DOLORES PROJECT DROUGHT CONTINGENCY PLAN

A plan to reduce the impacts of drought for users of the Dolores Project by implementing mitigation and response actions to decreases theses impacts

DOLORES WATER CONSERVANCY DISTRICT

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2. ADS, Inc. Drainage Handbook, “Figure 3-1 Discharge Rates for ADS Corrugated Pipe with Smooth Interior Liner.” July 2014.
3. High Desert Conservation District/NRCS, “Full Service Area Center Pivot Assessments – 2016 Irrigation Season.” 2016.

ABBREVIATIONS AND DEFINITIONS

1998 Report – 1998 Reconnaissance Report
AF – acre-feet
CCL&W – Consolidated Land and Water Company
CCU – Crop Consumptive Use
CDOT – Colorado Department of Transportation
CEDS – Economic Development Strategy
cfs – cubic feet per second
CRBFC – Colorado Basin River Forecast Center
CRSP – Colorado River Storage Project Act of 1956
CWCB – Colorado Water Conservation Board
DCC – Dove Creek Canal
DPR – Definite Plan Report
DWCD – Dolores Water Conversancy District
DWR – Division of Water Resources
EDS – Energy Dissipating Structure
ENR – Engineering News Record
ENSO – El Niño/Southern Oscillation
EQIP – Environmental Quality Incentives Program
FEIS – Final Environmental Impact Statement
FRE – Ute Mountain Ute Tribe's Farm and Ranch Enterprise
FSA – Full Service Allocation Irrigators
HDCD – High Desert Conservation District
HDPE – High-density polyethylene
lbs – pounds
M&I – Municipal and industrial
McPhee – McPhee Reservoir
MVIC – Montezuma Valley Irrigation Company
MVID – Montezuma Valley Irrigation District
NASA – National Aeronautics and Space Administration
NIDIS – National Integrated Drought Information System
NOAA – National Oceanic and Atmospheric Administration
NRCS – Natural Resources Conservation Services
OM&R – Operation, Maintenance, and Replacement
Plan – Dolores Project Drought Contingency Plan or Drought Contingency Plan
Plateau – Upper Plateau Creek Reservoir
Project – Dolores Project
Reclamation – United States Bureau of Reclamation
SCADA – Supervisory control and data acquisition
SPI – Standard Precipitation Index
SNOTEL – Snow Telemetry
SWCD – Southwestern Water Conservation District
SWE – Snow water equivalent
THC – Towaoc/Highline Canal
USGS – Untied States Geological Survey
Western – Western Area Power Administration
WMCP – Water Management and Conservation Plan
WY – Water Year

EXECUTIVE SUMMARY

The Dolores Project (Project) is a Bureau of Reclamation (Reclamation) multi-purpose project in southwest Colorado in Montezuma and Dolores Counties. The Project is operated by the Dolores Water Conservancy District (DWCD). The primary facility is the 381,000 acre-foot (AF) McPhee Dam and Reservoir (McPhee), with 229,000 AF of active capacity, located on the Dolores River just downstream from the Town of Dolores, which was completed in 1986. Delivery canals and irrigation laterals were completed in 1999 when all Project waters users could receive their full allocations of water. In 1993, the DWCD and Reclamation initiated the process for transferring responsibility for the operation, maintenance and replacement (OM&R) of Project facilities, which was completed by 1998; DWCD provides OM&R for the Project.

The Dolores River, originating northeast of the District area in the San Juan and La Plata Mountains, is the main source of water for the Project and storage in McPhee. Flows in the river vary considerably within and between years. Peak flows result from spring snowmelt in the headwaters of the San Juan Mountains, usually occurring in May and averaging 2,000 cubic feet per second (cfs), but reaching 5,000 cfs in some years. The volume of spring runoff is similarly variable, ranging from about 60,000 to over 500,000 AF per year. Tributaries to the Dolores River also collected in McPhee include Lost Canyon Creek, West Dolores River, Beaver Creek, House Creek and Plateau Creek.

McPhee's active pool of approximately 229,000 AF has been fully allocated to specific water users through contracts with Reclamation to:

1) individual farmers with approximately 28,900 allocated acres of full service irrigation land northwest of McPhee delivered by the Dove Creek Canal;
2) 7,700 acres on the Ute Mountain Ute Reservation operated by the Ute Mountain Ute Tribe Farm and Ranch Enterprise (FRE) delivered through the Towaoc-Highline Canal;
3) Montezuma Valley Irrigation Company (MVIC) which receives a supplemental irrigation supply from the Project to supplement their historic Colorado water rights;
4) City of Cortez, the Town of Dove Creek, and the Tribal community of Towaoc that receive M&I water; and
5) Water to release from McPhee for downstream fish and wildlife purposes.

During drought conditions, all allocations except M&I water share *pro rata* in the shortage. Any water remaining in the Reservoir at the end of a water year on October 31st is carried over to the next year for re-allocation to all users; no users can carryover water from one year to the next.

DWCD prepared this Dolores Project Drought Contingency Plan (Plan) to evaluate potential mitigation and response actions to reduce the water shortages and provide greater drought resiliency for the Project water users primarily the irrigators and fishery downstream of the Project. A Planning Task Force was formed; consisting of DWCD, MVIC, FRE, and Reclamation representatives. They met regularly to discuss and develop actions while providing oversight of data analysis, reviewing work productions, and participated in public outreach efforts. The Plan serves as a source of information about the Project including the six required elements of a drought contingency plan.

The current drought monitoring process by DWCD and Reclamation utilize the runoff projections made by NOAA's Colorado Basin River Forecast Center (CBRFC), and other agencies was described. DWCD monitors data using an inflow/outflow spreadsheet which tabulates Project water supply and usage daily. Low elevation snowpack, between about 7,500 and 9,00 feet, is manually monitored to be used in conjunction with daily NRCS SNOTEL data for higher elevation sites. Drought monitoring by other agencies is also utilized. The CBRFC provides information on weather, climate, streamflow data, and water supply forecasts. The Colorado River Basin is unique in that nearly 80% of the runoff in the Basin comes from snowmelt. Forecasting this snowmelt and subsequent runoff is an ever-moving target thus CBRFC issues seasonal forecasts for water supply and snowmelt peak flows at monthly and bi-monthly during the runoff period.

The Project water users have experienced three major shortages since 2000 in the years 2002, 2003, and 2013. In the years 2002 and 2013 the Project water users received approximately a 25% to 30% supply and in 2003 a 50% supply of water. A water supply shortage may be caused by hydrology (i.e. the drought of 2002) or operational obligations (i.e. a user's legally allowed water supply). The vulnerability assessment qualitatively and to the extent possible, quantitatively evaluates the impact of the shortages on each of the Project water users.

The FRE is vulnerable to actual hydrologic shortages and projected shortages whether there is an actual shortage or not; this vulnerability is partially due to the summer planting plans and available April 1st runoff projections. The Full Service Area (FSA) irrigators are vulnerable to hydrologic drought. Unlike FRE, irrigated lands are located at higher elevations allowing for utilization of May 1st runoff projections (in general, runoff projections become more accurate as time goes by). Therefore, FSA irrigators are vulnerable to actual droughts and less dependent upon projections. MVIC has very senior direct flow water rights, allowing users to be less vulnerable to hydrologic droughts unless conditions are extreme. MVIC is vulnerable in runoff years when McPhee spills because its water stored in McPhee in April, May and June also spills. The native fish downstream of McPhee are most vulnerable to long term, year after year, shortages and less so to one year shortages. During drought years, there are obviously no spills and no boating because stored non-excess water is dedicated to Project users to provide for contractual allocation and carry-over storage. The boaters are vulnerable to below average runoff which occurs in approximately half of the years based on historic hydrology.

Numerous potential mitigation and response actions were identified and evaluated. A mitigation action aims to mitigate the risks posed by drought and build long-term resiliency. Mitigation actions proposed are categorized by structural and non-structural actions a implemented prior to a drought. A response action is a non-structural response to be implemented during a drought year; actions are triggered during stages of drought to better manage the limited supply and decrease severity of immediate drought related impacts.

Throughout the Plan's development, the Planning Task Force discussed and evaluated these potential mitigation actions. Three actions, or categories of actions, clearly rose to the top as priorities for members of the task force: on-farm efficiency improvements, system wide efficiency improvements, and joint operations of facilities.

The need for efficiency improvements both on-farm and system wide exist. On-farm efficiency improvements could be utilized by all Project irrigators. Many opportunities exist for infrastructure upgrades to improve water delivery, water management, and provide irrigators with pressurized water existing in within the MVIC system. System wide improvements lead to more on-farm improvement opportunities. For the FSA irrigators, the biggest potential exists for on-farm efficiency improvements. DWCD is partnering with High Desert Conservation District (HDCD) in an effort to investigate and improve eligibility requirements for FSA irrigators. For all irrigations, implementation needs financial backings. Signification opportunities exist if funding becomes available.

The need for joint operations of facilities exists. Examples of coordination of Project users may be to better manage releases down a specific canal to eliminate waste, moving stored water from one reservoir to another for Project wide benefits, or joint communications and messaging to the general public.

Non-structural response actions were identified to be implemented during a drought year. The response actions are triggered during stages of drought to better manage the limited supply and decrease severity of immediate drought related impacts. While some actions are, applicable no matter the severity or type of drought, others are only applicable during one type of drought. Response actions include:

- An active communication structure among all Project users during a drought to provided information surrounding the timing and volume of available water. Monitoring of water supply projections would be increased to better inform forecasts used by Project users.
- Leasing of available water from one Project user to another when specific types of shortages are experienced.
- Re-operations of reservoirs during specific types of shortages.

DWCD shall take the lead in monitoring drought conditions and notifying Project users of the severity of potential shortages. Project users are responsible for implementing actions specific to their structural and non-structural water management needs. Procedures needed to implement actions may vary by action or by Project user responsible for implementation. When an action involves policy agreement between multiple parties, staff will facilitate coordination to seek common alignments among the parties.

The Plan should not be considered the last word on the present and future mitigation and response actions for the Dolores Project and its users. The Plan will be reviewed and updated periodically to assure that it is responding effectively to current hydrologic conditions and the changing needs of the many groups and communities that benefit from the Dolores Project.

DISTRICT BOARD RESOLUTION TO ADOPT PLAN

To be included later once Plan has been reviewed by Boards and interested parties

ACKNOWLEDGEMENTS

The Dolores Water Conservancy District Board of Directors thanks all who participated in the 2017 Dolores Project Drought Contingency Plan development process. This Plan was funded by the United States Bureau of Reclamation, Dolores Water Conservancy District, Montezuma Valley Irrigation Company and the Ute Mountain Ute Tribe's Farm and Ranch Enterprise. Along with the funding partners and their staff, the Plan was prepared with cooperation of the Colorado Division of Water Resources, Dolores Water Conservancy District Full Service Area Irrigators, Montezuma Valley Irrigation Company shareholders, and other interested stakeholders. Harris Water Engineering, Inc. would like to especially thank the members of the Planning Task Force for their regular participation in meetings, cooperation, patience and assistance in preparation of the Plan.

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The Dolores Water Conservancy District welcomes any comments that may improve the utility of this Plan. Please forward comments to the follow address:

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1 Introduction

1.1 Purpose of the Drought Contingency Plan

The Dolores Project (Project) experienced severe shortages in 2013 (40% supply) and as of May first in 2014 and 2015 were projecting shortage conditions until unusual late spring rains provided sufficient water to achieve a full supply. The three funding entities of the Drought Contingency Plan (Plan) are the Dolores Water Conservancy District (DWCD), the Montezuma Valley Irrigation Company (MVIC) and the Ute Mountain Ute Tribe's Farm and Ranch Enterprise (FRE). These entities represent the Project contracted water users that are most vulnerable to shortages due to drought. The Plan allowed a comprehensive formal evaluation of mitigation and response actions to reduce the water shortages and provide greater drought resiliency for the Project irrigators and the fishery downstream of the McPhee Reservoir (McPhee).

1.2 Planning Area

See Figure 1 showing the Project area and facilities. The Project is in the Dolores River and San Juan River basins. The Project service area is in Montezuma and Dolores counties. The Project provides water to the Dove Creek Canal (DCC) which travels northwest from McPhee; lands are served adjacent to the canal and southwest of the DCC. The Project provides water by way of the Great Cute Dike and Dolores Tunnel to Montezuma Valley. The Project also provides water by way of the Towaoc Highline Canal (THC) serving lands along the way from south of Cortez to Towaoc and the FRE. The Project provides water to approximately 73,900 acres of irrigated land.

The Dolores River, originating northeast of the Project, in the San Juan and La Plata Mountains, is the main source of water for the Project and storage in McPhee. The Dolores River and tributaries feeding McPhee have an average annual runoff of about 351,000 acre-feet (as listed in the Definite Plan Report (DPR)). Tributaries to the Dolores River that also flow into McPhee include Lost Canyon Creek, West Dolores River, Beaver Creek, House Creek and Plateau Creek. The Project, including McPhee, was authorized in order to store water for supplemental and full service irrigation and municipal and industrial (M&I) use, as well as reservoir recreation and fish and wildlife enhancement.

McPhee is located in the center of the Project's service area, midway between the northern and southern boundaries and sits at the southern edge of the San Juan Mountains at an elevation of approximately 6,924 feet at full. McPhee has a maximum surface area of 4,470 acres, with a storage capacity of 381,000 acre-feet (AF) and an active capacity of 229,000 AF. The Great Cut Dike, 64 feet high and 1,900 feet long, and McPhee Dam, 270 feet high and 1,370 feet long, store the waters of the Dolores River to create McPhee.

McPhee's active pool of approximately 229,000 AF has been fully allocated to specific water users through contracts with United States Bureau of Reclamation (Reclamation) to:

1) Individual farmers with approximately 28,900 allocated acres of full service irrigation land northwest of McPhee delivered by the DCC;
2) 7,500 acres on the Ute Mountain Ute Reservation operated by the FRE delivered through the THC;

3) MVIC which receives an irrigation supply from the Project to supplement their historic Colorado water rights;
4) City of Cortez, the Town of Dove Creek, and the Tribal community of Towaoc that receive M&I water; and
5) Water to release from McPhee for downstream fish and wildlife purposes.

During drought conditions, all Project allocations except M&I water share *pro rata* in the shortage. No user can carryover water from one water year to the next.

1.2.1 Geography

The Dolores River Basin watershed encompasses approximately 4,620 square miles in southwestern Colorado and southeastern Utah. Its headwaters in the San Juan Mountains include peaks exceeding 14,000 feet in elevation, while the elevation at McPhee Dam is 6,924 feet and at the River's confluence with the Colorado River in Utah is 4,400 feet. The Lower Dolores River generally flows from south to north in a deep canyon, interrupted only where the River crosses the Gypsum and Paradox Valleys. The River courses through a range of plant communities, from alpine grasslands to montane forest areas to semiarid shrub lands.

The area draining into McPhee is approximately 800 square miles. It includes almost no urban development, including only the towns of Rico and Dolores, with populations of about 260 and 940, respectively. The San Miguel River, which joins the Dolores River at an elevation of about 5,535 feet, is the only significant tributary to the Dolores River downstream of McPhee Dam. At the confluence, the watershed area of the Dolores River has grown to approximately 1,341 square miles, yet water yield increases only slightly below McPhee because most of the Lower Dolores River tributaries have only intermittent or ephemeral flow.

Most of the lands within the Dolores River watershed are owned by Bureau of Land Management or the U.S. Forest Service, meaning that most of the land use has low intensity development, such as timber harvesting or grazing. Rico was a historically important mining district and private ranches are present along the Upper Dolores River corridor and its major tributaries. Private lands within the Lower Dolores River corridor are limited to sites where settlers in Slick Rock, Disappointment Valley, and Paradox Valley could gain access to the River. Development in the River and tributary corridors is limited to ranching and small commercial developments because the valleys are all quite narrow.

1.2.2 Hydrology

Flows in the Dolores River, both naturally and as regulated by McPhee Dam, vary considerably within and between years. The yield at McPhee has varied from 80,000 AF to over 600,000 AF annually over the past 50 years. Peak flows result from spring snowmelt in the headwaters of the San Juan Mountains, usually occurring in May and averaging 2,000 cfs, but reaching 5,000 cfs in some years at the Town of Dolores (*See* Figure 2, 1897 through 2016 for past hydrology). The volume of inflows during the runoff months (April, May, June) is similarly variable, ranging from about 60,000 to over 500,000 AF per year in the past 50 years. Even with McPhee capturing and regulating spring flows, McPhee spring spills are still highly variable. High intensity thunderstorms cause localized peak flows intermittently during July, August, September and October.

1.2.3 Precipitation

The Dolores River Basin above McPhee is largely forested and produces most of its runoff from snowmelt. The Lower Dolores River basin is largely semi-arid, characterized by low precipitation and humidity, abundant sunshine, a fairly large daily temperature range, and moderate westerly winds. Because of topographic changes, the local climate exhibits large variations within short distances, with increases in precipitation and decreases in temperature generally found from southwest to northeast. Average annual precipitation in the area above McPhee averages 30 inches while the entire Dolores River watershed's annual average precipitation is 20 inches.

The DWCD operation office is located at Great Cut on the west edge of McPhee where a weather station is maintained. The precipitation data from that weather station is shown on Figure 3; summarized by water year is the annual precipitation from 1986 through 2016. Since 2000, there is only five years of the 16 years where precipitation was above average.

The combined inches of water for the four highest SNOTEL gages on May 1st in the Dolores River basin are shown on Figure 4. It is generally accepted that the May first average SWE between these sites suitably indicates the amount of runoff that will occur. As in the other graphs, it can be seen that on average since 2000, a lesser the low amount of accumulates annually with four years with no snow left on May first. This is well below the longer-term average.

Figure 1. Location Map

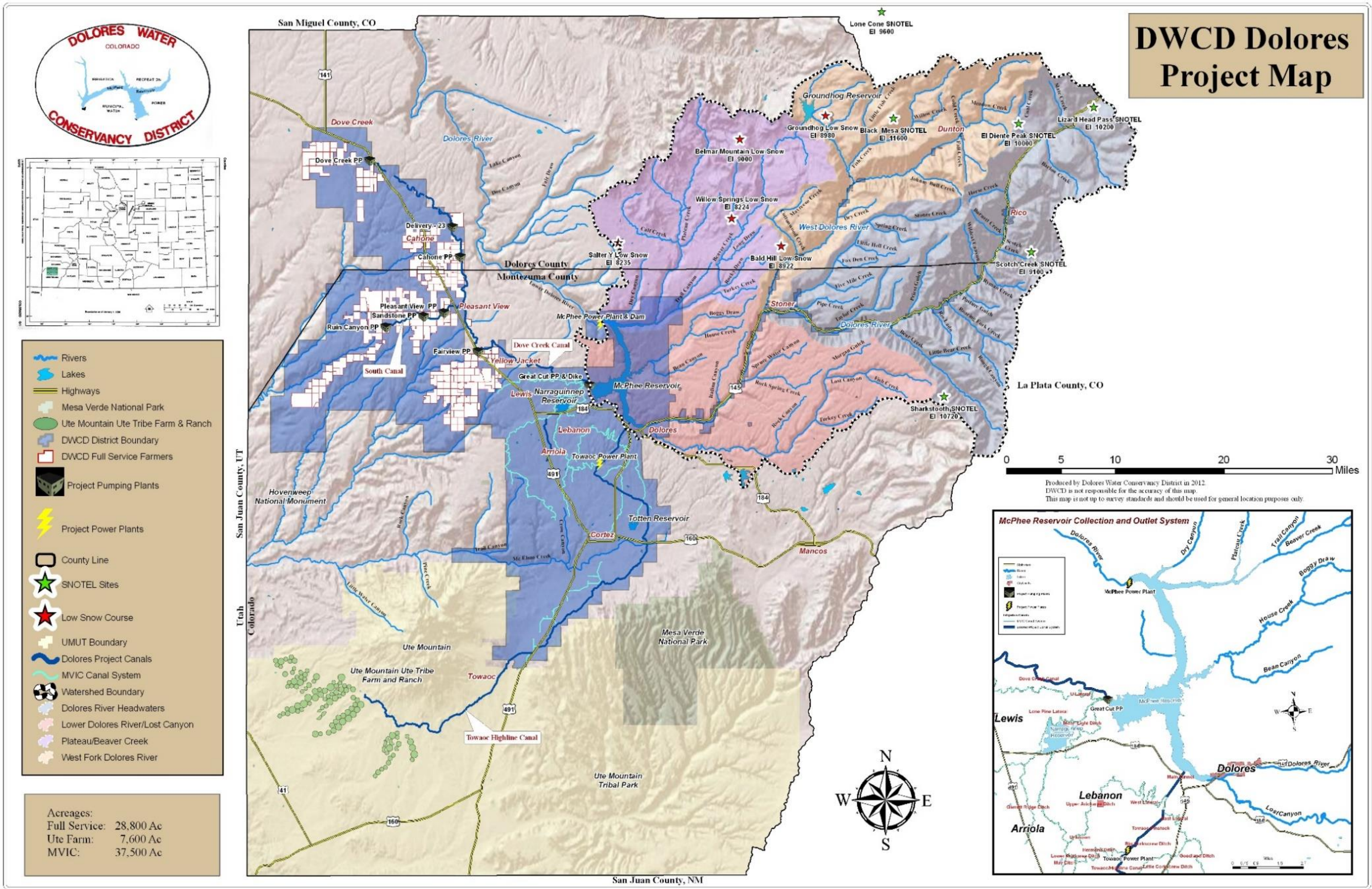


Figure 2. Yearly Streamflow of the Dolores River at the Town of Dolores (1896-2016)

