SOUTHWEST BASINS ROUNDTABLE
STEVEN C HARRIS, CHAIR
% Southwestern Water Conservation District
841 East Second Avenue
Durango, Colorado 81301
970-247-1302

EMAILED January 11, 2007

Mr. Rick Brown
Chief, Intrastate Water Management and Development Section
Colorado Water Conservation Board
1580 Logan Street, Suite 600
Denver, Colorado 80203

SUBJECT: Water Supply Reserve Account Applications for the Southwest Basins Roundtable

Dear Mr. Brown:

The Southwest Basins Roundtable (Roundtable) is pleased to submit two applications, of five considered, for Water Supply Reserve Account (Account) funding for consideration at the March, 2007 CWCB Board Meeting. Both applications received unanimous approval by our roundtable during its January 10, 2007 meeting at the Dolores Water Conservancy District Offices in Cortez. This letter serves as the Roundtable's introduction and support for the applications described below and attached.

The evaluation process consisted of providing the completed applications to the Roundtable for review one week prior to the meeting. During the Roundtable meeting each of the applicants were allowed to present their application. After each presentation, the Roundtable members asked the applicant questions. The meeting minutes summarize the discussion of the applications.

After lengthy discussion on all of the applications and thorough review of the content of the applications in relation to the CWCB criteria, the San Juan Water Conservancy District and Goodman Point Water Association applications were unanimously approved for funding. Though all applications met important needs in our basin, the two approved at this time, were exceptional both in the content of the applications and the need for the projects. The justification for each project is explained below.

Since these are the first set of applications submitted to the CWCB for SB179 funding, the Southwest Basins Roundtable requests that the CWCB Interstate Water Management and Development Section work with our Roundtable and the applicants to further develop the enclosed applications so that they have the best opportunity to be approved for funding during the CWCB Board Meeting in March. We welcome any suggestions you have to improve these applications.

San Juan Water Conservancy District

The San Juan Water Conservancy District in partnership with the Pagosa Area Water and Sanitation District (PAWSD) have begun the 12 to 18 year process to construct Dry Gulch Reservoir (aka San Juan Reservoir in application) to provide municipal water to the Pagosa Springs area for the next 100 years. SJWCD and PAWSD have water rights for the reservoir and the diversion from the San Juan River to fill the reservoir, decreed in 2006. The details of the project are described in their application.

The application is attached to this letter as an email. The extensive supporting documents have been provided to you separately by SJWCD in December.

Due to the efforts of the volunteer Board President, SJWCD over the last two years has negotiated a land purchase agreement with the family who presently own most of the reservoir basin. SJWCD owning this land is absolutely critical to constructing this reservoir. The $1 million in funding, though a small portion of the overall Dry Gulch Reservoir construction cost of nearly $100 million, is extremely important at this time to secure the land purchase.

SJWCD and PAWSD have studied, over the past 20 years, enlargements and new reservoir sites that could potentially meet future water needs and identified one enlargement and the new Dry Gulch Reservoir. In 2007 PAWSD will be initiating construction of a small enlargement of the existing Stevens Reservoir from 800 acre-feet to about 1,800 acre-feet, after over 15 years of studies and permitting. This is the only existing reservoir that has the potential for enlargement. With enlargement of Stevens Reservoir, PAWSD will have about 3,900 acre-feet of usable storage.

PAWSD and SJWCD, based on water demand projections, have estimated additional storage is needed by 2015 but Dry Gulch Reservoir cannot be constructed and available for use until 2021 at the very earliest. The need is critical to proceed as quickly as possible with development of Dry Gulch Reservoir. SJWCD and PAWSD are in the process of initiating various types of fees that are planned to generate adequate funds to eventually construct Dry Gulch Reservoir but presently there are not adequate funds for the land purchase.

Dry Gulch Reservoir was included in the Statewide Water Supply Initiative Study report as “Major Identified Projects and Processes”.

The Southwest Roundtable highly recommends that the CWCB fund this critical project from the State “pool” of SB179 funds.

Goodman Point Water Association

The Goodman Point Water Association is a small group of homeowners about 8 miles west of Cortez who have organized themselves to attempt to extend service of the Montezuma Water Company rural water system to their homes. The Association has applied for funding from Rural Development which requires a Preliminary Engineering Report and Environmental Report. These studies are underway but the Association is $7,700 short of being able to fully fund the studies.

The application is attached to this email letter.

The Southwest Roundtable unanimously support providing $7,700 from our basin fund to assist the Association in completing the studies so they can continue the work to extend the water lines to serve their homes.

Though this project was not specifically identified in SWSI it does comply with the SWSI "Projects and Processes" to utilize the existing water rights and water supplies of Montezuma Water Company to meet water needs in Montezuma County.

The Southwest Roundtable highly recommends that the CWCB approve funding of this critical project from the Southwest Basin "pool" of SB179 funds.

Please contact me at 970-259-5322, steve@durangowater.com, if you have questions on the enclosed applications or wish discuss these applications in more detail.

Sincerely,

Steven C Harris, P.E.
Southwest Basins Roundtable Chair

San Juan Water Conservancy District

PO Drawer 4632
Pagosa Springs, CO 81157
(970) 731-2691
(970) 731-2693 [fax]

December 28, 2006

Colorado Water Conservation Board (CWCB)
Intrastate Water Management and Development
1580 Logan Street, Suite 600
Denver, CO 80203

Dear CWCB Members:

Attached, for your review and consideration, is the San Juan Water Conservancy District (SJWCD or District) Grant Application for the CWCB 2006-2007 Water Supply Reserve Account. Specifically, the SJWCD is requesting $1 million of a total $9.1 million (representing 11 percent) to purchase property for development of the critically needed San Juan (aka Dry Gulch) Reservoir.

Reservoir development is necessary for the health and welfare of the Districts' constituents due to unprecedented growth (7.1 percent per year based on equivalent unit usage; see attached Economic Development Region Nine *Healthy Communities Survey*) within the District boundaries. These growth figures, which exceed the census growth figures, do not reflect the large number of seasonal residents in the area. A local study on second homes indicates that 60 percent of properties are owned by people that live outside of the County. As an example of growth, historic water connections within the District average about 200 per year. There were, however, 309 connections in 2006 and already a request for 359 connections in 2007. The current water storage capacity in the District is a mere 2,900 acre-feet (AF). Studies indicate that an additional 12,000 AF of storage capacity will be necessary by the year 2040 to meet the water needs of area residents.

The District has been working on this Reservoir storage project since the mid-1980's. Therefore, all of the necessary studies have already been conducted (see attached), including an extensive inventory and review of more than 13 potential sites within the SJWCD and county (Archuleta) boundaries. This analysis revealed that there were only two geotechnical, topographical, and economically feasible sites to choose from that have the least environmental concerns associated with them. One site has been purchased by a developer. Thus, time is of the essence to secure the last remaining potential Reservoir site in the District before it is either lost to development and/or a financial impossibility due to extreme land escalation costs in the County.

Of positive note related to Phase I of the Reservoir site land acquisition is that it is totally enclosed on private property, thereby alleviating the necessity to negotiate with multiple parties. In addition, the land is currently under contract with an anticipated first closing scheduled for July-August 2007. It should be noted, too, that the vitally important water rights for the Reservoir have already been secured (see attached Court Orders). In addition, the District

successfully de-Bruced in the November 2006 election, thereby alleviating potential TABOR issues.

The SJWCD plans to fund the remaining $8.1 million balance of the Reservoir land acquisition through a series of finance strategies to include: a) a current mill levy of approximately $60,000 per year; b) reserve accounts of $300,000; c) impact fees of approximately $350,000 per year; and d) a proposed increase to the current mill levy on the November 2007 General Election ballot to generate, in total, approximately $750,000 per year. In the event the ballot issue fails, the SJWCD, in conjunction with the Pagosa Area Water and Sanitation District (PAWSD), has obtained a commitment to increase water rates to pay for project financing.

The SJWCD has strong support for the Reservoir project from the PAWSD, the Town of Pagosa Springs, Archuleta County, and all of the various and affected water companies/agencies in the District. In addition, the purchase of land for Reservoir development meets the following CWCB water management objectives as follows:

- It will sustainably meet municipal and industrial demands;
- It will sustainably meet agricultural demands;
- It optimizes existing and future water supplies;
- It will substantially enhance recreational opportunities;
- It promotes cost effectiveness as the only economically viable site location;
- The project will comply with all applicable laws, regulations, and water rights; and
- The project provides an excellent location and supply of raw water for forest fire suppression.

Moreover, funding assistance will help meet Colorado's future water needs—namely, projected capacity shortfalls in the San Juan River Basin. It also addresses a gap between available water supply and future needs as identified in the Statewide Water Supply Initiative and the roundtable basin-wide water needs assessment. In addition, storage of this Headwater preserves water quality and provides drought protection. As commented by the San Juan National Forest Regional Forester, "the Reservoir will provide an excellent source of water for forest fire fighting." Finally, the San Juan Reservoir will protect Colorado's water share from future Lower Compact States designs on Colorado water by allowing the District to store entitled rights.

We thank you in advance for the opportunity to apply for this grant and for your time and consideration. Please direct any questions to Fred Schmidt, the SJWCD Chair, at (970) 903-8675. Until then, we anxiously await your decision.

Sincerely,

Fred W. Schmidt
Chairman
SJWCD Board of Directors

Attachments

COLORADO WATER CONSERVATION BOARD

WATER SUPPLY RESERVE ACCOUNT
2006-2007 GRANT APPLICATION FORM

San Juan Reservoir [San Juan/Dolores River Basin]

Name of Water Activity/Project **River Basin Location**

$1,000,000.00	☐ Basin Account	☐ Yes
Amount of Funds Requested	☑ Statewide Account	☐ No
	Please Check Applicable Box	Approval Letter Signed By Roundtable Chair and Description of Results of Evaluation and Approval Process

*** For the Basin Account, the Application Deadline is 60 Days Prior to the Bimonthly CWCB meeting. The CWCB meetings are posted at www.cwcb.state.co.us and are generally the third week of the month.**

*** For the Statewide Account, the Application Deadline is 60 Days Prior to the March and September CWCB Board Meetings.**

*** In completing the application you may attach additional sheets if the form does not provide adequate space. If additional sheets are attached please be sure to reference the section number of the application that you are addressing (i.e., A.1. etc.).**

Instructions: This application form should be emailed, typed, or printed neatly. The Water Supply Reserve Account Criteria and Guidelines can be found at http://cwcb.state.co.us/IWMD/. **The criteria and guidelines should be reviewed and followed when completing this application.** You may attach additional sheets as necessary to fully answer any question, or to provide additional information that you feel would be helpful in evaluating this application. Include with your application a cover letter summarizing your request for a grant. If you have difficulty with any part of the application, contact Rick Brown of the Intrastate Water Management and Development (Colorado Water Conservation Board) for assistance, at (303) 866-3514 or email Rick at rick.brown@state.co.us.

Generally, the applicant is also the prospective owner and sponsor of the proposed water activity. If this is not the case, contact the Rick Brown before completing this application.

Water Supply Reserve Account – Grant Application Form

Form Revised October 2006

Part A. - Description of the Applicant (Project Sponsor or Owner);

1. Applicant Name(s): San Juan Water Conservancy District (SJWCD)

Mailing address: P.O. Box 4632
Pagosa Springs, CO 81157

Taxpayer ID#: 84-1088817 Email address: carrie@pawsd.org

Phone Numbers: Business: 970-731-2691
Home: 970-903-8675
Fax: 970-731-2693

2. Person to contact regarding this application if different from above:

Name: Mr. Fred Schmidt

Position/Title SJWCD Board of Directors Chairman

3. Provide a brief description of your organization below: Refer to Part 2 of criteria and guidance for required Information. Attach additional sheet(s) as needed.

The San Juan Water Conservancy District (SJWCD) was formed in October 1987 in accordance with C.R. S., sections 37-45-109 (2.5) and 37-45-139 to 37-45-141, and the general election laws of the state of Colorado. Notice of the election was published in conformance with C.R.S., section 37-45-140. The SJWCD is a political subdivision of the State of Colorado and a body corporate with all the powers of a public or municipal corporation as authorized by the statutes of the State of Colorado under C.R.S., section 37-45-010 et seq. The purpose of the SJWCD is to conserve, maximize and utilize the water resources of the San Juan River and its tributaries, and that property within the District will be benefited by this purpose. The highest priority of the SJWCD is to provide water for the health and welfare of its constituents. The contact for the SJWCD is Mr. Fred Schmidt, Board of Directors Chairman, POB 609, Pagosa Springs, CO 81147, (970) 903-8675.

Part B. - Description of the Water Activity – Please Refer to Criteria and Guidance Document for Eligibly Criteria

1. Name of water activity/project:

   San Juan (aka Dry Gulch) Reservoir

2. What is the purpose of this grant application? Check one.

   Environmental compliance and feasibility study

   Technical assistance regarding permitting, feasibility studies, and environmental compliance

   Studies or analysis of structural, nonstructural, consumptive, nonconsumptive water needs, projects, or activities (Please specify)

   ✓ Structural and/or nonstructural water project or activity

3. Please provide an overview of water project or activity to be funded including – type of activity, statement of what the activity is intended to accomplish, the need for the activity, the problems and opportunities to be addressed, expectations of the participants, why the activity is important, the service area or geographic location, and any relevant issues etc. Please include any relevant Tabor issues. Please refer to Part 2 of criteria and guidance document for additional detail on information to include. Attach additional sheets as needed.

Type of activity: Funding assistance for the initial purchase of Phase I land acquisition for the San Juan Reservoir.
Amount of funding requested: The SJWCD requests $1 million from the CWCB 2006-2007 Water Supply Reserve Account, which represents only 11 percent of the total $9.1 million land fund requirements.
Statement of what the activity is intended to accomplish: The funds obtained from this grant application will be used to purchase Phase I property for the San Juan Reservoir.
The need for the activity: Reservoir development is necessary for the health and welfare of the Districts' constituents due to unprecedented growth (7.1 percent per year based on equivalent unit usage) within the District boundaries. More than 60 percent of this growth is associated with second home construction/purchase. As an example of growth, historic water connections within the District average about 200 per year. There were, however, 309 connections in 2006 and already a request for 359 connections in 2007. The current water storage capacity in the District is 2,900 acre-feet (AF). Studies indicate that an additional 12,000 AF of storage capacity will be necessary by the year 2040 to meet the water needs of area residents. Since the lead-time to construct a new reservoir is typically 20 years or more, work to construct a new reservoir must begin immediately in order to have a reservoir constructed when needed. Unless the land is immediately purchased, it could be lost to other development interests and/or a financial impossibility due to extreme land escalation costs in the County.
The problems and opportunities to be addressed, including relevant project history: One large problem relates to the critical need for additional water storage. Another problem relates to the fact that there is only one feasible site in the County that meets the location needs to economically build a reservoir. An extensive inventory and review of more than 13 potential sites within the SJWCD and county (Archuleta) boundaries revealed that there were only two geo-technical, topographical, and economically feasible sites to choose from that have the least environmental concerns associated with them. One site has since been purchased for development. Thus, time is of the essence to secure the last remaining potential Reservoir site in the District, before it is either lost to development and/or a financial impossibility due to extreme land escalation costs in the County. A third problem relates to the vast cost and need for financial assistance to acquire the land and build a new reservoir. Opportunities include the obvious added storage capacity to meet water demands associated with growth and drought, as well as the recreational potential associated with the Reservoir.
Expectations of the participants: The expectations of the SJWCD and the community they serve are to identify initial supplemental funding assistance for land acquisition related to Reservoir development.
Why the activity is important: (see Need for the Activity above) As stated above, the SJWCD must provide an additional 12,000 acre-feet of water storage capacity by the year 2040 to meet the water needs of area residents and there is only one viable Reservoir site location in the District.
The service area or geographic location, maps, and socio-economic characteristics: The SJWCD encompasses a significant portion of Archuleta County, including the Town of Pagosa Springs and the Pagosa Area Water and Sanitation District. The Reservoir site is located less than one mile from the historic downtown area of Pagosa Springs and is adjacent to the San Juan River. The attached maps indicate the topography and locations of major streams, as well as the locations of existing facilities, proposed project facilities, and boundaries of lands to be served. The 2005 population of the Town of Pagosa Springs was 1,640 residents and 11,716 residents for Archuleta County as a whole. These population figures, however, do not reflect the large number of seasonal residents in the area. A local study on second homes indicates that 60 percent of properties are owned by people that live outside of the County. Population within the SJWCD is estimated to be approximately 52,000 by the year 2040. Per capita income (2000) was $18,481. While tourism continues to play a major employment role, real estate and home building have both realized an upward trend.
Relevant issues: As described above, the largest relevant issue related to this project is the fact that there is only one viable site left in the County for Reservoir development and the SJWCD is in need of financial assistance for Phase I land acquisition. Another relevant issue relates to the sheer magnitude of total Reservoir project costs, estimated at $145 million.
Relevant TABOR issues: In an effort to qualify for available grants and other sources of funds, and as further indication of overall public support for the Reservoir, the SJWCD successfully de-Bruced in the November 2006 election. Therefore, the relevant TABOR issues that would have been associated with this project have been alleviated.

4. Please provide a brief narrative of any related or relevant previous studies. Attach additional sheets as needed.

Appraisal Report to Evaluate Future Raw Water Demands and Water Supply Alternative Plans (attached). Prepared for the San Juan Water Conservancy District and the Pagosa Area Water and Sanitation District. Prepared by Harris Water Engineering, Inc. March 2003.

Narrative: The purpose of this report, which was initiated in the spring of 2000 and concluded in the spring of 2003, was to evaluate the raw water supply needed in 2040 within the SJWCD and the possible alternative plans which might be constructed to serve the 2040 water needs. The report concluded that an additional 18.5 cfs of diversion capacity was required from the San Juan River and at least 12,000 acre-feet of additional storage would be required in 2040. The report further concluded that the least costly and most efficient alternative to meet the demands is to begin the process to acquire the land and then construct the San Juan (aka Dry Gulch) Reservoir. Many alternatives were investigated and the San Juan Reservoir site was clearly the best location.

Preliminary Engineering Study of Water Supply Alternatives for [San Juan Water Conservancy District] and the Pagosa Area Water and Sanitation District (attached). Prepared by Davis Engineering Service, Inc. July 2001.

Narrative: The purpose of this report was to provide information for use in the 404 Permit process addressing the need for additional water supplies and the alternatives that were considered to provide the water supply. The study identified a number of recommended strategies to gain additional water supply including the enlargement of Stevens Reservoir and Dutton Ditch. However, the enlargement of Stevens Reservoir is only a very temporary short term solution to the water storage problem.

5. Please provide a copy of the proposed scope of work. Please refer to Part 2 of the criteria and guidance document for detailed requirements. Attach additional sheets as needed.

Detailed summary of the water activity: The funds obtained from this grant application will be used for the initial purchase of Phase I land acquisition for the San Juan Reservoir.
Description of the goals of the water activity and how the water activity will accomplish those goals: The goal of this project is to obtain the land necessary to provide an additional 12,000 to 35,000 AF of storage capacity to meet water needs related to growth and drought in the SJWCD. Development of the San Juan Reservoir will accomplish this goal by providing an adequate water supply through the year 2040.
Description of how the work will be accomplished and major deliverables/products: The negotiations for the purchase of the San Juan Reservoir property have been ongoing for over two years. The final agreement for the purchase of the main ranch and two adjacent parcels have been agreed upon. A major deliverable involves a first close of escroe for the land purchase scheduled for July-August 2007.
A list of participants and their qualifications to accomplish the project/water activity: For purposes of this funding request for land acquisition related to the San Juan Reservoir, financial participants include the SJWCD to fund the $8.1 million land acquisition balance. In addition, the Town of Pagosa Springs and Archuleta county are also financial participants with their adoption of impact fees. The Pagosa Area Water and Sanitation District is a financial partner in the form of increased rates to to pay for project financing. Wells Fargo Bank may be a financial participant with a lease purchase agreement, as well as investment bankers, George K. Baum. Related to the project as a whole, additional participants include Park Ditch Water Company and Aspen Springs Metropolitan District. The SJWCD is comprised of a very capable Board of Directors with recognized and varying degrees of expertise related to water resources finance and development. The SJWCD continues to have significant representation on its Board to include leading members of Town and County government. Early in 2007 the District intends to form its' team of consultants.
A detailed budget by activity, level of effort, and rates, as well as the budget detailing the source of matching funds. The budget also includes any other outstanding or previously applied for funding that also supports the water activity. For purposes of this funding request for land acquisition related to the San Juan Reservoir, all funds will go toward the purchase of land. The SJWCD plans to fund the remaining $8.1 million balance of the Reservoir land acquisition through a series of finance strategies to include: a) a current mill levy of approximately $60,000 per year; b) reserve accounts of $300,000; c) impact fees of approximately $350,000 per year; and d) a proposed increase to the current mill levy on the November 2007 General Election ballot to generate, in total, approximately $750,000 per year. In the event the ballot issue fails, the SJWCD, in conjunction with the Pagosa Area Water and Sanitation District, has obtained a commitment to increase water rates for project financing.
A detailed project schedule including key milestones: Funding from this Account will allow the SJWCD to begin purchase of land for the San Juan Reservoir in 2007. The Reservoir is estimated to be needed by about 2015, but it is not possible to complete all of the pre-construction work in that time frame. Since the Reservoir cannot be constructed and ready for use until about 2025, the SJWCD has the ability to construct the reservoir in two phases. Depending on the economic conditions, water demands, and costs, it may make sense to construct 12,000 AF in phase I and the remaining 23,000 AF in phase II, which will supply the water needs through about 2100. However, upon further evaluation, the entire project could be built to the 35,000 AF capacity in one phase.

6. List the names and addresses of any technical or legal consultants retained to represent the applicant or to conduct investigations for the water activity/project.

Name	Address/Phone Number
Collins, Cockrel and Cole Jim Collins	390 Union Blvd, Suite 400, Denver, CO 80228 (800) 354-5941
Davis Engineering	POB 1840, Alamosa, CO 81101 (719) 657-3304
Harris Water Engineering, Inc. Steve Harris	954 E. 2nd Ave, Durango, CO 81301 (970) 259-5322

7. Water Availability and Sustainability – this information is needed to assess the viability and effectiveness of the water project or activity. Please provide a description of each water supply source to be utilized for, or the water body to be affected by, the water activity. For water supply sources being utilized, describe its location, yield, extent of development, and water right status. For water bodies being affected, describe its location, extent of development, and the expected effect of the water activity on the water body, in either case, the analysis should take into consideration a reasonable range of hydrologic variation. Attach additional sheets as needed.

The San Juan Reservoir would be an off-stream reservoir located approximately one mile north of historic downtown Pagosa Springs along US Highway 160. The Reservoir site is capable of up to approximately 35,000 acre-feet, subject to geotechnical evaluations of the dam site. If only the Park Ditch is used to fill the Reservoir, the capacity would be restricted to about 7,000 acre-feet. The Reservoir drainage basin will not yield adequate water to fill the Reservoir and would require diversions from the San Juan River. The Reservoir is planned to be constructed to 35,000 acre-feet, which will require a pump and pipeline from the San Juan River. Based on estimates of about 10 to 15 years to acquire land, conduct environmental investigations and approvals, and conduct engineering studies and designs, actual work on the dam would not begin until the early 2020's.

As stated previously, the San Juan Reservoir is estimated to be needed by about 2015, but it is not possible to complete all of the pre-construction work in that time frame. Since the Reservoir cannot be constructed and ready for use until about 2025, the SJWCD has the ability to construct the reservoir in two phases. Depending on the economic conditions, water demands, and costs, it may make sense to construct 12,000 AF in phase I and the remaining 23,000 AF in phase II, which will supply the water needs through about 2100. However, upon further evaluation, the entire project could be built to the 35,000 AF capacity in one phase. Water rights have been acquired for the Reservoir and diversion from the San Juan River.

8. If you have not specifically and fully addressed the Evaluation Criteria found in Part 3 of the criteria and guidance document please provide additional detail here. Attach additional sheet(s) if needed.

See attached "a" through "t" responses.

9. Additional Information – If you feel you would like to add any additional pertinent information please feel free to do so here. Attach additional sheets as needed.

N/A

The above statements are true to the best of my knowledge:

Signature of Applicant:

Print Applicant's Name: Fred Schmidt

Project Title: San Juan Reservoir

Return this application to:

Mr. Rick Brown
Intrastate Water Management and Development Section
COLORADO WATER CONSERVATION BOARD
1580 Logan Street, Suite 600
Denver, CO 80203

To submit applications by Email, send to: rick.brown@state.co.us

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Reference Information

The following information is available via the internet. The reference information provides additional detail and background information regarding these criteria and guidelines and water policy issues affecting our state.

Colorado Water Conservation Board Policies

Loan and Grant policies and information are available at - http://cwcb.state.co.us/Finance/

Water Supply Reserve Account Criteria and Guidelines –

http://cwcb.state.co.us/IWMD/tools.htm#Water_Supply_Reserve_Account

Interbasin Compact Committee and Basin Roundtables

Interbasin Compact Committee By-laws and Charter –

http://dnr.state.co.us/Home/ColoradoWaterforthe21stCentury/Interbasin+Compact+Committee/IbccHomePage.htm

Basin Roundtable By-laws –

http://dnr.state.co.us/Home/ColoradoWaterforthe21stCentury/IbccHome.htm

Legislation

House Bill 05-1177 - Also known as the Water for the 21st Century Act –

http://cwcb.state.co.us/IWMD/statutes.htm

House Bill 06-1400 – Adopted the Interbasin Compact Committee Charter –

http://cwcb.state.co.us/IWMD/statutes.htm

Senate Bill 06-179 – Created the Water Supply Reserve Account –

http://cwcb.state.co.us/IWMD/statutes.htm

Statewide Water Supply Initiative

General Information - http://cwcb.state.co.us/IWMD/

Phase 1 Report - http://cwcb.state.co.us/IWMD/PhaseIReport.htm

Water Supply Reserve Account – Grant Application Form
Adopted October 18, 2006

Evaluation Criteria "a" through "t"

a. The water activity addresses multiple needs or issues or the needs and issues of multiple users or multiple basins. In addition to providing water needs for the SJWCD constituents, the San Juan Reservoir will also augment the water needs for: Archuleta County, the Town of Pagosa Springs, the Pagosa Area Water and Sanitation District and their customers, Park Ditch Water Company, Aspen Springs Metropolitan District, and other downstream users.

b. The number and types of entities represented in the application and the degree to which the activity will promote cooperation and collaboration, and if applicable, the degree to which the water activity is effective in addressing intrabasin or interbasin needs or issues. There is one entity represented in this application—the San Juan Water Conservancy District--a political subdivision of the State of Colorado and a body corporate with all the powers of a public or municipal corporation. The project will promote a high degree of cooperation and collaboration among a number of entities listed in 8.a. above. The San Juan Reservoir addresses interbasin needs within the San Juan and Dolores River Basin by helping to address the 26 percent (18,000 AF) water supply shortfall identified in the SWSI report.

c. Funding from this account will reduce the uncertainty that the water activity will be implemented. Funds received from this CWCB Account will make a significant difference for the initial land acquisition for the San Juan Reservoir. The SJWCD serves a small, suburban and urban population, with a limited tax base and available financial resources. Funding will provide the necessary capital to move forward with land acquisition. Although the SJWCD anticipates covering the majority (89 percent) of the land acquisition costs through a series of finance strategies (e.g., significant impact fees, water rate increases, etc.), funding obtained from this grant application is vital to the funding portfolio.

d. There is an urgency of need for the water activity and/or compelling "window of opportunity" that may be missed without funding from the Account. There is an ***absolute*** urgency of need for the San Juan Reservoir site acquisition. As stated previously, the Reservoir is estimated to be needed in about 2015, yet will likely not be constructed and ready for use until about 2020's. This leaves a minimum of about a five-year water deficit. One compelling "window of opportunity" that may be missed without funding from this Account is the fact that there is only one feasible site in the County that meets the location needs to economically build a reservoir. **Unless the land is immediately purchased, it could be lost to other development interests and/or a financial impossibility due to extreme land escalation costs in the County.**

e. The length of time needed to implement the water activity (preference will be given to activities which can be implemented in the least amount of time taking into consideration the complexity of the activity). Funding from this Account will allow the SJWCD to begin purchase of land for the San Juan Reservoir in 2007.

f. The applicant of the water activity has the expertise and ability to implement the proposed activity. The SJWCD is comprised of a very capable Board of Directors with recognized and varying degrees of expertise related to water resources and development. The current (and past) Board has been working on this project for more than 20 years and is very familiar with the steps necessary to implement the development of San Juan Reservoir. In addition, the SJWCD has assembled a talented and capable team of contractors and subcontractors to assist with project development. Finally, many of the affected multiple users (e.g., Archuleta County, the Town of Pagosa Springs, the Pagosa Area Water and Sanitation

District, etc.) are also members of the SJWCD Board of Directors and have been and will continue to be actively involved with the project. The SJWCD has worked diligently to involve all affected entities and levels of government in their planning process. Representatives have the expertise necessary to implement the land acquisition and associated tasks related to the San Juan Reservoir.

g. The applicant of the water activity is providing matching funds and the amount of matching funds or is obtaining partial funding from other sources and the amount and source of such other funds. The SJWCD is providing matching funds in the amount of $8.1 million through a series of finance strategies to include: a) a current mill levy of approximately $60,000 per year; b) reserve accounts of $300,000; c) impact fees of approximately $350,000 per year; and d) a proposed increase to the current mill levy on the November 2007 General Election ballot to generate, in total, approximately $750,000 per year. In the event the ballot issue fails, the SJWCD, in conjunction with the Pagosa Area Water and Sanitation District (PAWSD), has obtained commitment to increase water rates for project financing.

h. The applicant of the water activity has a demonstrated need for financial assistance based on the inability or difficulty obtaining funding elsewhere. As previously stated, the SJWCD serves a small, suburban and urban population, with a limited tax base and available financial resources. As stated in 8.c., above, although the SJWCD anticipates covering the majority (89 percent) of the land acquisition costs through a series of finance strategies (e.g., significant impact fees, water rate increases, etc.), funding obtained from this grant application is vital to the funding portfolio. As stated by one Director, "we have done all that we can do to raise the necessary finances; we have squeezed all that we can and yet we're still short $1 million."

i. The water activity helps complete a needs assessment that was not fully funded from other sources. Not Applicable.

j. The water activity meets one or more of the water management objectives identified in the Statewide Water Supply Initiative,[1] helps implement projects and processes identified as helping meet Colorado's future water needs, and/or addresses the gap areas between available water supply and future need as identified in the Statewide Water Supply Initiative or a roundtable's basin-wide water needs assessment done in accordance with the Colorado Water for the 21st Century Act. The purchase of land for the San Juan Reservoir meets the following six water management objectives: 1) it will sustainably meet municipal and industrial demands; 2) it will sustainably meet agricultural demands; 3) it optimizes existing and future water supplies; 4) it will substantially enhance recreational opportunities; 5) it promotes cost effectiveness as the only economically viable site location; 6) the project will comply with all applicable laws, regulations, and water rights; and 7) the project provides an excellent location and supply of raw water for forest fire suppression. Funding will help to implement a project (San Juan Reservoir) to meet Colorado's future water needs—namely, projected capacity shortfalls in the San Juan and Dolores River Basin. It also and most definitely addresses a gap between available water supply and future need as identified in the Statewide Water Supply Initiative AND the roundtable basin-wide water needs assessment.

k. The water activity promotes water conservation and efficiency. Although the acquisition of land for the San Juan Reservoir does not have a specific conservation and efficiency component, there are a few items of note. First, conservation and efficiency measures have been and are

[1] The nine water management objectives are: sustainably meet municipal and industrial demands; sustainably meet agricultural demands; optimize existing and future water supplies; enhance recreational opportunities; provide for environmental enhancements; promote cost effectiveness; protect cultural values; provide for operational flexibility; and comply with all applicable laws, regulations, and water rights.

continuing to be actively and aggressively promoted in the community through the Pagosa Area Water and Sanitation District's (PAWSD) Conservation Plan. Examples include, but are not limited to: toilet and high-efficiency clothes washer rebate programs; a restaurant pre-rinse spray valve give-away program; hotel and motel Project Planet program; Responsible Landscape workshops; xeriscape™ demonstration gardens development and enhancements; leak detection programs; commercial and residential water audits; and WaterWise programs. In addition, the San Juan Reservoir will be a state-of-the-art facility that will utilize the most efficient technologies on the market. Moreover, the District is exploring options to utilize alternative energy systems (i.e., solar) to augment or help augment power requirements.

l. The applicant has an existing water conservation plan. Although the SJWCD does not have a water conservation plan per se, as described above, the PAWSD does have an aggressive Water Conservation Plan and water conservation is a vital component in the Districts' community water resources portfolio.

m. The water activity will make new water available for use/utilizes unappropriated waters. The SJWCD already has adjudicated water storage rights and in-stream rights for the San Juan (aka Dry Gulch) Reservoir (see attached Division 7 Water Court, Case Number 04CW85).

n. The water activity involves reoperation, enlargement, or rehabilitation of existing facilities. No. The San Juan Reservoir development project is new.

o. The water activity helps sustain agriculture, and open space, or meets environmental or recreational needs. Yes. The development of the San Juan Reservoir will assist Park Ditch Water Company with water, thereby preserving their agricultural practices. Open space will be preserved with a multitude of planned parks and recreational facilities, mainly through the Town of Pagosa Springs and Archuleta County.

p. The Water activity assists in the administration of compact-entitled waters or addresses problems related to compact entitled waters and compact compliance and the degree to which the activity promotes maximum utilization of state waters. Yes. The water supply developed by the San Juan Reservoir would be provided by Colorado's allocation under the Colorado River Compact. The project would allow Colorado to continue to utilize that allocation by allowing the District to store entitled rights. Storage of this Headwater also preserves water quality and provides drought protection.

q. The water activity assists in the recovery of threatened and endangered wildlife species or the conservation of existing wildlife species. Yes. Land acquisition for the development of the San Juan Reservoir will substantially increase wetlands around the site and will help stabilize in-stream flow during drought.

r. The water activity provides a high level of benefit to Colorado in relationship to the amount of funds requested. Yes. The acquisition of land for this project is critical because the Reservoir site is presently undeveloped. If the land is not retained for the Reservoir now, it may be lost to other development and/or become financially prohibitive.

s. The project or water activity is complimentary to or assists in the implementation of other CWCB program. The project is complimentary to the CWCB program to utilize Colorado's Compact apportionments. The diversion from the San Juan River into the San Juan Reservoir is junior to a CWCB in-stream flow water right. The Reservoir will not provide flood control benefits.

t. The water activity helps support the State's economic vitality and competitiveness in national and international markets. Yes, the San Juan Reservoir project will help support the State's economic vitality with enhanced local, regional, state, national, and to some extent international tourism potential/visits to the Reservoir and associated facilities.

Population Trends

From 1990 to 2000, the population of Archuleta County grew by 8.5% annually, and was ranked 5th of 63 Colorado counties (14th nationwide) for rate of growth. Since 2000, the estimated rate of growth has slowed down to about 3.7% annually, with most of the growth in the unincorporated areas of the county. The estimated population in 2005 was 11,716.

The majority of the county's population is concentrated within the Town of Pagosa Springs and its surrounding subdivisions. According to the 2000 Census, the median age was 40.8. Males comprised 51% and females comprised 49% of the total population. The average household size was 2.47 people.

	Census 2000	Estimates					Avg Annual % Change 2000-2005
		2001	2002	2003	2004	2005	
Archuleta	9,898	10,548	10,912	11,196	11,464	11,716	3.7%
Pagosa Springs	1,591	1,621	1,621	1,618	1,620	1,640	0.6%
Unincorporated	8,307	8,927	9,291	9,578	9,844	10,076	4.3%

Source: Colorado Demography Section estimates 8-06

This rate of growth is expected to continue through 2030, presenting challenges for the provision of adequate facilities and infrastructure.

	Forecasts					
Archuleta	2005	2010	2015	2020	2025	2030
Population	11,716	14,108	16,632	19,546	22,880	30,538
Avg. Annual % Change		3.8%	3.3%	3.3%	3.2%	3.2%

Source: Colorado Demography Section estimates 8-06

These population figures, however, do not reflect the large number of seasonal residents in the area. A local study on 2nd homes indicates that 60% of properties are owned by people that live outside of the county. The social and economic impacts of these 2nd homes are still being assessed.

The Local Economy

Unemployment Rates

The current strength of the economy supports a low unemployment rate, although seasonal fluctuations are seen in the winter months, when unemployment rises. The unemployment rate has been declining since 2002, and was lower than state and national levels from 2003 to 2005.

Unemployment Rates Compared 2000-2005						
	2000	2001	2002	2003	2004	2005
Archuleta	3.7%	4.3%	5.7%	5.5%	4.9%	4.8%
State Unemploy. Rate	2.8%	3.7%	5.7%	5.7%	5.2%	5.0%
National Unemploy. Rate	4.0%	5.3%	5.8%	6.0%	5.5%	5.1%

Source: Colorado Dept of Labor

Employment and Income 2005

Bureau of Economic Analysis (BEA) employment and income statistics lag by about two years, thus 2004 is the latest year available for review from that agency.

Archuleta County 2005 Total Employment	# of Jobs	% of Jobs	Income ($000)	% of Inc.	Avg. annual wage
*Agriculture	259	4%	$ (4,048)	-3%	*
Mining & Utilities	76	1%	$ 4,099	3%	$ 53,934
Construction	966	16%	$ 29,511	18%	$ 30,052
Manufacturing	85	1%	$ 1,793	1%	$ 21,094
Transportation & Warehousing	45	1%	$ 1,069	1%	$ 23,756
Retail Trade	901	15%	$ 21,762	13%	$ 23,941
Wholesale Trade	57	1%	$ 3,225	2%	$ 56,579
Finance, Insurance & Real Estate	638	11%	$ 25,315	16%	$ 39,066
Services	2,271	38%	$ 51,997	32%	$ 22,896
Government	650	11%	$ 26,853	17%	$ 41,312
Total	5,950	100%	$ 161,576	100%	

Source: Colorado Demography Section 11/06

*Agricultural income reflects net losses from livestock and crop production

However, the Colorado Demography Section makes local adjustments to these data using 2005 employment and income figures.

From this table we see that proprietors (owners) form a substantial part of the total number of jobs, especially in agriculture, construction, and transportation sectors. Note – the differences in total jobs seen in these charts reflect changes made by the Demography Section to some proprietor's data.

# of Wage and Salary Jobs as Compared to # of Proprietors					
Archuleta County	Wage/Salary Jobs		Proprietors		# of Total Jobs
Job Sectors	#	%	#	%	
Agriculture	25	10%	236	90%	261
Mining & Utilities	54	71%	22	29%	76
Construction	438	45%	544	55%	982
Manufacturing	54	63%	31	37%	85
Transportation & Warehousing	18	40%	27	60%	45
Retail Trade	677	74%	232	26%	909
Wholesale Trade	37	65%	20	35%	57
Finance, Insurance & Real Estate	357	55%	291	45%	648
Services	1,517	66%	779	34%	2,296
Government	650	100%	0	0%	650
Total Employment	3,827	64%	2,184	36%	6,011

The service sector is composed of many types of jobs, and very different wage scales. These include highly paid professionals, as well as entry level wage earners.

Archuleta County 2005 Service Sectors	# of Jobs	% of Jobs	Income ($000)	% of Inc.	Avg. annual wage
Information	69	3%	$ 5,838	11%	$ 84,609
Professional, Scientific, Technical	469	21%	$ 10,709	21%	$ 22,834
Education, Health, Social Assistance	314	14%	$ 6,570	13%	$ 20,924
Arts, Entertainment, Recreation	239	11%	$ 8,731	17%	$ 36,531
Accomodation, Food Service	659	29%	$ 10,518	20%	$ 15,961
Other Services	521	23%	$ 9,631	19%	$ 18,486
Total	2,271	100%	$ 51,997	100%	$ 22,896

Source: Colorado Demography Section Sept.06. Includes wage labor and proprietors

Many of the service jobs in Archuleta County support tourism, in accommodation (lodging) and food services.

Town Retail Trade

We can also look at how retail trade is distributed within the county. Pagosa Springs is the only town, but it serves a relatively large population living in unincorporated areas. In 2003 Pagosa Springs pulled in the lion's share (80%) of sales and had most of the retail firms (60%). This changed in 2005, with a decline in Pagosa's total sales, and a rise in sales in unincorporated areas of the county.

Town	Population Estimate 2005	Total Retail Sales	Estimated # of Retail Firms	Average Sales per Firm	Per Capita Sales	% of Sales	% of Firms
Pagosa Springs	1,640	$ 114,444,000	316	$ 362,165	$ 69,783	52.9%	59.5%
Unincorporated	10,076	$ 102,072,000	215	$ 474,753	$ 10,130	47.1%	40.5%
Total	11,716	$ 216,516,000	531	$ 407,751	$ 18,480	100.0%	100.0%

Actual versus Expected Sales

Expected sales are an estimate of the sales level a town would achieve if it were performing on par with Colorado towns of a similar size. This provides a means of comparing what is expected for a town of a certain size to what is actually happening. *Expected sales is the product of town population, state per capita sales, the index of income, and the typical pull factor.* We selected 10 towns from Western Colorado for comparison to Pagosa Springs to calculate a "typical" pull factor, as shown on page five.

2003 Actual Sales $137,891,000	2005 Actual Sales $179,876,000
Expected Sales $25,956,462	Expected Sales $37,833,644
Pagosa 431% above expected	Pagosa 375% above expected

Actual sales in Pagosa Springs far exceeded expected sales (375%).This is probably because the town serves a much larger population in the unincorporated areas, as well as seasonal visitors and 2nd homeowners, who are not included in population figures.

However, the percentage above expected sales is down from 2003. This may indicate that more sales are leaving the county in 2005.

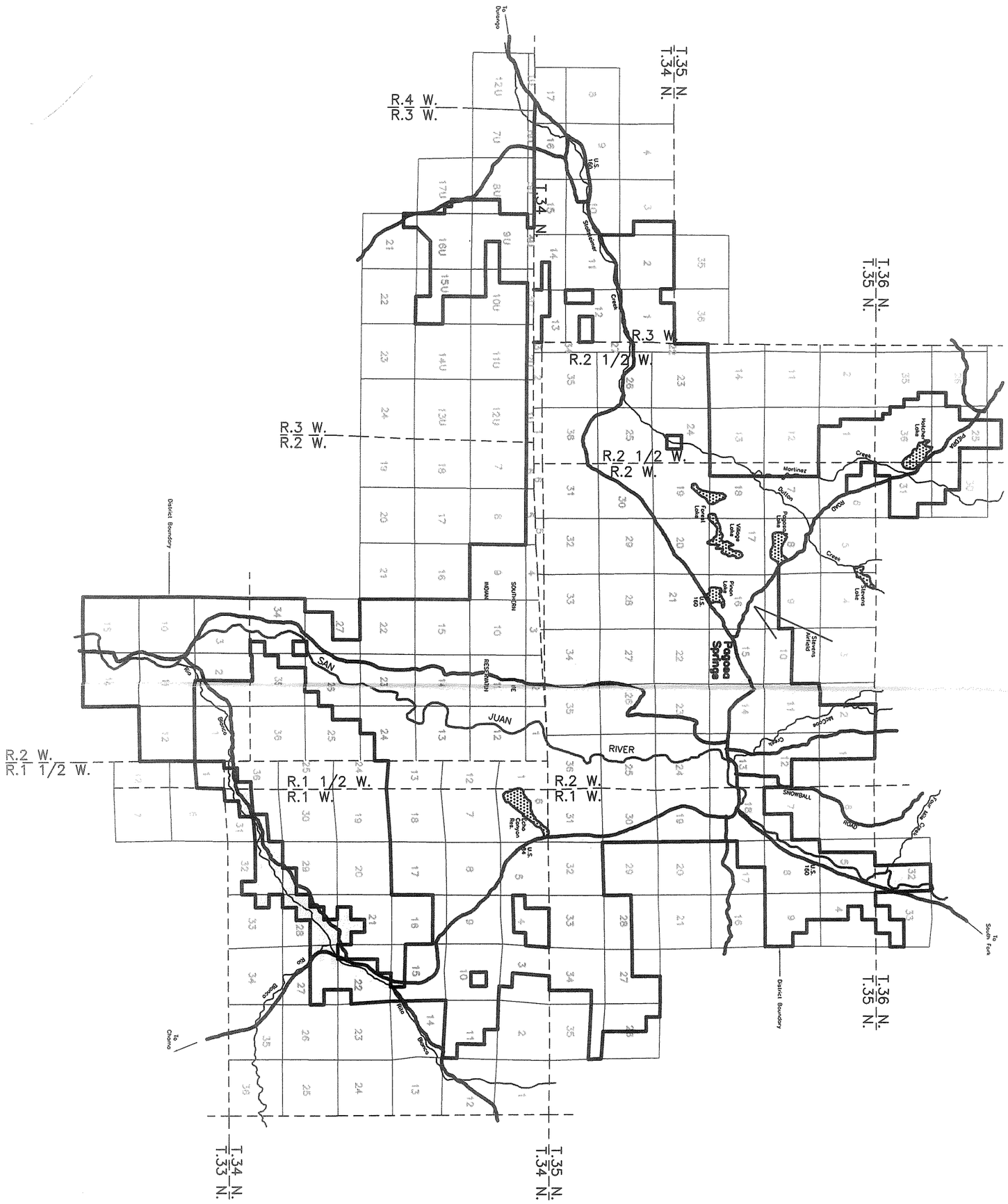
Town of Pagosa Springs potential sales by merchandise category 2005

From this analysis we see that most of Pagosa's retail trade sectors are very strong, although many of the sectors are not disclosed. This suggests that Pagosa Springs serves as a trade center for surrounding areas, which probably include nearby portions of New Mexico. The strongest sector (building materials and garden shops) probably reflects the large number of second / seasonal homes which have been built in Archuleta County by residents from outside of the area. About 59% of private properties in the county are owned by non-locals according to a recent study.

Potential sales are the product of Pagosa's population(1,640), state per capita sales ($26,067), and the index of income (0.59).

