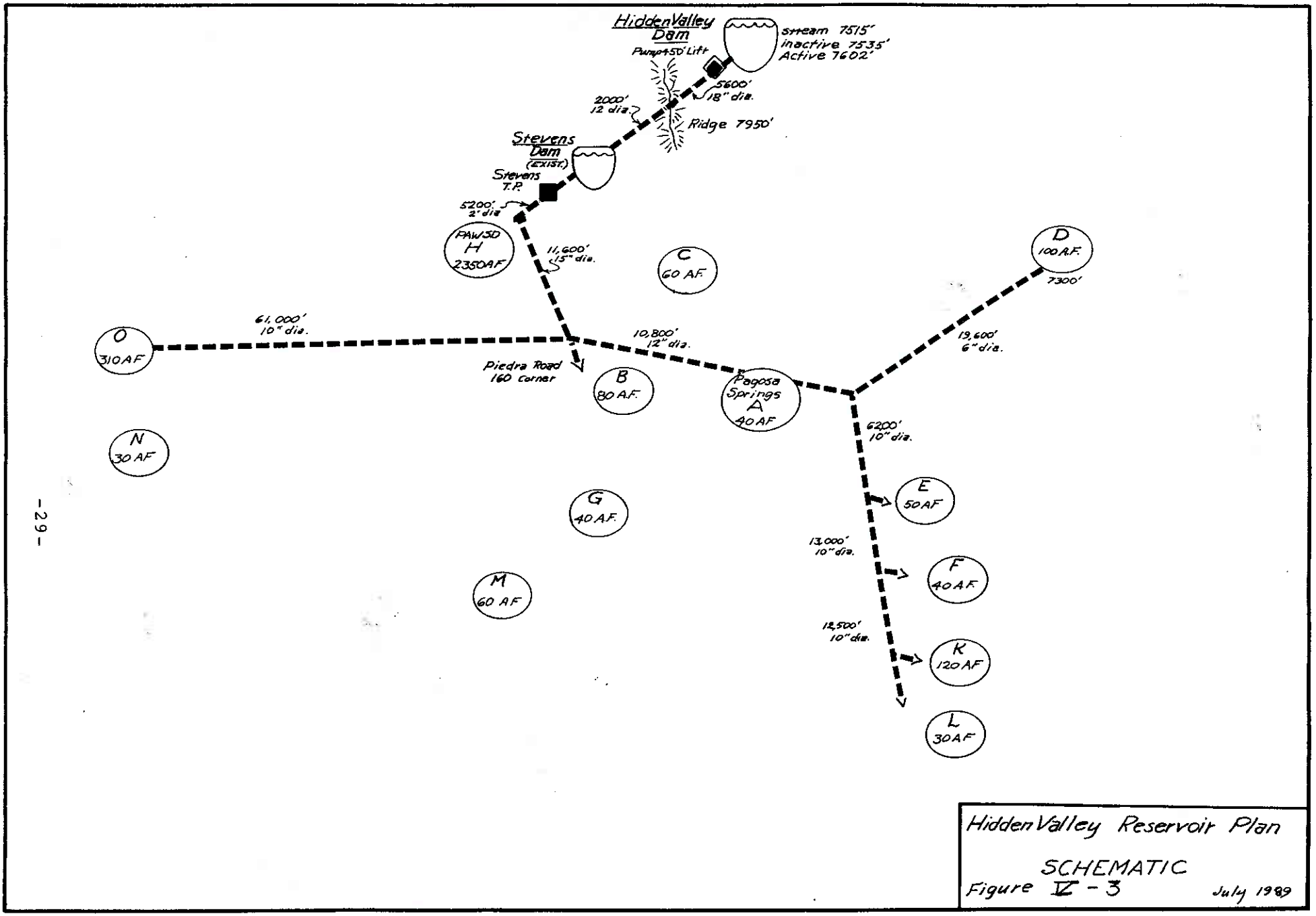
This section describes the facilities that would be needed to distribute water from the Stevens Treatment Plant to existing water users. The following section describes facilities to distribute water to areas currently not served. These distribution facilities will probably not be included in the facilities that the SJWCD will construct with the Hidden Valley Reservoir, but will be constructed by individual water entities as water is needed. The SJWCD presently plans to finance and construct facilities to provide water to a treatment plant, which in this case is the Hidden Valley Reservoir, Dutton Ditch enlargement, and the pump and pipeline to Stevens Treatment Plant.

In the Hidden Valley Reservoir alternative plan it is assumed that the PAWSD would treat water for all of the entities within the SJWCD that require additional water. The PAWSD has the greatest demand but there would also be a demand from the Archuleta Water Company, the Aspen Springs Metro District, and other areas not currently organized. The Town of Pagosa Springs will probably not need any treated water from the plant since their 2025 water demand is essentially the same as today, but the use of their water system to convey water to entities on the north and east of the Town is essential.

The entire water system for the Hidden Valley Reservoir Alternative Plan is shown on Figure V-3, in schematic form. The distances shown are not to scale.

The distribution system to connect the existing water systems to the Stevens Treatment Plant would involve a trunkline that begins at the treatment plant, runs southwest along Dutton Creek to the Piedra Road. At this point the water for the PAWSD would be taken from the line. The trunk line would continue southeast along the Piedra Road to the intersection with Highway 160, at which point a turnout would be provided to the Archuleta Water Company's west system. The trunkline would continue east along Highway 160 until connecting to the Pagosa Springs system.

The trunkline would have an initial size of 24 inches and be 5200 feet long. The existing capacity in the pipelines from the treatment plant were not considered and may result in a reduced size for the trunkline. The second section would be 15 inch diameter and be 11,600 feet long. The third and last section would be 12 inch diameter and be 10,800 feet long.




Hidden Valley Reservoir Plan

SCHEMATIC

Figure V - 3 July 1989

## DISTRIBUTION TO NEW AREAS

The distribution system to new service areas includes areas that presently do not have central water service or the existing lines do not extend far enough.

A 10 inch diameter distribution line is included from the Piedra Road and Highway 160 intersection, west along Highway 160 to the Aspen Springs Metro District. Taps would be included along the way for users. This area presently does not have central service and the homes are on individual wells.

The largest new area is to the east of Pagosa Springs, along Highway 160 east, and Highway 84 south. The Archuleta Water Company presently has small lines along both corridors and it is assumed that the Company would continue to serve these areas in the future. The existing lines are undersized and are at best half long enough, so new larger pipelines that extend to the edge of the SJWCD boundary are included.

A 6 inch diameter line would begin at the edge of Pagosa Springs and extend 19,600 feet northeast along Highway 160. Another pipeline, 10 inches in diameter, beginning at the same place as the 6 inch line, would extend south along Highway 84 to the Loma Linda area. These two lines would probably be constructed by the Archuleta Water Company when needed.

Two small water subareas G and M are not served by pipelines in the comparison because the cost would be the same in all three alternatives and the water demand is so small that they may never be served with a central system.

## COST ESTIMATE

The cost estimate for the construction of the Hidden Valley Reservoir plan facilities is determined in this section. The costs are at an appraisal level. The costs are inaccurate in relation to the actual cost of construction but they do show the general magnitude of difference between the three alternative plans. Also, the costs generally indicate the amount of financing that will be required.

The unit costs were derived from information on various other projects in the area. The dam embankment is the major cost of the plan but the cost to place the embankment is the most variable. The cost to excavate, haul and place embankment fill can range from $3 to $10 per cubic yard, depending upon the quantity of fill, the location, the type of material, etc. An amount of $5 was used in the estimate.

The pipe costs are more reliable than the embankment but still PVC pipe costs are changing every week. The estimate only includes large items that can easily be identified; for this reason a large unlisted items amount of 20% is included. A typical contingency amount of 15% is also included.

A cost of 20% of the construction cost is added for engineering, inspection, environmental studies and permits.

Table V-7 summarizes the cost of all the raw water costs, separated into the Dutton Ditch, Hidden Valley Reservoir, and the pump and pipeline to the treatment plant. Table V-8 shows that costs for distribution system.

TABLE V-7
HIDDEN VALLEY RESERVOIR ALTERNATIVE
APPRAISAL CONSTRUCTION COST ESTIMATE

RAW WATER FACILITY COST ESTIMATE

Hidden Valley Dam and Reservoir

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| Land Purchase | 300 ac | $2,000 | $600,000 |
| Mobilization | lump sum | $100,000 | $100,000 |
| Foundation Excavation | 7400 cy | $2.00 | $14,800 |
| Zone 1 Excavation & Haul | 440800 cy | $3.00 | $1,322,400 |
| Zone 2 Excavation & Haul | 71800 cy | $3.00 | $215,400 |
| Embankment Compaction | 512600 cy | $2.00 | $1,025,200 |
| Rip Rap | 12740 cy | $40.00 | $509,600 |
| Spillway Pipe, 66" dia. | 320 ft | $220.00 | $70,400 |
| Outlet Pipe, 30" dia. | 644 ft | $80.00 | $51,520 |
| Access Road | 5000 ft | $20.00 | $100,000 |
| Unlisted Items | 20% | | $801,864 |
| Contingency | 20% | | $962,200 |
| Total Estimated Construction Cost | | | $5,773,000 |
| Engineering and Permits (20%) | | | $1,155,000 |
| | | | $6,928,000 |

Dutton Ditch Enlargement

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| Dutton Ditch Enlgmnt., 18100ft | 24150 cy | $10.00 | $241,500 |
| Unlisted Items | 20% | | $48,300 |
| Contingency | 15% | | $43,470 |
| Total Estimated Construction Cost | | | $333,000 |
| Engineering and Permits (20%) | | | $67,000 |
| | | | $400,000 |

Pump and Pipeline to Treatment Plant

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| 18 inch, 200 psi, Pipe | 5600 ft | $27 | $151,200 |
| 12 inch, 160 psi, Pipe | 2000 ft | $13.30 | $26,600 |
| Pump Station, 7.0 cfs, 450 ft | 1 ea | $50,000.00 | $50,000 |
| Unlisted Items | 20% | | $45,560 |
| Contingency | 15% | | $41,000 |
| Total Estimated Construction Cost | | | $314,000 |
| Engineering and Permits (20%) | | | $63,000 |
| | | | $377,000 |

TABLE V-8
HIDDEN VALLEY RESERVOIR ALTERNATIVE
APPRAISAL CONSTRUCTION COST ESTIMATE

DISTRIBUTION FACILITY COST ESTIMATE

Distribution to Existing Water Systems

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| 24 inch, 100 psi Pipe | 5200 ft | $32.00 | $166,400 |
| 15 inch, 100 psi Pipe | 11600 ft | $17.00 | $197,200 |
| 12 inch, 160 psi Pipe | 10800 ft | $13.30 | $143,640 |
| Unlisted Items | 20% | | $101,448 |
| Contingency | 15% | | $91,300 |
| Total Estimated Construction Cost | | | $700,000 |
| Engineering and Permits (20%) | | | $140,000 |
| | | | $840,000 |

Distribution to New Water Demand Areas

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| 10 inch, 350 psi Pipe | 61000 ft | $17.30 | $1,055,300 |
| 10 inch, 160 psi Pipe | 31700 ft | $10.00 | $317,000 |
| 6 inch, 160 psi Pipe | 19600 ft | $7.00 | $137,200 |
| Unlisted Items | 20% | | $301,900 |
| Contingency | 15% | | $271,700 |
| Total Estimated Construction Cost | | | $2,083,000 |
| Engineering and Permits (20%) | | | $417,000 |
| | | | $2,500,000 |

# CHAPTER VI
# DRY GULCH RESERVOIR PLAN

The Dry Gulch Reservoir Plan is the second of three alternative plans to develop a water supply for future municipal water demands in the SJWCD. This plan would utilize flows of the San Juan River to fill Dry Gulch Reservoir. Also, this plan is different than Hidden Valley due to the location of the reservoir relative to the areas that need water. The specifics of the plan are described in the following sections.