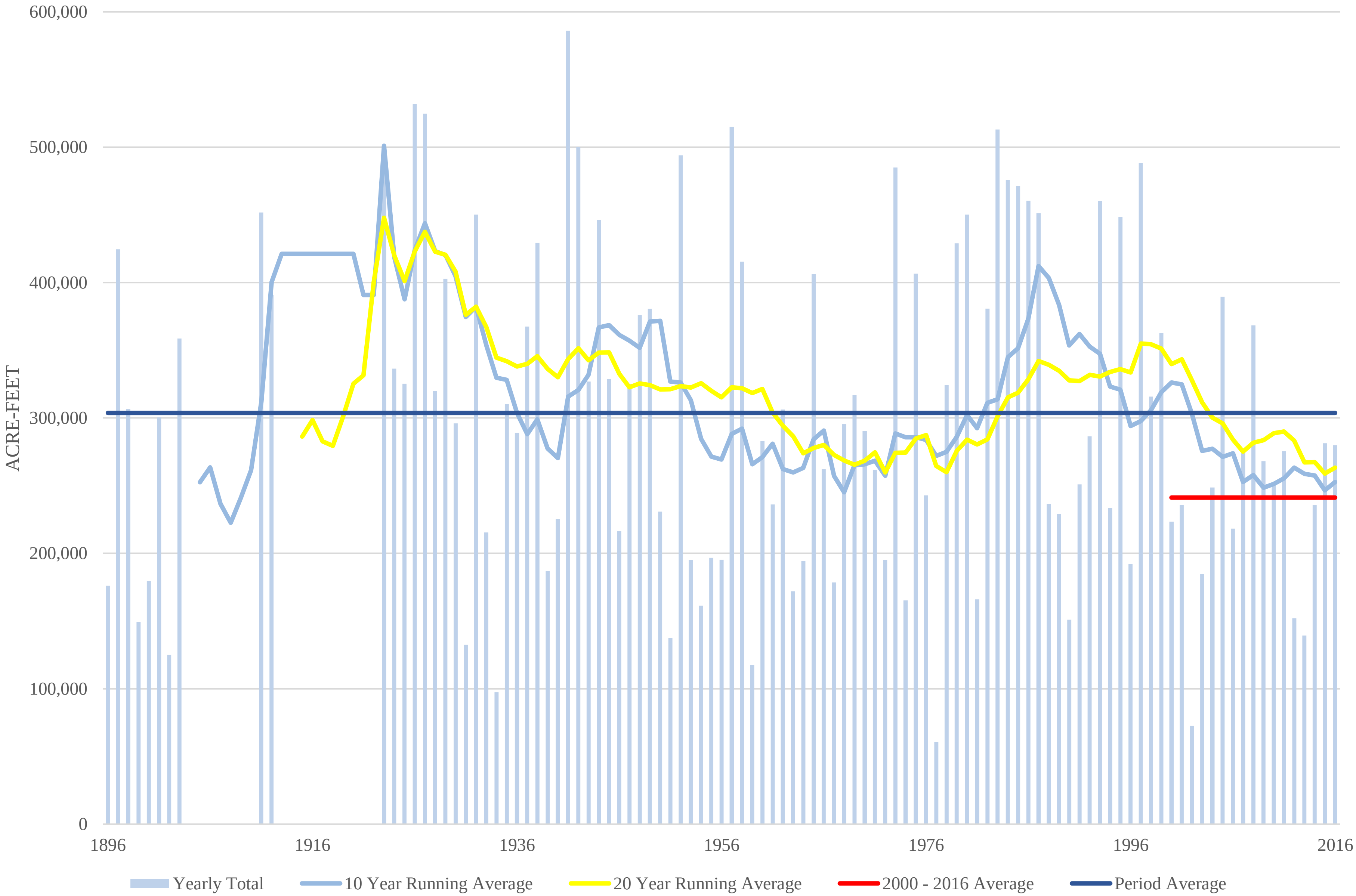


Figure 3. Precipitation at Great Cut

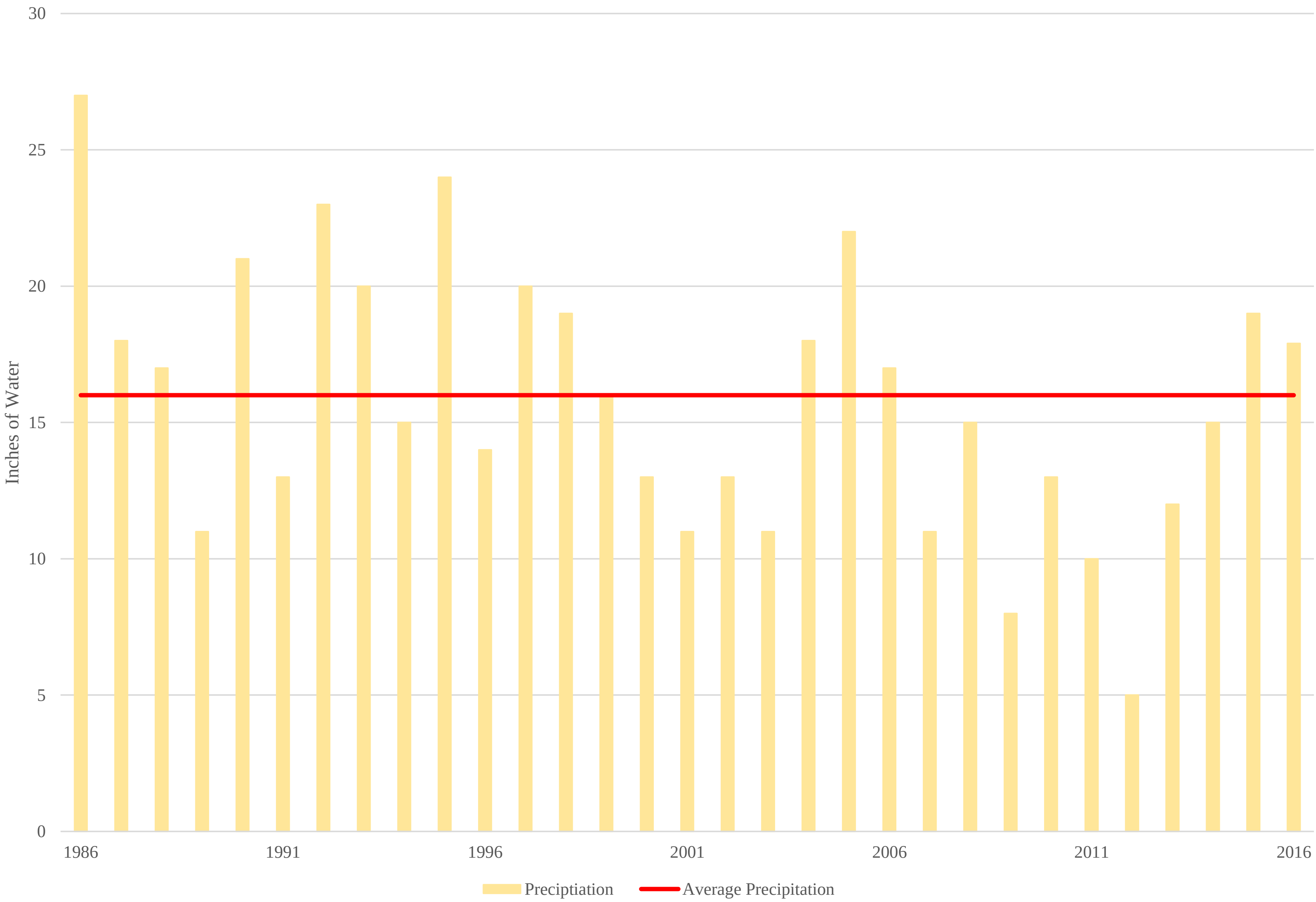
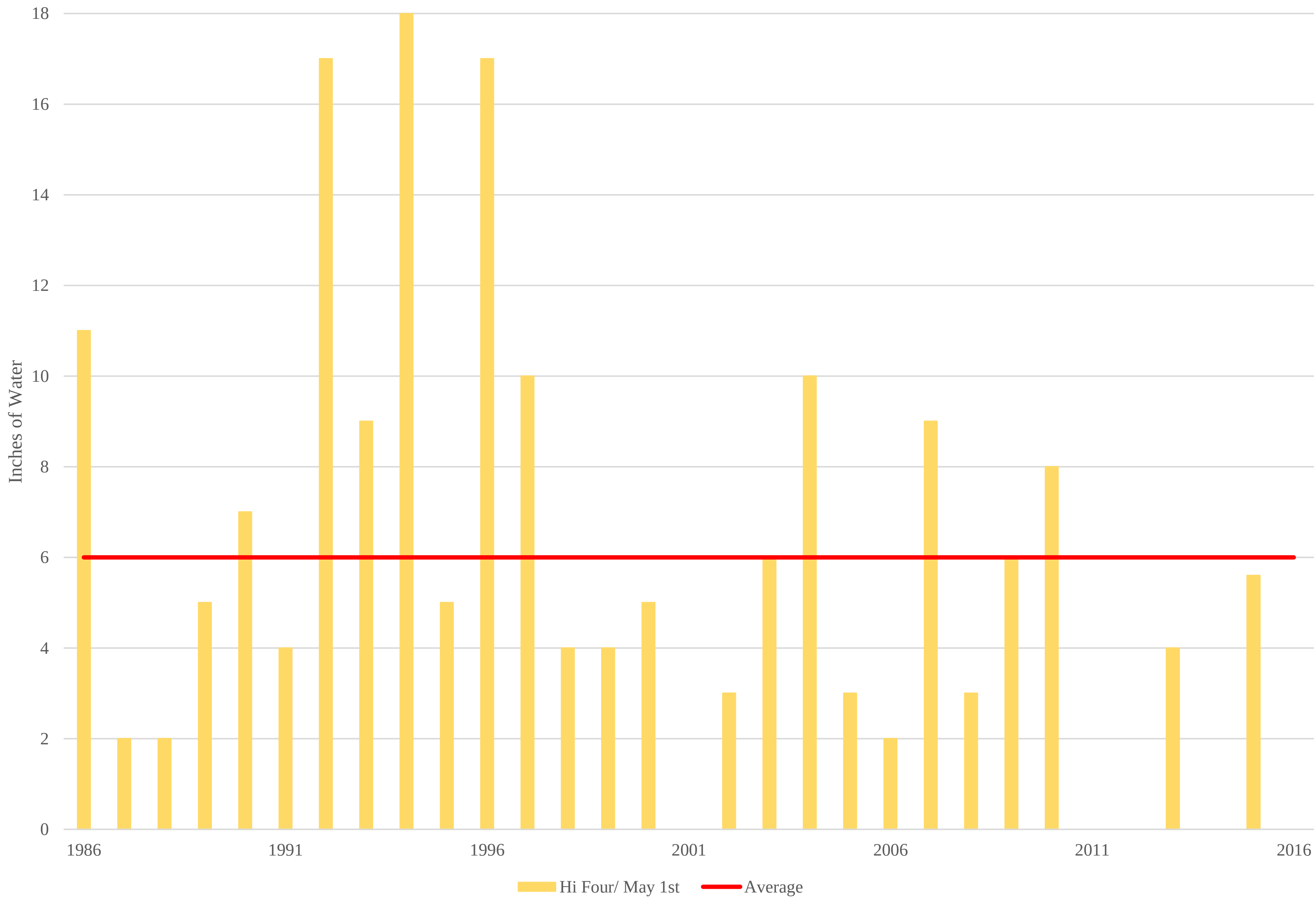


Figure 4. HI Four Snow Pack on May 1st



1.3 History of Dolores Project

On expedition to find a route from New Mexico to California in August of 1776, the Spanish Fathers Dominguez and Escalante camped near what is now McPhee. Found in their journals is a conception of what became the Project over two centuries later:

> *[T]here is everything that a good settlement needs for its establishment and maintenance as regards irrigable lands [and] pasturage…if the water supply could be brought to the vast expanse of land to south and west it would sustain a civilization.*

1.3.1 Irrigation of the Montezuma Valley

The first permanent settlers arrived in the Dolores Valley in about 1877 to ranch and farm, capitalizing on the needs of the miners in Rico. Even though the Valley was isolated from the rest of Colorado, including the nearby city of Durango, there was a lucrative market for vegetables, meat, and hay. Although early ranchers and farmers settled in the Dolores River Valley close to the available water, the Valley's limited land area constrained the amount and vitality of agriculture in Montezuma and Dolores Counties. Most of the arable land in the area lies outside of the Dolores River Valley in the Montezuma Valley, part of the San Juan River basin.

This condition, and the desire to sell land to settlers, led to projects to divert Dolores River water outside of the Dolores River basin and into Montezuma Valley. An ambitious irrigation project was proposed as early as 1878, but low settlement numbers, restricted transportation, and limited financial resources inhibited support for the project. Cortez, established in the neighboring, drier Montezuma Valley in 1886, needed a dependable water supply. In February 1886, the Montezuma Valley Water Supply Company commenced work on a canal and a tunnel through, the narrow ridge that separates the Dolores River from Montezuma Valley. The tunnel allowed much needed domestic and irrigation water to reach Cortez and the Montezuma Valley. Completed in November 1889, it was dubbed "one of the greatest irrigation enterprises, not only in the state, but in the West," by *The Durango Herald*.

As this 5,400-foot tunnel was nearing completion, another diversion, 4,000 feet long by 40 feet deep, the "Great Cut," was being constructed to serve the same market through a low divide northwest of the tunnel. The Dolores Number Two Land and Canal Company started constructing a six-mile canal, the Morton Flume and Great Cut, in April 1887, to serve lands west and north of those served by the tunnel. Together the two diversions were purported to have a combined 1,300 cfs capacity. When both companies faced bankruptcy, they consolidated into the Colorado Consolidated Land and Water Company ("CCL&W") in 1889. By 1890, when diversion dams channeled the flow of water from the Dolores River into the tunnel and Great Cut, over 100 miles of canals had been built throughout the Montezuma Valley to distribute water, and an early Narraguinnep Reservoir of approximately 6,000 AF had been partially constructed. Water reached the Town of Cortez in July of 1890 via a three-mile long Cortez Flume. By 1892, the CCL&W had obtained a surface water rights decree for 1,300 cfs. The CCL&W planned to serve Cortez, predicted to grow to 50,000 people, and to irrigate much of the Montezuma Valley.

Years of financial difficulty led to changing company ownership, looming bankruptcy, and farmers facing water shortages. Efforts to provide the farmers with storage capacity and a reliable water supply spurred the formation of the Montezuma Valley Irrigation District (MVID), which developed an irrigation system under the Irrigation District Law of 1901, allowing it to levy taxes, issue bonds, and purchase, construct, and maintain canals. The first meeting of MVID's Board of Directors was held on January 7, 1902, but MVID did not buy the water company from the company's debt holders until April 30, 1907. MVID floated a bond for $795,000 to buy the water rights and rebuild the irrigation system, including an enlargement of Narraguinnep Reservoir to 9,000 AF and a new, small Groundhog Reservoir (Groundhog) which was later breached by MVID in 1920. The High Line Canal, also known as the Mesa Verde Lateral, was leased to the U.S. Government to supply water to the Ute Mountain Ute Tribe. When MVID later failed, in 1920, the MVIC was incorporated to operate the irrigation system.

In 1938, MVIC initiated plans to replace the breached Groundhog, with funding from the Works Progress Administration, to construct 21,700 AF of storage. During the 1950's and 1960's, MVIC again enlarged Narraguinnep, increasing its capacity to 19,000 AF. Other system improvements included repairing or replacing flumes, canals and delivery turnouts and construction of the 3,000 AF Totten Reservoir in 1965. These improvements still did not provide MVIC's irrigators with a late season supply.

MVIC's diversion of water for trans-basin use during the irrigation season left the Dolores River nearly dry immediately downstream of MVIC's points of diversion once spring runoff subsided. Dolores River flows started dropping in June and, by July, were less than MVIC's demand. Providing a reliable supply of water for late-season irrigation and year-round M&I use would require a larger storage reservoir.

1.3.1 Trans-Basin Diversions and Montezuma Valley

In Colorado, the administration of trans-basin diversions is different from that for in-basin diversions. For in-basin diversions, any water diverted from a stream "belongs" to that stream except to the extent that it is lawfully appropriated: a diverter takes water from the river, makes the decreed beneficial use, and returns any excess to the river of origin. Any water diverted, but not consumed by beneficial use, is owed back to the river. These return flows may seep slowly through the ground or run back to the river, but will be available for other appropriators (i.e., one person's return flow is another's supply).

Water imported into a different basin, such as MVIC's trans-basin diversions from the Dolores River to the Montezuma Valley, does not belong to the receiving basin. The importer of water, diverted from the stream of origin in priority pursuant to decree terms, has the right to use and re-use to extinction the imported water, regardless of priorities in the receiving stream, as long as the importer maintains dominion and control over the imported water. Once the importer loses control of the imported water, the excess imported water becomes part of the receiving stream, subject to appropriation in priority in that stream. Although water rights can be obtained for return flows of imported water when available, such appropriations have no right to the continued importation or to the water use practices that initially made that water available.

MVIC and DWCD's importation of water to the Montezuma Valley is intertwined with the use of MVIC return flows by farmers on McElmo Creek and its tributaries. Farmers along McElmo Creek and its tributaries early on anticipated making use of return flows of imported Dolores River water. The first McElmo water rights filings were made in 1888, within a few years after construction of the tunnel and Great Cut began. Today, some farmers have adjudicated water rights dependent on those return flows. Further, some landowners within the MVIC service area hold both shares in MVIC and separate individual water rights.

1.3.2 Formation of the Dolores Water Conservancy District

Realizing the need for a reliable late growing-season water supply, a volunteer economic development committee, "Cortez Bootstraps," was formed in the late 1950's to promote a large reservoir project on the Dolores River. Reclamation had been investigating the Dolores River/McPhee site for a large water storage facility and the Project was authorized by the Colorado River Storage Project Act of 1956 ("CRSP"). When Representative Wayne Aspinall, Chairman of the House Interior Committee, visited the area he suggested that Cortez Bootstraps form a water conservancy district under Colorado law to be entitled to obtain Federal funding for the Project.

On November 20, 1961, the DWCD was created by decree of the Colorado District Court, Montezuma County, to support, organize, and manage the nascent Project, and to contract with the Reclamation as a public entity under the Colorado Water Conservancy District Act. With the DWCD's support and a finding of Project feasibility by the Reclamation, the Project's DPR and Final Environmental Impact Statement (FEIS) were completed in 1977. On February 8, 1977, registered voters within the DWCD approved, 3,926 votes in favor to 329 votes opposed, the DWCD's Project repayment contract with the United States, to be supported by an ad valorem tax (1977 Repayment Contract). The repayment contract governs the terms for repaying the Federal government for reimbursable Project costs, DWCD's operation, maintenance and replacement ("OM&R") obligations, and various Project water allotments. Project construction began in the spring of 1978. When President Carter created a reclamation project "hit list," construction was suspended on all Reclamation projects in the western United States. In part because of the Project's role in resolving the Ute Mountain Ute Tribe's reserved water rights claim in the Mancos River, the Project was the first Reclamation project to be removed from that list and construction proceeded in 1979.

1.3.3 A Cooperative Venture with MVIC

MVIC, incorporated as a mutual ditch company, owns some of the earliest water rights on the Dolores River. The Southwestern Water Conservation District (SWCD) applied for the original water rights for the Project in 1947. Because MVIC's water rights were senior, the Project could not have been constructed without MVIC's participation. Complex and lengthy negotiations were held to determine how MVIC would participate in the Project in a way that provided MVIC irrigators with a late-season irrigation supply while MVIC retained control of its irrigation water delivery system and ownership of its senior water rights. Those negotiations culminated in a 1977 contract between DWCD and MVIC under which MVIC retained most of its senior water rights while obtaining an allocation of supplemental irrigation water from the Project (1977 DWCD/MVIC Contract).

Full Service (or Non-MVIC) irrigators would receive their full water supply from the Project, pursuant to individual petitions (contracts) with DWCD. Certain limitations on MVIC's use of its Non-Project water rights were required to ensure that the assumptions upon which the Project's yield was calculated in the DPR would remain valid and to prevent injury from expanded use of water rights senior to those of the Project. Additional issues addressed in the 1977 DWCD/MVIC Contract and in the DWCD/Reclamation 1977 Repayment Contract included how water would be delivered to MVIC using Project facilities, how much Project water would be delivered to MVIC each year consistent with MVIC's direct flow rights, how MVIC's Project repayment and OM&R payment obligations would be determined, and how much of MVIC's Non-Project Water MVIC could be used for other than irrigation purposes (i.e., 3,000 AF annually for stock and domestic purposes).

1.3.4 Colorado Ute Indian Water Rights Settlement Act

The Colorado Ute Indian Water Rights Settlement Act passed by Congress in 1988 (Settlement) was primarily based on utilizing water allocations in the Project to offset the Tribe's Winters Doctrine claims in the Mancos River basin. The Project helped to achieve one of the earliest Indian reserved water rights settlements, which helped to preserve the status quo for non-Indian water users on the Mancos River in eastern Montezuma County. The reserved rights settlement provided, for the first time, a safe domestic water supply to Towaoc, the Tribe's principal town, late in the 20th century. A total of 1,000 AF is allocated for M&I purposes for the Ute Mountain Ute Tribe. Water is treated by the City of Cortez and then a long pipeline conveys water to the Tribe town of Towaoc. Delivery of a safe drinking water supply substantially improved life on the Tribe's Reservation and eliminated the need for the hauling of water for over 1,500 people.

The FRE was allocated approximately 23,300 AF (DPR average annual 22,900 AF, with shortages). The FRE operates a 7,500 acre irrigated farm using 108 center pivot sprinklers on the west side of the Tribe's reservation. FRE is a major enterprise of the Tribe employing many Tribal members and providing income to the Tribe. As a part of the Settlement, the Federal Government through Reclamation paid for a gravity pressurized irrigation delivery system to sprinkler irrigate the 7,500 acres with maximum efficiency. This system is similar in efficiency to the irrigators along the Dove Creek Canal except the non-Indian full service irrigators have their water pumped.

1.3.5 Construction of the Dolores Project

McPhee Dam was completed by 1986 and Project water was made available to Cortez and MVIC that year. The first Project full service irrigators received Project water in June 1987, but the majority of the Project was not fully on line until the mid-1990s, with completion of facilities to serve the Ute Mountain Ute Tribe's lands. By 1999, all the Project facilities that would ultimately be built were completed. Project construction thus covered a span of 20 years, from September 20, 1979, through October 10, 1999. DWCD crews started in 1985 on preliminary DWCD operations. In 1993, the DWCD and Reclamation initiated the process for transferring responsibility for the OM&R of Project facilities to DWCD, which was completed by 1998.

The cost of the Project, including interest during construction, totaled $752.4 million. Reimbursable costs of the Project, totaling $426.5 million, are paid by a combination of CRSP power revenues, Project water users yearly assessments over 50 years, and taxes from landowners within the DWCD. Non-reimbursable costs of the Project, which do not have to be repaid by the local community, include archeological mitigation, fish and wildlife mitigation, recreation, salinity features, and facility relocations.

The Project was one of the last Federal projects constructed as part of the CSRP. The Project is unique in that it incorporates two purposes that have not historically been part of a Reclamation project. First, it assisted in satisfying the Ute Mountain Ute Tribe's reserved water rights claims. Second, it provided for a fishery release to the lower Dolores River and is the second largest allocation of Project water stored in McPhee.

1.3.6 DWCD Activities since Project Construction

The DWCD operates the DCC to provide pressurized irrigation water to approximately 29,000 acres using pumps to lift and pressurize delivery pipelines.

- Great Cut pumping plant lifts the water into the earth lined DCC at rates of up to 350 cfs.
- Water then travels via gravity down the canal.
- Water is controlled by check structures in the canal.
- Water is delivered to local pumping plants.
- Local pumping plants deliver the water through over 100 miles of piped laterals under pressure to the Project's Full Service farmers.

This technology provides efficient deliveries, with conveyance losses limited to about 5%, versus 25% or more for older traditional flood irrigation systems. Additionally, Project farmers have maximum flexibility in how and when to take their Project water, which allows greater on-farm efficiencies than under historic irrigation practices. These design decisions allowed the use of pivot and side roll irrigation on the 100% pressurized Project system. These improvements involve significant technical complexity, including fiber communications, computerized control systems, and high voltage electrical power systems. This infrastructure design requires staffing with highly trained technicians and craftsmen to carry out round-the-clock irrigation season water deliveries.

As a benefit to both MVIC and DWCD, DWCD purchased 6,000 AF of water from MVIC as Class B shares under the Purchase Agreement dated August 27, 2002. Under that Purchase Agreement, DWCD also purchased Totten Reservoir and its water rights, which DWCD has utilized for the last three years to provide water to various McElmo Creek irrigators. DWCD's Class B share water is available to irrigate 3,000 acres of land originally designated to be irrigated by MVIC but for which MVIC never provided irrigation water. This new irrigation water, referred to as Class B water, was to be priced at an up-front cost of $250.00 per allotted acre and payment of the same annual costs as those paid by DWCD full service irrigators, including an account charge, a DWCD construction charge, and a proportionate share of DWCD's OM&R costs. In allotting available water, the Board gave priority to "Affordable Blocks" of land which could be economically served by pressurized water. Those areas included: (1) land which could be served by the Sandstone, Ruin Canyon, and Fairview Pump Stations; and (2) land near the DCC. Fifty-four individuals, owning

13,186 acres, petitioned for water, including some of the successors of the *Hollen* lawsuit plaintiffs. A DWCD Engineering team evaluated the lands to determine how each parcel could best be served, with capacity and feasibility criteria the primary considerations. To make this water available, the DWCD also negotiated a contract with Reclamation to transport the Class B water through Project facilities (pump plants and canals). In 2002, the DWCD Board allotted that irrigation water to eligible landowners.

In 2008, DWCD completed its Dove Creek Lawn and Garden Irrigation System. 200 contracts were originally sold and by 2013, 177 lawn and garden irrigators in Dove Creek had metered taps installed. This program provides Project water for lawn and garden irrigation. Those irrigators pay an annual fee to lease water and for O&M of the system. DWCD took out a loan from CWCB to establish the system, which has been repaid. DWCD also purchased thirteen taps for re-sale to Dove Creek residents, some of which have been resold.

The DWCD has installed and upgraded electronic equipment to allow for remote monitoring and operation of Project facilities. An original SCADA system came partially on line in 1991 for Reach 1 of the DCC. Further sections of DCC came on line through 1993 until completely automated. The THC followed from 1993 to 1995. Those early systems included two mainframe computers and all copper wiring. The computers have been replaced several times and are now off-the-shelf desktop models with Microsoft operating systems and a Rockwell software package. The copper wiring was replaced in phases between 2004 and 2007. Terminal hardware has migrated during these years from Remote Terminal Units to Programmable Logic Controllers in conjunction with the new fiber lines and software upgrades. Finally, an early multi-mode fiber cable to McPhee Dam was replaced in 2013 to current single mode fiber standard hardware to control the power plant and dam gates.

DWCD reached agreement with Reclamation and the CWCB to provide an annual set amount, 700 AF, of Project Water, to replace water injected by Reclamation's Paradox Valley Unit to control salinity loads in the Dolores River. The original augmentation Plan for the salinity works had allowed a variable amount of augmentation water annually (i.e., 71 to 924 AF) depending on the filling of McPhee.

In settlement of a lawsuit brought by MVIC against DWCD and Reclamation in 2009, DWCD, Reclamation, and MVIC, together with the Ute Mountain Ute Tribe, agreed to a procedure for calculating MVIC's annual allocation of Project water. Exhibit "A" to the Stipulated Settlement, a calculation sheet, provides a clean-cut process for determining the amount of Project Water MVIC is entitled to annually.

DWCD maintains what is known as the "inflow/outflow" spreadsheet which keeps track of the water availability and water usage for each Project user versus their allocation on a daily basis during the irrigation season (April through October) and weekly during the non-irrigation season. The inflow/outflow spreadsheets are available from the middle 1990's to present and provide detailed data on historic water availability and usage which will be used extensively in evaluation of actions in the Plan. The inflow/outflow spreadsheet is distributed by email to Project water users and other interested persons four times a week.

With all water users fully drawing their allocations of water beginning in 2000, the Project has 16 years of good operational data of which 3 years have seen significant shortages beyond the DPR estimates due to the continual drought in the upper Colorado River basin. Also, in 2014 and 2015, shortages were based on the April first runoff forecast and shortage conditions were initiated but April and/or May precipitation was adequate to provide a full supply. Therefore, in the three recent years there was either an actual shortage (2013) or projected shortage as late as May first (2014 and 2015).

1.4 Dolores Project Drought Background

The Project has had three years of actual water shortage beginning with 2002 and two more years of projected shorted that were saved by unusually late spring precipitation. There appears to be a long-lasting weather pattern that has resulted in sustained drought in the Colorado River basin and specifically the Dolores River basin. The Project has implemented drought actions "on the fly" since 2002 but has not developed a contingency plan to address drought that appears to be continuing. The development of this Plan allowed for primary Project water users (Reclamation, DWCD, FRE, and MVIC), who represent all of the water users susceptible to drought caused water shortages, to cooperatively evaluate actions to mitigate and respond to future droughts. Given the weather pattern over the past 16 years, the next drought and shortage year could be next year. The M&I water users are provided a full supply even if other water users are in shortage, so these users are not susceptible to drought as are the irrigators and fishery.

As shown on figures and tables throughout the Plan, including several at the end of this section, the Project has suffered water shortages in 2002, 2003 and 2013 and projected May first shortages in 2014 and 2015. MVIC sued DWCD and Reclamation in Federal Court in June of 2009 over breach of contract for water deliveries. The Ute Mountain Ute Tribe also became a party to the action. The suit was eventually settled through negotiations and a water allocation formula referred to as "Exhibit A", which determines the amount of water MVIC is to receive under the Project contracts was implemented. In order to not have tensions increase to the point of a lawsuit again, all of the parties have taken steps to cooperate more effectively. The lack of conflict during the shortages in 2013 showed that the parties have learned to work cooperatively. Also, the Plan's development process shows the improved cooperation with the Funding Stakeholders jointly developing the Plan.

The projected May first shortages in 2014 and 2015 were saved by unusually late spring precipitation. On May first of 2015, the Project was anticipating a 40% supply based on runoff projections at that time and DWCD announced that shortage conditions would exist for water users. Luckily, there was exceptional precipitation in May and June of 2015 which resulted in a full supply but the increased supply came too late for some irrigators, especially the FRE, to adjust their cropping plans to utilize the available water, resulting in reduced crop production and loss of income.

Overall, the most significant risk to the irrigators is the reduced crop production and associated secondary income throughout the community. The risk is exacerbated on the Ute Mountain Ute Reservation where reduced income to the FRE equates to less Tribal employment. The risk to the fishery is significant to the native sensitive species (bluehead sucker, flannelmouth sucker, and roundtail chub) downstream in the Dolores River canyon and the non-native trout population immediately downstream of McPhee. The Project includes two hydro power plants that produce power for use in the Western Area Power Administration system. By producing less renewable power, the Western Area Power Administration system may need to supplement power production with non-renewable sources. McPhee itself is a source of recreation as well as the Dolores River downstream of the dam. These recreational options are diminished during a drought or discourage tourists from visiting a drought impacted area.