Pagosa Springs Retail Trade Sectors 2005	Estimated # of Firms	Average Sales per Firm	Actual Sales	Potential Sales	Surplus or Leakage	Surplus or Leakage as a % of Potential	Percent of Actual Sales
Motor Vehicles/Parts	5	$ 855,600	$ 4,279,000	$ 2,790,009	$ 1,488,991	53%	4%
General Merchandise	5	$ 1,316,400	$ 6,582,000	$ 2,008,057	$ 4,573,943	228%	6%
Sport/Hobby Shops	13	$ 169,385	$ 2,202,000	$ 489,303	$ 1,712,697	350%	2%
Clothing	10	$ 243,100	$ 2,431,000	$ 529,193	$ 1,901,807	359%	2%
Furniture	9	$ 332,667	$ 2,994,000	$ 486,943	$ 2,507,057	515%	3%
Non-store Outlets	16	$ 168,563	$ 2,697,000	$ 318,141	$ 2,378,859	748%	3%
Misc Retail Stores	28	$ 180,643	$ 5,058,000	$ 489,035	$ 4,568,965	934%	5%
Bldg Materials/Garden	8	$ 3,309,625	$ 26,477,000	$ 1,143,080	$ 25,333,920	2216%	26%
Electronics/Appliances	NA	NA	NA	NA	NA	NA	NA
Healthcare Products	NA	NA	NA	NA	NA	NA	NA
Gas Stations	NA	NA	NA	NA	NA	NA	NA
Food/Bevarage Stores	NA	NA	NA	NA	NA	NA	NA
*Confidential Sectors	NA	NA	$ 51,032,000	NA	NA	NA	49%
Total	94	$ 6,576,182	$ 103,752,000				100%

NA = Not available (confidential); *Includes all confidential sectors for which specific data is not available



Sheet 1 of 1

D00831

CLIENT

~~P.A.W.S.D.~~ SJWCD

~~P.O. Drawer 6210~~ 4632

Pagosa Springs, CO 81147

San Juan Water Conservancy District

Area Map

STAMP

SINCE 1948

DAVIS ENGINEERING SERVICE, INC.

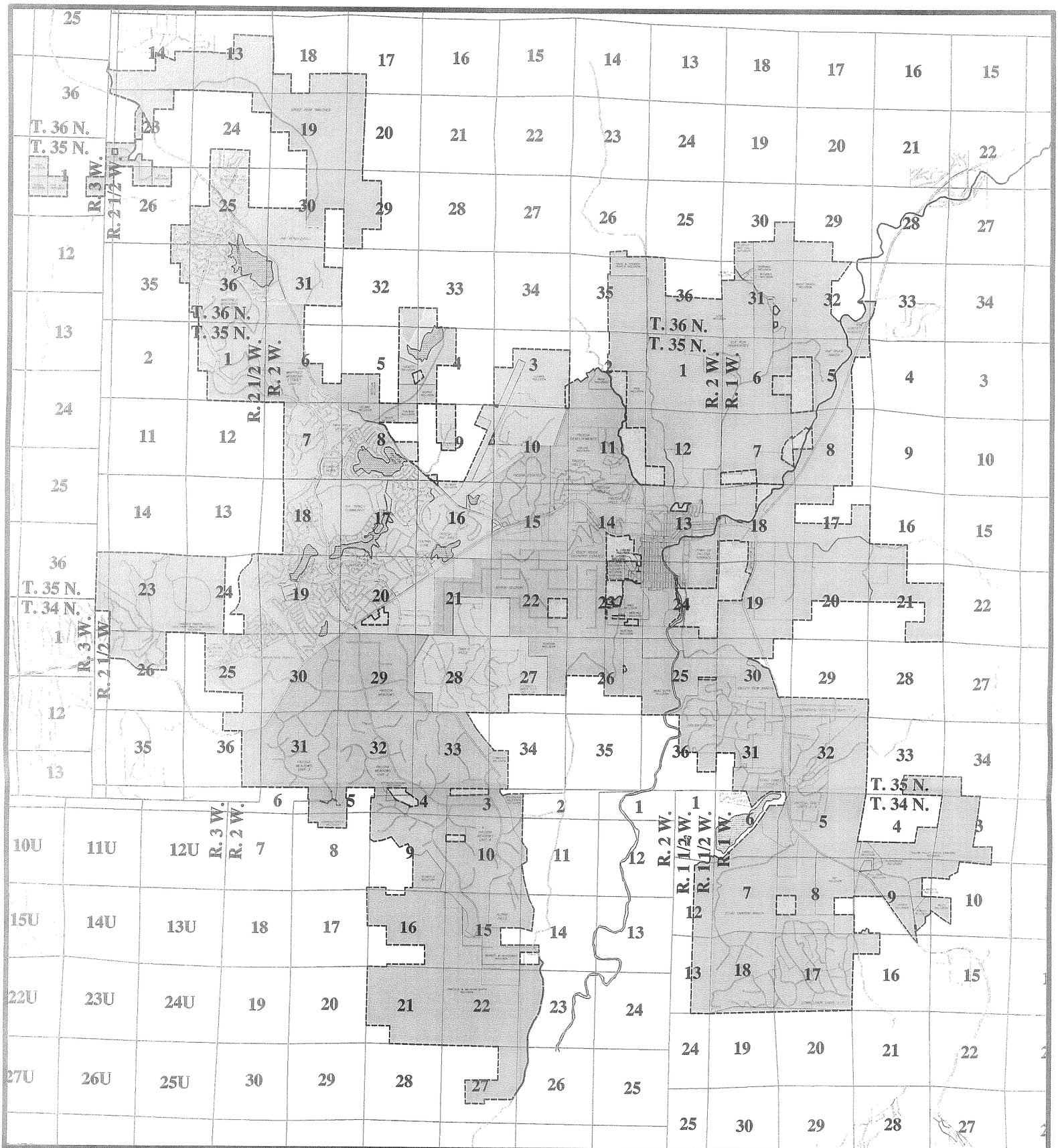
DESIGNED	CHECKED	SCALE
XXX	XXX	1" = 10,000'
DRAWN	APPROVED	DATE
XXX	XXX	January 19, 1995

DAVIS ENGINEERING SERVICE, INC.
185 S. 5th STREET - P.O. BOX 1208
PAGOSA SPRINGS, COLORADO 81147
PHONE: (970) 264-4055
FAX: (970) 264-4055

0' 1" 1.5" 2"

ELEVATION BASE ASSUMED

REV.	DATE	BY	APVD.



YEAR ADDED	INCLUSION NAME	EQUIVALENT UNITS
1994	Beaugureau & MacKenzie	2
	Echo Canyon Ranch	25
	Cleman	20
	Collins	2
	Dempsey & Leal	2
	Eagle Peak Ranches	12
	Giordano	1
	P. & M. Gupta	2
	R. Gupta	13
	Hyde	19
	Quintana	10
	Wilsey	1
1995	Martinez	1
	Sands	1
1996	Alpine Hills Subdivision	12
	Dawson	23
	Forrest	4
	Leake	2
	Maez	5
	Outerbridge	1
	Schaeper	2

YEAR ADDED	INCLUSION NAME	EQUIVALENT UNITS
1997	Ray	6
	Wagner	3
	Dillard	3
	Downey	1
	Bauer	1
	Wildflower Sub. (ex. lots 27, 35, 42-45)	45
	Kukla	1
	Tesman	1
	The River Ranch (S.J.R.E., LLC)	8
	Lucero	1
	Stretton	1
	Frazier (Valley View Ranch, Tr. 1)	1
	Victory Mgmt. (Valley View Ranch, Tr. 2)	2
	Clare (Valley View Ranch, Tr. 3)	1
	Frazier (Valley View Ranch, Tr. 4)	1
	Brown (Valley View Ranch, Tr. 5)	2
	Pond	1
	Gibson	1
	Phy. Med. (Barker)	1
1998	Thalmon	2
	Ketchum	2
	Colorado's Timber Ridge (Machack)	260
	Belmear	14

YEAR ADDED	INCLUSION NAME	EQUIVALENT UNITS
1999	Maes	1
	Macht Ranch	2
	Timbered Canyon, LLC (Elk Park)	119
	David and Yolanda Parker	4
2002	Lunnen/Carter (Hidden Meadows)	5
	Atkinson/Donhart	0
	Wienpahl	1
	Hansen	0
2003	Lomasney	1
	Payne	1
	Morris	1
2004	Humane Society of Pagosa Springs	2
	Hockett	1
2005	Jimmy Lucero	2
	Bernardo Lucero	1
	Madaline Lucero	2

P.A.W.S.D.

PAGOSA AREA WATER AND SANITATION DISTRICT

ORIGINAL SCALE: 1" = 7000'

0' 7000'

INCLUDED IN DISTRICT WATER AND SEWER SERVICE

INCLUDED IN DISTRICT WATER SERVICE ONLY

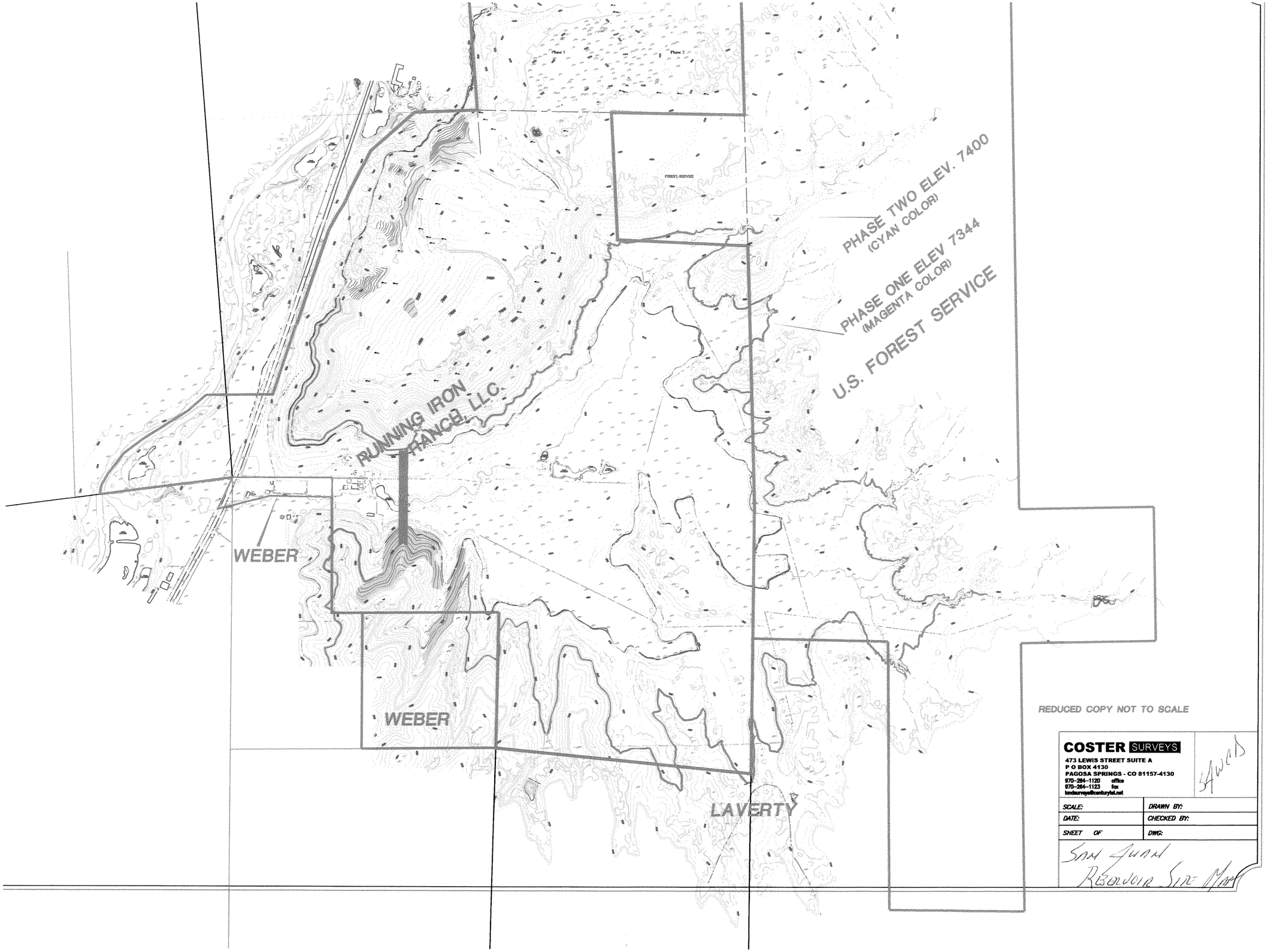
EXCLUDED FROM DISTRICT

MAP OF
PAGOSA AREA WATER AND SANITATION DISTRICT
ARCHULETA COUNTY, COLORADO

PREPARED BY

DAVIS ENGINEERING SERVICE, INC.
188 S. 8th STREET – P.O. BOX 1208
PAGOSA SPRINGS, COLORADO 81147

REVISED DECEMBER 14, 2005



COSTER SURVEYS
473 LEWIS STREET SUITE A
P O BOX 4130
PAGOSA SPRINGS - CO 81157-4130
970-264-1120 office
970-264-1123 fax
landsurveys@centurytel.net

SCALE:	DRAWN BY:
DATE:	CHECKED BY:
SHEET OF	DWG:

SAN JUAN
RESERVOIR SITE MAP

20609216 9/25/2006 12:07 PM June Madrid
1 of 9 JD R$46.00 D$0.00 Archuleta County

(9)

DISTRICT COURT, WATER DIVISION 7, STATE OF COLORADO Court Address: LaPlata County Courthouse 1060 2nd Avenue P. O. Box 3340 Durango, CO 81302	▲ COURT USE ONLY ▲
CONCERNING THE APPLICATION FOR WATER RIGHTS OF THE PAGOSA AREA WATER AND SANITATION DISTRICT AND THE SAN JUAN WATER CONSERVANCY DISTRICT **IN THE SAN JUAN RIVER AND ITS TRIBUTARIES** **IN ARCHULETA COUNTY**	Case No.: 2004CW085 Div.: 7 Ctrm.:

FINDINGS OF FACT, CONCLUSIONS OF LAW, JUDGMENT AND DECREE

THE COURT, having considered the pleadings of the parties and the evidence presented, does hereby find and conclude as follows:

1. Pagosa Area Water and Sanitation District ("PAWSD") and San Juan Water Conservancy District ("SJWCD") (together hereinafter referred to as the "Districts") filed the subject Application for Water Rights on December 20, 2004. The Districts' addresses are:

Pagosa Area Water and Sanitation District
P.O. Box 4610
Pagosa Springs, Colorado 81157

San Juan Water Conservancy District
P.O. Box 4632
Pagosa Springs, Colorado 81157

2. All notices of the application were given in the manner required by law and the Court has jurisdiction over the subject matter of this proceeding and over all persons and property affected hereby, irrespective of whether those persons or owners of property have appeared.

3. Statements of Opposition were filed by Koinonia, LLC, Trout Unlimited, the Park Ditch Company, Inc. and the "Weber Entities" (a collective name for the separate entities of Donald L. Weber, Kathryn L. Weber, Donald Andrew Weber, J.I. Hathaway Family Trust, Running Iron Ranch, LLC and Weber Ranches of Pagosa, LLC; all listed on one Statement of

RETURN:
EVAN D. ELA
COLLINS COCKREL + COLE
390 UNION BLVD. #400
DENVER CO 80228

Opposition c/o Kathryn L. Weber). The time for filing Statements of Opposition has now expired. No other party has made an appearance in this matter.

3.1 Koinonia, LLC stipulated to a draft of this ruling on April 28, 2006, and said stipulation was approved by this Court on April 28, 2006.

3.2 The Park Ditch Company, Inc. stipulated to a draft of this ruling on December 8, 2005, and said stipulation was approved by this Court on April 5, 2006.

3.3 The Weber Entities stipulated to a draft of this ruling on September 16, 2005, and said stipulation was approved by this Court on September 22, 2005.

4. The Division Engineer for Water Division 7 filed a Summary of Consultation with the court on December 20, 2005, based on timely publication of this application in the December 2004 Water Court Resume.

5. Trial to the Court was held on May 3, 4 and 5, 2006, at which evidence was presented by Co-Applicants and Objector, Trout Unlimited.

6. PAWSD is a quasi-municipal corporation of the State of Colorado organized under Section 32-1-101 *et seq.*, C.R.S. PAWSD owns and operates a municipal water system that provides treated and raw water for multiple beneficial uses within its service area, including the Town of Pagosa Springs, Colorado and the majority of residential development within Archuleta County, Colorado. PAWSD has the statutory authority to appropriate water rights, to have and exercise the power of eminent domain and dominant eminent domain, to plan and construct water development projects, and to establish instream flow rights for recreational purposes, among other powers.

7. SJWCD is a quasi-municipal corporation of the State of Colorado organized under Section 37-45-101 *et seq.*, C.R.S. SJWCD provides water conservation, water resources planning, stream improvement, water rights protection and development services within its service area. SJWCD has the statutory authority to appropriate water rights, to have and exercise the power of eminent domain and dominant eminent domain, to sponsor water resources projects, to construct water development projects, to develop and operate augmentation plans and to establish instream flow rights for recreational purposes, among other powers.

8. The Districts filed this application in order to adjudicate conditional water rights for a joint water resources development project that will provide for the future water demands of property owners and residents within both Districts, as such district boundaries change over time.

9. The Districts seek a decree confirming conditional direct flow and water storage appropriations from the San Juan River for the structures and locations described below (hereinafter collectively referred to as the "Dry Gulch Project" or the "Subject Water Rights"):

9.1 Dry Gulch Reservoir.

9.1.1 Legal description of dam and reservoir: Dry Gulch Reservoir will be an off-channel reservoir located on Dry Gulch, an ephemeral tributary to the San Juan River. The center point on the dam axis is located on the section line separating Sections 5 and 8, Township 35 North, Range 1 West, of the N.M.P.M., at a point 1,300 feet west from the Southeast corner of said Section 5. Dry Gulch Reservoir will occupy all or portions of the following quarter-sections, all located in Township 35 North, Range 1 West, of the N.M.P.M.: all of the SW/4, the S/2 of the NW/4, the S/2 and NE/4 of the NE/4, and the S/2 and NW/4 of the SE/4 of Section 4; the SE/4 of the SE/4 of Section 5; the N/2 and SE/4 of the NE/4 of Section 8; and all of the NW/4, all of the NE/4, the N/2 of the SW/4, and the NW/4 of the SE/4 of Section 9.

9.1.2 Dry Gulch Reservoir shall be filled by collecting native runoff and streamflow occurring within the Dry Gulch watershed, and by diversions from the San Juan River at either, or both, the Dry Gulch Pumping Station and Park Ditch river headgate. Dry Gulch Reservoir will be located within Dry Gulch, and depending on its constructed size, will inundate a portion of the Park Ditch. Legal description of filling structures:

9.1.2.1 The point of diversion for the proposed Dry Gulch Pumping Station will be in the San Juan River as it flows through the SE/4 of the SW/4 of Section 5, Township 35 North, Range 1 West, of the N.M.P.M., at a point 3,100 feet from the east section line and 750 feet from the south section line of said Section 5.

9.1.2.2 The point of diversion for the existing Park Ditch is located on the east bank of the San Juan River at a point 11 chains and 10 feet east and 8 chains and 43 feet north of the quarter corner between Sections 27 and 22, Township 36 North, Range 1 West, of the N.M.P.M., from which point the ditch extends in a generally southwesterly direction.

9.1.3 Source: Dry Gulch, an ephemeral tributary to the San Juan River, and the San Juan River.

9.1.4 Date of Appropriation: December 20, 2004, by the filing of the Application in this case. The water storage rights are conditional, water has not yet been applied to beneficial use.

9.1.5 Amount claimed: 29,000 ac-ft, CONDITIONAL, with the right to fill at up to 100 cfs in combination from all sources of water by the exercise of the Dry Gulch Reservoir water storage right, and with the right to refill at the same rate up to 35,000 ac-ft whenever in priority after initial annual filling is achieved. The water storage right claimed herein will be exercised in conjunction with

SJWCD's existing Dry Gulch Reservoir water storage right for 6,300 ac-ft to achieve an initial annual filling of 35,300 ac-ft.

9.1.6 Uses: Water derived from the Subject Water Rights may be used for all municipal uses, including, but not limited to, domestic, industrial, commercial, mechanical, fire protection, sewage treatment, watering of parks, lawns, gardens and other public spaces, irrigation, agriculture, recreation (including releases to benefit decreed recreational in-channel rights), piscatorial and wildlife preservation (including releases to benefit instream flow rights decreed to the Colorado Water Conservation Board), lake and reservoir evaporation, and aesthetic purposes, and for replacement, adjustment and regulation of the Co-Applicant's respective storage and delivery systems, and those of its users, among themselves and with others. Water derived from the Subject Water Rights may also be used to provide raw water by contract to certain customers for irrigation. Co-Applicants may divert, store and use the water directly, by and for exchange, augmentation, substitution, replacement or otherwise, as may be appropriate to maximize its lawful use. Co-Applicants may reuse, successively use, dispose of, and/or otherwise apply all water to extinction. The effluent or other return flow, such as from lawn irrigation, that is discharged or released by Co-Applicants attributable to the exercise of the Subject Water Rights shall have associated with it the same rights of use, reuse, successive use and disposition as water initially diverted. The water may be placed to use within the PAWSD or SJWCD service areas as such now exist or may exist in the future. In addition to all of the uses described herein, prior to storage, water derived by the exercise of the Subject Water Rights at the described points of diversion may be used by relinquishing a portion thereof to the stream to satisfy bypass flow requirements of any federal permits obtained for development of the Dry Gulch Project.

9.1.7 Reservoir dimensions:

9.1.7.1 Total surface area of the reservoir at high water line (elevation 7,400 feet above M.S.L.) will be approximately 621 acres.

9.1.7.2 The maximum height of the dam will be approximately 160 feet.

9.1.7.3 The maximum total length of the dam will be approximately 3,000 feet.

9.1.8 Reservoir capacity: Total capacity of the reservoir is estimated at 35,300 ac-ft, of which 35,000 ac-ft will be active capacity and 300 ac-ft will be dead storage.

9.2 Dry Gulch Pumping Station.

9.2.1 Legal description of point of diversion: same as described in paragraph 8.1.2.1 herein.

9.2.2 Source: San Juan River and its tributaries.

9.2.3 Date of Appropriation: December 20, 2004, by the filing of the Application in this case. The water rights claimed are conditional, water has not yet been applied to beneficial use.

9.2.4 Amount claimed: 80 cfs, CONDITIONAL, for direct flow purposes and/or for storage in reservoirs owned or controlled by the Co-Applicants.

9.2.5 Uses: same as described in paragraph 9.1.6 herein.

10. The Districts have demonstrated a specific plan and intent to divert, store or otherwise capture, possess and control specific quantities of water for specific beneficial uses.

11. The Districts have demonstrated that water can and will be diverted, stored, or otherwise captured, possessed and controlled, will be beneficially used, and that the appropriations will be completed with diligence within a reasonable time.

12. The Districts may divert or store, under the priority awarded herein in the amounts and rates of flow claimed from the San Juan River and Dry Gulch, a tributary of the San Juan River, at the specified diversion points, subject to the terms and conditions specified herein. The Districts have demonstrated that the amount of water conditionally appropriated by this decree is reasonable for the anticipated growth in the population they are responsible to serve.

CONCLUSIONS OF LAW

13. Timely and adequate notice of this application was given in the manner required by law and the court has jurisdiction over the subject matter of this proceeding and over all persons and water rights affected thereby, irrespective of whether those persons or owners of water rights have appeared in accordance with §§ 37-92-203 and 37-92-302, C.R.S.

14. The Districts have entered into Stipulations with Koinonia, LLC, the Park Ditch Company, Inc. and the Weber Entities as described in paragraph 3 herein. The terms of said Stipulations are incorporated herein as enforceable terms of the decree granted herein.

15. The Districts have properly initiated the appropriation of the Subject Water Rights as of December 20, 2004, have proceeded with reasonable diligence in the development of the Subject Water Rights from the date of initiation, have demonstrated that water can and will be

diverted and beneficially used, and that completion of the appropriations can be accomplished with diligence and within a reasonable time, and therefore the Districts are entitled to a decree confirming and approving the Subject Water Rights within the meaning of §§ 37-92-103(3)(a) and 37-92-305, C.R.S. The Districts' intent to beneficially use the Subject Water Rights is nonspeculative and based upon its reasonable needs for a growing population.

16. This decree is administrable by water officials of the State of Colorado.

JUDGMENT AND DECREE

17. The foregoing Findings of Fact and Conclusions of Law are hereby adopted and incorporated into this Ruling, Judgment and Decree as if fully set forth herein.

18. The Districts are hereby decreed a conditional water storage right for Dry Gulch Reservoir confirming the right to storage in the amount of 29,000 acre-feet, along with the right to fill and refill continuously to achieve a total annual storage volume of 64,000 acre-feet by capture of inflow tributary to the reservoir and by diversion from the San Juan River via the Dry Gulch Pumping Station and Park Ditch points of diversion, together at a combined rate not to exceed 100 cfs (not including the additional right described at ¶9.2 herein), with a priority established by the appropriation date of December 20, 2004.

19. The Districts are hereby decreed an additional conditional water right for the Dry Gulch Pumping Station confirming the right to divert water from the San Juan River for direct flow purposes and/or for storage in reservoirs owned or controlled by the Districts, including trans-basin use and storage in District 78 (Piedra River watershed), at a rate of up to 80.0 cfs (not including the 100 cfs additional right described in ¶9.1 herein), with a priority established by the appropriation date of December 20, 2004.

20. The Districts may exercise the storage or direct flow rights independently or in any combination, with the overall limitation that the total combined diversion from all sources, including the Dry Gulch Pumping Station, Park Ditch, and tributary inflow to Dry Gulch Reservoir, shall never exceed 180 cfs at any given time.

21. The Districts shall install and maintain meters, measuring devices or other structures as required by the Division Engineer for Water Division No. 1 to properly account for the water diverted and beneficially used pursuant to this decree.

22. The Districts shall develop accounting forms that accurately account for the use of the water diverted and/or stored by exercise of the Subject Water Rights separately from other water rights owned and exercised by the Districts. Such accounting forms shall be submitted for approval by the Division Engineer prior to the diversion and use of water by exercise of the subject Water Rights, and may be revised from time to time thereafter as deemed appropriate, or as may be required by the Division Engineer.

23. The Offices of the State and Division Engineers dispute whether the Co-Applicants' release of portions of the Subject Water Rights at the points of diversion for satisfying potential bypass flow requirements imposed by federal permits or made a condition of this decree is a beneficial use of water under Colorado water law. The State and Division Engineers and Co-Applicants recognize that the Subject Water Rights are comprised of both direct flow and storage components. The direct flow component will be used to meet direct flow water demand of the Co-Applicants and the storage component will be used to effect storage in Dry Gulch Reservoir. The subject Dry Gulch Reservoir is an off-stream reservoir that relies on diversions from the San Juan River through both gravity-flow and pumped-flow fill structures. Therefore, as terms and conditions of this decree, the State and Division Engineers and Co-Applicants agree that any such release of direct flow water rights to the stream may not be considered a beneficial use by the State and Division Engineers, but the Co-Applicants reserve the right to assert that such use is a beneficial use in future proceedings concerning such rights. In addition, the State and Division Engineers and Co-Applicants agree that although a release to the stream of diversions for storage (fill) at the points of diversion for such rights may not be considered a beneficial use by the State and Division Engineers, such releases shall be administered by such officials as an incidental loss in the exercise of such storage water rights and accounted for against any fill under the priority of the storage rights. Furthermore, Co-Applicants reserve the right to assert that such incidental losses are a beneficial use in future proceedings concerning such rights. The State and Division Engineers reserve the right to assert that any uses described herein, incidental or otherwise, are not beneficial uses in future proceedings concerning the water rights that are the subject of this decree.

24. Return flows from water derived from the Subject Water Rights and returned to the San Juan River shall be reusable by the Districts using any available means that can be properly accounted for. In addition, the Districts, or either of them, may devise and employ an augmentation and/or exchange plan that relies on the reuse of the water appropriated herein. Prior to reusing any portion of the water appropriated herein, the Districts, or either of them, shall obtain water court approval of an augmentation plan and/or appropriative rights of exchange that incorporate the reuse of such water and that provides a specific plan for the quantification, accounting, control and administration of the reuse of such water.

25. The Subject Water Rights are part of the PAWSD integrated municipal water system, and diligence on any part of this system, including other water rights owned by PAWSD, may be considered as proof of diligence as to the conditional Subject Water Rights. Likewise, the Subject Water Rights are part of the SJWCD integrated plans for water resources development, and diligence on any other water resource projects or other water rights owned by SJWCD may be considered as proof of diligence as to the conditional Subject Water Rights.

26. The Park Ditch Company, a *pro se* Objector in this matter, operates the Park Ditch, which traverses through the Dry Gulch Reservoir site and the headgate for which has been designated as a point of diversion for filling Dry Gulch Reservoir by exercise of the Subject Water Rights. The Districts have adopted the following terms and conditions and have entered into a Stipulation with the Park Ditch Company to address the Districts' obligations to

protect the water rights and other assets of the Park Ditch shareholders in connection with the Districts' construction of the project and the use of the Park Ditch as a filling structure for Dry Gulch Reservoir.

26.1 As a condition precedent to diverting water in the Park Ditch by exercise of the Subject Water Rights, the Co-Applicants will enter into an operations and maintenance agreement with the Park Ditch Company addressing the impacts to the Park Ditch Company caused by the Districts' use of the Park Ditch.

26.2 As a condition precedent to modifying the Park Ditch where it crosses the Dry Gulch Project site, the Co-Applicants will consult with the Park Ditch concerning the design standards for modified ditch structures through the site, the schedule that will be followed during construction of such modifications and the methods to ensure continued water deliveries to Park Ditch shareholders located down-ditch.

26.3 The Districts will be responsible for obtaining and bearing the cost of any U.S. Forest Service special use permits, if required by the Districts' use of the Park Ditch for other than strictly irrigation purposes.

27. The Weber Entities, a *pro se* Objector in this matter, own the land upon which the Dry Gulch dam would be constructed and much of the land that would be inundated by Dry Gulch Reservoir. Any activities occurring on land owned by any of the Weber Entities associated with feasibility, design and construction of Dry Gulch Reservoir shall not commence until an agreement has been executed between the Districts, or either of them, and the Weber Entities, or successors and assigns of any of them, concerning the lands affected by such activities, or the affected lands have otherwise been acquired by the Districts, or either of the Districts independently.

28. Trout Unlimited, an Objector in this matter, asserts that certain streamflow rates in the San Juan River should not be diminished by the exercise of the Subject Water Rights. Diversions from the San Juan River shall not be made by exercising the Subject Water Rights at any time that the streamflow in the San Juan River, as measured at the U.S. Geological Survey streamgage known as San Juan River at Pagosa Springs (gage identification no. 09342500), is at or below 50.0 cfs during the period March 1st through August 31st and 30.0 cfs during the period September 1st through February 29th.

29. The conditional water rights priorities awarded herein were filed in the water court in the year 2004, shall be administered as having been filed in that year and shall be administered as junior to priorities filed in previous years. As between competing rights filed in 2004, priority shall be determined by historical dates of appropriation and not affected by the date of entry of this Ruling, Judgment and Decree.

30. If the Districts desire to maintain these conditional subject Water Rights, an application for a finding of reasonable diligence shall be made on or before the last day of September, 2012, or a showing made on or before such date that the conditional water rights

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9 of 9 JD R$46.00 D$0.00 Archuleta County

have been made absolute by reason of completion of the appropriation. The next ensuing diligence period upon which the Court shall make determinations of reasonable diligence and/or findings of perfection shall extend from the date of this decree.

DATED this _15th__ day of _September____, 2006.

Original Signature On File
Gregory G. Lyman
Water Judge
Water Division No. 7

CC: All Parties e-filed

ARCHULETA COUNTY, CO 0170429 04/05/1990 12:24
BK 288 PG 5 JUNE MADRID, RECORDER

Reception No. _____ order.

QUIT CLAIM DEED

SOUTHWESTERN WATER CONSERVATION DISTRICT OF COLORADO

whose address is P.O. Box 475, Durango

County of La Plata , and State of

Colorado , for the consideration of

Ten Dollars and other good and valuable consideration ~~Dollars~~ in hand paid,

STATE DOCUMENTARY FEE
Date APR 5 1990
$ Ø

hereby sell(s) and quit claim(s) to SAN JUAN WATER CONSERVANCY DISTRICT

whose address is P.O. Box 4610, Pagosa Springs

County of Archuleta , and State of Colorado , the following real

property, in the County of Archuleta , and State of Colorado, to wit:

Six thousand, three hundred (6,300) acre feet of water in Dry Gulch Reservoir, adjudicated in Case No. 73-308D on December 19, 1968, Conditional. Appropriation date: July 22, 1967

Location: intersection of dam axis with center line of channel of dry gulch, whence S1/ 4 corner of Section 8, T35N, R1W, N.M.P.M. bears S09° 13' W, 5,724.0 ft., San Juan River.

No Real Property Transfer Declaration accompanied document at time of recording
Archuleta County Clerk & Recorder

~~also known as street and number~~

~~with all its appurtenances~~

Signed this 30th day of March , 19 90

SOUTHWESTERN WATER CONSERVATION DISTRICT OF COLORADO

BY: Fred V. Kroeger
Fred V. Kroeger, President

John E. Toner
John E. Toner, Secretary

STATE OF COLORADO,
} ss.
County of La Plata

The foregoing instrument was acknowledged before me this 30th day of March 1990, by Fred V. Kroeger, President and John E. Toner, Secretary of the Southwestern Water Conservation District of Colorado.

My commission expires 5-5-92

WITNESS my hand and official seal.

Susan Baldinger
Notary Public

APPRAISAL REPORT
TO EVALUATE
FUTURE RAW WATER DEMANDS
AND
WATER SUPPLY ALTERNATIVE PLANS
AS OF MARCH 2003

Prepared for:
SAN JUAN WATER CONSERVANCY DISTRICT
And
PAGOSA AREA WATER AND SANITATION DISTRICT

Prepared by:
Harris Water Engineering, Inc.
954 East Second Avenue
Durango, Colorado 81301
970-259-5322
970-247-0587 fax
steve@durangowater.com

March, 2003

SUMMARY OF TECHNICAL DATA

The Pagosa Area Water and Sanitation District (PAWSD) and the San Juan Water Conservancy District (SJWCD) jointly funded Harris Water Engineering, Inc. to prepare this report. The report was initiated in the spring of 2000 and concluded in the spring of 2003 to evaluate the raw water supply needed in 2040 within the two Districts and the possible alternative plans which might be constructed to serve the 2040 water needs. The study period included the 2002 drought which was the worst drought in historic record and resulted in the firm yield from the alternatives presented herein being modified downward from the initial work in 2000 and 2001.

New information is continually being developed and new conditions are occurring such that the results shown in this report are likely to change in the future; therefore, this report documents the findings as of March of 2003. Any and all of the results summarized in the following bullets are subject to change in the future.

- PAWSD has constructed facilities that will meet the PAWSD water demands through about 2010. With the enlargement of Stevens Reservoir and the Dutton Ditch Pipeline Improvement, the available supply will extend about another 5 years. PAWSD and SJWCD are not in a position of having to develop facilities to meet the current demand, but can focus on meeting the future demands approximately 10 years from now.

- The PAWSD service area has grown at a rate of about 7.1% per year for the past seven years based on equivalent unit usage growth. The Archuleta County population has grown at a rate of 6.4% from 1990 to 2000 based on the US Census data. Since 1980 Archuleta County has grown a rate of 5.1% per year.

- The present PAWSD water usage is 215 gallons per day per permanent resident which was determined by dividing the total water treated by PAWSD by the permanent population within PAWSD (based on 2000 Census data). The water usage by the transient and part time residents is factor into the 215 gallons per day

- The SJWCD/PAWSD annual demand in 2040 based on extrapolation of the historic population growth and water usage is estimated to be 11,732 acre-feet. The water usage and population projections used to estimate the water demand are recommended to be re-evaluated every five years.

- A total flow of 25.4 cfs of water is needed constantly during the peak month for existing and new estimated future water needs.

- Presently there is 6.9 cfs available from the San Juan River in the worst drought; 2.3 cfs from the Snowball Pipeline and 4.6 cfs from the San Juan River Intake.

- 18.5 cfs of new capacity is needed, however, the San Juan River does not have adequate water in a 2002 type drought during July to September requiring storage to supply the demand during the three months.

- A minimum of 4,000 acre-feet of storage is needed to meet the 2040 Demand in July through September including evaporation, seepage and other losses.

- Presently PAWSD has 2,630 acre-feet of existing useable storage. An additional 900 acre-feet of new storage will be provided by the Stevens enlargement and a minimum of another 500 acre-feet is needed at another location. These volumes will just barely meet 2040 demand and will result in all Stollsteimer basin reservoirs being empty in a dry year.

- Enlargement of Stevens Reservoir is assumed to proceed.

- The SJWCD/PAWSD Board of Directors have decided to incorporate the concept of a Supply Safety Margin to establish water supplies through facilities or other measures which will provide the safety margin water managers can rely on when in the middle of drought conditions. This is water in addition to the 25.4 cfs and 4,000 acre-feet of water described above. The Safety Supply Margin components may include:
  - Storage of a one year supply in 2040 or about 12,000 acre-feet of yield.
  - Drought year water restrictions could reduce storage requirement a small amount.
  - The temporary use of up to 18.7 cfs of firm senior water rights (probably irrigation) that could be used during a drought. These water rights would only be used during significant droughts, in most years the water would be used as it was historically.

- One year of storage is the only option that positively provides a Safety Supply Margin. Purchase of senior water rights in a dry year will significantly reduce storage requirement but probably not eliminate storage. Water restrictions do not reduce demand adequately to provide a significant portion of the safety supply margin.

- The Dry Gulch Pump Station is the least costly method to provide the 18.5 cfs of new diversion capacity. This alternative would also replace the 2.3 cfs of existing Snowball pipeline capacity, for a total diversion capacity of 20.8 cfs. This combination with the 4.6 cfs San Juan Pump system will provide 25.4 cfs needed in 2040.

- Dry Gulch Reservoir is the least costly storage alternative for any size reservoir. Dry Gulch Reservoir could be constructed to provide all of the storage requirements.

- The West Fork Reservoir or East Fork Reservoir may be necessary if the Dry Gulch site cannot be developed.

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FUTURE WATER DEMANDS & SUPPLY
FOR THE
PAGOSA AREA WATER AND SANITATION DISTRICT
AND
SAN JUAN WATER CONSERVANCY DISTRICT

The San Juan Water Conservancy District (SJWCD) and Pagosa Area Water and Sanitation District (PAWSD) are working together to develop plans to supply the year 2040 raw water needs within the Districts. The purpose of this summary is to provide the public with an overview of the year 2040 water needs and the status of alternative plans being considered to meet those needs. A firm water supply is defined as "adequate raw water facilities incorporated with conservation measures to provide the normal water demand without mandatory restrictions plus a one year supply safety margin".

How many people will reside in the SJWCD in the year 2040? Based on the US Census data, the Archuleta County population grew at a rate of 4% per year between the years 1980 to 1990, and 6.4% per year between the years 1990 to 2000, for an average of 5.1% per year from the years 1980 to 2000. From the years 1995 to 2001, PAWSD equivalent water units grew at a rate of 7.1% per year. Extrapolating the historic growth, the year 2040 population is estimated to be approximately 52,000.

How much water will be needed? The historic average yearly water usage per person within PAWSD has been 215 gallons per day per person. The value was determined by dividing the total water treated by the permanent population within PAWSD; therefore, the water usage by tourists and commercial use is factored into the 215 gallons per day per person. Extrapolating the historic water usage including anticipated reductions for future water conservation measures, approximately 11,700 acre-feet of water will be necessary in the year 2040 within the boundaries of the Districts.

How accurate are the estimates of population and water demand? Projecting population and water demands nearly 40 years into the future is an exercise in crystal ball gazing. The Districts used the best data available, which is the actual population and equivalent water unit growth rates over the past 20 years. The Districts hope that the estimates are on the high side because having extra capacity in the year 2040 is preferable, rather than having less than the actual needs. The Districts intend to formally review the growth projections and actual water usage approximately every five years to continually monitor water needs and adjust new facilities requirements as appropriate.

Have conservation measures been incorporated into the future estimates? Although not yet adopted, water conservation measures have been assumed that will reduce the average usage per person from the present 215 gallons per day to 200 gallons per day in the year 2035. The Districts will continually review water conservation measures to attempt to reduce the water usage even further.

What is the present annual water usage? The residents of PAWSD presently use about 2,500 acre-feet per year.

What types of facilities are needed to meet the year 2040 demand? The Districts have conducted studies to evaluate the types of facilities needed in the year 2040. A total of 18.5 cfs of new diversion capability is needed from the San Juan River, in addition to the existing 6.9 cfs (2.3 cfs at Snowball and 4.6 cfs at the San Juan Pump). Also, new storage of approximately 500 acre-feet is needed without a safety margin, in addition to the Stevens Reservoir enlargement. These facilities are projected to barely meet the year 2040 demand during a drought such as occurred in the year 2002.

Are the Districts considering a supply safety margin in the event of an even worse drought or some other type of unforeseen situation? Yes! The Districts are investigating three options for a safety supply margin: (1) additional storage to provide 12,000 acre-feet of yeild; (2) emergency conservation measures; and (3) purchase of an interruptible supply from high priority water rights. The Districts are conducting investigations to attempt to have an adequate safety supply margin from any one or a combination of the three options.

How bad was the year 2002 drought? The flow of the San Juan River at the USGS gage at Pagosa Springs was only 13% of the average from April through November. More importantly, during the highest water demand months of June, July and August the San Juan River flow was only 5% of the historic average. In the year 2002, PAWSD was barely able to divert 2.3 cfs at the Snowball Pipeline and 4.6 cfs from the San Juan Pipeline from the San Juan River. Also, the reservoirs were at 45% of capacity in October of 2002.

Did residents reduce water consumption in 2002? The PAWSD residents significantly reduced water usage in 2002, more than was expected. When asked, the residents reduced summer usage by 30% to 40% to levels normally seen in the winter. The Districts sincerely thank the residents for reducing water usage during the drought.

What does the year 2003 water supply look like? The year 2003 water supply looks to be better than the year 2002 but still below average. With the completion of the San Juan Pipeline and assuming somewhat better flows in the San Juan River in year 2003, the PAWSD water needs can be met. However, there is very little safety margin because all of the existing reservoirs may not fill.

How has the drought impacted the ability to meet the year 2040 water demand? The previous driest year, 1977, had adequate summer flows in the San Juan River to meet the summer demands without storage. This was not the case in year 2002, and raw water storage will be necessary to meet nearly the entire year 2040 summer time demand if the San Juan River flows are the same in year 2040 as in the year 2002. The year 2002 drought significantly increased the amount of storage needed to meet the year 2040 demand.

Are existing facilities adequate to meet the existing demand? The present facilities are adequate to provide the daily water demand with the availability of the 4.6 cfs San Juan Pipeline and the 2.3 cfs of direct diversion capability through the Snowball pipeline. If filled, the existing reservoirs (approximately 2,600 acre-feet in Hatcher Reservoir, Stevens Reservoir, Lake Pagosa, and Forest Lake, exclusive of Village Lake) would provide a one year safety supply margin for the present 2,500 acre-foot demand. The Districts do not need to "play catch up" with the raw water facilities but can concentrate on meeting demands after year 2010. Further, with the planned enlargement of Stevens Reservoir in the next two to four years, the existing facilities will meet the demand beyond year 2010.

Where would the additional 18.5 cfs of diversions from the San Juan River and new reservoir sites be located? The Districts are presently evaluating a full range of alternative facilities to meet the raw water demands and no decisions have been made.

Will a vote of residents in one or both Districts be held before construction can begin? Yes. In order to finance construction of the facilities, residents of one or both Districts will vote on the issuance of bonds, depending on whether one or both Districts finance the facilities. Prior to the vote, the Districts will provide specific information on the facilities to be constructed, why those facilities were selected, the cost of the facilities, the ability of the facilities to meet the future water demand, and other pertinent information.

Since there are adequate facilities to meet the demand through about year 2010, why begin evaluating plans now? The lead time to construct a new reservoir is typically a minimum of 10 years and commonly 20 years or more. Therefore, serious work to construct a new reservoir must begin immediately in order to have any chance of having a reservoir constructed when needed.

What needs to be done during the next few years? The Districts will continue to study the potential facilities to determine which facilities are feasible and develop a specific plan to meet the year 2040 demand. The impacts of the year 2002 drought will continue to be evaluated. Water conservation opportunities will continue to be evaluated and incorporated as appropriate.

APPRAISAL REPORT TO EVALUATE FUTURE RAW WATER DEMANDS And WATER SUPPLY ALTERNATIVE PLANS

1.0 INTRODUCTION

The San Juan Water Conservancy District (SJWCD) encompasses a significant portion of Archuleta County including the Town of Pagosa Springs (Town) and the Pagosa Area Water and Sanitation District (PAWSD).

The SJWCD and PAWSD are working in partnership to develop plans to supply the 2040 raw water needs within the two districts. The purpose of this report is to estimate future raw water usage within SJWCD/PAWSD through the year 2040 and to determine what water rights and alternative facilities might be able to provide the firm future raw water supply. A firm water supply for this report is defined as "adequate raw water facilities incorporated with conservation measures to provide the normal water demand without mandatory restrictions plus a one year supply safety margin".

The water treatment and distribution facilities necessary to deliver water to customers are not addressed in this report. The location of the growth relative to County Planning issues are also not addressed.

This report utilizes past work and studies to the maximum extent. For instance, the reports and evaluations for the proposed enlargement of Stevens Reservoir and the improvement of Dutton Ditch for PAWSD have been integrated.

The preparation of this report began in the spring of 2000 and initially used the 1977 drought to estimate the firm yield. Before the completion of the report, it became clear that the 2002 drought was much drier than 1977 and redefined the firm water supply from existing and proposed facilities. Data from and lessons learned in 2002 have been incorporated to the extent available.

2.0 ESTIMATED WATER DEMAND

2.1 Population Estimate

The future water use projections are based on historic population growth using the results of the 1980, 1990, and 2000 US Census and equivalent unit data from PAWSD. The census data shows the population of Archuleta County to be 3,664 in 1980, 5,346 in 1990, and 9,898 in 2000. The associated annual growth rates are: 4% from 1980 to 1990, and 6.4% from 1990 to 2000, and an average of 5.1% from 1980 to 2000. The PAWSD equivalent water units have increased at a rate of about 7.1% per year from 1995 to 2000.

The census populations are for the entire Archuleta County. The SJWCD does not encompass the entire County and for purposes of estimating the population within SJWCD, it is assumed that 95% of the County population is within the SJWCD boundaries. Further, it is assumed that PAWSD serves 75% of the 2000 County population. Based on these assumptions in the year 2000, approximately 9,400 people resided within the SJWCD boundaries and approximately 7,420 people resided within the PAWSD service area. Approximately 2,000 people resided within the SJWCD but outside of PAWSD.

2.2 Analysis of 2002 Drought Year

2002 was the worst drought on record, especially during the summer high usage months. Table A shows a comparison of the flow of the San Juan River at the USGS gage at Pagosa Springs for 1977 (the previous worst drought year), 2002 and the historic average. The entire summer from April through November was only 13% of average. As can be seen the drought was worst in the highest water demand months of June, July and August when there was only 5% of the historic average; 1977 had considerably more flow due to summer rains than 2002.

