PROJECT EXTENSION REPORT

DEVELOPMENT OF MINER FLAT DAM AND CANYON DAY IRRIGATION PROJECT

IN CONJUNCTION WITH BONITO CREEK AND CIBECUE CREEK DEVELOPMENT

WHITE MOUNTAIN APACHE TRIBE
FORT APACHE INDIAN RESERVATION

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CONTRIBUTOR LIST

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The Economics Group of ENTRIX (formerly Northwest Economic Associates (NEA)) specializes in natural resource economic consulting with offices in Vancouver, Washington, and Sacramento, California. In February 2004, NEA merged with ENTRIX, Inc., an environmental consulting firm specializing in water and natural resource management, environmental geosciences, environmental risk management, and facility permitting and compliance. ENTRIX employs 300 people in about 19 offices through the U.S., Canada, and Ecuador, and is incorporated in the State of Texas. NEA became the Economics Division of ENTRIX, and employs 21 persons, including three with Ph.D. and nine with Master's degrees in applied economics. The staff includes experienced professionals with discipline and work specialties in economic analysis, litigation and negotiation support, natural resources management, agricultural production, regional economics, GIS/GPS mapping, fishery economics, energy, and FERC re-licensing analysis. Expertise in the allied disciplines of land use and recreation planning, water resource planning, forestry, energy conservation, socioeconomic analysis, EA/EIS preparation, impacts analysis, as well as technical writing, editing, and exhibit preparation also are represented on the ENTRIX staff.

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EXECUTIVE SUMMARY

The White Mountain Apache Tribe, which resides on its aboriginal homelands within the Fort Apache Indian Reservation in east central Arizona, undertook a series of investigations from the late 1970s to the present to determine the best use of the water resources on its Reservation for a growing population and the need for economic development. The first of these investigations focused on the White River for irrigation and drinking water purposes.

Planning for the White River development included an alternative for delivery of water to the community of Cibecue for domestic purposes as well, some sixty miles from the proposed storage project. The community of Cibecue is situated on Cibecue Creek and relies on wells drilled in the alluvium adjacent to the stream. Development of Cibecue Creek for future domestic purposes and other multi-purposes, including irrigation and recreation, was considered an alternative to the delivery of water from the White River to Cibecue.

Bonito Creek is an alternative to or supplement of the White River for domestic water supply to the Greater Whiteriver area when future demand exceeds the dependable, regulated water supply of the White River. Bonito Creek can be developed for irrigation of Bonito Prairie until the supply is needed for domestic purposes. The transfer of the Bonito Creek supply from irrigation to domestic uses will be needed in the next century.

Groundwater was considered an alternative to the Reservation streams described above. The development and sustainability of groundwater was found infeasible for current and future domestic water demands of the communities served by the Greater Whiteriver, Cedar Creek, Carrizo and Cibecue public water systems.

ES-1. Plan Formulation

The formulation of the plans and the feasibility of the alternatives presented in the report are summarized here. The basic elements of the planning within each of the three watersheds, White River, Cibecue Creek and Bonito Creek, are described in the following sections.

ES-1.1 White River

By the early 1980s, the Tribe had begun irrigating part of the Canyon Day Flat approximately 8 miles southwest of the tribal headquarters community of Whiteriver. This was the first undertaking of the Tribe to irrigate bench lands or flats above the valley floors along the streams crossing the Reservation. Historically, the Tribe had irrigated more than 4,000 acres on the valley floors using ancient ditches developed before the settlement of Arizona. The Tribe developed 885 acres of land at Canyon Day Flat with water for sprinkler irrigation pumped from the White River below the confluence of the North and East Forks of the White River.

Recognizing that storage would be required to significantly expand the irrigated acreage in the Canyon Day Irrigation Project (to a total 5,875 acres), the Tribe considered several damsites along the White River and North Fork of the White River before selecting a location east of Miner Flat as a preferred alternative. The damsite is approximately 19 miles upstream from the community of Whiteriver, is situated on the North Fork of the White River and has regulatory capability to deliver water to the public water system serving the community and surrounding area and to supply water for the Canyon Day Irrigation Project. Geotechnical characteristics were explored in the 1980s and early 1990s to assess the foundation and abutments at the damsite and within the reservoir area.

Prior to the mid-1990s, the Tribe relied on wells in the alluvium of the North Fork of the White River for drinking water supply to the Greater Whiteriver Area. The 2000 census reported that 9,889 persons or 80% of the Reservation population resided in the area served by this public water system. An increasing population and changes in safe drinking water regulations required the Tribe to seek an alternative supply to the alluvial wells. While Miner Flat dam would provide a dependable supply of high-quality raw water from the North Fork requiring minimal treatment, the hurdles to authorize and fund the project and to overcome speculative environmental concerns of federal agencies required a more immediate solution.

As part of the geotechnical investigations at Miner Flat Dam, groundwater had been discovered in a southern remnant of the Coconino formation underlying Miner Flat to the west of the damsite. This potential source of supply was tested for hydraulic properties and water quality and was considered at the time as an adequate, long-term drinking water source for Whiteriver. By 1995, a series of wells were under construction, and the Indian Health Service designed and constructed an interconnecting pipeline from the well-field to Whiteriver. Miner Flat Dam no longer included a community water supply purpose, and the net benefits of the dam were diminished accordingly.

By 2000, however, water levels in the well-field had declined at a rate that had not been anticipated. The well-field had lost significant capacity. A new source of water supply for the community was needed, and planning for Miner Flat Dam was revitalized. The purpose of the reservoir to regulate water supply for the downstream community of Whiteriver and lesser surrounding communities, in conjunction with irrigation of Canyon Day Flat, was restored.

Miner Flat Dam was not the only option for the Whiteriver public water supply. Alternatives were investigated, including the potential for development of the Coconino aquifer along the northern boundary of the Reservation. Significant use of this regional aquifer system has been undertaken north of the Reservation with success, and the Tribe considered development of the system within the Reservation. Investigations demonstrated that the groundwater supply was more costly than development of Miner Flat Dam. The ability to develop an adequate groundwater supply was questionable.

As a related but separate matter, the Tribe also recognized the potential for drawdown of water levels within the Reservation caused by wells pumping from the north of the Reservation. Pumping from existing wells serving the off-Reservation communities of Show Low, Pinetop and Lakeside were not known to impact groundwater levels within the Reservation but had the potential for lowering water levels. There was also concern that the base flow of the North Fork of the White River and other streams reliant on tributary discharges from water producing zones (springs in seeps) of the Coconino aquifer system, particularly the Fort Apache limestone, could be diminished by pumping north of the Reservation.