Additional risks to the public are economic impacts. The decline of income for irrigators reverberates throughout the community. This decline in turn affects other members of the community who rely on the irrigators spending for their own income (i.e. local equipment supplies and supplier of agriculture products). Public health concerns are less significant due to M&I water not sharing in shortages, but could arise from lower, warmer flows.

From the data in the figures shown hereafter, it can be seen that the Project has been in drought since 2000 with especially dry periods in 2002 to 2004 and 2013. The WaterSMART grant funding provided an opportunity for the Project water users to take a broader look at how better to mitigate and respond to persistent drought and associated shortage conditions. Included in this section are the following figures displaying data of persistent drought conditions from 2000 to 2016, 16 years.

- <u>Figure 5. McPhee Maximum Active Capacities 2000 – 2016</u>
  This figure shows that McPhee has only been full in seven of the last 16 years and will fill in 2017.

- <u>Figure 6. Total McPhee Reservoir Inflow</u>
  This figures shows the total inflow to McPhee from 1986, the first-year McPhee was operational, to 2016. Since 2000, there are only two years where the inflow was greater than the average. The average for the last 16 years is over 125,000 acre feet less than the average for the first 14 years of the Project's operation.

- <u>Figure 7. McPhee Ending Active Capacity and Spill</u>
  The capacity of McPhee at the end of the water year on October 31 and the amount of spill, if any, from 1986 to 2016 is shown. Active storage in McPhee is near empty in six of the 16 years creating below average carry-over for 10 of the last 16 years. Only two years with significant spills and five years with minimal spills.

- <u>Figure 8. Percentage of Full Allocation Available</u>
  The previous figures show data on the water supply and storage available since 2000. Figure 8 shows the resulting supply to the non-Indian FSA irrigators, the FRE, and the fishery release as a percentage of full supply. The figure shows that there were actual shortages in three of the 16 years. The table doesn't show years that shortages were predicted on May first but wet late springs provided just enough water to provide a full supply (2004, 2014, and 2015).

Figure 5. McPhee Maximum Active Capacities

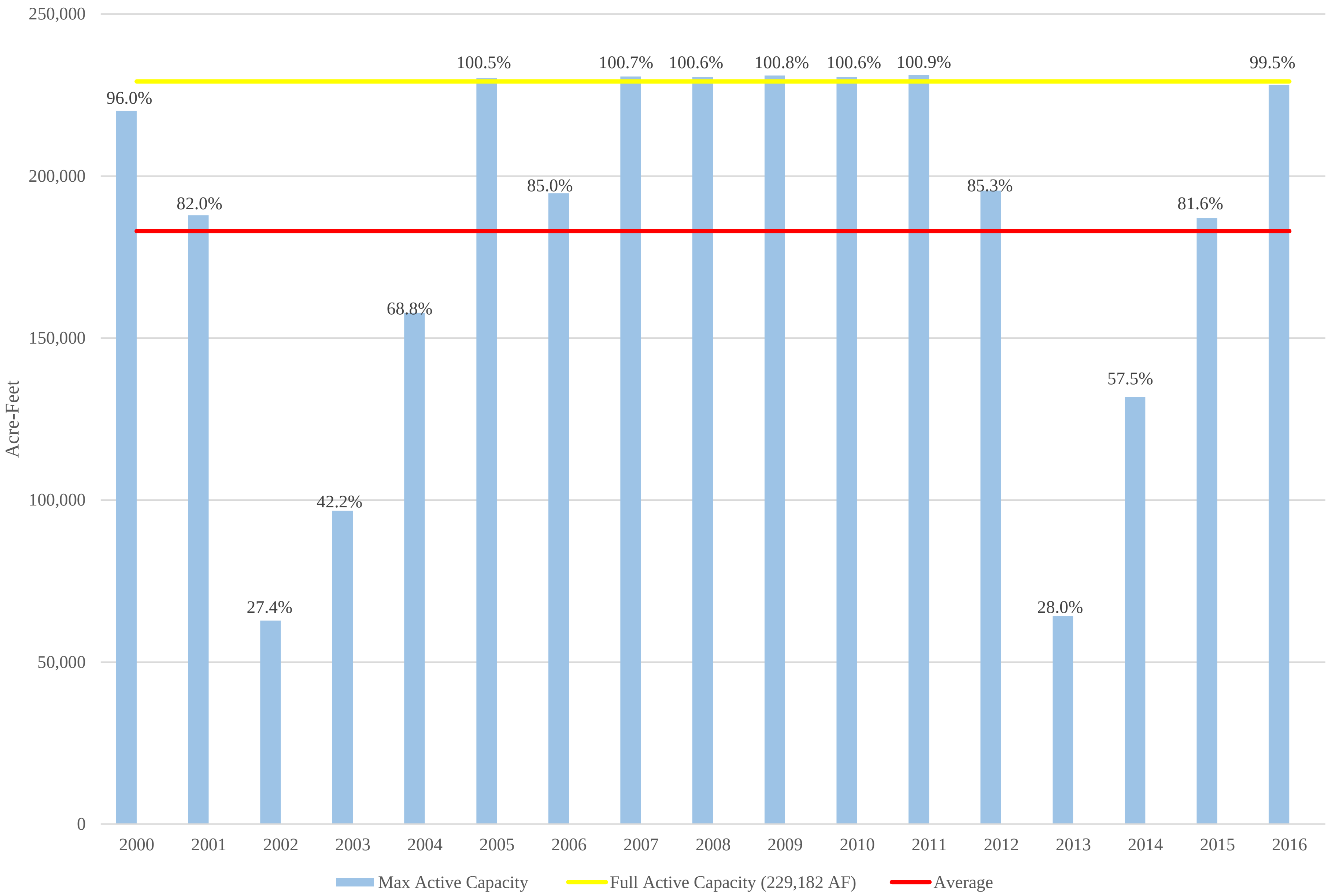
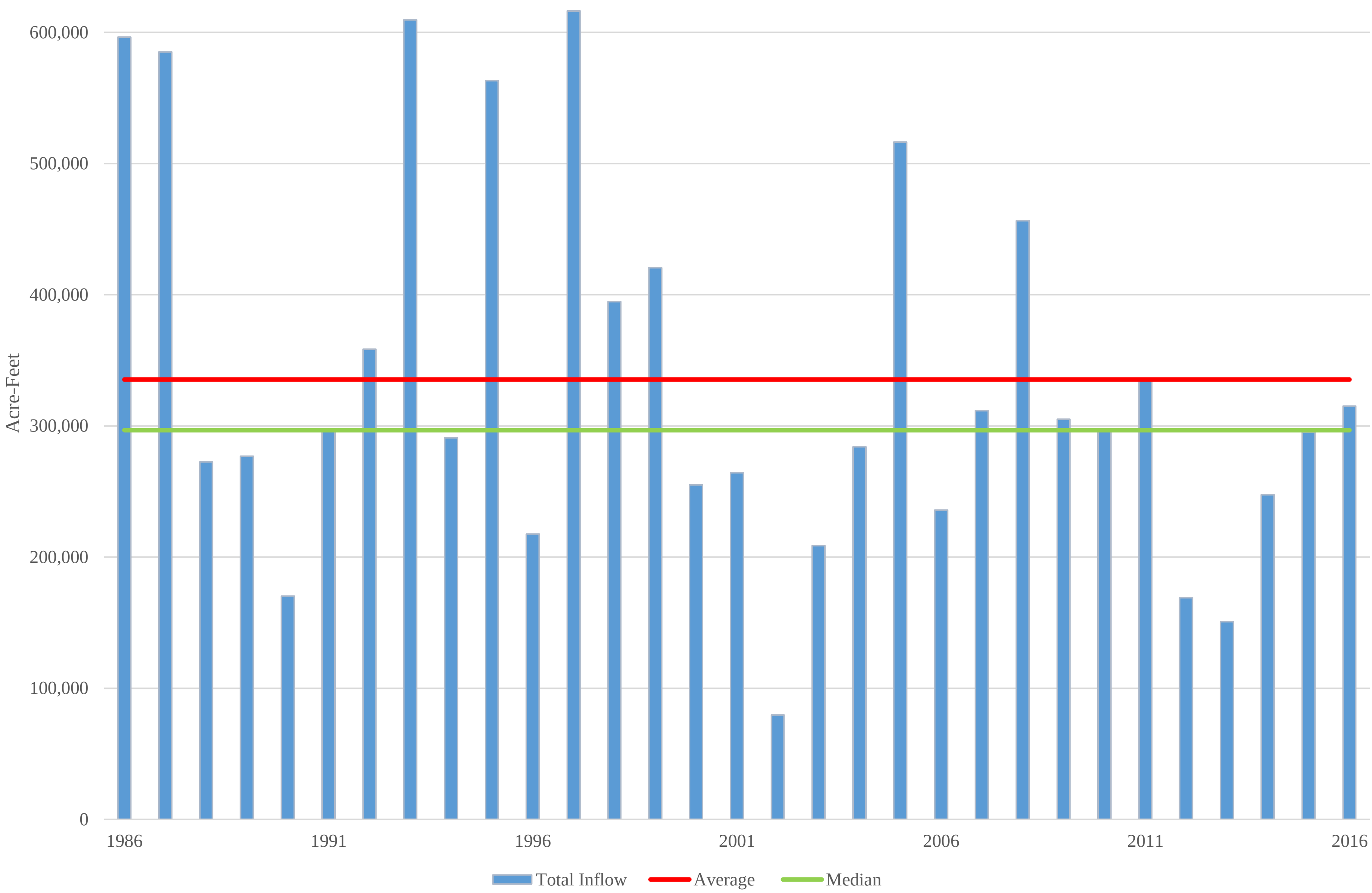


Figure 6. Total McPhee Reservoir Inflow



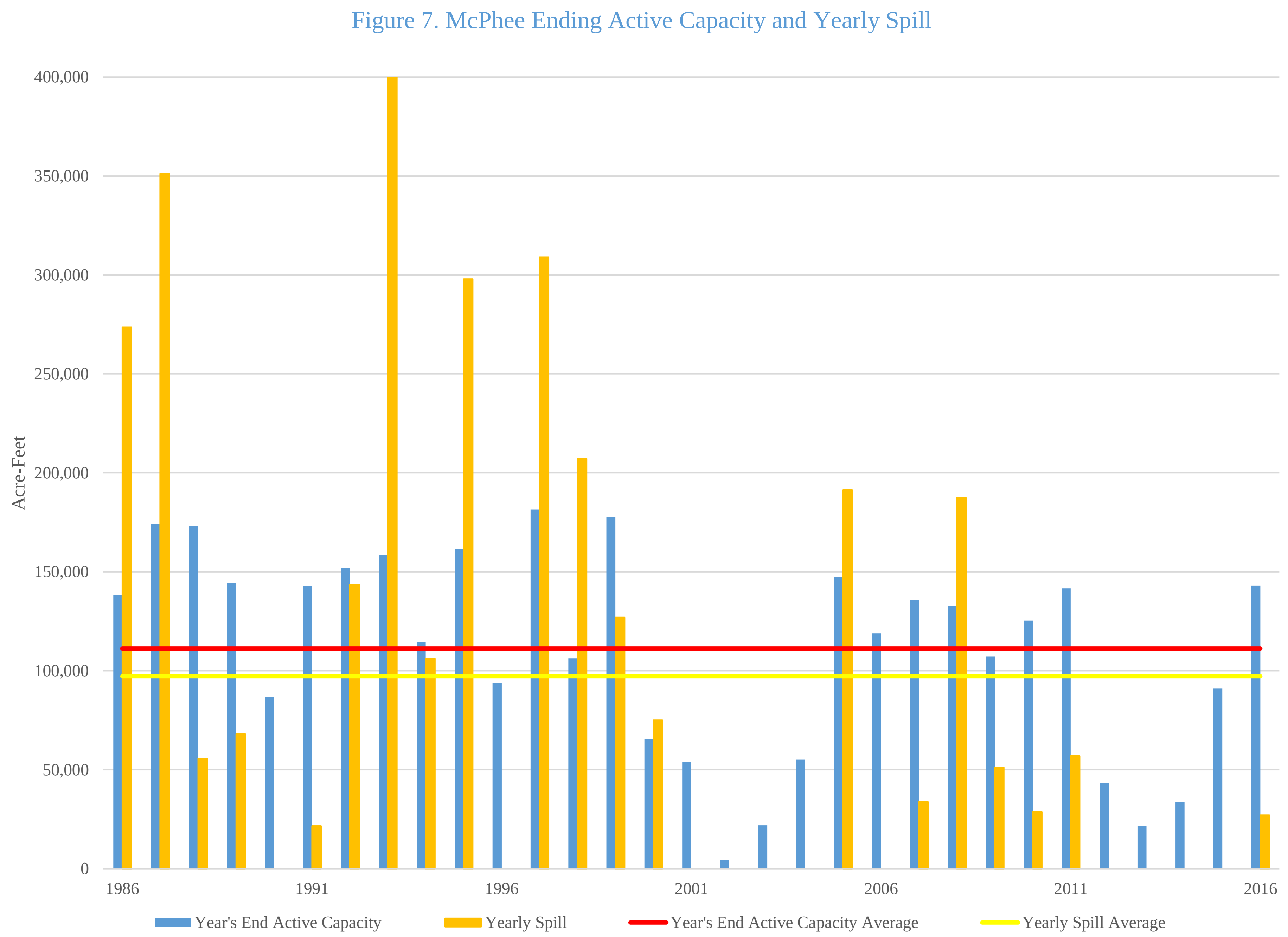
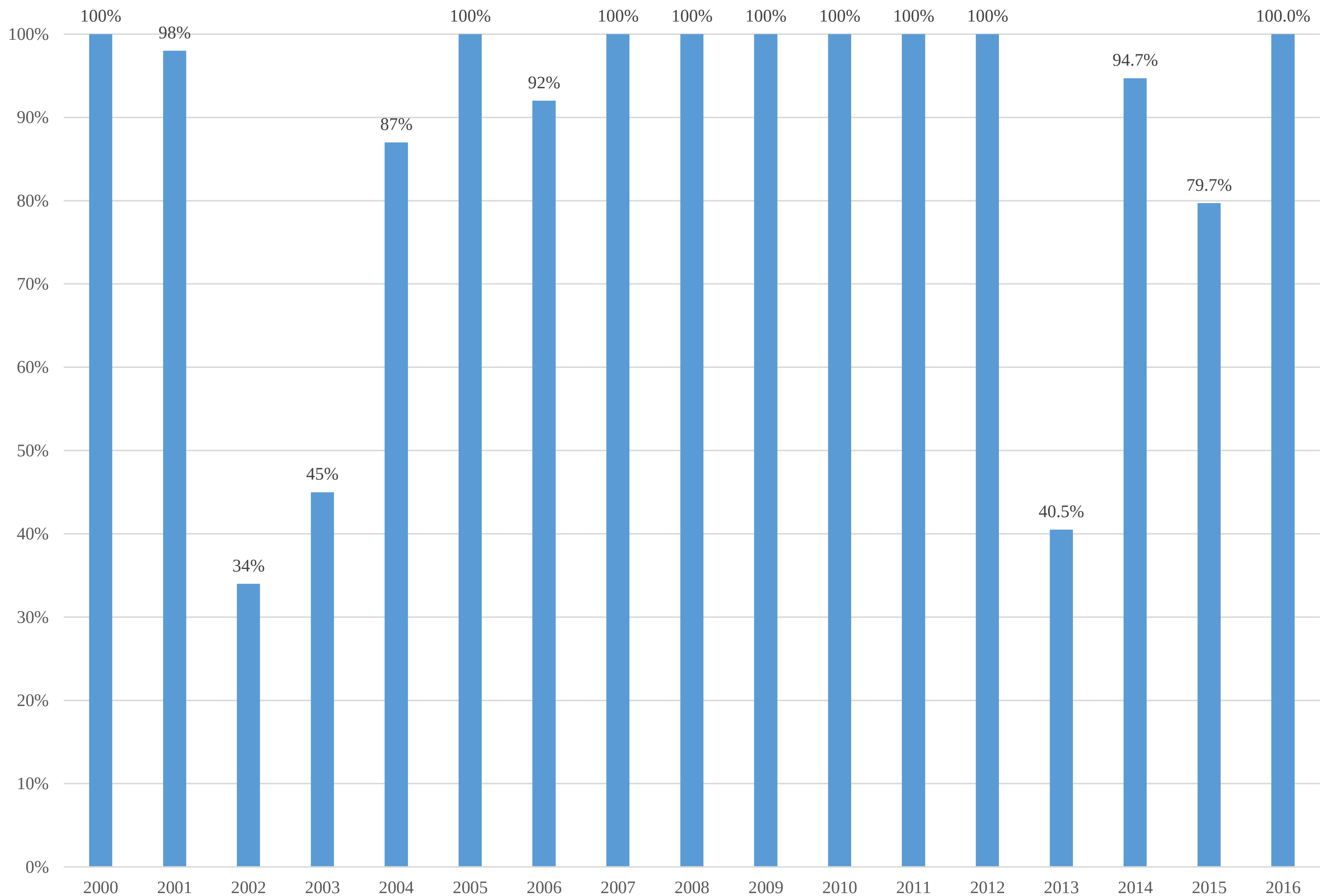


Figure 7. McPhee Ending Active Capacity and Yearly Spill
Acre-Feet
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1986
1991
1996
2001
2006
2011
2016
Year's End Active Capacity
Yearly Spill
Year's End Active Capacity Average
Yearly Spill Average

Figure 8. Percentage of Full Allocation Available



2 Stakeholder and Public Involvement

Note: To be updated after public comment period and meeting

2.1 Planning Task Force

The Plan was funded by Reclamation and three non-federal entities; DWCD, MVIC, and FRE provided matching cash and in-kind contributions for the grant. The Planning Task Force consisted of the DWCD, MVIC, FRE, and Reclamation. The Planning Task Force provided oversight for the bulk of the baseline data analysis, reviewed work products, and participated in public outreach efforts. Under the leadership of the grant recipient, the DWCD, the Planning Task Force supervised and provided guidance in the development of the Plan and organized the involvement of the stakeholders. Though not members of the Planning Task Force representatives of the Colorado Division of Water Resources and High Desert Conservation District attended most of the meetings.

2.2 Task Force Involvement

The Planning Task Force met regularly throughout the entire development process of the Plan. The group met at a minimum monthly while sometimes meeting multiple times a month. The agendas consisted of brainstorming drought mitigation actions, reviewing mitigation actions, receiving drought updates from task force members, discussing scheduling of tasks, and other topics.

2.3 Stakeholder Identification

The Planning Task Force identified key stakeholders to be involved in the Plan's development process. A draft of the Plan will be sent to members of the Dolores River Dialogue as well as made available for the public at large on DWCD's website. A public meeting will be held on June 6, 2017 at the DWCD office (60 S. Cactus, Cortez Colorado) at 7 p.m.

2.4 Stakeholder Involvement and Comments

2.5 Public Involvement and Comments

3 Drought Monitoring

3.1 Methodology for Monitoring, Accounting, and Determining Drought

Over the last decade drought has become a national issue, though the negative impacts are very specific to each local area. This concern led to more coordinated federal action and resulted in the National Integrated Drought Information System (NIDIS) website that maintains the U.S. Drought Monitor, a current status for drought in all 50 states. Because of the U.S. diversity, regional information is more valuable and we follow the Intermountain West NIDIS monitor with Colorado Climate Center.

As a starting point consider defining drought. The National Drought Mitigation Center outlines the following operational definitions of drought:

1. *Meteorological drought* is usually an expression of precipitation's departure from normal over some period of time. Meteorological measurements are the first indicators of drought.

2. *Agricultural drought* occurs when there is not enough soil moisture to meet the needs of a particular crop at a particular time. Agricultural drought happens after meteorological drought but before hydrological drought. Agriculture is usually the first economic sector to be affected by drought.

3. *Hydrological drought* refers to deficiencies in surface and subsurface water supplies. It is measured as streamflow and as lake, reservoir and groundwater levels. There is a time lag between lack of rain and less water in streams, rivers, lakes and reservoirs, so hydrological measurements are not the earliest indicators of drought. When precipitation is reduced or deficient over an extended period of time, this shortage will be reflected in declining surface and subsurface water levels.

4. *Socioeconomic drought* occurs when physical water shortage starts to affect people, individually and collectively. Or, in more abstract terms, most socioeconomic definitions of drought associate it with the supply and demand of an economic good.

Several frequently asked questions from the CWCB help enlighten our Colorado conditions:

- Is Colorado currently in a drought? This is an all too common question in Colorado and there is no straightforward answer. Drought is a prevalent natural phenomenon in Colorado. Single season droughts over some portion of the State are common. Prolonged periods of drought develop slowly over several years and are cyclical in nature. With Colorado's semiarid and variable climate, there will always be a concern for water availability within the State.

- What is a drought declaration? Drought declarations are traditionally made by public officials and may be made at the local, state and federal level. In Colorado, the Water Availability Task Force is responsible for assessing drought conditions and recommends to the governor when an official drought declaration should be made. Water providers can also officially declare a drought. Water restrictions and other drought response measures may be enforced following local drought declarations.

- How often does drought occur? Historical analysis of precipitation and other drought indices show that drought is a frequent occurrence in Colorado. Short duration drought as defined by the three-month Standardized Precipitation Index (SPI) occur somewhere in Colorado in nearly nine out of every ten years. However, severe, widespread multiyear droughts are much less common. Since the 1893, Colorado has experienced six droughts that are widely considered "severe." These droughts affected most of the state, involved record-breaking dry spells, and/or lasted for multiple years.

Beyond the historic 120 years of record we may consider longer term data from Colorado River Basin Paleo Climate studies based on long term tree ring studies reaching back to approximately 750 AD showing droughts of multi-decadal length. This includes the 12th century drought that likely drove the Ancestral Pueblo people from our area. Finally, the CWCB Colorado River Water Availability Study and Reclamation's Colorado River Basin Water Supply and Demand Study attempted to integrate potential climate change scenarios into future planning.

The Colorado Climate Center clarifies a Colorado problem with the above as follows. The government officially defines drought as "a period of insufficient rainfall for normal plant growth, which begins when soil moisture is so diminished that vegetation roots cannot absorb enough water to replace that lost by transpiration." This is a good definition for areas that depend on rainfall for their moisture, but, in Colorado, 80 percent of our surface water supplies come from melting snowpack. A better definition of drought for Colorado might read:

> *"A period of insufficient snowpack and reservoir storage to provide adequate water to urban and rural areas."*

The Project can be affected by all of the definitions above. As an irrigation project, the Project relates the interactions to how they ultimately result in delivery of water to crops and the resulting production numbers from Project producers. The various definitions above do lead to a natural sequence of monitoring that is relative to different seasons of the year.

Monitoring is an annual cyclical process where each year rolls into the next with variable carryover affects. The water year in Colorado and established by contract for the Project is November 1st through October 31st. This has historic roots in the state laws that reflect the climatic and hydrologic realities of Colorado snowfall to runoff to irrigation cycles.

Starting with November 1st the Project measures the current water storage levels in both McPhee and the MVIC reservoirs. MVIC immediately starts filling their reservoirs with senior water rights on November 1st. Carryover storage has averaged about 100,000 to 120,000 AF in McPhee which can supply approximately 40+% of the annual project diversions. Groundhog, as a high elevation reservoir with a small collecting basin, is usually not drained because it may take multiple years to re-fill similar to McPhee. Narraguinnep on the other hand is often drained and has historically filled up in all but 3 years of the 105 year record. The status of all three reservoirs determines the starting point for the next hydrologic cycle. Carryover storage can vary from very low raising the risk of future shortage to very full, limiting the risk of a shortage on the following year. This reservoir data and the river flow to fill them is monitored via reservoir elevations and from state & USGS gages.

November begins the snow accumulation season that will determine the water supply for the next year. Fall monsoon rains, specifically falling in the higher elevation terrain from July through October determine the starting soil moisture for the natural mountain reservoir water storage above the man-made structures. This information is not precise, but is relative to observed fall precipitation, then modeled and checked against base flows. Soil moisture has a measurable 10 to 20% effect on subsequent runoff.

November through May should accumulate snow in the mountains tracked by snow water equivalent, SWE, the true measure to the future water supply for the immediate year. This comes down in the April through July runoff period that generally yields 80% of the Colorado River and Project water supply.

To understand and track this natural reservoir progress through the season DWCD tracks several sources including NRCS SNOTEL sites, a low snow course monitored by the DWCD, river gages as available, lake elevations, and other regional data such as the Dust on Snow reports from the Silverton based Center for Snow and Avalanche Studies. The snowpack leads to a runoff forecast courtesy of the NRCS and the NOAA Colorado River Basin Forecast Center (CBRFC) based on years of records, statistical analysis, modeling and some satellite data as available. These forecasts combined with carryover storage yield most of the season's supply for McPhee and the Project. This target moves throughout the winter snow accumulation season and becomes more accurate as we approach April, May, and June. Depending on when decisions must be made can drive the accuracy of the available water supply forecast. This was demonstrated most recently in 2015 with rapidly changing May and June forecasts.

3.2 Description of Past Dolores Project Droughts

The USGS Dolores River Gage gives over 100 years of record that can be used as the longest available record specific to this basin. As 82% of the Project supply comes over this gage, it effectively can be a proxy for the total Project supply historically. More recently 2000 through 2014, the driest 14 years in Colorado River basin history has been used for short term potential ranges of possible future weather.

Analysis of these records show those two specific drought years, 1977 and 2002, would cause water shortages regardless of the Project carryover. Carryover would have been higher than possible with normal use from a full reservoir the year prior. In both cases the natural water supply was less than 25% of the long term average.

The DPR studied 1928 to 1973, a 48 year record, and modeled only two significant shortages and two minor shortages, but obviously missed the more recent record dry years of 1977 and 2002. These DPR shortages came from several years of low flows and normal diversions that depleted carryover that, combined with a lower than average snowpack, did not deliver sufficient inflow. These historic looks, particularly the DPR, saw dry decades, the 1930's dust bowl and 1950's

Colorado drought of record. These long term droughts demonstrate how multi-year dry spells often lead to Project shortage.