Table B shows the number of days below 30 cfs, 20 cfs, and 10 cfs during historic low flow periods from 1952 to present. The last row shows 2002 which is the only year that has had flows less than 10 cfs for a significant length of time and 2002 had the most days below 20 cfs. To compound the impact on the ability to provide the 2040 water demand the drought occurred during the highest usage period for June, July and August.

The PAWSD Water Conservation Plan initiated in 2000 describes four water conservation levels that can be instituted in drought conditions. A summary of the conservation levels is below. Refer to the Water Conservation Plan for a full description of each level.

> Alert Status: PAWSD will begin daily observations of water levels in the reservoirs and direct flow rates in the river. Preliminary notification given to customers explaining that if the conditions responsible for the water depletions continue, water restrictions may be forthcoming and asking for their voluntary help in conserving water.
>
> Conservation Level One: Raw water irrigation of lawns (including golf course) will be restricted to the hours of 8:00 pm to 8:00 am on odd numbered days. Treated water irrigation will be allowed every other day based on street address from 8:00 pm to 8:00 am.

TABLE A

COMPARISON OF AVERAGE, 1977 AND 2002 SAN JUAN RIVER FLOW AT PAGOSA SPRINGS

	San Juan River at Pagosa Springs USGS Gage (09342500)								
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Accum.
1977 Monthly volume (af)	8,376	15,535	9,684	5,942	15,084	8,547	9,452	4,123	76,743
1977 % of average	26%	19%	13%	27%	118%	88%	97%	71%	31%
2002 Monthly volume (af)	9,124	9,823	3,573	913	810	1,572	4,141	3,252	33,208
2002 % of average	28%	12%	5%	4%	6%	16%	42%	56%	**13%**
Historical average (af)	32,100	79,980	73,890	22,413	12,748	9,742	9,794	5,831	246,498

May through September 2002 flow was 8% of the historic average.
June through August 2002 flow was 5% of the historic average.

Assumptions: 2002 flow data is provisional and subject to small changes by USGS when published.

TABLE B

DAYS SINCE 1952 WITH LESS THAN 30 CFS AT THE SAN JUAN RIVER AT PAGOSA SPRINGS GAGE

Period	Season of Year	Total # Of Days Less Than 30 cfs	Days Between 20 - 30 cfs	Days Between 10 - 20 cfs	Days Less Than 10 cfs
(1)	(2)	(3)	(4)	(5)	(6)
9/4/53 to 10/14/53	fall	39	15	24	
11/28/54 to 12/18/54	winter	6	6		
11/2/55 to 11/16/55	fall	20	18	2	
9/1/56 to 10/23/56	early fall	53	18	33	2
9/1/62 to 9/20/62	late summer	14	12	2	
1/9/64 to 2/22/64	winter	20	20		
10/27/66 to 11/6/66	fall	11	11		
9/5/74 to 9/21/74	early fall	12	12		
11/10/75 to 11/27/75	fall	10	10		
12/21/76 to 1/1/77	winter	12	12		
8/18/78 to 10/22/78	late summer	48	28	20	
11/28/89 to 2/17/90	winter	59	56	3	
6/26/02 to 9/27/02	summer	82	15	47	20

Assumptions: Gage records for San Juan at Pagosa gage begin in 1952.

The days below a certain flow are not always consecutive during the period.

Conservation Level Two: Raw water irrigation of lawns and gardens will be restricted to the hours of 8:00 pm to midnight one day per week. Treated water irrigation will be allowed once per week for 4 hours. Significant rate increases are instituted for usage over 8,000 gallons per equivalent unit per month. Please see the Water Conservation Plan for the details of implementing this Conservation Level.

Conservation Level Three: No outside watering. Monthly minimum usage is reduced to 5,000 gallons from 10,000 gallons and water usage over 5,000 gallons has a major cost penalty. Please see the Water Conservation Plan for the details of implementing this Conservation Level.

Table C shows the results of initiating the various Conservation Levels in 2002, measured in gallons used per capita per month. Table C shows the historic usage per capita in column 2, the actual usage in 2002 resulting from restrictions in column 3, the 2002 percent of average in column 4, and column 5 lists the Conservation Level.

PAWSD initiated Alert Status in May of 2002 with essentially the same per capita usage as occurred historically. Level One Conservation began on about June first with a substantial reduction in water usage, 77.5% of average. The usage decreased further in July under Level One Conservation to 60.2% of average. Level Two Conservation began on about August first and the usage dropped further per capita to 175 in August then 156 in September and 143 in October. The September and October usage was below the historic winter usage. Once the Level One Conservation measures were implemented the PAWSD water users significantly reduced water consumption to respond to the drought. The average percentage decrease in per capita usage for the June through October period is about 70% of the historic average.

The drought of 2002 showed the following:

- ✓ The firm supply from the San Juan River during the drought is only about 6.9 cfs.
- ✓ Mandatory conservation reduced the water usage during the drought by about 30% of the historic average usage.
- ✓ The reduction in water usage was primarily achieved by restricting outside irrigation. However, in-house use was also reduced as indicated by the September and October usage amounts that are less than the historic winter use.
- ✓ Promotion of water conservation measures to reduce outside irrigation will reduce the per capita usage to a large extent and in-house measures will reduce usage to a lesser extent.
- ✓ In the middle of a drought, water managers will be extra conservative because the water availability may continue to worsen. A supply safety margin is needed to provide water over and above the "normal" supply.

TABLE C

2002 WATER RESTRICTION RESULTS

Month	Historic Average (g/cap/day	2002 Average (g/cap/day	% of Average	Restriction Level
(1)	(2)	(3)	(4)	(5)
January	164			none
February	168			none
March	169			none
April	169			none
May	238	251	105.4%	voluntary
June	332	257	77.5%	Level 1
July	312	188	60.2%	Level 1
August	253	175	69.4%	Level 2
September	240	156	65.3%	Level 2
October	184	143	77.5%	Level 2
November	168			
December	178			

Assumptions: The historic average is calculated using the PAWSD water treatment plant production each month from 1995 through 2000 and dividing the production by the population. The population is determined by a straight line interpolation between the 1990 and the 2000 Census data shown in Table D.

PAWSD has approximately 1.5 people per equivalent unit.

2.3 Existing Water Usage

At the end 2000, PAWSD was serving 5,081 equivalent units. Based on the US Census explained above, the permanent population estimate within PAWSD is 7,420. Therefore, there is approximately 1.5 people per equivalent unit.

The population estimate used herein only includes permanent residents as defined by the Census Bureau. Therefore, the population estimate does not include the significant transient population from tourism from over 1,350 motel rooms, condos/time shares, cabins, and bed and breakfasts within the PAWSD service area. In addition, many of the homes in the service area are used only part of the year, with the residents having their permanent homes in other states. The water usage by the transient population is factored into the permanent population per capita water usage.

In order to determine the water usage, the records kept by PAWSD were used to estimate the per capita (permanent resident) and per equivalent unit water usage and are summarized in Table D.

The Table D columns are:

- Column 1 shows the years from 1995 to 2000 which data is available.
- Column 2 is the estimated permanent population within PAWSD for each year, estimated by a straightline interpolation between the 1990 and 2000 Census data.
- Column 3 is the actual end of year equivalent units determined by PAWSD.
- Column 4 is the actual total water treated each year.
- Column 5 is the average yearly usage per person, determined by dividing the water treated (Column 4) by population (Column 2).

The average daily water usage for PAWSD for the 6 year period from 1995 through 2000 is 215 gallons per capita (325 gallons per equivalent unit). The average yearly use of 215 gallons per person per day is assumed to reflect the water usage for the entire SJWCD area.

The projection of population within the SJWCD/PAWSD service area is for the purposes of estimating future raw water demands and the resulting need for facilities. The population estimates are NOT meant to be used for land use planning nor were they correlated with land use plans. An attempt was made to make the projections slightly on the high side, because being too low could result in future water shortages due to lack of facilities. The projections should be reevaluated every five years to assess whether adjustments should be made in the projections and the resulting need for facilities. At this point in time, the worst that can happen if the population projections are a little high is the facilities may be able to meet the water demand a few years past 2040.

TABLE D
PAWSD WATER USAGE PER CAPITA AND EQUIVALENT UNITS

Year	Estimated Population (persons)	Actual Equivalent Units (eq)	Actual Total Water Treated (mg)	Average Yearly Per Capita Usage (g/p/d)
(1)	(2)	(3)	(4)	(5)
1995	5410	3593	442.43	212
1996	5815	3905	461.99	209
1997	6215	4215	486.31	208
1998	6615	4482	574.08	233
1999	7020	4761	547.90	211
2000	7420	5081	594.46	220
Six Year Average Usage				215

Table D Assumptions:
The population estimates for each year are a straightline extrapolation between the 1990 and 2000 census estimates.

The Equivalent units are year end values.

The Total Water Treated is water produced at the treatment plants and does not include raw water irrigation, primarily at the golf course. Losses in the distribution system are included with the per capita use estimates, per capita usage at each home will be less.

2.4 2040 Water Demand Estimate

Table E shows the estimated future water usage in five year increments from 2000 to 2040 based upon: (1) 215 gallons per capita per day in the first 10 years decreasing to 200 in 2035 to reflect water conservation measures; (2) 7.1% per year from 2000 to 2010 to coincide with growth during the 1990's reflected in the census data (6.4% per year) and the equivalent tap growth (7.1% per year); (3) 4.0% per year from 2010 to 2025 to reflect the growth during an economically depressed period such as occurred in the 1980's; and (4) 3% per year from 2025 to 2040 to reflect the long term growth rate for purposes of this report. The average growth rate for the 40 year period is 4.4% per year.

The columns in Table E are:

- Column 1 shows the years in 5 year increments from 2000 to 2040.
- Column 2 is the yearly growth rate during each 5 year increment.
- Columns 3 and 4 show the equivalent units and the population for each 5 year increment.

- Column 5 is the per capita use estimate of 215 gallons per person per day initially derived in Table D decreased to 200 in 2035 to reflect water conservation.
- Columns 6 and 7 are the estimated water demand for each 5 year increment in acre-feet and million gallons. The total water demand in SJWCD/PAWSD in 2040.

The PAWSD portion of the SJWCD water requirements is shown on Table F which has the same format and columns as Table E. Of the 11,732 acre-feet requirement within SJWCD, 9,261 acre-feet is estimated to be needed within the PAWSD service area if PAWSD water usage and/or boundaries expand at the same rate as the population. PAWSD could have greater or smaller expansion depending upon policies to include areas presently not in PAWSD, resulting in a larger or smaller population in PAWSD. Also, the cooperation and cost sharing relationship of service to homes in the SJWCD but outside PAWSD is not considered herein.

TABLE E

ESTIMATED SJWCD/PAWSD FUTURE RAW WATER DEMANDS

Year	Annual Growth Rate	Equivalent Units (EQ)	Estimated Permanent Population	Per Capita Daily Usage (g/per/day)	Total Annual Demand (acre-feet)	Total Annual Demand (million gallons)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
2000		6,437	9,400	215	2,264	738
	7.1%					
2005		9,070	13,246	215	3,190	1,039
	7.1%					
2010		12,781	18,665	215	4,495	1,465
	4.0%					
2015		15,550	22,709	210	5,342	1,741
	4.0%					
2020		18,919	27,628	210	6,499	2,118
	4.0%					
2025		23,018	33,614	205	7,719	2,515
	3.0%					
2030		26,684	38,968	205	8,948	2,916
	3.0%					
2035		30,934	45,175	200	10,120	3,298
	3.0%					
2040		35,861	52,370	200	11,732	3,823

Assumptions:

* The growth rates are based on 1980, 1990, and 2000 census data and PAWSD Equivalent growth from 1995 to 2001.
* The per capita usage is decreased from 215 to 200 to reflect water conservation actions.
* The SJWCD service area is assumed to have 95% of the Archuleta County 2000 census.

TABLE F

ESTIMATED PAWSD FUTURE RAW WATER DEMANDS

Year	Annual Growth Rate	Equivalent Units (EQ)	Estimated Permanent Population	Per Capita Daily Usage (g/per/day)	Total Annual Demand (acre-feet)	Total Annual Demand (million gallons)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
2000		5,081	7,420	215	1,787	582
	7.1%					
2005		7,160	10,456	215	2,518	821
	7.1%					
2010		10,089	14,733	215	3,548	1,156
	4.0%					
2015		12,275	17,925	210	4,217	1,374
	4.0%					
2020		14,934	21,809	210	5,130	1,672
	4.0%					
2025		18,170	26,534	205	6,093	1,985
	3.0%					
2030		21,063	30,760	205	7,063	2,302
	3.0%					
2035		24,418	35,659	200	7,989	2,603
	3.0%					
2040		28,308	41,339	200	9,261	3,018

Note: The year 2000 equivalent units are the actual PAWSD units at the end of 2000.
The year 2000 population is 75% of the 2000 census for Archuleta County.
The growth rates are based on census data and equivalent units.

2.5 Estimated Existing Supply

With the completion of the San Juan River Intake in the spring of 2002 and the record drought in 2002, the operation and yield of the existing facilities has changed from estimates made previous to 2002. The existing supply described herein is based on criteria developed during 2002 (see Section 2.2).

A firm water supply for this report is defined as "adequate raw water facilities and conservation measures to provide the normal (non-shorted) water demand in 2040 plus a one year supply safety margin of one year".

Preliminary conclusions from the 2002 drought include changing the PAWSD operation in order to keep the upper reservoirs full to the extent possible. The Hatcher and Stevens Treatment Plants would only be used when there is water in excess of the amount needed to keep the upper reservoirs full. The San Juan Pipeline and Treatment Plant would be utilized most of the time. The following hierarchy would implement the concept through the allocation of Dutton Ditch water and runoff in the reservoirs:

Priority 1. Fill Hatcher Reservoir and keep full by continually replacing evaporation
Priority 2. Fill Stevens Reservoir and keep full by continually replacing evaporation
Priority 3. Fill Lake Pagosa and keep full by continually replacing evaporation
Priority 4. Operate Hatcher Treatment Plant to serve Just Hatcher Area
Priority 5. Fill Lake Forest and keep full by continually replacing evaporation
Priority 6. Fill Village Lake but do not replace evaporation
Priority 7. Use Hatcher and/or Stevens Treatment Plants to serve the entire PAWSD area to the extent of the water supply available after meeting the Priorities 1 through 7 and treatment plant capacity is available
Priority 8. Keep Village Lake full
Priority 9. Spill

By the end of 2002, PAWSD will have the following facilities installed:

- Direct diversion firm supply from Snowball of 2.3 cfs
- Direct diversion firm supply from San Juan Intake of 4.6 cfs
- Ability to convey treated water from San Juan TP to entire Hatcher service area
- Available active storage of 2,630 acre-feet in Hatcher, Stevens, Pagosa and Forest (Village not included) assumes that Dutton Ditch will be able, as a minimum, keep these reservoirs filled

If the proposed Dutton Ditch/Upper Reservoir operating criteria and the facilities listed above had been in place in the year 2000 and fully operational prior to the drought of 2002, PAWSD would have had 6.9 cfs of firm direct supply from the San Juan River (2.3 cfs Snowball and 4.6 cfs San Juan Pipeline) and 2,630 acre-feet of capacity in the four lakes other than Village. This water supply would have been adequate to supply the non-restricted water demands during 2002 with a one year supply in reserve storage, thus meeting the definition of a firm water supply for the 2000 and 2005 PAWSD water demand.

In summary, PAWSD has done an excellent job in constructing facilities to meet the existing demand and have a good supply safety margin. PAWSD and SJWCD do not have to "catch up" with facilities to meet existing demand but can focus on new facilities to meet future water demands.

2.6 Estimated New Supply to Meet 2040 Demand

Table G shows a dry year scenario, such as occurred in 2002, to estimate the new diversion capacity and storage requirement to meet the 2040 demand.

- Column 1 – Month of the year.
- Column 2 - The 2040 monthly demand in acre-feet based on the historic monthly use pattern for PAWSD. June is the peak month needing 1,512 acre-feet.
- Column 3 - The 2040 monthly demand in average cfs for the month. June is the peak month needing 25.4 cfs.
- Column 4 - The firm supply in acre-feet from the existing 4.6 cfs San Juan diversions.
- Column 5 - The firm supply in acre-feet from the existing 2.3 cfs Snowball diversion.
- Column 6 - The remaining demand to be met by future diversions and existing storage.
- Column 7 - New diversions from the San Juan River of 18.5 cfs to meet the 25.4 cfs demand but there is insufficient flow in the San Juan River from July through September in a dry year to provide the new 18.5 cfs.
- Column 8 – 2,403 acre-feet of water needed from storage to supplement the direct diversions from the San Juan River from July through September.
- Column 9 – Potential inflow to Stollsteimer Reservoirs (Hatcher, enlarged Stevens, Pagosa, Forest, not Village) from the Dutton Ditch, assumed to be 3 cfs during November and December.
- Column 10 - The Stollsteimer basin reservoirs with 3,530 acre-feet of available capacity (2,630 acre-feet existing plus 900 acre-feet from enlarged Stevens, refer to Table H) are used to supplement the direct diversions, but are totally emptied by the end of August. The reservoirs are partially filled by inflow in November and December. The calculation assumes 30 acre-feet per month per reservoir of evaporation (total 120 acre-feet per month) from May through September. The reservoirs are emptied by the end of August leaving 493 acre-feet of water to be provided by another reservoir.
- Column 11 – Assumes an offstream reservoir such as Dry Gulch that can be filled with San Juan River water either by pumping or gravity. This reservoir will be used to meet the 493 acre-feet of demand not met by the Stollsteimer Reservoirs. Assumes 60 acre-feet per month of evaporation from May through September.
- Column 12 – Inflow from the San Juan River to refill the reservoir.

Table G shows that the facilities needed to meet the 2040 demand must provide:

- At least 25.4 cfs of direct supply from the San Juan River, 6.9 cfs already exists; therefore, 18.5 cfs of new diversion capacity is required.

- About 4,000 acre-feet of active storage capacity is needed when the San Juan River diversions are inadequate and to account for evaporation. The existing storage capacity in the Stollsteimer Basin Reservoirs including the Stevens Reservoir Enlargement is about 3,530 acre-feet. An additional 493 acre-feet is needed.

- A Supply Safety Margin - see discussion below.

This study focuses on the water demand in 2040 and potential facilities to meet the demand. The net new water supply needed in 2040 is:

- 18.5 cfs of direct diversion (25.4 cfs minus 6.9 cfs)

- Enlargement of Stevens Reservoir with existing Stollsteimer basin reservoirs will provide about 3,530 acre-feet of storage.

- Additional storage of at least 493 acre-feet is required to just barely meet the 2040 demand.

- Supply Safety Margin of approximately a one year supply, available in unforeseen circumstances, as discussed below.

TABLE G

2040 Demand versus Dry Year Supply

Month	SJWCD 2040 Demand (Ac-Ft)	SJWCD 2040 Demand (cfs)	San Juan Intake 4.6 cfs	Snowball Intake 2.3 cfs	Remaining Demand	New SJ Diversion(s) 18.5 cfs	Needed From Storage	Inflow to Stoll Storage	Stollsteimer Reservoirs EOM	Dry Gulch Reservoir EOM	Inflow to Dry Gulch Res
	(Ac-Ft)	(cfs)	(Ac-Ft)	(Ac-Ft)	(Ac-Ft)	(Ac-Ft)	(Ac-Ft)	(Ac-Ft)	(Ac-Ft)	(Ac-Ft)	(Ac-Ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
January	750	12.2	283	141	326	326	0		3530	4000	
February	766	13.8	256	128	383	383	0		3530	4000	
March	773	12.6	283	141	349	349	0		3530	4000	
April	768	12.9	274	137	357	357	0		3530	4000	
May	1085	17.6	283	141	661	661	0		3410	3940	
June	1512	25.4	274	137	1101	1101	0		3290	3880	
July	1420	23.1	283	141	996	0	996		2174	3820	
August	1152	18.7	283	141	728	0	728		1327	3760	
September	1090	18.3	274	137	679	0	679		647	3700	
October	842	13.7	283	141	418	418	0		647	4193	493
November	765	12.9	274	137	354	354	0	180	827	4193	
December	809	13.2	283	141	385	385	0	180	1007	4193	
Totals	11732		3331	1666	6735	4333	2403				

Assumptions:

* Stollsteimer Reservoirs include: Hatcher, Enlarged Stevens, Pagosa, Forest, not Village.
* Assumes that the Stollsteimer Reservoirs will be filled in the spring before a 2002 type drought.
* The monthly water demand in columns 2 and 3 was derived from PAWSD usage data from 1995 to 2000.
* Evaporation is estimated as 30 acre-foot per month from May to Sept. for each Stollsteimer Reservoir and accounted for in Reservoir EOM.
* Evaporation is estimated as 60 acre-foot per month from May to Sept. for Dry Gulch and accounted for in Reservoir EOM.
* Column 9 assumes 3 cfs of inflow from the Dutton Ditch beginning in November to fill the Stollsteimer Basin Reservoirs.
* Dry Gulch Reservoir is used to supply the additional 493 acre-feet as an example with inflow capacity of at least 9 cfs.
* The 2002 drought showed that the San Juan River would not yield more than 6.9 cfs therefore there are no new diversions during July to September.
* EOM is end of month.

2.7 Supply Safety Margin

The need for a Supply Safety Margin became very clear during the drought of 2002. Even though the supply numbers showed there was probably adequate water without restrictions, the PAWSD Board instigated Level One then Level Two restrictions in order to assure adequate water this winter and next summer. In short, when you are in the middle of a drought you do not know how long the drought will last so conservatism is the best policy. The concept of a Supply Safety Margin is to establish water supplies through facilities or other measures which will provide the safety margin water managers can rely on when in the middle of drought or other unforeseen conditions.

Through discussions with the PAWSD and SJWCD Boards, the minimum Supply Safety Margin was determined to be a one year supply in reserve through one or all of the following methods.

Three conceptual types of safety margins:

1. **Construct facilities that can provide a firm supply if all other sources of supply are not available.** This requires storage and is assumed to be a one year supply in storage which would be about 12,000 AF of annual yield. The actual storage amount is dependent upon reservoir location, water supply and other conditions.

2. **Emergency conservation measures.** Based on Level 1 and 2 restrictions, the 2040 summer demand could be reduced about 1,800 AF and the amount needed from storage from 2,400 AF to 1,300 AF. Thus, the supply safety margin storage amount is only reduced to about 11,000 AF of annual yield. The estimated does not include additional conservation measures that may be instituted by the District's to attempt to reduce the 2040 demand.

3. **Develop plans to purchase water during dry years from high priority irrigation water rights to supplement summer demands.** Approximately 18.7 cfs of additional firm water supply during a drought year might replace most, if not all, of the one year safety supply storage volume. This supply is only needed in the worst drought case, maybe once in 50 or 100 years.

2.8 Water Demand Location

The location of the water demands is important in evaluating alternative facilities to provide the 2040 supply. Though difficult to predict, the majority of the water demands are expected to occur in and west of Pagosa Springs in the Stollstiemer Creek basin. Though there will be increases east and south of Pagosa Springs, as well.

This report is based upon the existing SJWCD boundaries but no assumption is made regarding the future PAWSD boundaries. When water service is provided within the SJWCD but outside the existing PAWSD, it is not yet clear whether PAWSD will expand to include the new areas or whether SJWCD will serve these areas. The net 2040 raw water demand is only generally separated by service area as shown in Table F.

2.9 Comparison to 1989 Report

An engineering report was prepared in 1989 to estimate the population and water usage from 1990 to 2025. The Report assumed that the 1990 population of the SJWCD was 8,935 persons which was significantly higher than the 1990 census population of 5,346; as a result, the 2000 population was over-estimated to be 13,240 rather than the actual number of 9,898. However, the rate of growth was underestimated to be 4.8% from 1990 to 1995 and 3.9% from 1995 to 2000; the actual rate was over 6.5 %.

The 2025 population estimate in 1989 was 23,665 compared to the current estimate of 33,614.

Even though the 1989 population estimate was high through 2000, it was low for the following years. Also, the population estimate outside of the PAWSD was significantly over-estimated in 1989. Most of the growth in the SJWCD has occurred in the PAWSD service area.

3.0 AVAILABLE WATER RIGHTS

The water rights available to SJWCD and PAWSD are listed in Table I. The water rights are separated into Stollsteimer Creek Basin and San Juan River Basin. A comment is included for each right to indicate its current status and availability for future water supply. These water rights are described in more detail below.

3.1 Stollsteimer Creek Basin Water Rights

3.1.1. Dutton Ditch

The Dutton Ditch has three water rights, 8.0 cfs of absolute rights for diversion from Four Mile Creek, 40 cfs of conditional water rights for diversion from Four Mile Creek half held by PAWSD and half by SJWCD, and 12.5 cfs of absolute water rights to collect intervening runoff into the Dutton Ditch.

PAWSD is planning to improve the Dutton Ditch by installation of a pipeline to more efficiently convey the 8.0 cfs of absolute and maybe a portion of the 40 cfs of conditional rights.

3.1.2 Hatcher Reservoir

Hatcher Reservoir is an existing reservoir with 1,734 acre-feet of capacity of which 884 acre-feet is active and available. Hatcher is filled primarily by the Perkins Ditch and Dutton Ditch. The improved Dutton Ditch will provide more water to the reservoir.

3.1.3 Existing Stevens Reservoir

Stevens Reservoir is an existing reservoir with 634 acre-feet of capacity with 530 acre-feet active and available, 104 acre-feet is inactive to allow for sediment and poor water quality. Stevens is filled by the Dutton Ditch and basin runoff. The improved Dutton Ditch will provide more water to the reservoir.

3.1.4 Lake Pagosa (aka Sullenberger Reservoir)

Pagosa Lake is an existing reservoir with 1,120 acre-feet of capacity of which 920 acre-feet is active and available, 200 acre-feet is inactive to allow for sediment and poor water quality. Pagosa is filled primarily from basin runoff and spills from Stevens Reservoir. The improved Dutton Ditch will provide more water to the reservoir.

3.1.5 Village Lake

Village Lake is an existing reservoir with 615 acre-feet of capacity. Village is filled primarily from basin runoff and spills from Lake Pagosa. The reservoir is the source of water for the golf course and the water supply is used primarily for the golf course. PAWSD and the golf course are attempting to develop facilities so that the reservoir can also be filled using the San Juan Pipeline.

For purposes of the analysis herein, Village Lake is assumed to be used exclusively for the golf course. Filling of this reservoir is the last priority for PAWSD water supplies.

3.1.6 Lake Forest

Lake Forest is an existing reservoir with 450 acre-feet of capacity of which 300 acre-feet is active and available, 150 acre-feet is inactive to allow for sediment and poor water quality. Forest can be filled from basin runoff, spills from Lake Pagosa, and the San Juan Pipeline.

3.1.7 Stollsteimer Basin Storage Summary

Table H is a summary of storage in the Stollsteimer Basin.

TABLE H
SUMMARY OF STOLLSTEIMER BASIN STORAGE

Reservoir Name (1)	Capacity When Full (ac-ft) (2)	Approx. Unusable Capacity (ac-ft) (3)	Maximum Useable Capacity (ac-ft) (4)
Hatcher	1734	854	880
Stevens	634	104	530
Forest	450	150	300
Village	615	Golf course	0
Pagosa	1120	200	920
Totals	4553	970	2,630

Table H Assumptions:
Village Lake is assumed to be used totally for golf course irrigation and is not available for municipal water supply.

Hatcher Reservoir unuseable amount is due to the configuration of the reservoir and outlet pipe which precludes use of 854 acre-feet without removing a ridge in the reservoir.

The inactive capacities for Stevens, Forest, and Pagosa are to allow loss of storage due to sediment and poor water quality when the reservoirs are nearly empty. The values are subjective estimates.

The primary assumption for the Stollsteimer Creek basin water rights is that all of the water available in Stollsteimer Creek and from Dutton Ditch diversions from Fourmile Creek will be utilized with the Steven's Reservoir enlargement and the Dutton Ditch improvement. The data from the 2002 drought indicates that if the new Dutton Ditch procedures (section 2.5) had been used prior to the 2002 drought, the Stollsteimer Creek reservoirs would have been full in the spring of 2002.

The analysis also assumes that the water collected from the improved Dutton Ditch will be at least adequate to fill the enlarged Stevens Reservoir but the data is not adequate to predict additional water. Therefore, if additional facilities (e.g. Martinez Reservoir) are developed in the Stollsteimer basin, another water source is necessary to provide the raw water supply, such as the San Juan River. The additional water source could be an extension of the San Juan River Pipeline to fill Village, Pagosa and possibly Stevens Reservoirs.

3.1.8 Enlarged Stevens Reservoir

PAWSD is planning to enlarge Stevens by about 900 acre-feet at about the same time as the Dutton Ditch is improved. A portion of the 2,900 acre-foot conditional decree for Martinez Reservoir will be used as the water right for the 900 acre-feet Stevens enlargement.

3.1.9 Martinez Reservoir

Martinez Reservoir is a potential reservoir located adjacent to Hatcher Reservoir. The reservoir is decreed for 2,900 acre-feet but about 900 acre-feet is planned to be transferred to the Stevens enlargement leaving about 2,000 acre-feet for Martinez. Preliminary plans for the reservoir construction indicate a capacity of about 700 acre-feet is appropriate.

3.1.10 Summary of Stollsteimer Basin Water Rights Supply

The dry year water supply from the Dutton Ditch with improvements and runoff from Martinez Creek are believed to be adequate to fill the existing 2,630 acre-feet of storage capacity plus the additional 900 acre-feet of storage in the enlarged Stevens Reservoir.

The supply is not believed to be adequate to fill 700 acre-feet of Martinez Reservoir.

3.2 San Juan River Water Rights

The San Juan River water rights are also listed in Table I. Most of the San Juan River water rights are not currently being used, particularly the large rights. The current status and future availability of these water rights is summarized in this section. The water rights are incorporated into alternative plans in Section 4.

3.2.1 A.D. Archuleta, Keith, and Pagosa Lumber Co. #1 Ditches

The A.D. Archuleta (2.5 and 1.0 cfs), Keith (1.0 cfs), and Pagosa Lumber Co. #1 (2.0 cfs) Ditch water rights total 6.5 cfs of allowed diversions but are limited to an annual consumptive use from the San Juan River of 105.11 acre-feet. These water rights have been transferred to the San Juan Intake and are used for the existing diversions. Refer to cases W-1061-73, 97CW51, and 99CW71.

3.2.2 Snowball Pipeline

A total of 5.0 cfs of water rights are available at the Snowball Pipeline headgate from the alternative points of diversion (see decree W-1433-76) for the Pagosa Springs #3, #8, and #10 water rights. The Snowball Pipeline is presently restricted to 2.3 cfs of the decreed 5.0 cfs due to pipeline capacity limitations between the diversion point and the Snowball Treatment Plant in Pagosa Springs. In order to increase the diversion above the existing 2.3 cfs, a new pipeline must be constructed around the Jackson Mountain slide area, as described in Section 4.

Based on the experience in 2002, 2.3 cfs can be diverted at the Snowball intake at all times, but diversions greater than 2.3 cfs would be curtailed from July through September of an extremely dry year. Full use of the existing 5.0 cfs Snowball Pipeline water right is recommended for inclusion in future water supply plans, either at the existing location or transfer to an alternate point.

3.2.3 San Juan River Intake and Pipeline

The San Juan River Intake has two decrees. A 6.5 cfs senior water right is used for current diversions. A second conditional water right for 16.58 cfs, decreed for nearly all uses including storage, is available for additional diversions. The existing intake/pump/pipeline capacity is 4.6 cfs and was operational in 2002.

The drought in 2002 showed that diversions above 4.6 cfs are not firm and there may be a period from July through September of an extreme dry year when no additional water is available.

This water right will likely be a significant component in plans to meet future water demands.

3.2.4 Dry Gulch Reservoir

Dry Gulch Reservoir is an offstream conditional decree for 6,300 acre-feet of storage. The reservoir site is capable of up to approximately 35,000 acre-feet, subject to geotechnical evaluations of the dam site. If the Park Ditch is used to fill the reservoir, the capacity would be restricted to 4,000 acre-feet. Capacities greater than 4,000 acre-feet will require a pump into the reservoir.

The reservoir drainage basin will not yield adequate water to fill the reservoir and would require diversions from the San Juan River. The diversions might be made using the West Fork Canal water rights moved to an appropriate location. The conveyance from the San Juan River to the reservoir might use a new pump station such as the Dry Gulch Pump location to pump water into the reservoir or a conveyance agreement with the Park Ditch (see size limitation above).

The reservoir is best used in conjunction with a direct diversion, such as the San Juan River Intake and Pipeline. The direct diversion would be used to provide water during most months, then releases would be made from the reservoir in the high demand months.

3.2.5 West Fork Canal

The West Fork Canal water right is for 70 cfs at a diversion point about 4 miles upstream from the confluence of the East and West Forks. The water right is for irrigation, municipal and industrial uses but the existing point of use does not include the PAWSD service area which may require modification.

The water right would be out of priority for at least July through September of an extreme dry year and maybe longer depending on how much of the 70 cfs water right is used.

3.2.6 West Fork Reservoir

West Fork Reservoir is decreed for 39,356 acre-feet for nearly all purposes. A reservoir at the decreed capacity would inundate 3 miles of Highway 160, the Wolf Creek Campground and all of the other campgrounds and buildings at the foot of Wolf Creek Pass. A reservoir size of about 8,000 acre-feet would only inundate about 1 mile of the highway and none of the campgrounds; however, most of the flat area in the valley would be inundated. The yield in the drought of 2002 would be the reservoir capacity of 8,000 acre-feet. The reservoir would best be used in conjunction with the West Fork Canal which was the original concept. An 8,000 acre-foot reservoir is used in the evaluations herein, though a larger size is not precluded in future evaluations.

In order to construct the dam and reservoir, right-of-way must be obtained. Also, the cost of the dam is expected to be significant due to the spillway cost to pass the large design flood; a roller compacted embankment would appear to be the best option.

3.2.7 San Juan River Canal System

The San Juan River Canal System is a water right for up to 150 cfs from a combination of the East and West Forks; however, it is decreed for irrigation only and therefore cannot be used for municipal and industrial uses. This water right is not likely to be a component used in meeting future demands due to the use restriction. This water right is held by the Southwestern Water Conservation District.

3.2.8 East Fork Reservoir

East Fork Reservoir is a conditional water right for 35,200 acre-feet of storage for nearly all uses. The dam is about 2 miles upstream from the confluence. The reservoir would require the relocation of the Forest Service Road and a gas pipeline. The Piano Creek development is well upstream of the reservoir. A Forest Service permit would be required which will include an unknown bypass flow. This water right is held by the Southwestern Water Conservation District.

Due to the potential land acquisition problems with the West Fork Reservoir this reservoir is evaluated as an alternative.

3.2.9 Potential, Non-Decreed San Juan River Facilities

The following are potential facilities along the San Juan River but do not have existing water rights.

3.2.10 Dry Gulch Pump

The Dry Gulch Pump location presently does not have any water rights at the potential location, near the confluence of Dry Gulch and San Juan River. The Dry Gulch Pump could be used in conjunction with the Snowball pipeline or replace the Snowball Pipeline in order to eliminate the problems with the Jackson Mountain slide.

This plan is predicated upon either moving the necessary water rights to the diversion locations or a new water right. The CWCB instream flow water right will have an impact, though unknown at this time, on the amount of water that can be transferred to this new diversion point.

3.2.11 Turkey Creek Reservoir

Turkey Creek Reservoir does not have a water right but was studied in the early 1980's to provide water to the Town of Pagosa Springs. Based on the earlier studies, the maximum reservoir size is about 4,000 acre-feet capacity with a 140 foot high dam at the mouth of Turkey Creek.

The reservoir would be used in conjunction with the Snowball Pipeline. The pipeline would be oversized from the headgate to the reservoir so that the reservoir could be filled from the San Juan River if there was insufficient flow in Turkey Creek. The pipeline would be sized from the reservoir to Pagosa Springs to provide the portion of the 2040 demand needed from the Snowball Pipeline. The West Fork Canal water right would likely be used for the San Juan diversions.

3.2.12 San Juan River Summary

All of the water rights listed are decreed for municipal, industrial, and domestic except for the San Juan River Canal System which is for irrigation only. The other water rights can potentially be used to meet a part or all of the 2040 water demand at the existing locations or through transfers.

TABLE I

SJWCD AND PAWSD WATER RIGHTS

Name	Amount	Units	Comment	Available for Future Use
San Juan River				
A D Archuleta	2.5	cfs	PAWSD has the use of the diversion amounts shown but the total annual consumptive use is limited	
A D Archuleta	1	cfs	to 105.11 AF from combined diversions of all four ditches at the San Juan River Intake. Refer to	
Keith Ditch	1	cfs	water court cases W-1061-73 and 97CW51. These water rights have been transferred to San Juan	
Pagosa Lumber Co. #1	2	cfs	River Intake.	
San Juan River Intake	6.5	cfs	Present pump capacity 4.6 cfs.	
				yes
Pagosa Springs Sp #3	3	cfs	Transfered to and diverted at Snowball Pipeline heading	
Pagosa Springs Sp #8	1	cfs	Transfered to and diverted at Snowball Pipeline heading	
Pagosa Springs Sp #10	1	cfs	Transfered to and diverted at Snowball Pipeline heading	
West Fork - Snowball	5	cfs	Snowball Pipeline, presently limited to 2.3 cfs at slide.	
San Juan River Intake	16.58	cfs	Present pump capacity of 4.6 cfs not using the conditional water rights.	yes - 2.7 cfs
West Fork Canal	70	cfs	Could be used in conjunction with Snowball Pipeline or separately	yes
West Fork Reservoir	35,797	AF	Need partnership with land owner. 10,000 AF PAWSD & 25,797 AF SJWCD	yes
San Juan River Canal Sys	150	cfs	West or East Fork, decreed for irrigation only, held by SWCD	yes
East Fork Reservoir	35200	AF	Held by SWCD	no
Dry Gulch Reservoir	6300	AF	Requires diversion from SJ River using Park Ditch or Pump/Pipe from San Juan River.	yes
				yes
Stollsteimer Creek				
JB Martinez	1.25	cfs	Being used as part of Hatcher/Stevens Yield	
Linn & Clark Ditch	8.5	cfs	Being used as part of Hatcher/Stevens Yield	used now
GS Hatcher Ditch	7.5	cfs	Being used as part of Hatcher/Stevens Yield	used now
Hersch Ditch	8	cfs	Being used as part of Hatcher/Stevens Yield	used now
Dutton Ditch & Extension	8	cfs	Being used as part of Hatcher/Stevens Yield	used now
Dutton Ditch Collection	12.5	cfs	Will be used with Dutton Ditch Pipeline Expansion	used now
Perkins Ditch	20	cfs	Being used as part of Hatcher/Stevens Yield	used now
Linn & Clark Reservoir	426	AF	aka Lake Pagosa	used now
Linn & Clark Res Enlg	571.26	AF	aka Lake Pagosa	used now
GS Hatcher Reservoir	193.24	AF	Being used as part of Hatcher/Stevens Yield	used now
GS Hatcher Res Enlg	1536.05	AF	Being used as part of Hatcher/Stevens Yield	used now
Stevens Reservoir	634.84	AF	Being used as part of Hatcher/Stevens Yield	used now
Hersch Reservoir	32.04	AF		used now
Town Center Lake	600	AF	aka Village Lake	not avail
Lake Forest	500	AF		used now
Pinon Lake	161.85	AF	Can't be utilized in storage plans.	used now
Stevens Reservoir Enlg	795	AF	Part of Dutton Ditch and Stevens Enlargement, plan to transfer from Martinez decree	not avail
Martinez Reservoir	2900	AF	Will be used as part of Hatcher/Stevens Yield	will be used
Dutton Ditch Enlargement	20	cfs	PAWSD Share, Used with Dutton Ditch & Stevens Enlargements	yes
Dutton Ditch Enlargement	20	cfs	SJWCD Share, May not be water available	will be used
				unsure

4.0 EVALUATION OF ALTERNATIVE PLANS

Alternative facilities to utilize the water rights described in Section 3.0 are described in this section. The plans described below include numerous assumptions such as: cost estimates, availability of right-of-way for construction, facilities can be constructed as generally described, able to either acquire or transfer water rights to new locations, and water availability where there are no gage records. Specific assumptions are included in the narrative for each plan. Additional studies are recommended to address the overall constructability of the plans.

The cost estimates for each of the alternatives are "ball park". The same unit cost amounts were used for each alternative so the cost are comparable. The final construction cost will be different than the amounts shown herein, but the relative cost for each alternative should remain the same. For example, the more expensive alternatives will remain the more expensive alternatives even if the unit costs increase or decrease.

4.1 Direct Diversion Alternatives

The following is a description of the alternatives to develop: (1) at least 25.4 cfs of direct diversion capability of which 18.5 cfs would be new capability and (2) storage facilities to provide 500 acre-feet of water to meet the 2040 demand and meet the one year Supply Safety Margin criteria.

4.1.1 Snowball Pipeline Improvement and Replacement Plans

There are two options for the Snowball Pipeline. The smaller option involves reconstruction of the existing pipeline to convey 5.0 cfs, 2.7 cfs more than the existing 2.3 cfs. The second option involves construction of a large pipeline to provide 16.7 cfs.

5.0 cfs Option:

The smaller option would modify the existing pipeline to remove the 2.3 cfs restriction due the Jackson Mountain Slide. A new pipeline varying in diameter from 18 to 24 inches is required to convey 5.0 cfs to the Snowball Treatment Plant. The new pipeline must bypass the Jackson Mountain slide. The additional yield is 2.7 cfs. Full utilization of this water right at the existing location, or an alternate point, is recommended so the unused portion will not be abandoned.

The available streamflow data from 2002 indicates that only about 2.3 cfs is available on a firm supply. Therefore, 2.7 cfs of the 5.0 cfs capacity is not firm from July through September based on the 2002 drought. The firm supply from the new 5.0 cfs pipeline would be 1,666 acre-feet from 2.3 cfs and 1,462 acre-feet from January through July and October through December, total of 3,128 acre-feet.

20.8 cfs Option:

If construction of a 5.0 cfs pipeline is considered, then building a larger pipeline to provide 20.8 cfs (2.3 cfs existing and 18.5 cfs new capacity) should be evaluated to meet the 2040 water demand. The larger option would involve construction of a 30 inch pipeline from the present Snowball Pipeline diversion point to the Snowball Treatment Plant. The Snowball pipeline water rights would be used for the existing 5.0 cfs plus transfer of 15.8 cfs of the West Fork Canal water rights to the Snowball diversion point.

Of the 20.8 cfs capacity, 2.3 cfs is firm year round and 18.5 cfs is not firm from July through September. The new firm supply from the 20.8 cfs pipeline would be 4,332 acre-feet plus the existing firm supply of 1,666 acre-feet, for a total of 5,998 acre-feet.

The cost of the small option is shown on Table J and the large option on Table K. The primary advantage of the Snowball Pipeline is gravity flow into the Snowball Treatment Plant. The disadvantages are: (1) the cost of the long pipeline; (2) the upstream diversions deplete the river flows for the longest distance of any plan; (3) water rights must be transferred; and (4) constructing the pipeline to avoid the slide area.

TABLE J

5.0 CFS SNOWBALL PIPELINE

(Note: Increases Snowball supply from 2.3 cfs to 5.0 cfs to utilize the senior water right.)

Item Description	Units	Quantity	Cost/Unit	Total Cost
River Diversion	lump sum	1	$50,000	$50,000
24" DIP Pipe	feet	10400	$60	$624,000
21" DIP Pipe	feet	16690	$55	$918,000
18" DIP Pipe	feet	13720	$50	$686,000
River Crossings	lump sum	2	$30,000	$60,000
Highway Crossings	feet	120	$600	$72,000
Air Release Stations	lump sum	8	$4,000	$32,000
Blow Off Valves	lump sum	8	$3,500	$28,000
Contingency			20.0%	$494,000
Total Field Construction Cost				$2,964,000
Overhead and Miscellaneous Costs			lump sum	$891,000
TOTAL ESTIMATED COST				$3,855,000
Cost Per Acre-Foot of New Firm Yield	1462	acre-feet		$2,637

TABLE K

20.8 CFS SNOWBALL PIPELINE

(Note: 20.8 cfs includes the existing 2.3 cfs diversion and the new 18.5 needed from the San Juan River.)

Item Description	Units	Quantity	Cost/Unit	Total Cost
River Diversion	lump sum	1	$100,000	$100,000
30" DIP Pipe	feet	40810	$95	$3,877,000
River Crossings	lump sum	2	$30,000	$60,000
Highway Crossings	feet	120	$800	$96,000
Air Release Stations	lump sum	8	$4,000	$32,000
Blow Off Valves	lump sum	8	$3,500	$28,000
Contingency			20.0%	$839,000
Total Field Construction Cost				$5,032,000
Overhead and Miscellaneous Costs			lump sum	$1,408,000
TOTAL ESTIMATED COST				$6,440,000
Cost Per Acre-Foot of New Firm Yield	4332	acre-feet		$1,487

4.1.2 San Juan River Pipeline Stages

There are two potential new stages for the San Juan Intake and Pipeline Plan. The existing facility has a capacity of 4.6 cfs and firm supply of 3,331 acre-feet in all months.

Stage 1 would fully utilize the capacity of the existing 16 inch pipeline by increasing the velocity of flow in the pipeline from 3.3 feet per second to about 5 feet per second which would result in conveyance capacity of about 6.6 cfs rather than the current 4.6 cfs. The additional capacity would be a result of larger pumps to deliver more flow and about 100 feet higher head. The capability of the pipeline to withstand the additional pumping head must be evaluated.

The available streamflow data from 2002 indicates that only 4.6 cfs is available on a firm supply; therefore, 2.0 cfs is not firm from July through September. The firm supply from the Stage 1 expansion would be 1,083 acre-feet from January through June and October through December.

Stage 2 would involve construction of a second pipeline and pump system to deliver about 16.5 cfs in order to meet the 2040 demand; 2.3 cfs would be provided by the existing Snowball Pipeline and 4.6 cfs by the existing San Juan Pipeline, and 2.0 cfs by Stage 1. The existing 16.58 cfs of conditional water rights would be used. The facilities would involve a second 27 inch pipeline from the San Juan River and would be placed in the existing 50 foot easement. The firm supply from the Stage 2 expansion would be 3,249 acre-feet from January through June and October through December.

The cost estimate for Stages 1 and 2 are shown on Tables L and M.

The primary advantages of either Stage are: (1) the diversion point is downstream of the Town and will have no impact on flows through Town nor the CWCB instream flow water right; (2) there are existing facilities in place to minimize new impacts; (3) the plan can be developed in stages, with Stage 1 being relatively inexpensive; (4) the water is provided west of the Town where the majority of the growth is occurring; and (5) no transfers of water rights are necessary to implement the plan. The primary disadvantages involve acquiring additional easements if the existing easement is not adequate to construct the second pipeline and the cost of pumping.