## WATER SUPPLY

The water supply for Dry Gulch Reservoir is the San Juan River through diversions from the existing Park Ditch. The SWWCD holds a water storage right for Dry Gulch Reservoir in the amount of 6300 acre-feet and holds a direct diversion right from the San Juan River in the amount of 70 cfs for the West Fork Canal. The SWWCD would be requested to transfer part or all of both rights to the SJWCD if this plan were to be developed.

The San Juan River has excess water available for diversion in all but the peak irrigation month in the driest year on record. The San Juan River at Pagosa Springs has dropped to about 10 cfs in dry years but it is believed that the Park Ditch was not taking the full right, which potentially could dry up the river. If the SWWCD water rights were developed, there would be longer water shortage periods. Also, a minimum stream flow would probably be required if an entity proposed to divert all of the river. The result is the need for a reservoir.

The primary constraint on the Dry Gulch water supply is the availability of capacity in the Park Ditch to convey water to the reservoir. The Park Ditch has a capacity of about 40 cfs and is generally operated from early May through early October. Many times the diversions in May and October are less than the full capacity. The distance from the headgate to the reservoir is about 22,000 feet.

This study assumes that water could be conveyed through the Park Ditch to the reservoir in April, May, October, and November of each year. These are off peak for irrigation. The Park Ditch Company would require compensation for use of their ditch in the form of operation and maintenance funds, or storage capacity in the reservoir, or both. Though no discussions have been held with the Park Ditch Company, it is likely that some sort of arrangement could be developed that is beneficial to both parties.

Table VI-1 is the reservoir operation study for Dry Gulch Reservoir. The same study period, 1975 through 1979, used for Hidden Valley is used again. Column 1 is the year and month.

TABLE VI-1
DRY GULCH DAM OPERATION STUDY

| Date (1) | San Juan River Avail For Diversion (Ac-Ft) (2) | Park Ditch Off Irrig. To Dry Gulch Reservoir (Ac-Ft) (3) | Park Ditch Irrigation Tradeoff Water (Ac-Ft) (4) | M & I Supply (Ac-Ft) (8) | Evap & Misc Loss (Ac-Ft) (9) | E O M Content (Ac-Ft) (10) |
|---|---|---|---|---|---|---|
| 1975 JAN | 1337 | 0 | 0 | 241 | 2 | 1300 |
| FEB | 1266 | 0 | 0 | 221 | 2 | 1077 |
| MAR | 2046 | 0 | 0 | 228 | 2 | 847 |
| APR | 7019 | 1382 | 0 | 241 | 21 | 1967 |
| MAY | 52124 | 370 | 0 | 277 | 27 | 2000 |
| JUNE | 80566 | 0 | 0 | 360 | 31 | 1609 |
| JULY | 39668 | 0 | 0 | 373 | 33 | 1203 |
| AUG | 6690 | 0 | 0 | 350 | 26 | 827 |
| SEPT | 4123 | 0 | 0 | 284 | 21 | 522 |
| OCT | 2456 | 900 | 0 | 234 | 15 | 1173 |
| NOV | 1762 | 1050 | 0 | 254 | 2 | 1967 |
| DEC | 1956 | 0 | 0 | 241 | 2 | 1724 |
| TOTALS | 201013 | 3702 | 0 | 3304 | 184 | |
| 1976 JAN | 1847 | 0 | 0 | 241 | 2 | 1481 |
| FEB | 2049 | 0 | 0 | 221 | 2 | 1258 |
| MAR | 4454 | 0 | 0 | 228 | 2 | 1028 |
| APR | 11954 | 1200 | 0 | 241 | 21 | 1966 |
| MAY | 45376 | 370 | 0 | 277 | 27 | 2000 |
| JUNE | 44694 | 0 | 0 | 360 | 31 | 1609 |
| JULY | 10852 | 0 | 0 | 373 | 33 | 1203 |
| AUG | 2845 | 0 | 0 | 350 | 26 | 827 |
| SEPT | 4289 | 0 | 0 | 284 | 21 | 522 |
| OCT | 3559 | 1230 | 0 | 234 | 15 | 1503 |
| NOV | 1891 | 760 | 0 | 254 | 2 | 2000 |
| DEC | 1171 | 0 | 0 | 241 | 2 | 1757 |
| TOTALS | 134981 | 3560 | 0 | 3304 | 184 | |
| 1977 JAN | 1103 | 0 | 0 | 241 | 2 | 1514 |
| FEB | 907 | 0 | 0 | 221 | 2 | 1291 |
| MAR | 1252 | 0 | 0 | 228 | 2 | 1061 |
| APR | 4198 | 1200 | 0 | 241 | 21 | 1999 |
| MAY | 9507 | 0 | 0 | 277 | 27 | 1695 |
| JUNE | 8023 | 0 | 0 | 360 | 31 | 1304 |
| JULY | 3506 | 0 | 0 | 373 | 33 | 898 |
| AUG | 9712 | 0 | 0 | 350 | 26 | 522 |
| SEPT | 7063 | 0 | 0 | 284 | 21 | 217 |
| OCT | 6021 | 1230 | 0 | 234 | 15 | 1198 |
| NOV | 2734 | 1060 | 0 | 254 | 2 | 2000 |
| DEC | 1669 | 0 | 0 | 241 | 2 | 1757 |
| TOTALS | 55695 | 3490 | 0 | 3304 | 184 | |
| 1978 JAN | 1548 | 0 | 0 | 241 | 2 | 1514 |
| FEB | 1534 | 0 | 0 | 221 | 2 | 1291 |
| MAR | 3906 | 0 | 0 | 228 | 2 | 1061 |
| APR | 13809 | 1200 | 0 | 241 | 21 | 1999 |
| MAY | 34109 | 370 | 0 | 277 | 27 | 2000 |
| JUNE | 48086 | 0 | 0 | 360 | 31 | 1609 |
| JULY | 7619 | 0 | 0 | 373 | 33 | 1203 |
| AUG | 708 | 0 | 0 | 350 | 26 | 827 |
| SEPT | 682 | 0 | 0 | 284 | 21 | 522 |
| OCT | 2093 | 900 | 0 | 234 | 15 | 1173 |
| NOV | 2680 | 1190 | 0 | 254 | 2 | 2000 |
| DEC | 1426 | 0 | 0 | 241 | 2 | 1757 |
| TOTALS | 118200 | 3660 | 0 | 3304 | 184 | |
| 1979 JAN | 1792 | 0 | 0 | 241 | 2 | 1514 |
| FEB | 1643 | 0 | 0 | 221 | 2 | 1291 |
| MAR | 2837 | 0 | 0 | 228 | 2 | 1061 |
| APR | 17783 | 1200 | 0 | 241 | 21 | 1999 |
| MAY | 74944 | 370 | 0 | 277 | 27 | 2000 |
| JUNE | 94325 | 0 | 0 | 360 | 31 | 1609 |
| JULY | 35527 | 0 | 0 | 373 | 33 | 1203 |
| AUG | 7527 | 0 | 0 | 350 | 26 | 827 |
| SEPT | 2295 | 0 | 0 | 284 | 21 | 522 |
| OCT | 2073 | 0 | 0 | 234 | 15 | 273 |
| NOV | 1407 | 1190 | 0 | 254 | 2 | 1207 |
| DEC | 1436 | 0 | 0 | 241 | 2 | 964 |
| TOTALS | 243589 | 2760 | 0 | 3304 | 184 | |

Column 2 is the flow available in the San Juan River after senior rights have diverted. These values were taken from work Harris Water Engineering performed for the SWWCD. Column 3 is the water diverted through the Park Ditch to the reservoir. Column 4 is included in the event that the Park Ditch irrigators want storage in the reservoir. Column 8 is the municipal and industrial water demand, which is 3300 acre-feet per year. Column 9 is losses from the reservoir. The last column, 10, is the end-of-month content of the reservoir.

Column 2 shows that there is a very large amount of water available in the San Juan River for diversion on a monthly basis. Not shown is the daily flows which are very low and could be zero if senior rights had taken all of the water they were entitled to. The result is that the reservoir is only needed for carryover within each year and not from year to year. The reservoir would need an active capacity of about 2000 acre-feet to provide 3300 acre-feet per year. The reservoir fills in the spring is drawn down over the summer, fills in the fall then is drawn down again over the winter. The reservoir would also provide storage should the river be contaminated for some reason or the ditch is breeched.

DAM AND RESERVOIR

Dry Gulch Dam is located about 2 miles northeast of Pagosa Springs on Dry Gulch. The dam is located on the section line between sections 5 and 8 in T35N, R1W. Figure VI-1 shows the location of the dam and the reservoir basin. The elevation, area, and capacity values are shown in Table VI-2.

Figure VI-1 shows the relationship of the Park Ditch and the reservoir basin. The ditch enters the basin at elevation 7340 feet on the east abutment and exits at elevation 7290 on the west abutment. The crest of the dam will be below the entrance elevation of 7340 feet, so water can be easily released from the ditch into the reservoir. The crest of the dam will be above the exit elevation of the ditch so a modification will be necessary.

The plan herein is for all of the ditch flow to be released into the reservoir. An inactive pool will be maintained at elevation 7290 feet so that water can be released to the ditch on the west abutment from the reservoir. This will allow at least a mile of the ditch to be abandoned, which goes around Dry Gulch and serves land that will be in the reservoir. The major problem would be the amount of sediment deposited in the reservoir from all of the ditch flows going through the reservoir.