More recent project experience, since 2000 when the Project came fully on line, shows several shortages over a brief period. After 2002, 2003 remained in shortage due to low carryover from 2002 combined with approximately 50% of normal inflow. Likewise, 2012 saw full Project deliveries, but left the McPhee so low, 37,000 AF, that combined with only 140,000 AF total annual inflow was not enough to meet Project needs. This lingered into 2014 without a full supply, 90+% by the end of the runoff. Again in 2015 as of May 1st DWCD had announced shortages that were only alleviated by record setting May precipitation. The Project appears to continue in a decade plus long drought starting in 2000. 2017 is an above average, but it is still unknown if the drought has been left behind or not.

early spring Project supply shortages also had very specific impacts for the FRE planning and subsequent operations. Once a full supply became apparent, the FRE had committed to and prepared for a dry year farming plan. Although some adjustments were made they could not fully execute on their production needs. The other Project irrigators were able to adjust to the full supply.

These historical records give some milestones on precursor snow pack levels that may indicate upcoming drought in the immediate season. Specifically, we should look at various CBRFC forecasts 90%, 70% and 50% starting March 1st in combination with current carryover to project the upcoming years potential water supply. These early forecasts largely relate to the current snow pack, fall modeled soil moisture, and some forward looking short term forecasts.

3.3 Current Drought Monitoring and Potential Future Improvements

Predicting Drought Empirical studies conducted over the past century have shown that meteorological drought is never the result of a single cause. It is the result of many causes, often synergistic in nature. A great deal of research has been conducted in recent years on the role of interacting systems in explaining regional and even global patterns of climatic variability. One such phenomenon is the El Niño/Southern Oscillation (ENSO) that seems useful in the tropics.

The immediate cause of drought is the predominant sinking motion of air (subsidence) that results in compressional warming (high pressure), which inhibits cloud formation and results in lower relative humidity and less precipitation. Prolonged droughts occur when large-scale anomalies in atmospheric circulation patterns persist for months or seasons (or longer). The extreme drought that affected the United States and Canada during 1988 resulted from the persistence of a large-scale atmospheric circulation anomaly.

Scientists don't know how to predict drought a month or more in advance for most locations. Predicting drought depends on the ability to forecast two fundamental meteorological surface parameters, precipitation and temperature. From the historical record, we know that climate is inherently variable. We also know that anomalies of precipitation and temperature may last from several months to several decades. How long they last depends on air–sea interactions, soil moisture and land surface processes, topography, internal dynamics, and the accumulated influence of dynamically unstable synoptic weather systems at the global scale. The potential for improved drought predictions in the near future differs by region, season, and climatic regime.

Our area, latitude 37+ degrees above the tropics, faces current long-range forecasts that are of very limited reliability. The ability that does exist is primarily the result of empirical and statistical relationships. In the tropics, empirical relationships have been demonstrated to exist between precipitation and ENSO events, but few such relationships have been confirmed above 30 north latitude. Meteorologists do not believe that reliable forecasts are attainable for all regions a season or more in advance.

So where do we go from here? Much more information is available over the internet today than ever before. While loaded with information the national drought web sites don't provide equal utility to the Project users. The national and state sites are trying to use uniform definitions and data platforms. The more focused regional information is more helpful to specific Project operation planning. These sites provide some guidance, but as listed above can give no long term specific guidance.

Therefore, at any given stage of the continuous water year cycle we can assess current status and future potential scenarios. This data would of course include current reservoir storage and mountain SWE. The fall soil moisture, modeled and observed, will affect future CBRFC forecasts. The CBRFC specifically uses the actual 1980 through 2015 weather as future potential inputs to formulate probabilistic forecasts for subsequent runoff starting from the current conditions. Some local data, like the DWCD Low Snow Course, can add some local precision to the modeled forecasts. Other demand side local information may also affect future irrigator demands that are not directly available beyond our area.

We can also support the continued evolving tools used by the CRBFC, including the incorporation of more satellite observations and future more sophisticated snow models. Likewise, we can support the use of new or additional observational tools by national agencies primarily the NRCS on the SNOTEL data, but could also include USGS tools. One potential is for remote SWE sensing from satellite technology currently under preliminary development by NASA and other science based agencies. This offers the potential to have more accurate data that leads to forecasts improving their precision in the future.

With the above information, we can run the Dolores Project Allocation sheet & MVIC Project Water calculations that ultimately determine the available Project supplies to the irrigators. With a variety of possible future scenarios, the various governing bodies can plan accordingly for the future.

4 Vulnerability Assessment

The Project water users have experienced three major shortages since 2000 in the years 2002, 2003, and 2013. In the years 2002 and 2013 the Project water users received approximately a 25% to 30% supply and in 2003 a 50% supply of water. This section qualitatively, and to the extent possible, quantitatively evaluates the impact of the shortages on each of the Project water users.

4.1 Impact of Past Dolores Project Droughts on Water Users

4.1.1 Ute Mountain Ute Tribe Farm and Ranch Enterprise

The FRE operates a 7,500 acre irrigated farm using 108 center pivot sprinklers on the west side of the Ute Mountain Ute Tribe's reservation. The land is irrigated by the 43 mile long THC that conveys up to 135 cfs of water to the FRE from McPhee. The THC begins near the south end of McPhee at the outlet of the Dolores Tunnel and the Towaoc Power Plant. The THC then goes south and southwest to the FRE.

The 7,500 acres of land is split into six irrigated land blocks with delivery pipelines beginning from the THC. Blocks 5 and 6 have separate headgates from the THC. Blocks 1, 2, 3, and 4 are served by one headgate at the end of the THC. The THC is high enough in elevation that all the sprinkler systems are pressurized by gravity and no pumping is required. In fact, the entire delivery system to the FRE is gravity flow beginning at McPhee to each sprinkler field.

In the Reclamation DPR, the crop consumptive use of the FRE was estimated using an assumed crop mix of 50% alfalfa, 20% grain, 10% pinto beans, 15% pasture, and 5% corn. The net delivery requirement at McPhee was estimated to be 3.11 acre-feet per acre to provide an average of 2.34 acre-feet per acre of crop consumptive use. The allocated total annual irrigation supply was 23,300 acre-feet based on 3.11 acre-feet per acre and 7,500 acres (not including the Ute Mountain Ute Tribe's M&I allocation). The 23,300 AF is included in the Colorado Ute Settlement Act of 1988 as a "Project Reserved Water Right".

The estimated water requirement of 23,300 AF per year has proven to be insufficient to adequately irrigate the 7,500 acres. The reason is more alfalfa is grown than estimated in the DPR because of favorable market conditions. The result is the FRE needs an additional 2,000 to 4,000 AF per year. In essence, FRE is water short nearly every year.

In the drought year of 2002 the FRE received only 6,300 AF, 27% of the allocated 23,300 AF. In 2003, the FRE received 12,600 AF, 54%. The 2013 supply was 9,100 AF, 39%. The shortages in these three drought years caused a major reduction in the crop production and income to FRE.

Also 2015 was an unusual year which demonstrates the problem with spring runoff projections. The projected water supply on both April and May first indicated that there would only be a 40% to 50% Project water supply. Based on this information, FRE determined it was best not to plant all the fields due to the projected shortage of water. Beginning in the middle of May, there were significant rains that changed the actual water supply to 100%. These rains covered the entire Upper Colorado River Basin and was called the "miracle May" because the water supply went from drought to average conditions within a few weeks from middle May to middle June. Even though the FRE water supply shows a full supply the crop production and income was reduced because planting could not be recovered to use the supply.

The FRE records are not formatted to directly provide the total reduction in crop production and associated income but was adequate to provide the relative reduction in income. Table 1 shows for each of the drought years: the supply, percent supply, and the percent of income. The percent of income is based on an indicator crop, alfalfa, which is assumed to reflect the income from all the FRE crops.

Table 1. FRE Drought Water Supply and Income

Year	AF Supply	% of Average Supply	% of Average Income
Normal	23,300	100%	n/a
2002	6,300	27%	16%
2003	12,600	54%	28%
2013	9,100	39%	17%
2015	21,400	92%	71%

In a 12 year period from 2002 to 2013 the FRE had 3 years where production and income were only 16% to 28% of the average income when compared to income with a full water supply. Note again that 2015 had nearly a full water supply but the income was reduced because the availability of a full water supply was not known until late May.

Though the data doesn't readily show how many years it takes to recover from drought conditions, statements from FRE indicate that drought impacted lands were not back into full production until 2 to 3 years after the drought due to: a loss of markets; the reality that 2 years is required to re-establish alfalfa stands; and economically impacted farm families who sell farm land and/or move elsewhere.

The growing season for FRE starts in mid-April, therefore the water supply projection in early April is the basis that FRE uses to decide what crops to plant in the coming irrigation season. When there is a full water supply FRE has approximately 60% of the irrigated land in alfalfa because that has proven to be the best income; however, alfalfa uses the most water of any crop and is the least flexible from year to year because it takes a couple years to develop a mature stand. Annual grains (e.g. wheat and corn) are more flexible each year and take less water but the income is less. In early April FRE must decide what crops can be irrigated in the coming season, such as: whether to rotate some alfalfa fields to grain; fallow fields; and how much wheat and corn to plant.

In a full water supply year, the entire 7,500 acres can be irrigated with a proper mix of high water use alfalfa and lower water use grains. In projected shortage years, the decision is much harder to balance the available water with the amount of alfalfa and grains. Also, annual grains cannot be decided last minute because the seed may not be readily available. 2015 emphasizes the problem of using the April forecast as explained above, it was not possible to change the cropping plan from a significant shortage projection in early April to a full supply year at the end of May.

The FRE bases its summer planting plans on the April first runoff projection of whether there will be a shortage of irrigation water. FRE is vulnerable to actual hydrologic shortages and projected shortages whether there is an actual shortage or not.

4.1.2 Non-Indian Full Service Irrigators

The non-Indian full service irrigators utilize the 40 mile long DCC that diverts from the Great Cut Dike on the west side of McPhee. The DCC goes northwest from McPhee and ends near the Town of Dove Creek. Approximately 28,985 acres are irrigated by individual land owners. The land is all sprinkler irrigated using pumping plants along the DCC to pressurize the water to each parcel of land.

The Reclamation DPR allocated an average of 1.96 AF per acre for most of the Project and 2.15 AF/acre for the Hovenweep area, with a maximum diversion to the land of 55,282 AF. Each parcel of irrigated land has a specific volume of allocated water that is provided through a delivery box with a meter to monitor the allocation. The DPR crop consumptive use was estimated assuming a crop mix of 55% alfalfa, 20% grain, 15% pinto beans, 3% pasture, and 7% corn. As with FRE, the FSA irrigators have planted more than 55% alfalfa because of the strong market which has resulted in some farmers having less water than they need.

Table 2 is similar to Table 1 in the above section for FRE and shows the percent supply in the drought years compared to a normal year and the percent of average income. The percent of average income is based on the data in Table 3. Table 3 is data collected by the DWCD each year for the FSA irrigators and provides a good indication of the fluctuation in farm income.

Table 2. Full Service Irrigation Drought Water Supply and Income*

Year	AF Supply	% of Average Supply	% of Average Income
Normal	56,600	100%	n/a
2002	17,000	30%	37%
2003	28,000	49%	60%
2013	16,700	30%	43%

Not only do the FSA irrigators have significantly reduced income during a shortage but the DWCD also has reduced income. DWCD sells water to full service farmers using a base charge and so much an acre-foot. When there is only a 30% supply the DWCD income is reduced nearly 70%. For instance, in 2013 DWCD had nearly $1 million in lost revenue that reduced reserves significantly. DWCD irrigators have agreed to replenish the “Water Supply” reserves through an annual surcharge to full service users to provide rate relief during drought periods, without diminishing DWCD’s long term capacity to perform O&M on what is a complex, relatively high-tech water storage and delivery system. The cost of drought has an immediate and long term impact on the FSA irrigators and DWCD.

Table 3. Full Service Irrigation Crop Census Summary

	2000	2001	2002	2003	2004	2005	2006	2007	2008
HAY									
Total Acres	22,633	22,730	19,598	19,948	18,357	20,133	21,964	21,409	21,359
Percent of Total	90%	92%	87%	81%	73%	79%	85%	82%	82%
Total Value*	$7,917,480	$8,593,715	$3,403,357	$5,547,266	$6,529,809	$7,842,977	$9,416,350	$10,572,391	$10,552,651
SMALL GRAIN									
Total Acres	1,254	1,200	1,392	1,627	1,868	978	1,070	2,664	2,135
Percent of Total	5%	5%	6%	7%	7%	4%	4%	10%	8%
Total Value*	$577,412	$868,238	$538,286	$738,252	$787,241	$332,840	$637,690	$1,362,967	$844,492
BEANS									
Total Acres	345	475	1,130	2,670	4,387	3,880	1,868	1,004	1,004
Percent of Total	1%	2%	5%	11%	17%	15%	7%	4%	4%
Total Value*	$65,243	$118,108	$251,715	$670,969	$1,953,167	$1,137,897	$683,130	$704,976	$704,976
PASTURE & OTHER									
Total Acres	884	390	345	426	599	626	847	911	1,440
Percent of Total	4%	2%	2%	2%	2%	2%	3%	4%	6%
Total Value*	$169,303	$136,513	$191,611	$219,953	$673,338	$959,426	$955,563	$1,212,061	$1,629,983
TOTAL ACRES	*25,116*	*24,795*	*22,465*	*24,700*	*25,211*	*25,617*	*25,749*	*25,989*	*25,938*
*TOTAL VALUE**	*$8,729,438*	*$9,716,574*	*$4,384,969*	*$7,176,440*	*$9,943,555*	*$10,273,142*	*$11,692,734*	*$13,852,395*	*$13,732,102*

	2009	2010	2011	2012	2013	2014	2015	Average (2000-2015)
HAY								
Total Acres	20,749	20,797	20,213	20,294	17,866	20,764	19,754	20,536
Percent of Total	79%	79%	75%	75%	81%	95%	90%	83%
Total Value*	$8,258,777	$8,994,764	$14,794,144	$14,898,157	$4,226,782	$10,476,059	$12,116,650	$9,008,833
SMALL GRAIN								
Total Acres	2,425	1,938	3,306	1,370	1,442	1,579	1,964	1,763
Percent of Total	9%	7%	12%	5%	7%	7%	9%	7%
Total Value*	$816,782	$552,257	$1,516,700	$366,732	$367,365	$640,223	$601,750	$721,827
BEANS								
Total Acres	1,683	2,379	1,462	2,335	1,536	2,030	1,550	1,859
Percent of Total	6%	9%	5%	9%	7%	9%	7%	7%
Total Value*	$839,651	$1,044,536	$1,552,580	$2,979,294	$520,792	$2,025,540	$3,841,712	$1,193,393
PASTURE & OTHER								
Total Acres	1,363	2,379	1,462	2,335	1,536	1,683	2,015	1,202
Percent of Total	5%	9%	5%	9%	7%	8%	9%	5%
Total Value*	$1,790,601	$1,044,536	$1,552,580	$2,979,294	$520,792	$1,097,012	$120,092	$953,291
TOTAL ACRES	*26,219*	*26,326*	*26,973*	*26,996*	*21,967*	*26,056*	*25,283*	*25,337*
*TOTAL VALUE**	*$11,705,811*	*$12,492,459*	*$21,247,455*	*$19,267,638*	*$5,858,932*	*$14,238,834*	*$16,680,204*	*$11,877,344*

**Note: total values were not adjusted to account for inflation*

Similar to the data in Tables 2 and 3, the "Colorado Agricultural Statistics" for 2010 to 2015 were also reviewed for Dolores and Montezuma Counties to assess whether per acre yields would provide information regarding the reduced crop production as a result of the 2013 drought. Tables 4 and 5 summarize the per acre yield which definitively indicates that the 2013 drought reduced the hay production to approximately one third average production in both counties. The hay production is an indicator for the other crops.

Table 4. Dolores County Drought Crop Yield Per Acre

Year	Water Supply	Yield Tons/Acre	% of Average Production
2010	Average	3.6	100%
2011	Average	3.35	100%
2012	Average	4.75	120%
2013	30% Average	1.35	35%
2014	Average	3.8	100%

Table 5. Montezuma County Drought Crop Yield Per Acre

Year	Water Supply	Yield Tons/Acre	% of Average Production
2010	Average	3.9	100%
2011	Average	3.55	100%
2012	Average	4.4	110%
2013	30% Average	1.8	46%
2014	Average	3.8	100%

The data in Tables 2, 4, and 5 indicate the significant reduction in crop production resulting from the droughts of 2002, 2003, and 2013 which shows the vulnerability of irrigation to hydrologic drought in those years.

The FSA irrigators can use the May first runoff projections to determine their planting for the summer because their growing season begins in mid-May. The May first projection is much more accurate than the April first that FRE uses and the FSA irrigators have an extra month to modify their cropping plans if there will be a shortage. Therefore, the FSA irrigators are vulnerable to actual droughts but less so projections. The lost income to the FSA irrigators and the reduction in revenue to DWCD from the reduced sale of water is both a short and long term burden. The FSA irrigators are vulnerable to the shortage from drought both immediately in lost income in the drought year but long term in a surcharge to DWCD to make up for lost revenue during a drought. A certain amount of funds is needed every year to maintain and operate the irrigation portion of the Project and if income is short in a drought year it must be replaced in later years.

4.1.3 Montezuma Valley Irrigation Company

MVIC water supply is primarily provided through its direct flow water rights from the Dolores River and supplemented by stored Project water from McPhee. The amount of Project water is determined based on the amount provided by the direct flow rights to the classified arable acres within the MVIC system. The more the direct flow rights provide the less Project water is required. On the other hand, the less direct flow the more Project water. Also, MVIC is allowed to store water in McPhee prior to July 1 that is not diverted under their 795 cfs water right; however, in spill years this stored water is spilled. The result is that MVIC tends to have less water in years that their pre-July 1 water is spilled. As can be seen in Table 6 the MVIC water supply is fairly constant (e.g. 90% of average or better) unless there is an exceptional drought such as 2002.

The MVIC system has been in operation since the 1880's and is a combination of century old ditches and irrigation practices in half of the area of the system while the other half is served by the THC and sprinkler irrigation systems. The crops under MVIC are nearly all grass hay and alfalfa used for pasture and harvest. There is nearly no grain. Grass hay generally has lesser economic export value compared to alfalfa. Even in 2002 MVIC irrigators had adequate water to maintain the grass hay, though the production was reduced, so that re-planting was not necessary. The economic loss was not as severe as for the FRE and FSA Irrigators.

Table 6. Total MVIC Project and Non-Project Water Supply*

Year	Average AF Supply	% of Average Supply
Normal	135,000	100%
2002	80,300	60%
2003	118,400	88%
2013	118,700	88%
2015	122,700	91%

**Note: MVIC does not have a specific volume Project water allocation but the volume varies based upon the amount of water provided by their non-project direct flow water rights.*

MVIC is less vulnerable to hydrologic drought than FRE or FSA irrigators, due to its very senior direct flow water rights. Only extreme drought years such as 2002 (see Table 6), cause deep shortage and more typical smaller shortages are not nearly as severe, as for the Dolores Project irrigators, who rely strictly on storage. MVIC is vulnerable in runoff years when McPhee spills because its water stored in McPhee in April, May and June also spills. Oddly MVIC has more water in years that McPhee does not spill. MVIC is vulnerable to drought in extreme hydrologic drought years and years when McPhee spills.

4.1.4 Fishery Downstream of McPhee Reservoir

The fishery below McPhee consists of both native and non-native fish populations. The non-native population is trout and is located within approximately the first 20 miles below McPhee to the Bradfield Bridge. The native population consisting primarily of roundtail chub and a few bluehead suckers were surveyed from the Bradfield Bridge downstream to the confluence with of the San Miguel River. The native fish population has become more of a priority over the years since

McPhee was constructed, as sensitive species any of which could be listed under the Endangered Species Act at some point. Table 7 shows the Project water supply provided to the fishery in a normal and the drought years.

Table 7. Downstream Fishery Water Supply

Year	AF Supply	% of Average Supply
Normal	29,500	100%
2002	7,200	24%
2003	9,960	34%
2013	6,000	20%
2015	29,500	100%

The 29,000 AF in Table 7 is the Project water supply allocated to the fishery but there is an additional 2,300 AF of Non-Project water that is also used for the fishery. The total fishery water is 31,800 AF in a full supply year.

The non-native trout population is more dramatically affected by drought than the native fish population. The density of trout (fish per mile) dropped by 65% and the biomass (lbs of trout per surface acre of river) went from 24 lbs per AF in 2012 to 5 lbs per AF in 2013 (79% drop) after the 2013 low water year (these data are collected from 3 historic sites spanning from just below McPhee to about 3 miles above Bradfield Bridge). The impact on the non-native fishery in the 2002/2003 drought period did not decline in the same proportion as the drop in flows. Trout density (average of 2000 and 2001 numbers compared 2002 and 2003 numbers) dropped by 36% and biomass by 26%. The flows dropped 76%.

In 2013, the native fish population (using roundtail chub that are the only reliable fish captured downstream of the non-native fishery segment – Bradfield Bridge) did not change much and in fact the number of fish caught (just total numbers) went from 103 fish in 2012 to 139 fish in 2013 (26% increase). The native fish have evolved with periodic drought and are relatively mobile species that can move in the river basin to find suitable flows in the short-term.

Less is known about the potential long-term effects on native fishes of drought. Although roundtail chub seem to be doing fine (most likely because they are a pool adapted species of fish), the native sucker population has been surveyed in very small numbers with little age class diversity since the Dolores Project came fully on-line in 2000. Flows large enough to support the sucker species occur below the confluence of the San Miguel River with the Dolores.

The native fish downstream of McPhee are most vulnerable to long term, year after year, shortages and less so to one year shortages. The roundtail chub surveys well even in these dry periods, but the sucker species appear unable to get established above the San Miguel confluence. It would be informative to compare surveys below the San Miguel to see how the suckers are doing.

4.1.5 Boating Downstream of McPhee Reservoir

Boating is dependent on adequate runoff to provide excess water for a managed spring release for recreational boating and the ecological health of the river. Boating does not have a Project water allocation in McPhee and is therefore dependent on excess water that cannot be stored in McPhee for Project Purposes. DWCD closely monitors the runoff each spring using data described in Section 3 to assess whether there is the potential for a managed release. DWCD attempts to schedule releases of excess water so that McPhee Reservoir fills but all the excess water is release through the outlet works and no water goes over the spillway. The managed releases are aggregated and advertised to maximize the opportunity for boating. The boating community has been very cooperative in coordinating boating releases with opportunities to use high flows to improve ecological conditions below McPhee Reservoir.

Managed Spring releases of excess water, generally occur when McPhee has considerable carryover storage. When a spill is anticipated the potential volume of the spill is estimated so that the number of days at a certain flow release can be determined. To the extent possible, the boating days and flow magnitudes are coordinated with boating organizations to provide the best possible boating experience, accomplish ecological objectives and fill McPhee Reservoir as the managed release is concluded. Years with significant spill volumes gives DWCD more flexibility to match releases with boating and ecological objectives and provide advance notification to boaters and those conducting fish, sediment and floodplain monitoring.

During drought years, there are obviously no spills and no boating because stored non-excess water is dedicated to Project users to provide for contractual allocation and carry-over storage. The boaters are vulnerable to below average runoff which occurs in approximately half of the years based on historic hydrology.

4.2 Summary of Past and Future Risk of Economic Losses

The estimated economic loss from drought is best estimated by the relative reduction in production and income from the irrigated land. The actual dollar loss is difficult because the market value of the crop changes significantly from year to year. During the major drought years in 2002, 2003, and 2013, the FRE and Full Service Irrigators generally sustained economic losses of 70% to 85% of income. Further, discussions with irrigators indicate that it took 2 to 3 years to fully recover from drought. For instance, if an alfalfa crop was lost during the drought, because of no water, it requires 2 more years after the drought to get the field back up to full production – one year to re-plant the alfalfa and another year for the stand to mature.

There is no data to estimate the economic impacts to the fishery, native and non-native. The reduction in trout biomass during drought periods is the best indicator of loss of sport fishing opportunity and economic input. Downriver Boating is not possible in drought years with no resulting economic input.

4.3 Summary of Past and Future Risk of Social and Environmental Losses

Reduced agricultural production has economic ripple effects throughout Montezuma County and especially in Dolores County because agriculture is the largest segment of the economy. The most recent economic reports that could be found for the two counties is the 2011 "Economic Development Strategy" (CEDS) which quantified the employment by sectors in each county. The assessment for each county is described in this section.

4.3.1 Montezuma County

The following are quotes and information from the CEDS:

> *"Agriculture is a very important base industry in Montezuma County. The county has consistently ranked first in agricultural production in Region 9 (southwest Colorado) based on the Census of Agriculture Statistics."*

> *"It is difficult to obtain accurate data for measuring the economic impact of the agriculture in the county. Traditionally, economic impact is measured by number of jobs, percent of total economy, income generated, and average annual wage. The numbers for agriculture are often among the lowest when compared with other sectors. However, agriculture continues to contribute to the economic development of Montezuma County. An important measure to consider is the amount of total land used in agriculture. Farmland accounted for 52.8% of all land Montezuma County."*

The CEDS report estimates that agriculture directly accounts for 6% of the jobs (684 of 12,045) in Montezuma County. When accounting for secondary jobs due to agricultural production the percentage increases to 7% (841 of 12,045).

Though agriculture is not the largest economic driver in Montezuma County it remains significant because the area began as an agricultural community, employs many people in agriculture, is a major land use on private land, and the community continues to identify strongly with its agricultural roots. When agriculture is short of water, the City of Cortez also institutes water restrictions.

4.3.2 Dolores County

The following are quotes and information from the CEDS:

> *"Over the last 20 years, there has been a significant shift in Dolores County regarding agriculture. In 1990, 70% of the total economy was agricultural based – today it is less than 40%. In the early 1990's, a sophisticated irrigation system (Dolores Project) provided water to the western portion of the county, but the water reaches only 7,600 acres out of a total of 150,000 acres."*

The CEDS report estimates that agriculture directly accounts for 23% of the jobs (150 of 664) in Dolores County and is the largest economic sector in the county. When accounting for secondary jobs due to agricultural production the percentage increases to 29% (190 of 664).

Agriculture is the primary economic driver in Dolores County and when the production is reduced due to drought the impact is felt directly throughout the businesses in the county.