A regional model of the Coconino aquifer, Fort Apache limestone and Redwall formation was completed by the Tribe to assess impacts on base flow of pumping north of the Reservation. The conclusion was that base flow of Reservation streams (Canyon Creek, Cibecue Creek, Carrizo Creek and the North Fork of the White River) could be reduced by as much as 2.2 to 2.5% by year 2050, assuming heavy pumping scenarios in the future. An eventual reduction of 11% was projected but will take centuries to develop. No detectable lowering of base flow emerges from review of historic streamflow records.

The regional model indicated that although reduction of stream base flow due to off-reservation pumping will take a long time, there is a more immediate threat to the groundwater levels in the Coconino Sandstone part of the Coconino Aquifer along the northern boundary of the reservation. Accordingly, the Tribe's future use of the model will examine impacts of drawdown in the Coconino Sandstone on the Reservation from pumping north of the Reservation. Monitoring wells will be needed to provide the Tribe with early detection of declining water levels and to refine conclusions from the model on the degree and timing of reduction of base flows.

In its examination of Miner Flat Dam water supply potential, the Tribe considered a series of pipeline alternatives for domestic[1] supply that would deliver water west of the community of Whiteriver to as far as the community of Cibecue about 60 miles distant from Whiteriver. The communities of Cedar Creek and Carrizo lie along the proposed pipeline route between Whiteriver and Cibecue. The three respective options were to deliver water to (1) the first community to the west, Cedar Creek, (2) Cedar Creek and the second community to the west, Carrizo, and (3) all of the communities, including Cedar Creek, Carrizo and Cibecue.

[1] Domestic water needs are defined for the purposes of this report as water necessary to meet requirements of the public water systems and individual household needs outside the public water systems. Domestic water needs include in-home purposes, such as cooking, drinking, bathing, and sanitation; outside residential purposes, such as lawns and gardens; schools; institutions, such as offices of the Tribe, offices of other agencies and hospitals; parks; and commercial purposes, such as shopping centers, service stations and other relatively light water uses required by wholesale, retail and service establishments. Domestic water needs do not include heavier water using activities required by the Fort Apache Timber Company, for example, or commercial development along the Tribe‘s Northern Reservation boundary.

The concept of a single water source serving a series of communities through an extended pipeline system is not without precedent. When wells failed in the 1990s in the community of Cedar Creek, the Indian Health Service built a pipeline from Whiteriver to Cedar Creek, a distance of 20 miles. Cedar Creek relies on water from the Miner Flat well-field along with the public water system serving Whiteriver and its surrounding communities. Drinking water projects in the Northern Great Plains, such as the Mni Wiconi Project, Lewis and Clark Project and Fort Peck Reservation Rural Water System are provided with a single, regional water treatment plant for each project and thousands of miles of pipeline serving small communities and rural residences.

The Tribe projected its population for the next 100 years and determined that additional water sources would be required at the end of this century to supplement water supplies from the North Fork of the White River and Cibecue Creek. The latter source currently serves irrigation and the public water system for the community of Cibecue. The Cibecue public water system relies on wells drawing water from the alluvium adjacent and hydraulically connected to Cibecue Creek.

ES-1.2 Cibecue Creek

As an alternative to a pipeline to Cibecue from the North Fork of the White River, the Tribe gave consideration to the development and regulation of the streamflows of Cibecue Creek, which could also benefit from development of a smaller, future irrigation project to the west of the community (1,079 acres). This alternative would reduce costs of the regional water treatment plant north of Whiteriver and the costs of pipelines and related facilities between Whiteriver and Cibecue.

ES-1.3 Bonito Creek

Bonito Creek, tributary to the Black River in the southwestern corner of the Fort Apache Indian Reservation, was identified as the best alternative water source for the community of Whiteriver toward the end of this century. The Tribe thus began to examine storage potential on Bonito Creek as both an alternative to Miner Flat Dam in the near term and a reserve supply in the long term. Lands on Bonito Prairie (9,060 acres) could be irrigated from Bonito Creek until water is needed for domestic purposes in the longer-term for the Greater Whiteriver Area.

ES-2. Costs and Benefits

Table ES-1 presents the costs and benefits of developing the North Fork of the White River, Bonito Creek and Cibecue Creek for domestic water supply and irrigation. The development of reservoirs for regulation of the domestic and irrigation water supply in each of the watersheds creates a water surface with recreation potential. Construction, operation, maintenance and replacement of water supply facilities, as well as irrigated farming activities, create earnings for the residents of the Reservation and employ a greater proportion of the labor force than is currently employed. Systemic unemployment is addressed by the projects.

TABLE ES-1

SUMMARY OF BENEFITS AND COSTS
NORTH FORK WHITE RIVER , BONITO CREEK AND CIBECUE CREEK
(BASED ON 100 YEAR PROJECT LIFE)

	North Fork White River	Bonito Creek	Cibecue Creek	Total
Project Costs	$263,316,000	$331,264,000	$88,896,000	$683,476,000
Life-Cycle Costs, NPV				
Domestic	203,320,000	0	0	203,320,000
Irrigation	235,396,000	359,123,000	107,136,000	701,655,000
Recreation	22,106,000	179,665,000	19,774,000	221,545,000
Total	460,822,000	538,788,000	126,910,000	1,126,520,000
Benefits, NPV				
Domestic	468,707,000	0	0	468,707,000
Irrigation	238,637,000	301,650,000	77,645,000	617,932,000
Recreation	34,200,000	211,260,000	50,588,000	296,048,000
Employment				
Construction	52,212,000	62,777,000	15,237,000	130,226,000
Project Operation	36,552,000	46,213,000	9,084,000	91,849,000
Farm	142,178,000	33,205,000	78,419,000	253,802,000
Total	972,486,000	655,105,000	230,973,000	1,858,564,000
Net Benefits, NPV	$511,664,000	$116,317,000	$104,063,000	$732,044,000
Benefit-Cost Ratio	2.11	1.22	1.82	1.65

Project costs include investments in construction of the facilities and supporting activities and total $683.476 million for the projects in the three watersheds. Project costs range from $88.896 million for the project in the Cibecue Creek watershed to $331,264,000 for the project on Bonito Creek and Bonito Prairie. The Cibecue Creek project would be built over a three-year construction period, and the Bonito Creek project would be built over a five-year construction period. Potential funding sources include the Lower Colorado River Development Fund, congressional appropriations (subject to authorization) and nonfederal investment.

Total life-cycle costs, reflecting the present values of construction, interest during construction and annual operation, maintenance and replacement of facilities necessary to store and deliver water, total $1.127 billion over a 100 year project life. A discount rate of 3% was used. Costs were allocated using a "separable costs, remaining benefits" method for each project.[2]

[2] U.S. Bureau of Reclamation, Undated; *Economics Guidebook, Chapter 3, Cost Allocation Methodology*, Denver Technical Center.

The total present value of benefits is $1.859 billion over the same 100 year life of the projects with 3% discount rate. The difference between present value of benefits and costs is $732 million. The benefit to cost ratio for the combined projects is 1.65.