The large inactive pool to maintain a level of 7290 feet would cause the dam to be about 12 feet higher than a very small inactive. If the ditch water were not routed through the

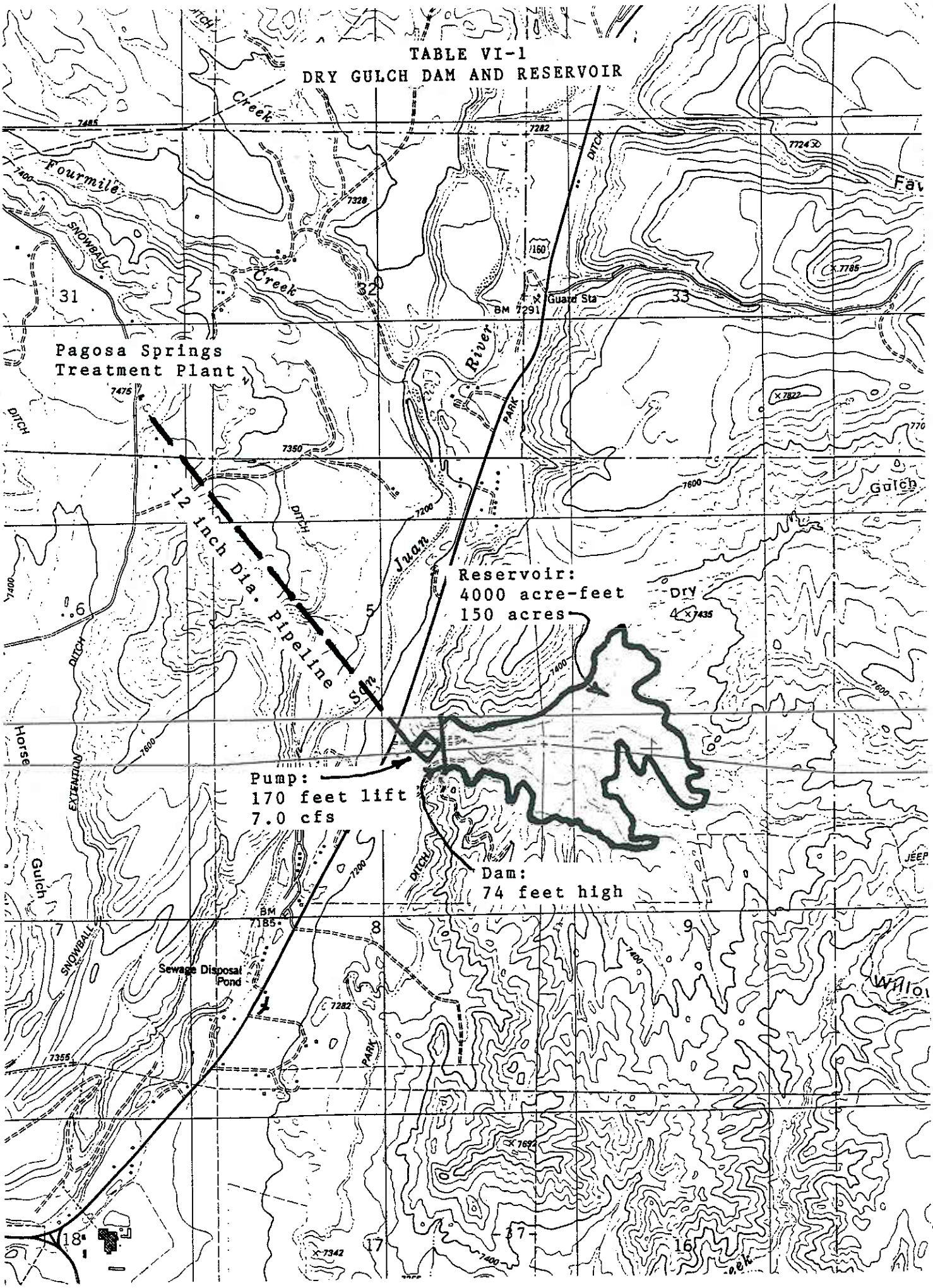


TABLE VI-1
DRY GULCH DAM AND RESERVOIR
Pagosa Springs
Treatment Plant
12 inch Dia. Pipeline
Reservoir:
4000 acre-feet
150 acres
Pump:
170 feet lift
7.0 cfs
Dam:
74 feet high
Sewage Disposal
Pond
Guard Sta
BM 7291
BM 7185
Fourmile
Creek
SNOWBALL
Horse
Gulch
EXTENSION
DITCH
PARK
River
Juan
Dry
Gulch
JEEP
31
32
33
6
5
7
8
9
18
17
16

TABLE VI-2
DRY GULCH RESERVOIR
AREA-CAPACITY TABLE

| Elevation (feet) | Area (Acres) | Capacity (Ac-Ft) | Elevation (feet) | Area (Acres) | Capacity (Ac-Ft) |
|---|---|---|---|---|---|
| 7240 | 0 | 0 | 7291 | 95.75 | 2057 |
| 7241 | 1.5 | 1 | 7292 | 99 | 2154 |
| 7242 | 3 | 3 | 7293 | 102.25 | 2255 |
| 7243 | 4.5 | 7 | 7294 | 105.5 | 2359 |
| 7244 | 6 | 12 | 7295 | 108.75 | 2466 |
| 7245 | 7.5 | 19 | 7296 | 112 | 2576 |
| 7246 | 9 | 27 | 7297 | 115.25 | 2690 |
| 7247 | 10.5 | 37 | 7298 | 118.5 | 2807 |
| 7248 | 12 | 48 | 7299 | 121.75 | 2927 |
| 7249 | 13.5 | 61 | 7300 | 125 | 3050 |
| 7250 | 15 | 75 | 7301 | 128.25 | 3177 |
| 7251 | 16.5 | 91 | 7302 | 131.5 | 3307 |
| 7252 | 18 | 108 | 7303 | 134.75 | 3440 |
| 7253 | 19.5 | 127 | 7304 | 138 | 3576 |
| 7254 | 21 | 147 | 7305 | 141.25 | 3716 |
| 7255 | 22.5 | 169 | 7306 | 144.5 | 3859 |
| 7256 | 24 | 192 | 7307 | 147.75 | 4005 |
| 7257 | 25.5 | 217 | 7308 | 151 | 4154 |
| 7258 | 27 | 243 | 7309 | 154.25 | 4307 |
| 7259 | 28.5 | 271 | 7310 | 157.5 | 4463 |
| 7260 | 30 | 300 | 7311 | 160.75 | 4622 |
| 7261 | 31.5 | 331 | 7312 | 164 | 4784 |
| 7262 | 33 | 363 | 7313 | 167.25 | 4950 |
| 7263 | 34.5 | 397 | 7314 | 170.5 | 5119 |
| 7264 | 36 | 432 | 7315 | 173.75 | 5291 |
| 7265 | 37.5 | 469 | 7316 | 177 | 5466 |
| 7266 | 39 | 507 | 7317 | 180.25 | 5645 |
| 7267 | 40.5 | 547 | 7318 | 183.5 | 5827 |
| 7268 | 42 | 588 | 7319 | 186.75 | 6012 |
| 7269 | 43.5 | 631 | 7320 | 190 | 6200 |
| 7270 | 45 | 675 | 7321 | 194.4 | 6392 |
| 7271 | 46.5 | 721 | 7322 | 198.8 | 6589 |
| 7272 | 48 | 768 | 7323 | 203.2 | 6790 |
| 7273 | 49.5 | 817 | 7324 | 207.6 | 6995 |
| 7274 | 51 | 867 | 7325 | 212 | 7205 |
| 7275 | 52.5 | 919 | 7326 | 216.4 | 7419 |
| 7276 | 54 | 972 | 7327 | 220.8 | 7638 |
| 7277 | 55.5 | 1027 | 7328 | 225.2 | 7861 |
| 7278 | 57 | 1083 | 7329 | 229.6 | 8088 |
| 7279 | 58.5 | 1141 | 7330 | 234 | 8320 |
| 7280 | 60 | 1200 | 7331 | 238.4 | 8556 |
| 7281 | 63.25 | 1262 | 7332 | 242.8 | 8797 |
| 7282 | 66.5 | 1327 | 7333 | 247.2 | 9042 |
| 7283 | 69.75 | 1395 | 7334 | 251.6 | 9291 |
| 7284 | 73 | 1466 | 7335 | 256 | 9545 |
| 7285 | 76.25 | 1541 | 7336 | 260.4 | 9803 |
| 7286 | 79.5 | 1619 | 7337 | 264.8 | 10066 |
| 7287 | 82.75 | 1700 | 7338 | 269.2 | 10333 |
| 7288 | 86 | 1784 | 7339 | 273.6 | 10604 |
| 7289 | 89.25 | 1872 | 7340 | 278 | 10880 |
| 7290 | 92.5 | 1963 | 7341 | 282.4 | 11160 |

Note: Areas taken from USGS 7.5 minute Quad maps.

reservoir, the ditch on the west side of the gulch would have to be raised in order to be above the crest of the dam. The advantages and disadvantages of each plan will need more careful study if this plan is developed. The costs included in the plan should be adequate to cover either option.

The active capacity of the reservoir was determined to be 2000 acre-feet in the previous section. The inactive capacity would also be about 2000 acre-feet for the reasons described above. The inflow design flood will be handled in the same manner as for Hidden Valley. The drainage area at the dam is only 3.2 square miles so the flood inflow has a volume of only 870 acre-feet, which will be stored in the reservoir rather than passed through a large spillway. Table VI-3 summarizes the reservoir data.

TABLE VI-3
DRY GULCH RESERVOIR DATA

| Reservoir Level | Elevation (feet) | Capacity (ac-ft) | Incremental Capacity |
|---|---|---|---|
| Streambed | 7240 | 0 | 0 |
| Inactive | 7290 | 1963 | 1963 |
| Active | 7307 | 4005 | 2042 |
| Flood Storage | 7313 | 4950 | 945 |
| Dam Crest | 7314 | n/a | n/a |

The height of the dam above streambed would be 74 feet. The embankment is presently planned to be a zoned earthfill with 3.5:1 upstream slope and 3.0:1 downstream slope. The crest would be 20 feet wide. The stripping depth would be 3 feet to remove all loose material and plants. The foundation is estimated to be 25 feet to bedrock. The key trench would have a 30 foot wide base, be 25 feet deep, and 1:1 sideslopes. Based upon that data the embankment and foundation would have 328,000 cubic yards of zone 1 material (impervious) and 47,000 cubic yards of zone 2 (pervious) material. A total of 375,000 cubic yards of material would be placed assuming a 20% compaction factor.

The outlet works would be installed in the dam to provide water to the pipe and pump system to the Pagosa Springs Treatment Plant and for safety purposes to drain the reservoir. The Colorado State Engineer presently requires that the outlet works drain the top 5 feet of the reservoir in 5 days which will result in a 90 cfs outlet. The municipal demand is 7 cfs so the safety requirement sizes the outlet. A 3.5 foot diameter outlet pipe is included in the dam. At the downstream end of the outlet pipe there would be one branch to the treatment plant and one branch to the stream.

The spillway will be a 4.5 foot diameter pipe placed on the east abutment to drain the surcharge capacity in 5 days. The pipe would discharge to Dry Gulch.

PUMP AND PIPELINE TO TREATMENT PLANT

The closest treatment plant to Dry Gulch Reservoir is the Pagosa Springs plant located 1.5 miles to the north. In this plan it is assumed that Pagosa Springs would be willing to treat water for all of the entities or that a new treatment plant would be constructed at the same location by another entity. The cost of the treatment plant is not included because the cost would be the same for each of the three alternatives.

The pipeline and pump would be sized to deliver 7.0 cfs. An 18 inch pipeline is used. These facilities are shown on Figure VI-1. The pump lift would be 190 feet. Daily peaks are assumed to be met from storage at the treatment plant.