TABLE L

STAGE 1 - 6.6 CFS SAN JUAN PIPELINE

(Note: Increases San Juan Pipeline from 4.6 cfs to 6.6 cfs.)

Item Description	Units	Quantity	Cost/Unit	Total Cost
River Diversion	lump sum	1	$50,000	$50,000
Pump Station Expansion	lump sum	1	$80,000	$80,000
Booster Pump Station Expansion	lump sum	1	$80,000	$80,000
Contingency			20.0%	$42,000
Total Field Construction Cost				$252,000
Overhead and Miscellaneous Costs			lump sum	$38,000
TOTAL ESTIMATED COST				$290,000
Cost Per Acre-Foot of New Firm Yield	1083	acre-feet		$268

TABLE M

STAGE 2 - 16.5 CFS SECOND SAN JUAN PIPELINE

(Note: Adds a second San Juan Pipeline to meet deliver 16.5 cfs assuming the 6.6 cfs is built.)

Item Description	Units	Quantity	Cost/Unit	Total Cost
River Diversion	lump sum	1	$100,000	$100,000
27" DIP Pipe	feet	32800	$75	$2,460,000
New Pump Station	lump sum	1	$300,000	$300,000
New Booster Station	lump sum	1	$300,000	$300,000
Air Release Stations	lump sum	6	$4,000	$24,000
Blow Off Valves	lump sum	6	$3,500	$21,000
Contingency			20.0%	$641,000
Total Field Construction Cost				$3,846,000
Overhead and Miscellaneous Costs			lump sum	$962,000
TOTAL ESTIMATED COST				$4,808,000
Cost Per Acre-Foot of NewFirm Yield	3249	acre-feet		$1,480

4.1.3 Dry Gulch Pump Plan

A 20.8 cfs pump facility would be constructed on the San Juan River near the confluence with Dry Gulch to divert San Juan River water to the Snowball Treatment Plant when flow is available. The existing San Juan Pump and Pipeline would continue to deliver 4.6 cfs. The pump facilities would include a diversion structure on the river, a pump station, and a pipeline to the Snowball treatment plant. The diversion location was selected to allow the option of using the diversion and pump to fill Dry Gulch Reservoir. This plan assumes that the Dry Gulch Pump would replace the Snowball Pipeline.

The plan is predicated upon water court proceedings to transfer existing water rights which would be limited to the water supply available at the original points of diversion. Depending on which rights are transferred, the CWCB instream flow water rights will have an impact on the transfer of water rights to the Dry Gulch Pump diversion point. New water rights are also an option.

The new firm supply from the Dry Gulch Pump is 4,332 acre-feet from January through June and October through December plus the existing firm supply of 1,665 acre-feet from the present 2.3 cfs Snowball Pipeline for a total supply of 5,998 acre-feet.

The cost estimate is shown on Table N.

The advantages of the Dry Gulch Pump Plan include: (1) the long pipeline from the West Fork around the slide area is avoided; (2) all San Juan River diversions on the east side of Pagosa Springs are consolidated at one location; (3) the pump can deliver water to both the treatment plant and to the Dry Gulch Reservoir. The disadvantages are the pumping cost and if growth continues to be primarily on the west side of Pagosa Springs and the water must be piped from the east to west side of Pagosa Springs.

TABLE N

20.8 CFS DRY GULCH PUMP STATION

(Note: This facility would replace the Snowball Pipeline.)

Item Description	Units	Quantity	Cost/Unit	Total Cost
River Diversion	lump sum	1	$175,000	$175,000
30" DIP Pipe, to Snowball TP	feet	8000	$95	$760,000
Pump Station	lump sum	1	$350,000	$350,000
River Crossings	lump sum	1	$30,000	$30,000
Highway Crossings	feet	120	$600	$72,000
Air Release Stations	lump sum	3	$4,000	$12,000
Blow Off Valves	lump sum	2	$3,500	$7,000
Contingency			20.0%	$281,000
Total Field Construction Cost				$1,687,000
Overhead and Miscellaneous Costs			lump sum	$532,000
TOTAL ESTIMATED COST				$2,219,000
Cost Per Acre-Foot of Firm Yield	4332 acre-feet			$512

4.1.4 Summary of Diversion Alternatives

The following table compares the cost per acre-foot of useable yield to meet the 2040 demand for each of the diversion alternatives.

TABLE O
COMPARISON OF ALTERNATIVE DIVERSIONS

Alternative	New Firm Yield	$/acre-foot
5.0 cfs Snowball Pipeline	1,462 AF	$2,637
20.8 cfs Snowball Pipeline	4,332 AF	$1,487
2.0 cfs San Juan Pipeline Increase	1,083 AF	$268
16.5 cfs Second San Juan Pipeline	3,249 AF	$1,480
20.8 cfs Dry Gulch Pump	4,332 AF	$503

4.2 Storage Alternatives

The storage alternatives are described in this section. All of the assumptions described for Diversions alternatives apply to the reservoirs plus the assumption that geotechnical evaluations will not significantly increase the construction cost of the reservoirs. All of the analysis is based on USGS Quadrangle maps.

4.2.1 Stevens Reservoir Enlargement

The Stevens Reservoir Enlargement has been extensively described in various studies which are used in this analysis. Based on the preliminary data from 2002, it appears that the existing Stevens Reservoir could have been full in the spring of 2002 if the San Juan Pipeline had been operational, but there does not appear to be adequate water to have filled the enlargement.

Based on work performed by Davis Engineering, approximately 950 acre-feet of additional yield is provided by the Dutton Ditch Improvement which is just adequate to fill the 900 acre-feet of enlarged Stevens.

The costs shown on Table P are taken from the Davis Engineering study with a small increase. The annual yield from the enlargement and Dutton Ditch Improvement is estimated to be 900 acre-feet on any demand pattern.

The advantages of the Stevens Reservoir Enlargement include: (1) an existing reservoir site to minimize the environmental impacts; (2) the reservoir is filled by gravity and gravity flow out of the reservoir; (3) engineering and environmental studies of the enlargement are nearly completed; (4) funding has been approved by vote of PAWSD residents in fall of 2002. The disadvantages are: (1) appears to require the Dutton Ditch Improvement to fill the enlargement; (2) the lack of data on the potential diversions from Four Mile Creek into the Dutton Ditch Improvement to accurately determine the yield from the enlargement; (3) the cost is greater than other alternatives.

TABLE P

STEVENS RESERVOIR ENLARGEMENT

(Note: The enlargement would add 900 acre-feet of firm storage filled by Dutton Ditch Improvement.)

Item Description	Units	Quantity	Cost/Unit	Total Cost
Mobilizatlon	lump sum	1	$50,000	$50,000
Diversion and Dewatering	lump sum	1	$50,000	$50,000
Haul Road	feet	5000	$20	$100,000
Excavation Existing Dam	cubic yards	7833	$2.12	$17,000
Stipping	cubic yards	4000	$1.00	$4,000
Zone 1 Fill	cubic yards	39094	$1.93	$75,000
Zone 2 Fill	cubic yards	39418	$1.62	$64,000
Chimney Drain	cubic yards	2618	$21.17	$55,000
Rip Rap	cubic yards	14653	$40.00	$586,000
Rip Rap Bedding	cubic yards	4884	$15.00	$73,000
Filter Fabric	sq yards	4884	$1.52	$7,000
Clear and Gub	acres	150	$1,000.00	$150,000
Outlet Works Inlet Structure	lump sum	1	$35,000.00	$35,000
Outlet Works Inlet Structure	lump sum	1	$20,000.00	$20,000
Outlet Works 18 inch Pipeline	feet	150	$200.00	$30,000
Outlet Works Extension	feet	100	$80	$8,000
Outlet Works 18 inch BFV	lump sum	1	$5,000	$5,000
Contingency			30.0%	$399,000
Total Field Construction Cost				$1,728,000
Overhead and Miscellaneous Costs			lump sum	$446,000
TOTAL ESTIMATED RESERVOIR COST				$2,174,000
Cost per Acre-Foot of Active Storage	900 acre-feet			$2,416
Dutton Ditch Improvement				
Diversion Structure	lump sum	1	$18,000	$18,000
24" Pipe	feet	19000	$75	$1,425,000
Discharge Structure	lump sum	1	$4,000	$4,000
Isolation Valves	lump sum	19	$5,500	$105,000
Air/Vaccum Release Stations	lump sum	9	$4,500	$41,000
Blow Off Valves	lump sum	19	$1,800	$34,000
Contingency			20.0%	$325,000
Total Field Construction Cost				$1,952,000
Overhead and Miscellaneous Costs			lump sum	$390,000
TOTAL ESTIMATED COST				$2,342,000
TOTAL ESTIMATED COST OF ENLARGEMENT AND DITCH IMPROVEMENT				$4,516,000
Cost Per Acre-Foot of Firm Yield	900 acre-feet			$5,018

Note: The Dutton Ditch Improvement may yield more water than just filling the enlarged Stevens Reservoir.

4.2.2 Martinez Reservoir

Martinez Reservoir has also been studied extensively and that data is used herein. Based on the preliminary data from 2002, there does not presently nor with the Dutton Ditch Improvement, appear to be adequate water to fill a 700 acre-foot Martinez Reservoir. In order to provide adequate water, the San Juan Pipeline must be extended to Pagosa Lake so that Dutton Ditch water presently used to fill Pagosa Lake can be used to fill Martinez Reservoir. The San Juan Pipeline will fill Pagosa Lake.

The costs shown on Table Q are taken from the Davis Engineering study with a small increase. The annual yield from Martinez Reservoir in conjunction with the San Juan Pipeline extension to Pagosa Lake is 700 acre-feet.

The advantages of the Martinez Reservoir include: (1) the reservoir is filled by gravity and gravity flow out of the reservoir; (2) can utilize water in the Martinez Creek basin and from Dutton Ditch that are presently not being captured. The disadvantages are: (1) the cost of construction and pumping to provide water to Pagosa Lake to allow Martinez to be filled; (2) the cost is greater than other alternatives.

TABLE Q

MARTINEZ RESERVOIR

(Note: The extension of the San Juan Pipeline to Pagosa Lake is necessary to fill Martinez .)

Item Description	Units	Quantity	Cost/Unit	Total Cost
Clearing and Grubbing	cubic yards	22500	2.00	$45,000
Placement of Earth Fill	cubic yards	328075	1.50	$492,000
Core Trench Excavation	cubic yards	48425	5.00	$242,000
Chimney & Blanket Drain	cubic yards	23735	15.00	$356,000
Rip Rap and Bedding	cubic yards	10970	15.00	$165,000
Spillway Excavation	cubic yards	318000	2.00	$636,000
Spillway Concrete	cubic yards	200	$450.00	$90,000
Spillway Rip Rap	cubic yards	10000	$15.00	$150,000
Outlet Works 36 inch Pipe	feet	500	$40.00	$20,000
Cut-off Collars	cubic yards	9	$500.00	$5,000
Slide Gate	lump sum	1	########	$40,000
Stilling Basin	cubic yards	22	$600.00	$13,000
Perkins Ditch Construction	feet	1400	$25.00	$35,000
Pump To Hatcher TP	lump sum	1	########	$75,000
14 inch Pipeline to Hatcher TP	feet	1750	$18.00	$32,000
Contingency			30.0%	$719,000
Total Field Construction Cost				$3,115,000
Overhead and Miscellaneous Costs			lump sum	$779,000
TOTAL ESTIMATED RESERVOIR COST				$3,894,000
Cost per Acre-Foot of Active Storage	700	acre-feet		$5,563
Extension of San Juan Pipeline to Pagosa Lake				
River Diversion	lump sum	1	$100,000	$100,000
18" Pipe to Pagosa Lake	feet	12000	$50	$600,000
Road Crossings	feet	120	$600	$72,000
Air Release Stations	lump sum	1	$4,000	$4,000
Blow Off Valves	lump sum	1	$3,500	$4,000
Contingency			20.0%	$156,000
Total Field Construction Cost				$936,000
Overhead and Miscellaneous Costs			lump sum	$284,000
TOTAL ESTIMATED PIPE COST				$1,220,000
TOTAL ESTIMATED RESERVOIR AND PIPE COST				$5,114,000
Cost Per Acre-Foot of Firm Yield	700	acre-feet		$7,306

4.2.3 Dry Gulch Reservoir and Pump Plan

The Dry Gulch Reservoir is an off-stream reservoir with a maximum reservoir storage capability of about 35,000 acre-feet subject to geotechnical studies to verify that the dam site is adequate. However, for this evaluation two sizes are considered, 4000 acre-feet so that the Park Ditch can be used for inflow and 12,500 acre-feet to provide 500 acre-feet needed to meet the 2040 demand and 12,000 acre-feet for the supply safety margin.

4,000 Acre-Foot Reservoir:

The small 4,000 acre-feet plan, assumes that the Park Ditch may be used for inflow in the future but for the analysis in this report, the Dry Gulch Pump is used to fill the reservoir. The Park Ditch will be siphoned across Dry Gulch rather than inflow into and out of the reservoir which allows the reservoir to operate independently of the ditch. The purpose of the reservoir would be to provide storage to supplement direct diversions from Dry Gulch Pump but could also be used in conjunction with a 20.8 cfs Snowball pipeline or the San Juan River Pipeline.

The dam would be a 75 foot high earth embankment.

The yield analysis is predicated upon inflow from the San Juan River using the Dry Gulch Pump when capacity is available. The Dry Gulch Pump will have from 3 to 13 cfs of unused capacity in all months but June. Dry Gulch Reservoir is planned to be 4,000 acre-feet of the decreed amount of 6,300 acre-feet.

A 20.8 cfs pump facility would be constructed on the San Juan River near the confluence with Dry Gulch to divert San Juan River water to the Snowball treatment plant and fill Dry Gulch Reservoir when flow is available. The pump facilities would include a diversion structure on the river, a pump facility, and a pipeline to the Snowball treatment plant. The diversion location is selected to allow the option of using the diversion and pump to either convey water to the Snowball Treatment Plan and/or fill Dry Gulch Reservoir. This plan assumes that the Dry Gulch Pump would replace the Snowball Pipeline.

The plan is predicated upon water court proceedings to transfer existing water rights which would be limited to the water supply available at the original points of diversion. Depending on which rights are transferred, the CWCB instream flow water rights will have an impact on the transfer of water rights to the Dry Gulch Pump diversion point.

The firm water supply from the Dry Gulch Reservoir and Pump would be 4,000 acre-feet from the reservoir on any demand pattern and 4,332 acre-feet from the Dry Gulch Pump diversions during January through June and October through December, for a total of 8,332 acre-feet of new firm yield.

The reservoir costs shown on Table R are taken from the Davis Engineering study with a small increase.

12,500 Acre-Foot Reservoir:
The large reservoir plan would utilize the Dry Gulch Dam and Reservoir to provide the 500 acre-feet needed to supply the 2040 demand and the 12,000 acre-feet for the supply safety margin, a total of 12,500 acre-feet. All studies to date on Dry Gulch have evaluated a size in the 4,000 acre-foot range, so no evaluations of the larger size have been made from geotechnical, land availability, etc. The obvious advantage of this large plan is to provide all of the storage needed for 2040 at one location rather than two. Also, if the reservoir were larger than 12,500 acre-feet it may be able to provide water beyond 2040, assuming that adequate repayment was available.

The dam would be 114 feet high, also an earth embankment. All inflow would be pumped from the Dry Gulch Pump station.

The Dry Gulch Pump Station would be nearly identical to the version for the smaller reservoir except that the pump lift would be 40 feet greater.

The firm water supply from the Dry Gulch Reservoir and Pump would be 12,500 acre-feet from the reservoir on any demand pattern and 4,332 acre-feet from the Pump diversions during January through June and October through December, for a total of 16,832 acre-feet of new firm yield.

The advantages of either size of the Dry Gulch Reservoir and Pump Plan include: (1) the long pipeline from the West Fork around the slide area is avoided; (2) all San Juan River diversions on the east side of Pagosa Springs are consolidated at one location; (3) the Dry Gulch Pump can deliver water to the Dry Gulch Reservoir and directly to the treatment plant; (4) Dry Gulch Reservoir can work with any diversion plans, not just the Dry Gulch Pump; (5) the construction cost is the least of any alternative. The disadvantages are: (1) the pumping cost; (2) need for a Forest Service Permit for the larger size reservoir; and (3) if growth continues to be primarily on the west side of Pagosa Springs the water must be piped from the east to west side of Pagosa Springs.

TABLE R

4,000 AF DRY GULCH RESERVOIR AND 20.8 CFS PUMP STATION

(Note: Dry Gulch Reservoir and Pump Station are developed together.)

Item Description	Units	Quantity	Cost/Unit	Total Cost
Dry Gulch Reservoir				
Clearing and Grubbing	lump sum	1	$150,000	$150,000
Earth Excavation and Compaction	cubic yards	430000	$7	$3,010,000
Toe Drain	feet	400	$50	$20,000
Rip Rap	cubic yards	2800	$30	$84,000
Spillway	feet	350	$500	$175,000
42 Inch Outlet Pipe	feet	435	$300	$131,000
Cut-off Collars	cubic yards	9	$500	$5,000
Slide Gate	lump sum	1	$40,000	$40,000
Stilling Basin	cubic yards	22	$600	$13,000
30 inch Pipeline To Dry Gulch Pump	feet	3000	$95	$285,000
30 inch Pipeline Park Ditch Siphon	feet	1200	$95	$114,000
Contingencies			35.0%	$1,251,000
Total Field Construction Cost				$5,278,000
Overhead and Miscellaneous Costs			lump sum	$3,060,000
TOTAL ESTIMATED RESERVOIR COST				$8,338,000
Cost per Acre-Foot of Active Storag	4000	acre-feet		$2,085
Dry Gulch Pump				
River Diversion	lump sum	1	$150,000	$150,000
30" DIP Pipe, to Snowball TP	feet	8000	$95	$760,000
Pump Station	lump sum	1	$350,000	$350,000
River Crossings	lump sum	1	$30,000	$30,000
Highway Crossings	feet	120	$600	$72,000
Air Release Stations	lump sum	3	$4,000	$12,000
Blow Off Valves	lump sum	2	$3,500	$7,000
Contingency			20.0%	$276,000
Total Field Construction Cost				$1,657,000
Overhead and Miscellaneous Costs			lump sum	$524,000
TOTAL ESTIMATED PUMP COST				$2,181,000
TOTAL ESTIMATED COST FOR PUMP AND RESERVOIR				$10,519,000
Cost Per Acre-Foot of Firm Yield	8332	acre-feet		$1,262

TABLE S

12,500 AF DRY GULCH RESERVOIR AND 20.8 PUMP STATION

(Note: Dry Gulch Reservoir and Pump Station are developed together.)

Item Description	Units	Quantity	Cost/Unit	Total Cost
Dry Gulch Reservoir				
Clearing and Grubbing	lump sum	1	$250,000	$250,000
Earth Excavation and Compaction	cubic yards	1120000	$7	$7,840,000
Toe Drain	feet	600	$50	$30,000
Rip Rap	cubic yards	6000	$30	$180,000
Spillway	feet	800	$500	$400,000
42 Inch Outlet Pipe	feet	900	$300	$270,000
Cut-off Collars	cubic yards	20	$500	$10,000
Slide Gate	lump sum	1	$40,000	$40,000
Stilling Basin	cubic yards	22	$600	$13,000
30 inch Pipeline To Dry Gulch Pump	feet	3000	$95	$285,000
30 inch Pipeline Park Ditch Siphon	feet	1200	$95	$114,000
Contingencies			35.0%	$3,143,000
Total Field Construction Cost				$12,575,000
Overhead and Miscellaneous Costs			lump sum	$6,994,000
TOTAL ESTIMATED RESERVOIR COST				$19,569,000
Cost per Acre-Foot of Active Storage	12500	acre-feet		$1,566
Dry Gulch Pump				
River Diversion	lump sum	1	$175,000	$175,000
30" DIP Pipe, to Snowball TP	feet	8000	$95	$760,000
Pump Station	lump sum	1	$400,000	$400,000
River Crossings	lump sum	1	$30,000	$30,000
Highway Crossings	feet	120	$600	$72,000
Air Release Stations	lump sum	3	$4,000	$12,000
Blow Off Valves	lump sum	2	$3,500	$7,000
Contingency			20.0%	$291,000
Total Field Construction Cost				$1,747,000
Overhead and Miscellaneous Costs			lump sum	$547,000
TOTAL ESTIMATED PUMP COST				$2,294,000
TOTAL ESTIMATED COST FOR PUMP AND RESERVOIR				$21,863,000
Cost Per Acre-Foot of Firm Yield	16832	acre-feet		$1,299

4.2.4 West Fork Reservoir

The West Fork Reservoir is located on the West Fork of the San Juan River about 3 miles upstream from the confluence. Harris Water Engineering performed studies on this reservoir site in the 1980's for the Southwestern Water Conservation District. The data presented herein is derived from those studies but the reservoir size has been modified and the costs were updated.

If the reservoir were constructed to the decreed capacity of about 35,000 acre-feet it would inundate the entire valley including the campgrounds and county roads. A size of about 8,000 acre-feet which would impact only about 1 mile of Highway 160 and none of the campgrounds, is used for the evaluations herein, though a larger size may be necessary.

The preliminary plans for the dam are a roller compacted concrete gravity dam so that the entire crest of the dam can be a spillway to pass the large design flood. The dam is only 85 feet high. The dam is located on the main channel, so filling is assured every year and an annual firm yield of 8,000 acre-feet. The estimated cost is shown on Table T.

The advantages of the West Fork Reservoir include: (1) the reservoir is on the mainstem and can be filled every year, even 2002; (2) the reservoir can provide water to any of the diversion locations; (3) the reservoir site is as large as any alternative; (4) the reservoir could be a new fisherman/tourist attraction for the area. The disadvantages include: (1) the land cost may be higher due to legal complications; (2) a Forest Service permit is required for larger sizes; and (3) the environmental analysis of reservoirs located on major streams can be significant.

TABLE T
WEST FORK DAM AND RESERVOIR

(Note: West Fork Reservoir can be used with any of the diversion locations .)

Item Description	Units	Quantity	Cost/Unit	Total Cost
Clearing and Gubbing	acres	50	$1,000	$50,000
Mobilization	lump sum	1	$100,000	$100,000
Foundation Excavation	cubic yards	33000	2.00	$66,000
RCC Placement	cubic yards	200000	70.00	$14,000,000
Outlet Works	lump sum	1	$300,000	$300,000
Road Relocation	miles	1	$2,000,000	$2,000,000
Contingency			30.0%	$4,355,000
Total Field Construction Cost				$20,871,000
Overhead and Miscellaneous Costs			lump sum	$13,218,000
TOTAL ESTIMATED RESERVOIR COST				$34,089,000
Cost per Acre-Foot of Active Storage	8000 acre-feet			$4,261
Cost Per Acre-Foot of Firm Yield	8000 acre-feet			$4,261

4.2.5 East Fork Reservoir

The East Fork Reservoir is located on the East Fork of the San Juan River about 1 mile upstream from the confluence with the West Fork. Harris Water Engineering performed studies on this reservoir site in the 1980's for the SJWCD and the Southwestern Water Conservation District. The data presented herein is derived from those studies but the reservoir size has been modified and the costs were updated.

The decreed capacity of the reservoir is about 35,000 acre-feet. The larger the reservoir the lower the cost per acre-foot. For purposes of this report to compare the East Fork with the other reservoir sites a size of 12,000 acre-feet is used in order to supply the 2040 water demand. When this reservoir is considered in the future, a larger size should be investigated.

The preliminary plans for the dam are a roller compacted concrete gravity dam so that the entire crest of the dam can be a spillway to pass the large design flood. The dam is 345 feet high so the embankment volume is very large.

The dam is located on the main channel, so filling is assured every year and an annual firm yield of 12,000 acre-feet. The US Forest Service access road and a gas pipeline must be relocated. The land is US Forest Service land so there would not be a land cost but Forest Service will likely place conditions on approval of a special use permit that will be significant, the estimated cost of the conditions is not included because they are not known. The estimated cost is shown on Table U.

The advantages of the East Fork Reservoir include: (1) the reservoir is on the mainstem and can be filled every year, even 2002; (2) the reservoir can provide water to any of the diversion locations; (3) the reservoir site is the largest of any alternative; (4) the reservoir could be a new fisherman/tourist attraction for the area. The disadvantages include: (1) Forest Service special use permit; (2) the cost of relocating the road and gas pipeline are large; (3) the environmental analysis of reservoirs located on major streams can be significant.

TABLE U

EAST FORK DAM AND RESERVOIR

(Note: East Fork Reservoir can be used with any of the diversion locations .)

Item Description	Units	Quantity	Cost/Unit	Total Cost
Clearing and Gubbing	acres	50	$1,000	$50,000
Mobilization	lump sum	1	$100,000	$100,000
Foundation Excavation	cubic yards	23000	2.00	$46,000
RCC Placement	cubic yards	791000	70.00	$55,370,000
Outlet Works	lump sum	1	$300,000	$300,000
Road Relocation	miles	5	$1,500,000	$7,500,000
Gas Pipeline Relocation	miles	5	$500,000	$2,500,000
Contingency			30.0%	$16,760,000
Total Field Construction Cost				$82,626,000
Overhead and Miscellaneous Costs			lump sum	$20,657,000
TOTAL ESTIMATED RESERVOIR COST				$103,283,000
Cost per Acre-Foot of Active Storage	12000	acre-feet		$8,607
Cost Per Acre-Foot of Firm Yield	12000	acre-feet		$8,607

4.2.6 Turkey Creek Reservoir

Turkey Creek Reservoir was studied in the early 1980's by Western Engineers (Grand Junction) for the Town of Pagosa Springs. The reservoir size selected for inclusion herein is the largest in the previous study, at 4,000 acre-feet. The dam would be located at the mouth of Turkey Creek. The dam construction quantities shown in Table P were obtained from the Western Engineers report with updated unit costs.

The water supply for Turkey Creek Reservoir would be a combination of Turkey Creek and diversions from the San Juan River. In 2002, there was little if any water available in Turkey Creek so the reservoir must be filled by San Juan River water diverted during the winter and spring. A 30 cfs pipeline is included to convey water from the San Juan River to the reservoir.

The cost of the reservoir is shown in Table Q. The firm yield from the reservoir is 4,000 acre-feet per year on any demand pattern.

The advantages of the Turkey Creek Reservoir include: (1) off stream site; (2) Turkey Creek flows would be adequate in most years to fill the reservoir; (3) San Juan River water can be conveyed to the reservoir by gravity; (4) the reservoir can be operated in conjunction with a large Snowball Pipeline. The disadvantages include: (1) the dam and reservoir site are not optimum as reflected in the high cost per acre-foot and (2) a Forest Service permit is required.

TABLE V

TURKEY CREEK RESERVOIR

(Note: Turkey Creek Reservoir is integrated with enlargement of the Snowball Pipeline .)

Item Description	Units	Quantity	Cost/Unit	Total Cost
Dam and Reservoir				
Mobilization	lump sum	1	$100,000	$100,000
Care and Diversion of Creek	lump sum	1	$100,000	$100,000
Clearing	acres	140	1,000.00	$140,000
Stipping	cubic yards	90000	1.50	$135,000
Foundation Excavation	cubic yards	56300	2.00	$113,000
Grouting	holes	190	$3,000	$570,000
Embankment	cubic yards	1367090	3.00	$4,101,000
Chimney filters	cubic yards	54450	$15	$817,000
Outlet Works	feet	620	$600	$372,000
Spillway RCC Concrete	cubic yards	41910	$100	$4,191,000
Rip Rap	cubic yards	28700	$30	$861,000
Pipeline	feet	800	$50	$40,000
Contingency			30.0%	$176,000
Total Field Construction Cost				$11,716,000
Overhead and Miscellaneous Costs			lump sum	$3,729,000
TOTAL ESTIMATED RESERVOIR COST				$15,445,000
Cost per Acre-Foot of Active Storage	4000	acre-feet		$3,861
30 cfs Inlet Pipe from San Juan River				
River Diversion	lump sum	1	$100,000	$100,000
36" Pipe from SJ to Reservoir	feet	15000	$125	$1,875,000
River Crossings	lump sum	1	$50,000	$50,000
Highway Crossings	feet	120	$600	$72,000
Air Release Stations	lump sum	2	$4,000	$8,000
Blow Off Valves	lump sum	2	$3,500	$7,000
Contingency			20.0%	$422,000
Total Field Construction Cost				$2,534,000
Overhead and Miscellaneous Costs			lump sum	$709,000
TOTAL ESTIMATED INLET PIPE COST				$3,243,000
TOTAL ESTIMATED COST FOR RESERVOIR, INLET PIPE				$18,688,000
Cost Per Acre-Foot of Firm Yield	4000	acre-feet		$4,672

4.2.7 Summary of Reservoir Storage Alternatives

The following table compares the cost per acre-foot of active capacity and the cost per acre-foot of yield for each of the reservoir alternatives.

TABLE W
COMPARISON OF ALTERNATIVE RESERVOIRS

Alternatives	Reservoir Capacity	$ per acre-foot of Capacity	Firm Yield with Related Facilities	$ per acre-foot of Yield
Stevens Enlargement and Dutton Improvement	900	$2,416	N/A	
Martinez Reservoir and San Juan Pipe Extension	700	$5,563	700	$7,306
4,000 AF Dry Gulch Reservoir and Pump Station	4,000	$2,085	8,332	$1,262
12,500 AF Dry Gulch Reservoir and Pump Station	12,500	$1,566	16,832	$1,299
West Fork Reservoir	8,000	$4,261	N/A	
East Fork Reservoir	12,000	$8,607	N/A	
Turkey Creek Reservoir and Inlet Pipe	4,000	$3,861	4,000	$4,672

Table X summarizes the cost of diversion alternatives and storage alternatives including firm supply, cost per acre-foot and total cost of the alternative. The alternatives are listed by cost per acre-foot.

4.3 Water Treatment and Distribution Facilities

The purpose of this report is to evaluate the water rights and facilities to provide at least the net 2040 raw water demand. The impact of the projected population increase from 9,400 in 2000 to over 45,000 in 2040 will require about five times more treatment and distribution facilities. The cost of the treated water facilities will be significantly greater than the raw water facilities.

This report assumes that water treatment will continue to be at the Snowball and San Juan Treatment Plant sites. However, the development pattern of the treated water facilities may have an impact on the location for raw water facilities and the resulting cost. Alternative locations for raw water facilities have been included to attempt to provide flexibility to coordinate with the treated water facility development.

TABLE X

SUMMARY OF ALTERNATIVE COSTS

Diversion Alternatives	Firm Supply (acre-feet)	Cost per Acre-Foot Of Yield	Total Cost Of Alternative
2.0 cfs San Juan Pipeline Increase	1,083	$268	$290,000
20.8 cfs Dry Gulch Pump Station	4,332	$512	$2,219,000
16.7 cfs Second San Juan Pipeline	3,249	$1,480	$4,808,000
20.8 cfs Snowball Pipeline	4,332	$1,487	$6,440,000
5.0 cfs Snowball Pipeline	1,462	$2,637	$3,855,000
Storage Alternatives			
Dry Gulch Reservoir 4,000 AF and Pump	8,332	$1,262	$10,519,000
Dry Gulch Reservoir 12,000 AF and Pump	16,832	$1,299	$21,863,000
Stevens Enlargement	900	$2,416	$2,174,000
West Fork Reservoir	8,000	$4,261	$34,089,000
Turkey Creek Reservoir and Inlet Pipeline	4,000	$4,672	$18,688,000
Martinez Reservoir and SJ Pipeline Extension	700	$7,306	$5,114,000
East Fork Reservoir	12000	$8,607	$103,283,000

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SUBJECT TO CHANGE
JULY 10, 2001

PRELIMINARY ENGINEERING STUDY

OF

WATER SUPPLY ALTERNATIVES

FOR

PAGOSA AREA WATER AND SANITATION DISTRICT

JULY, 2001 DRAFT

By

Davis Engineering Service, Inc.
P.O. Box 1840, 1314 11th Street
Alamosa, Colorado 81101

_____ _____
Registered Engineer Date
Colorado Certificate No. 13349

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Figures

Appendix

1. STUDY OBJECTIVES

The Pagosa Area Water and Sanitation District (PAWSD) is developing plans to enlarge the existing Dutton Ditch and Stevens Reservoir to provide additional water supplies to residents of PAWSD. The enlargement will require a 404 Permit from the Corp of Engineers. The purpose of this report is to provide information for use in the 404 Permit process addressing the need for additional water supplies and the alternatives that were considered to provide the water supply.

2. SERVICE AREA

The Pagosa Area Water and Sanitation District (PAWSD) encompasses approximately 64.7 square miles in the San Juan Mountains of southwestern Colorado. It includes within its boundaries the Town of Pagosa Springs and unincorporated portions of Archuleta County, including the Pagosa Lakes resort community. A map outlining the service area and PAWSD is included as Figure 2-1.

3. DESCRIPTION OF WATER SUPPLY NEEDS

The present population and water usage is described in this section, followed by the projected population and water usage in 5-year increments through the year 2025.

3.1. PRESENT POPULATION AND WATER USAGE IN SERVICE AREA

PAWSD provides water to approximately 85% of the population of Archuleta County, including the Town of Pagosa Springs, the dissolved Archuleta Water Company service area, and the PAWSD area west of the Town. The 2000 Census shows the population in Archuleta County increased: (1) from 3,664 in 1980 to 5,345 in 1990 to 9,898 in 2000; (2) 1980 to 2000 annual growth rate was 5.1%; (3) the 1980 to 1990 growth rate was 4.0%; and (4) the 1990 to 2000 annual growth rate was 7.1%.

The year 2000 permanent population served by PAWSD is approximately 8,410. The total water treated by PAWSD in 2000 was 594.5 million gallons (1,825 acre-feet), resulting in an average usage of approximately 195 gallons per person per day. Table 3-1 shows the per capita usage from 1995 through 2000 using estimated populations interpolating between the 1990 and 2000 Census estimates. The average per capita usage for the 6 year period was 195 gallons per person per day.

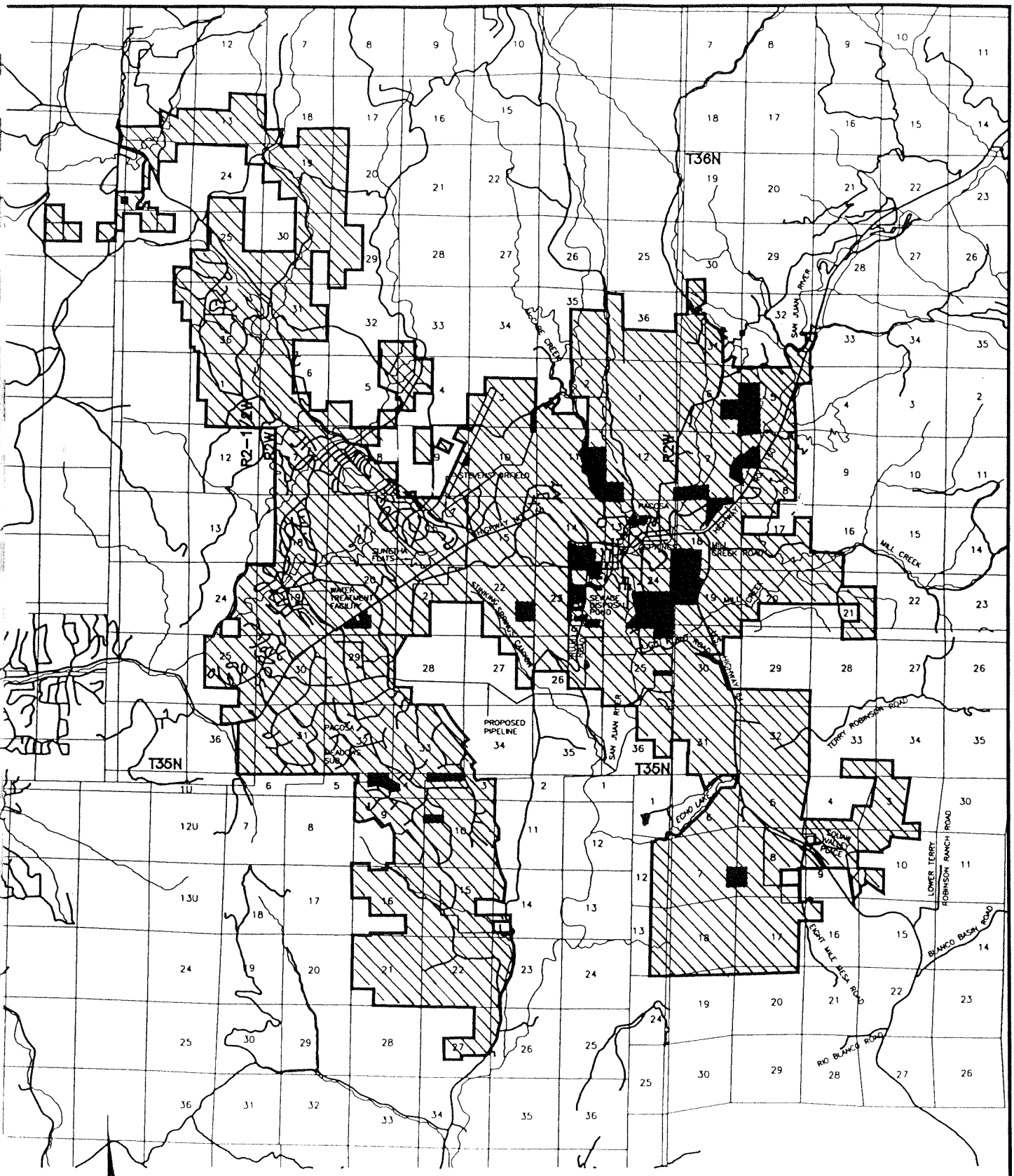


FIGURE 2-1
MAP OF PAGOSA AREA WATER AND SANITATION DISTRICT SERVICE AREA

SCALE: 1" = 10,000'

Table 3-1
Per Capita Water Usage Estimate

Year	Estimated Population	Total Water Treated (m.g.)	Average Yearly Per Capita Usage (g.p.d.)
1995	6135	442.4257	198
1996	6590	461.994	192
1997	7045	486.3108	189
1998	7500	574.0772	210
1999	7955	547.90802	189
2000	8410	594.45835	194
	Six Year Average Usage		195

The population estimate does not include the significant transient population from tourism. There are 1,354 motel rooms, condos/time shares, cabins, and bed and breakfasts within the PAWSD service area. In addition, many of the homes in the service area are used mainly during summer months, with the residents also having homes in other states. The above water usage is based on the permanent population in the PAWSD service area which is inflated due to the transient water usage.

Typical daily per capita water usage is 150 to 200 gallons for cities and towns in southwest Colorado. For instance, the City of Durango is approximately 200 gallons per person per day, which also has a significant transient population. The average of 195 gallons per person per day for PAWSD is reasonable for water systems that include lawn and garden watering and have a significant tourist economy.

A daily per capita usage rate of 195 gallons is recommended for estimating future water usage.

3.2. FUTURE POPULATION AND WATER USAGE PROJECTIONS

As described above, for the past 10 years Archuleta County has grown at a rate of 7.1% per year and for the past 20 years at a rate of 4% per year, these growth rates would also apply to the PAWSD service area. The growth within PAWSD is expected to continue at the 7.1% rate for the next 10 years, then after 2010, the growth rate is expected to reduce to the long term value of 4% per year.

The estimated permanent population within PAWSD and the water usage using 195 gallons per person per day are shown in Table 3-2 for each 5-year increment from 2000 to 2025. The population within the PAWSD in 2000 is estimated to be 85% of the Census count, or 8,410. The PAWSD 2000 permanent population of 8,410 is increased at the annual rate of 7.1% from 2000 to 2010 and 4% from 2010 to 2025.

Table 3-2
Estimated PAWSD Future Water Demand

Year	Annual Growth Rate	Estimated Permanent Population	Annual Use Per Capita (g./cap./day)	Total Annual Demand (acre-feet)	Total Annual Demand (million gallons)
2000		8,410	195	1,825	599
	7.10%				
2005		11,851	195	2,589	843
	7.10%				
2010		16,699	195	3,648	1,189
	4%				
2015		20,317	195	4,438	1,446
	4%				
2020		24,719	195	5,399	1,759
	4%				
2025		30,074	195	6,569	2,141

The population in the service area in 2025 is projected to be about 30,074. The associated annual water demand is 2,141 million gallons or 6,569 acre-feet.

The monthly water usage within the year varies as shown in Table 3.3, from a low of 6.1% in February to a high of 12.5% in June. The water supply facilities not only have to provide the annual water demand shown in Table 3-2 but also must be able to provide the monthly demand shown in Table 3-3.

Table 3-3
Monthly Water Demand in 2025

Month	% of Annual Usage Each Month	Monthly Usage (million gallons)	Monthly Usage (acre-feet)
Jan	6.5%	138	425
Feb	6.0%	130	399
Mar	6.7%	143	438
Apr	6.4%	139	426
May	9.1%	203	624
June	12.5%	273	838
July	12.2%	263	807
Aug	10.2%	215	660
Sept	9.0%	194	595
Oct	7.5%	154	473
Nov	6.6%	137	422
Dec	7.2%	151	463
Total	100%	2,141	6,569

3.3. SUMMARY OF 2025 WATER DEMAND

PAWSD plans to have raw water facilities constructed by 2010 that are adequate to supply the estimated 2025 annual and monthly water demand as shown in Table 3-3.

PAWSD is attempting to develop plans that will allow the construction of water supply facilities to be well ahead of the estimated water demand because: (1) the 2025 water demand is based on long term population increases for Archuleta County, should the population growth seen in the past decade continue for the next two decades the 2025 water demand will occur between 2015 and 2020 rather than 2025; and (2) the time to construct new water supply facilities is significant due to permitting, funding, and other issues which commonly delay construction of new facilities.

Water conservation will continue to be a component of the PAWSD water supply plan. A "Water Conservation Master Plan" has been approved and implemented by PAWSD in January, 2000. The average per capita usage of 195 gallons per day is consistent with cities and towns with significant summer lawn watering, and tourist economies; however, PAWSD will continue to attempt to reduce the per capita usage.

4. EXISTING WATER SUPPLY SOURCES

4.1. INTRODUCTION

This section describes the three existing raw water supply systems that are available to the PAWSD. In addition to the existing systems, the Vista Water Treatment Plant, which is presently under construction, is included in this section. Knowledge of the raw water sources and systems has been derived from interviews with PAWSD personnel and through review of past water supply studies.

A surface water operations model has been used to predict water yield during drought conditions from two of the water supply sources. The two sources that were modeled included Hatcher and Stevens Reservoirs both of which obtain significant supplemental supplies from Fourmile creek. Camp, Dresser & McKee Inc. as part of a study entitled "Feasibility Study Hidden Valley Reservoir and Stevens Lake Dam Enlargement" developed the basic model. Some modifications have been made to the model as a result of new data. For purposes of this report, the model is referred to as the "CDM modified model." Since an extremely dry series of years has not occurred since the raw water systems have been operating at their present levels, water availability during a drought is not known. The model includes the very dry years of 1976, 1977 and 1978. Model runs are contained in Appendix A and a description of the model is included in Appendix B.

Water supply for the Vista and Snowball water treatment plants were not modeled. Availability of supply for these sources was based on historical measurements of flow in the San Juan River that demonstrated water availability.

4.2. HATCHER RESERVOIR AND WATER TREATMENT PLANT

4.2.1. General Description

Hatcher Reservoir has a capacity of 1,729 acre-feet and is the source of supply for the Hatcher Water Treatment Plant (WTP). The reservoir stores water under its own decrees, runoff from Martinez Creek diverted under its J.B. Martinez and Perkins Ditch decrees and obtains water from Dutton Ditch through an extension pipeline. Dutton Ditch obtains its supply from Fourmile Creek. Hatcher WTP, with a capacity of 2 m.g.d., draws its supply from Hatcher Reservoir. A map showing the major components of the Hatcher Reservoir and water treatment plant is included as Figure 4-1.

4.2.2. Water Supply

The water supply for this facility is largely dependent on the natural runoff characteristics of the reservoir basin, Martinez and Fourmile Creeks. During years when precipitation is average and above, experience has indicated that a nearly full water supply is available to

this water treatment plant. Since municipal water use does not decrease during dry periods, continued water supply availability is critical.

To prepare for these dry periods, the CDM modified model was operated for Hatcher Reservoir and WTP to estimate available water supplies during drought conditions. The model output is included as Case 4, page A-8, in Appendix A.

The referenced model indicates that a production rate from the Hatcher WTP of 90 acre-feet per month during the period May through September and 20 acre-feet per month during the remaining portion of the year could be maintained during drought conditions. The 90 and 20 acre-feet per month are equal to 0.96 m.g.d and 0.21 m.g.d. respectively. Production at the maximum rate is equal to less than one-half of the capacity of the water treatment plant. Therefore, the model indicates that drought conditions will significantly reduce the water supply available from Hatcher WTP.