The project on the North Fork of the White River would provide domestic, irrigation, recreation and employment benefits that exceed costs of $460.822 million by $511.664 million, resulting in a benefit to cost ratio of 2.11. The projects on Bonito Creek and Cibecue Creek have irrigation, recreation and employment benefits that exceed costs by $116.317 million and $104.063 million, respectively. The Bonito Creek project will be needed beyond this century to address domestic water supply shortages from a continually growing population served by the North Fork of the White River. The Bonito Creek project will have significant benefits at that time, but the present value of the domestic benefit is minimal and has not been displayed.

The benefit values in Table ES-1 reflect the following proportional contributions to total benefits from the multi-purpose projects:

Domestic	25%
Irrigation	33
Recreation	16
Employment	26
Total	100%

ES-2.1 Domestic Benefits

Domestic benefits were determined as the cost of the alternative most likely to be implemented in the absence of the plan to develop the North Fork of the White River. The benefits of $468,707,000 for the plan for the North Fork of the White River (Table ES-1) are the costs of developing the best alternative, which is Bonito Creek.

ES-2.2 Irrigation Benefits

Irrigation benefits were based on a future cropping pattern for each of the three irrigation projects proposed for Canyon Day, Bonito Prairie and Cibecue Creek. Tables ES-2, ES-3 and ES-4 provide annual present value of net revenues for the three irrigation projects, respectively. The corresponding acreages and water requirements for each project are presented in Table ES-7. An analysis was conducted to determine the long-term viability of markets for the recommended crops. The market analysis identified the maximum crop production that can be introduced into the market without adversely impacting the price. Acreages of the proposed crops do not exceed this maximum production level or market constraint.

The Canyon Day irrigation project covers 5,875 acres and includes an apple orchard, vineyard, berries and field crops in rotation. The average net annual return is $1,405 per acre. Note in Table ES-1 that irrigation costs are listed separately and are not reflected in the net benefits given here. Orchards and field crops are elements of the historic irrigated cropping pattern on the alluvium of the Reservation streams, particularly in the White River and Cibecue valleys.

The Bonito Creek irrigation project was based on hybrid poplar and Christmas tree plantations as presented in Table ES-3. The project would irrigate 9,060 acres with annualized net revenues of $1,046 per acre. Poplar benefits were based on “stumpage” or sale value at the plantation supplemented by (1) value from the manufacture of the raw logs into various lumber products, (2) improvements in management of the Tribe’s pine and mixed-conifer forest stemming from an additional supply of raw logs and (3) carbon credits resulting from the new poplar and Christmas tree plantations. The tree plantations are compatible with the Tribe’s historical forest industry and represent a continuation of the economic culture within the Reservation, albeit with a new species and more intensive management than necessary in the indigenous forest.

TABLE ES-2

ANNUALIZED NET RETURNS TO IRRIGATION, CANYON DAY

Crop, (Years) in Rotated Crops	Acres	Net Return / Acre	Total Net Return
Organic Apple	280	$3,920	$1,098,000
Organic Grape	200	4,520	904,000
Blackberry (processed)	180	980	176,000
Blackberry (fresh)	70	22,070	1,545,000
Raspberry (processed)	340	3,090	1,051,000
Raspberry (fresh)	100	17,390	1,739,000
Blue Corn (1), Soybean (1), Wheat (1), Soybean (1)	2,549	313	799,000
Grain Corn (1),Dry Bean (1), Oats (1), Dry Bean (1)	503	193	97,000
Alfalfa (3), Grain Corn (1), Dry Bean (1) Oats (1)	47	287	13,000
Corn Silage (1), Dry Bean (1), Grain Corn (1), Dry Bean (1)	170	193	33,000
Dry Bean (1),Corn Silage (1), Alfalfa (3), Oats (1)	249	287	71,000
Cantaloupe (1), Onion (1), Chili (1), Cantaloupe (1), Onion (1)	1,188	610	724,000
Total	5,875	$1,404	$8,250,000

TABLE ES-3

ANNUALIZED NET RETURNS TO IRRIGATION, BONITO

Crop	Acres	Net Return / Acre	Total Net Return
Hybrid Poplar	8,560	$1,052	$9,003,000
Christmas tree (wholesale)	450	770	346,000
Christmas tree (U-cut)	50	2,510	126,000
Total	9,060	$1,046	$9,475,000

The Cibecue irrigation project would irrigate 1,079 acres of bench lands west of Cibecue Creek. The cropping pattern would include orchard crops grow in the area historically (with the possible exception of cherries) and asparagus. Annualized net returns were projected at $2,420 per acre, the highest of all the projects and considered realistic on the smaller acreage.

TABLE ES-4

ANNUALIZED NET RETURNS TO IRRIGATION, CIBECUE

Crop	Acres	Net Return / Acre	Total Net Return
Organic Apple	335	$3,920	$1,313,000
Organic Peach	310	2,400	744,000
Organic Cherry	96	1,660	159,000
Asparagus	338	1,150	389,000
Total	1,079	$2,414	$2,605,000

ES-2.3 <u>Recreation Benefits</u>

The Fort Apache Indian Reservation is well known for its recreational programs including many lakes which are popular for fishing and are stocked with trout through the Alchesay - Williams Creek National Fish Hatchery. The multi-purpose reservoirs required for domestic and irrigation purposes will also provide additional water resources attracting more visitors to the Reservation for fishing, boating, and camping. Water quality available to the Alchesay National Fish Hatchery on the North Fork of the White River will be enhanced, thus enabling the hatchery to increase fish production for stocking the new reservoirs. The economic benefits associated with increased visitation include revenue from additional permit sales, profits from angler expenditures, labor benefits, and economic value to Tribal members. Projected benefits by reservoir are summarized in Table ES-5.

TABLE ES-5

NET PRESENT VALUE OF RECREATION BENEFITS AT MULTIPURPOSE RESERVOIRS

Reservoir	Benefits
Miner Flat	$34,200,000
Bonito	211,260,000
Salt Wash	50,588,000
Total	$296,048,000

ES-2.4 <u>Employment Benefits</u>

Historically, the Fort Apache Indian Reservation has had chronic and persistent unemployment. Employment benefits presented in Table ES-1 were based solely on the earnings of otherwise unemployed persons in the current and future labor force without development of the projects proposed here. Projection of the future labor force is presented in Table ES-6 below. The total present values of employment benefits of all three projects from construction, operation and farming activities were projected at $130.226 million, $91.849 million and $253.802 million, respectively (Table ES-1).

ES-3. Future Population Characteristics

The future economy of the Fort Apache Indian Reservation will be developed from a growing population with a corresponding need for employment. Table ES-6 summarizes the projected population, housing and employment needs through the 21st century.