4.4 Assessment of Climate Change on Future Risk

The CWCB prepared the "Colorado River Water Availability Study Phase I Report" in March of 2012. The analysis in that report for southwest Colorado, not specifically the Dolores River basin, predicted a 5% to 10% reduction in precipitation (Table 3-8, page 3-27) from April through October and a 10% to 15% increase in temperature (Table 3-4, page 3-15) both for 2070. The analysis also predicted a 9% decrease in consumptive use (Table 3-17, page 3-74).

However, the impact on precipitation from climate change is not well defined especially for southwest Colorado that is on a “boundary” between downscaled global climate models. More recent climate change models since 2012 indicate that southwest Colorado may have less, more or the same precipitation; however, the precipitation is more likely to be as rainfall rather than snowfall. With McPhee to store the water no matter whether rain or snow, there may not be a noticeable impact on the future water supply and number of droughts depending upon which climate models turn out to be accurate. Even if average precipitation is lower than historically, McPhee is located to make maximum use of whatever water is available, though if climate models predicting less precipitation are accurate the frequency of drought may increase.

As the actual effects of climate change unfold over the future decades, the potential impact will be continually monitored.

5 Mitigation Actions Prior to a Drought

These mitigation actions aim to mitigate the risks posed by drought and build long-term resiliency to drought. This section identifies structural and/or non-structural actions that can be implemented prior to a drought to better utilize the available water supply and/or make the water users more resilient to drought.

The Planning Task Force, along with input from the entities they represent, brainstormed and developed the following proposed mitigation actions as part of the Plan's development process. Multiple discussions were conducted pertaining to a specific action including: steps for evaluation, cost and potential funding sources, feasibility, and priority relative to other actions. Since the Project has been subject to multiple droughts in recent years, many of these actions are response actions based on lessons learned during those water short years. Mitigation and response actions will always be intertwined; learning from each experience leads to a variety of actions and the timing of implementing these actions is the biggest distinguishing factor between a mitigation or response action.

The mitigation actions are described herein in no particular order. The mitigation actions are categorized by structural and non-structural actions. Most actions will require some form of board(s) approval, whether it is approval of expending funds for a project or developing policies for improving water management efforts.

5.1 Structural Mitigation Actions

The proposed structural mitigation actions are described below for FRE, MVIC, DWCD, and system wide efforts. Each entity has potential for structural improvements in their systems while individual MVIC and DWCD individual also have on-farm opportunities. Actions listed below are in no particular priority.

To implement an action, the applicable entity will develop plans that includes proposed funding source(s) (e.g. loans, and grants), permitting, cost estimates, preliminary and final designs. Individual irrigators could implement their on-farm improvements without involvement by DWCD or MVIC. To implement certain actions involvement and support from all or a combination of specific entities and individuals are necessary. The actions are not prioritized since each entity will implement actions based on their own priorities and needs. In most cases, implementing actions will be undertaken by after the Plan is finalized and accepted by the Board(s).

5.1.1 Ute Mountain Farm and Ranch Enterprise Actions

Representatives from FRE attended the Planning Task Force meetings and individual meetings with consultants to develop their actions. The FRE operates a 7,500 acre irrigated farm using 108 center pivot sprinklers on the west side of the Tribe's Reservation. The farm was allocated approximately 23,300 AF subject to shortages.

The FRE conducts routine OM&R of the farm's infrastructure. This has been an ongoing process for many years which has led to pivot upgrades, delivery system improvements and improved water runoff management. While many improvements have been performed, some areas of concern were identified after a water short year. The need for more localized control of irrigation blocks and pressurization of other Tribal irrigated lands were identified as top priorities. These actions are described in detail below.

5.1.1.1 Control Valves

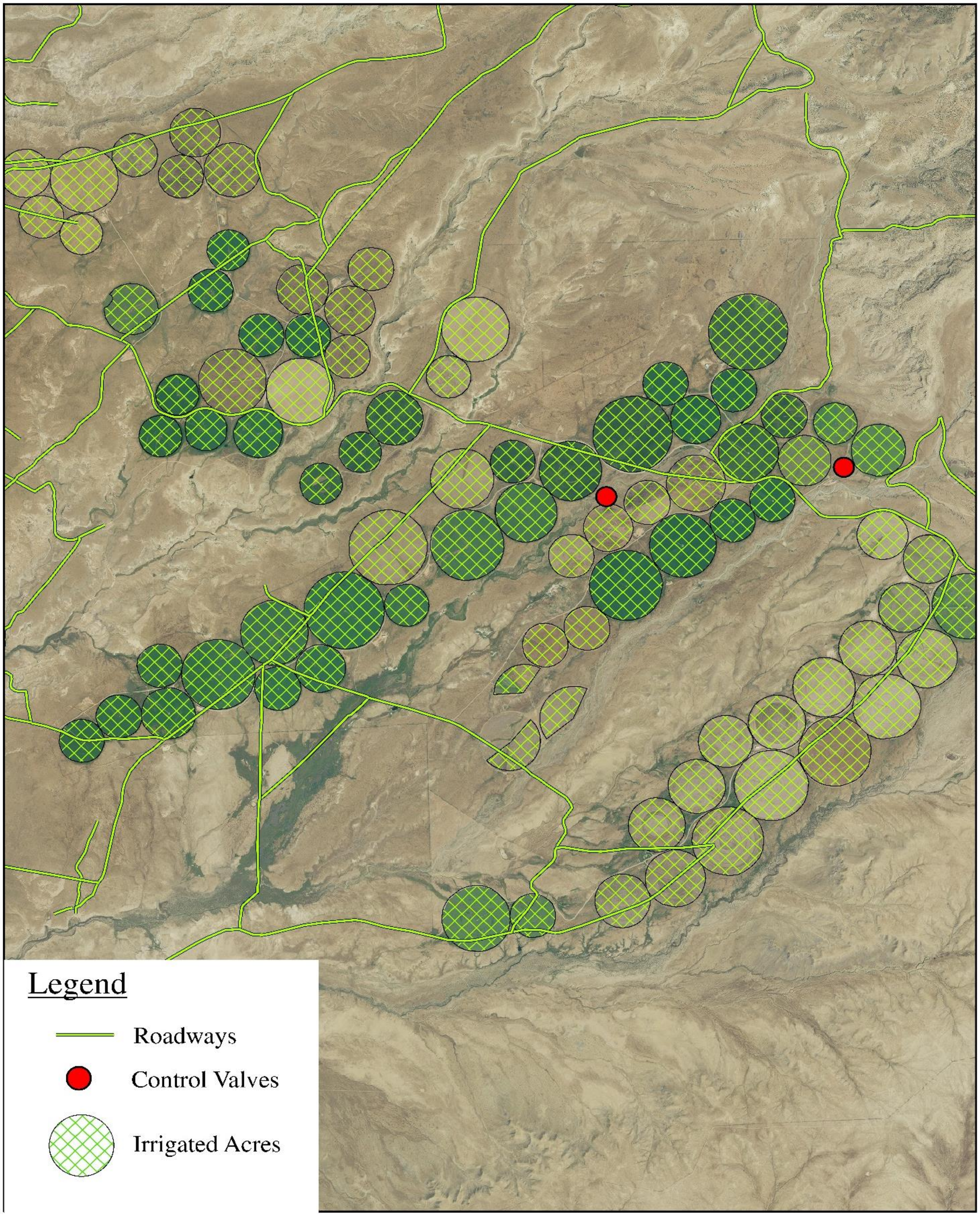
Isolation valves are needed to better control the delivery system to handle water fluctuations within some of the irrigation blocks (a total of 6 blocks serve entire 7,500 acres). An irrigation block consists of lands that are served from a main delivery pipeline. There is potential for the installation of two valves on the main lateral #39.9. The proposed gate valves would be located along blocks 2 and 3. The valves will be 33 inch and be an equivalent standard as the current equipment. The Figure 9 below depicts the location of the two proposed valves and Table 8 provides a general cost estimate.

Block 2 irrigates approximately 1,070 acres. Block 3 irrigates approximately 1,784 acres. These acres are under crop rotation, with crops including grass pasture, alfalfa, small grains, and corn.

Table 8. Installation Cost Estimate

Item	Description	Unit	Est. Quantity	Unit Price	Total Price
1	Excavate, backfill & compact	LS	2	$3,000	$6,000
2	Installation of valve(s) & associated parts	LS	2	$50,000	$100,000
3	Furnish 33” butterfly valve(s)	LF	2	$95,000	$190,000
				Sub-Total	$296,000
				Construction Administration (5%)	$14,800
				Sub-Total	$310,800
				Contingency (10%)	$31,080
				Total	$341,880

Figure 9. General Location of Valves



5.1.1.2 Connect Irrigated Lands Near the Casino Directly to Rocky Ford Lateral

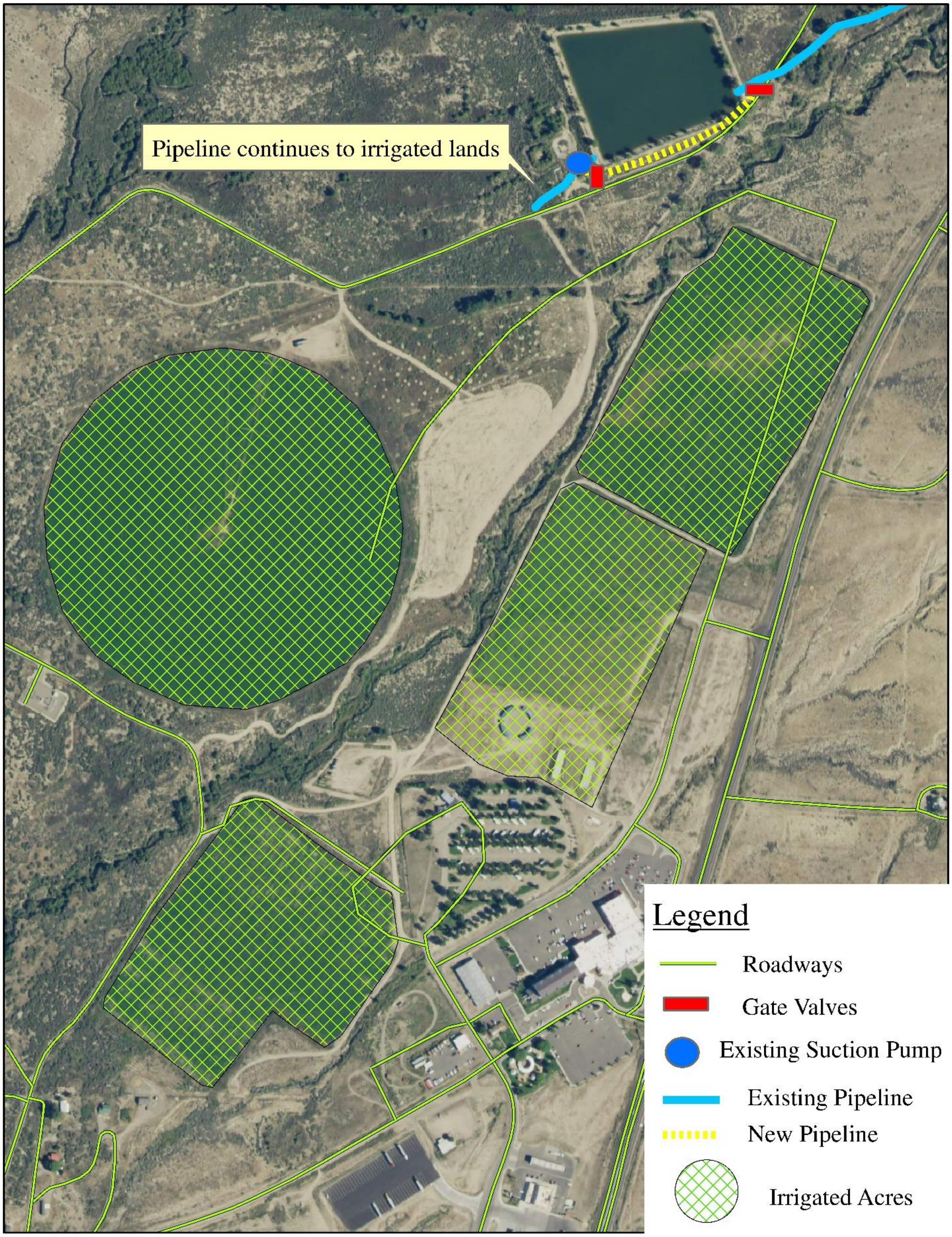
FRE uses a center pivot and three side roll sprinklers to irrigate land north of the Casino. These sprinklers are currently served by pumping from a small reservoir. The irrigated lands are used to produce pasture grass for a total of approximately 122 acres; a single pivot irrigates 49 acres while side rolls irrigate a total of 73 acres on three fields. These sprinklers are currently served by pumping from a small reservoir.

The action proposes installing an 8 inch pipeline along the southeast edge of the reservoir connecting the reservoir's delivery pipeline to the existing suction pump on the reservoir's outlet. This would eliminate the need of the reservoir. While it could not be quantified at this time, the potential existing for water savings from eliminating some evaporation. The Figure 10 depicts the location of the connection, pipeline, and Table 9 provides general cost estimates.

Table 9. Connection of Irrigated Lands to Rock Ford Cost Estimate

Item	Description	Unit	Est. Quantity	Unit Price	Total Price
1	Mobilization	LS	1	$1,390	$1,390
2	Clear & Grub	LS	1	$250	$250
3	Connection to existing lateral	A	1	$2,400	$2,400
4	Excavate, install, backfill, & compact 8" C-900 DR-18 pipe	LF	965	$30	$28,950
5	Furnish & install 8" gate valve	EA	2	$1,250	$2,500
7	Reseed disturbed area	SF	9,750	$0.06	$585
				Sub-Total	$36,075
				Design/Inspection (8%)	$2,886
				Construction Administration (5%)	$1,804
				Sub-Total	$40,765
				Contingency (10%)	$4,076
				Total	$44,841

Figure 10. General Location of Pipeline Improvements



5.1.2 MVIC Service Area and Users Actions

Representatives from MVIC attended Planning Task Force meetings and individual meetings with consultants to develop the actions. The MVIC delivery system provides Project and non-Project water to over 1,500 shareholders. MVIC irrigators primarily utilize gravity flow irrigation. Many opportunities exist for infrastructure upgrades to improve water delivery, water management and provide irrigators with pressurized water. Possible opportunities include improvement in water measurement by the addition of satellite measuring stations, remote system controls, and piping of existing laterals.

A total of 27 actions were identified and prioritized by the Board. MVIC staff provided input on willingness of landowners, funding opportunities, and identified areas of need for better water management for the numerous actions. Below are the actions ranked as the top priorities for future implementation. These actions focus on better water management through measurement, monitoring, and infrastructure improvements within the MVIC delivery system.

5.1.2.1 General System Improvements

There are opportunities to improve the MVIC delivery system due to aging infrastructure. These improvements include: piping open ditches, installing pipeline valves, installation of equipment for better control and management, and investigating areas of bottleneck within the distribution system. MVIC has been and will continue to evaluate their system and identify areas of need, the most important of which are included in this report. The primary limitation is funding for identified actions.

5.1.2.2 Measuring Stations with Remote Monitoring in MVIC Delivery System

Specific locations within the MVIC delivery system need measuring stations that are monitored remotely to allow for better water management, to reduce operational spills for example. The measuring stations are initially a mitigation action until installed but will then become a response action by providing better water management when a shortage occurs.

MVIC also identified existing measuring stations that should be moved to another location. These existing stations are in areas that lack reliable signal service. The new locations will provide better measurements and benefit water management. All work and labor will be done by MVIC.

5.1.2.3 Upgrade Canal Communication System

MVIC plans to upgrade their canal communication system from the current analog audio signals to digital systems. The market has converted entirely to digital systems, and as analog components deteriorate, their replacement is extremely expensive because replacement parts are no longer manufactured. Also, as a system ages, the computer signals become less reliable. Digital systems will improve measurement reliability and therefore delivery efficiency, water management and water conservation. A more reliable communication system will also decrease long term costs because less time is spent in the field by staff.

5.1.2.4 Piping Improvements for Existing Infrastructure

As described above, improvements and replacements will be necessary in the upcoming years due to the aging infrastructure of the MVIC system. The following paragraphs and tables describe the highest improvement priorities for the MVIC delivery system that is primarily piping of open canals. These priorities are not a list of all potential improvements but the most important.

Potential water savings and salt reductions were calculated for each section of canal. Appendix B "Water Supply/Hydrosalinity", part of the supplement to DPR, was used to estimate seepage and salt loading quantities. The summary table is found on page 111 of the appendix and attached to this report as an excerpt. These estimates assumed "*future conditions with salinity control features*" already in place. This assumes "*the Dolores Project will provide a full water supply to MVIC supplemental lands and that the salinity features are built. This includes combining the Towaoc Canal with MVIC's Lower Hermana Lateral and Rocky Ford and Highline Ditches… providing pipe laterals from the Towaoc Canal to serve areas along the abandoned Rocky Ford Ditch, and lining portions of the Lone Pine and Upper Hermana Laterals*." It was assumed the ground water concentrations remain constant and the reduction in volume of water that enters the ground water system results in less salt loading. This table is attached in Appendix A to the Plan.

For all canal piping actions, high density polyethylene (HDPE) is the recommend piping material. This pipe made from petroleum has a high strength-to-density ratio. The standard dimension ratio is a method of rating a pipe's durability against pressure. This ratio describes the correlation between a pipe's dimension and the pipe's wall thickness. The higher the ratio the pipe's wall is thinner compared to the pipe's diameter. For all improvement projects a standard dimension ratio of 32.5 is recommended.

General pricing for materials was solicited from vendors. The Engineering News Record (ENR) and the Colorado Department of Transportation (CDOT) Construction Cost Indices were utilized to adjust various costs from prior estimates. Costs for fusing HDPE pipe, labor, equipment and general production information came from these quoted sources: HDPE.com, WL Plastics, Grand Junction Pipe, and average cost data from recently constructed projects of a similar nature. Maps, GIS, and Google Earth images were used to assist with quantities. These quantities are appraisal level estimates and lack detail until further ground truthing is conducted. For that reason, they will need to be refreshed when specific projects are identified to include minor details which have been generalized and incorporated in the cost estimates provided below. The costs should be reviewed regularly as HDPE costs are volatile and tied to the cost of petroleum products which fluctuate daily.

A. Lower Arickaree Canal

a. Site Description

The Lower Arickaree Canal (Lower Arickaree) is in Sections 4 and 3 of Township 36 North and Section 33 of Township 37 North in Range 16 West and Prime Meridian New Mexico in the MVIC service area. The Lower Arickaree has a single road way crossing with Road P at about the half way point of the canal's total length. The Lower Arickaree currently serves 19 headgates in total with some headgates serving multiple users. The headgates range in sizes from 6 to 36 inches. Some users may want their own individual headgate instead of a combined one when the new pipeline is installed. Please see Figure 11 for the location map and further details.

Water is typically released from Narraguinnep Reservoir to the Hermana Canal (Hermana) which feeds water to the Lower Arickaree. The Lower Arickaree is 10,400 feet in length and delivers 10 cfs. In addition to the water needed by the users of the Lower Arickaree, an additional 2 to 4 cfs must be conveyed to operate the ditch that is turned out at the end of the Lower Arickaree and is not put to use. This operational water is about 2 cfs during the shoulder months of the season (April, May September, October 15) and increases to 4 cfs during the hottest time of year (June, July, and August).

b. Recommend Improvements

It is recommended that a pipeline be constructed for the entire length of the Lower Arickaree. The amount of water lost due to seepage is estimated at 89 AF. Piping would result in conservation of 1,240 AF of water and an average savings of 350 tons per year in salinity pickup (salt loading). The seepage conserved water and reduction in salt loading is based on estimates presented in Appendix A.

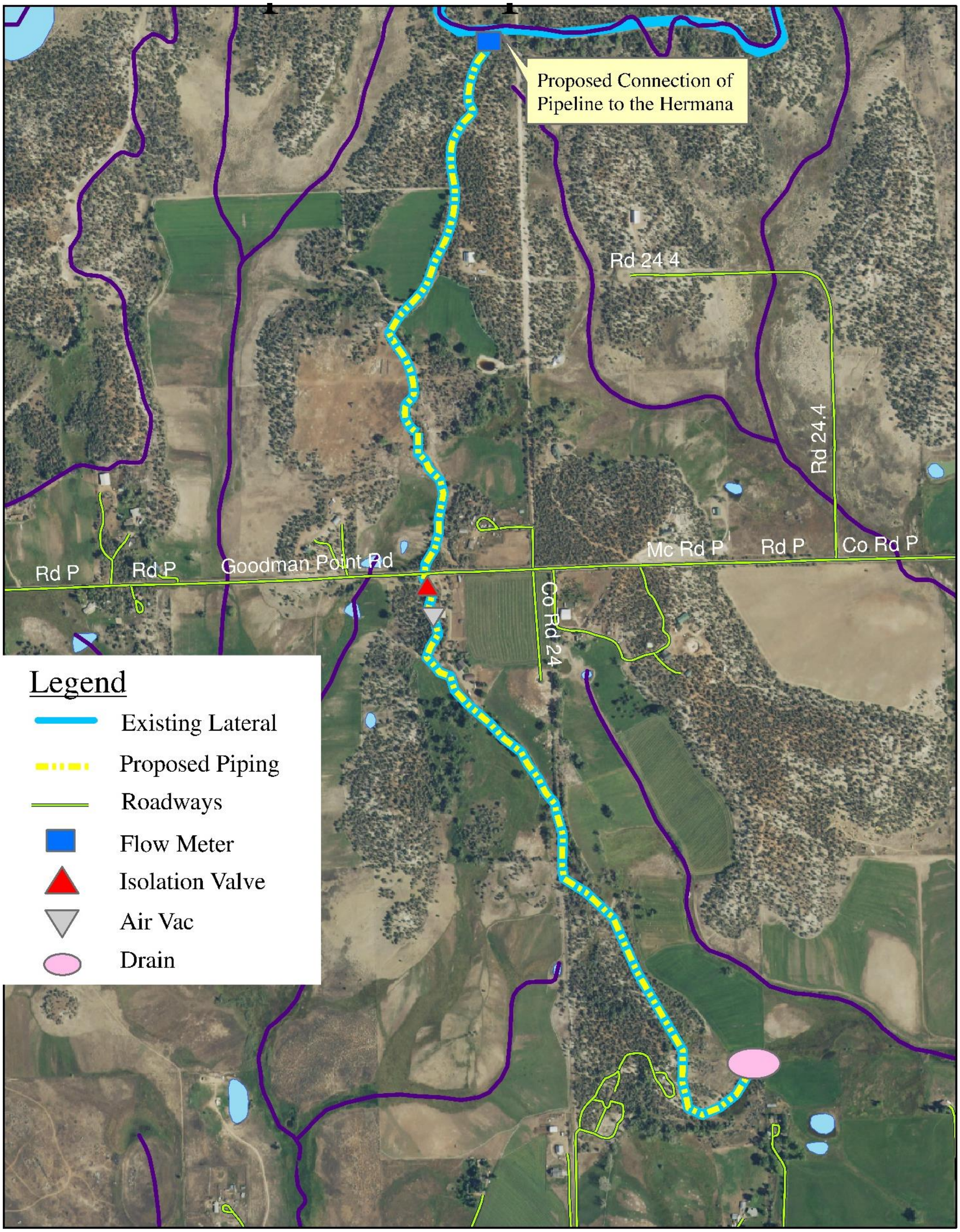
The 2 to 4 cfs of operational water now being lost would be stored in Narraguinnep Reservoir and results in increased storage of up to 1,151 AF. The estimated cost of this action is $1,935,296 as shown in Table 11. This action would cost $1,561 per AF of water conserved.

It is recommended that 32.5 standard dimension ratio 36 inch HDPE pipe be installed for a total length of 10,400 feet. The pipe was sized to provide a minimum of 10 cfs. In addition to piping the canal other equipment is proposed to improve ease of access and water management. An isolation valve is proposed south of Road P to allow the canal to be isolated in sections. A flow meter and isolation valve are proposed at the start of the Lower Arickaree from the Hermana. A drain will also be included at the end of the pipeline.

Table 10. Lower Arickaree Canal Cost Estimate

Item	Description	Unit	Est. Quantity	Unit Price	Total Price
1	Mobilization	LS	1	$59,000	$59,000
2	Clear & Grub	LS	1	$11,000	$11,000
3	Connection to Existing Lateral	EA	1	$11,000	$11,000
4	Excavate, install, backfill, & compact 36" SDR 32.5 HDPE pipe	LF	10,400	$30	$312,000
5	Furnish 36" SDR 32.5 HDPE pipe	LF	10,400	$74	$769,600
6	Excavate, install, backfill, & compact 30" SDR 32.5 HDPE pipe Manholes (400')	EA	25	$330	$8,250
7	Furnish & install 3" combination air vacuum valve	LF	10	$3,000	$30,000
8	Mainline flow meter 36" Ø	EA	1	$4,000	$4,000
9	Furnish & install isolation valves	EA	2	$86,000	$172,000
10	Furnish & install 6" turnout tees, 2 butterfly valves, and flow meter	EA	19	$4,000	$76,000
11	Reseed disturbed area	SF	345,000	$0.06	$20,700
12	Roadway surface repair	SF	100	$6.00	$600
13	Import backfill material	CY	0	$6.00	$0
14	Traffic Control @ County Road crossings	LS	1	$1,800	$1,800
15	Driveway Crossings	LS	2	$910	$1,820
				Sub-Total	$1,478,000
				Design/Inspection (8%)	$118,000
				Cultural Resources (5%)	$74,000
				NEPA Compliance (1.5%)	$22,000
				Construction Administration (5%)	$74,000
				Sub-Total	$1,766,000
				Contingency (10%)	$177,000
				Total	$1,943,000

Figure 11. Lower Arickaree General Location of Pipeline Improvements



B. Goodland Canal

a. Site Description

The Goodland Canal (Goodland) is in Sections 4 and 9 of Township 36 North and Sections 29, 32, and 33 of Township 37 North in Range 15 West and Prime Meridian New Mexico. Improvements are proposed in all sections of the canal. The Goodland crosses multiple roadways. Please see Figure 12 for the location map and further details. Water is released from McPhee through the Dolores Tunnel to the East Lateral which feeds water to the Goodland. The total length of the Goodland is about 17,000 feet in length and delivers 18 cfs. This canal suffers from severe erosion starting at Road P to the end of the canal. Any excess water is turned out at the end of Goodland to the old Rocky Ford Ditch; this tail water eventually makes it way to Totten Reservoir.

b. Recommend Improvements

It is recommended that the entire length of Goodland be piped and the draw where tail water collects to be piped to the THC to capture any excess water; allowing this excess to be put to use elsewhere in the system. The length of this pipeline is about 4,300 feet. Piping of the Goodland would result in conservation of an average of 164 AF and an average savings of 282 tons per year in salinity pickup (salt loading). Piping of the excess water would result in saving of 66 AF and an average saving of 180 tons per year in salinity pickup (salt loading). The average amount of conserved water and saved salt loading is based on estimates presented in Appendix A.