DISTRIBUTION TO EXISTING WATER SYSTEMS

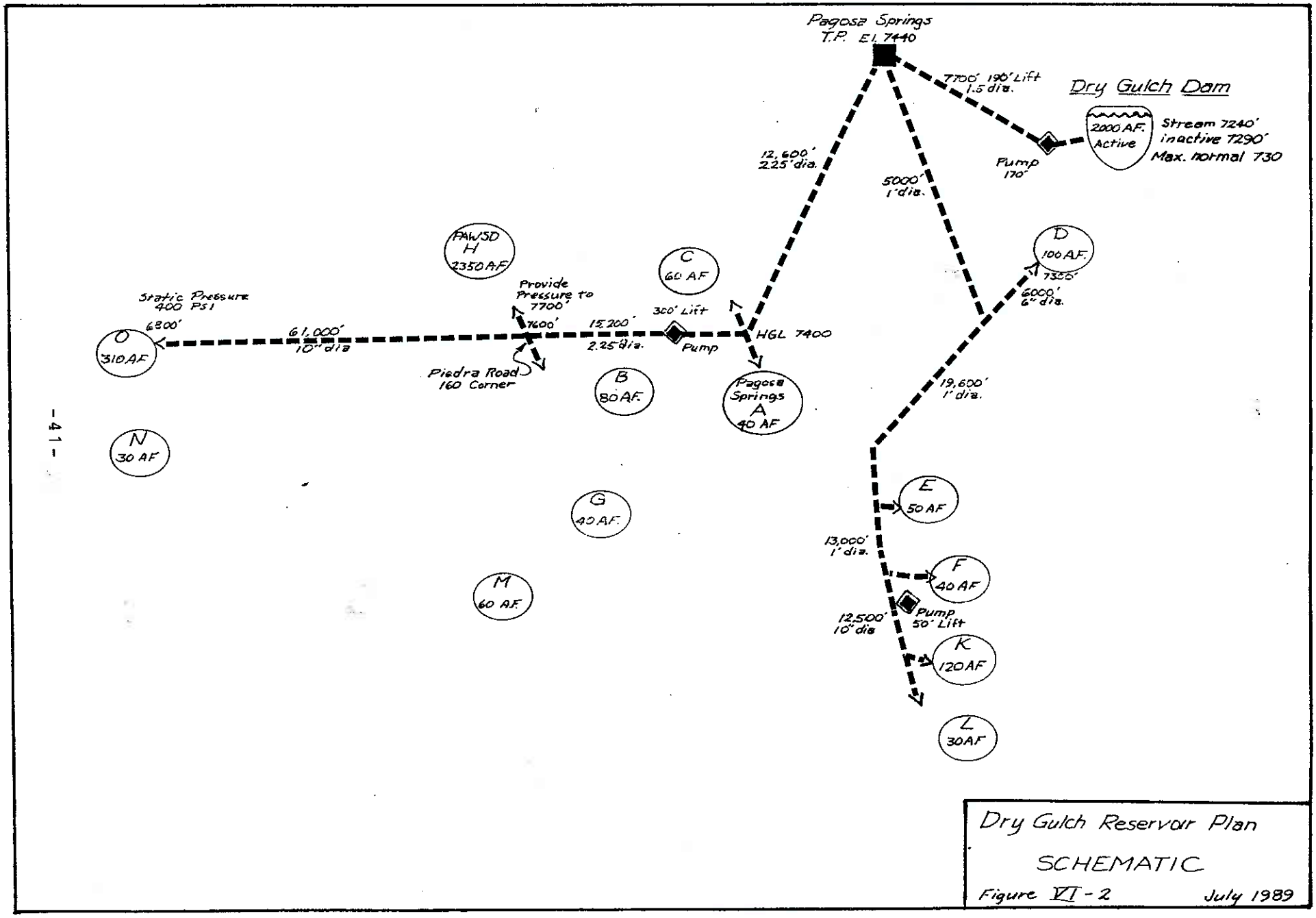
The distribution pipelines to connect the existing water systems to the treatment plant is far more complicated in this plan than for Hidden Valley. Figure VI-2 is a schematic of the pipelines and pumps needed for these facilities and distribution lines to new areas.

The major water demand is in the PAWSD area which is about 5 miles to the west. A 27 inch pipeline is needed from the treatment plant to the north edge of Pagosa Springs, to connect to that system, then west to the intersection of the Piedra Road and Highway 160. The PAWSD demand is delivered at the intersection at a water pressure elevation of 7700 feet. In order to provide the water pressure, a 300 lift booster pump is required. The total length of the pipeline is 27,800 feet.

DISTRIBUTION TO NEW AREAS

Distribution system to new areas is the same as described for Hidden Valley. There is a 61,000 foot long, 10 inch diameter pipe from the Piedra Road and Highway 160 intersection, west to Aspen Springs Metro District.

The Highway 160 and 84 corridors, east of Pagosa Springs are served differently. Rather than conveying water through the Pagosa Springs system, a pipeline runs from the treatment plant to a line along Highway 160. From this point there is short line to the northeast and a long line southwest toward Pagosa Springs which then follows Highway 84 south to Loma Linda. There would be 37,600 feet of 12 inch pipeline, 12,500 feet of 10 inch pipeline, and 6000 feet of 6 inch pipeline. There would also be a 50 foot booster pump at the ridge into the Loma Linda area.




Dry Gulch Reservoir Plan

SCHEMATIC

Figure VI - 2 July 1989

## COST ESTIMATE

The method for estimating the costs for this plan are identical to those used for Hidden Valley. The estimates for the facilities described above are summarized in Tables VI-4, Raw Water Costs, and VI-5, Distribution Costs.

The dam costs include the same items as described for Hidden Valley. A cost to rehabilitate some portions of the Park Ditch is included at a rate of $3 per foot for the 22,000 feet of ditch. The funds would be spent at critical locations rather than over the entire length of the ditch.

TABLE VI-4
DRY GULCH RESERVOIR ALTERNATIVE
APPRAISAL CONSTRUCTION COST ESTIMATE

RAW WATER FACILITY COST ESTIMATE

Dry Gulch Dam and Reservoir

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| Land Purchase | 250 ac | $2,000 | $500,000 |
| Mobilization | lump sum | $100,000 | $100,000 |
| Foundation Excavation | 32600 cy | $2.00 | $65,200 |
| Zone 1 Excavation & Haul | 327900 cy | $3.00 | $983,700 |
| Zone 2 Excavation & Haul | 47500 cy | $3.00 | $142,500 |
| Embankment Compaction | 375400 cy | $2.00 | $750,800 |
| Rip Rap | 6000 cy | $40.00 | $240,000 |
| Spillway Pipe, 54" dia. | 350 ft | $190.00 | $66,500 |
| Outlet Pipe, 42" dia. | 435 ft | $130.00 | $56,550 |
| Pipe to Park Ditch, 42" dia. | 200 ft | $130.00 | $26,000 |
| Unlisted Items | 20% | | $586,250 |
| Contingency | 20% | | $703,500 |
| Total Estimated Construction Cost | | | $4,221,000 |
| Engineering and Permits (20%) | | | $844,200 |
| | | | $5,065,200 |

Park Ditch Rehabilitation

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| Park Ditch Rehabilitation | 22000 ft | $3.00 | $66,000 |
| Unlisted Items | 20% | | $13,200 |
| Contingency | 15% | | $11,880 |
| Total Estimated Construction Cost | | | $91,000 |
| Engineering and Permits (20%) | | | $18,000 |
| | | | $109,000 |

Pump and Pipeline to Treatment Plant

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| 18 inch, 100 psi Pipe | 7700 ft | $21 | $161,700 |
| Pump Station, 7.0 cfs, 170 ft | 1 ea | $50,000.00 | $50,000 |
| Unlisted Items | 20% | | $42,340 |
| Contingency | 15% | | $38,100 |
| Total Estimated Construction Cost | | | $292,000 |
| Engineering and Permits (20%) | | | $58,000 |
| | | | $350,000 |

TABLE V-5
DRY GULCH RESERVOIR ALTERNATIVE
APPRAISAL CONSTRUCTION COST ESTIMATE

DISTRIBUTION FACILITY COST ESTIMATE

Distribution to Existing Water Systems

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| 27 inch, 100 psi Pipe | 12600 ft | $40.00 | $504,000 |
| 27 inch, 160 psi Pipe | 15200 ft | $47.00 | $714,400 |
| Pump Station, 13 cfs, 300 ft | 1 ea | $50,000.00 | $50,000 |
| Unlisted Items | 20% | | $253,680 |
| Contingency | 15% | | $228,300 |
| Total Estimated Construction Cost | | | $1,750,000 |
| Engineering and Permits (20%) | | | $350,000 |
| | | | $2,100,000 |

Distribution to New Water Demand Areas

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| 12 inch, 100 psi Pipe, 30% rck | 5000 ft | $13.10 | $65,500 |
| 12 inch, 100 psi Pipe | 19600 ft | $11.00 | $215,600 |
| 12 inch, 160 psi Pipe | 13000 ft | $13.30 | $172,900 |
| 10 inch, 350 psi Pipe | 61000 ft | $17.30 | $1,055,300 |
| 10 inch, 160 psi Pipe | 12500 ft | $10.00 | $125,000 |
| 6 inch, 100 psi Pipe | 6000 ft | $6.20 | $37,200 |
| Pump Station, .7 cfs, 50 ft | 1 ea | $10,000.00 | $10,000 |
| Unlisted Items | 20% | | $336,300 |
| Contingency | 15% | | $302,700 |
| Total Estimated Construction Cost | | | $2,321,000 |
| Engineering and Permits (20%) | | | $464,000 |
| | | | $2,785,000 |

# CHAPTER VII
# ECHO RESERVOIR PLAN

The Echo Reservoir plan is the third and last of the alternative plans to provide a future municipal water supply to the SJWCD.

## WATER SUPPLY

The Echo Reservoir would store flows from the Rito Blanco that are diverted to the reservoir through the Echo Ditch. The Echo Ditch is an existing facility used to provide irrigation water to land in Echo Canyon. In order to provide the required 3300 acre-feet per year, the entire ditch would have to be purchased for inflow to the reservoir and the period when diversions from Rito Blanco are made, would have to be extended.

Table VII-1 is the reservoir operation study for Echo Reservoir. The format for ths table is similar to the operation studies for Hidden Valley and Dry Gulch. The time period for the study is also from 1975 through 1979. Column 1 of the table is the year and month.

Columns 2 and 3 are diversions from the Rito Blanco through the Echo Ditch. Column 2 is the recorded diversions by the State Engineer. If all of the historic diversions are stored in the reservoir the yield would only be about half of the required 3300 acre-feet. The historic diversions did not typically begin until June; in order to increase the water supply, diversions had to be assumed beginning in April. Column 3 shows the diversions that were assumed to be possible in April, May and June. There are no records on Rito Blanco to substantiate the availability of the diversions. Column 4 is the water that is assumed to be diverted to Echo Reservoir.

Column 5 is the amount of water not needed in the reservoir that could be made available for irrigation. Column 6 is the municipal and industrial demand of 3300 acre-feet per year. Column 7 is the evaporation and other losses. Column 8 is the end-of-month content of the reservoir.