As described in Chapter 2, population is projected to grow from 12,400 to 94,000 persons by the end of the century. The youthful population at the beginning of the projection will gradually age, and persons per household will decline from 4.0 to 2.5 persons, more in keeping with the surrounding region. This implies that the number of occupied housing units will increase from 3,100 to 37,000. The labor force will grow from 7,100 to 58,000 persons. There were 3,849 persons employed in 2000, and unemployment was estimated at 47%. Table ES-6 shows the number of jobs needed in each decade of the century to achieve 95% employment. The number of necessary jobs will grow from 6,792 to 55,648. The number of students is projected to increase from 4,321 to 20,069.

TABLE ES-6

FUTURE POPULATION CHARACTERISTICS

Year	Persons	Persons Per Household	Households	Labor Force	Cumulative Jobs Needed	Students
2000	12,429	4.0	3,100	7,149	6,792	4,321
2010	19,423	3.9	5,147	11,013	10,462	7,247
2020	28,660	3.7	7,195	16,807	15,967	9,868
2025	33,612	3.6	9,242	19,626	18,644	10,719
2030	38,563	3.5	12,040	22,444	21,322	11,570
2040	48,445	3.4	14,839	27,629	26,248	13,705
2050	57,409	3.3	17,637	33,379	31,710	15,413
2060	63,683	3.2	20,589	39,269	37,306	15,983
2070	69,956	3.0	23,540	43,959	41,761	17,465
2075	76,230	2.9	26,492	46,589	44,260	18,222
2080	82,098	2.8	30,172	49,219	46,758	18,978
2090	87,965	2.6	33,853	54,598	51,868	19,496
2100	93,833	2.5	37,533	58,577	55,648	20,069

ES-4. Future Water Requirements

The growing population will require dependable water supplies for domestic consumption and for economic development. Relatively small tracts of lands on the

Canyon Day Flat, Bonito Prairie and west of Cibecue totaling 16,104 acres can be irrigated to supplement advances in other sectors of the Tribe's economy. The water requirements associated with the projects described in sections ES-1 and ES-2 are presented in Table ES-7.

Future irrigation in the three project areas will deplete Cibecue Creek, the White River and Bonito Creek by an aggregate of 49,432 acre-feet annually. The federal fish hatcheries, particularly the Alchesay National Fish Hatchery, are expected to benefit from a regulated water supply on the North Fork of the White River that can also assist in moderating summer and winter temperatures. The Alchesay Hatchery will continue to require water from springs and the North Fork but will re-circulate water back to the stream and will not deplete the downstream supply. The population served by the projects will reach an estimated 86,910 persons by year 2100. The remaining population (about 7000 persons) will reside outside the project boundaries and will be served by other sources.

ES-5. Dependable, Regulated Water Supply

Regulation of streamflows available to the projects on the White River, Bonito Creek and Cibecue is required to store water during snowmelt and periods of rain for release during seasonal dry periods, especially during the irrigation season, and during extended droughts. Construction of dams on the streams is necessary to provide adequate

TABLE ES-7

WATER REQUIREMENTS FOR PROJECT PURPOSES

Purpose		Project Cibecue Creek	White River	Bonito Creek	Total
Future Irrigation					
	Acres	1,079	5,875	9,060	16,014
	Water Duty, af/ac/y	2.99	3.59	2.99	3.21
	Diversion, af/y	3,231	21,080	27,089	51,401
	Depletion, af/y	3,316	19,813	26,303	49,432
Fish Hatcheries					
	Diversion, af/y		2,175		2,175
	Depletion, af/y		0		0
Domestic and Commercial					
	100 Year Population	11,694	74,657	559	86,910
	Diversion, af/y	2,672	17,061	128	19,861
	Depletion, af/y	1,624	10,370	78	12,072
Total					
	Diversion, af/y	5,903	40,316	27,217	73,437
	Depletion, af/y	4,940	30,183	26,380	61,504
	Return Flow, af/y	963	10,133	837	11,933
Distribution of Depletion, %		8.03%	49.08%	42.89%	100.00%

af/ac/y acre feet per acre per year
af/y acre feet per year

regulation to meet future demands. Monthly simulation studies based on hydrology from 1958 through 2003 were conducted to determine the capability of four storage reservoirs on or adjacent to the respective streams to supply future demands without shortage. The simulation studies demonstrated that dams with storage capacities as given in Table ES-8 can provide adequate regulation to meet future demands and continue existing uses.

The dams will fill reservoirs with usable conservation storage of 155,000 acre-feet and corresponding surface areas ranging from 159 to 1,102 acres (Table ES-8). These surface acres will diminish as conservation storage is released during dry seasons and over extended drought years. The surface acres provide a pool for recreation and a basis for the benefits presented for that purpose. Shoreline along the reservoirs also provides recreational opportunities.

ES-6. Relationship of Water Use From Projects to Total Reservation Needs

The diversion for the proposed projects will total 73,437 acre-feet annually (Table ES-7), and the future downstream depletion will total 61,504 acre-feet annually. The total depletions on the Fort Apache Indian Reservation for the projects proposed here and

TABLE ES-8

STORAGE REQUIREMENTS TO REGULATE STREAMFLOWS
AND RELATED STATISTICS

	Dam			
Feature	Miner Flat	Bear Canyon	Bonito Creek	Salt Wash
Source water	North Fork White River	White River	Big Bonito Creek	Cibecue Creek
Inflow, acre-feet per year, 1958-2003	61,831	--	50,854	9,077
Storage, acre-feet				
Total	8,415	17,771	115,350	14,436
Dead	1,253	805	5,915	1,408
Conservation	7,162	16,966	109,435	13,028
Dam Height, ft	155	165	335	170
Surface Area, acres	159	350	1012	288
Shoreline, Miles	6.17	6.42	18.76	--

other historic and future purposes are estimated at 88,861 acre-feet annually. Therefore, the proposed projects account for 69% of the total historic and future depletion. Historic depletions are estimated at 12,280 acre feet annually. Other future depletions, outside the scope of the proposed projects, total 15,078 acre-feet annually.

The downstream depletion from the projects of 61,504 acre-feet annually will reduce inflow to Lake Roosevelt, lower reservoir levels and reduce lake evaporation and spills from Lake Roosevelt into the Salt River Valley. The total impact on downstream users will be less than 61,504 acre-feet annually depending upon the level of spill reduction at Roosevelt Dam. Simulation of upstream depletions and Lake Roosevelt operations (assuming historic releases from Lake Roosevelt are reasonably representative of future releases) suggests that less than 50,000 acre feet annually of Central Arizona Project replacement supply for Salt River Valley water users would be adequate to offset all future upstream depletions on the Fort Apache Indian Reservation.

1 -- INTRODUCTION

1. Location

The setting for the multi-purpose water development projects discussed in this report is the Fort Apache Indian Reservation, the 1.6 million acre homeland of the White Mountain Apache Tribe.