It is recommended that 32.5 standard dimension ratio 36 inch HDPE pipe be installed for a total length of 17,000 feet. This canal has a relatively steep grade so a small pipe size is proposed to improve hydraulics when flowing minimum of 18 cfs. In additional to piping the canal other equipment is proposed to improve ease of access and water management. Isolation valves are proposed intermittently throughout the pipeline. A flow meter and isolation valve are proposed at the start of the Goodland from the East Lateral. An energy dissipating structure and flow measurement are necessary at the connection of the Goodland to the THC.

Cost estimates were prepared for piping the entire existing Goodland in Table 11 and piping the tail water of the Goodland to the THC in Table 12. The costs may be reduced if the sections were combined into a single project. At this time, the priority would be to pipe the tail water of the Goodland to the THC with no improvements to the existing Goodland.

The total water savings of piping the entire Goodland is 164 AF with a total project cost estimate of $3,170,986. These improvements cost $19,335 per AF of water conserved. The total water savings of piping the tail water of the Goodland to the THC is 66 AF with a total project cost estimate of $994,808. This improvement costs $15,072 per AF of water conserved.

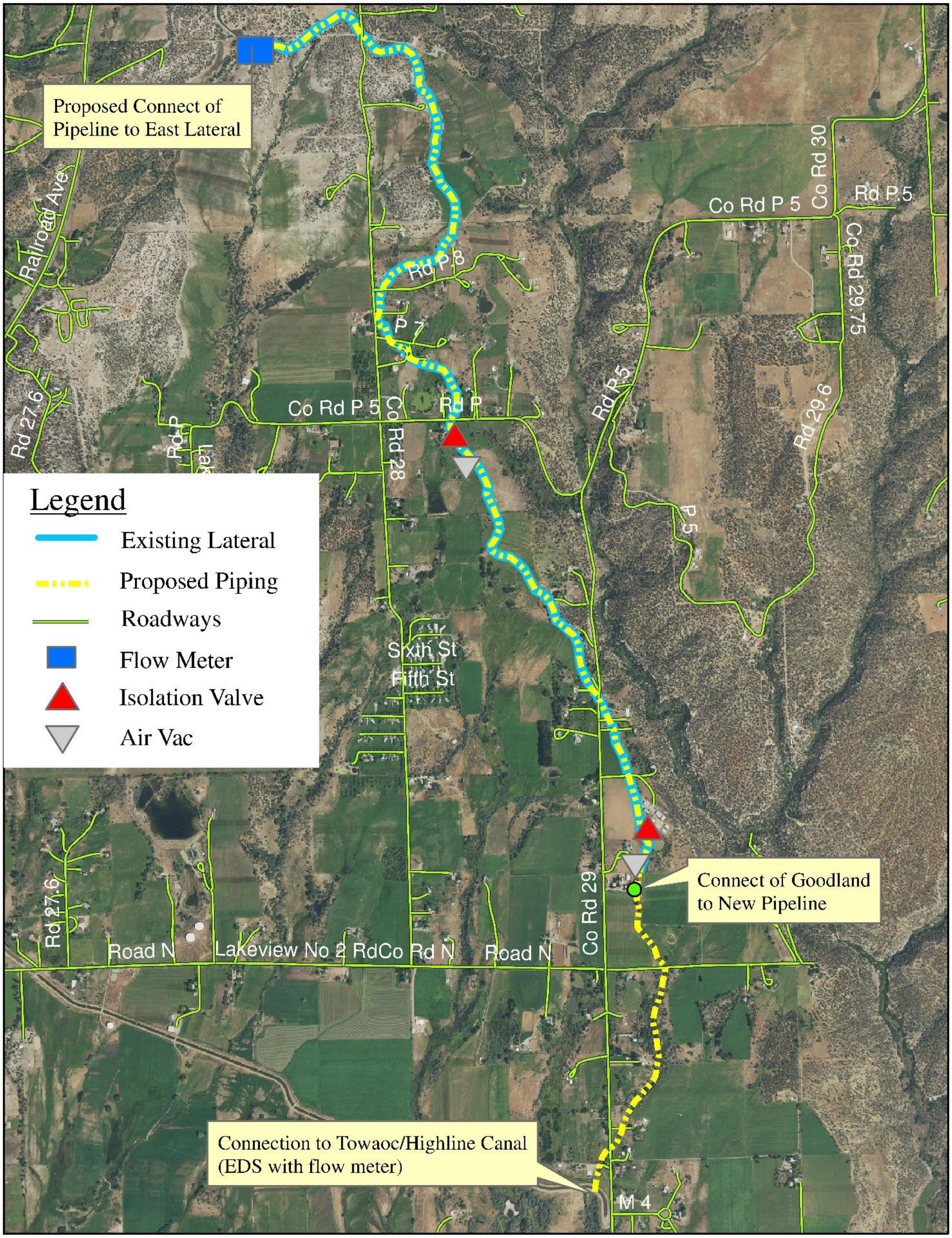
Table 11. Piping of Existing Goodland Canal Cost Estimate

Item	Description	Unit	Est. Quantity	Unit Price	Total Price
1	Mobilization	LS	1	$97,000	$97,000
2	Clear & Grub	LS	1	$17,000	$17,000
3	Connection to Existing Lateral	EA	1	$11,000	$11,000
4	Excavate, install, backfill, & compact 36" SDR 32.5 HDPE pipe	LF	17,000	$104	$1,768,000
5	Excavate, install, backfill & compact 30" SDR 32.5 HDPE pipe manholes @ 1,000'	EA	20	$327	$6,540
6	Furnish & install 3" combination air vacuum valve	LF	40	$2,800	$112,000
7	Mainline flow meter 36" Ø	EA	1	$4,100	$4,100
8	Furnish & install isolation gate valves	EA	2	$86,000	$172,000
9	Furnish & install 6" turnout tees, 2 butterfly valves, and flow meter	EA	45	$4,000	$180,000
10	Reseed disturbed area	SF	350,000	$0.06	$21,000
11	Roadway surface repair	SF	500	$6.00	$3,000
12	Import backfill material	CY	0	$6.00	$0
13	Traffic Control @ County Road crossings	LS	2	$1,800	$3,600
14	Driveway Crossings	LS	25	$910	$22,750
				Sub-Total	$2,418,000
				Design/Inspection (8%)	$193,000
				Cultural Resources (5%)	$121,000
				NEPA Compliance (1.5%)	$36,000
				Construction Administration (5%)	$121,000
				Sub-Total	$2,889,000
				Contingency (10%)	$289,000
				Total	$3,178,000

Table 12. Piping of Goodland Canal Tail Waters to THC Cost Estimate

Item	Description	Unit	Est. Quantity	Unit Price	Total Price
1	Mobilization	LS	1	$24,000	$24,000
2	Clear & Grub	LS	1	$4,000	$4,000
3	Connection to Existing Lateral	EA	1	$11,000	$11,000
4	Excavate, install, backfill, & compact 36" SDR 32.5 HDPE pipe for Towaoc/Highline connection	LF	4,300	$104	$447,200
5	Excavate, install, backfill & compact 30" SDR 32.5 HDPE pipe manholes @ 1,000'	EA	4	$327	$1,308
6	Energy Dissipating Structure	LS	1	$40,000	$40,000
7	Furnish & install 3" combination air vacuum valve	LF	6	$3,000	$18,000
8	Mainline flow meter 36" Ø	EA	1	$4,000	$4,000
9	Furnish & install isolation gate valves	EA	2	$86,000	$172,000
10	Furnish & install 6" turnout tees, 2 butterfly valves, and flow meter	EA	6	$4,000	$24,000
11	Reseed disturbed area	SF	86,000	$0 0.6	$5,160
12	Import backfill material	CY	0	$6.00	$0
13	Traffic Control @ County Road crossings	LS	2	$2,000	$4,000
14	Driveway Crossings	LS	4	$900	$3,600
				Sub-Total	$758,000
				Design/Inspection (8%)	$61,000
				Cultural Resources (5%)	$38,000
				NEPA Compliance (1.5%)	$11,000
				Construction Administration (5%)	$38,000
				Sub-Total	$906,000
				Contingency (10%)	$91,000
				Total	$997,000

Figure 12. Goodland General Location of Pipeline Improvements



C. Moonlight Canal

a. Site Description

The Moonlight Canal (Moonlight) is in Sections 3, 4, and 6 of Township 37 North and Section 34 of Township 38 North in Range 16 West and Prime Meridian New Mexico. Please see Figure 13 for the location map and further details. Improvements are proposed in Section 3 of Township 37 North and Section 34 of Township 38 North. Water is typically released from McPhee through Great Cut Dike to the U Lateral. The U Lateral delivers water to Moonlight that begins with a siphon that releases water into an open ditch. The open earth lined ditch meanders around Narraguinnep Reservoir approximately 9,000 feet until changing to a concrete lined ditch that continues 5,200 feet before connecting to a 26 inch HDPE pipeline. The open ditch only serves a single headgate.

b. Recommended Improvements

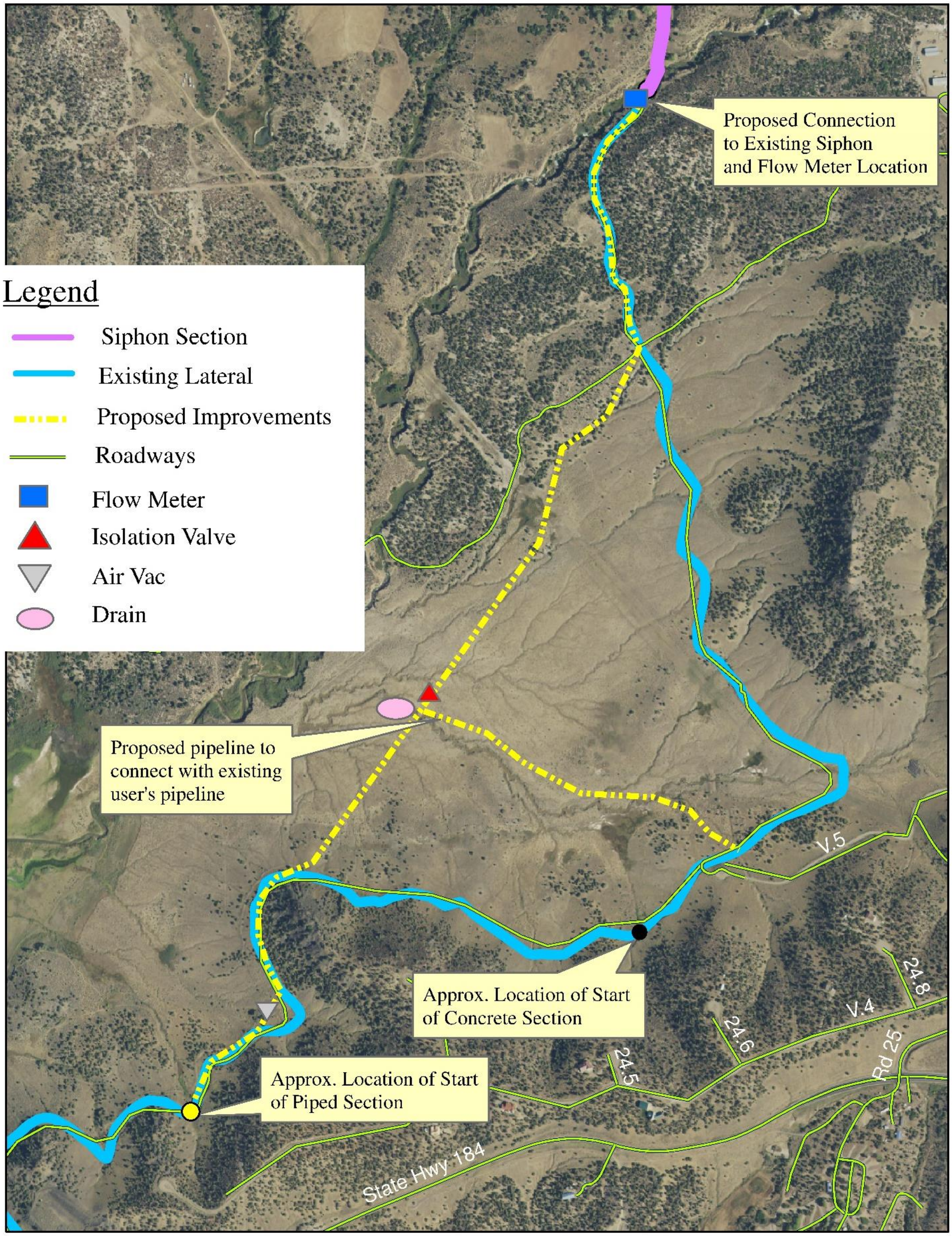
It is recommended that a pipeline be constructed connecting the existing siphon to the beginning of the piped section of the Moonlight. This would eliminate the earth lined open ditch and all the concrete lined open ditch. Piping of this canal would improve delivery efficiencies and water management operations. Piping of the Moonlight (9,000 feet of open ditch) would result in an average 33 AF savings of conserved water and an average savings of 121 tons per year in salinity pickup (salt loading). The total water savings of piping Moonlight is 33 AF with a total project cost estimate of $973,861. This improvement costs $29,511 per AF of water conserved. The average amount of conserved water and saved salt loading is based on estimates presented in Appendix A.

It is recommended that 32.5 standard dimension ratio 26 inch HDPE pipe be installed for a total length of 8,400 feet. The pipe was sized to provide a minimum of 13 cfs. A turnout for the single headgate and piping to existing user's delivery system is needed. A 4 inch pipe for a length of 2,600 feet is proposed for the connection of this single user. In addition to the piping improvements, a flow meter is proposed at the beginning of the Moonlight for better management of the water.

Table 13. Moonlight Canal Cost Estimate

Item	Description	Unit	Est. Quantity	Unit Price	Total Price
1	Mobilization	LS	1	$48,000	$48,000
2	Clear & Grub	LS	1	$6,000	$6,000
3	Connection to Existing Lateral	EA	1	$11,000	$11,000
4	Siphon (Existing)	LF	1,000	$0	$0
5	Drain	LS	1	$0	$0
6	Excavate, install, backfill & compact 26"Ø SDR 32.5 HDPE	LF	8,400	$20	$166,908
7	Furnish 26"Ø SDR 32.5 HDPE	LF	8,400	$38	$319,200
8	Furnish & Install 3" Combination Air Vacuum Valve	LF	2	$3,000	$6,000
9	Mainline Flow Meter 26"Ø	EA	1	$3,000	$3,000
10	Furnish & Install isolation valves	EA	2	$48,000	$96,000
11	Furnish & Install 6" turnout tees, 2 butterfly valves and flow meter	EA	20	$1,800	$36,000
12	Reseed Disturbed Areas	SF	346,500	$0.06	$20,790
13	Roadway Surface Repair	SF	0	$6.00	$0
14	Import Backfill Material	CY	0	$6.00	$0
15	Traffic Control @ County Road Crossings	LS	2	$1,800	$3,600
16	RV User Pipeline 4"Ø DR 32.5 Furnish and Install	LF	2,600	$8.00	$20,800
				Sub-Total	$737,000
				Design/Inspection (8%)	$59,000
				Cultural Resources (5%)	$37,000
				NEPA Compliance (1.5%)	$11,000
				Construction Administration (5%)	$37,000
				Sub-Total	$881,000
				Contingency (10%)	$88,000
				Total	$969,000

Figure 13. Moonlight General Location of Pipeline Improvements



5.1.2.5 MVIC Service Area On-Farm Efficiency Improvements

In addition to identifying delivery system efficiency improvements, on-farm opportunities also exist. As the MVIC delivery canals are piped there is the potential to deliver pressurized water to shareholders which allows the farmer to upgrade from flood irrigation to sprinkler irrigation. The water savings from changing from flood to sprinkler irrigation are substantial; typical improvements increase efficiency from 40% for flood to 75% for side rolls or 90% for center pivots. Water conserved by these improvements may be used to better irrigate the crop or saved in storage.

The biggest hurdle for farmers is the investment in sprinkler equipment and piping from the canal pipe to sprinkler. Costs range widely for different systems, with pivot packages costing upwards of $100,000. Unlike other areas of the Project, MVIC service area has the opportunity to apply for cost sharing funds through NRCS Environmental Quality Incentives Program (EQIP). EQIP provides financial and technical assistance to agricultural producers implementing conservation practices. While a variety of funding programs exist, the MVIC service area is located in a designated area of the Colorado River Salinity Program. This allows farmers to apply to this specific program for cost sharing of improvement projects.

For example, the most recent MVIC delivery system improvement was piping of the May Canal which now provides pressurized water to the shareholders. This area has potential to upgrade on-farm systems to pressurized irrigation systems.

5.1.2.6 Hydropower Development Opportunities

Potential exists within the MVIC delivery system for hydropower generation. A study is recommended to analyze the potential for hydropower generation. The study should evaluate the feasibility of possible sites based on the projected yearly income from the generated power relative to the combined costs of OM&R and the loan payment to finance the construction. The study would probably cost between $15,000 and $25,000.

For site evaluation, the head and flow characteristics would be measured. Actual flow data records are used to create a flow duration curve; the curve displays the range of flows and their occurrence throughout the period of record. This allows for design sizing to maximum the kilowatt hours generated. Potential revenue from the sale of the power would be estimated using the most recent power payment rates available from electric utilities. Proposed site cost estimates should include total construction cost for the site including and annual OM&R expense.

One example to evaluate feasibility of a site, is to compare the annual cost with the annual income for a 20 year period. The annual income needs to be greater than the annual cost. Some sites may be feasible when different power payment rates or loan repayment rates are applied.

5.1.3 DWCD Service Area Actions

Representatives from DWCD attended the Planning Task Force meetings and individual meetings with consultants to develop the below actions. The FSA irrigators represent 40% of the Project's irrigated area, consisting of irrigated lands within the northern Montezuma and Dolores counties. The delivery system is 100% pressurized allowing FSA irrigators flexibility in how and when they take their Project water as well as supporting the use of pivot or side roll irrigation. Opportunities exist for infrastructure improvements to improve water deliver and management.

The DWCD recently prepared a Water Management and Conservation Plan (WMCP) to address present and future water uses. The WMCP helped the DWCD Board and staff identify water management and conservation measures that could be implemented. Many of the mitigation actions were identified in the WMCP and further evaluated as part of this Plan’s development process.

5.1.3.1 General System Improvements

The need will always exist within the DWCD delivery system to improve water deliveries and water conservation. Aging infrastructure coupled with innovative technologies creates opportunities for significant improvements. These improvements range from lessening seepage, evaporation, preservation of canal lining, installing flow controls, and DCC regulating reservoirs.

The DCC has a clay liner throughout its length which is eroding in some locations, especially on bends. Reducing the erosion and replacing the clay liner is a mitigation action. Areas of erosion have been identified.

Also, regulating reservoirs along the DCC would provide a means to handle water fluctuations that are caused by individual irrigators changing of side roll sprinklers (on/off). If locations can be identified these reservoir(s) would provide better spill management at the end of the DCC.

Through routine monitoring, DWCD will continue to evaluate their system and identify areas of improvement. While many needs may be identified for further investigation and determined beneficial, funding for projects may be the limiting factor for implementation.

5.1.3.2 Full Service Allocation Area On-Farm Efficiency Improvements

On-farm efficiency improvement opportunities exist in the FSA irrigated lands. FSA irrigators have maximum flexibly in how and when they take their Project water, which allows for greater on-farm efficiencies compared to historic irrigation practices. The use of center pivot and side roll irrigation are possible on the 100% pressurized Project delivery system. The delivery system efficiency to the irrigator is approximately 94% on average. The greatest improvement potential exists on-farm.

This action is the structural component of the non-structural mitigation action in Section 5.2.5. One outcome of the non-structural mitigation action, is for FSA irrigators to identify areas of improvement on their farms. Improvements may include better use of existing irrigation technologies enhanced soil health management, and adjusting or changing cropping patterns to lower water demand and usage. When improvements are made, water savings is not the only benefit. Other benefits include: decreased labor, potential yield increases, and decreased energy demand.

For instance, nozzles packages used by any sprinkler degrade over time. Poor application increases water pumping time and thus energy use. Routine assessment determines if components have worn out, are clogging, or not producing the desired wetted perimeter or droplet size. Improvements made to the nozzles have a positive effect on the soils by allowing faster movement of the pivot and reducing the risk of surface sealing.

Water conserved when upgrading from side roll irrigation to center pivots is substantial, going from 75% efficient to 90% efficient. Costs range widely for different systems, with pivot packages costing upwards of $100,000.

Soil health also affects how well water is used and applied to the crop. By decreasing excess water in pivot wheel tracks, issues with rutting of the tracks may be prevented. This in turn decreases soil erosion. Soil management may improve water infiltration when correct tillage strategies are used or cover crops are planted. Working through the assessments described in Section 5.2.5 will identify areas of opportunity within a farm's current soil management practices.

5.1.3.3 Hovenweep Delivery System Improvements

The Hovenweep delivery system gravity feeds 2,688 acres that is part of the Project Full Service Irrigation system. The Hovenweep pipe lateral has a length of 10.6 miles. Full Service land is allocated a maximum annual supply of 1.96 AF per acre on all Project lands except the Hovenweep area, where 2.15 AF per acre are allocated. The pipe system has very high pressure and actions to reduce the pressure along the pipeline and to individual irrigators would improve operation. These actions are primarily for improved operation but there would be water conservation as well.

5.1.4 Storage Actions

5.1.4.1 New Plateau Reservoir and Pump Storage Project

Upper Plateau Creek Reservoir (Plateau) would be a new dam and reservoir upstream of McPhee on Plateau Creek. The embankment is on US Forest Service land and the reservoir basin is primarily on CPW land (Lone Mesa State Park) but a small amount of the basin is on BLM land. The DWCD has been evaluating Plateau to increase the water supply for the fishery downstream of McPhee.

Plateau was first evaluated in a 1998 Reconnaissance Report (1998 Report) which investigated options for increasing the water supply to all Dolores Project water users, especially for the downstream fishery. Based on the findings in the 1998 Report, the DWCD obtained aerial topography for Plateau that is suitable for designs and development. DWCD also arranged for 15 test pits located in the reservoir basin to be excavated and logged in June 1999 to assess the availability of material to construct an earthfill dam. The test logs and lab results are available upon request. All the testing indicated that there is adequate and suitable material to construct an earthfill dam. Test borings at the dam site were not conducted to assess the dam foundation.

Another result of the 1998 Report was DWCD obtained a water right for Plateau Creek Reservoir in Division 7 Water Court Case No. 00CW97 for 21,000 AF of storage. The decreed purposes are: recreation, domestic, municipal, industrial, piscatorial for the fishery downstream of McPhee. Irrigation was purposely not included to indicate that the reservoir was primarily for fishery releases to the Dolores River downstream of McPhee.

The preliminary planning for the dam indicates the dam crest elevation would be 7,625 feet and the streambed at the center of the dam would be 7,500 feet resulting in a 125 foot high dam. The reservoir normal maximum water surface would be at elevation 7,610 feet which will have 20,500 AF of total capacity and 710 surface acres.

To estimate the yield from Plateau, DWCD installed a measuring gage on Plateau Creek in 1997 and has recorded flows in most years since then. The average inflow is approximately 5,360 AF during the period, with a high of 11,200 AF in 2008 and a low of 305 AF in 2002. Plateau Creek is a fairly low elevation drainage area with high runoff in March, April, and sometimes May; there is nearly no runoff in the other months. The Plateau Creek runoff ends about the time the high runoff is beginning into McPhee from the Dolores River.

Plateau has a very junior water right priority and can only retain water in storage in water years that McPhee spills. Plateau would be operated to store the early runoff from Plateau Creek if McPhee is likely to spill; however, if McPhee does not spill the volume of water stored in the current water year would be gradually released to McPhee by October 31. The water year is from November 1 to October 31.