The operation study shows that the reservoir active capacity needs to be 2200 acre-feet in order to provide the demand. The reservoir is almost empty in March of 1978.

The water supply for Echo Reservoir is based upon the major assumption that the Rito Blanco can supply the diversions shown in column 3 of Table VII-1. If this plan is considered further this assumption must be verified through flow measurements on

TABLE VII-1
ECHO RESERVOIR OPERATION STUDY

| Date (1) | Echo Ditch Flow: Recorded 28 cfs (Ac-Ft) (2) | Echo Ditch Flow: Divert Earlier (Ac-Ft) (3) | Diverted To Echo Reservoir (Ac-Ft) (4) | Irrig. Tradeoff Water (Ac-Ft) (5) | M & I Supply (Ac-Ft) (6) | Evap & Misc Loss (Ac-Ft) (7) | E O M Content (Ac-Ft) (8) |
|---|---|---|---|---|---|---|---|
| 1975 JAN | 0 | 0 | 0 | 0 | 241 | 2 | 1100 |
| FEB | 0 | 0 | 0 | 0 | 221 | 2 | 877 |
| MAR | 0 | 0 | 0 | 0 | 228 | 2 | 647 |
| APR | 0 | 830 | 830 | 0 | 241 | 21 | 1215 |
| MAY | 0 | 1700 | 1700 | 0 | 277 | 27 | 2200 |
| JUNE | 772 | 610 | 1382 | 1000 | 360 | 31 | 2191 |
| JULY | 1184 | 0 | 1184 | 770 | 373 | 33 | 2199 |
| AUG | 297 | 0 | 297 | 0 | 350 | 26 | 2120 |
| SEPT | 228 | 0 | 228 | 0 | 284 | 21 | 2043 |
| OCT | 150 | 0 | 150 | 0 | 234 | 15 | 1944 |
| NOV | 0 | 0 | 0 | 0 | 254 | 2 | 1688 |
| DEC | 0 | 0 | 0 | 0 | 241 | 2 | 1445 |
| TOTALS | 2631 | 3140 | 5771 | 1770 | 3304 | 184 | |
| 1976 JAN | 0 | 0 | 0 | 0 | 241 | 2 | 1202 |
| FEB | 0 | 0 | 0 | 0 | 221 | 2 | 979 |
| MAR | 0 | 0 | 0 | 0 | 228 | 2 | 749 |
| APR | 0 | 830 | 830 | 0 | 241 | 21 | 1317 |
| MAY | 51 | 1700 | 1751 | 560 | 277 | 27 | 2200 |
| JUNE | 195 | 610 | 805 | 410 | 360 | 31 | 2200 |
| JULY | 202 | 0 | 202 | 0 | 373 | 33 | 1996 |
| AUG | 220 | 0 | 220 | 0 | 350 | 26 | 1840 |
| SEPT | 180 | 0 | 180 | 0 | 284 | 21 | 1715 |
| OCT | 360 | 0 | 360 | 0 | 234 | 15 | 1826 |
| NOV | 0 | 0 | 0 | 0 | 254 | 2 | 1570 |
| DEC | 0 | 0 | 0 | 0 | 241 | 2 | 1327 |
| TOTALS | 1208 | 3140 | 4348 | 970 | 3304 | 184 | |
| 1977 JAN | 0 | 0 | 0 | 0 | 241 | 2 | 1084 |
| FEB | 0 | 0 | 0 | 0 | 221 | 2 | 861 |
| MAR | 0 | 0 | 0 | 0 | 228 | 2 | 631 |
| APR | 44 | 0 | 44 | 0 | 241 | 21 | 413 |
| MAY | 511 | 0 | 511 | 0 | 277 | 27 | 620 |
| JUNE | 609 | 0 | 609 | 0 | 360 | 31 | 838 |
| JULY | 415 | 0 | 415 | 0 | 373 | 33 | 847 |
| AUG | 608 | 0 | 608 | 0 | 350 | 26 | 1079 |
| SEPT | 376 | 0 | 376 | 0 | 284 | 21 | 1150 |
| OCT | 331 | 0 | 331 | 0 | 234 | 15 | 1232 |
| NOV | 41 | 0 | 41 | 0 | 254 | 2 | 1017 |
| DEC | 0 | 0 | 0 | 0 | 241 | 2 | 774 |
| TOTALS | 2935 | 0 | 2935 | 0 | 3304 | 184 | |
| 1978 JAN | 0 | 0 | 0 | 0 | 241 | 2 | 531 |
| FEB | 0 | 0 | 0 | 0 | 221 | 2 | 308 |
| MAR | 0 | 0 | 0 | 0 | 228 | 2 | 78 |
| APR | 0 | 830 | 830 | 0 | 241 | 21 | 646 |
| MAY | 0 | 1700 | 1700 | 0 | 277 | 27 | 2042 |
| JUNE | 984 | 560 | 1544 | 1000 | 360 | 31 | 2195 |
| JULY | 624 | 0 | 624 | 200 | 373 | 33 | 2200 |
| AUG | 96 | 0 | 96 | 0 | 350 | 26 | 1920 |
| SEPT | 67 | 0 | 67 | 0 | 284 | 21 | 1682 |
| OCT | 52 | 0 | 52 | 0 | 234 | 15 | 1485 |
| NOV | 0 | 0 | 0 | 0 | 254 | 2 | 1229 |
| DEC | 0 | 0 | 0 | 0 | 241 | 2 | 986 |
| TOTALS | 1823 | 3090 | 4913 | 1200 | 3304 | 184 | |
| 1979 JAN | 0 | 0 | 0 | 0 | 241 | 2 | 743 |
| FEB | 0 | 0 | 0 | 0 | 221 | 2 | 520 |
| MAR | 0 | 0 | 0 | 0 | 228 | 2 | 290 |
| APR | 0 | 830 | 830 | 0 | 241 | 21 | 858 |
| MAY | 0 | 1700 | 1700 | 0 | 277 | 27 | 2200 |
| JUNE | 236 | 940 | 1176 | 800 | 360 | 31 | 2185 |
| JULY | 1342 | 0 | 1342 | 900 | 373 | 33 | 2200 |
| AUG | 475 | 0 | 475 | 70 | 350 | 26 | 2200 |
| SEPT | 94 | 0 | 94 | 0 | 284 | 21 | 1989 |
| OCT | 23 | 0 | 23 | 0 | 234 | 15 | 1763 |
| NOV | 0 | 0 | 0 | 0 | 254 | 2 | 1507 |
| DEC | 0 | 0 | 0 | 0 | 241 | 2 | 1264 |
| TOTALS | 2170 | 3470 | 5640 | 1770 | 3304 | 184 | |

TABLE VII-2
ECHO RESERVOIR
AREA-CAPACITY TABLE

| Elevation (feet) | Area (Acres) | Capacity (Ac-Ft) | Elevation (feet) | Area (Acres) | Capacity (Ac-Ft) |
|---|---|---|---|---|---|
| 7694 | 0 | 0 | 7740 | 33.37 | 706 |
| 7695 | 0.52 | 0 | 7741 | 34.12 | 740 |
| 7696 | 1.04 | 1 | 7742 | 34.87 | 774 |
| 7697 | 1.56 | 2 | 7743 | 35.62 | 809 |
| 7698 | 2.08 | 4 | 7744 | 36.37 | 845 |
| 7699 | 2.6 | 6 | 7745 | 37.12 | 882 |
| 7700 | 3.12 | 9 | 7746 | 37.87 | 919 |
| 7701 | 3.64 | 12 | 7747 | 38.72 | 957 |
| 7702 | 4.16 | 16 | 7748 | 39.57 | 996 |
| 7703 | 4.68 | 20 | 7749 | 40.42 | 1036 |
| 7704 | 5.2 | 25 | 7750 | 41.27 | 1077 |
| 7705 | 5.72 | 30 | 7751 | 42.16 | 1119 |
| 7706 | 6.24 | 36 | 7752 | 43.05 | 1162 |
| 7707 | 6.76 | 43 | 7753 | 43.94 | 1205 |
| 7708 | 7.28 | 50 | 7754 | 44.83 | 1249 |
| 7709 | 7.8 | 58 | 7755 | 45.72 | 1294 |
| 7710 | 8.32 | 66 | 7756 | 46.61 | 1340 |
| 7711 | 9.05 | 75 | 7757 | 47.5 | 1387 |
| 7712 | 9.78 | 84 | 7758 | 48.39 | 1435 |
| 7713 | 10.51 | 94 | 7759 | 49.28 | 1484 |
| 7714 | 11.24 | 105 | 7760 | 50.17 | 1534 |
| 7715 | 11.97 | 117 | 7761 | 51.06 | 1585 |
| 7716 | 12.7 | 129 | 7762 | 51.95 | 1637 |
| 7717 | 13.43 | 142 | 7763 | 52.84 | 1689 |
| 7718 | 14.16 | 156 | 7764 | 53.73 | 1742 |
| 7719 | 14.89 | 171 | 7765 | 54.62 | 1796 |
| 7720 | 15.62 | 186 | 7766 | 55.51 | 1851 |
| 7721 | 16.52 | 202 | 7767 | 56.4 | 1907 |
| 7722 | 17.42 | 219 | 7768 | 57.29 | 1964 |
| 7723 | 18.32 | 237 | 7769 | 58.18 | 2022 |
| 7724 | 19.22 | 256 | 7770 | 59.07 | 2081 |
| 7725 | 20.12 | 276 | 7771 | 59.96 | 2141 |
| 7726 | 21.02 | 297 | 7772 | 60.85 | 2201 |
| 7727 | 21.92 | 318 | 7773 | 61.74 | 2262 |
| 7728 | 22.82 | 340 | 7774 | 62.63 | 2324 |
| 7729 | 23.72 | 363 | 7775 | 63.52 | 2387 |
| 7730 | 24.62 | 387 | 7776 | 64.41 | 2451 |
| 7731 | 25.42 | 412 | 7777 | 65.3 | 2516 |
| 7732 | 26.22 | 438 | 7778 | 66.19 | 2582 |
| 7733 | 27.02 | 465 | 7779 | 67.08 | 2649 |
| 7734 | 27.82 | 492 | 7780 | 67.97 | 2717 |
| 7735 | 28.62 | 520 | 7781 | 68.86 | 2785 |
| 7736 | 29.42 | 549 | 7782 | 69.75 | 2854 |
| 7737 | 30.22 | 579 | 7783 | 70.64 | 2924 |
| 7738 | 31.02 | 610 | 7784 | 71.53 | 2995 |
| 7739 | 31.82 | 641 | 7785 | 72.42 | 3067 |
| 7740 | 32.62 | 673 | 7786 | 73.31 | 3140 |

Note: The areas were taken from data developed by SCS.

the Rito Blanco, near the Echo Ditch headgate. The possiblity of purchasing the Echo Ditch and the water rights must also be investigated, because there would not be any water remaining for irrigation.