It is important to recognize that all modeled assumptions do not replicate past operation of the Hatcher WTP source. Significant assumptions used in the model include:

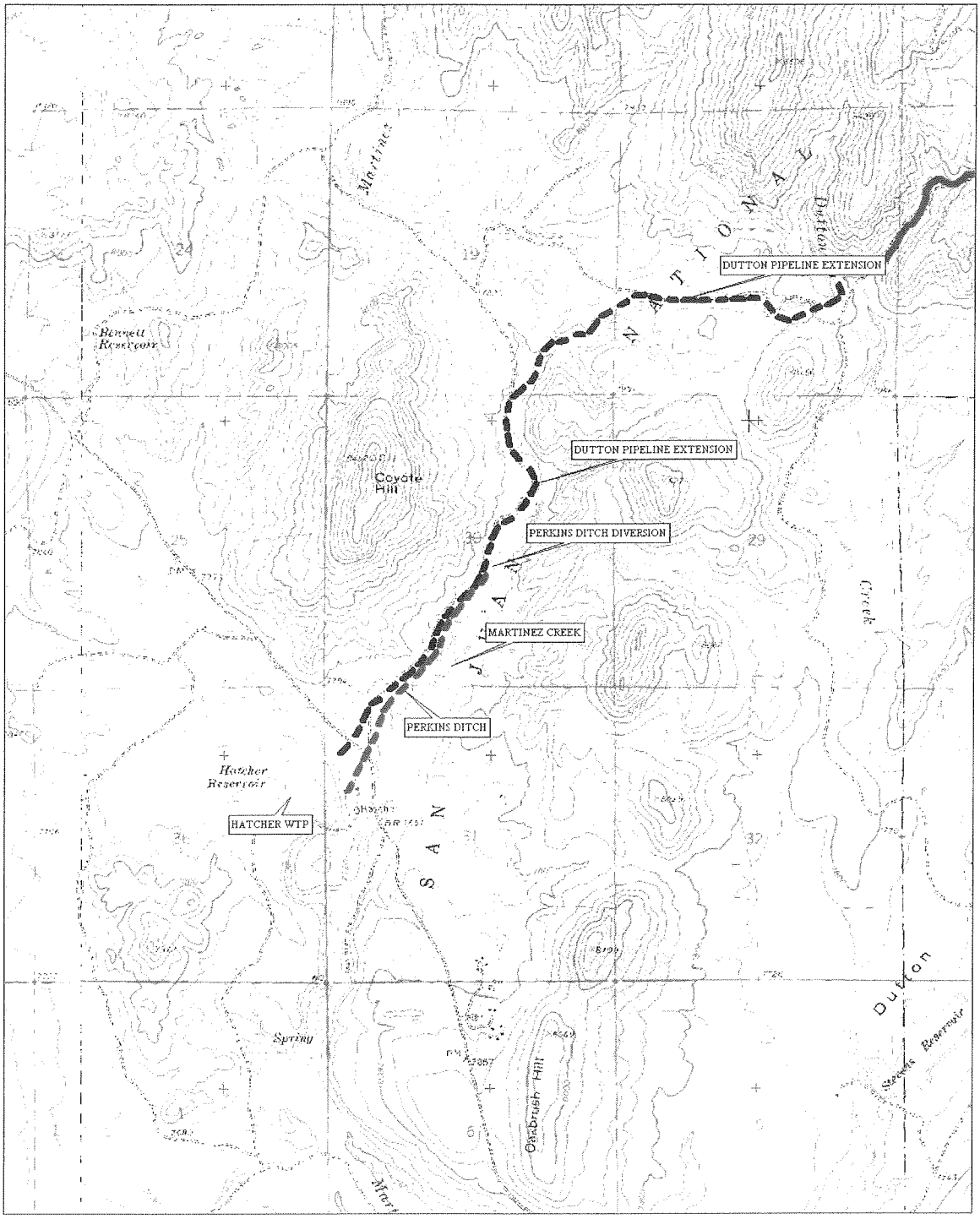
- Diversion of 21.25 c.f.s. under the JB Martinez and Perkins Ditch rights through the Perkins Ditch when water is available in Martinez Creek. At the present time, the ditch is of insufficient size to carry the full water right.
- The present ability to draw Hatcher Reservoir down to a storage level of only 850 acre-feet was maintained in the model. The WTP supply pump is set at an elevation that permits withdrawal of water only from the upper portion of the reservoir.

Descriptions of all model assumptions are contained in Appendix B.

4.3. SNOWBALL WATER TREATMENT PLANT

4.3.1. General Description

The existing water supply facilities at Snowball WTP include a 2 m.g.d. water treatment plant, 8 million gallon raw water reservoir, 250,000 gallon treated water storage tank, and a water transmission pipeline. The transmission pipeline carries water by gravity from the intake on the West Fork of the San Juan River 8 miles to a raw water reservoir. At a site immediately below the reservoir, water from the reservoir passes through a water treatment plant, storage tank and then flows through a three-mile pipeline to its connection with the distribution system in the Town of Pagosa Springs. A sketch showing the location and major components is included as Figure 4-2.



3-DTopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS 600 ft Scale: 1: 26,125 Detail: 13-0 Datum: WGS84

FIGURE 4-1
MAP OF HATCHER RESERVOIR
AND WATER TREATMENT PLANT

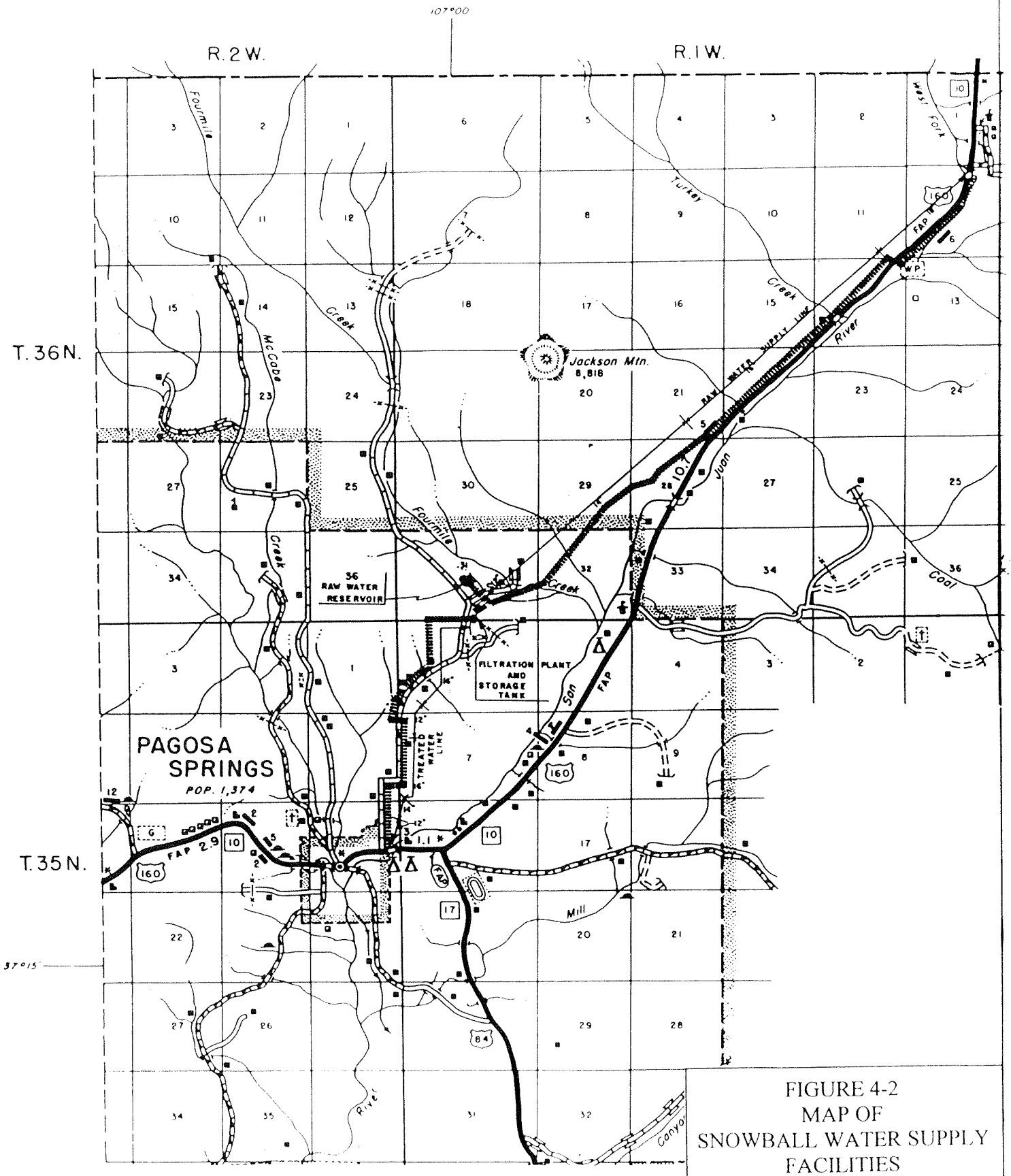


FIGURE 4-2
MAP OF
SNOWBALL WATER SUPPLY
FACILITIES

SCALE: 1" = ±7,540'

4.3.2. Water Supply

The transmission pipeline above the treatment plant has a design capacity of 2.0 m.g.d. using the planned pipe sizes and grades. A soil slide along the pipeline route is 4.1 miles downstream from the diversion from the West Fork of the San Juan at Jackson Mountain. As a result of numerous repairs to the pipeline that has raised the elevation of the pipeline where it crosses the soil slide, the capacity of the pipe has been reduced from the design of 2.0 m.g.d. to approximately 1.5 m.g.d. The soil slide moves continuously with the most rapid movement occurring during periods of high precipitation. A catastrophic event along the active slide area is very likely. Such an event would result in complete loss of the pipeline over a length of approximately ¼ of a mile. The treated water transmission pipeline below the plant has a design capacity of 4.0 m.g.d.

Experience during the record dry years of 1976, 1977 and 1978 indicate that water availability and water rights in the West Fork are adequate even during dry years to maintain this supply.

4.4. STEVENS RESERVOIR AND WATER TREATMENT PLANT

4.4.1. General Description

With a storage capacity of 635 acre-feet, Stevens Reservoir is located in Dutton Creek drainage approximately 4½ miles northwesterly of Pagosa Springs, Colorado. The reservoir stores water under its own decree and from Dutton Ditch which diverts from Fourmile Creek and discharges in Dutton Creek. The 0.5 m.g.d. Stevens (WTP) is located immediately below the reservoir and draws its supply from the reservoir. A map showing the location of the Reservoir is included as Figure 4-3.

4.4.2. Water Supply

The water supply for Stevens Reservoir and water treatment plant is largely dependent on the natural runoff characteristics of the reservoir basin and water diverted through Dutton Ditch from Fourmile Creek. There is a nearly full water supply for this water treatment plant during years when precipitation is average and above. Since a series of extremely dry years has not occurred since this water treatment plant has been operating at its present level, water availability is not known.

To prepare for these dry periods, the CDM modified model was operated for Stevens Reservoir and WTP to estimate available water supplies during drought conditions. The model output is included as Case 4, page A-9, in Appendix A. Descriptions of operational assumptions are contained in Appendix B.

The referenced model indicates that a production rate from the Stevens Reservoir of 92 acre-feet per month during the period May through September could be maintained during drought years. No production would be available during the remaining portion of the year. 92 acre-feet per month is equal to 0.99 m.g.d. which exceeds the present

capacity of the water treatment plant. Therefore, it was assumed the maximum production rate during a drought would be 0.5 m.g.d. during May through September. The remaining storage would be divided throughout the other seven months of the year and produce 0.35 m.g.d. Due to water quality limitations, it was assumed the lower 150 acre-feet of the reservoir could not be used to supply the WTP.

4.5. SAN JUAN RIVER DIVERSION AND VISTA WATER TREATMENT PLANT

4.5.1. General Description

The 3 m.g.d. Vista WTP is located approximately six miles westerly of Pagosa Springs, Colorado. Water is supplied to the water treatment plant through a 6.1 mile transmission pipeline that diverts from the San Juan River approximately four miles south of Pagosa Springs. This project is presently under construction with completion of the first stage expected late 2001. The project is being built in stages with the first stage providing a capacity of 2 m.g.d. A map of the major components of this water supply system is included as Figure 4-4.

4.5.2. Water Supply

Although there has been no experience concerning the physical availability of water at the river diversion or the reliability of the water rights, historical records indicate that a full water supply will be available from the San Juan River at this point of diversion.

4.6. SUMMARY OF ESTIMATES OF AVAILABLE WATER SUPPLY DURING DRY PERIODS

The present maximum treatment plant production capacity during the peak usage time including the Vista WTP, when entirely completed, is approximately 5.96 m.g.d. A tabulation of the maximum yield from each source is presented in Table 4-1.

Table 4-1
Summary of Water Availability
During Dry Periods

Water Source	Maximum Yield During May – September Period (m.g.d.)	Maximum Yield During October – April Period (m.g.d.)
Hatcher Water Treatment Plant	0.96	0.21
Snowball Water Treatment Plant	1.50*	1.50*
Stevens Water Treatment Plant	0.50	0.35
Vista Water Treatment Plant	3.00**	3.00**
Total	5.96	5.06

* Limited by transmission pipeline capacity.
** First stage construction will be 2.0 m.g.d. with the additional 1 m.g.d. to be installed when needed.

These estimated supply amounts are the maximum possible during assumed dry year conditions. A safety factor for unforeseen events has not been included.

The monthly water supply from existing sources based on the CDM modified model during May through September is 179 million gallons and the monthly water supply during October through April is 152 million gallons. A comparison of the monthly water demand as shown in Table 3-3 and the supply from current facilities is shown in Table 4-2.

Table 4-2
Monthly Water Demand in 2025
Compared to Current Supply

Month	Monthly Usage (million gallons)	Monthly Supply (million gallon)	Shortage (million gallon)
Jan	138	152	None
Feb	130	152	None
Mar	143	152	None
Apr	139	152	None
May	203	179	24
June	273	179	94
July	263	179	84
Aug	215	179	36
Sept	194	179	15
Oct	154	152	2
Nov	137	152	None
Dec	151	152	None
Total	2,141	1,959	255

The maximum monthly water shortage is in June with a projected shortfall of 94 million gallons (289 acre-feet). The summer shortfall volume is 255 million gallons or 782 acre-feet.

Alternative facilities to supply all or part of the shortfall are described in Chapter 5.

In addition to the 1.02 m.g.d. projected shortfall, there remains some question whether the Vista WTP can produce at capacity during a dry year. 3 m.g.d. of water requires a diversion from the San Juan River of at least 4.6 c.f.s. The lowest recorded flow of the San Juan River is 9.7 c.f.s. at Pagosa Springs on October 5, 1956. The river flow at Pagosa Springs during the early fall of 2000 has dropped to 19 c.f.s. It is likely to be difficult to divert 4.6 c.f.s during very low flow conditions. In addition, no determination

has been made of the legal availability of the water from the San Juan River under extreme low flow conditions.

It should be noted that the primary source of water supply during a drought is from the San Juan River. The Snowball and Vista plants together are projected to supply 4.50 m.g.d. of the total available 5.96 m.g.d. Therefore these plants supply 75% of the total. A major state highway parallels much of the San Juan River. The pipeline that supplies water to the Snowball plant passes through an active major soil slide. If the river became contaminated as a result of a traffic accident or the pipeline should fail, the largest portion of the District's supply would be lost. To improve water supply reliability, it is apparent that water supply alternatives from alternate sources should be considered. In particular, increased raw water storage capacity should be considered for alleviation of short-term interruptions in supply caused by pipeline failures, stream contamination and extreme low flow periods.

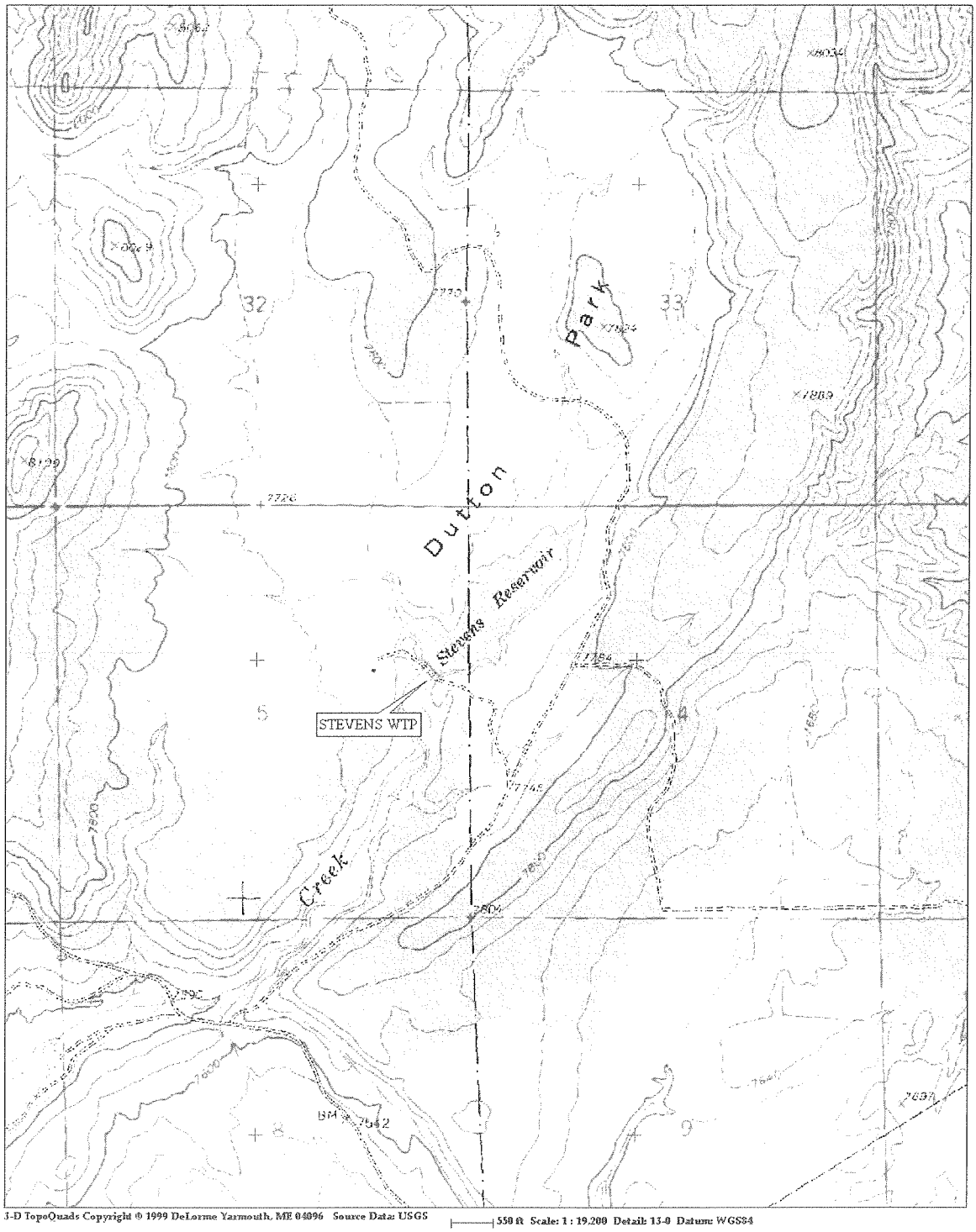


FIGURE 4-3
MAP OF STEVENS RESERVOIR
AND WATER TREATMENT PLANT

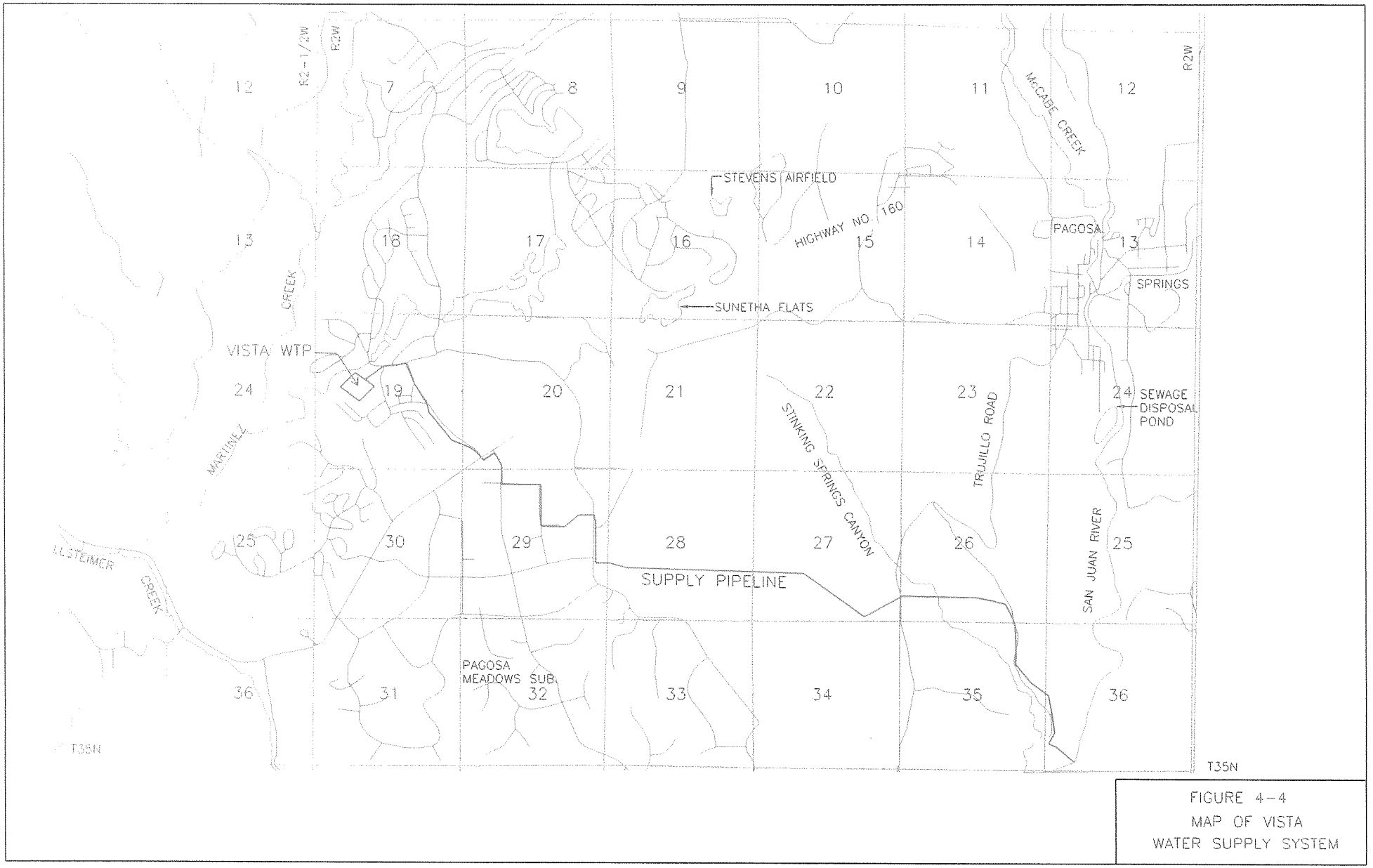


FIGURE 4-4
MAP OF VISTA
WATER SUPPLY SYSTEM

5. ALTERNATE ADDITIONAL WATER SUPPLY SOURCES

5.1. GENERAL DESCRIPTION

The following three sections discuss alternate water supply sources available to PAWSD to meet all or part of the project shortfall described in Chapter 4. Although each alternative is viable, the primary concern is how to provide additional water to the District in the most cost effective manner and with minimal environmental impacts.

A list of the alternate water supply sources considered and the estimated drought water yield for each is presented in Table 5-1. More detailed descriptions of the alternatives are included in subsequent portions of this section. The water yields were derived from the CDM modified model that is described in Appendix B. The model runs are contained in Appendix A. A copy of Table 5-1 showing model runs used to derive the projected yields is also included in Appendix A.

Table 5-1
List of Alternate Water Supply Sources

Sec. No.	Alternate Description	Projected Additional Yield (a.f./yr.)
5.2.	Increase Supply and Capacity of Snowball Water Treatment Plant	1,904
5.3.	Enlarge Stevens Reservoir and Water Treatment Plant to 2 m.g.d.	682
5.4.	Construct Martinez Dam and Use of Hatcher Water Treatment Plant	325
5.5.	Enlarge Dutton Ditch with:	
	Existing Reservoirs with Enlarged Stevens WTP to 1 m.g.d.	717
	Existing Hatcher WTP, Enlarge Stevens Res. and WTP to 2 m.g.d.	1,172
	Construct Martinez Dam and Enlarge Hatcher WTP to 2.5 m.g.d.	730
5.6	Construct Dry Gulch Dam and Enlarge Snowball WTP to 6.5 m.g.d.	3,300

In order to compare alternatives, the annual cost of the alternative was divided by the estimated dry year raw water yield.

Due to the very low yielding wells within the District and high mineral content of the groundwater, wells were not considered as a viable alternative. The very low river flow that occurs during dry years at the diversion for the Vista WTP eliminated from consideration the possibility of expanding this WTP.

5.2. INCREASE SUPPLY AND CAPACITY OF SNOWBALL WATER TREATMENT PLANT

5.2.1. Existing Water Supply Facilities

The existing water supply facilities at this location include a 2 m.g.d. water treatment plant, 8 million gallon raw water reservoir, 250,000 gallon treated water storage tank, and a water transmission pipeline. A more detailed description is included in Section 4.3.

5.2.2. Improvements To Increase Supply and Capacity of Water Treatment Plant

Raw Water Pipeline

To increase the water supply from this facility, the first step would be to increase the capacity of the 8 miles of raw water transmission pipeline. . The existing water right for diversion from the San Juan River is 5 c.f.s. which is equal to 3.23 m.g.d. To match the water right, the raw water pipeline capacity should be increased to approximately 3.2 m.g.d.

There are two options readily available for increasing the pipeline capacity. The options include; 1) installing a pump at the river diversion and 2) constructing a larger pipeline. A pump at the river diversion would increase the flow in the pipeline by increasing the water pressure in the pipeline. The larger pipeline would simply provide more area for the water to flow through.

To increase the flow in the pipeline to approximately 3.2 m.g.d., it is estimated that a 2,220 g.p.m. pump producing about 70 feet of head would be required. The existing raw water transmission pipeline was constructed using asbestos cement pipe with a pressure rating that only slightly exceeds existing operating pressures. Historically the pipeline has suffered numerous breaks that may have been caused by the pipe's inability to accommodate existing pressures. Therefore, installing a pump to increase the pressure and flow in the existing pipeline is impractical.

The existing raw water transmission pipeline varies in size from 18" to 14" diameter and was designed to carry 2.0 m.g.d. Preliminary design calculations indicated that it would be necessary to increase the pipe diameter to 24" to 18" to carry the desired 3.2 m.g.d. A new enlarged diversion structure at the West Fork of the San Juan River would also be required. The soil slide that the transmission pipeline presently crosses remains active. An alternate pipeline route that extends to the opposite side of the river from the soil slide and then returns to the present pipeline route below the soil slide would avoid the unstable area. This change in route would add approximately 2,000 feet to the present pipeline route.

There would be temporary disruption of wetlands associated with streams, ditches and meadows during construction of a replacement pipeline. Permanent loss of wetlands or riparian habitat should not occur as a result of the construction. However, an increase in

diversion from the river is likely to negatively impact wetlands and aquatic habitat that relies on river flow. The present maximum diversion is approximately 1.5 m.g.d. (2.3 c.f.s.). The diversion for the proposed pipeline would be 3.2 m.g.d. (5.0 c.f.s.), an increase of 2.7 c.f.s.

Water Treatment Plant

The existing 2.0 m.g.d. surface water treatment plant was retro fitted into a building without space for expansion. Therefore, replacement of the entire plant with a new 3.5 m.g.d. water treatment plant is proposed. Package water treatment plants are typically available in increments of 0.5 m.g.d. 3.5 m.g.d. is the next larger size to match the supply pipeline capacity. In order to accommodate the larger facility, acquisition of an additional 15 acres of property would be needed.

Distribution System Booster Pump

The Snowball WTP supplies water to a low-pressure portion of the distribution system. If additional water supply is produced at this location, a booster pump system will be needed on the westerly side of Pagosa Springs. The booster pump system will lift water from the lower Pagosa Springs pressure zone to the higher westerly pressure zone. A pumping capacity of about 1 m.g.d. will be needed.

5.2.3. Cost Estimates and Annual Cost Projections

The following preliminary cost estimates are based on prevailing wage, equipment and material costs as of July, 2001. Future users of these estimates should adjust them for inflation as needed. Although the cost estimates prepared as part of this report represent the best judgment of the writer herein as a design professional familiar with the construction industry, the writer does not guarantee that any proposals, bids or actual construction costs will not vary from the cost estimates prepared by him.

Table 5-2

PRELIMINARY COST ESTIMATES
FOR
IMPROVEMENTS TO INCREASE SUPPLY AND CAPACITY
OF SNOWBALL WATER TREATMENT PLANT

Item Description	Quantity	Unit	Unit Price	Total Price
Contractor Mobilization/Demobilization	1	l.s.	50,000	50,000
Transmission Pipeline:				
River diversion	1	l.s.	100,000	100,000
24" Dia. D.I.P. transmission pipeline	10,400	l.f.	60	624,000
21" Dia. D.I.P. transmission pipeline	16,690	l.f.	55	917,950
18" Dia. D.I.P. transmission pipeline	13,720	l.f.	50	686,000
River crossing	2	ea.	30,000	60,000
Highway crossing	120	l.f.	600	72,000
Air release station	8	ea.	4,000	32,000
Blow off valve	8	ea.	3,500	28,000
Water Treatment Plant:				
3.5 m.g.d. water treatment plant	1	l.s.	1,400,000	1, 400,000
Sludge dewatering lagoons	1	l.s.	175,000	175,000
Building for WTP	1	l.s.	400,000	400,000
Booster Pump Between Pressure Zone:				
Pump - 700 g.p.m. @ 380 ft. T.D.H.	1	l.s.	100,000	100,000
8" Dia. D.I.P. transmission pipeline	7,700	l.f.	20	154,000
Total Estimated Construction Cost (TECC)				$4, 798,950
Contingency @ 20% of TECC				959,790
Engineering & Legal @ 20% of TECC				959,790
Land Purchase - 15 acres @ $10,000/ac.				150,000
TOTAL ESTIMATED PROJECT COST				$6,868,530

The annual cost projections were prepared assuming a loan at an interest rate of 6% per year with a 20 year repayment schedule.

Table 5-3

ESTIMATE OF ANNUAL COST OF OPERATION
FOR
IMPROVEMENTS TO INCREASE SUPPLY AND CAPACITY
OF SNOWBALL WATER TREATMENT PLANT

Annual Cost of Operation:

Total Estimated Project Cost (TEPC) =		$6,688,530	
Number of years of payments =	20		
Interest rate =	6.0%		
Annual Debt Service = $\left[\frac{i}{(1+i)^n - 1} + i\right] x\, TEPC =$			$598,830

O & M Costs per year:

Treatment of 1,904 a.f. @ $166/a.f. =	316,064	
Power & chemical costs 1,904 a.f. @ $150/a.f. =	285,600	
Pipeline maintenance	15,000	
Booster pump power costs	59,000	
		$675,664
Total Estimated Annual Cost		$1,274,494

The estimated increase in yield from the proposed improvements would be the difference between the proposed capacities of 3.2 m.g.d. and the existing transmission pipeline capacity of 1.5 m.g.d. Therefore, the yield would be 1.7 m.g.d. This yield is equivalent to1,904 a.f./yr.

The estimated water cost would be $2.05 per 1,000 gals. Calculations are shown below.

$$\text{Water Cost} = \frac{\$1,274,494 \text{ / yr. x } 1,000 \text{ gals.}}{1,904 \text{ a.f./yr. x } 325,851 \text{ gals./a.f.}} = \$2.05 \text{ per } 1,000 \text{ gals.}$$

5.3. ENLARGE STEVENS RESERVOIR AND WATER TREATMENT PLANT

5.3.1. General Description

This alternative would involve enlarging Stevens Reservoir to 1,430 acre feet by raising the dam by ±10 feet and expanding the water treatment plant. The present storage capacity of Stevens Reservoir is 635 acre feet and the associated water treatment plant maximum capacity is 0.5 m.g.d. A sketch showing the location and major components is included as Figure 5-1.

5.3.2. Proposed Improvements

Stevens Reservoir

Stevens Reservoir dam is an existing earthfill dam built in the early 1950's and is 24 feet in height. The length of the existing dam is approximately 1,000 feet with a crest width of 20 feet. State Engineer Office's safety inspection reports indicate that the outlet conduit is corroded and the slide gate is difficult to operate. Reservoir water quality for purposes of water supply is becoming poor and cleaning is needed. To correct these deficiencies, it will be necessary to drain the reservoir in the near future. The enlarged reservoir water surface area would be about 130 acres, increased from about 80 acres presently.

It is anticipated that the proposed enlargement will raise the top of the dam by approximately 10 feet above the existing crest to an elevation of 7730 feet. This will increase the length of the dam from the existing 1,000 feet to 1,225 feet. The toe of the dam is at an elevation of 7694 feet. The proposed spillway has been located at 7723 feet and the high water line has been calculated at 7729 feet. All elevations are feet above mean sea level, 1929 datum.

Water Treatment Plant

Additional water treatment plant capacity is needed. Projected water availability during a drought is 460 a.f./yr. District personnel have indicated that most urgent need for this water is during the months of May through September when additional water use occurs because of outside irrigation, tourist and summer residences. Dividing the total available water into five months results in 92 a.f./month. 92 a.f./month is equal to 0.98 m.g.d. To treat this quantity of water, the existing 0.5 m.g.d. plant needs to be enlarged to 1 m.g.d.

If the reservoir is enlarged, total yield is approximately doubled. Therefore, a 2 m.g.d. water treatment plant is needed if the reservoir is enlarged. The existing water treatment plant is located in a building immediately below the dam. There is no available space in the existing building, so a new building and plant are proposed.

5.3.3. Water Supply

The water supply for the proposed enlarged Stevens Reservoir and Dutton Ditch has been estimated using the CDM modified hydrologic model. The estimated additional yield from an enlarged reservoir is 682 a.f./yr. From both an enlarged reservoir and Dutton Ditch, the estimated additional yield is 1,172 a.f./yr. For both of these scenarios, the water treatment plant use is planned for only the peak water demand months of May through September.

5.3.4. Cost Estimates and Annual Cost Projections

The following preliminary cost estimates are based on prevailing wage, equipment and material costs as of July, 2000. Future users of these estimates should adjust them for inflation as needed. Although the cost estimates prepared as part of this report represent the best judgment of the writer herein as a design professional familiar with the construction industry, the writer does not guarantee that any proposals, bids or actual construction costs will not vary from the cost estimates prepared by him.

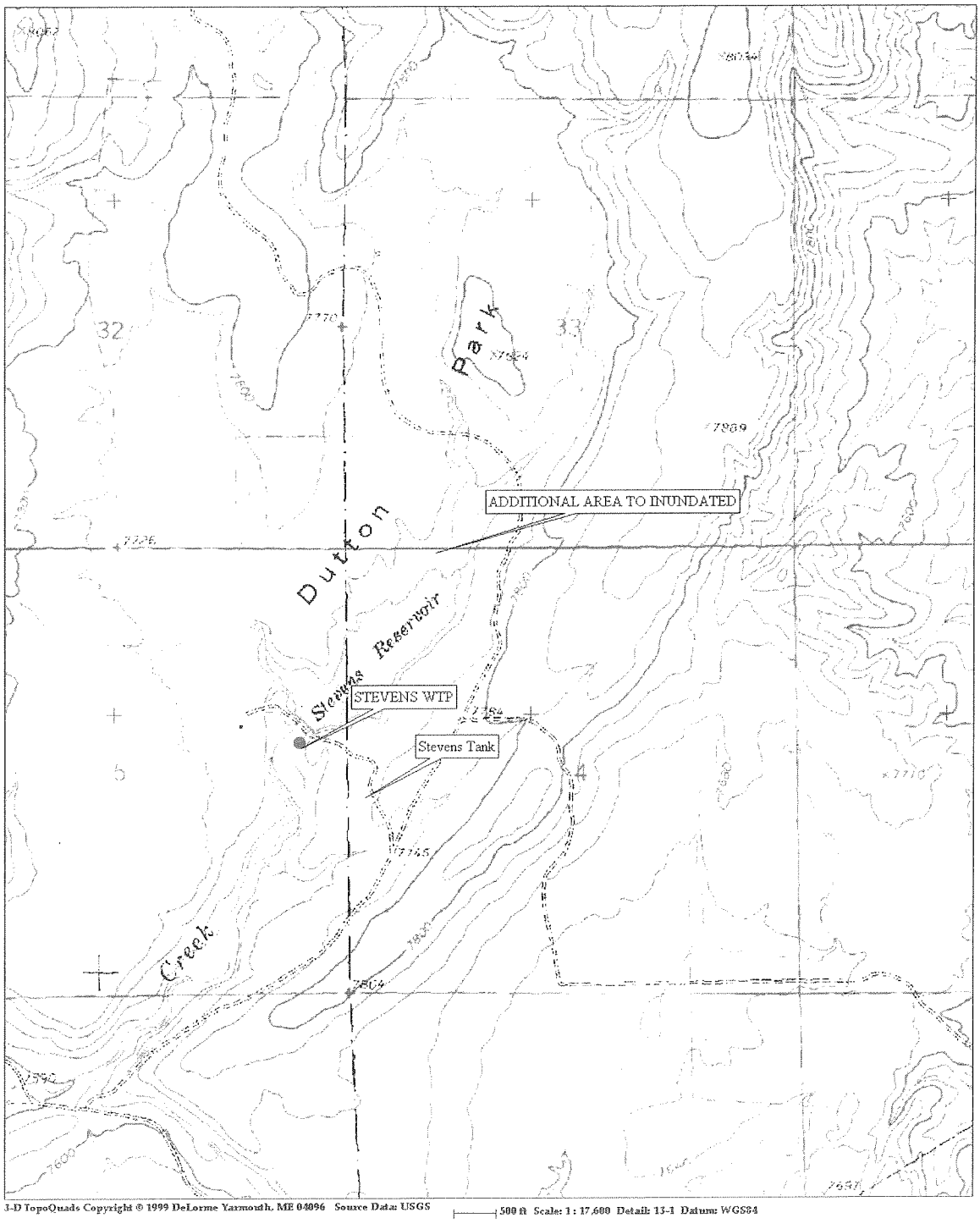


FIGURE 5-1
MAP OF STEVENS RESERVOIR
ENLARGEMENT

Table 5-4

PRELIMINARY COST ESTIMATES
FOR
PROPOSED ENLARGEMENT OF STEVENS RESERVOIR

Item Description	Quantity	Unit	Unit Price	Total Price
Contractor Mobilization/Demobilization	1	l.s.	50,000.00	50,000
Diversion & Dewatering	1	l.s.	50,000.00	50,000
Haul road	5,000	l.f.	20.00	100,000
Excavation of Existing Dam	7,833	c.y.	2.12	16,606
Strip borrow area	4,000	c.y.	1.00	4,000
Zone 1 fill	39,094	c.y.	1.93	75,451
Zone 2 fill	39,418	c.y.	1.62	63,857
Chimmey drain	2,618	c.y.	21.17	55,423
Rip rap	14,653	c.y.	40.00	586,120
Rip rap bedding	4,884	c.y.	15.00	73,260
Filter fabric	4,884	s.y.	1.52	7,424
Clear & grub	150	ac.	1,000.00	150,000
Use Existing Spillway				
Outlet Works				
Inlet structure	1	l.s.	35,000.00	35,000
Outlet structure	1	l.s.	20,000.00	20,000
Slip line 18" pipeline	150	l.f.	200.00	30,000
18" Outlet extension	100	l.f.	80.00	8,000
18" BFV	1	ea.	5,000.00	5,000
Total Estimated Construction Cost (E.C.C.)				$1,330,141
Land Acquisition 20 ac.@ $5,000/ac.				$100,000
Contingency @ 20% of E.C.C.				266,028
Engineering & Legal @ 20% of E.C.C.				266,028
TOTAL ESTIMATED PROJECT COST				$1,962,198

Table 5-5

PRELIMINARY COST ESTIMATES
FOR
PROPOSED ADDITIONAL ½ M.G.D. WATER TREATMENT PLANT
AT EXISTING STEVENS RESERVOIR

Item Description	Quantity	Unit	Unit Price	Total Price
½ m.g.d. package water treatment plant	1	l.s.	220,000.00	220,000
Metal building for WTP	1	l.s.	150,000.00	150,000
Booster pump - ½ m.g.d.	1	l.s.	20,000.00	20,000
Raw water pump - ½ m.g.d.	1	l.s.	40,000.00	40,000
Total Estimated Construction Cost (TECC)				$430,000
Contingency @ 20% of TECC				86,000
Engineering & Legal @ 20% of TECC				86,000
TOTAL ESTIMATED PROJECT COST				$602,000

Table 5-6

PRELIMINARY COST ESTIMATES
FOR
PROPOSED ADDITIONAL 1½ M.G.D. WATER TREATMENT PLANT
AT PROPOSED STEVENS RESERVOIR

Item Description	Quantity	Unit	Unit Price	Total Price
1½ m.g.d. package water treatment plant	1	l.s.	550,000.00	550,000
Metal building for WTP	1	l.s.	200,000.00	200,000
Booster pump - 1½ m.g.d.	1	l.s.	60,000.00	60,000
Raw water pump - 1½ m.g.d.	1	l.s.	120,000.00	120,000
Total Estimated Construction Cost (TECC)				$930,000
Contingency @ 20% of TECC				186,000
Engineering & Legal @ 20% of TECC				186,000
TOTAL ESTIMATED PROJECT COST				$1,302,000

The annual cost projections were prepared assuming a loan at an interest rate of 6% per year with a 20 year repayment schedule.

Table 5-7

ESTIMATE OF ANNUAL COST OF OPERATION
FOR
EXISTING STEVENS RESERVOIR AND 1 M.G.D. WTP
WITH YIELD FROM DUTTON DITCH ENLARGEMENT

Annual Cost of Operation:

Estimated Project Cost - Additional ½ m.g.d. WTP	602,000	
Total Estimated Project Cost (TEPC) =	$602,000	
Number of years of payments (n) =	20	
Interest rate (i) =	6%	
Annual Debt Service $\left[\frac{i}{(1+i)^n - 1} + i\right] x TEPC =$		$52,485

O & M Costs per year:

Treatment of 717 a.f. @ $166/a.f. =	119,022	
Power & chemical costs 717 a.f. @ $150/a..f. =	107,550	
Dam maintenance =	15,000	
		$241,572
Total Estimated Annual Cost		$294,057

With Dutton Ditch enlargement and the existing reservoir, Stevens Reservoir is projected to yield ±460 a.f./yr. The higher water demand by users during the summer months results in a projected operational need of ±92 a.f./mo. for a five month period. 92 a.f./mo. is equivalent to 0.98 m.g.d. The existing Stevens water treatment (WTP) capacity is 0.5 m.g.d. Therefore, the increased yield from enlarging the WTP is 0.48 m.g.d. for a five month period or 227 a.f./yr. Increased yield from the existing Hatcher Reservoir and water treatment plant is projected to be 490 a.f./yr. Together, the total increased yield is 717 a.f./yr. Dry year annual cost for this alternative is tabulated in Table 5-16 and the calculation deriving the cost per 1,000 gallons is shown following the table.

Table 5-8

ESTIMATE OF ANNUAL COST OF OPERATION
FOR
ENLARGED STEVENS RESERVOIR AND 2 M.G.D. WTP

Annual Cost of Operation:

Estimated Project Cost - Stevens Res.	1,962,198	
Estimated Project Cost - Additional 1½ m.g.d. WTP	1,302,000	
Total Estimated Project Cost (TEPC) =	$3,264,198	
Number of years of payments (n) =	20	
Interest rate (i) =	6%	
Annual Debt Service = $\left[\frac{i}{(1+i)^n - 1} + i\right] x TEPC =$		$284,588

O & M Costs per year:

Treatment of 681 a.f. @ $166/a.f. =	113,046	
Power & chemical costs 681 a.f. @ $135/a.f. =	91,935	
Dam maintenance =	15,000	
		$219,981
Total Estimated Annual Cost		$504,569

Water yield from the enlarged Reservoir and water treatment plant is projected to be 681 a.f./yr. without Dutton Ditch enlargement. Dry year water costs would be:

Cost without Dutton Ditch enlargement = $2.27/1,000 gallons

$$\text{Water Cost} = \frac{\$504,569/\text{ yr.} \times 1,000\text{ gals.}}{681\text{ a.f./yr.} \times 325,851\text{ gals./a.f.}} = \$2.27 \text{ per } 1,000\text{ gals.}$$

Table 5-9

ESTIMATE OF ANNUAL COST OF OPERATION
FOR
ENLARGED STEVENS RESERVOIR, WTP TO 2 M.G.D.
WITH ADDED YIELD FROM ENLARGED DUTTON DITCH*

Annual Cost of Operation:

Estimated Project Cost - Stevens Res.	1,962,198	
Estimated Project Cost - Additional 1½ m.g.d. WTP	1,302,000	
Total Estimated Project Cost (TEPC) =	$3,264,198	
Number of years of payments (n) =	20	
Interest rate (i) =	6%	
Annual Debt Service = $\left[\frac{i}{(1+i)^n - 1} + i\right] x TEPC =$		$284,588

O & M Costs per year:

Treatment of 1,172 a.f. @ $166/a.f. =	194,552	
Power & chemical costs 1,172 a.f. @ $135/a.f. =	158,220	
Dam maintenance =	15,000	
		$367,772
Total Estimated Annual Cost		$652,360

* Construction costs, O & M for Dutton Ditch Enlargement not included.

Additional water yield from the enlarged Reservoir and treatment plant would be 1,172 a.f./yr. with Dutton Ditch enlargement. Dry year annual cost for this alternative is tabulated in Table 5-16 and the calculation deriving the cost per 1,000 gallons is shown following the table.

5.4. CONSTRUCT MARTINEZ DAM AND ENLARGE HATCHER WATER TREATMENT PLANT

5.4.1. General Description

The proposed Martinez Dam would provide approximately 760 acre feet of storage which could be used at an expanded Hatcher WTP which is within approximately ½ mile of the dam site. The dam site is on Martinez Creek. In addition to inflow from the drainage basin, it has been assumed that water from an expanded Dutton Ditch would be delivered to the reservoir site. Dutton Ditch diverts from nearby Four Mile Creek. A sketch showing the location and major components is included as Figure 5-2.

5.4.2. Proposed Improvements

Martinez Dam

The proposed dam would be an earthfill dam constructed to a height of 50 feet above the existing Martinez Creek channel. A concrete chute spillway is proposed on the northerly side of the dam. The total tributary area above the dam is approximately 10.7 square miles. The normal water level in the reservoir would be below the elevation of the water level in Hatcher Reservoir. In order to convey water from the reservoir to an enlarged Hatcher water treatment plant, it will be necessary to construct a pumping system and conveyance structure to deliver the reservoir water to the water treatment plant.

Water Treatment Plant

If both Martinez Dam and the Dutton Ditch enlargement were constructed, enlargement of the Hatcher water treatment plant would be required. The existing 2.0 m.g.d. surface water treatment plant would be enlarged to a capacity of 2.5 m.g.d.

5.4.3. Water Supply

The water supply for the proposed Martinez Reservoir has been estimated using the CDM modified hydrologic model developed by initially by Camp, Dresser & McKee Inc. Initially, the model was run with Hatcher Reservoir and with Hatcher and Martinez Reservoirs during drought conditions to estimate yield of the additional reservoir. The spreadsheets that calculate the two conditions are included on pages A-11 and A-8. The difference between the two model runs indicate the yield from the additional reservoir during drought conditions is 325 a.f./yr.

In addition, the model was run comparing the yield from the reservoir with enlargement of the Dutton Ditch. The net increase in yield from both the addition of Martinez Dam and the enlarged Dutton Ditch during drought conditions was estimated to be 730 a.f./yr.

5.4.4. Cost Estimates and Annual Cost Projections

The following preliminary cost estimates are based on prevailing wage, equipment and material costs as of July, 2001. Future users of these estimates should adjust them for inflation as needed. Although the cost estimates prepared as part of this report represent the best judgment of the writer herein as a design professional familiar with the construction industry, the writer does not guarantee that any proposals, bids or actual construction costs will not vary from the cost estimates prepared by him.