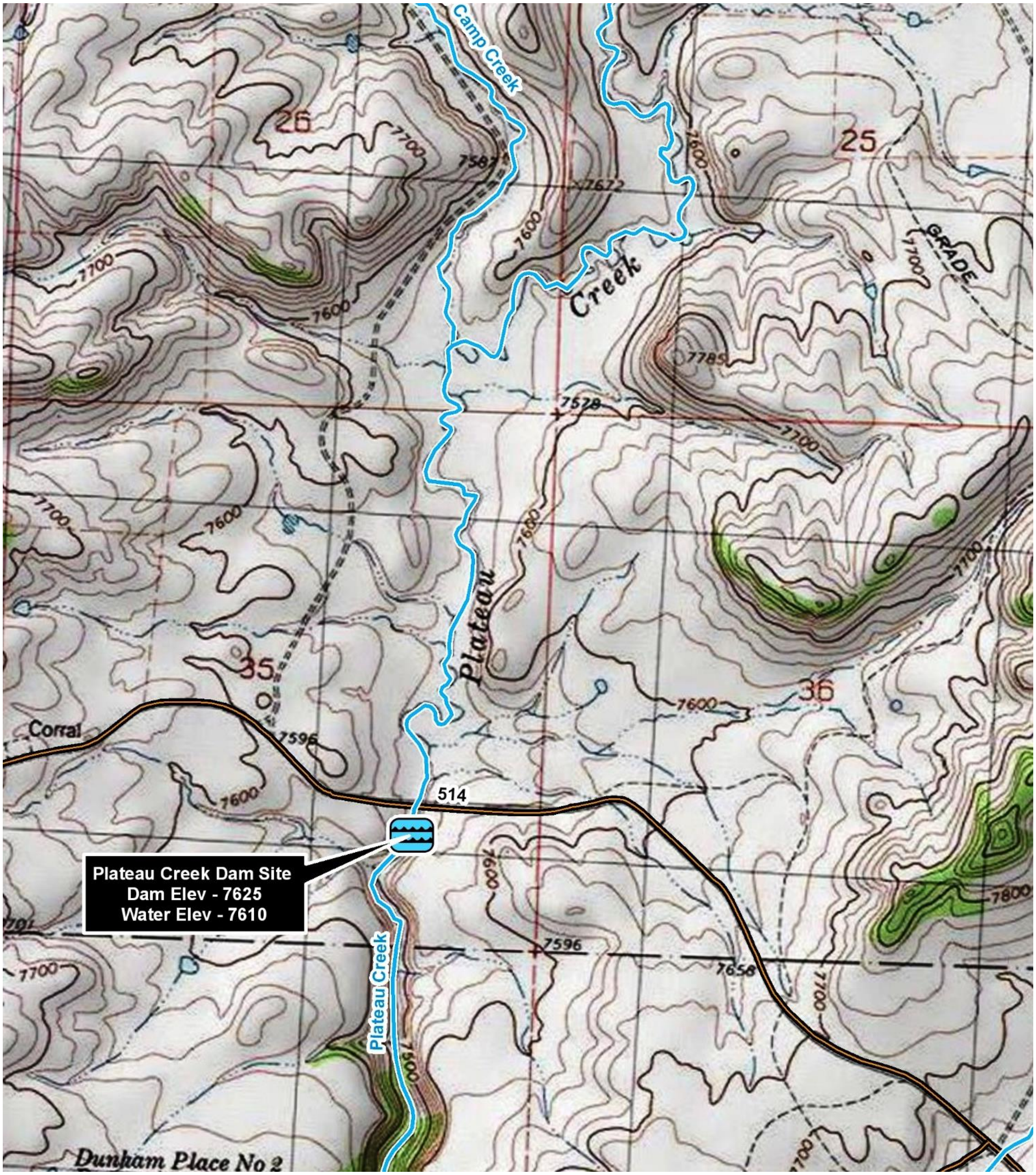
An evaluation of the yield from the 20,000 AF Plateau was prepared using the stream gage data at the Plateau dam site, actual McPhee spill amounts, and the years from 1997 to present (inclusive of the major 2002 drought). The results of the yield evaluation showed that approximately 3,000 AF per year would be available for the fishery downstream of McPhee. The study showed that filling the reservoir would require multiple years because there is not sufficient runoff to fill in one year. Further, the reservoir would also be lowered over multiple years. The multiple year filling and release is important in considering the benefits from Plateau for recreation and fishery. Also, the multiple year fill will minimize the reduction of the McPhee Managed Spill amount in any one year.

The estimated 3,000 AF of annual yield is not Dolores Project water so releases are not constrained by Project purposes and criteria. Plateau will have significant flexibility to release water on a pattern that is most beneficial to the fishery. For instance, the 3,000 AF per year could be released in each year or could be “slugged” so that more than 3,000 AF is released in drought years and less in wet years. The fishery interests would be able to use the storage in the reservoir to maximize the benefits to the fish. The release and storage of water would be coordinated with CPW which has responsibility both for management of the fishery downstream of McPhee and the management of the Lone Mesa State Park where Plateau Reservoir would be located.

Plateau Dam is very similar in size to a recently constructed dam called Long Hollow Dam in the La Plata River drainage. The construction cost of Long Hollow was used to estimate the cost of Plateau at approximately $32 million.

Numerous studies and evaluations have been conducted to determine how best to increase the water supply for the fishery downstream of McPhee. Plateau is the most reliable option to increase the yield from the Dolores River and provide an average of approximately 3,000 AF per year to the downstream fishery on a long term basis.

Figure 14. Location Map of Reservoir and Project



5.1.4.2 Increase Totten Reservoir Inflow

Totten Reservoir is shown on Figure 1 to the east of Cortez. Totten was acquired by the DWCD in 2002 from MVIC and is currently used for recreation and releases to augment the flow in McElmo Creek for irrigators in McElmo Canyon. Currently Totten has a small amount of inflow from natural runoff, return flow from MVIC irrigation, and occasionally Dolores River water conveyed through the Dolores Tunnel and THC and discharged into Totten.

Project and non-Project water users would benefit from the increased water supply at Totten with potential uses including: lease to McElmo Canyon irrigators, pump to THC to increase the Project supply such as FRE, and augmentation water for water critical areas (such as the McElmo basin in the early irrigation season). To make any of these leases permanent multiple steps must be completed to:

1) Measure Totten inflow(s);
2) Satisfy all Division of Water Resources Dam Safety requirements;
3) Contract development and negotiations between DWCD and lessee; and
4) Increase the inflow to Totten.

Pumping water from Totten into the THC could provide additional water during shortage situations to reduce, but not alleviate, the impacts of drought.

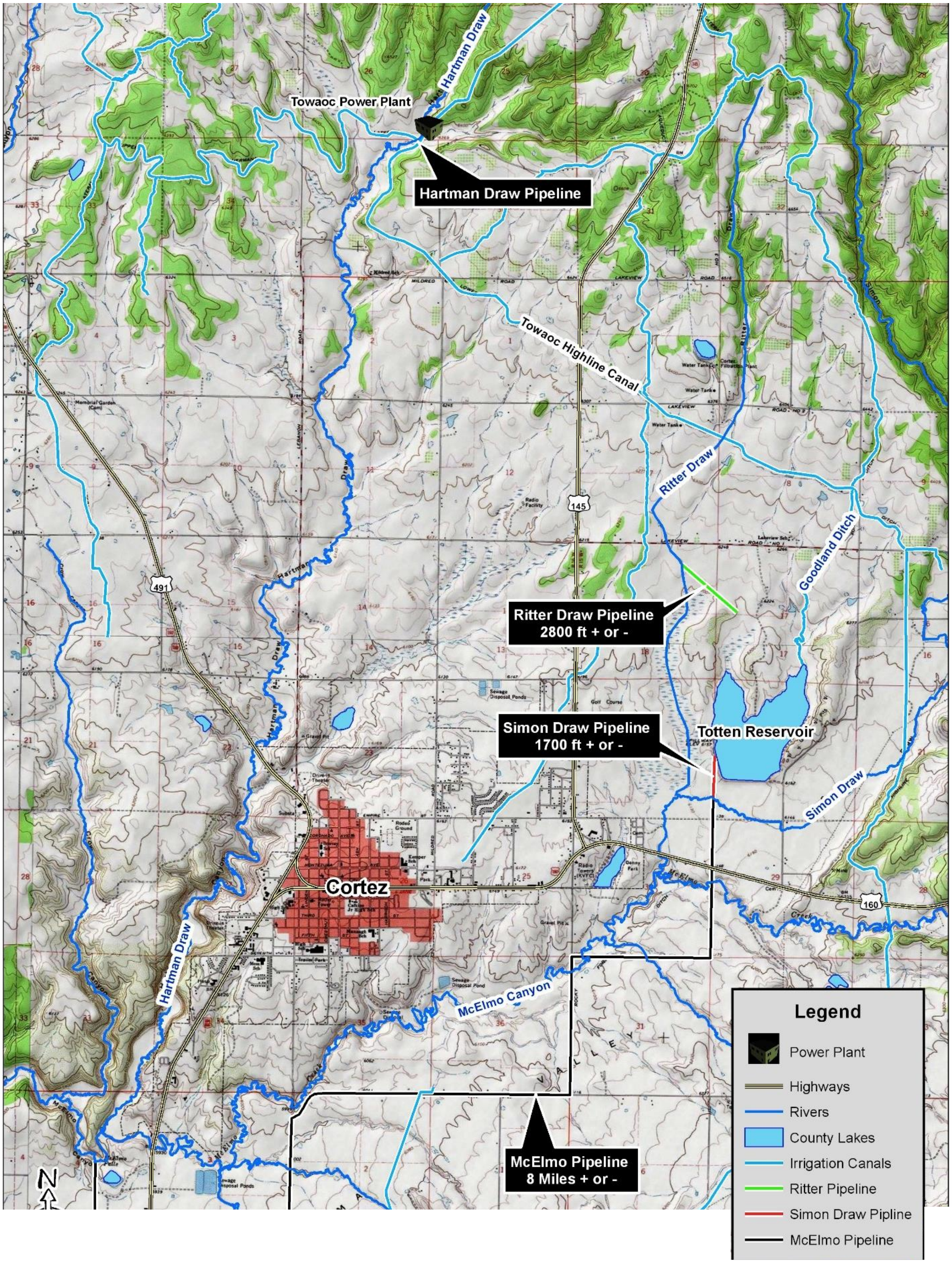
Totten is located near the THC, but lower in elevation, so that water from Totten would have to be pumped into the THC. Options have been evaluated to increase the inflow into Totten to increase the reservoir yield and the amount pumped to the THC for use by Project water users. These options were evaluated in the "Reconnaissance Study to Evaluate Potential Water Needs and Supplies" for the Ute Mountain Ute Tribe and DWCD, January 2012 and summarized herein.

The inflow would be increased by diversion of flows from Simon and Ritter Draws into Totten. Simon Draw is located south and east of Totten and water would be pumped into Totten. Ritter Draw is located west of Totten and water could be gravity diverted into Totten through a pipeline. The combined average annual inflow from the two draws is estimated to be 1,450 AF. The cost of the diversions from the draws and the pump and pipeline THC is in the range of $4.5 to 5.0 million.

McElmo Creek flows out of Colorado west of Cortez with an average annual volume of 30,000 AF leaving the state. Most of this water is return flow from MVIC irrigation. Reuse of a portion of this water might be achieved through a pump and pipeline from McElmo Creek downstream of Hartman Draw, west of Cortez. This plan is called the McElmo Pumpback and would increase the inflow into Totten by 4,500 AF per year. The increased reservoir yield would be pumped again into the THC to increase the water supply to Project users. The cost of the McElmo pump and pipeline and the pump and pipeline THC is in the range of $15 to $16 million.

DWCD has a water right to divert flows in upper Hartman Draw near the beginning of the THC into the THC for direct use in the canal or conveyance to Totten. Winter diversions (December through February) into the THC are assumed to not be possible due to conveyance problems caused by icing. The potential diversion volume is roughly estimated to be 2 cfs for 6 months; approximately 700 AF.

Figure 15. Totten Reservoir and Potential Inflows



5.1.4.3 Totten Reservoir Pump to THC

This action is required to utilize the yield from Totten by pumping into the THC. The capacity of the pump would be approximately 8 to 9 cfs. The THC flow where the water would enter is commonly over 250 cfs. The Totten water would reduce the releases from McPhee which can then be used at any location within the Project or kept in storage for future years. A carriage contract with Reclamation may be required depending on which facilities are used to delivery water.

An additional consideration in the use of Totten are the elevated levels of salinity in the reservoir (compared to Dolores River water) which is a concern when combined with the lower salinity water in THC. An evaluation of the impact of the Totten water quality mixed with the THC water was conducted. In three of the four years with available data, the conductivity reading for the mixed water is projected to be below 300 which is excellent water quality and in the fourth year the conductivity is between 300 and 350 that is still decent quality. The data shows that the potential for increased salinity levels in the THC are not significant for any of the options.

Finally, all dam infrastructure should comply with DWR requirements. This includes repairing the transverse cracking in a section of the embankment to utilize the entire capacity of the reservoir. Additional measuring equipment may be necessary to monitor inflows and releases.

The cost of the pump and pipeline from Totten to THC is estimated at $3 to $5 million. Repairs are needed to the Totten embankment that are approximately $1 million. The Totten drought water supply would cost in the range of $4 to $6 million to be able to use up to 2,200 AF.

5.1.4.4 Pump San Juan River Water to FRE

In the 1988 water rights settlement the Tribe received 10 cfs of water rights from the San Juan River where the river crosses the reservation. A pump and pipeline to convey water from the San Juan River to the FRE lands during a shortage are physically possible but very expensive because of the distance and elevation difference. The cost of the facilities was not estimated because the cost appears to be extremely high.

5.1.4.5 Groundhog Reservoir Enlargement/ Increased Capacity

A recent bathymetric survey of Groundhog has shown additional capacity exists within the reservoir. MVIC has worked with DWR to meet dam safety requirements and has filed a water court application to secure the additional volume. Based on this survey, DWR recommends storage be allowed up to 73.0 feet. MVIC plans to store up to 72.3 feet. The remaining 0.7 feet of water was offered to DWCD for their own interests and ownership. This amounts to approximately 520 AF.

The additional storage for the top 0.7 feet will inundate land currently not impacted. Based on the survey approximately 11.2 acres would be inundated. Much of the inundated lands are undeveloped mostly utilized for grazing; only a single house and small structure may be affected by the expansion. In order to fill the 520 AF a reservoir operation agreement is needed between MVIC and DWCD which is not being contemplated at this time.

5.1.4.6 Hydropower Development Opportunities

The DWCD prepared the "Hydropower Feasibility Study of Potential Sites Within the Dolores Project Water Delivery System" in December 2010 prepared by Harris Water Engineering, Inc. with funding from the Colorado Water Resources and Power Development Authority. The report provides an extensive evaluation of the locations within the Project canals that have hydropower potential and evaluates which should be pursued based on cost and potential power sales. Hydropower development does not increase the water supply during a drought but provides additional funds for DWCD to both develop drought mitigation measures and replace revenue lost during a drought.

The report identified installation of a turbine and generator at the Energy Dissipating Structure (EDS) at the discharge end of the 2 miles of pipe drop at the beginning of Reach 3 of the THC. The EDS is on Tribally owned land and all of the water through the power plant is for delivery to FRE for irrigation. DWCD and the Tribe have been in discussions to develop the site but have not pursued it to construction.

5.2 Non-Structural Mitigation Actions

5.2.1 Improve Joint Operations of McPhee and other Reservoirs

As part of the Plan, options for better use of existing reservoirs and water supplies to provide drought mitigation were evaluated. These options were presented and discussed at a joint Board meeting between DWCD and MVIC. The following concepts were presented and discussed.

A drought reserve would be water stored during times of large runoff then held over multiple years for use in times of drought. The reservoirs being evaluated are Groundhog, Narraguinnep, and Totten reservoirs. Each reservoir has a different potential to provide a drought reserve. Actions specific to Groundhog and Totten reservoirs are mitigation actions. Whereas the action specific to Narraguinnep is a response action. Please see Section 6.4 for the description of the Narraguinnep response action.

Groundhog and Narraguinnep reservoirs are owned and operated by MVIC. Totten Reservoir and its water rights were purchased by DWCD in 2002. One option to maximize the use of these reservoirs is to designate pools within each that are to be used only in drought situations to increase water supply when needed the most. These drought situations would be determined by specific triggers set by MVIC and the DWCD when the action is implemented.

5.2.1.1 Drought Reserve using Groundhog Reservoir

Groundhog appears to have potential for a drought reserve subject to further discussion and formulation of a plan that provides benefits to both the Project water users and MVIC. Groundhog has a senior capacity of 21,710 AF and MVIC is seeking a junior capacity of 4,410 AF for a total of 26,120 AF. There is a 3,960 AF minimum fish pool agreement between MVIC and CPW. The reservoir capacity is more than double the average annual inflow; it is approximately 9,000 to 11,000 AF. The period of record (1972 to present) shows a minimum inflow of 277 AF and a maximum of 19,000 AF.

Historically, MVIC has used the "top half" of Groundhog's available capacity. Only in the wettest of years would Groundhog fill if it was drained to the fish pool the previous year. With the 3,960 AF fish pool, an inflow is needed of 22,160 AF to fill. The period of record indicates this is a rare occurrence.

The concept for the Groundhog drought reserve is to operate the "top half" of the reservoir, approximately 13,000 AF. While keeping the "bottom half" of the reservoir, a net of 9,040 AF less the fish pool as a drought reservoir. An agreement would be needed for MVIC to leave water in Groundhog without it counting against their Non-Project water calculations in Exhibit A, used to determine MVICs annual Project Water entitlement. This would provide the maximum use of their existing water rights and open up for fills under their junior capacity water right. No new facilities would need to be constructed for implementation.

5.2.1.2 Drought Reserve using Totten Reservoir

Totten has the potential to provide additional water during a drought subject to construction of new facilities to convey water from Totten to the THC. This action is described in detail under Section 5.1.4.3; please reference for a full description. The Totten drought reserve cost would be in the range of $4 to $6 million to be able to use up to 2,200 AF.

5.2.2 Water Users Leasing Water to Other Users

The potential exists in the Project contracts and physically for Project allocations for an individual or group of individuals to be leased to another Project user on a voluntary and compensated basis. This would require approval by the DWCD Board and concurrence by Reclamation. The leases may be made on either a year by year basis or multi-year basis. The actions described below include the possibility of leasing.

5.2.2.1 FRE Leasing Water From DWCD

For many years, the FRE has been seeking an additional permanent supply of irrigation water in the amount of 4,000 AF. In order to secure the water, it will be necessary to utilize temporary leases until such time that a permanent supply is developed.

Potential sources of water to meet FRE needs exist. DWCD may provide water from reallocation of senior downstream water rights, allocation of Class B shares to exchange with Project water, reallocation of Project water, and Totten releases through the THC.

5.2.2.2 MVIC Leasing Opportunities

In order for MVIC to lease non-project water to another user, a methodology would be developed to integrate the leased water into accounting for MVICs contractual entitlement to Project Water, and other contractual rights and obligations. The methodology could provide a basis for determining in the future if MVIC has water supplies that might be leased for purposes allowed by MVICs water right decrees. The DWR determined that the FRE lands and the southern portion of the DCC lands are within the decreed area for MVIC. Since MVIC water is non-Project water, a carriage contract is required with the Reclamation to convey the water through Project facilities; a carriage contract exists for the DCC but not for any other Project facilities. Historic delivery patterns and tribal sovereignty may affect the need for a carriage contract for facilities on the FRE.

Opportunity exists for the creation of Class C shares within MVIC. These shares would be created with the conserved water saved by system-wide efficiency improvements. A need exists for additional water supply to the Redlands, McElmo Creek and/or Goodman Point irrigators.

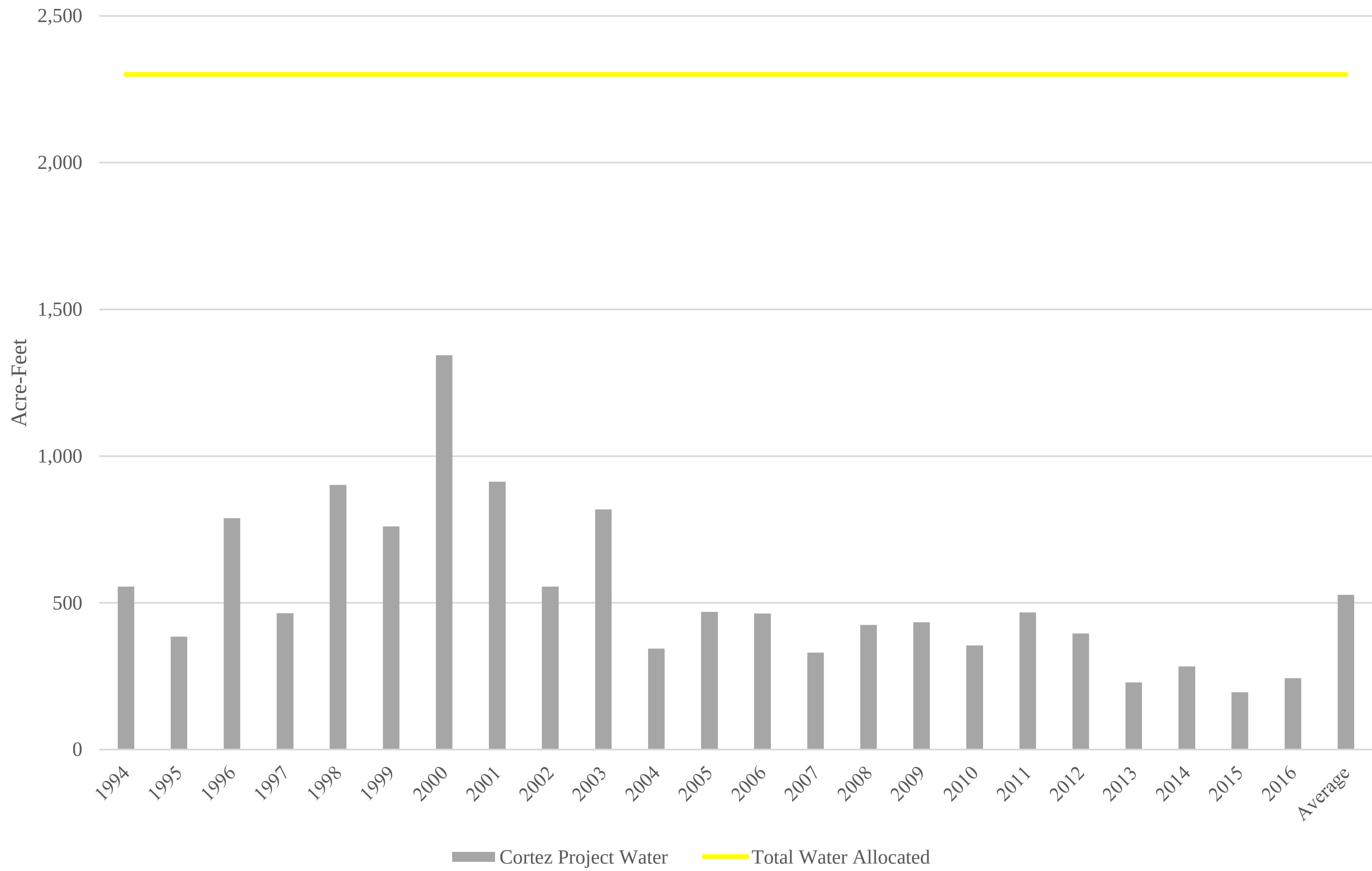
5.2.2.3 M&I Leasing Opportunities

A total of 8,700 AF of M&I water is allocated to Project users: DWCD's total is 5,120 AF, Dove Creek's total is 280 AF, City of Cortez's total is 2,300 AF, and the Ute Mountain Ute Tribe's total is 1,000 AF.

The DWCD owns 5,120 AF of M&I water from the Project of which approximately 4,500 AF is not contracted and available for lease. Although the water is not committed to a specific contracted user, the DWCD is repaying the cost of the water to the federal government through a property tax mill levy approved by the voters of the DWCD. The contracted water is utilized by providing 318 lawn and garden taps, augmenting 155 upstream users and truck haulers for various stock and construction purposes. As M&I water is permanently committed to upstream and/or lawn and garden users, the repayment obligation for each AF is moved from the tax role to the new payors that have contracted for M&I water. Uncommitted supplies are often leased to FRE, used to supplement the FSA irrigator pool or left in McPhee storage.

The City of Cortez owns 2,300 AF of Project water. Figure 15 below depicts the annual amount of Project water the City of Cortez has used. Since 1994, the City of Cortez has used on average 556 AF leaving an average of 1,744 AF of Project water not currently used by the city. The available unused Project water ranges from a minimum of 956 AF in 2000 to a maximum of 2,071 AF available in 2014. Unused supplies may be leased to other Project water users by arrangement through DWCD.

Figure 16. City of Cortez Annual Municipal Use



5.2.2.4 Class B Shares

In 2002, the DWCD purchased a water supply in the form of 1,500 Class B shares providing 4.0 AF/share from MVIC. These shares equate to a total diversion of up to 6,000 AF annually. This water is subject to shortages similar to Project water. Class B water is being used to increase the supply in the FSA irrigation pool for use when needed by the irrigators or for added carryover storage in McPhee.

Class B shares may also be used as a drought response action. See section 6.3.1 for further details and descriptions.

5.2.2.5 Late Season Water Availability

Late season water sales are possible when a year's water supply is greater than the demand of FSA irrigators. The FSA irrigators do not use the same amount of water each year due to variable climatic conditions. In years that the amount of water allocated to some FSA irrigators is not fully used the available water could be provided to other irrigators that need additional water. One method to create additional availability of water is to set a predetermined cap on water supplied to each irrigator. The benefit of this cap would be twofold:

1) By setting a limit the irrigator is forced to become as efficient as possible with what water supply they have available and
2) By generating income to DWCD by increased water sales to those willing to pay for water above their cap, and potentially to other entities with a short-term water need.

These revenues can be reinvested in Project O&M and/or replenishing the reserve dedicated to capital replacement, and the reserve set up to reduce water charges during periods of drought and economic hardship.

5.2.3 Hermana Canal Coordination with THC Operations

The Hermana receives 7 cfs of water from Narraguinnep. The tail water of the Hermana enters the THC and bypasses the Dolores Tunnel and Towaoc Power Plant. This means that any flows through the Hermana not utilized by turnouts along the canal are flows that could otherwise be diverted through the Dolores Tunnel to the Towaoc Power Plant to produce power.

An existing flume is located at the downstream end of the Hermana. This flume is back-flooded, making it difficult to measure the flows in the Hermana. By not having accurate measurements it is difficult to regulate these flows, especially when water needs to be well managed during years of short supply. For example, an isolated rain storm will occur and due to the lack of measurement of the Hermana, releases will not be decreased. This leads to wasted tail water and upset shareholders. In 2013, approximately 5 to 10 AF were wasted; this amount during drought conditions is significant.

The reason for the back-flooding is sedimentation build up in the Hermana downstream of the flume which has worsened over the years and was very noticeable in 2016. Currently, the original discharge measuring equipment is non-functional allowing only a simple bob and meter to provide flow measurements. Intermediate attempts have been made to induce ideal free-flow conditions in the flume but this method is inconvenient for control room technicians and is not a long-term solution.

There are several options for resolving the back-flooding issues. These options are listed below.

1. Repair the original equipment at the flume. This allows for submergence and stage data to be collected. The discharge would be estimated, but with some inaccuracy, as using a submergence to measure under back-flooding conditions is an imperfect system. This option is likely the most convenient and quickest to implement, even if it is only part of the solution.
2. If after investigation the original flume equipment is inoperable, a new collection of equipment would be installed to collect the information separately from the flume's equipment while still utilizing the submergence to estimate back-flooding. Personnel to periodically collect the date would need to be identified. The same level of accuracy would be achieved as in option #1.
3. Mechanical removal of the sediment downstream of the flume. This has the potential to eliminate the problems associated with back-flooding entirely. This may be the best option, to eliminate the problem, but routine maintenance would be required into the future to keep the sediment accumulation from occurring again.
4. Instead of rehabilitating the existing flume, install an "up-looker" in the flume. An "up-looker" is a sonic device capable of measuring the velocity profile of the flow in the canal. This would provide a discharge value not influenced by submergence.