The Fort Apache Indian Reservation is located in east central Arizona. The northern boundary of the reservation is the "south edge of Black Mesa" at the terminus of the Colorado Plateau, known locally as the Mogollon Rim. The southern boundary of the reservation follows the centerline of the Black and Salt Rivers (Figure 1-1). The east boundary of the reservation is a north to south line located along latitude 109° 30'. The west boundary of the reservation is parallel to the east boundary along latitude 110° 47' from the Mogollon Rim southerly to Sombrero Butte and then south, southeasterly to the Salt River near Gleason Flat. The reservation is 75 miles across from east to west and 35 miles deep (on the average) from north to south.

The reservation lies almost exclusively within the Salt River subbasin of the Gila River Basin, tributary to the lower Colorado River near Yuma.[1] The reservation contains Canyon Creek, Cibecue Creek, Carrizo Creek, White River and Black River tributaries to the Salt River. The Salt River is formed by the confluence of the White and Black rivers along the southern boundary of the reservation. The Salt River Project, including Roosevelt, Horse Mesa, Mormon Flat, Stewart Mountain and Granite Reef dams and the canal system serving the Salt River Valley, are located downstream from the reservation. The Salt River Project relies on the Salt River to serve its water users in Phoenix, Mesa, Tempe and the general region in the Salt River Valley known as the Kent decree area. The reservation is situated in a watershed and on a stream system of considerable importance to downstream interests, which is equally important to the White Mountain Apache Tribe to sustain its future.

2. Geologic History

The geologic deposits supporting the earth's surface and comprising the subsurface materials of the earth exert tremendous influence on man's activities. These influences may be subtle, such as the amount of soil moisture holding capacity to support plant growth, to highly visible, such as landslides or volcanoes. The geology of the earth's crust dictates, among many things, the locations continents and seas, of mountains and plains, the distribution of minerals, and the distribution and availability of groundwater. Geology influences the suitability of the earth's surface for man's use, including the bearing capacity of materials to support foundations for structures, the stability of slopes, the risk that an earthquake may occur, and the probability that a well will discover water.