DAM AND RESERVOIR

The Echo dam and Reservoir is located in section 25 and 26 of T35N, R1W, about 6 miles east of Pagosa Springs. The dam and reservoir are shown on Figure VII-1. The area and capacity of the reservoir at various elevations is shown in Table VII-2.

The active capacity of the reservoir, necessary to yield 3300 acre-feet per year was established in Table VII-2 as 2200 acre-feet. In addition to the active capacity there must also be a small amount of inactive capacity to allow for sedimentation. An amount of 202 acre-feet is included for inactive capacity.

Flood surcharge capacity is also required to provide flood storage to reduce damage downstream and reduce the size of the spillway. The inflow design flood at the reservoir, resulting from a severe thunderstorm in the 1.7 square mile drainage area would have a peak of about 7,000 cfs but a volume of only about 600 acre-feet. Rather than construct a spillway to pass the flood, which would require an extremely large spillway, 8 feet is added to the height of the dam which will provide 544 acre-feet of capacity to store the entire flood. A small spillway, 60 cfs, will be installed to drain the flood surcharge within a 5 day period.

Table VII-3, below, summarizes the elevations and capacities at various levels in the reservoir.

TABLE VII-3
ECHO RESERVOIR DATA

| Reservoir Level | Elevation (feet) | Capacity (ac-ft) | Incremental Capacity |
|---|---|---|---|
| Streambed | 7694 | 0 | 0 |
| Inactive | 7721 | 202 | 202 |
| Active | 7776 | 2451 | 2249 |
| Flood Storage | 7784 | 2995 | 544 |
| Dam Crest | 7785 | n/a | n/a |

The height of the dam above streambed would be 91 feet. The embankment is presently planned to be a homogeneous earthfill with 4.5:1 upstream slope and 3.5:1 downstream slope which was

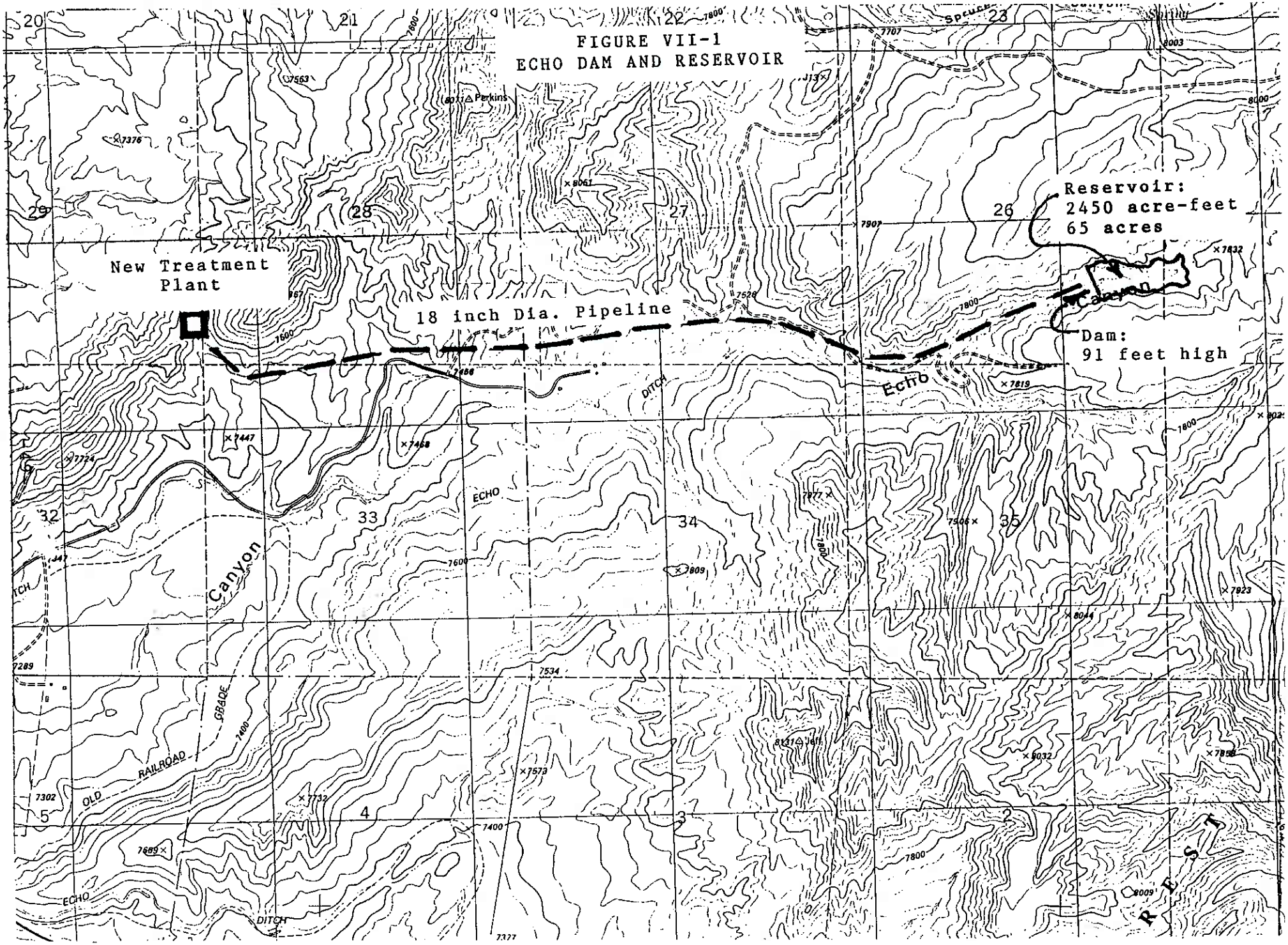


FIGURE VII-1
ECHO DAM AND RESERVOIR
New Treatment Plant
18 inch Dia. Pipeline
Reservoir:
2450 acre-feet
65 acres
Dam:
91 feet high
Echo Canyon
Canyon
ECHO
DITCH
RAILROAD GRADE
OLD
Perkins
Spruce
REST

the preliminary design proposed by SCS in the late 1970's based upon the geotechnical investigations that they performed at the site. The SCS dam design was for a 60 foot high dam, which is more suitable to the site than 91 feet. Echo Dam is the only dam of the three alternatives that has had geotechnical investigations.

The crest would be 20 feet wide. The stripping depth would be 3 feet to remove all loose material and plants. The foundation is estimated to be 10 feet to bedrock. The key trench would have a 30 foot wide base, be 10 feet deep, and 1:1 sideslopes. Based upon that data the embankment and foundation would have 735,000 cubic yards of material, assuming a 20% compaction factor.

The outlet works would be installed in the dam to provide water to the pipe system to convey water to a treatment plant and for safety purposes to drain the reservoir. The Colorado State Engineer presently requires that the outlet works drain the top 5 feet of the reservoir in 5 days which will result in a 35 cfs outlet. The municipal demand is 7 cfs so the safety requirement sizes the outlet. A 2 foot diameter outlet pipe is included in the dam. At the downstream end of the outlet pipe there would be one branch to the treatment plant and one branch to the stream.

The spillway will be a 3.5 foot diameter pipe placed on the south abutment to drain the surcharge capacity in 5 days.

A two mile access road will be required from the Four Mile Road to the downstream side of the dam. The land is owned by the U.S. Forest Service so there would not be a purchase cost but the cost to perform the enviromental and other studies to use the land would be about the same cost.

ECHO DITCH

The Echo Ditch would be purchased and the water rights converted to municipal usage. The conversion of the rights may be a problem because of users in Echo Canyon that utilize the present irrigation return flows. The municipal water would be conveyed out of the drainage so that there would no longer be any return flow. There may be substantial injury to water users in Echo Canyon, which could necessitate releases to these users.

Assuming that the water rights can be converted. The ditch would require some improvement and a short relocation to convey water to the reservoir. The ditch is about 24,000 feet long from the headgate to the turnout to the reservoir. Improvements would be made at critical sections along the way.

## PIPELINE TO TREATMENT PLANT

Echo Reservoir is too far from an existing treatment plant so a new treatment plant is included in the plan, at a location about 3 miles west of the reservoir, on a ridge between Echo Canyon and Mill Creek. The plant was not located at the dam because of access in the winter and availability of utilities. The proposed plant location would have better access and a shorter distance to utilities. The plant location would be at about 7600 feet which is about 100 feet lower than the reservoir, so pumping would not be required. Figure VII-1 shows the location of the dam and treatment plant, with the proposed pipeline route between the locations. The pipeline would be 18 inch diameter to convey 7.0 cfs and be 15,000 feet long.

The entity who would operate the new treatment plant is unknown. The cost to construct the new treatment plant would be greater than the enlargement of a treatment plant used in the other alternatives; however, it is assumed the costs are the same.

## DISTRIBUTION TO EXISTING WATER SYSTEMS

The pipelines and pumps to deliver water to Pagosa Springs and PAWSD system is very long. Figure VII-2 is a schematic of the overall plan, including the distribution pipelines to existing and new users.

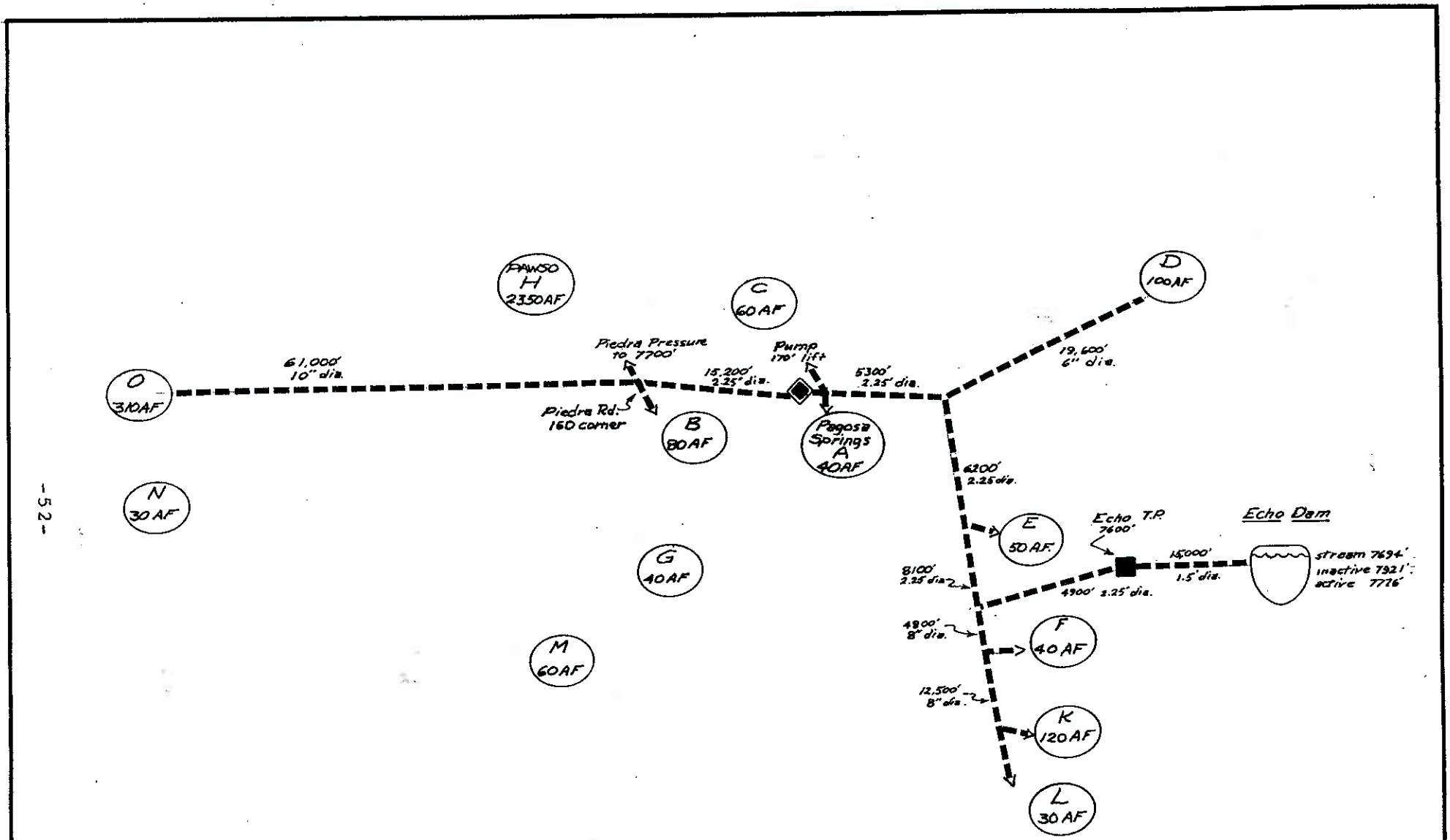
A trunkline would begin at the proposed treatment plant and run west to Highway 84. The line would then follow Highway 84 north, then skirt around the north side of Pagosa Springs. The line would then run to the intersection of Piedra Road and Highway 160 where the PAWSD system would connect. A pump lift of 170 feet would be required to deliver water at the necessary pressure. The entire line would be 27 inch diameter.