To implement this action, coordination between DWCD and MVIC will be necessary to investigate, identify, discuss, and implement the best option to improve water management of the Hermana.

Benefits of this action would include conserved water, increased power production, and better water management of the delivery system. This action provides for more operational control and generates more power.

5.2.4 Precipitation Augmentation

The DWCD provides annual funding to cloud seeding programs sponsored by SWCD, Colorado Water Conservation Board (CWCB), Lower Colorado River Basin and other interests. In 2004, CWCB initiated a grant program to cost share cloud seeding operations with local sponsors. Recently, grants from the Lower Colorado River Basin states to CWCB to increase the Colorado River water supply.

Cloud seeding is the process of burning silver iodide through an ice nucleus generator that is carried up into the clouds to stimulate the precipitation process. The type of weather modification utilized in the West Dolores and Telluride Resort Ski Area Program is ground-based targeting the upper regions of the West Dolores and San Miguel River drainage basins. Yearly monitoring of the program is necessary to gage effectiveness of cloud seeding, quantity efforts, and determine best locations and technologies that should be used.

Future program efforts include funding new meteorological instrumentation, new remote generators to maximize the effectiveness of seeding operations, new manual generators only if carefully reviewed and approved, and on-going scientific evaluations of seeding effectiveness and generation equipment location and type. Existing funds are not adequate to take advantage of all opportunities; whether that be seeding events or utilization of new technologies. Currently, the program seeks to create a strategic plan that investigates program modernization strategies and priorities.

5.2.5 Full Service Area Assessments

This action is the non-structural component of the structural mitigation action in Section 5.1.3.2. Irrigators face many hurdles when they try to improve on farm efficiency but the cost of equipment appears to be the most limiting factor. If funding were made available to help cost share improvements then irrigators will be in a stronger position to invest in efficiencies. Potential exists in the FSA area for upgraded systems from side roll to center pivot irrigation. Understanding what applicable equipment to use and best management practices to promote conservation are key outcomes.

One source of funding is through the Natural Resources Conservation Service (NRCS) through their Environmental Quality Incentives Program (EQIP). The EQIP is

"a voluntary program that provides financial and technical assistance to agricultural producers to plan and implement conservation practices that improve soil, water, plant, animal, air and related natural resources on agricultural land."

DWCD partnered with High Desert Conservation District (HDCD) in an effort to expand outreach to the FSA irrigators and to investigate eligibility requirements. Under existing specifications, CO NRCS Standard 442 for center pivots, land exceeding 3% slope on 50% or more of the field, or 5% slope on 50% or more of the field (for fine and course textured soils), are not eligible for funding. Collected data, present and future, will be used by the local NRCS engineer to assess slope criteria and if variances may be given to individuals.

Data collection began in the 2016 irrigation season. HDCD worked with approximately 20 volunteer farms utilizing center pivots or farms wanting to upgrade to pivot packages. A total of 1,089 acres were assessed in 2016. Assessments looked at pivot design, nozzle packages, soils information, system data, and catch can collection data. Please reference Appendix A for the first year's assessment report. By using center pivots and system packages, the benefits are labor savings, potential yield increases, and potential water conservation. Assessments should be continued in the future until enough data is collected for NRCS to evaluate the slope criteria.

From the assessment, the following conclusions should be considered for existing and additional pivot assessments:

- Soils Data: Soil texture dictates the slope criteria and more soil data is needed. During the 2016 season, only one site's soil data was collected.
- Infiltration Rates: While average area soil infiltration rates are typically used, more site-specific rates coupled with soil data will better inform system design and management considerations.
- Follow-up Assessments: Assessing sites over time will yield data on how systems and their operations change over time.

5.2.6 McElmo Transit Water Loss Study

To better manager water delivery from Totten to McElmo Creek users a field study to better estimate the transit water loss is necessary. A pilot program to lease Totten water was conducted recently, but the transit water losses were estimated based on the lack of field study verification. A study is proposed to better quantify the water lost in transit to prevent releases greater than needed. Any excess in releases from Totten flow out of Colorado and cannot be recovered.

The proposed study would segment the length of McElmo Creek that is used to convey water. Dependent upon the available funding the number of multiple measurements' locations will be determined and data collected at each location including width and depth of the channel. The study will involve an attempt to measure a steady flow rate throughout the segment (no diversions), with flow measurements at each location, to assess any reduction in flow. The data collected in the field, through evaluation, will result in transit loss rates for the study area.

5.2.7 DWCD Drought Financial Reserves

The DWCD invested monies into reserves as part of the initial Project development. These reserves are used to reduce the financial burden of paying the water base cost to FSA irrigators when there is insufficient water to raise a full crop during a drought. During recent droughts, the DWCD's reserve accounts were depleted (nearly $1 million) due to the reduced income from water sales. After the most recent drought, a long-term strategy was implemented to replenish these reserves. The farmers supported an incremental assessment per AF on water purchased over a ten-year period. These payments will equal the amount expended from the existing reserves during the last drought year.

6 Response Actions to a Drought

This section identifies non-structural response actions to be implemented during a drought year. The response actions are triggered during stages of drought to better manage the limited supply and decrease severity of immediate drought related impacts.

The Project and its users experience two types of droughts: (1) hydrological and (2) operational shortages. A hydrological drought occurs when minimal water supply is available in the streams resulting in minimal inflow into the McPhee. This type of drought, such as 2002, affects all Project users. An operational shortage drought is due to a specific users legally allowed water supply. For instance, during a Managed Spill year all or a portion of MVIC's stored water in McPhee will be released, because Project Water storage takes precedent, causing MVIC to be water short in the latter portion of the irrigation season. While this is occurring, McPhee is full or nearly full which provides other Project users a full supply.

The Planning Task Force, along with input from the entities they represent, brainstormed and developed the following proposed response actions as part of the Plan's development process. Multiple discussions were conduct pertaining to a specific action; including steps for evaluation, cost and potential funding sources, feasibility, and priority relative to other actions.

Response actions for both types of droughts are described herein in no particular order. While some actions are, applicable no matter the severity or type of drought, others are only applicable during one type of drought. Some actions will require some form of board(s) approval for implementing the actions when necessary.

6.1 Active Communication Structure

Communication is key during any drought regardless of the severity. Active communication provides Project users with up to date information to better inform themselves of how best to manage a limited water supply. Close communication among all water management entities associated with McPhee Reservoir is critical to the coordination of drought response by managers and field crews, as they work together to make the most of scarce water availability. This structure encourages communication amongst all Project water users. While communication is necessary throughout any water year, during a drought year communication should be increased proportionally to the decrease in available supply. DWCD staff will meet regularly to monitor water supply forecasts and projections and communicate the latest projections to FSA irrigators, MVIC, FRE, and others. MVIC staff will meet regularly with ditch riders to monitor their facilities and shareholders. FRE staff will meet regularly to monitor facilities and assess drought related changes in cropping pattern. Direct phone calls will be made regularly between DWCD, MVIC, and FRE; if necessary monthly or bi-monthly meetings may be held to discuss the water supply.

6.2 Improve Water Supply Projections and Timing

DWCD currently does a plethora of monitoring (see Section 3: Drought Monitoring) using their own data (e.g. low snow measurement) and information from NOAA's CBRFC. As this information accumulates over the course of the winter, the following time periods are used by DWCD to track the likelihood of shortages to water users during the next irrigation season.

- November – If the McPhee active content in November is less than 60,000 AF there is a potential for shortage the following irrigation season. Based on Figure 7 if the active McPhee content was more than 60,000 AF there was never a shortage the next irrigation season but if the content was less than 60,000 AF shortages could occur such as in 2002, 2003 and 2013. Though the McPhee content criteria does not accurately predict shortages it does indicate if there is a possibility.

- January – The January forecast of the April through July runoff volume is provided by the CBRFC; this is the first prediction that begins to be useful to DWCD. If the snowpack is high, the chance of shortage is lower but if the snowpack is low then more careful monitoring will occur from then on.

- February – Similar to January, if the snowpack is high, the chance of shortage is lower but if the snowpack is low then more careful monitoring and communication with water users will occur. In addition to the CBRFC, DWCD also maintains low snow measurement sites which provide an indication of the amount of low snow. February provides a good indication of low snow moisture.

- March 1 – In March the amount of runoff and the potential for shortage is better predicted though still early in the season. If shortage is a possibility the DWCD will begin to notify the water users of the potential and the amount of shortage.

- March 15 – If a shortage is a possibility, a mid-March runoff forecast will be used and new estimates of the chance and amount of shortage prepared. Particularly for FRE the mid-March forecast provides an indication of the water supply and in order to begin to determine the cropping pattern. Direct and continuous contact will begin with all of the irrigators and the fishery interests as the potential for shortage unfolds. Though DWCD has made these contacts in the past droughts, as a result of the Plan there will be a greater effort to keep water users as knowledgeable as possible.

- April 1 – The April 1 forecast is especially critical to the FRE because the cropping pattern for the next irrigation season is planned based on the water supply. If there is a shortage predicted FRE will take steps to reduce water use. Adjusting the cropping pattern afterwards is difficult if not impossible. DWCD will of course be in constant contact with FRE but will continue notification of FSA irrigators of the potential and amount of shortage. The first estimate of the irrigation water cap to FSA irrigators will be determined. DWCD contact with water users will be even more often, possibly weekly.

- April 1 to 30 – If there is a potential shortage, DWCD will constantly monitor the runoff forecast throughout April and notify the FRE, MVIC, and FSA irrigators of the situation.

The estimated FSA irrigator water cap will be adjusted as appropriate to reflect the changing runoff conditions.

- May 1 – The final amount of water available to all of the irrigators and the fishery will be established based on DWCD collected data and informed by the CBRFC April through July runoff volume forecasts. If the weather is extremely wet or dry periods after May 1 the prediction may change as occurred in May and June of 2015. By this date, the FRE has already determined the cropping pattern but the FSA irrigators will now finalize their cropping plans based on the water supply.

Due to the variability of spring storms, it is hard to forecast the available water supply before the April 1 forecast and even after that time the runoff has change for better or worse. As can be seen in the above time periods, the there is little opportunity to improve the forecasting of water supply projections. The best opportunity to reduce the impact of shortage is in communication with users so they can the best possible decisions on how to utilize the available water supply. Figure 17 depicts the active capacity found on November 1^{st} versus April 1^{st} for the McPhee.

Figure 17. November 1st vs. April 1st McPhee Active Capacity

6.3 Use of DWCD Water Portfolio for Other Project Uses During a Drought

6.3.1 Class B Shares

As discussed above, in 2002, the DWCD purchased a water supply in the form of 1,500 Class B shares with a supply of 6,000 AF but is shorted the same at FSA irrigators. During an operational shortage, when MVIC is experiencing shortage while the Project water supply is not shorted, a potential exists for DWCD to lease Class B shares to MVIC. During these years, MVIC would benefit if the Class B water was used by MVIC, under the circumstances DWCD does not need the Class B supply.

MVIC Class A shares are not subject to the same shortages as Class B shares. The contract calls for Class B diversions to the Project's FSA irrigators to be shorted in the same proportion as Project water. During a hydrologic shortage, when direct river flows only satisfy MVIC's water rights and provide no additional flow for storage in McPhee, shorting Class B shares the same as Class A shares would benefit Project water users.

The ability of MVIC to use Class B water, when spilling of call water constrains MVIC supplies and for DWCD FSA irrigators to receive Class B water that is only shorted in drought years to the same degree as MVIC Class A shares, may provide the basis for a tradeoff that is beneficial to both organizations. Details on when such benefits would be triggered, related water accounting procedures, and what changes would be needed in the Class B contract, will require further discussion and evaluation based on the board(s) direction.

6.3.2 Water Exchange Between Users

A FSA irrigator's water payments include a base rate and a cost per AF used. Regardless of the volume of water purchased, an irrigator pays the base water charge. During a shortage, an irrigator's water supply will only be sufficient for decreased acreage or only available for one cutting of alfalfa. Because of this lack of production and subsequent income, an irrigator may wish to not irrigate at all that year.

Thus, a potential exists during a shortage for FSA irrigators to be relieved of their water and water charges in exchange for leaving their allocated share of water in the pool. This would require administrative mechanisms that don't currently exist. To the extent that such forgone water contributes to a revenue generating lease by DWCD, the proceeds will be reinvested in the OM&R of the Project using revenue that is not generated by water charges from FSA irrigators.

6.4 Narraguinnep Reservoir Re-Operations

Narraguinnep has the potential to provide additional water during a drought through exchange storage in McPhee. The response action would be to store water typically stored in Narraguinnep in McPhee at specific times of year as necessary for drought protection. In a year when the space is available in McPhee, for example in a drought year, a volume of water is stored in McPhee during the run-off season would be treated as Narraguinnep water and would not be physically stored in Narraguinnep. The Narraguinnep water would be available for use by MVIC as it would be if stored in Narraguinnep.

There are Project wide benefits for storing Narraguinnep water in McPhee such as the lake elevation of McPhee would be increased that will reduce pumping costs at Great Cut Dike and delay or avoid reaching elevations in McPhee Reservoir that make it impossible to pump water to the DCC, U Lateral and Lone Pine. Also, in times when water from Narraguinnep cannot reach all MVIC shareholders it can be released to MVIC shareholders from McPhee through the Dolores Tunnel. Therefore, storage of Narraguinnep water in McPhee increases the versatility for MVIC especially during a water short year. This also results in the option to release more water through the Towaoc Power Plant subsequently producing more power for Western.

While storing Narraguinnep water in McPhee leads to more flexible water management it may come at additional costs. There may be a carriage cost by Reclamation for MVIC use of Project facilities. The increased surface area of McPhee may lead to greater evaporation losses. The decision to store Narraguinnep water in McPhee would have to be made prior to the run-off season, before physically filling Narraguinnep, which may be too early in the season to identify the year as a "Drought Year".

6.5 Increase MVIC Early Direct Flow Diversions in Years of Managed Spills

When Project inflows are greater than McPhee storage capacity, water is gradually released throughout the spring to avoid using the McPhee spillway. These releases are considered Managed Spills. Due to the high natural variability and limitations in forecasting yearly runoff volumes, this approach helps insure that a full Project water supply could be stored before risking the release of substantial volumes of water downstream. Managed Spills do not occur every year. Since 2000, only two years with significant spills and five years with minimal spills have occurred. However, long term hydrology indicates nearly half the years will have a Managed Spill.

MVIC's senior water rights allow it to divert water and under Project governing documents the difference between the actual diversion and water rights can be stored (referred to as "call water") in McPhee up to a maximum of 72,000 AF in April, May, June. However, in years with a Managed Spill, Project governing documents also require the call water to be the first water released from McPhee as part of the spill.

The proposed action would be to increase direct diversion to MVIC irrigators as allowed by their water right, in the beginning of the irrigation season, in anticipation of a Managed Spill while minimizing the amount of water spilled downstream. MVIC's irrigation season typically begins in late April but as early as April 1st.

The proposed action was not further evaluated because water diverted in April and May may not be beneficially used by the crop and may not be needed fill the soil profile. Before the Project, MVIC made these early diversions, every year and found them to not be generally useful, the water just flows down to McElmo Creek. While stock water runs occur in the early spring, the delivery system is not fully charged or operational for early diversions to begin. Also, the need for early season water in a Managed Spill year has not been expressed to date.

7 Operation and Administrative Framework

The Planning Task Force members were responsible for the decision making and development process of the Plan. The Planning Task Force met regularly to provide guidance to contractors on analysis, work products and stakeholder outreach efforts. Final review of the Plan and approval will be done by the Boards, the Planning Task Force and input from stakeholders.

7.1 Roles

The operational and administrative framework to implement the Plan will be led by DWCD who is responsible for Project operations and the delivery of water to the users. DWCD already has an administrative framework established with the water users that rely on McPhee. The current framework involves coordination on nearly a daily basis beginning in early February as projections of the yearly water supply are being made. The daily coordination continues during the irrigation season and other critical times.

7.2 Responsibilities & Procedures

Project users are responsible for implementing actions specific to their structural and non-structural water management needs. Procedures needed to implement actions may vary by action or by Project user responsible for implementation. When an action involves policy agreement between multiple parties, staff will facilitate coordination to seek common alignments among the parties.

DWCD drought responsibilities will include:

- Drought monitoring and notification directly to Project water users,
- Drought notification to general public and second level stakeholders,
- Notification of the potential and amount of water shortage due to drought,
- Notification of Colorado Parks and Wildlife of a shortage to the fishery releases,
- Notification to boating interests that there is not sufficient water for a boating season,
- Implementation of drought response actions described in the Plan with MVIC and FRE,
- Initiate securing resources to assist during drought other than DWCD resources,
- Request for State and/or National Disaster Declaration, and
- Following the drought, review and evaluation of the Plan's effectiveness with MVIC and FRE to determine if updates are necessary.

MVIC drought responsibilities will include:

- Drought monitoring of its reservoirs and other facilities,
- Drought notification to shareholders,
- Notification of the potential and amount of water shortage due to drought,
- Implementation of drought response actions described in the Plan with DWCD and FRE,
- Initiate securing resources to assist during drought other than MVIC resources,
- Request for State and/or National Disaster Declaration, and
- Following the drought, review and evaluation of the Plan's effectiveness with DWCD and FRE to determine if updates are necessary.

FRE drought responsibilities will include:

- Drought monitoring of facilities and cropping pattern,
- Implementation of drought response actions described in the Plan with MVIC and DWCD,
- Initiate securing resources to assist during drought other than FRE resources,
- Request for State and/or National Disaster Declaration, and
- Following the drought, review and evaluation of the Plan's effectiveness with DWCD and FRE to determine if updates are necessary.

8 Plan Update Process

8.1 Plan Evaluation Process

The Plan is viewed as a process, not a static document that will apply indefinitely into the future. The Plan should not be considered the last word on Mitigation and Response Actions for the Dolores Project and its users. The Plan will be reviewed and updated periodically to assure that it responds effectively to the changing needs of the many groups and communities that benefit from the Dolores Project.

The National Drought Mitigation Center 10 step drought planning process provided guidance for how the Plan evaluation will be conducted to test the Plan effectiveness. The evaluations will address climatic and environmental aspects, how pre-drought planning was useful, and weaknesses or problems with the Plan.

8.2 Measuring the Effectiveness of the Plan

The Plan's purpose is to reduce risk to all Project users due to drought related impacts. The DWCD and other users have already begun to transition from crisis management approach to a more proactive risk-based management approach. This has taken place over many years since the first drought induced shortages in Project history in 2002-03, followed by severe drought and Project Water shortages in 2013.The Plan is another step towards that risk-based management approach built on the foundation of lessons learned from previous droughts. The plan will be measured for effectives and adapted based on:

1) Ongoing evaluation of progress on mitigation measures and
2) Post drought evaluations.

Each Project user is responsible for implementing and measuring the effectiveness of actions specific to their structural and non-structural water management needs. The Planning Task Force may work together in the future to assess actions in the Plan if the action relates to more than one user. All entities will work together to measure the effectiveness of the Plan after a drought to discuss and determine what actions were effective, which where were not, reasons why some measures may not have been as effective, as a basis for identifying future actions to help manage future drought risk.

8.2.1 Ongoing Evaluation

The ongoing evaluation will track how changes in technology, forecasting, laws, and political context which may affect the Project's operations and drought risk. While drought risk may be evaluated frequently, this does not mean the Plan needs to be updated as often. Using the risk-based management approach, any lessons learned by may be implemented without needing to update the Plan.

8.2.2 Post-Drought Evaluation

A post-drought evaluation is necessary to assess the effectiveness of the Plan's response actions to a drought. Without an evaluation, it is hard to learn from past success, mistakes, and identify future needed actions. The evaluation should include:

- Analysis and assessment of climate, hydrology, and environmental impacts,
- Identify any economic or social consequences,
- Assess the extent the Plan's actions were useful (or not) in mitigating impacts, and
- Identify any other weaknesses or problems caused by or not coved by the Plan.

Once the evaluation is completed, individual entities and the Planning Task Force should identify any future mitigation and/or response actions that address any outstanding needs. By working together and approaching drought planning as an ongoing process, Project users collectively lessen the potential risks associated with drought.

8.3 Timing of Updates to the Plan

Drought planning, as stated previously, is an ongoing process that continues to evolve over time. It is necessary to continually evaluate changing vulnerabilities and how Project users may work together to lessen the risk. The Plan should be updated as needed which may not occur on a regular basis. At a minimum, the ongoing evaluation should help inform the need of an update and identify the applicable timing of when an update should occur. It is recommended anytime a post-drought evaluation is triggered, the Plan should be updated with this latest information.

9 Summary of Drought Plan Actions and Recommendations

The Planning Task Force generated the below priority list. These are preliminary priories subject to change after review by DWCD Board, MVIC Board, and/or FRE. While the actions have been prioritized for purposes of this Plan, these prioritizations should not be the final implementation schedule. Many factors affect the ability to implement an action. Due to this, some actions may come to fruition regardless of their priority. These priorities are to be used as a tool to direct DWCD, MVIC, FRE and other Project users' resources to the appropriate measures for implementation.

9.1 Mitigation Actions

The below table prioritizes structural and/or non-structural actions that can be implemented prior to a drought to better utilize the available water supply and/or make the water users more resilient to drought.

Table 14. Recommended Structural Mitigation Actions

Section	Priority and Action	Description
High Priority		
5.1.1.1	FRE Action: Control Valves	The need for isolation valves exists in the delivery system to handle water fluctuations
5.1.2.1	MVIC Action: General System Improvements	The need for delivery system improvements within the MVIC system
5.1.2.2	MVIC Action: Measuring Stations with Remote Monitoring in MVIC Delivery System	Satellite measuring stations in MVIC delivery system to reduce operational spills
5.1.2.4	MVIC Action: Piping Improvements for Existing Infrastructure	Priority piping improvements for MVIC delivery system
5.1.2.5	MVIC Action: MVIC Service Area On-Farm Efficiency Improvements	On-farm efficiency improvement opportunities exist in the MVIC service area
5.1.3.1	DWCD Action: General System Improvements	The need for delivery system improvements within the DWCD system to improve water conservation and delivery
5.1.3.2	DWCD Action: Full Service Allocation Area On-Farm Efficiency Improvements	On-farm efficiency improvement opportunities exist in the FSA irrigated lands
Medium Priority		
5.1.1.2	FRE Action: Connect Irrigated Lands near Casino directly to Rocky Ford Lateral	Connect existing irrigated lands near the Casino to the Rocky Ford Lateral
5.1.2.3	MVIC Action: Upgrade Canal Communication System	Convert canal communication system control to a digital SCADA system
5.1.3.3	DWCD Action: Hovenweep Delivery System Improvements	The need for Hovenweep delivery system high pressure improvements
5.1.4.1	DWCD Action: New Plateau Reservoir & Pump Storage Project	Construction of a new reservoir to increase water supplies for the fishery and M&I
5.1.4.3	Multi User Action: Totten Reservoir pump to THC	A pumpback project to pump water from Totten Reservoir into the THC for Project uses
Low Priority		
5.1.2.6	MVIC Action: Hydropower Development Opportunities	Potential hydropower development exists on MVIC facilities
5.1.4.5	DWCD Action: Groundhog Reservoir Enlargement	Enlargement of Groundhog for additional pool of water for use as drought mitigation
5.1.4.6	DWCD Action: Hydropower Development Opportunities	Additional hydropower development exists on Project facilities
5.1.4.4	FRE Action: Pump San Juan River to FRE	A pumpback project to pump water from the San Juan River to FRE
5.1.4.2	Multi User Action: Increase Totten Reservoir Inflow	A pumpback project to pump water from McElmo Creek back to Totten Reservoir for Project uses

Table 15. Recommended Non-Structural Mitigation Actions

Section	Priority and Action	Description
High Priority		
5.2.1	Improve Joint Operations of McPhee and other Reservoirs	Opportunity for better use of existing reservoirs and water supplies by jointly managing facilities
5.2.2.1	FRE Leasing Water From DWCD	FRE is seeking an additional permanent supply of irrigation water in the amount of 4,000 AF
5.2.2.2	MVIC Leasing Opportunities	Potential to lease MVIC water to other Project users or lands within existing service area
5.2.2.3	M&I Leasing Opportunities	Potential to lease Cortez M&I water to Project users (on either a year by year basis or multi-year basis)
5.2.5	Full Service Area Assessments	Opportunity to conduct assessments for individual irrigators or entities interested in evaluating their current irrigation practices; program could collect valuable information about irrigation practices and provide feedback on efficiency improvements
5.2.7	DWCD Drought Financial Reserves	Replenish drought financial reserves used to reduce the financial burden on FSA irrigators during a drought
Medium Priority		
5.2.4	Precipitation Augmentation	Provide annual funding to cloud seeding programs
5.2.2.4	Class B Shares Leasing Opportunities	MVIC use of Class B shares when spill of Call Storage water occurs
5.2.2.5	Late Season Water Availably	In years that the amount of water allocated to some FSA irrigators is not fully used the available water could be provided to other irrigators that need additional water
Low Priority		
5.2.3	Hermana Canal Coordination	Improve Hermana Canal operations; including during rain events
5.2.6	McElmo Transit Water Loss Study	A field study to better estimate the transit water losses in McElmo Creek as it relates to releases from Totten Reservoir downstream

9.2 Response Actions

The below table prioritizes non-structural response actions to be implemented during a drought year. The response actions are triggered during stages of drought to better manage the limited supply and decrease severity of immediate drought related impacts.

Table 16. Recommended Response Actions

Section	Priority and Action	Description
High Priority		
6.1	Active Communication Structure	Evaluations of the available water supply communicated between farmers, DWCD staff, MVIC staff, FRE staff, and other Project users
6.2	Improve Water Supply Projections and Timing	Continue to work on improving application of forecast and projections to the available water supply
6.4	Narraguinnep Reservoir Re-Operations	Store Narraguinnep water in McPhee at specific times as necessary for drought protection
Medium Priority		
6.3	Use of DWCD Water Portfolio for Other Project Uses During a Drought	Potential during a declared shortage for FSA irrigators to be relived of water and water charges when a willing payer exists that would utilize their water supply
Low Priority		
6.5	Increase MVIC Early Direct Flow Diversions in Years of Managed Spills	Increase MVIC early direct flow diversions for April, May, and June when call water shortage is limited