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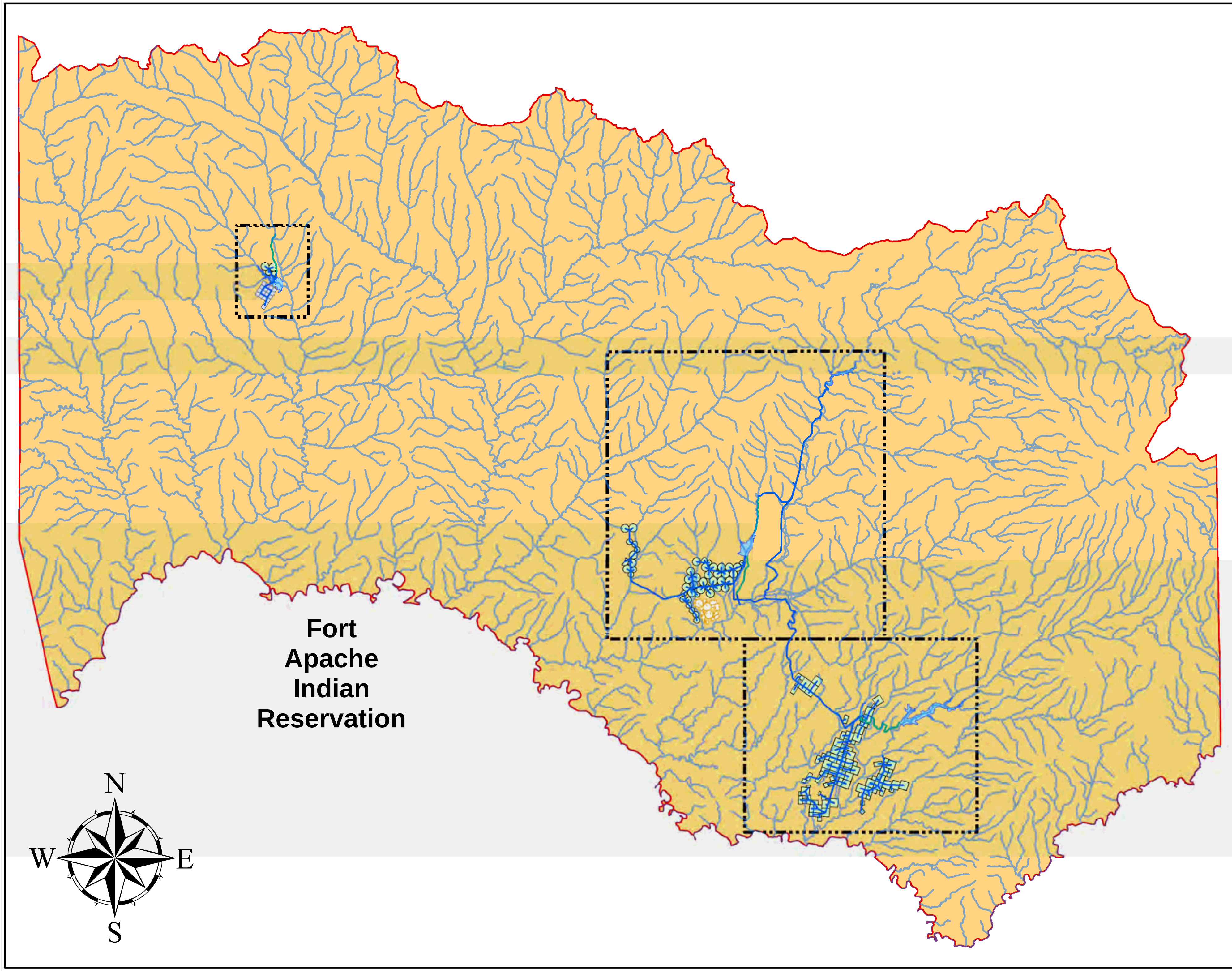
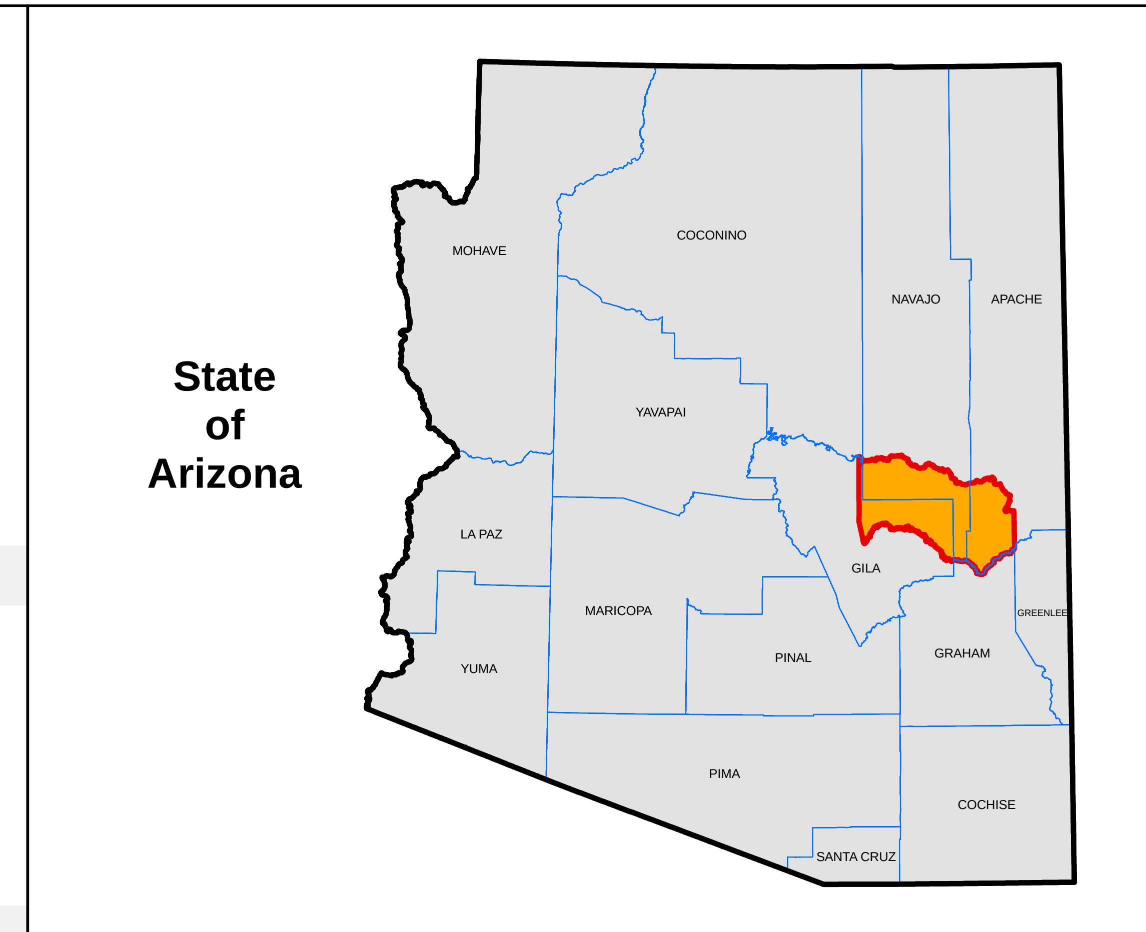
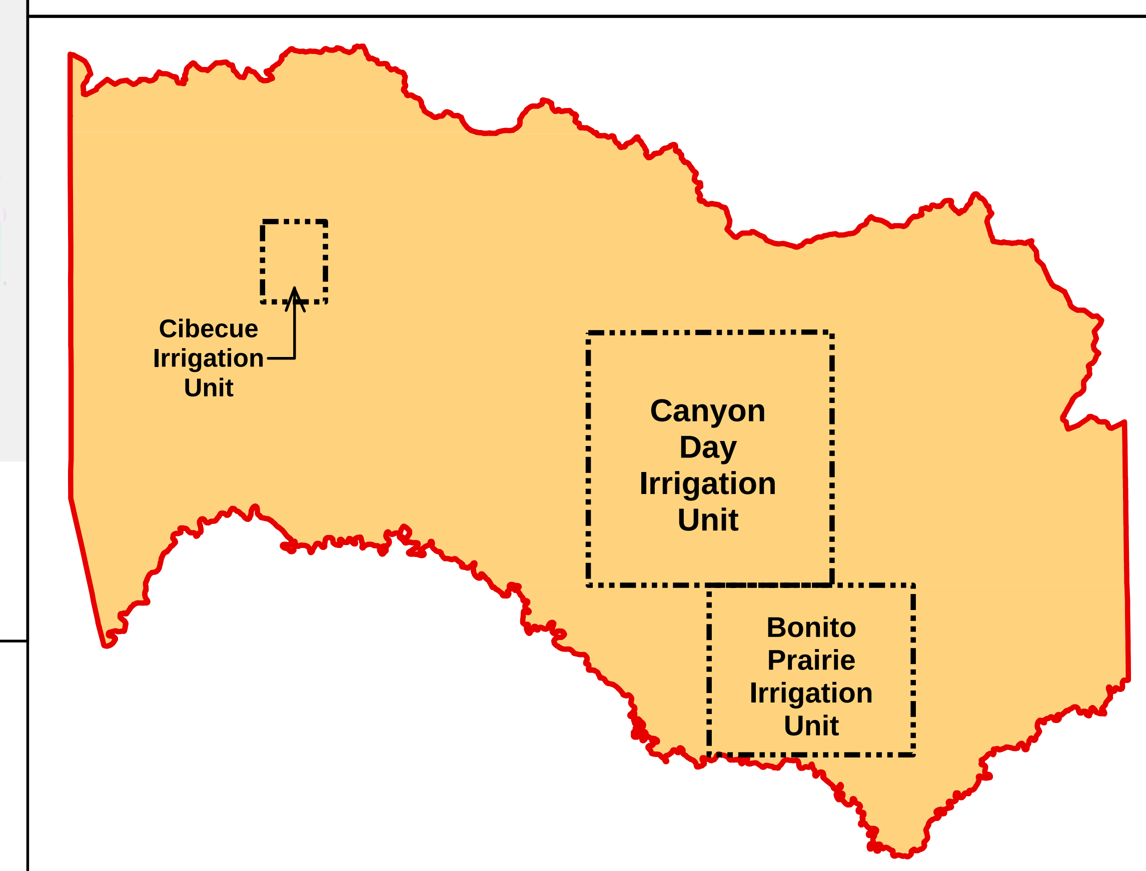
[1] Minor exceptions to exclusive containment within the Salt River watershed are small areas along the northern boundary of the reservation that drain to the Little Colorado River.







Map Legend

- Arizona State Boundary
- County Boundary
- Irrigation Unit
- Reservation Boundary
- Streams

Irrigation Unit Legend

- Canal
- Pipeline
- Orchards
- Existing Pivots and Fields
- Pivots & Fields
- Reservoir

MINER FLAT DAM **PROJECT EXTENSION REPORT**	FIGURE
GENERAL OVERVIEW MAP	NUMBER 1-1

Therefore, planners and engineers involved in public works deal with geologic processes and conditions, whether they are aware of this fact or not. Those who are aware of the role of geologic factors in their work strive to understand geology and apply that knowledge for practical results. When one has recognized a relationship between geologic conditions and the factors that affect engineering design requirements or other activities related to public works and planning, the logical questions are, “How did it get this way?” and “Is there a pattern here that is useful to me?”, or “Can I use this knowledge as a predictive tool?” Accordingly, it becomes beneficial to understand the geologic history of an area in order to answer the questions, “How did it get this way?” and “Is there a pattern here that is useful to me?”