This trunkline would probably not be contructed by the SJWCD but the cost to build the line will have an impact on which of the three alternatives has the least overall development cost.

## DISTRIBUTION TO NEW AREAS

There would be three lines to serve new areas. The longest is the line from the Highway 160 and Piedra Road intersection, west to Aspen Springs. This same 10 inch diameter, 61,000 foot long line has been included in each of the alternatives.

There would also be a line from the east edge of Pagosa Springs that would run north along Highway 160 toward Wolf Creek. Water for this line would come from the trunkline rather than through the Pagosa Springs system. The line would be 6 inch diameter and be 19,600 feet long.




Echo Reservoir Plan

SCHEMATIC

Figure VII - 2 July 1989

The third line would extend south along Highway 84 from the trunkline. This line would be 8 inch diameter and 17,300 feet long.

These lines would be constructed by entities who need the water rather than the SJWCD. Facilities are included in each of the three alternatives to serve the same amount of water to the subareas described in Chapter II.

## COST ESTIMATE

The cost estimate for the facilities described in this chapter was derived in the same manner as the other two plans. Table VII-4 is the estimate of the costs to deliver raw water to the treatment plant which would be part of the costs of constructing the reservoir. Table VII-5 is a summary of the costs to distribute the water to the users. The contingency amount for the dam is 15% in this plan, rather than 20% in the other two plans, because geotechnical data was available.

TABLE VII-4
ECHO RESERVOIR ALTERNATIVE
APPRAISAL CONSTRUCTION COST ESTIMATE

RAW WATER FACILITY COST ESTIMATE

Echo Dam and Reservoir

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| Land Purchase | 150 ac | $0 | $0 |
| Mobilization | lump sum | $100,000 | $100,000 |
| Foundation Excavation | 13850 cy | $2.00 | $27,700 |
| Embankment Excavation & Haul | 735450 cy | $3.00 | $2,206,350 |
| Embankment Compaction | 735450 cy | $2.00 | $1,470,900 |
| Rip Rap | 15150 cy | $40.00 | $606,000 |
| Spillway Pipe, 42" dia. | 700 ft | $130.00 | $91,000 |
| Outlet Pipe, 24" dia. | 760 ft | $56.00 | $42,560 |
| Access Road | 9000 ft | $35.00 | $315,000 |
| Unlisted Items | 20% | | $971,902 |
| Contingency | 15% | | $875,000 |
| Total Estimated Construction Cost | | | $6,706,000 |
| Engineering and Permits (22%) | | | $1,341,000 |
| | | | $8,047,000 |

Echo Ditch Rehabilitation

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| Echo Ditch Rehabilitation | 24150 ft | $3.00 | $72,450 |
| Unlisted Items | 20% | | $14,490 |
| Contingency | 15% | | $13,041 |
| Total Estimated Construction Cost | | | $100,000 |
| Engineering and Permits (20%) | | | $20,000 |
| | | | $120,000 |

Pump and Pipeline to Treatment Plant

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| 18 inch, 100 psi Pipe | 15000 ft | $21 | $315,000 |
| Unlisted Items | 20% | | $63,000 |
| Contingency | 15% | | $57,000 |
| Total Estimated Construction Cost | | | $435,000 |
| Engineering and Permits (20%) | | | $87,000 |
| | | | $522,000 |

TABLE VII-5
ECHO RESERVOIR ALTERNATIVE
APPRAISAL CONSTRUCTION COST ESTIMATE

DISTRIBUTION FACILITY COST ESTIMATE

Distribution to Existing Water Systems

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| 27 inch, 100 psi Pipe | 24500 ft | $40.00 | $980,000 |
| 27 inch, 160 psi Pipe | 15200 ft | $47.00 | $714,400 |
| Pump Station, 13 cfs, 170 ft | 1 ea | $50,000.00 | $50,000 |
| Unlisted Items | 20% | | $348,880 |
| Contingency | 15% | | $314,000 |
| | | | |
| Total Estimated Construction Cost | | | $2,407,000 |
| Engineering and Permits (20%) | | | $481,000 |
| | | | $2,888,000 |

Distribution to New Water Demand Areas

| Item | Units | Cost/Unit | Total Cost |
|---|---|---|---|
| 10 inch, 350 psi Pipe | 61000 ft | $17.30 | $1,055,300 |
| 8 inch, 160 psi Pipe | 17300 ft | $8.00 | $138,400 |
| 6 inch, 160 psi Pipe | 19600 ft | $7.00 | $137,200 |
| Unlisted Items | 20% | | $266,180 |
| Contingency | 15% | | $239,600 |
| | | | |
| Total Estimated Construction Cost | | | $1,837,000 |
| Engineering and Permits (20%) | | | $367,000 |
| | | | $2,204,000 |

# CHAPTER VIII
# COMPARISON OF RESERVOIR PLANS

The tradeoffs between various aspects of each of the three reservoir plans are described in this chapter.

## WATER SUPPLY

Each of the three plans utilizes inflow from another basin through an existing ditch to fill the respective reservoirs. Hidden Valley is the only plan that has enough basin runoff to yield some water, 900 acre-feet, to meet demands; the other two reservoirs are totally dependent upon imported water. In each case water is imported through an existing ditch that is enlarged or rehabilitated.

The reliability of the water sources for each plan varies considerably. Dry Gulch Reservoir has the most reliable source, by far, with the San Juan River. There is no doubt that the San Juan River has adequate flow to serve the 3300 acre-feet demand and much more. The Hidden Valley Reservoir has the next best source, not because there is more water than the Rito Blanco but because there are existing water rights to be used on Four Mile Creek. The Hidden Valley Reservoir supply from basin runoff is believed to be conservative which may result in an increased supply as additional data is collected during the next few years.

The physical and legal availability of water on the Rito Blanco is very questionable, making this the most unknown source of water. The potential to purchase the Echo Ditch and conversion to municipal use would have a major impact on the plan.

## DAM AND RESERVOIR

The Echo Dam site requires considerably more embankment volume to construct the dam, as compared to the other two sites. This is because of the need for a homogeneous fill which has flatter slopes and the valley is wider. Hidden Valley has the narrowest valley but is the highest dam resulting in 30% greater embankment volume than Dry Gulch. Dry Gulch is the lowest dam but has a wide valley. Table VIII-1 summarizes pertinent data for the three dams and reservoirs.

TABLE VIII-1
COMPARISON OF DAM AND RESERVOIRS

| Item | Hidden Valley | Dry Gulch | Echo |
|---|---|---|---|
| Population Served | 14,730 | 14,730 | 14,730 |
| Acre-foot Supply | 3,300 | 3,300 | 3,300 |
| Total Res. Capacity | 8,305 | 4,950 | 2,995 |
| Active Res. Capacity | 6,461 | 2,042 | 2,249 |
| Dam Height, feet | 96 | 74 | 91 |
| Geotech. Investig. | no | no | yes |
| Type of Dam | zoned | zoned | homogen. |
| Embankment, cy | 505,000 | 375,000 | 735,000 |
| Dam Cost | $6,928,000 | $5,065,000 | $8,047,000 |
| Cost/ac-ft of Yield | $2,100 | $1,535 | $2,440 |

The above table shows that the Dry Gulch Dam has the least embankment volume and cost. Hidden Valley is the middle dam of the three in terms of cost. The Echo Dam is significantly more costly. Surveys of the dam center lines have been performed on all three dams which results in reliable embankment volumes. Geotechnical investigations have not been performed on Hidden Valley and Dry Gulch which could affect the design of the embankment, flattening or steepening the side slopes. Echo Dam has a smaller contingency allowance to reflelct the better geotechnical data.

INFLOW DITCHES

Each of the three reservoir plans requires an existing ditch to convey water to the reservoir. The Hidden Valley plan would require the enlargement of 18,100 feet of Dutton Ditch by 25 cfs; which is a major reconstruction of the ditch. The Dry Gulch and Echo plans require the rehabilitation of 22,000 feet and 24,000 feet, respectively, of existing ditches; both are minor reconstructions. The Echo plan requires that the entire ditch and all of the shares be purchased. The Dry Gulch plan requires that an arrangement be made with the existing ditch users to convey water to the reservoir during the off peak times.

The Dry Gulch and Hidden Valley plans would leave the existing ditch users intact, while the Echo plan would reduce the irrigated acreage in Echo Canyon. Table VIII-2 summarizes pertinent data for the three inflow ditches. The U.S. Forest Service environmental requirements to enlarge the Dutton Ditch could be a significant issue if a pipeline is necessary.

TABLE VIII-2
COMPARISON OF INFLOW DITCHES

| Item | Hidden Valley | Dry Gulch | Echo |
|---|---|---|---|
| Ditch Length, feet | 18,100 | 22,000 | 24,150 |
| Modification Needed | enlargement | rehab. | rehab. |
| U.S. Forest Service Permit | yes | no | no |
| Impact on Users | none | minor | major |
| Cost Estimate | $400,000 | $109,000 | $120,000 |

The Hidden Valley inflow ditch is the most costly diversion ditch of the three ditches but would have no impact on existing users, except during construction. The Dry Gulch plan would have a minor impact on the Park Ditch users because another user would have to be considered in the operation of the ditch but there would be another entity to share costs thereby reducing costs to the users. The purchase of the Echo Ditch has been discussed above, which is a major problem with this plan.