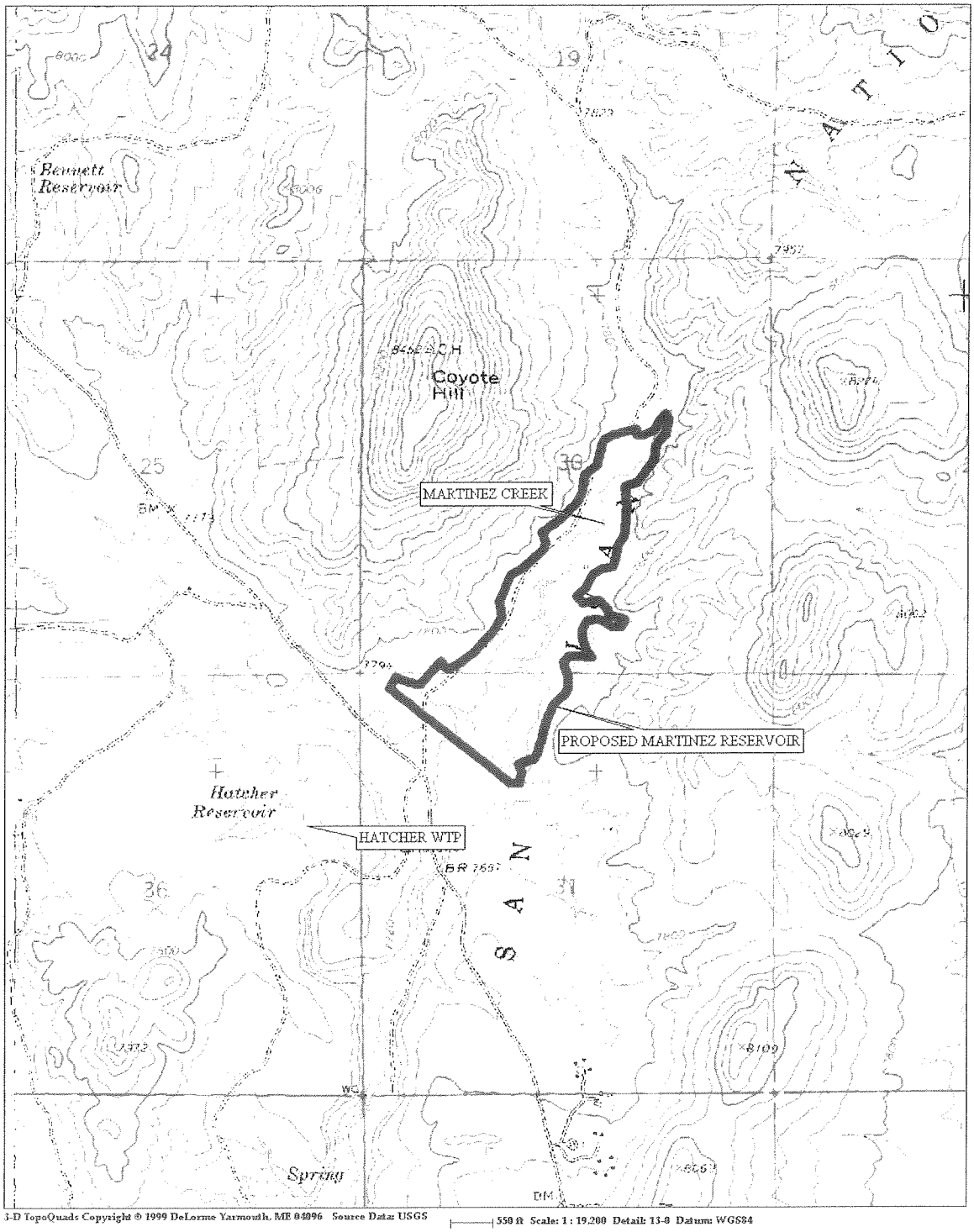


FIGURE 5-2
SKETCH OF PROPOSED MARTINEZ
DAM AND RESERVOIR

Table 5-10

PRELIMINARY COST ESTIMATES
FOR
PROPOSED MARTINEZ RESERVOIR WATER SUPPLY

Item Description	Quantity	Unit	Unit Price	Total Price
Embankment				
Clearing and Grubbing of Dam Site	22,500	c.y.	2.00	45,000
Placement of Earth Fill	328,075	c.y.	1.50	492,113
Core Trench Excavation	48,425	c.y.	5.00	242,125
Chimney & Blanket Drain	23,735	c.y.	15.00	356,025
Riprap & Bedding - Dam	10,970	c.y.	15.00	164,550
Spillway				
Excavation of Spillway	318,000	c.y.	2.00	636,000
Concrete	200	c.y.	450.00	90,000
Riprap	10,000	c.y.	15.00	150,000
Outlet Works				
Outlet Pipe, 36" dia. Concrete	500	l.f.	40.00	20,000
Concrete Cut-Off Collars	9	c.y.	500.00	4,500
Slide Gate w/operator	1	l.s.	40,000.00	40,000
Still Basin	22	c.y.	600.00	13,200
Connection of Hatcher Reservoir				
Pump station for delivery to Hatcher WTP	1	l.s.	75,000.00	75,000
Pipeline Lateral - 14" D.I.P.	1,750	l.f.	18.00	31,500
Perkins ditch construction	1,400	l.f.	25.00	35,000
Total Estimated Construction Cost (TECC)				$2,395,013
Contingency @ 20% of TECC				479,003
Engineering & Legal @ 20% of TECC				479,003
TOTAL ESTIMATED PROJECT COST				$3,353,018

Table 5-11

PRELIMINARY COST ESTIMATES
FOR
PROPOSED ADDITIONAL ½ M.G.D. WATER TREATMENT PLANT
AT HATCHER RESERVOIR

Item Description	Quantity	Unit	Unit Price	Total Price
½ m.g.d. package water treatment plant	1	l.s.	220,000.00	220,000
Metal building for WTP	1	l.s.	150,000.00	150,000
Booster pump - ½ m.g.d.	1	l.s.	20,000.00	20,000
Total Estimated Construction Cost (TECC)				$390,000
Contingency @ 20% of TECC				78,000
Engineering & Legal @ 20% of TECC				78,000
TOTAL ESTIMATED PROJECT COST				$546,000

The annual cost projections were prepared assuming a loan at an interest rate of 6% per year with a 20 year repayment schedule.

Table 5-12

ESTIMATE OF ANNUAL COST OF OPERATION
FOR
MARTINEZ RESERVOIR AND EXISTING 2 M.G.D. HATCHER WTP

Annual Cost of Operation:

Estimated Project Cost - Martinez Res.	3,353,018	
Total Estimated Project Cost (TEPC) =	$3,353,018	
Number of years of payments (n) =	20	
Interest rate (i) =	6%	
Annual Debt Service = $\left[\frac{i}{(1+i)^n - 1} + i\right] x TEPC =$		$292,331
O & M Costs per year:		
Treatment of 325 a.f. @ $166/a.f. =	53,950	
Power & chemical costs 325 a.f. @ $150/a.f. =	48,750	
Dam maintenance =	15,000	
		$117,700
Total Estimated Annual Cost		$410,031

Projected water yield from the new Martinez Reservoir would be 325 a.f./yr. without Dutton Ditch enlargement. Dry year water costs would be:

Cost without Dutton Ditch enlargement = $3.39/1,000 gallons

$$\text{Water Cost} = \frac{\$410{,}031/\text{yr.} \times 1{,}000\ \text{gals.}}{325\ \text{a.f./yr.} \times 325{,}851\ \text{gals./a.f.}} = \$3.39\ \text{per}\ 1{,}000\ \text{gals.}$$

Table 5-13

ESTIMATE OF ANNUAL COST OF OPERATION
FOR
MARTINEZ RESERVOIR AND ENLARGED HATCHER WTP TO 2.5 M.G.D.
WITH YIELD FROM ENLARGED DUTTON DITCH

Annual Cost of Operation:

Estimated Project Cost - Martinez Res.	3,353,018	
Estimated Project Cost - Additional ½ m.g.d. WTP	546,000	
Total Estimated Project Cost (TEPC) =	$3,899,018	
Number of years of payments (n) =	20	
Interest rate (i) =	6%	
Annual Debt Service = $\left[\frac{i}{(1+i)^n - 1} + i\right] x TEPC =$		$339,934

O & M Costs per year:

Treatment of 730 a.f. @ $166/a.f. =	121,180	
Power & chemical costs 730 a.f. @ $150/a.f. =	109,500	
Dam maintenance =	15,000	
		$245,680
Total Estimated Annual Cost		$585,614

Additional water yield from the new Martinez Reservoir with Dutton Ditch enlargement is projected to be 730 a.f./yr. Dry year annual cost for this alternative is tabulated in Table 5-16 and the calculation deriving the cost per 1,000 gallons is shown following the table.

5.5. ENLARGE DUTTON DITCH

5.5.1 General Description

The existing Dutton Ditch diverts water from Fourmile Creek and conveys it into the Dutton Creek drainage. The largest portion of the water rights in the Ditch is used for irrigation purposes with the remainder available for domestic use. Absolute water rights in the ditch currently total 22.85 c.f.s. The rights are as follows in order of priority:

Order	Amount	Use	Owned by
1	12.85 c.f.s	Irrigation	Roger Dolese
2	8.00 c.f.s.	Domestic	PAWSD
3	2.00 c.f.s.	Irrigation	Bud Seavy

PAWSD also owns a 20 c.f.s conditional water right in the Dutton Ditch for the enlargement of the ditch capacity.

Although historically the ditch could carry substantially more, the present ditch physical capacity has declined to approximately 4 c.f.s. at the most constricted flow section. The decline in capacity is a result of accumulation of sediment in the ditch and difficulty in maintaining full capacity at two locations where it crosses unstable hillsides. The result of the above priority and the ditch capacity is that during the irrigation season (typically April 15 to October 15), only a portion of the first 12.85 c.f.s. is diverted by the ditch for irrigation purposes. For the period outside of the irrigation season, diversions up to 8.0 c.f.s. are available for PAWSD. An 8 c.f.s. pipeline was constructed during 1993 from the ditch near its discharge to Dutton Creek over the drainage divide to Hatcher Reservoir. This is called the Dutton Ditch extension pipeline.

During winter months ice forms and prevents use of the Ditch by PAWSD. Further, the varying ditch capacity limits diversion of in-priority domestic rights by PAWSD during both the non-irrigation and irrigation season.

5.5.2. Proposed Improvements

To increase the availability of water from the District's Dutton Ditch right, construction of a pipeline paralleling a large portion of the ditch is proposed. Physical enlargement of the Ditch has also been considered, but soil instability conditions at several locations along the existing ditch make this alternative difficult and probably impractical.

The proposed pipeline will improve ability to divert throughout the year whenever water rights are in priority. It will be particularly useful during the winter because the buried pipeline will be able to carry water during periods when water in the restricted sections of the open ditch froze and stopped flowing. Further, a water-tight pipeline will eliminate present losses to seepage from the ditch.

A preliminary feasibility study of ditch enlargement alternatives was done in December, 1993 by Davis Engineering Service, Inc. In that study two pipeline alternatives were investigated. Both would carry approximately 12 c.f.s. of domestic water which the previously described CDM Model indicates would be frequently available. One of the alternatives assumes construction of a pipeline 19,000 feet long from the diversion on Fourmile Creek to a point below the unstable sections of the existing ditch and where the remaining portion of the Ditch has a capacity of approximately 25 c.f.s. The other alternative assumed construction of a pipeline 28,500 feet long from Fourmile Creek to the Dutton Ditch extension pipeline. For purposes of this study, only the more economical shorter length of pipeline was included. The 19,000 feet long pipeline improves the ability to divert water during the winter and increases the capacity of the system so PAWSD's 8 c.f.s. water rights can be carried without interference from other users of the ditch. The District may decide to construct the entire 28,500 feet of pipeline to minimize erosion and improve water quality. A map of the Dutton Ditch and proposed pipelines is included as Figure 5-3.

5.5.3. Water Supply

The water supply for the proposed enlargement of Dutton Ditch has been estimated using the CDM modified model. A more detailed description of the model is included in section 4.1. As described in this referenced paragraph and Appendix B, the model was used in the very dry years of 1976, 1977 and 1978 to estimate the benefits of improvements during the critical dry year periods. This same model has been used to estimate increased water supply from the proposed Dutton Ditch pipeline.

To maximize additional yield from the enlarged pipeline, a reservoir is needed to capture the water when pipeline flow exceeds the current demand. To estimate the benefits of the enlarged pipeline, three alternate reservoir and WTP combinations have been considered. Following is a summary of the alternatives considered and the resulting yield:

Table 5-14
List of Alternatives Considered
With Enlargement of Dutton Ditch

Description of Alternative	Additional Yield (a.f./yr.)
Existing Reservoirs and Enlarged Stevens WTP to 1 m.g.d.	717
Enlarge Stevens Reservoir and WTP to 2 m.g.d.	1,172
Construct Martinez Dam and Enlarge Hatcher WTP To 2.5 m.g.d.	730

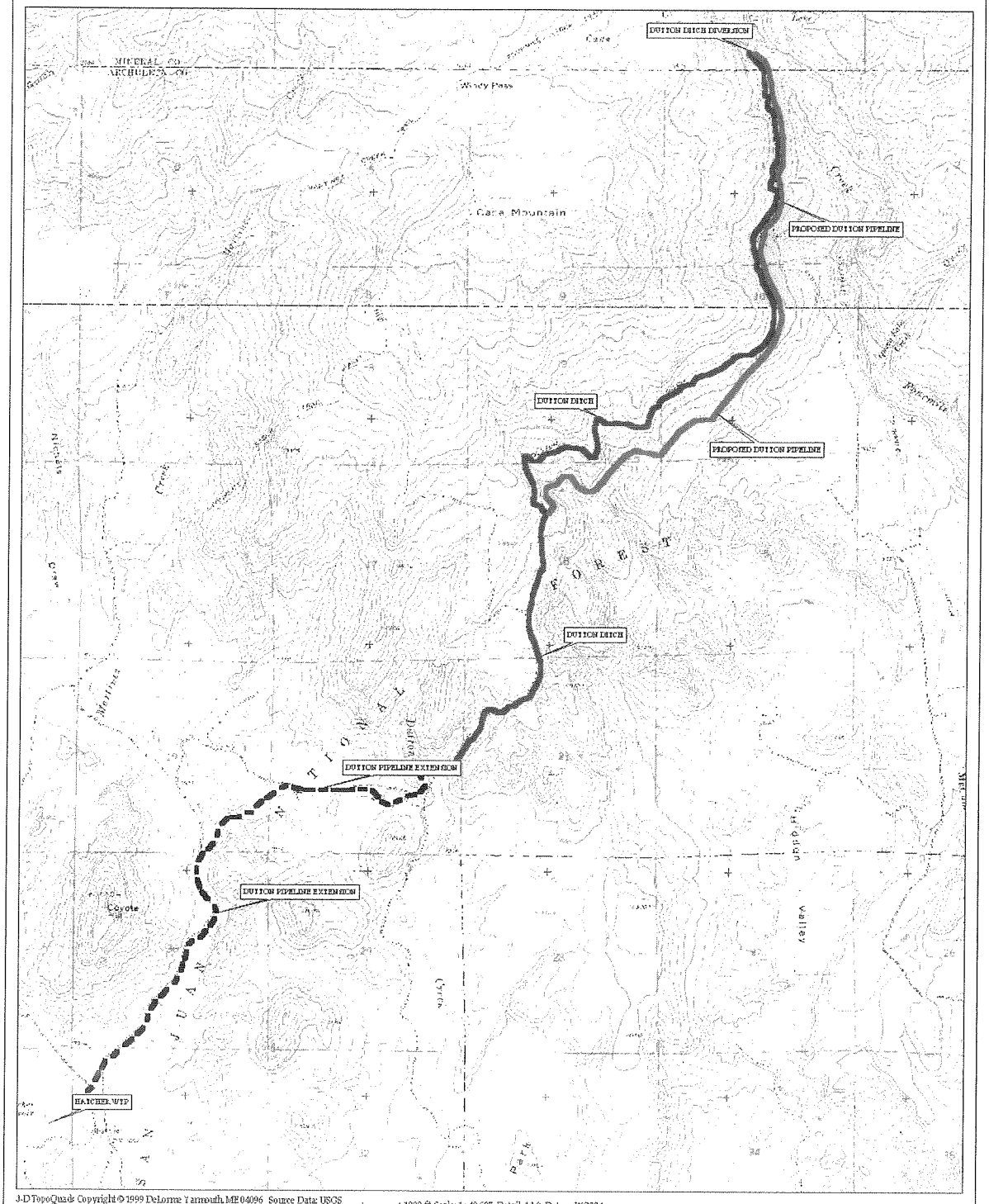


FIGURE 5-3
MAP OF DUTTON DITCH AND
PROPOSED PIPELINE

Dutton Ditch diverts from Fourmile Creek, which is a tributary of the San Juan River. Therefore the proposed enlargement of the Dutton Ditch would result in a reduction in flow in Fourmile Creek and the San Juan River. However, the additional diversion would occur largely during the winter months rather than during the critical low flow months of July, August and September and thus have limited impact to the District's other San Juan River water rights. Storage of resulting additional flows in an enlarged or new reservoir may permit a reduction in reliance on diversions from the river by Vista and Snowball water treatment plants during summer low flow periods. Construction of an enlarged Dutton Ditch may incidentally benefit aquatic habitat and wetlands along the San Juan River.

5.5.4. Cost Estimates and Annual Cost Projections

The following preliminary cost estimates are based on prevailing wage, equipment and material costs as of July, 2001. Future users of these estimates should adjust them for inflation as needed. Although the cost estimates prepared as part of this report represent the best judgment of the writer herein as a design professional familiar with the construction industry, the writer does not guarantee that any proposals, bids or actual construction costs will not vary from the cost estimates prepared by him.

Table 5-15

PRELIMINARY COST ESTIMATES
FOR
PROPOSED ENLARGEMENT OF DUTTON DITCH
WITH A PIPELINE

Item Description	Quantity	Unit	Unit Price	Total
Pipe, 24" dia.	19,000	l.f.	75	1,425,000
Air/Vacuum valve w/vault	9	ea.	4,500	40,500
Blowoff valve	19	ea.	1,800	34,200
Diversion structure	1	l.s.	18,000	18,000
Discharge structure	1	l.s.	4,000	4,000
Isolation valve	19	ea.	5,500	104,500
Total Estimated Construction Cost (TECC)				$1,626,200
Contingency @ 20% of TECC				325,240
Engineering & Legal @ 20% of TECC				325,240
TOTAL ESTIMATED PROJECT COST				$2,276,680

The annual cost projections were prepared assuming a loan at an interest rate of 6% per year with a 20 year repayment schedule.

Annual Cost of Operation:

Total Estimated Project Cost (TEPC) = $2,276,680

Number of years of payments (n) = 20

Interest rate (i) = 6%

Annual Debt Service = $\left[\frac{i}{(1+i)^n - 1} + i\right] x\, TEPC =$ $198,491

O & M Costs per year:

	Unit Cost	No.	Total
Ditch maintenance	10,000	1	10,000
			$10,000
Total Estimated Annual Cost			$208,491

To compare the alternative, the total annual cost for the WTP and reservoir is added to the annual cost for Dutton Ditch enlargement. A tabulation of those estimated annual costs are included in Table 5-16.

Table 5-16
Tabulation of Annual Cost
For
Dutton Ditch Enlargement Alternatives

Alternative	Existing Hatcher & Stevens Res. with enlarged WTP @ Stevens	Enlarged Dutton Ditch	Total
Additional Estimated Annual Cost	$294,057	$208,491	$502,548
Alternative	Enlarge Stevens Reservoir & WTP	Enlarged Dutton Ditch	Total
Additional Estimated Annual Cost	$652,360	$208,491	$860,851
Alternative	Construct Martinez Dam & Enlarge Hatcher WTP	Enlarged Dutton Ditch	Total
Additional Estimated Annual Cost	$585,614	$208,491	$794,105

Dry year water costs for Dutton Ditch enlargement alternatives would be:

Cost with existing reservoirs and enlarged Stevens WTP = $2.15/1,000 gallons

$$\text{Water Cost} = \frac{\$502{,}548/\text{ yr. x } 1{,}000 \text{ gals.}}{717 \text{ a.f./yr. x } 325{,}851} = \$2.15 \text{ per } 1{,}000 \text{ gals.}$$

Cost with enlarged Stevens Reservoir = $2.25/1,000 gallons

$$\text{Water Cost} = \frac{\$860{,}85 / \text{ yr. x } 1{,}000 \text{ gals.}}{1{,}172 \text{ a.f./yr. x } 325{,}851 \text{ gals./a.f.}} = \$2.25 \text{ per } 1{,}000 \text{ gals.}$$

Cost with new Martinez Reservoir and enlarged Hatcher WTP = $3.34/1,000 gallons

$$\text{Water Cost} = \frac{\$794{,}105/\text{y r. x } 1{,}000 \text{ gals.}}{730 \text{ a.f./yr. x } 325{,}851 \text{ gals./a.f.}} = \$3.34 \text{ per } 1{,}000 \text{ gals.}$$

5.6. CONSTRUCT DRY GULCH DAM AND ENLARGE SNOWBALL WATER TREATMENT PLANT

5.6.1. General Description

The proposed Dry Gulch Dam would provide 4000 acre feet of storage, 2000 acre-feet active and 2000 acre-feet inactive. Water from the reservoir would be conveyed to an expanded Snowball WTP through a pipeline and pump. The dam site is on Dry Gulch about 2 miles east of the Town of Pagosa Springs and is tributary to the San Juan River. The primary source of water for the reservoir is planned to be diversions from the San Juan River through the Park Ditch, which passes through the reservoir basin.

5.6.2. Proposed Improvements

Dry Gulch Dam

The proposed dam would be an earthfill dam constructed to a height of ±74 feet with a total capacity of 4000 acre-feet. The tributary area above the dam is approximately 3.2 square miles. The Park Ditch enters the reservoir basin at elevation 7340 feet on the east abutment and exits the basin at elevation 7290 on the west abutment. The crest of the dam is planned to be at 7314 feet so that water from the Park Ditch can be discharged into the reservoir. The top of the inactive pool is at 7290 feet so that water can be released from the reservoir into the Park Ditch. The segment of the Park Ditch in the reservoir basin would no longer be used, the Park Ditch water required downstream of the dam would pass though the reservoir.

The normal high water level in the reservoir would be 7307 feet. The crest of the dam is planned to be at 7314 feet allowing 7 feet of freeboard and flood storage. The water surface area at the normal high water is about 147 acres.

The inflow design flood is very small, allowing all of the flood to be stored in the surcharge pool. A small concrete chute spillway is proposed on the east side of the dam to drain the surcharge pool in 5 days as required by Colorado dam safety standards.

Raw Water Pipeline

An 18 inch diameter, approximately 8000 feet long pipeline, is included to convey up to 7 cfs to the Snowball WTP. The Snowball WTP is higher than the reservoir, so a pumping plant would be needed.

Water Treatment Plant

The existing Snowball 2.0 m.g.d. surface water treatment plant was retro fitted into a building without space for expansion. Therefore, replacement of the entire plant with a new 6.5 m.g.d. water treatment plant is proposed, with 2.0 m.g.d. to utilize the existing Snowball Pipeline and 4.5 m.g.d. to utilize the 7 cfs from Dry Gulch Reservoir. Package water treatment plants are typically available in increments of 0.5 m.g.d. so 6.5 m.g.d. is the selected size to match the supply pipelines capacity. In order to accommodate the larger facility, acquisition of an additional 15 acres of property would be needed.

Treated Water Pipeline

The existing treated water transmission pipeline from the Snowball WTP to Pagosa Springs has a design capacity of 4.0 m.g.d. In order to obtain full benefit from the 6.5 m.g.d. supply, enlargement of the three mile long pipeline to 18 inch diameter would be needed.

The Snowball WTP supplies water to a low-pressure portion of the distribution system. If additional water supply is produced at this location, a booster pump system will be needed on the westerly side of Pagosa Springs. The booster pump system will lift water from the lower Pagosa Springs pressure zone to the higher westerly pressure zone. A pumping capacity of 1 m.g.d. will be needed.

5.6.3. Water Supply

The water supply for the proposed Dry Gulch Reservoir would be diversions from the San Juan River under water rights held by the Southwestern Water Conservation District for the West Fork Canal and Dry Gulch Reservoir. The diversions are planned to be made through an arrangement with the Park Ditch Company to utilize the existing Park Ditch when capacity is available.

The Park Ditch has a capacity of about 40 cfs and is generally operated from early May through early October with diversions in May and October less than the capacity. The operation plan is predicated upon using the Park Ditch to convey water for storage in the

reservoir in April, May, October and November. Arrangements to utilize the Park Ditch have not been discussed; therefore, the availability of the Park Ditch is not known. A successful change in the point of diversion of the West Fork Canal to the headgate of the Park Ditch may also be necessary for the completion of this project.

The water supply for Dry Gulch Reservoir is based upon studies performed by Harris Water Engineering, Inc. in a 1989 study titled "Alternative Reservoir Site Evaluation". A preliminary reservoir yield analysis was performed which showed that about 3,300 acre-feet per year could be provided using the assumptions herein.

5.6.4. Cost Estimates and Annual Cost Projections

The following preliminary cost estimates are based on prevailing wage, equipment and material costs as of July, 2001. Future users of these estimates should adjust them for inflation as needed. Although the cost estimates prepared as part of this report represent the best judgment of the writer herein as a design professional familiar with the construction industry, the writer does not guarantee that any proposals, bids or actual construction costs will not vary from the cost estimates prepared by him.

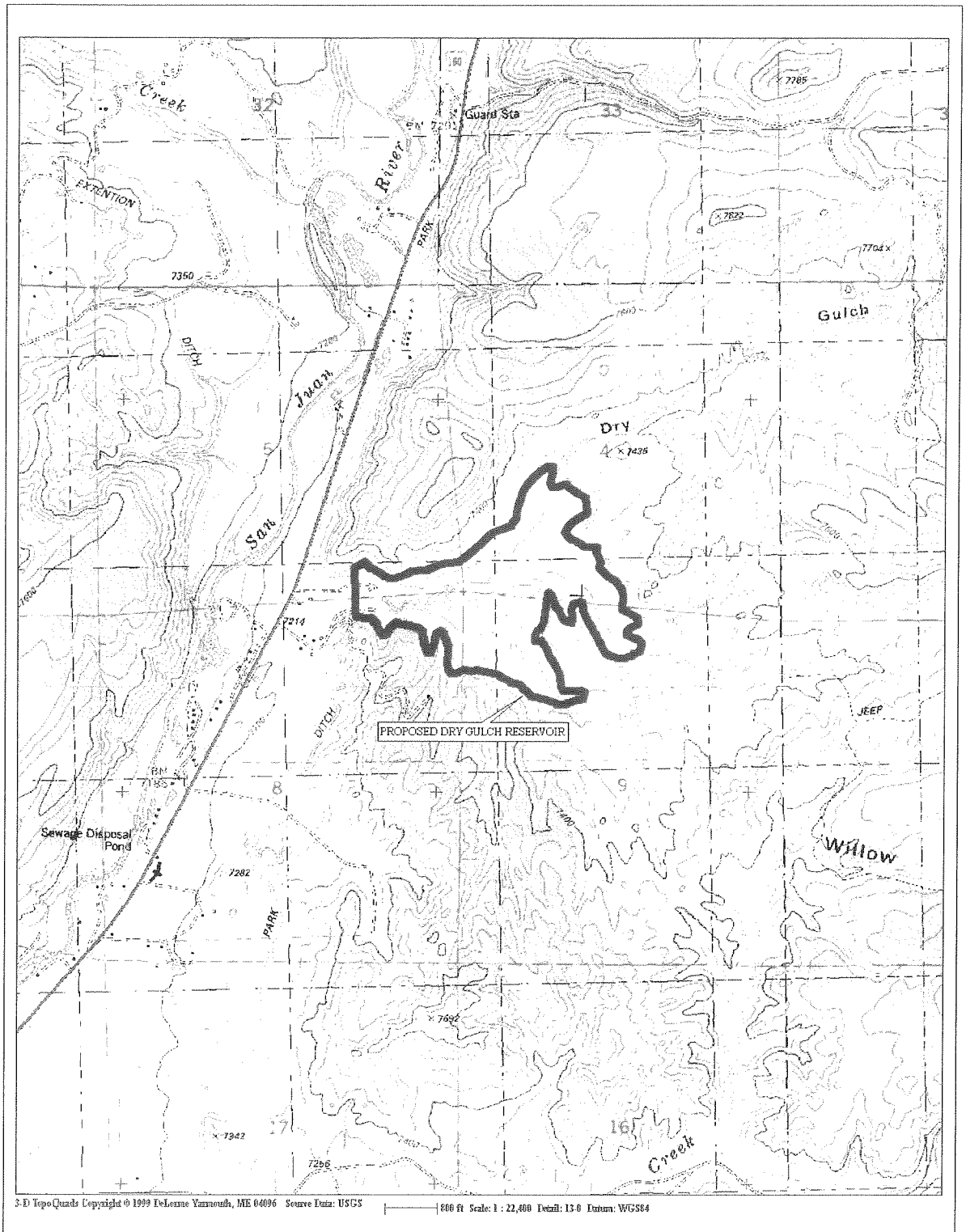


FIGURE 5-4
SKETCH OF PROPOSED DRY GULCH
DAM AND RESERVOIR

Table 5-17

PRELIMINARY COST ESTIMATES
FOR
PROPOSED DRY GULCH RESERVOIR WATER SUPPLY

Item Description	Quantity	Unit	Unit Price	Total Price
Embankment				
Clearing and Grubbing of Dam Site				150,000
Placement of Earth Fill	409,000	c.y.	7.00	2,863,000
Toe Drain	400	l.f.	30.00	12,000
Riprap & Bedding	2,800	c.y.	30.00	112,000
Spillway				
54" Overflow Pipe	350	l.f.	500.00	175,000
Outlet Works				
Outlet Pipe, 42" dia. Concrete	435	l.f.	300.00	131,000
Concrete Cut-Off Collars	9	c.y.	500.00	4,500
Slide Gate w/operator	1	l.s.	40,000.00	40,000
Still Basin	22	c.y.	600.00	13,200
Unlisted Items				400,000
Park Ditch Upgrades				
Upgrade ditch and river diversion headgate				300,000
Pipeline to Snowball Pagosa Springs WTP				
Pump station for delivery to Snowball WTP	1	l.s.	75,000.00	75,000
Pipeline Lateral - 18" D.I.P.	8,000	l.f.	50.00	400,000
Unlisted Items				50,000
Total Estimated Raw Water Construction Cost				$4,725,700
Reservoir Land Acquistion	200 ac	@	$5,000	$1,000,000
Contingency @ 20%				945,000
Engineering & Legal @ 20%				945,000
TOTAL ESTIMATED PROJECT COST				$7,615,700

Table 5-18

PRELIMINARY COST ESTIMATES
FOR
PROPOSED 6.5 M.G.D. SNOWBALL WATER TREATMENT PLANT

Item Description	Quantity	Unit	Unit Price	Total Price
6.5 m.g.d. package water treatment plant	1	l.s.	220,000.00	2,800,000
Metal building for WTP				800,000
Sludge Lagoons				400,000
Pump to Distribution System				200,000
14" D.I.P. Transmission Pipeline	7,700	l.f.	40.00	308,000
Total Estimated Construction Cost (TECC)				$4,508,000
Contingency @ 20% of TECC				901,000
Engineering & Legal @ 20% of TECC				901,000
TOTAL ESTIMATED PROJECT COST				$6,310,000

The annual cost projections were prepared assuming a loan at an interest rate of 6% per year with a 20 year repayment schedule.

Table 5-19

ESTIMATE OF ANNUAL COST OF OPERATION
FOR
DRY GULCH RESERVOIR AND SNOWBALL WTP

Annual Cost of Operation:

Raw Water Cost	7,615,700
Treated Water Cost	6,310,000
Total Estimated Project Cost (TEPC) =	$13,925,700
Number of years of payments (n) =	20
Interest rate (i) =	6%

Annual Debt Service = $\left[\frac{i}{(1+i)^n - 1} + i\right] x\, TEPC =$ $1,214,100

O & M Costs per year:

Treatment of 3300 a.f. @ $166/a.f. =	548,000
Power & chemical costs 3300 a.f. @ $150/a.f. =	495,000
Dam maintenance =	15,000

Total Estimated Annual Cost $2,272,100

Additional water yield from the new Dry Gulch Reservoir 3,300 a.f./yr. Dry year water costs would be:

$$\text{Water Cost} = \frac{\$2{,}272{,}100 \text{ / yr. x } 1{,}000 \text{ gals.}}{3300 \text{ a.f./yr. x } 325{,}851 \text{ gals./a.f.}} = \$2.11 \text{ per } 1{,}000 \text{ gals.}$$

6. EVALUATION OF ALTERNATIVES AND SELECTED PLAN

Table 6-1 contains a summary list of the alternates evaluated to provide additional water supply sources and their respective dry year estimated water yield, construction cost and annual cost per 1,000 gallons of water produced. The cost estimates are preliminary, meaning that alternatives within 10% to 15% are essentially the same cost.

Table 6-1
Comparison of Cost For Additional Alternate Water Supply Sources

	Alternate Water Supply Source	Estimated Dry-Year Yield (a.f./yr.)	Construction Cost	Annual $ per 1000 gals.
1	Increase Supply and Capacity of Snowball Water Treatment Plant	1,904	$6,868,530	$2.05
2	Enlarge Dutton Ditch and Stevens WTP to 1 m.g.d. With Existing Reservoirs	717	$2,878,680	$2.15
3	Enlarge Dutton Ditch With Enlarged Stevens Reservoir and WTP to 2 m.g.d.	1172	$6,142,878	$2.25
4	Construct Martinez Dam Without Enlarged Dutton Ditch	325	$3,353,018	$3.39
5	Construct Martinez Dam and Enlarge Hatcher Water Treatment Plant With Enlarged Dutton Ditch	730	$6,175,698	$3.34
6	Enlarge Stevens Reservoir and WTP to 2 m.g.d. Without Enlarged Dutton Ditch	682	$3,264,198	$2.27
7	Construct Dry Gulch Reservoir and New Snowball WTP	3,300	$12,925,700	$2.11

The alternatives to provide additional water supplies to PAWSD are separated into two cost categories. Alternatives 1, 2, 3, 6 and 7 have nearly the same annual cost per 1,000 gallons and are in the lowest cost group. Alternatives 4 and 5 are in the high cost group, about 50% greater than the low cost group.

Alternatives 4 and 5 are not recommended for consideration because of the significantly higher group cost than alternatives 1, 2, 3, 6 and 7.

Alternatives 1 and 7 are not recommended because their yield is more than double the amount needed in 2025. In the case of alternative 7, the existing rate payers are not able to finance the debt service to construct this large project and the existing water distribution system has insufficient capacity to utilize the large yield.

Alternatives 2 and 6 provide 717 and 682 acre-feet per year respectively. Individually these yields are not quite adequate for the 2025 demand of 782 acre-feet per year.

Alternative 3 provides 1,172 acre-feet per year which is enough water to serve 2025 projected population with some buffer to offset possible inaccurate estimates. The conveyance capacity of the existing Dutton Ditch has declined in the last 15 years. It is a critical supply to the water treatment plants at Hatcher and Stevens Reservoirs. Alternative 3 can provide the added benefit of improving the delivery system to both the Hatcher and Stevens WTPs.

These alternate water supply sources included in Alternative 3 have the ability to provide an emergency water supply to the town portion of the system if the Jackson Mountain soil slide disables the transmission pipeline that supplies the Snowball WTP or contamination of the river should occur. In addition, these sources will provide gravity flow of an additional water supply to the town portion of the distribution system. As these alternatives would divert during largely none irrigation season periods, reduction in river flow to critical levels would be less likely compared to direct river diversions.

Alternative 3, Enlarge Dutton Ditch, Stevens Reservoir and its WTP to 2 m.g.d., is the alternative that provides water at the lowest unit cost and meets the 2025 water demand. Table 6-2 provides a summary of alternative evaluations.

Table 6-2
Summary of Alternative Evaluations

	Alternate Water Supply Source	Summary of Evaluation
1	Increase Supply and Capacity of Snowball Water Treatment Plant	Provides more water than is needed
2	Enlarge Dutton Ditch and Stevens WTP to 1 m.g.d. With Existing Reservoirs	Does not provide an adequate amount of water to meet 2025 demand

3	Enlarge Dutton Ditch With Enlarged Stevens Reservoir and 2 m.g.d. WTP	Recommended Plan – Lowest unit water cost that adequately matches 2025 demand
4	Construct Martinez Dam Without Enlarged Dutton Ditch	Highest unit water cost and does not supply sufficient water to meet 2025 demand
5	Construct Martinez Dam and Enlarge Hatcher Water Treatment Plant With Enlarged Dutton Ditch	The unit water cost is nearly the highest and does not supply sufficient water to meet 2025 demand
6	Enlarge Stevens Reservoir and WTP to 2 m.g.d. Without Enlarged Dutton Ditch	Higher unit water cost than selected plan and does not supply sufficient water to meet 2025 demand
7	Construct Dry Gulch Reservoir and New Snowball WTP	Provides far more water than is needed and is beyond PAWSD ability to finance

7. SELECTED PLAN

7.1. Description of the Selected Plan

The selected plan is the enlargement of the existing Dutton Ditch, Stevens Reservoir and the associated water treatment plant to 2 m.g.d. capacity.

Dutton Ditch

The Dutton Ditch derives its water supply from Fourmile Creek at a diversion approximately nine miles northerly of the Town of Pagosa Springs. The ditch then conveys water into the Dutton Creek drainage that is tributary to Stevens Reservoir. A pipeline is available to carry a portion of the Dutton Creek flow to Hatcher Reservoir. The capacity of the open ditch has declined from ±12 c.f.s. to ±4 c.f.s. within the last 15 years due to accumulation of sediment and difficulty in stabilizing the ditch at two locations where it crosses unstable hillsides. This portion of the selected plan would involve construction of a pipeline largely along Forest Service access roads to a point below the unstable sections. The pipeline would carry at least PAWSD's water rights in the ditch. The pipeline would be ±19,000 feet long and would be designed to carry ±12 c.f.s.

The pipeline improves the ability to divert water during the winter and increases the capacity of the system so PAWSD's water right can be carried regardless of other priorities in the ditch.

Stevens Reservoir

Located approximately 4.5 miles northwest of the Town of Pagosa Springs on Dutton Creek, a tributary of Stollsteimer Creek which is a tributary of the Piedra River. Stevens Reservoir has an existing capacity of 635 acre-feet. The selected plan would enlarge the reservoir by 795 acre-feet to a total of 1,430 acre-feet. The reservoir is at an elevation of 7700 feet.

The inactive capacity of the enlarged reservoir will total 150 acre-feet, resulting in an active capacity of 1,280 acre-feet. The enlargement will involve raising the crest of the existing dam about 10 feet and increasing the crest length to 1,225 feet.

The additional yield predicted by the CDM modified model for the enlargement during the 1976 to 1978 drought period is estimated to be 682 acre-feet. Dutton Ditch and tributary water from the natural reservoir drainage basin that is presently lost because of lack of storage capacity will fill the enlarged reservoir.

The Stevens Water Treatment Plant will be enlarged to 2.0 m.g.d. to treat the additional supply. Treated water from the treatment plant will be conveyed to the PAWSD distribution system for use in a similar manner as now occurs.

The reservoir is located in Dutton Park which is a relatively flat uplands area consisting of a mixture of meadows interspersed with montane forest. Soils consist of clay and silt loams derived from underlying shales, sandstones and glacial till. These soils generally exhibit low permeability and low to high water capacity. Bedrock varies from 1 to more than 5 feet in depth depending on the slope of the soil.

7.2. Hydrology

The drainage area upstream of the reservoir is 5.8 square miles, 5.87 miles long, and has a vertical drop of 1,440 feet. The Probable Maximum Thunderstorm is 10,400 c.f.s. which is routed through the reservoir and used to size the spillway to be 100 feet wide with one foot of freeboard during the flood event. The drainage area of Fourmile Creek above the diversion for Dutton Ditch is approximately 16 square miles.

The yields of the existing PAWSD raw water sources and the additional yield from the enlarged Dutton Ditch and Stevens Reservoir used in deriving unit costs are based on the three-year drought conditions that occurred from 1976 to 1978. Though difficult to predict it appears that a drought year such as 1977 may occur two or three times a century.

In a year such as 1977, Stevens Reservoir would be emptied to meet demands. In years with greater runoff, the operation of Stevens Reservoir will be dependent on other factors such as capacity at other locations, outages at other treatment plants, rotation of water supplies, and flow through Stevens Reservoir to maintain water circulation. Operating

criteria is not proposed herein because there are too many unknown variables to develop a realistic operation plan. However, generally the reservoir will not be used to its full extent except in times of drought or other unusual operation requirements.

7.3. Reservoir Embankment Description

A plan view of the 10 foot increase in the dam is shown in Figure 7-1. After the enlargement, the upstream embankment slope will be 3.5 to 1.0 and the downstream embankment slope will be 3.0 to 1.0. The crest will be 20 feet wide. The spillway will be located over the original spillway on the east abutment of the dam. This location takes advantage of the natural side drainage to Dutton Creek. The spillway will be composed of riprap. No plunge pool or extended channel is anticipated because it lies in a natural drainage way which directs flow away from the downstream face of the dam.

A cross section of the dam through the outlet works is shown in Figure 7-2. The dam is composed of earthfill with a clay core using material excavated from the reservoir area. The upstream face of the dam will be covered with 18 inch diameter rip rap, 3 feet thick extended from the crest to the toe. A chimney drain is included to channel seepage to a toe drain consisting of gravel filter material.

The outlet works will be sized to discharge a peak day flow of 3.1 cfs (2.0 m.g.d.) and will consist of a single 18 inch diameter pipe. Control will be provided by an 18 inch butterfly valve operated by a stem riser contained in a vertical wet well located at the upstream toe of the dam. The valve operator will be accessed from a catwalk located at the new crest of the dam. The outlet will discharge to an existing conveyance structure which will route water to the treatment facility.

7.4. Environment Analysis

Attached is a report prepared by Aqua-Hab, Inc. titled "Wetland Delineation of Stevens Reservoir" which describes the environmental analysis for the enlargement. A similar report is attached for Dutton Ditch improvements.

7.5. Environmental Permitting

There may be different environmental impacts that result from the Dutton Ditch improvements and the Stevens Reservoir enlargement. The Dutton Ditch improvements largely include construction of a buried pipeline that can be conditioned and permitted by a U.S. Army Corps of Engineers Nationwide 12 permit. The reservoir enlargement may have broader environmental impact requiring the acquisition of an individual U.S. Army Corps of Engineers 404 permit.

7.6 Depletion Analysis

The following depletion analysis is included for the Section 7 consultation between the U.S. Corps of Engineers and the U.S. Fish and Wildlife Service regarding the endangered fish in the San Juan River.

The selected plan will allow diversion of an additional 1,172 acre-feet into the PAWSD drinking water distribution system. The water will be used for typical municipal purposes including in-house uses, commercial uses and lawn/garden irrigation. The homes served by the system are primarily served by a central sewer system with some homes using individual septic systems. Also, most homes have outside watering. Lacking the necessary data for an evaluation of the PAWSD system to determine the percentage of drinking water depleted, the standard depletion rate for municipal use of 33% is recommended. The result is an annual depletion of 390 acre-feet from the additional annual diversion of 1,172 acre-feet.

The plan includes construction of both improvement to the Dutton Ditch and enlargement of Stevens Reservoir. Of the total additional dry year annual diversion of 1,172 acre-feet as predicted by the CDM modified hydrologic model, 682 acre-feet will be derived from the enlargement of Stevens Reservoir with balance of 490 acre-feet derived from improvement of Dutton Ditch. Using the standard depletion rate of 33%, annual depletion is estimated at 227 acre-feet for enlargement of Stevens Reservoir and 163 acre-feet for improvement of Dutton Ditch.

The total annual dry year depletion to the San Juan River basin from improvement of Dutton Ditch and enlargement of Stevens Reservoir is estimated to be 390 acre-feet.