The geologic processes that deposited subsurface strata, changed sedimentary deposits into rock, shaped the earth’s crust with mountain-building events, and eroded the present landscape onto the earth’s surface take a long time. We use the term “geologic time” to refer to the long periods of time required for geologic processes. The geologic time scale is shown on Table 1-1, including the time in millions of years before present (mybp) conventionally accepted by geologists for the various divisions of the geologic past. The subdivisions of the geologic time scale are useful for describing the respective age of geologic strata and the order of the events that produced them in their present form.

Figure 1-2 shows a generalized stratigraphic column depicting the sequence of subsurface strata under the Fort Apache Indian Reservation from the oldest (Precambrian) to the youngest (Quaternary), including generalized thicknesses and geologic ages. Figure 1-3 is a generalized geologic map of the Fort Apache Indian Reservation showing where the subsurface layers are exposed at the land surface. Some of the layers are combined into single mapping units on Figure 1-2 according to geologic age because the map is too small to include all of the detail of the rock outcrop distributions.

Figure 1-2 shows that most of the subsurface materials above the deep crystalline Precambrian basement rocks consist of sedimentary rocks. Lesser amounts of volcanic rocks were deposited on top of the sedimentary rocks in the northeastern part of the reservation and on top of now dissected remnants of a once extensive layer of Tertiary-aged sediments referred to locally as the “Rim Gravels”. The volcanic rocks consist primarily of basalt that was deposited over a period of time and consist of two main subdivisions; older stratified basalts with interbedded sediments along the east side of the Fort Apache Reservation, extending from the Mogollon Rim to the Black River and the Springerville Volcanic field deposited primarily north of the Mogollon Rim and extending a short distance into the reservation , resting on Tertiary sediments, sedimentary bedrocks, and the older stratified basalts.

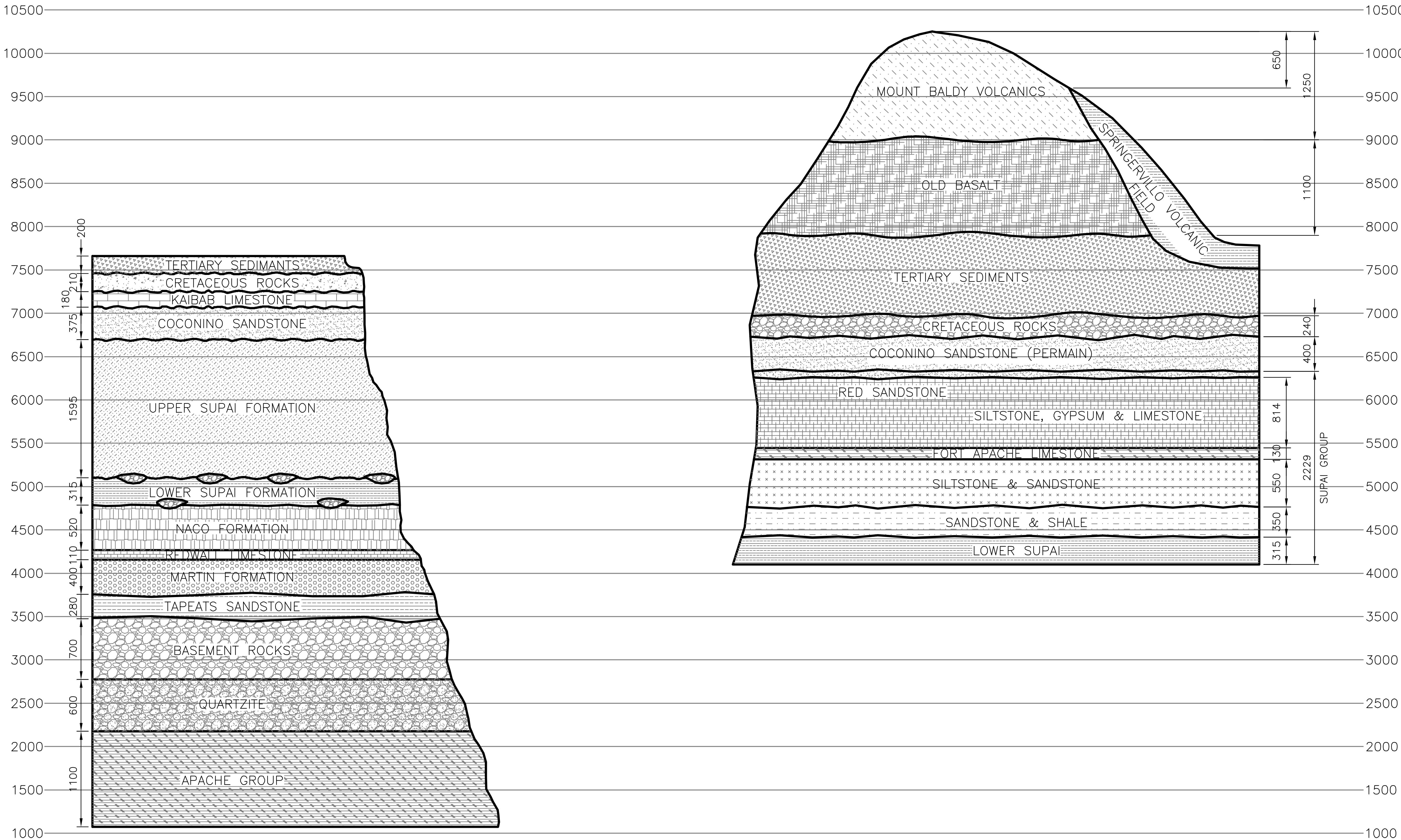
TABLE 1-1

GEOLOGIC TIME SCALE

Eon	**Era**	**Period**		**Epoch**	**Time Starting (millions of years before present)**
Phanerozoic	Cenozoic	Quaternary		Holocene	0.01
				Pleistocene	1.6
		Tertiary	Neogene	Pliocene	5.3
				Miocene	23.7
			Palaeogene	Oligocene	36.6
				Eocene	57.8
				Paleocene	66.4
	Mesozoic	Cretaceous		late Cretaceous	97.5
				early Cretaceous	144
		Jurassic		late Jurassic	163
				middle Jurassic	187
				early Jurassic	208
		Triassic			245
	Palaeozoic	Permian			286
		Carboniferous		Pennsylvanian	320
				Mississippian	360
		Devonian			408
		Silurian			438
		Ordovician			505
		Cambrian			570
Proterozoic	Precambrian				4,600
Archaean					

3. Climate

Elevations within the Fort Apache Indian Reservation range from 2,640 feet in the southwest corner where the Salt River leaves the reservation boundary to 11,400 feet in the northeast corner of the reservation at the peak of Mount Baldy. At the lower elevations, the vegetation types are in transition from Sonoran Desert to the Upper Sonoran. The latter is predominantly interior chaparral and grasslands. At about 4,500 feet of elevation, the upper Sonoran zone gives way to a pinyon-juniper zone, which in turn gives way at about 5,000 feet to the lower Ponderosa pine zone. A mixed conifer zone begins at about 7,500 feet, and a spruce, alpine-fir zone begins at elevation 8,500 feet. The peak of Mount Baldy is above timberline, which begins at elevation 9,500 to 10,000 feet (Figure 1-4).