PUMP AND PIPELINE TO TREATMENT PLANT

These facilities vary with each plan because of the location of the reservoir and the assumption of where the water would be treated. The Hidden Valley and Dry Gulch facilities both require pumping with the Hidden Valley plan requiring the most pumping. The Echo plan does not require any pumping to convey water to the treatment plant. Table VIII-3 shows the comparison of facilities for each plan.

TABLE VIII-3
PUMP AND PIPELINE TO TREATMENT PLANT COMPARISONS

| Item | Hidden Valley | Dry Gulch | Echo |
|---|---|---|---|
| Pipeline Length, ft. | 7,600 | 7,700 | 15,000 |
| Pump Lift, ft. | 450 | 190 | none |
| Pipe Diameter, in. | 18/12 | 18 | 18 |
| Cost Estimate | $377,000 | $350,000 | $522,000 |

The construction cost for each of the facilities to deliver water to the treatment plant is about the same for each plan. The Echo plan does not have any power cost which will offset the slightly higher construction cost. There are no factors that makes one plan better than the others, for these facitilities.

Though the cost of the treatment plant is not considered herein, the entity that will construct and operate a plant is a major consideration. In the Dry Gulch plan it is assumed that Pagosa Springs would enlarge their plant to treat water for all of the entities, but in reality Pagosa Springs may not be interested in providing that service because it has essentially no water from the enlarged facilities. On the other hand, the PAWSD would have a major interest in a new plant because about two thirds of the new water would be for their service area and they probably wouldn't want another entity to be responsible for treating such a large proportion of their water supply.

The PAWSD is the most likely entity for enlarging or constructing a new treatment plant because it has the greatest interest in a new plant. For this reason, the Hidden Valley plan would suit them best because the plan utilizes an existing PAWSD plant.

DISTRIBUTION TO EXISTING SYSTEM

The distribution facilities to convey water to the existing water systems includes the pipeline and pumps to convey water from a treatment plant to the PAWSD and Pagosa Springs systems. These facilities vary considerably by each plan. The SJWCD would probably not construct these facilities but would be the responsibility of the water user entities. The costs are included in the evaluation in order to show the overall cost of each plan and not just the raw water costs.

Table VIII-4 shows comparison data for the distribution facilities for each plan.

TABLE VIII-4
DISTRIBUTION TO EXISTING SYSTEM COMPARISONS

| Item | Hidden Valley | Dry Gulch | Echo |
|---|---|---|---|
| Pipeline Length, ft. | 27,600 | 27,800 | 39,700 |
| Pump Lift, ft. | none | 300 | 170 |
| Pipe Diameter, in. | 24/15/12 | 27 | 27 |
| Cost Estimate | $840,000 | $2,100,000 | $2,888,000 |

The Hidden Valley plan is significantly less costly to distribute water to the existing systems. This is because it is the nearest reservoir to the PAWSD which receives the majority of the water. The Dry Gulch and Echo plans require that the PAWSD water be conveyed from the east side of Pagosa Springs to the west side, a considerable distance.

## DISTRIBUTION TO NEW AREAS

The distribution pipelines to serve new areas are included to show the general magnitude of the cost and because the cost is slightly different for each plan. Table VIII-5 summarizes the pertinent data.

TABLE VIII-5
DISTRIBUTION TO NEW AREAS COMPARISONS

| Item | Hidden Valley | Dry Gulch | Echo |
|---|---|---|---|
| Pipeline Length, ft. | 112,300 | 112,100 | 97,900 |
| Pump Lift, ft. | none | 50 | none |
| Pipe Diameter, in. | 6/10 | 12/10/6 | 10/8/6 |
| Cost Estimate | $2,500,000 | $2,785,000 | $2,204,000 |

## OVERALL COMPARISON

The cost estimate is the primary comparison between the alternatives, unless there is a major social or environmental issue that would significantly impact the potential to construct one of the plans. If the costs are about the same other items should be included in the evaluation to separate plans. Table VIII-6 summarizes the costs for each plan. The costs shown are "Total Construction Costs"; interest during construction and financing costs would have to be added to determine a total investment cost.

TABLE VIII-6
OVERALL COST COMPARISONS

| Item | Hidden Valley | Dry Gulch | Echo |
|---|---|---|---|
| Dam and Reservoir | $6,928,000 | $5,065,000 | $8,047,000 |
| Inflow Ditch | $400,000 | $109,000 | $120,000 |
| Pump & Pipe to T.P. | $377,000 | $350,000 | $522,000 |
| Raw Water Costs | $7,705,000 | $5,524,000 | $8,689,000 |
| Dist to Exist System | $840,000 | $2,100,000 | $2,888,000 |
| Raw Water & Dist. | $8,545,000 | $7,624,000 | $11,577,000 |
| Dist to New Areas | $2,500,000 | $2,785,000 | $2,204,000 |
| Total Cost | $11,045,000 | $10,409,000 | $13,781,000 |
| Annual Pump Cost | $164,000 | $155,000 | $52,000 |

The Hidden Valley and Dry Gulch plans have essentially the same total cost, given the level of accuracy of the estimates. The Echo plan is measurably greater. Given the fact that the water supply for the Echo plan involves the most assumptions and that the purchase of the Echo Ditch would have a significant impact on existing users, the Echo plan is the worst plan of the three.

The recommended plan between Hidden Valley and Dry Gulch is difficult because the total costs are essentially the same. The cost of dams and raw water conveyance favors Dry Gulch. When the Distribution to the Existing Systems is included the costs are about the same with Dry Gulch being about 10% less; which is not within the accuracy of the estimate.

If just the cost to the SJWCD for raw water facilities were considered, the Dry Gulch plan would probably be the recommended plan based upon those costs. If the total costs are considered, the Hidden Valley plan would be recommended because the costs are about the same and Hidden Valley is closest to the major water demand. This example shows why it is important to evaluate the total cost of the plans and not just the raw water costs.

The other major consideration between the Hidden Valley and Dry Gulch plans is the reliability of the water supply. Based upon the lack of data for the Hidden Valley plan, the Dry Gulch plan seems to be much more reliable because definitive water supply data is available. Proving or disproving the water supply for the Hidden Valley plan is a critical component of future studies.

The Hidden Valley plan also involves potential environmental problems with enlarging the Dutton Ditch. If the U.S. Forest Service requires a pipeline rather than a ditch, the enlargement may be prohibitively expensive.

# CHAPTER IX
# RECOMMENDATIONS AND FUTURE ACTIVITIES

Based upon the population projections developed by the SJWCD Population Committee, the population growth from 1990 to 2025 is estimated to be about 14,730 persons; of which about two thirds will be in the PAWSD service area. Using a per capita use rate of 200 gallons per person per day, results in a total yearly water demand in 2025 of 3,300 acre-feet. The water demand estimate is believed to be in the moderate to high range to assure that the reservoir will be adequately sized to deliver water through at least the year 2025.

An inventory of eight reservoir sites that could serve the 3300 acre-foot demand, showed that: the Hidden Valley site was the best reservoir to store Four Mile Creek flows through the enlarged Dutton Ditch, the Dry Gulch Reservoir is the best site to store San Juan River flows, and the Echo Reservoir is the only site that can store Rito Blanco flows.

Organizationally, the PAWSD is the only current entity, unless the SJWCD decides to also treat water, that would be in a position to undertake the responsibility of treating the 3300 acre-feet of water that would be developed. Pagosa Springs has an adequate water supply and treatment facilities for their present and future water needs, so it is unlikely that the Town would be interested in developing an enlarged treatment plant. Presently the SJWCD does not plan on treating water. This leaves the PAWSD with the majority of the growth and as the only entity to develop the treatment plant. The reservoir should be situated to provide water to a PAWSD treatment plant which Hidden Valley is best able to do.

Based upon the data presented in the previous chapters it is recommended that the Hidden Valley and Dry Gulch Reservoir plans be pursued concurrently. Each plan has significant advantages and disadvantages that cannot be fully evaluated at the present time and require additional investigation.

The Hidden Valley Reservoir plan is in a better location than Dry Gulch but the water supply must be proven beyond a doubt before it should be constructed. Also, discussions should be held with the Forest Service to determine the environmental issues with enlarging the Dutton Ditch.

The Dry Gulch Reservoir plan is not well located to meet the demands but has the advantage of having a reliable water supply, even if the Park Ditch doesn't work out and a pump from the San Juan River is necessary. Also, the plan could be staged if the water demands require water prior to construction of a reservoir; a direct diversion from the San Juan River could be utilized in the near term until the reservoir was completed.

When the reservoir is completed, releases from the reservoir could be made to the river and pumped from the diversion point or the diversion could be connected to the reservoir by a pipeline. The pumping costs could be twice as much as Hidden Valley.

The following activities are recommended to evaluate the Hidden Valley and Dry Gulch Reservoir plans:

1. The gage that was installed on Hidden Valley Creek is essential. Readings from the gage should be continued indefinitely.

2. A flume should be installed on Four Mile Ditch as it enters Hidden Valley. The flume would only need a staff gage and not a continuous recorder to measure imported water to Hidden Valley.

3. Flows of Four Mile Creek upstream of the Dutton Ditch headgate need to be measured. W.W. Wheeler tried to maintain a gage at this location in the 1970's but had problems which resulted in unreliable readings and no readings. The flows need to be measured, even if by a staff gage that is read once a week.

4. A water right to store water in Hidden Valley Reservoir should be obtained, by trying to purchase existing storage rights and/or applying for a new right. The new right should be for 10,000 acre-feet of storage capacity.

5. Obtain a topographic survey of the Hidden Valley and Dry Gulch Reservoir basins to prepare an estimate of the reservoir capacity, which can be used to better estimate the height of the dam.

6. Conduct geotechnical investigations, including depth to bed rock and availability of zone land 2 material, at the Hidden Valley and Dry Gulch dam sites.

7. The inlet ditches to the two reservoirs should be evaluated further. The environmental considerations associated with enlarging the Dutton Ditch should be discussed with the U.S. Forest Service. Discussions should also be held with the Park Ditch Comapny to jointly utilize the ditch.

The above activities are necessary prior to selecting a final plan. It will require at least 2 more years of data collection to prove or disprove the Hidden Valley water supply, so a decision on which of the two plans to prepare a feasibility study cannot be determined until late 1991, at the earliest.

The Feasibility study will be a costly undertaking and financial assistance from the Colorado Water Resources and Power Development Authority (Authority) or the Colorado Water Conservation Board (CWCB) will probably be necessary. The process to obtain funds for the feasibility study will require 6 to 12 months, possibly more. The feasibility study will require 12 to 18 months and cost about 3% to 5% of the estimated construction cost which would be in the $150,000 to $300,000 range, for the raw water facilities.

In general the feasibility study would include: additional geotechnical investigations of the dam site; topographic surveys of the access roads, and pipeline route; a feasibility design of the facilities, especially the dam; evaluation of necessary permits and preparation of the permit applications; environmental studies; and a construction cost estimate.