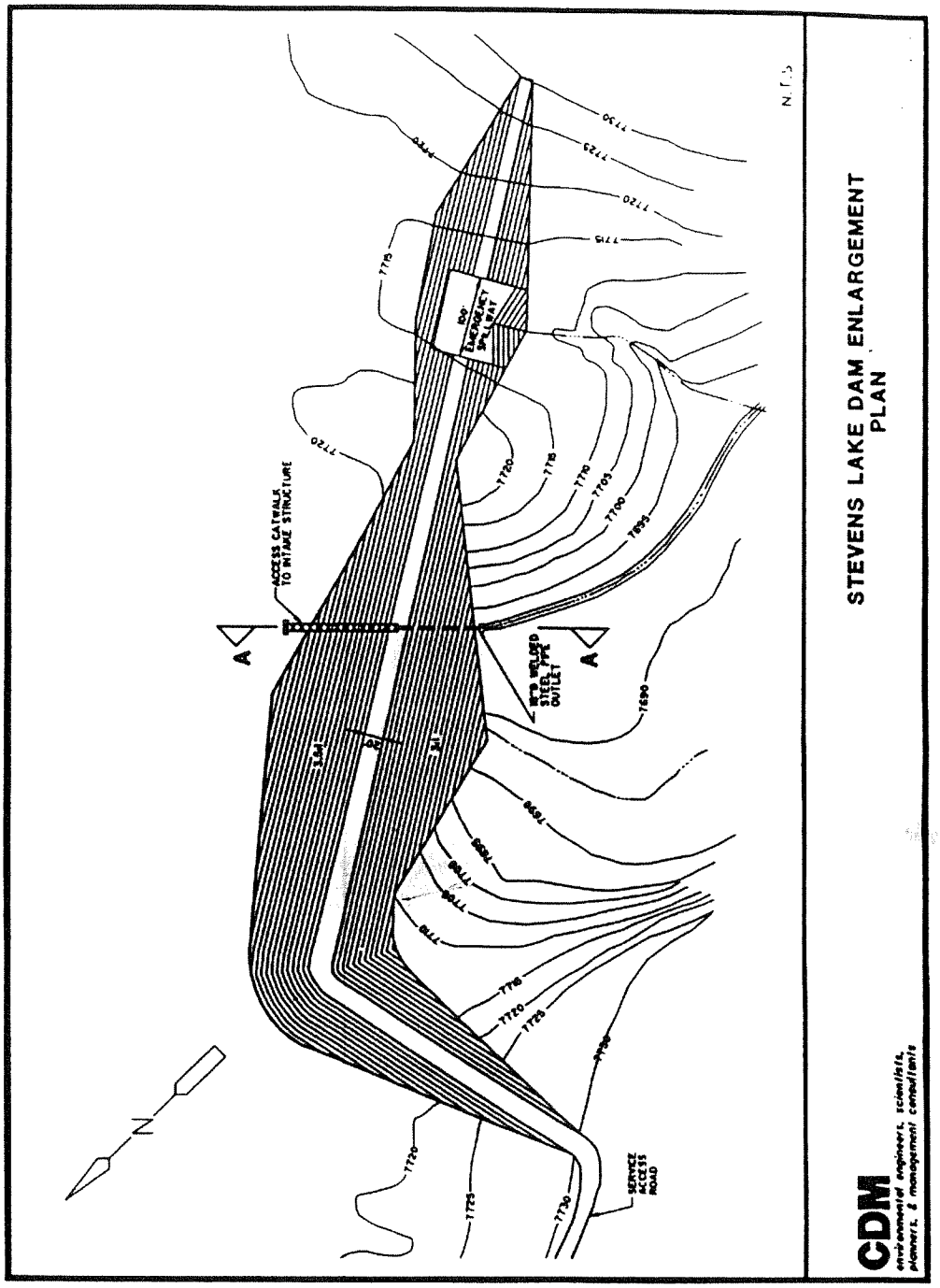


Figure 7-1
Plan View of Stevens Reservoir Enlargement

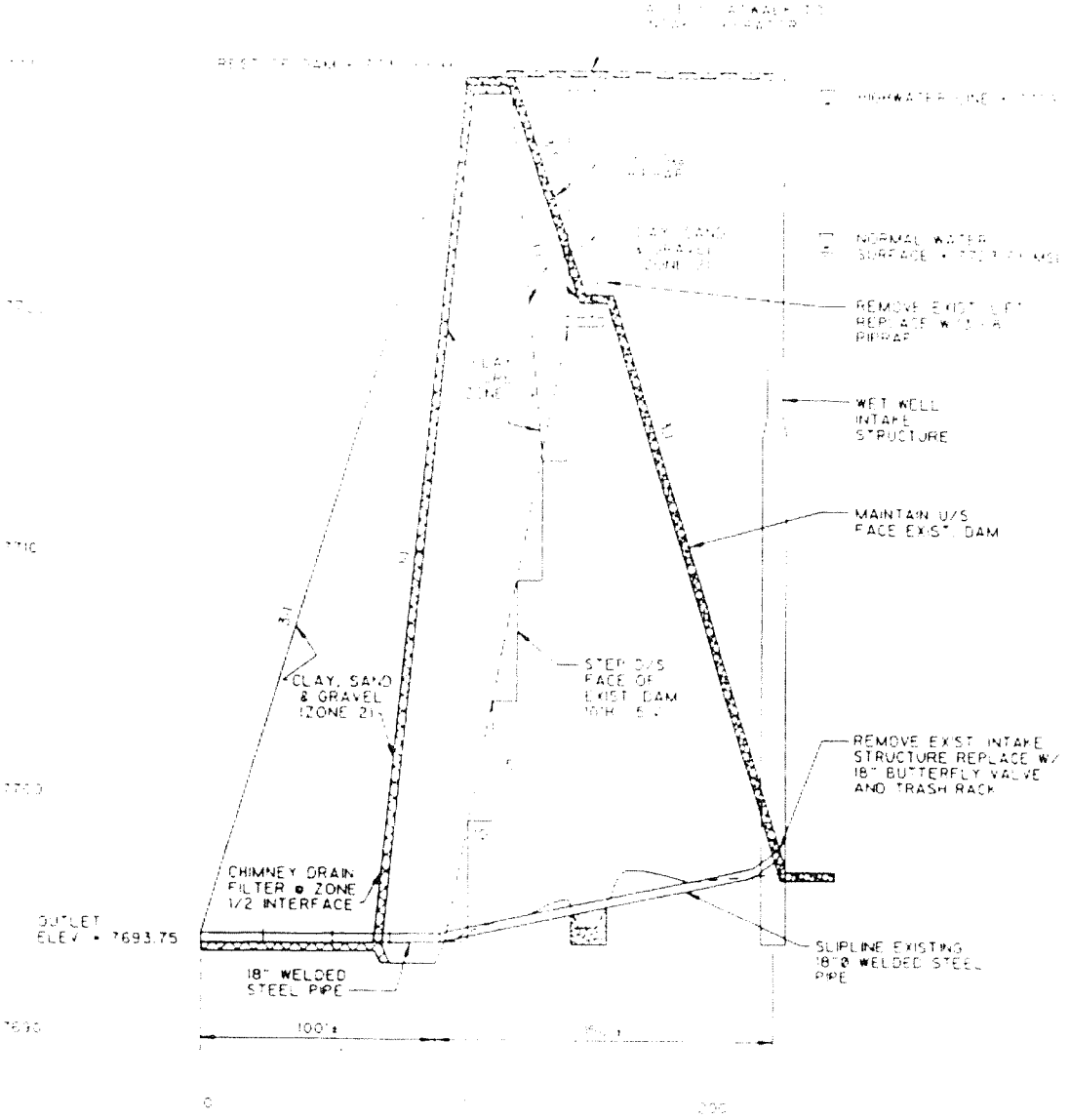


Figure 7-2
Cross Section of Stevens Reservoir Dam

APPENDIX A

ESTIMATES OF WATER YIELD

FOR

ALTERNATE WATER SUPPLY SOURCES

Hatcher Reservoir Operations — Low Water Years: 1976, 1977, 1978

Decreed Capacity 1729 ac-ft/yr — Minimum End of Month Live Storage: 850 ac-ft/yr

w/ Dutton Ditch, Steven's Res. expansion

CASE 1

Irrigation Year	Month	Perkins Ditch ac-ft	Hatcher Natural Inflow ac-ft	Available Inflow ac-ft	Storable Inflow ac-ft	Cumulative Inflow Stored ac-ft	Dutton Ditch Extension ac-ft	Dutton Extension Available ac-ft	Seepage Loss ac-ft	Surface Area ac	vaporation Loss ac-ft	Demand ac-ft	Potential Gain/ Loss ac-ft	EndMonth Live Storage ac-ft	Actual Gain/ Loss ac-ft	Net Spill/ Deficit ac-ft	Dutton Extension Remain ac-ft	Natural Inflow Spill ac-ft	Perkins Ditch Remain ac-ft	Demand Deficit ac-ft
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
entered	entered	min water rt	entered				entered, 175 min													
1976	NOV	0	0	0	0	0	175	149	2	110	0	20	127	1145	127	0	0	0	0	0
	DEC	0	0	0	0	0	175	149	2	117	0	20	126	1271	126	0	0	0	0	0
	JAN	0	30	0	0	0	175	149	3	123	0	20	126	1397	126	0	0	0	0	0
	FEB	0	30	0	0	0	175	149	3	129	0	20	126	1523	126	0	0	0	0	0
	MAR	162	53	15	15	15	29	25	3	136	0	20	179	1701	179	0	0	0	0	0
	APR	755	247	209	209	15	475	404	4	147	10	20	1334	1729	28	1307	475	209	694	0
	MAY	1282	716	678	678	15	491	417	4	149	26	188	2159	1729	0	2159	491	678	1064	0
	JUN	0	0	0	0	15	0	0	4	149	43	188	-234	1495	-234	0	0	0	0	0
	JUL	0	0	0	0	15	0	0	3	135	20	188	-211	1284	-211	0	0	0	0	0
	AUG	0	0	0	0	15	0	0	3	124	6	188	-197	1087	-197	0	0	0	0	0
	SEP	0	0	0	0	15	0	0	2	114	6	188	-196	891	-196	0	0	0	0	0
	OCT	0	0	0	0	15	175	149	2	103	0	20	127	1018	127	0	0	0	0	0
	YR	2199	1076	902	902	15	1870	1590	34		111	1080 (entry entered)	3466	1018	0	3466	966	887	1758	0
1977	NOV	0	0	0	0	0	175	149	2	110	0	20	127	1145	127	0	0	0	0	0
	DEC	0	0	0	0	0	175	149	2	117	0	20	126	1271	126	0	0	0	0	0
	JAN	0	0	0	0	0	175	149	3	123	0	20	126	1397	126	0	0	0	0	0
	FEB	0	0	0	0	0	175	149	3	129	0	20	126	1523	126	0	0	0	0	0
	MAR	43	14	0	0	0	0	0	3	136	0	20	20	1543	20	0	0	0	0	0
	APR	208	68	30	30	11	0	0	3	137	9	20	205	1729	186	19	0	19	0	0
	MAY	162	53	15	15	26	0	0	4	149	26	188	-41	1688	-41	0	0	0	0	0
	JUN	0	0	0	0	26	0	0	4	147	42	188	-233	1455	-233	0	0	0	0	0
	JUL	0	0	0	0	26	0	0	3	132	19	188	-210	1245	-210	0	0	0	0	0
	AUG	0	0	0	0	26	0	0	3	122	6	188	-197	1048	-197	0	0	0	0	0
	SEP	0	0	0	0	26	0	0	2	112	6	188	-196	852	-196	0	0	0	0	0
	OCT	0	0	0	0	26	175	149	2	101	0	20	127	979	127	0	0	0	0	0
	YR	413	135	45	45	26	875	744	33		109	1080 (entry entered)	-20	979	-39	19	0	19	0	0
1978	NOV	0	0	0	0	0	267	227	2	108	0	20	205	1184	205	0	0	0	0	0
	DEC	0	0	0	0	0	266	226	2	119	0	20	204	1387	204	0	0	0	0	0
	JAN	0	31	0	0	0	202	172	3	129	0	20	149	1536	149	0	0	0	0	0
	FEB	0	30	0	0	0	214	182	3	137	0	20	159	1695	159	0	0	0	0	0
	MAR	165	54	16	16	0	67	57	4	147	0	20	215	1729	34	180	67	16	107	0
	APR	939	307	269	269	0	475	404	4	149	10	20	1577	1729	0	1577	475	269	905	0
	MAY	1282	571	533	533	0	491	417	4	149	26	188	2014	1729	0	2014	491	533	1064	0
	JUN	0	0	0	0	0	0	0	4	149	43	188	-234	1495	-234	0	0	0	0	0
	JUL	0	0	0	0	0	0	0	3	135	20	188	-211	1284	-211	0	0	0	0	0
	AUG	0	0	0	0	0	0	0	3	124	6	188	-197	1087	-197	0	0	0	0	0
	SEP	0	0	0	0	0	0	0	2	114	6	188	-196	891	-196	0	0	0	0	0
	OCT	0	0	0	0	0	175	149	2	103	0	20	127	1018	127	0	0	0	0	0
	YR	2386	993	818	818	0	2157	1833	35		111	1080 (entry entered)	3811	1018	39	3772	1033	818	2076	0

Steven's Lake Operations
Decreed Capacity: 1420 ac-ft/yr
w/ Dutton Ditch, Steven's Res. expansion

Low Water Years, 1976, 1977, 1978
Minimum End of Month Live Storage: 150 ac-ft

CASE 1

Irrigation Year	Month	Steven's Natural Inflow ac-ft	Available Inflow ac-ft	Storable Inflow ac-ft	Cumulative Inflow Stored ac-ft	Dutton Ditch Extension	Dutton Extension Available	Seepage Loss	Surface Area ac	vaporation Loss	Demand	Potential Gain/ Loss	End of Mon Live Storage	Actual Gain/ Loss	Net Spill/ Deficit	Dutton Extension Remain	Natural Inflow Spill	Demand Deficit
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
entered	entered	entered				from Hatcher												
1976	NOV	0	0	0	0	0	0	2	99	0	0	-2	829	-2	0	0	0	0
	DEC	0	0	0	0	0	0	2	99	0	0	-2	827	-2	0	0	0	0
	JAN	0	0	0	0	0	0	2	99	0	0	-2	826	-2	0	0	0	0
	FEB	0	0	0	0	0	0	2	99	0	0	-2	824	-2	0	0	0	0
	MAR	83	53	53	53	29	25	2	99	0	0	76	900	76	0	0	0	0
	APR	389	359	359	412	475	404	2	103	7	0	754	1420	520	234	275	0	0
	MAY	1125	1095	1008	621	491	417	3	131	23	183	1216	1420	0	1216	491	799	0
	JUN	919	889	799	844	0	0	3	131	37	183	576	1420	0	576	0	576	0
	JUL	0	0	0	844	0	0	3	131	19	183	-205	1215	-205	0	0	0	0
	AUG	0	0	0	844	0	0	3	120	6	183	-192	1023	-192	0	0	0	0
	SEP	0	0	0	844	0	0	2	110	6	183	-191	833	-191	0	0	0	0
	OCT	0	0	0	844	0	0	2	99	0	0	-2	831	-2	0	0	0	0
	YR	2516	2396	2219	844	995	846	26		98	915 (entry entered)	2026	831	0	2026	766	1375	0
1977	NOV	0	0	0	0	0	0	2	99	0	0	-2	829	-2	0	0	0	0
	DEC	0	0	0	0	0	0	2	99	0	0	-2	827	-2	0	0	0	0
	JAN	0	0	0	0	0	0	2	99	0	0	-2	826	-2	0	0	0	0
	FEB	0	0	0	0	0	0	2	99	0	0	-2	824	-2	0	0	0	0
	MAR	22	0	0	0	0	0	2	99	0	0	-2	822	-2	0	0	0	0
	APR	107	77	77	77	0	0	2	99	7	0	69	891	69	0	0	0	0
	MAY	83	53	53	130	0	0	2	103	18	183	-150	741	-150	0	0	0	0
	JUN	229	199	199	329	0	0	2	93	27	183	-12	729	-12	0	0	0	0
	JUL	0	0	0	329	0	0	2	92	13	183	-198	531	-198	0	0	0	0
	AUG	0	0	0	329	0	0	1	76	4	183	-188	343	-188	0	0	0	0
	SEP	0	0	0	329	0	0	1	57	3	183	-187	156	-187	0	0	0	0
	OCT	0	0	0	329	0	0	0	32	0	0	0	156	0	0	0	0	0
	YR	441	329	329	329	0	0	17		72	915 (entry entered)	-675	156	-675	0	0	0	0
1978	NOV	0	0	0	0	0	0	0	32	0	0	0	156	0	0	0	0	0
	DEC	0	0	0	0	0	0	0	32	0	0	0	155	0	0	0	0	0
	JAN	0	0	0	0	0	0	0	32	0	0	0	155	0	0	0	0	0
	FEB	0	0	0	0	0	0	0	32	0	0	0	155	0	0	0	0	0
	MAR	85	55	55	55	67	57	0	31	0	0	112	266	112	0	0	0	0
	APR	482	452	452	507	475	404	1	47	3	0	852	1118	852	0	0	0	0
	MAY	898	868	868	1014	491	417	2	115	20	183	1080	1420	302	778	491	361	0
	JUN	1175	1145	406	1237	0	0	3	131	37	183	183	1420	0	183	0	183	0
	JUL	0	0	0	1237	0	0	3	131	19	183	-205	1215	-205	0	0	0	0
	AUG	0	0	0	1237	0	0	3	120	6	183	-192	1023	-192	0	0	0	0
	SEP	0	0	0	1237	0	0	2	110	6	183	-191	833	-191	0	0	0	0
	OCT	0	0	0	1237	0	0	2	99	0	0	-2	831	-2	0	0	0	0
	YR	2640	2520	1781	1237	1033	878	16		92	915 (entry entered)	1636	831	675	961	491	543	0

Hatcher Reservoir Operations — Low Water Years, 1976, 1977, 1978

Decreed Capacity 1729 ac-ft/yr — Minimum End of Month Live Storage: 850 ac-ft

w/ Dutton Ditch expansion, w/o Steven's Res expansion

CASE 2

Irrigation Year	Month	Perkins Ditch ac-ft	Hatcher Natural Inflow ac-ft	Available Inflow ac-ft	Storable Inflow ac-ft	Cumulative Inflow Stored ac-ft	Dutton Ditch Extension ac-ft	Dutton Extension Available ac-ft	Seepage Loss ac-ft	Surface Area ac	Evaporation Loss ac-ft	Demand ac-ft	Potential Gain/ Loss ac-ft	EndMonth Live Storage ac-ft	Actual Gain/ Loss ac-ft	Net Spill/ Deficit ac-ft	Dutton Extension Remain ac-ft	Natural Inflow Spill ac-ft	Perkins Ditch Remain ac-ft	Demand Deficit ac-ft
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
entered	entered	entered	entered				entered, 175 min													
1976	NOV	0	0	0	0	0	175	149	3	135	0	20	126	1632	126	0	0	0	0	0
	DEC	0	0	0	0	0	175	149	3	143	0	20	125	1729	97	28	33	0	0	0
	JAN	0	30	0	0	0	175	149	4	149	0	20	125	1729	0	125	147	0	0	0
	FEB	0	30	0	0	0	175	149	4	149	0	20	125	1729	0	125	147	0	0	0
	MAR	162	53	15	15	0	29	25	4	149	0	20	178	1729	0	178	29	15	138	0
	APR	755	247	209	209	0	475	404	4	149	10	20	1334	1729	0	1334	475	209	721	0
	MAY	1282	716	678	678	0	491	417	4	149	26	188	2159	1729	0	2159	491	678	1064	0
	JUN	0	0	0	0	0	0	0	4	149	43	188	-234	1495	-234	0	0	0	0	0
	JUL	0	0	0	0	0	0	0	3	135	20	188	-211	1284	-211	0	0	0	0	0
	AUG	0	0	0	0	0	0	0	3	124	6	188	-197	1087	-197	0	0	0	0	0
	SEP	0	0	0	0	0	0	0	2	114	6	188	-196	891	-196	0	0	0	0	0
	OCT	0	0	0	0	0	175	149	2	103	0	20	127	1018	127	0	0	0	0	0
	YR	2199	1076	902	902	0	1870	1590	38		111	1080 (entry entered)	3462	1018	-488	3950	1322	902	1924	0
1977	NOV	0	0	0	0	0	175	149	2	110	0	20	127	1145	127	0	0	0	0	0
	DEC	0	0	0	0	0	175	149	2	117	0	20	126	1271	126	0	0	0	0	0
	JAN	0	8	0	0	0	175	149	3	123	0	20	126	1397	126	0	0	0	0	0
	FEB	0	8	0	0	0	175	149	3	129	0	20	126	1523	126	0	0	0	0	0
	MAR	43	14	0	0	0	0	0	3	136	0	20	20	1542	20	0	0	0	0	0
	APR	208	68	30	30	11	0	0	3	137	9	20	205	1729	187	19	0	19	0	0
	MAY	162	53	15	15	26	0	0	4	149	26	188	-41	1688	-41	0	0	0	0	0
	JUN	0	0	0	0	26	0	0	4	147	42	188	-233	1455	-233	0	0	0	0	0
	JUL	0	0	0	0	26	0	0	3	132	19	188	-210	1245	-210	0	0	0	0	0
	AUG	0	0	0	0	26	0	0	3	122	6	188	-197	1048	-197	0	0	0	0	0
	SEP	0	0	0	0	26	0	0	2	112	6	188	-196	852	-196	0	0	0	0	0
	OCT	0	0	0	0	26	175	149	2	101	0	20	127	979	127	0	0	0	0	0
	YR	413	151	45	45	26	875	744	33		109	1080 (entry entered)	-20	979	-39	19	0	19	0	0
1978	NOV	0	0	0	0	0	267	227	2	108	0	20	205	1184	205	0	0	0	0	0
	DEC	0	0	0	0	0	266	226	2	119	0	20	204	1387	204	0	0	0	0	0
	JAN	0	31	0	0	0	202	172	3	129	0	20	149	1536	149	0	0	0	0	0
	FEB	0	30	0	0	0	214	182	3	137	0	20	159	1695	159	0	0	0	0	0
	MAR	165	54	16	16	0	67	57	4	147	0	20	215	1729	34	180	67	16	107	0
	APR	939	307	269	269	0	475	404	4	149	10	20	1577	1729	0	1577	475	269	905	0
	MAY	1282	571	533	533	0	491	417	4	149	26	188	2014	1729	0	2014	491	533	1064	0
	JUN	0	0	0	0	0	0	0	4	149	43	188	-234	1495	-234	0	0	0	0	0
	JUL	0	0	0	0	0	0	0	3	135	20	188	-211	1284	-211	0	0	0	0	0
	AUG	0	0	0	0	0	0	0	3	124	6	188	-197	1087	-197	0	0	0	0	0
	SEP	0	0	0	0	0	0	0	2	114	6	188	-196	891	-196	0	0	0	0	0
	OCT	0	0	0	0	0	175	149	2	103	0	20	127	1018	127	0	0	0	0	0
	YR	2386	993	818	818	0	2157	1833	35		111	1080 (entry entered)	3811	1018	39	3772	1033	818	2076	0

Steven's Lake Operations — Low Water Years, 1976, 1977, 1978

Decreed Capacity: 635 ac-ft/yr — Minimum End of Month Live Storage: 150 ac-ft

w/ Dutton Ditch expansion, w/o Steven's Res expansion

CASE 2

Irrigation Year	Month	Steven's Natural Inflow ac-ft	Available Inflow ac-ft	Storable Inflow ac-ft	Cumulative Inflow Stored ac-ft	Dutton Ditch Extension	Dutton Extension Available	Seepage Loss	Surface Area ac	Evaporation Loss	Demand	Potential Gain/ Loss	End of Mon Live Storage	Actual Gain/ Loss	Net Spill/ Deficit	Dutton Extension Remain	Natural Inflow Spill	Demand Deficit
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
entered	entered	entered				from Hatcher												
1976	NOV	0	0	0	0	0	0	1	56	0	0	-1	335	-1	0	0	0	0
	DEC	0	0	0	0	145	123	1	56	0	0	122	457	122	0	0	0	0
	JAN	0	0	0	0	147	125	1	69	0	0	124	581	124	0	0	0	0
	FEB	0	0	0	0	147	125	1	81	0	0	124	635	54	70	83	0	0
	MAR	83	53	53	1	29	25	1	85	0	0	76	635	0	76	29	52	0
	APR	389	359	359	8	475	404	1	85	6	0	756	635	0	756	475	352	0
	MAY	1125	1095	627	117	491	417	1	85	15	92	936	635	0	936	491	518	0
	JUN	919	889	518	234	0	0	1	85	24	92	401	635	0	401	0	401	0
	JUL	0	0	0	234	0	0	1	85	12	92	-106	529	-106	0	0	0	0
	AUG	0	0	0	234	0	0	1	76	4	92	-97	432	-97	0	0	0	0
	SEP	0	0	0	234	0	0	1	67	3	92	-96	336	-96	0	0	0	0
	OCT	0	0	0	234	0	0	1	56	0	0	-1	335	-1	0	0	0	0
	YR	2516	2396	1557	234	1434	1219	13		65	460 (entry entered)	2238	335	0	2238	1078	1322	0
1977	NOV	0	0	0	0	0	0	1	56	0	0	-1	335	-1	0	0	0	0
	DEC	0	0	0	0	0	0	1	56	0	0	-1	334	-1	0	0	0	0
	JAN	0	0	0	0	0	0	1	56	0	0	-1	333	-1	0	0	0	0
	FEB	0	0	0	0	0	0	1	56	0	0	-1	332	-1	0	0	0	0
	MAR	22	0	0	0	0	0	1	55	0	0	-1	332	-1	0	0	0	0
	APR	107	77	77	77	0	0	1	55	4	0	73	404	73	0	0	0	0
	MAY	83	53	53	130	0	0	1	64	11	92	-51	353	-51	0	0	0	0
	JUN	229	199	199	329	0	0	1	58	16	92	90	443	90	0	0	0	0
	JUL	0	0	0	329	0	0	1	68	10	92	-103	340	-103	0	0	0	0
	AUG	0	0	0	329	0	0	1	56	3	92	-96	245	-96	0	0	0	0
	SEP	0	0	0	329	0	0	1	44	2	92	-95	150	-95	0	0	0	0
	OCT	0	0	0	329	0	0	0	31	0	0	0	150	0	0	0	0	0
	YR	441	329	329	329	0	0	8		46	460 (entry entered)	-186	150	-186	0	0	0	0
1978	NOV	0	0	0	0	0	0	0	31	0	0	0	150	0	0	0	0	0
	DEC	0	0	0	0	0	0	0	31	0	0	0	149	0	0	0	0	0
	JAN	0	0	0	0	41	35	0	31	0	0	34	184	34	0	0	0	0
	FEB	0	0	0	0	186	158	0	36	0	0	158	342	158	0	0	0	0
	MAR	85	55	55	55	67	57	1	57	0	0	111	453	111	0	0	0	0
	APR	482	452	452	243	475	404	1	69	5	0	850	635	182	668	475	264	0
	MAY	898	868	392	351	491	417	1	85	15	92	701	635	0	701	491	284	0
	JUN	1175	1145	284	469	0	0	1	85	24	92	166	635	0	166	0	166	0
	JUL	0	0	0	469	0	0	1	85	12	92	-106	529	-106	0	0	0	0
	AUG	0	0	0	469	0	0	1	76	4	92	-97	432	-97	0	0	0	0
	SEP	0	0	0	469	0	0	1	67	3	92	-96	336	-96	0	0	0	0
	OCT	0	0	0	469	0	0	1	56	0	0	-1	335	-1	0	0	0	0
	YR	2640	2520	1183	469	1260	1071	9		64	460 (entry entered)	1721	335	186	1536	966	714	0

Hatcher Reservoir Operations
Decreed Capacity: 1729 ac-ft/yr
w/o Dutton Ditch expansion, w/ Steven's Res. Exp.

Low Water Years, 1976, 1977, 1978
Minimum End of Month Live Storage: 850 ac-ft
No Dutton Ditch Extension taken during months of Apr. through Sept.

CASE 3

Irrigation Year	Month	Perkins Ditch ac-ft	Hatcher Natural Inflow ac-ft	Available Inflow ac-ft	Storable Inflow ac-ft	Cumulative Inflow Stored ac-ft	Dutton Ditch Extension ac-ft	Dutton Extension Available ac-ft	Seepage Loss ac-ft	Surface Area ac	Evaporation Loss ac-ft	Demand ac-ft	Potential Gain/ Loss ac-ft	EndMonth Live Storage ac-ft	Actual Gain/ Loss ac-ft	Net Spill/ Deficit ac-ft	Dutton Extension Remain ac-ft	Natural Inflow Spill ac-ft	Perkins Ditch Remain ac-ft	Demand Deficit ac-ft
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
entered	entered	entered	entered				entered, 175 min													
1976	NOV	0	0	0	0	0	175	149	3	130	0	20	126	1532	126	0	0	0	0	0
	DEC	0	0	0	0	0	0	0	3	137	0	20	-23	1508	-23	0	0	0	0	0
	JAN	0	30	0	0	0	0	0	3	135	0	20	-23	1485	-23	0	0	0	0	0
	FEB	0	30	0	0	0	0	0	3	134	0	20	-23	1462	-23	0	0	0	0	0
	MAR	162	53	15	15	15	29	25	3	133	0	20	179	1641	179	0	0	0	0	0
	APR	755	247	209	209	15	0	0	3	143	10	20	931	1729	88	843	0	209	634	0
	MAY	1282	716	678	678	15	0	0	4	149	26	90	1840	1729	0	1840	0	678	1162	0
	JUN	0	0	0	0	15	0	0	4	149	43	90	-136	1593	-136	0	0	0	0	0
	JUL	0	0	0	0	15	0	0	3	140	20	90	-114	1479	-114	0	0	0	0	0
	AUG	0	0	0	0	15	0	0	3	134	7	90	-100	1379	-100	0	0	0	0	0
	SEP	0	0	0	0	15	0	0	3	128	7	90	-100	1280	-100	0	0	0	0	0
	OCT	0	0	0	0	15	175	149	3	123	0	20	126	1406	126	0	0	0	0	0
	YR	2199	1076	902	902	15	379	322	38		113	590	2683	1406	0	2683	0	887	1796	0
												(entry entered)								
1977	NOV	0	0	0	0	0	175	149	3	130	0	20	126	1532	126	0	0	0	0	0
	DEC	0	0	0	0	0	0	0	3	137	0	20	-23	1508	-23	0	0	0	0	0
	JAN	0	0	0	0	0	0	0	3	135	0	20	-23	1485	-23	0	0	0	0	0
	FEB	0	0	0	0	0	0	0	3	134	0	20	-23	1462	-23	0	0	0	0	0
	MAR	0	0	0	0	0	0	0	3	133	0	20	-23	1439	-23	0	0	0	0	0
	APR	0	0	0	0	0	0	0	3	132	9	20	-32	1407	-32	0	0	0	0	0
	MAY	0	0	0	0	0	0	0	3	130	23	90	-116	1291	-116	0	0	0	0	0
	JUN	0	0	0	0	0	0	0	3	124	35	90	-128	1163	-128	0	0	0	0	0
	JUL	0	0	0	0	0	0	0	2	118	17	90	-109	1054	-109	0	0	0	0	0
	AUG	0	0	0	0	0	0	0	2	112	6	90	-98	956	-98	0	0	0	0	0
	SEP	0	0	0	0	0	0	0	2	107	6	90	-98	858	-98	0	0	0	0	0
	OCT	0	0	0	0	0	175	149	2	101	0	20	127	985	127	0	0	0	0	0
	YR	0	0	0	0	0	350	298	32		95	590	-420	985	-420	0	0	0	0	0
												(entry entered)								
1978	NOV	0	0	0	0	0	267	227	2	108	0	20	205	1190	205	0	0	0	0	0
	DEC	0	0	0	0	0	0	0	2	119	0	20	-22	1168	-22	0	0	0	0	0
	JAN	0	31	0	0	0	0	0	2	118	0	20	-22	1145	-22	0	0	0	0	0
	FEB	0	30	0	0	0	0	0	2	117	0	20	-22	1123	-22	0	0	0	0	0
	MAR	165	54	16	16	16	67	57	2	116	0	20	216	1339	216	0	0	0	0	0
	APR	939	307	269	269	16	0	0	3	126	9	20	1176	1729	390	786	0	269	517	0
	MAY	1282	571	533	533	16	0	0	4	149	26	90	1695	1729	0	1695	0	533	1162	0
	JUN	0	0	0	0	16	0	0	4	149	43	90	-136	1593	-136	0	0	0	0	0
	JUL	0	0	0	0	16	0	0	3	140	20	90	-114	1479	-114	0	0	0	0	0
	AUG	0	0	0	0	16	0	0	3	134	7	90	-100	1379	-100	0	0	0	0	0
	SEP	0	0	0	0	16	0	0	3	128	7	90	-100	1280	-100	0	0	0	0	0
	OCT	0	0	0	0	16	175	149	3	123	0	20	126	1406	126	0	0	0	0	0
	YR	2386	993	818	818	16	509	433	34		111	590	2901	1406	420	2481	0	802	1679	0
												(entry entered)								

Steven's Lake Operations
Decreed Capacity: 1420 ac-ft/yr
w/o Dutton Ditch expansion, w/ Steven's Res. Exp.

Low Water Years, 1976, 1977, 1978
Minimum End of Month Live Storage: 150 ac-ft/yr
No Dutton Ditch Extension taken during months of Apr. through Sept. (irrigation) or Dec. through Feb.(ice)

CASE 3

Irrigation Year	Month	Steven's Natural Inflow ac-ft	Available Inflow ac-ft	Storable Inflow ac-ft	Cumulative Inflow Stored ac-ft	Dutton Ditch Extension	Dutton Extension Available	Seepage Loss	Surface Area ac	Evaporation Loss	Demand	Potential Gain/ Loss	End of Mo Live Storage	Actual Gain/ Loss	Net Spill/ Deficit	Dutton Extension Remain	Natural Inflow Spill	Demand Deficit
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
entered	entered	entered				from Hatcher												
1976	NOV	0	0	0	0	0	0	2	99	0	0	-2	829	-2	0	0	0	0
	DEC	0	0	0	0	0	0	2	99	0	0	-2	827	-2	0	0	0	0
	JAN	0	0	0	0	0	0	2	99	0	0	-2	826	-2	0	0	0	0
	FEB	0	0	0	0	0	0	2	99	0	0	-2	824	-2	0	0	0	0
	MAR	83	53	53	53	0	0	2	99	0	0	51	875	51	0	0	0	0
	APR	389	359	359	412	0	0	2	102	7	0	350	1225	350	0	0	0	0
	MAY	1125	1095	1008	813	0	0	3	121	21	183	801	1420	195	607	0	607	0
	JUN	919	889	607	1037	0	0	3	131	37	183	383	1420	0	383	0	383	0
	JUL	0	0	0	1037	0	0	3	131	19	183	-205	1215	-205	0	0	0	0
	AUG	0	0	0	1037	0	0	3	120	6	183	-192	1023	-192	0	0	0	0
	SEP	0	0	0	1037	0	0	2	110	6	183	-191	833	-191	0	0	0	0
	OCT	0	0	0	1037	0	0	2	99	0	0	-2	831	-2	0	0	0	0
	YR	2516	2396	2027	1037	0	0	25		96	915 (entry entered)	990	831	0	990	0	990	0
1977	NOV	0	0	0	0	0	0	2	99	0	0	-2	829	-2	0	0	0	0
	DEC	0	0	0	0	0	0	2	99	0	0	-2	827	-2	0	0	0	0
	JAN	0	0	0	0	0	0	2	99	0	0	-2	826	-2	0	0	0	0
	FEB	0	0	0	0	0	0	2	99	0	0	-2	824	-2	0	0	0	0
	MAR	22	0	0	0	0	0	2	99	0	0	-2	822	-2	0	0	0	0
	APR	107	77	77	77	0	0	2	99	7	0	69	891	69	0	0	0	0
	MAY	83	53	53	130	0	0	2	103	18	183	-150	741	-150	0	0	0	0
	JUN	229	199	199	329	0	0	2	93	27	183	-12	729	-12	0	0	0	0
	JUL	0	0	0	329	0	0	2	92	13	183	-198	531	-198	0	0	0	0
	AUG	0	0	0	329	0	0	1	76	4	183	-188	343	-188	0	0	0	0
	SEP	0	0	0	329	0	0	1	57	3	183	-187	156	-187	0	0	0	0
	OCT	0	0	0	329	0	0	0	32	0	0	0	156	0	0	0	0	0
	YR	441	329	329	329	0	0	17		72	915 (entry entered)	-675	156	-675	0	0	0	0
1978	NOV	0	0	0	0	0	0	0	32	0	0	0	156	0	0	0	0	0
	DEC	0	0	0	0	0	0	0	32	0	0	0	155	0	0	0	0	0
	JAN	0	0	0	0	0	0	0	32	0	0	0	155	0	0	0	0	0
	FEB	48	18	18	18	0	0	0	32	0	0	18	173	18	0	0	0	0
	MAR	85	55	55	73	0	0	0	34	0	0	55	227	55	0	0	0	0
	APR	482	452	452	525	0	0	0	42	3	0	449	676	449	0	0	0	0
	MAY	898	868	868	1393	0	0	1	88	16	183	668	1344	668	0	0	0	0
	JUN	1175	1145	27	1420	0	0	3	127	36	183	-195	1149	-195	0	0	0	0
	JUL	0	0	0	1420	0	0	2	117	17	183	-202	947	-202	0	0	0	0
	AUG	0	0	0	1420	0	0	2	106	5	183	-190	756	-190	0	0	0	0
	SEP	0	0	0	1420	0	0	2	94	5	183	-189	567	-189	0	0	0	0
	OCT	0	0	0	1420	0	0	1	80	0	0	-1	566	-1	0	0	0	0
	YR	2688	2538	1420	1420	0	0	13		82	915 (entry entered)	410	566	410	0	0	0	0

Hatcher Reservoir Operations
Decreed Capacity 1729 ac-ft/yr
w/o Dutton Ditch Steven's Res expansion

Low Water Years, 1976, 1977, 1978
Minimum End of Month Live Storage 850 ac-ft
No Dutton Ditch Extension taken during months of Apr. through Sept. (irrigation) or Dec. through Feb. (ice)

CASE 4

Irrigation Year	Month	Perkins Ditch ac-ft	Hatcher Natural Inflow ac-ft	Available Inflow ac-ft	Storable Inflow ac-ft	Cumulative Inflow Stored ac-ft	Dutton Ditch Extension ac-ft	Dutton Extension Available ac-ft	Seepage Loss ac-ft	Surface Area ac	vaporation Loss ac-ft	Demand ac-ft	Potential Gain/ Loss ac-ft	EndMonth Live Storage ac-ft	Actual Gain/ Loss ac-ft	Net Spill/ Deficit ac-ft	Dutton Extension Remain ac-ft	Natural Inflow Spill ac-ft	Perkins Ditch Remain ac-ft	Demand Deficit ac-ft
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
entered	entered	entered	entered				entered, 175 min													
1976	NOV	0	0	0	0	0	175	149	3	130	0	20	126	1532	126	0	0	0	0	0
	DEC	0	0	0	0	0	0	0	3	137	0	20	-23	1508	-23	0	0	0	0	0
	JAN	0	30	0	0	0	0	0	3	135	0	20	-23	1485	-23	0	0	0	0	0
	FEB	0	30	0	0	0	0	0	3	134	0	20	-23	1462	-23	0	0	0	0	0
	MAR	162	53	15	15	15	29	25	3	133	0	20	179	1641	179	0	0	0	0	0
	APR	755	247	209	209	15	0	0	3	143	10	20	931	1729	88	843	0	209	634	0
	MAY	1282	716	678	678	15	0	0	4	149	26	90	1840	1729	0	1840	0	678	1162	0
	JUN	0	0	0	0	15	0	0	4	149	43	90	-136	1593	-136	0	0	0	0	0
	JUL	0	0	0	0	15	0	0	3	140	20	90	-114	1479	-114	0	0	0	0	0
	AUG	0	0	0	0	15	0	0	3	134	7	90	-100	1379	-100	0	0	0	0	0
	SEP	0	0	0	0	15	0	0	3	128	7	90	-100	1280	-100	0	0	0	0	0
	OCT	0	0	0	0	15	175	149	3	123	0	20	126	1406	126	0	0	0	0	0
	YR	2199	1076	902	902	15	379	322	38		113	590 (entry entered)	2683	1406	0	2683	0	887	1796	0
1977	NOV	0	0	0	0	0	175	149	3	130	0	20	126	1532	126	0	0	0	0	0
	DEC	0	0	0	0	0	0	0	3	137	0	20	-23	1508	-23	0	0	0	0	0
	JAN	0	0	0	0	0	0	0	3	135	0	20	-23	1485	-23	0	0	0	0	0
	FEB	0	0	0	0	0	0	0	3	134	0	20	-23	1462	-23	0	0	0	0	0
	MAR	0	0	0	0	0	0	0	3	133	0	20	-23	1439	-23	0	0	0	0	0
	APR	0	0	0	0	0	0	0	3	132	9	20	-32	1407	-32	0	0	0	0	0
	MAY	0	0	0	0	0	0	0	3	130	23	90	-116	1291	-116	0	0	0	0	0
	JUN	0	0	0	0	0	0	0	3	124	35	90	-128	1163	-128	0	0	0	0	0
	JUL	0	0	0	0	0	0	0	2	118	17	90	-109	1054	-109	0	0	0	0	0
	AUG	0	0	0	0	0	0	0	2	112	6	90	-98	956	-98	0	0	0	0	0
	SEP	0	0	0	0	0	0	0	2	107	6	90	-98	858	-98	0	0	0	0	0
	OCT	0	0	0	0	0	175	149	2	101	0	20	127	985	127	0	0	0	0	0
	YR	0	0	0	0	0	350	298	32		95	590 (entry entered)	-420	985	-420	0	0	0	0	0
1978	NOV	0	0	0	0	0	267	227	2	108	0	20	205	1190	205	0	0	0	0	0
	DEC	0	0	0	0	0	0	0	2	119	0	20	-22	1168	-22	0	0	0	0	0
	JAN	0	31	0	0	0	0	0	2	118	0	20	-22	1145	-22	0	0	0	0	0
	FEB	0	30	0	0	0	0	0	2	117	0	20	-22	1123	-22	0	0	0	0	0
	MAR	165	54	16	16	16	67	57	2	116	0	20	216	1339	216	0	0	0	0	0
	APR	939	307	269	269	16	0	0	3	126	9	20	1176	1729	390	786	0	269	517	0
	MAY	1282	571	533	533	16	0	0	4	149	26	90	1695	1729	0	1695	0	533	1162	0
	JUN	0	0	0	0	16	0	0	4	149	43	90	-136	1593	-136	0	0	0	0	0
	JUL	0	0	0	0	16	0	0	3	140	20	90	-114	1479	-114	0	0	0	0	0
	AUG	0	0	0	0	16	0	0	3	134	7	90	-100	1379	-100	0	0	0	0	0
	SEP	0	0	0	0	16	0	0	3	128	7	90	-100	1280	-100	0	0	0	0	0
	OCT	0	0	0	0	16	175	149	3	123	0	20	126	1406	126	0	0	0	0	0
	YR	2386	993	818	818	16	509	433	34		111	590 (entry entered)	2901	1406	420	2481	0	802	1679	0

Steven's Lake Operations
Decreed Capacity: 635 ac-ft/yr
w/o Dutton Ditch. Steven's Res expansion

Low Water Years, 1976, 1977, 1978
Minimum End of Month Live Storage: 150 ac-ft/yr
No Dutton Ditch Extension taken during months of Apr. through Sept. (irrigation) or Dec. through Feb. (ice)

CASE 4

Irrigation Year	Month	Steven's Natural Inflow ac-ft	Available Inflow ac-ft	Storable Inflow ac-ft	Cumulative Inflow Stored ac-ft	Dutton Ditch Extension	Dutton Extension Available	Seepage Loss	Surface Area ac	vaporation Loss	Demand	Potential Gain/ Loss	End of Mo Live Storage	Actual Gain/ Loss	Net Spill/ Deficit	Dutton Extension Remain	Natural Inflow Spill	Demand Deficit
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
entered	entered	entered				from Hatcher												
1976	NOV	0	0	0	0	0	0	1	56	0	0	-1	335	-1	0	0	0	0
	DEC	0	0	0	0	0	0	1	56	0	0	-1	334	-1	0	0	0	0
	JAN	0	0	0	0	0	0	1	56	0	0	-1	333	-1	0	0	0	0
	FEB	0	0	0	0	0	0	1	56	0	0	-1	332	-1	0	0	0	0
	MAR	83	53	53	53	0	0	1	55	0	0	52	385	52	0	0	0	0
	APR	389	359	359	308	0	0	1	61	4	0	354	635	250	104	0	104	0
	MAY	1125	1095	327	417	0	0	1	85	15	92	218	635	0	218	0	218	0
	JUN	919	889	218	534	0	0	1	85	24	92	101	635	0	101	0	101	0
	JUL	0	0	0	534	0	0	1	85	12	92	-106	529	-106	0	0	0	0
	AUG	0	0	0	534	0	0	1	76	4	92	-97	432	-97	0	0	0	0
	SEP	0	0	0	534	0	0	1	67	3	92	-96	336	-96	0	0	0	0
	OCT	0	0	0	534	0	0	1	56	0	0	-1	335	-1	0	0	0	0
	YR	2516	2396	957	534	0	0	11		63	460 (entry entered)	423	335	0	423	0	423	0
1977	NOV	0	0	0	0	0	0	1	56	0	0	-1	335	-1	0	0	0	0
	DEC	0	0	0	0	0	0	1	56	0	0	-1	334	-1	0	0	0	0
	JAN	0	0	0	0	0	0	1	56	0	0	-1	333	-1	0	0	0	0
	FEB	0	0	0	0	0	0	1	56	0	0	-1	332	-1	0	0	0	0
	MAR	22	0	0	0	0	0	1	55	0	0	-1	332	-1	0	0	0	0
	APR	107	77	77	77	0	0	1	55	4	0	73	404	73	0	0	0	0
	MAY	83	53	53	130	0	0	1	64	11	92	-51	353	-51	0	0	0	0
	JUN	229	199	199	329	0	0	1	58	16	92	90	443	90	0	0	0	0
	JUL	0	0	0	329	0	0	1	68	10	92	-103	340	-103	0	0	0	0
	AUG	0	0	0	329	0	0	1	56	3	92	-96	245	-96	0	0	0	0
	SEP	0	0	0	329	0	0	1	44	2	92	-95	150	-95	0	0	0	0
	OCT	0	0	0	329	0	0	0	31	0	0	0	150	0	0	0	0	0
	YR	441	329	329	329	0	0	8		46	460 (entry entered)	-186	150	-186	0	0	0	0
1978	NOV	0	0	0	0	0	0	0	31	0	0	0	150	0	0	0	0	0
	DEC	0	0	0	0	0	0	0	31	0	0	0	149	0	0	0	0	0
	JAN	0	0	0	0	0	0	0	31	0	0	0	149	0	0	0	0	0
	FEB	0	0	0	0	0	0	0	31	0	0	0	149	0	0	0	0	0
	MAR	85	55	55	55	0	0	0	31	0	0	55	203	55	0	0	0	0
	APR	482	452	452	490	0	0	0	39	3	0	449	635	432	17	0	17	0
	MAY	898	868	145	598	0	0	1	85	15	92	37	635	0	37	0	37	0
	JUN	1175	1145	37	635	0	0	1	85	24	92	-81	554	-81	0	0	0	0
	JUL	0	0	0	635	0	0	1	78	11	92	-105	450	-105	0	0	0	0
	AUG	0	0	0	635	0	0	1	68	4	92	-96	353	-96	0	0	0	0
	SEP	0	0	0	635	0	0	1	58	3	92	-96	258	-96	0	0	0	0
	OCT	0	0	0	635	0	0	1	46	0	0	-1	257	-1	0	0	0	0
	YR	2640	2520	689	635	0	0	8		60	460 (entry entered)	162	257	107	54	0	54	0

Hatcher/Martinez Reservoir Operations 1729 760 Low Water Years, 1976, 1977, 1978

Decreed Capacity 2489 ac-ft/yr Minimum End of Month Live Storage, total 1000 ac-ft/yr

w/ Dutton Ditch expansion

**/ **/ */ */

CASE 5 Irrigation Year	Month	Perkins Ditch ac-ft	Hatcher Natural Inflow ac-ft	Martinez Natural Inflow ac-ft	Available Inflow ac-ft	Storable Inflow ac-ft	Cumulative Inflow Stored ac-ft	Dutton Ditch Extension ac-ft	Dutton Extension Available ac-ft	Hatcher Seepage Loss ac-ft	Martinez Seepage Loss ac-ft	Hatcher Surface Area ac	Martinez Surface Area ac	Hatcher Evaporation Loss ac-ft	Martinez Evaporation Loss ac-ft	Demand ac-ft	Potential Gain/ Loss ac-ft	EndMonth Live Storage ac-ft	Actual Gain/ Loss ac-ft	Net Spill/ Deficit ac-ft	Dutton Extension Remain ac-ft	Natural Inflow Spill ac-ft	Perkins Ditch Remain ac-ft	Demand Deficit ac-ft
(1)	(2)	(3)	(4)	(4')	(5)	(6)	(7)	(8)	(9)	(10)	(10')	(11)	(11')	(12)	(12')	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
entered	entered	entered	entered				entered, 175 min																	
1976	NOV	0	0	0	0	0	0	175	149	2	1	96	21	0	0	20	125	1686	125	0	0	0	0	0
	DEC	0	0	0	0	0	0	175	149	2	1	102	22	0	0	20	125	1811	125	0	0	0	0	0
	JAN	0	30	92	84	84	84	175	149	3	1	108	23	0	0	20	209	2020	209	0	0	0	0	0
	FEB	0	30	92	84	84	167	175	149	3	1	121	25	0	0	20	208	2228	208	0	0	0	0	0
	MAR	0	53	162	177	177	344	29	25	3	1	139	26	0	0	20	177	2405	177	0	0	0	0	0
	APR	0	247	755	964	964	466	475	404	3	2	158	27	11	2	20	1330	2489	84	1246	475	843	0	0
	MAY	0	716	2189	2867	2023	742	491	417	4	2	169	28	30	5	236	2165	2489	0	2165	491	1747	0	0
	JUN	0	0	0	0	0	742	0	0	4	2	169	28	48	8	236	-297	2192	-297	0	0	0	0	0
	JUL	0	0	0	0	0	742	0	0	3	1	136	26	20	4	236	-264	1928	-264	0	0	0	0	0
	AUG	0	0	0	0	0	742	0	0	3	1	115	24	6	1	236	-247	1681	-247	0	0	0	0	0
	SEP	0	0	0	0	0	742	0	0	2	1	101	22	5	1	236	-246	1435	-246	0	0	0	0	0
	OCT	0	0	0	0	0	742	175	149	2	1	91	20	0	0	20	126	1560	126	0	0	0	0	0
	YR	0	1076		4175	3332	742	1870	1590	35				119		1320 (entry entered)	3411	1560	0	3411	966	2590	0	0
1977	NOV	0	0	0	0	0	0	175	149	2	1	96	21	0	0	20	125	1686	125	0	0	0	0	0
	DEC	0	0	0	0	0	0	175	149	2	1	102	22	0	0	20	125	1811	125	0	0	0	0	0
	JAN	0	0	24	0	0	0	175	149	3	1	108	23	0	0	20	125	1936	125	0	0	0	0	0
	FEB	0	0	24	0	0	0	175	149	3	1	116	24	0	0	20	125	2061	125	0	0	0	0	0
	MAR	0	0	43	5	5	5	0	0	3	1	125	25	0	0	20	-19	2042	-19	0	0	0	0	0
	APR	0	0	208	170	170	175	0	0	3	1	123	25	8	2	20	136	2177	136	0	0	0	0	0
	MAY	0	0	162	124	124	299	0	0	3	1	134	26	24	5	236	-145	2033	-145	0	0	0	0	0
	JUN	0	0	0	0	0	299	0	0	3	1	122	25	35	7	236	-282	1750	-282	0	0	0	0	0
	JUL	0	0	0	0	0	299	0	0	3	1	105	23	15	3	236	-258	1492	-258	0	0	0	0	0
	AUG	0	0	0	0	0	299	0	0	2	1	93	21	5	1	236	-245	1247	-245	0	0	0	0	0
	SEP	0	0	0	0	0	299	0	0	2	1	85	19	4	1	236	-244	1003	-244	0	0	0	0	0
	OCT	0	0	0	0	0	299	175	149	1	1	76	16	0	0	20	127	1130	127	0	0	0	0	0
	YR	0	0		299	299	299	875	744	30				91		1320 (entry entered)	-430	1130	-430	0	0	0	0	0
1978	NOV	0	0	0	0	0	0	267	227	2	1	80	17	0	0	20	205	1335	205	0	0	0	0	0
	DEC	0	0	0	0	0	0	266	226	2	1	88	19	0	0	20	203	1538	203	0	0	0	0	0
	JAN	0	31	95	88	88	88	202	172	2	1	95	21	0	0	20	236	1774	236	0	0	0	0	0
	FEB	0	30	92	84	84	171	214	182	3	1	106	23	0	0	20	242	2016	242	0	0	0	0	0
	MAR	0	54	165	181	181	353	67	57	3	1	121	25	0	0	20	214	2230	214	0	0	0	0	0
	APR	0	307	939	1208	1208	648	475	404	3	1	139	26	10	2	20	1575	2489	259	1316	475	913	0	0
	MAY	0	571	1746	2279	1841	923	491	417	4	2	169	28	30	5	236	1983	2489	0	1983	491	1566	0	0
	JUN	0	0	0	0	0	923	475	404	4	2	169	28	48	8	236	107	2489	0	107	125	0	0	0
	JUL	0	0	0	0	0	923	48	41	4	2	169	28	24	4	236	-229	2260	-229	0	0	0	0	0
	AUG	0	0	0	0	0	923	0	0	3	1	142	26	7	1	236	-249	2011	-249	0	0	0	0	0
	SEP	0	0	0	0	0	923	175	149	3	1	121	25	6	1	236	-99	1912	-99	0	0	0	0	0
	OCT	0	0	0	0	0	923	175	149	3	1	114	24	0	0	20	125	2037	125	0	0	0	0	0
	YR	0	993		3839	3402	923	2855	2427	34				125		1320 (entry entered)	4312	2037	907	3406	1091	2478	0	0

Hatcher/Martinez Reservoir Operations 1729 760 Low Water Years, 1976, 1977, 1978 No Dutton Ditch Extension taken during months of Apr. through Sept.

Decreed Capacity 2489 ac-ft/yr Minimum End of Month Live Storage, total: 1000 ac-ft/yr

w/o Dutton Ditch expansion

CASE 6

Irrigation Year (1) entered	Month (2) entered	Perkins Ditch ac-ft (3) entered	Hatcher Natural Inflow ac-ft (4) entered	Martinez Natural Inflow ac-ft (4')	Available Inflow ac-ft (5)	Storable Inflow ac-ft (6)	Cumulativ Inflow Stored ac-ft (7)	Dutton Ditch Extension ac-ft (8) entered	Dutton Extension Available ac-ft (9)	Hatcher Seepage Loss ac-ft (10)	Martinez Seepage Loss ac-ft (10')	Hatcher Surface Area ac (11)	Martinez Surface Area ac (11')	Hatcher vaporatio Loss ac-ft (12)	Martinez vaporation Loss ac-ft (12')	Demand ac-ft (13)	Potential Gain/ Loss ac-ft (14)	EndMonth Live Storage ac-ft (15)	Actual Gain/ Loss ac-ft (16)	Net Spill/ Deficit ac-ft (17)	Dutton Extension Remain ac-ft (18)	Natural Inflow Spill ac-ft (19)	Perkins Ditch Remain ac-ft (20)	Demand Deficit ac-ft (21)
1976	NOV	0	0	0	0	0	0	175	149	3	1	112	24	0	0	20	125	2005	125	0	0	0	0	0
	DEC	0	0	0	0	0	0	0	0	3	1	120	25	0	0	20	-24	1981	-24	0	0	0	0	0
	JAN	0	30	92	84	84	84	0	0	3	1	119	24	0	0	20	60	2040	60	0	0	0	0	0
	FEB	0	30	92	84	84	167	0	0	3	1	123	25	0	0	20	59	2100	59	0	0	0	0	0
	MAR	0	53	162	177	177	344	29	25	3	1	128	25	0	0	20	177	2277	177	0	0	0	0	0
	APR	0	247	755	964	964	593	0	0	3	1	144	26	10	2	20	928	2489	212	716	0	716	0	0
	MAY	0	716	2189	2867	1896	787	0	0	4	2	169	28	30	5	155	1702	2489	0	1702	0	1702	0	0
	JUN	0	0	0	0	0	787	0	0	4	2	169	28	48	8	155	-216	2273	-216	0	0	0	0	0
	JUL	0	0	0	0	0	787	0	0	3	1	143	26	21	4	155	-184	2088	-184	0	0	0	0	0
	AUG	0	0	0	0	0	787	0	0	3	1	127	25	7	1	155	-167	1921	-167	0	0	0	0	0
	SEP	0	0	0	0	0	787	0	0	3	1	115	24	6	1	155	-166	1755	-166	0	0	0	0	0
	OCT	0	0	0	0	0	787	175	149	3	1	105	23	0	0	20	125	1880	125	0	0	0	0	0
	YR	0	1076		4175	3205	787	379	322	37				121		915 (entry entered)	2418	1880	0	2418	0	2418	0	0
1977	NOV	0	0	0	0	0	0	175	149	3	1	112	24	0	0	20	125	2005	125	0	0	0	0	0
	DEC	0	0	0	0	0	0	0	0	3	1	120	25	0	0	20	-24	1981	-24	0	0	0	0	0
	JAN	0	0	0	0	0	0	0	0	3	1	119	24	0	0	20	-24	1957	-24	0	0	0	0	0
	FEB	0	0	0	0	0	0	0	0	3	1	117	24	0	0	20	-24	1933	-24	0	0	0	0	0
	MAR	0	0	0	0	0	0	0	0	3	1	115	24	0	0	20	-24	1909	-24	0	0	0	0	0
	APR	0	0	0	0	0	0	0	0	3	1	114	24	8	2	20	-33	1875	-33	0	0	0	0	0
	MAY	0	0	0	0	0	0	0	0	3	1	112	24	20	4	155	-183	1692	-183	0	0	0	0	0
	JUN	0	0	0	0	0	0	0	0	2	1	102	22	29	6	155	-194	1499	-194	0	0	0	0	0
	JUL	0	0	0	0	0	0	0	0	2	1	94	21	14	3	155	-175	1324	-175	0	0	0	0	0
	AUG	0	0	0	0	0	0	0	0	2	1	87	19	5	1	155	-163	1161	-163	0	0	0	0	0
	SEP	0	0	0	0	0	0	0	0	2	1	82	18	4	1	155	-163	998	-163	0	0	0	0	0
	OCT	0	0	0	0	0	0	175	149	1	1	76	16	0	0	20	127	1125	127	0	0	0	0	0
	YR	0	0		0	0	0	350	298	29				79		915 (entry entered)	-755	1125	-755	0	0	0	0	0
1978	NOV	0	0	0	0	0	0	267	227	2	1	80	17	0	0	20	205	1329	205	0	0	0	0	0
	DEC	0	0	0	0	0	0	0	0	2	1	87	19	0	0	20	-23	1307	-23	0	0	0	0	0
	JAN	0	31	95	88	88	88	0	0	2	1	87	19	0	0	20	65	1372	65	0	0	0	0	0
	FEB	0	30	92	84	84	171	0	0	2	1	89	20	0	0	20	61	1432	61	0	0	0	0	0
	MAR	0	54	165	181	181	353	67	57	2	1	91	20	0	0	20	215	1648	215	0	0	0	0	0
	APR	0	307	939	1208	1208	1226	0	0	2	1	100	22	7	1	20	1176	2489	841	334	0	334	0	0
	MAY	0	571	1746	2279	1263	1421	0	0	4	2	169	28	30	5	155	1068	2489	0	1068	0	1068	0	0
	JUN	0	0	0	0	0	1421	0	0	4	2	169	28	48	8	155	-216	2273	-216	0	0	0	0	0
	JUL	0	0	0	0	0	1421	0	0	3	1	143	26	21	4	155	-184	2088	-184	0	0	0	0	0
	AUG	0	0	0	0	0	1421	0	0	3	1	127	25	7	1	155	-167	1921	-167	0	0	0	0	0
	SEP	0	0	0	0	0	1421	0	0	3	1	115	24	6	1	155	-166	1755	-166	0	0	0	0	0
	OCT	0	0	0	0	0	1421	175	149	3	1	105	23	0	0	20	125	1880	125	0	0	0	0	0
	YR	0	993		3839	2823	1421	509	433	31				118		915 (entry entered)	2158	1880	755	1403	0	1403	0	0

Table 5-1
List of Alternate Water Supply Sources

A	B	C	D	E
Sec. No.	Alternate Description	Yield From Model Runs (a.f./yr.)		Additional Yield (a.f./yr.) Column C-D
5.2.	Increase Supply and Capacity of Snowball Water Treatment Plant	None	None	1,904
5.3.	Enlarge Stevens Reservoir and Water Treatment Plant *Comparison of model runs of "Stevens Res. w/o Dutton Ditch expansion, w/Stevens Res. expansion" (Pg. A-7) WITH "Stevens Res. w/o Dutton Ditch expansion, w/o Stevens Res. expansion." (Pg. A-9)**	915	233*	682
5.4.	Construct Martinez Dam and Use of Hatcher Water Treatment Plant *Comparison of model runs of "Hatcher/Martinez Res. w/o Dutton Ditch expansion" (Pg. A-11) WITH "Hatcher Res. w/o Dutton Ditch expansion w/o Stevens Res. Expansion". (Pg. A-8)*	915	590	325
5.5.	Enlarge Dutton Ditch with:			
	Existing WTPs at Hatcher and Stevens Reservoirs *Comparison of model runs of "Hatcher Res. w/Dutton Ditch, w/o Stevens Res. expansion" (Pg. A-4) and "Stevens Res. w/Dutton Ditch, w/o Stevens Res. expansion" (Pg. A-5) WITH "Hatcher Res. w/o Dutton Ditch expansion, w/o Stevens Res. expansion" (Pg. A-8) and "Stevens Res. w/o Dutton Ditch expansion, w/o Stevens Res. expansion." (Pg. A-9)*	1080 460	590 233*	490 +227 717
	Enlarge Stevens Res. and WTP *Comparison of model runs of "Hatcher Res. w/Dutton Ditch, w/Stevens Res. expansion" (Pg. A-2) and "Stevens Res. w/Dutton Ditch, w/Stevens Res. expansion" (Pg. A-3) WITH "Hatcher Res. w/o Dutton Ditch expansion, w/Stevens Res. expansion" (Pg. A-6) and "Stevens Res. w/oDutton Ditch expansion, w/o Stevens Res. expansion." (Pg. A-9)*	1080 915	590 233*	490 +682 1172
	Construct Martinez Dam and Enlarge Hatcher WTP *Comparison of model runs of "Hatcher/Martinez Res. w/o Dutton Ditch" (Pg. A-11) and "Hatcher/Martinez Res. w/Dutton Ditch expansion" (Pg. A-10) WITH "Hatcher Res. w/o Dutton Ditch expansion w/o Stevens Res. Exp." (Pg. A-8) and "Hatcher/Martinez Res. w/o Dutton Ditch" (Pg. A-11)*	915 1320	590 915	325 405 730

* Projected yield was reduced from 460 a.f./yr. to 233 a.f./yr. because existing 0.5 m.g.d. water treatment plant will produce only 233 a.f./yr. when operated five months per year. Operation of the water treatment plant for five months per year was assumed for scenarios including Stevens Reservoir.

APPENDIX B

EXPLANATIONS OF SPREADSHEETS

Hatcher Reservoir Operations (Page numbers referenced are from the CDM report.)
Decreed Capacity: 1729 ac-ft/yr

(1), (2) Irrigation Year/Month

$$\begin{pmatrix} Irrigation \\ Year \end{pmatrix} = entered \qquad \begin{pmatrix} Irrigation \\ Month \end{pmatrix} = entered$$

(3) Perkins Ditch, ac-ft

During the months of March through May when Perkins Ditch is flowing, it was assumed the District's water right of 21.25 cfs (1282.02 ac-ft/mo) could be taken whenever it was available. The available flow in Perkins Ditch was taken as the natural inflow in the Martinez drainage. This was determined using the drainage area method described in the CDM report. The drainage area of Martinez Reservoir is 10.7 sq. mi.

$$If \begin{pmatrix} Martinez \\ Natural \\ Inflow \\ ac-ft \end{pmatrix} < 1282.02 \_\_\_\_ then \begin{pmatrix} Perkins \\ Ditch \\ ac-ft \end{pmatrix} = \begin{pmatrix} Martinez \\ Natural \\ Inflow \\ ac-ft \end{pmatrix} \_\_\_\_ otherwise \begin{pmatrix} Perkins \\ Ditch \\ ac-ft \end{pmatrix} = 1282.02$$

where

$$\begin{pmatrix} Martinez \\ Natural \\ Inflow \\ ac-ft \end{pmatrix} = \frac{10.7 acres}{3.5 acres} * \begin{pmatrix} Hatcher \\ Natural \\ Inflow \\ ac-ft \end{pmatrix}$$

(4) Hatcher Natural Inflow, ac-ft

Natural inflow is inflow from streams into the reservoir and does not include flow from diversions. It was estimated from flow in Four Mile Creek, based on the drainage area. Flow in Four Mile Creek was estimated from flow in Turkey Creek. All values were multiplied by 0.61 and in several cases further reduced by PAWSD personnel because the flows estimated with the drainage area method seemed high. (p. 6-10 to 6-12) For purposes of this analysis, data was entered.

$$\begin{pmatrix} Hatcher \\ Natural \\ Inflow \\ ac-ft \end{pmatrix} = entered$$

(5) Available Inflow, ac-ft

A minimum bypass requirement was determined based on the senior water rights located downstream of each reservoir. The average bypass requirement for Hatcher was 38 ac-ft/month. (p. 6-33) The remainder of the inflow was available.

$$If \begin{pmatrix} Natural \\ Inflow \\ ac-ft \end{pmatrix} - 38 > 0 \_\_\_\_ then \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix} = \begin{pmatrix} Natural \\ Inflow \\ ac-ft \end{pmatrix} - 38 \_\_\_\_ otherwise \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix} = 0$$

(6) Storable Inflow, ac-ft

The volume of water that could be stored in a reservoir was limited to the decreed capacity, 1729 ac-ft/yr for Hatcher. If the cumulative inflow stored at the beginning of the month plus the available inflow exceeded the decreed amount, the exceedance was

not included as storable inflow. Otherwise, the storable inflow equaled the available inflow.

$$If \begin{pmatrix} Cumulative \\ Inflow \\ Stored \\ ac-ft \end{pmatrix}_{n-1} + \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix}_n > 1729 ac-ft$$

$$then \begin{pmatrix} Storable \\ Inflow \\ ac-ft \end{pmatrix} = \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix}_n - \left[\begin{pmatrix} Cumulative \\ Inflow \\ Stored \\ ac-ft \end{pmatrix}_{n-1} + \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix}_n - 1729 ac-ft \right] \quad otherwise \begin{pmatrix} Storable \\ Inflow \\ ac-ft \end{pmatrix} = \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix}_n$$

(7) Cumulative Inflow Stored, ac-ft

This is a tally of the storable inflow accumulated for the year. If any natural inflow spills occurred, the cumulative inflow was reduced by that amount. The tally was reset to zero at the beginning of each irrigation year in November.

$$\begin{pmatrix} Cumulative \\ Inflow \\ Stored \\ ac-ft \end{pmatrix}_n = \begin{pmatrix} Cumulative \\ Inflow \\ Stored \\ ac-ft \end{pmatrix}_{n-1} + \begin{pmatrix} Storable \\ Inflow \\ ac-ft \end{pmatrix}_n - \begin{pmatrix} Natural \\ Inflow \\ Spill \\ ac-ft \end{pmatrix}_n$$

(8) Dutton Ditch Extension, ac-ft

Derivation of this amount is found in Table 6-7 (p. 6-20 to 6-28). It represents the flow available to Dutton Ditch from Four Mile Creek after other diversions were taken historically. When the actual diversion exceeded the decreed capacity for the water right listed, only the decreed amount was considered when determining flows available to Dutton Ditch.

For the Cases where Dutton Ditch enlargement was considered, the capacity was increased by 8 cfs so it will carry the water available. For the Cases where Dutton Ditch enlargement was not considered, no water was taken during the irrigation months. During the months of November through February and in September and October, the minimum flow was taken as 175 ac-ft/mo. For purposes of this analysis, data was entered from Table 6-11 and as noted.

$$\begin{pmatrix} Dutton \\ Ditch \\ Extension \\ ac-ft \end{pmatrix} = entered$$

(9) Dutton Extension Available, ac-ft

Conveyance losses for carrying water to Hatcher over 5.25 miles were estimated to be 15% of the water used for diversions. The available water is 85% of the ditch diversion amount. (p. 6-31)

$$\begin{pmatrix} Dutton \\ Extension \\ Available \\ ac-ft \end{pmatrix} = 0.85 * \begin{pmatrix} Dutton \\ Ditch \\ Extension \\ ac-ft \end{pmatrix}$$

(10) Seepage Loss, ac-ft

An annual seepage rate for water in the reservoir of 2.5 % was selected. The monthly loss was estimated by multiplying the rate by the beginning of month live storage and dividing that by the number of months in a year. (p. 6-31)

$$\begin{pmatrix} Seepage \\ Loss \\ ac-ft \end{pmatrix}_n = \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1} * \frac{.025}{12}$$

(11) Surface Area, ac

Surface area of the reservoir was needed to estimate evaporation losses. An area-capacity curve was developed for Stevens Reservoir (p. 6-35) and a best-fit equation was fitted to the data. Data was not available for Hatcher Reservoir, so the equation for Stevens was used. (p. 6-33) The equation was not supplied in the report, so points were taken from the curve and a best-fit equation found. The surface area used for evaporation losses was based on beginning of month live storage.

$$\begin{pmatrix} Surface \\ Area \\ ac \end{pmatrix}_n = 5.8340959 + 0.18175979 * \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1} - 0.00010785922 * \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}^2_{n-1} + 2.935741E-08 * \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}^3_{n-1}$$

(12) Evaporation loss, ac-ft

A net evaporation value in inches was developed for each month. (Table 6-8, p. 6-32). That value was multiplied by the surface area and then divided by 12 to get ac-ft.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0.82	2.11	3.42	1.74	0.62	0.62	0	0	0

$$\begin{pmatrix} Evaporation \\ Loss \\ ac-ft \end{pmatrix} = \begin{pmatrix} Surface \\ Area \\ ac \end{pmatrix} * NetEvaporationRate_{mon}(in) * \frac{ft}{12in}$$

(13) Demand, ac-ft

Demand changed based on the different reservoir conditions considered, but was a constant for a specific scenario. Reservoirs were allowed to fill with water only to their decreed capacity, but no reservoir was allowed to drop below 150 ac-ft. In each case considered, the demand, or the amount of water the District could expect to use, was adjusted under the specific scenario such that in the reservoir operations, the live storage never dropped below 150 ac-ft. The demand, then, became the maximum yield expected under the specific scenario.

$$\begin{pmatrix} Demand \\ ac-ft \end{pmatrix} = entered\_based\_on\_minimum\_reservoir\_storage$$

(14) Potential Gain/Loss, ac-ft

To derive the potential gain or loss, all the inputs to the reservoir were added and all the losses were subtracted. Inputs included Perkins Ditch, Storable Inflow, and

Dutton Extension Available. Losses included Seepage Loss, Evaporation Loss, and Demand.

$$\begin{pmatrix} Potential \\ Gain/ \\ Loss \\ ac-ft \end{pmatrix} = \begin{pmatrix} Perkins \\ Ditch \\ ac-ft \end{pmatrix} + \begin{pmatrix} Storable \\ Inflow \\ ac-ft \end{pmatrix} + \begin{pmatrix} Dutton \\ Extension \\ Available \\ ac-ft \end{pmatrix} - \begin{pmatrix} Seepage \\ Loss \\ ac-ft \end{pmatrix} - \begin{pmatrix} Evaporation \\ Loss \\ ac-ft \end{pmatrix} - \begin{pmatrix} Demand \\ ac-ft \end{pmatrix}$$

(15) End of Month Live Storage, ac-ft

The live storage in the reservoir was limited to the decreed capacity, 1729 ac-ft/yr for Hatcher. The potential gain/loss was added to the beginning of month live storage to get the end of month live storage. If it exceeded the decreed capacity, the end of month live storage defaulted to the decreed capacity.

$$If \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1} + \begin{pmatrix} Potential \\ Gain/ \\ Loss \\ ac-ft \end{pmatrix}_n > 1729 ac-ft \_\_\_\_ then \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_n = 1729 ac-ft$$

$$otherwise \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_n = \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1} + \begin{pmatrix} Potential \\ Gain/ \\ Loss \\ ac-ft \end{pmatrix}_n$$

(16) Actual Gain/Loss, ac-ft

The actual gain/loss was found by subtracting the end of month live storage from the beginning of month live storage.

$$\begin{pmatrix} Actual \\ Gain/ \\ Loss \\ ac-ft \end{pmatrix}_n = \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_n - \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1}$$

(17) Net Spill/Deficit, ac-ft

The net spill/deficit was found by subtracting the actual gain/loss from the potential gain/loss. (p. 6-40)

$$\begin{pmatrix} Net \\ Spill/ \\ Deficit \\ ac-ft \end{pmatrix} = \begin{pmatrix} Potential \\ Gain/ \\ Loss \\ ac-ft \end{pmatrix} - \begin{pmatrix} Actual \\ Gain/ \\ Loss \\ ac-ft \end{pmatrix}$$

(18) Dutton Extension Remain, ac-ft

When spill conditions existed, it was assumed first Dutton Ditch water would not be taken and therefore made available to Stevens Lake, limited to the amount of Dutton Ditch available. To get the amount remaining in the ditch, the available water was adjusted for the conveyance losses. (p. 6-40)

$$If\begin{pmatrix}Net\\Spill/\\Deficit\\ac-ft\end{pmatrix}>\begin{pmatrix}Dutton\\Extension\\Available\\ac-ft\end{pmatrix}\_\_then\begin{pmatrix}Dutton\\Extension\\Remain\\ac-ft\end{pmatrix}=\begin{pmatrix}Dutton\\Extension\\Available\\ac-ft\end{pmatrix}*\frac{1}{0.85}$$

otherwise

$$If\begin{pmatrix}Net\\Spill/\\Deficit\\ac-ft\end{pmatrix}>0\_\_\_\_then\begin{pmatrix}Dutton\\Extension\\Remain\\ac-ft\end{pmatrix}=\begin{pmatrix}Net\\Spill/\\Deficit\\ac-ft\end{pmatrix}*\frac{1}{0.85}\_\_\_\_otherwise\begin{pmatrix}Dutton\\Extension\\Remain\\ac-ft\end{pmatrix}=0$$

(19) Natural Inflow Spill, ac-ft

If spill conditions still existed, natural flows would then be spilled, limited to the amount of storable inflow. (p. 6-48)

$$If\begin{pmatrix}Net\\Spill/\\Deficit\\ac-ft\end{pmatrix}-\begin{pmatrix}Dutton\\Extension\\Available\\ac-ft\end{pmatrix}>\begin{pmatrix}Storable\\Inflow\\ac-ft\end{pmatrix}\_\_then\begin{pmatrix}Natural\\Inflow\\Spill\\ac-ft\end{pmatrix}=\begin{pmatrix}Storable\\Inflow\\ac-ft\end{pmatrix}$$

otherwise

$$If\begin{pmatrix}Net\\Spill/\\Deficit\\ac-ft\end{pmatrix}-\begin{pmatrix}Dutton\\Extension\\Available\\ac-ft\end{pmatrix}>0\_\_\_\_then\begin{pmatrix}Natural\\Inflow\\Spill\\ac-ft\end{pmatrix}=\begin{pmatrix}Net\\Spill/\\Deficit\\ac-ft\end{pmatrix}-\begin{pmatrix}Dutton\\Extension\\Available\\ac-ft\end{pmatrix}\_\_\_\_otherwise\begin{pmatrix}Natural\\Inflow\\Spill\\ac-ft\end{pmatrix}=0$$

(20) Perkins Ditch Remain, ac-ft

If spill conditions still existed, Perkins Ditch water would be left at the headgate, limited to the amount diverted for Perkins Ditch. (p. 6-48)

$$If\begin{pmatrix}Net\\Spill/\\Deficit\\ac-ft\end{pmatrix}-\begin{pmatrix}Dutton\\Extension\\Available\\ac-ft\end{pmatrix}-\begin{pmatrix}Storable\\Inflow\\ac-ft\end{pmatrix}>\begin{pmatrix}Perkins\\Ditch\\ac-ft\end{pmatrix}\_\_then\begin{pmatrix}Perkins\\Ditch\\Remain\\ac-ft\end{pmatrix}=\begin{pmatrix}Perkins\\Ditch\\ac-ft\end{pmatrix}$$

otherwise

$$If\begin{pmatrix}Net\\Spill/\\Deficit\\ac-ft\end{pmatrix}-\begin{pmatrix}Dutton\\Extension\\Available\\ac-ft\end{pmatrix}-\begin{pmatrix}Storable\\Inflow\\ac-ft\end{pmatrix}>0\_\_\_\_then\begin{pmatrix}Perkins\\Ditch\\Remain\\ac-ft\end{pmatrix}=\begin{pmatrix}Net\\Spill/\\Deficit\\ac-ft\end{pmatrix}-\begin{pmatrix}Dutton\\Extension\\Available\\ac-ft\end{pmatrix}-\begin{pmatrix}Storable\\Inflow\\ac-ft\end{pmatrix}\_\_\_\_otherwise\begin{pmatrix}Perkins\\Ditch\\Remain\\ac-ft\end{pmatrix}=0$$

(21) Demand Deficit, ac-ft

If the reservoir empties, the actual gain/loss becomes a deficit and demand is not met. (p. 6-40)

$$If\begin{pmatrix}EndMonth\\Live\\Storage\\ac-ft\end{pmatrix}<0\_\_\_\_then\begin{pmatrix}Demand\\Deficit\\ac-ft\end{pmatrix}=\begin{pmatrix}EndMonth\\Live\\Storage\\ac-ft\end{pmatrix}\_\_\_\_otherwise\begin{pmatrix}Demand\\Deficit\\ac-ft\end{pmatrix}=0$$

Stevens Lake Operations
Decreed Capacity: 1420 ac-ft/yr

(1), (2) Irrigation Year/Month

$$\begin{pmatrix} Irrigation \\ Year \end{pmatrix} = entered \qquad \begin{pmatrix} Irrigation \\ Month \end{pmatrix} = entered$$

(3) Stevens Natural Inflow, ac-ft

Natural inflow is inflow from streams into the reservoir and does not include flow from diversions. It was estimated from flow in Four Mile Creek, based on the drainage area of approximately 16 sq.mi. above the Dutton Ditch diversion. Flow in Four Mile Creek was estimated from flow in Turkey Creek. All values were multiplied by 0.61 and in several cases further reduced by PAWSD personnel because the flows estimated with the drainage area method seemed high. (p. 6-10 to 6-12) For purposes of this analysis, data in this table was entered.

$$\begin{pmatrix} Stevens \\ Natural \\ Inflow \\ ac-ft \end{pmatrix} = entered$$

(4) Available Inflow, ac-ft

A minimum bypass requirement was determined based on the senior water rights located downstream of each reservoir. The average bypass requirement for Stevens was 30 ac-ft/month. (p. 6-33) The remainder of the inflow was available.

$$If \begin{pmatrix} Natural \\ Inflow \\ ac-ft \end{pmatrix} - 30 > 0 \_\_\_\_ then \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix} = \begin{pmatrix} Natural \\ Inflow \\ ac-ft \end{pmatrix} - 30 \_\_\_\_ otherwise \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix} = 0$$

(5) Storable Inflow, ac-ft

The volume of water that could be stored in a reservoir was limited to the decreed capacity, 1420 ac-ft/yr for Stevens. If Stevens Lake is not enlarged, the capacity is 635 ac-ft. If the cumulative inflow stored at the beginning of the month plus the available inflow exceeded the decreed amount, the exceedance was not included as storable inflow. Otherwise, the storable inflow equaled the available inflow.

$$If \begin{pmatrix} Cumulative \\ Inflow \\ Stored \\ ac-ft \end{pmatrix}_{n-1} + \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix}_{n} > 1420 ac-ft$$

$$then \begin{pmatrix} Storable \\ Inflow \\ ac-ft \end{pmatrix} = \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix}_{n} - \left[\begin{pmatrix} Cumulative \\ Inflow \\ Stored \\ ac-ft \end{pmatrix}_{n-1} + \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix}_{n} - 1420 ac-ft \right]$$

$$otherwise \begin{pmatrix} Storable \\ Inflow \\ ac-ft \end{pmatrix} = \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix}_{n}$$

(6) Cumulative Inflow Stored, ac-ft

This is a tally of the storable inflow accumulated for the year. If any natural inflow spills occurred, the cumulative inflow was reduced by that amount. The tally was reset to zero at the beginning of each irrigation year in November.

$$\begin{pmatrix} Cumulative \\ Inflow \\ Stored \\ ac-ft \end{pmatrix}_n = \begin{pmatrix} Cumulative \\ Inflow \\ Stored \\ ac-ft \end{pmatrix}_{n-1} + \begin{pmatrix} Storable \\ Inflow \\ ac-ft \end{pmatrix}_n - \begin{pmatrix} Natural \\ Inflow \\ Spill \\ ac-ft \end{pmatrix}_n$$

(7) Dutton Ditch Extension, ac-ft

Data for this column is forwarded from worksheet Hatcher Reservoir Operations, entry "Dutton Extension Remain". It represents flow from Dutton Ditch that was not taken at Hatcher because the flows into Hatcher exceeded its decreed capacity. It was assumed Hatcher would take all flow it was capable of before passing any Dutton Ditch water for Stevens. (p. 6-40) During all scenarios irrigation water rights in Dutton Ditch were assumed to have priority.

$$\begin{pmatrix} Dutton \\ Ditch \\ Extension \\ ac-ft \end{pmatrix} = fowarded\_from\_Hatcher$$

(8) Dutton Extension Available, ac-ft

Conveyance losses for carrying water to Stevens over 5.0 miles were estimated to be 15% of the water used for diversions. The available water is 85% of the ditch diversion amount. (p. 6-31) There was consideration given to increasing losses, but gains to the ditch from side drainage flows were assumed to offset some losses due to ditch seepage.

$$\begin{pmatrix} Dutton \\ Extension \\ Available \\ ac-ft \end{pmatrix} = 0.85 * \begin{pmatrix} Dutton \\ Ditch \\ Extension \\ ac-ft \end{pmatrix}$$

(9) Seepage Loss, ac-ft

An annual seepage rate for water in the reservoir of 2.5 % was selected. The monthly loss was estimated by multiplying the rate by the beginning of month live storage and dividing that by the number of months in a year. (p. 6-31)

$$\begin{pmatrix} Seepage \\ Loss \\ ac-ft \end{pmatrix}_n = \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1} * \frac{025}{12}$$

(10) Surface Area, ac

Surface area of the reservoir was needed to estimate evaporation losses. An area-capacity curve was developed for Stevens Reservoir (p. 6-35) and a best-fit equation was fitted to the data. The equation was not supplied in the report, so points were taken from the curve and a best-fit equation found. The surface area used for evaporation losses was based on beginning of month live storage.

$$\begin{pmatrix} Surface \\ Area \\ ac \end{pmatrix}_n = 5.8340959 + 0.18175979 * \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1} - 0.00010785922 * \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}^2_{n-1} + 2.935741E-08 * \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}^3_{n-1}$$

(11) Evaporation loss, ac-ft

A net evaporation value in inches was developed for each month. (Table 6-8, p. 6-32). That value was multiplied by the surface area and then divided by 12 to get ac-ft.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0.82	2.11	3.42	1.74	0.62	0.62	0	0	0

$$\begin{pmatrix} Evaporation \\ Loss \\ ac-ft \end{pmatrix} = \begin{pmatrix} Surface \\ Area \\ ac \end{pmatrix} * NetEvaporationRate_{mon}(in) * \frac{ft}{12in}$$

(12) Demand, ac-ft

Demand changed based on the different reservoir conditions considered, but was a constant for a specific scenario. Reservoirs were allowed to fill with water only to their decreed capacity, but no reservoir was allowed to drop below 150 ac-ft. In each case considered, the demand, or the amount of water the District could expect to use, was adjusted under the specific scenario such that in the reservoir operations, the live storage never dropped below 150 ac-ft. The demand, then, became the maximum yield expected under the specific scenario.

$$\begin{pmatrix} Demand \\ ac-ft \end{pmatrix} = entered, based\_on\_minimum\_reservoir\_storage$$

(13) Potential Gain/Loss, ac-ft

To derive the potential gain or loss, all the inputs to the reservoir were added and all the losses were subtracted. Inputs included Storable Inflow and Dutton Extension Available. Losses included Seepage Loss, Evaporation Loss, and Demand.

$$\begin{pmatrix} Potential \\ Gain/ \\ Loss \\ ac-ft \end{pmatrix} = \begin{pmatrix} Storable \\ Inflow \\ ac-ft \end{pmatrix} + \begin{pmatrix} Dutton \\ Extension \\ Available \\ ac-ft \end{pmatrix} - \begin{pmatrix} Seepage \\ Loss \\ ac-ft \end{pmatrix} - \begin{pmatrix} Evaporation \\ Loss \\ ac-ft \end{pmatrix} - \begin{pmatrix} Demand \\ ac-ft \end{pmatrix}$$

(14) End of Month Live Storage, ac-ft

The live storage in the reservoir was limited to the decreed capacity, 1420 ac-ft/yr or 635 ac-ft/yr for Stevens. The potential gain/loss was added to the beginning of month live storage to get the end of month live storage. If it exceeded the decreed capacity, the end of month live storage defaulted to the decreed capacity.

$$If \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1} + \begin{pmatrix} Potential \\ Gain/ \\ Loss \\ ac-ft \end{pmatrix}_n > 1420 ac-ft \_\_\_\_ then \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_n = 1420 ac-ft$$

$$otherwise \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_n = \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1} + \begin{pmatrix} Potential \\ Gain/ \\ Loss \\ ac-ft \end{pmatrix}_n$$

(15) Actual Gain/Loss, ac-ft

The actual gain/loss was found by subtracting the end of month live storage from the beginning of month live storage.

$$\begin{pmatrix} Actual \\ Gain/ \\ Loss \\ ac-ft \end{pmatrix}_n = \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_n - \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1}$$

(16) Net Spill/Deficit, ac-ft

The net spill/deficit was found by subtracting the actual gain/loss from the potential gain/loss. (p. 6-40)

$$\begin{pmatrix} Net \\ Spill/ \\ Deficit \\ ac-ft \end{pmatrix} = \begin{pmatrix} Potential \\ Gain/ \\ Loss \\ ac-ft \end{pmatrix} - \begin{pmatrix} Actual \\ Gain/ \\ Loss \\ ac-ft \end{pmatrix}$$

(17) Dutton Extension Remain, ac-ft

When spill conditions existed, it was assumed first Dutton Ditch water would not be taken and therefore made available downstream, limited to the amount of Dutton Ditch available. To get the amount remaining in the ditch, the available water was adjusted for the conveyance losses. (p. 6-48)

$$If \begin{pmatrix} Net \\ Spill/ \\ Deficit \\ ac-ft \end{pmatrix} > \begin{pmatrix} Dutton \\ Extension \\ Available \\ ac-ft \end{pmatrix} \_\_\_\_ then \begin{pmatrix} Dutton \\ Extension \\ Remain \\ ac-ft \end{pmatrix} = \begin{pmatrix} Dutton \\ Extension \\ Available \\ ac-ft \end{pmatrix} * \frac{1}{0.85}$$

$$otherwise$$

$$If \begin{pmatrix} Net \\ Spill/ \\ Deficit \\ ac-ft \end{pmatrix} > 0 \_\_\_\_ then \begin{pmatrix} Dutton \\ Extension \\ Remain \\ ac-ft \end{pmatrix} = \begin{pmatrix} Net \\ Spill/ \\ Deficit \\ ac-ft \end{pmatrix} * \frac{1}{0.85} \_\_\_\_ otherwise \begin{pmatrix} Dutton \\ Extension \\ Remain \\ ac-ft \end{pmatrix} = 0$$

(18) Natural Inflow Spill, ac-ft

If spill conditions still existed, natural flows would then be spilled, limited to the amount of storable inflow. (p. 6-48)

$$If \begin{pmatrix} Net \\ Spill/ \\ Deficit \\ ac-ft \end{pmatrix} - \begin{pmatrix} Dutton \\ Extension \\ Available \\ ac-ft \end{pmatrix} > \begin{pmatrix} Storable \\ Inflow \\ ac-ft \end{pmatrix} \_\_\_\_ then \begin{pmatrix} Natural \\ Inflow \\ Spill \\ ac-ft \end{pmatrix} = \begin{pmatrix} Storable \\ Inflow \\ ac-ft \end{pmatrix}$$

otherwise

$$If \begin{pmatrix} Net \\ Spill/ \\ Deficit \\ ac-ft \end{pmatrix} - \begin{pmatrix} Dutton \\ Extension \\ Available \\ ac-ft \end{pmatrix} > 0 \_\_\_\_ then \begin{pmatrix} Natural \\ Inflow \\ Spill \\ ac-ft \end{pmatrix} = \begin{pmatrix} Net \\ Spill/ \\ Deficit \\ ac-ft \end{pmatrix} - \begin{pmatrix} Dutton \\ Extension \\ Available \\ ac-ft \end{pmatrix} \_\_\_\_ otherwise \begin{pmatrix} Natural \\ Inflow \\ Spill \\ ac-ft \end{pmatrix} = 0$$

(19) Demand Deficit, ac-ft

If the reservoir empties, the actual gain/loss becomes a deficit and demand is not met. (p. 6-48)

$$If \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix} < 0 \_\_\_\_ then \begin{pmatrix} Demand \\ Deficit \\ ac-ft \end{pmatrix} = \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix} \_\_\_\_ otherwise \begin{pmatrix} Demand \\ Deficit \\ ac-ft \end{pmatrix} = 0$$

Hatcher/Martinez Reservoir Operations (Only the entries that are different from Hatcher Operations are included here.)
Decreed Capacity: 1729 + 760 ac-ft/yr = 2489 ac-ft/yr

(3) Perkins Ditch, ac-ft

No Perkins Ditch flow was taken, as the ditch would be under the waters of the proposed Martinez Reservoir.

$$\begin{pmatrix} Perkins \\ Ditch \\ ac-ft \end{pmatrix} = 0$$

(4') Martinez Natural Inflow, ac-ft

Natural inflow is inflow from streams into the reservoir and does not include flow from diversions. For purposes of this analysis, the Martinez inflow was estimated from Hatcher natural inflow using the drainage area method described in the CDM report. The drainage area for Martinez is 10.7 acres and for Hatcher is 3.5 acres.

$$\begin{pmatrix} Martinez \\ Natural \\ Inflow \\ ac-ft \end{pmatrix} = \frac{10.7 acres}{3.5 acres} * \begin{pmatrix} Hatcher \\ Natural \\ Inflow \\ ac-ft \end{pmatrix}$$

(5) Available Inflow, ac-ft

A minimum bypass requirement was determined based on the senior water rights located downstream of each reservoir. The average bypass requirement for Hatcher and Martinez was 38 ac-ft/month, as they are in the same drainage. (p. 6-33) The remainder of the inflow was available.

$$If \begin{pmatrix} Natural \\ Inflow \\ ac-ft \end{pmatrix} - 38 > 0 \_\_\_\_ then \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix} = \begin{pmatrix} Natural \\ Inflow \\ ac-ft \end{pmatrix} - 38 \_\_\_\_ otherwise \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix} = 0$$

(6) Storable Inflow, ac-ft

The volume of water that could be stored in a reservoir was limited to the decreed capacity, 2489 ac-ft/yr for Hatcher and Martinez together. If the cumulative inflow stored at the beginning of the month plus the available inflow exceeded the decreed amount, the exceedance was not included as storable inflow. Otherwise, the storable inflow equaled the available inflow.

$$If \begin{pmatrix} Cumulative \\ Inflow \\ Stored \\ ac-ft \end{pmatrix}_{n-1} + \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix}_n > 2489 ac-ft$$

$$then \begin{pmatrix} Storable \\ Inflow \\ ac-ft \end{pmatrix} = \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix}_n - \left[\begin{pmatrix} Cumulative \\ Inflow \\ Stored \\ ac-ft \end{pmatrix}_{n-1} + \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix}_n - 2489 ac-ft \right] \_\_\_\_ otherwise \begin{pmatrix} Storable \\ Inflow \\ ac-ft \end{pmatrix} = \begin{pmatrix} Available \\ Inflow \\ ac-ft \end{pmatrix}_n$$

(10), (10') Seepage Loss, ac-ft

An annual seepage rate for water in the reservoir of 2.5 % was selected. The monthly loss was estimated by multiplying the rate by the beginning of month live storage and dividing that by the number of months in a year. (p. 6-31) Since two reservoirs have been combined in this spreadsheet, the total live storage in any month was divided between the two in the same ratio as their capacities. Hatcher has a capacity of 1729 ac-ft/yr and Martinez has a capacity of 760 ac-ft/yr.

$$\begin{pmatrix} Hatcher \\ Seepage \\ Loss \\ ac-ft \end{pmatrix}_n = \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1} * \frac{025}{12} * \frac{1729}{2489} \qquad \begin{pmatrix} Martinez \\ Seepage \\ Loss \\ ac-ft \end{pmatrix}_n = \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1} * \frac{025}{12} * \frac{760}{2489}$$

(11), (11') Surface Area, ac

Surface area of the reservoir was needed to estimate evaporation losses. An area-capacity curve was developed for Stevens Reservoir (p. 6-35) and a best-fit equation was fitted to the data. Data was not available for Hatcher Reservoir, so the equation for Stevens was used. (p. 6-33) The equation was not supplied in the report, so points were taken from the curve and a best-fit equation found. An area-capacity curve was developed for Martinez Reservoir from a separate report and a best-fit equation was fitted to the data.

The surface area used for evaporation losses was based on beginning of month live storage. Since two reservoirs have been combined in this spreadsheet, the total live storage in any month was divided between the two in the same ratio as their capacities. Hatcher has a capacity of 1729 ac-ft/yr and Martinez has a capacity of 760 ac-ft/yr.

$$\begin{pmatrix} Hatcher \\ Surface \\ Area \\ ac \end{pmatrix}_n = \left(5.8340959 + 0.18175979 * \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1} - 0.00010785922 * \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1}^2 + 2.935741E-08 * \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1}^3 \right) * \frac{1729}{2489}$$

$$\begin{pmatrix} Martinez \\ Surface \\ Area \\ ac \end{pmatrix}_n = \left(\frac{0.41499129 * (-2.1517762E+10) - (1.8559701E+10) * \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1}^{0.59581452}}{-(2.1517762E+10) + \begin{pmatrix} EndMonth \\ Live \\ Storage \\ ac-ft \end{pmatrix}_{n-1}^{0.59581452}} \right) * \frac{760}{2489}$$

(13) Demand, ac-ft

Demand changed based on the different reservoir conditions considered, but was a constant for a specific scenario. Reservoirs were allowed to fill with water only to their decreed capacity, but no reservoir was allowed to drop below 150 ac-ft. Since two reservoirs were combined in this spreadsheet, the total minimum capacity was taken as 300 ac-ft. In each case considered, the demand, or the amount of water the District could expect to use, was adjusted under the specific scenario such that in the reservoir operations, the live storage never dropped below 300 ac-ft. The demand, then, became the maximum yield expected under the specific scenario.