MINER FLAT DAM
PROJECT EXTENSION REPORT

STRATIGRAPHIC COLUMN

FIGURE
NUMBER
1-2

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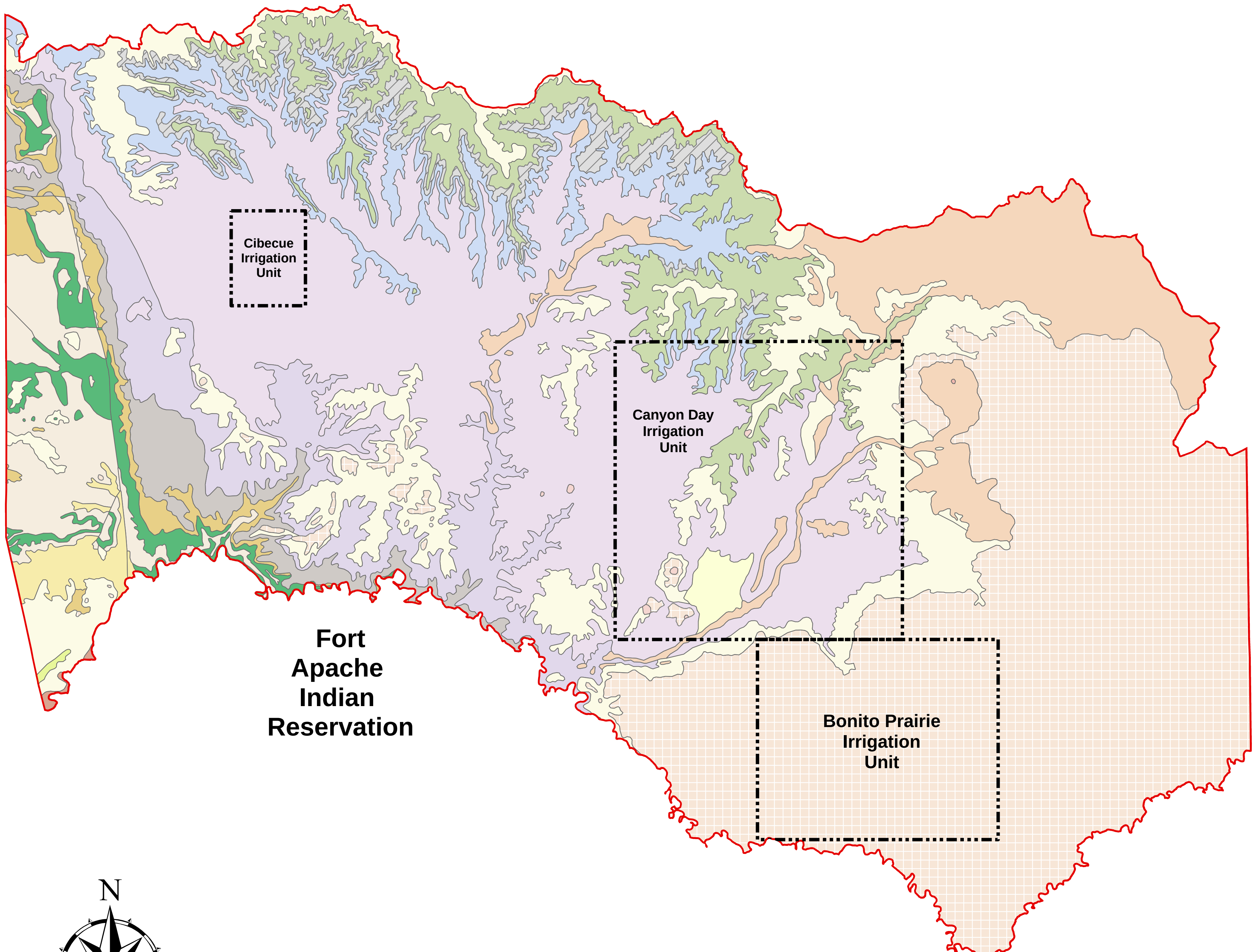
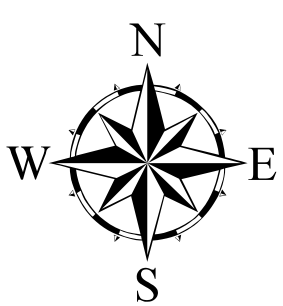
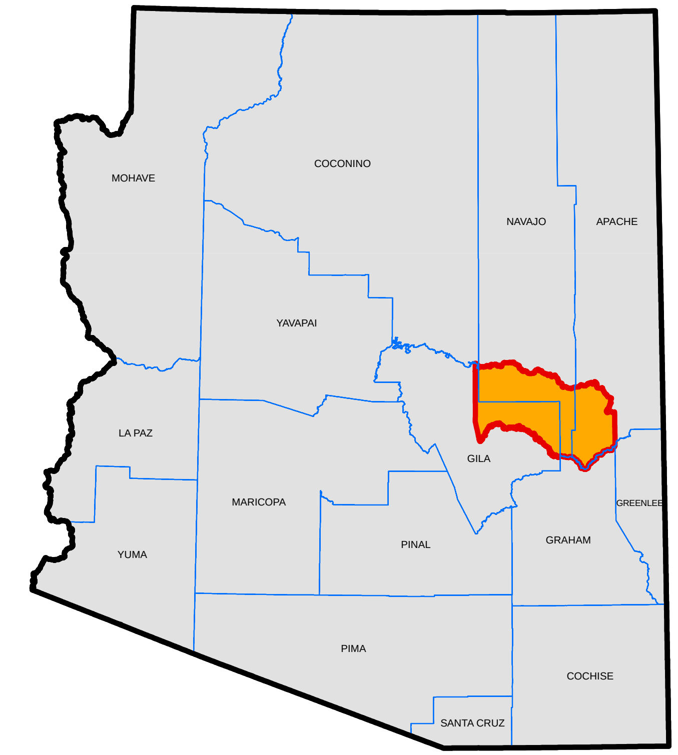




Source: Digital Geologic Map of Arizona: A Digital Database Derived from the 1983 Printing of the Wilson, Moore, and Cooper 1:500,000 Scale Map, Douglas H. Hirschberg and G. Stephen Pitts, 2000.

STATE OF ARIZONA



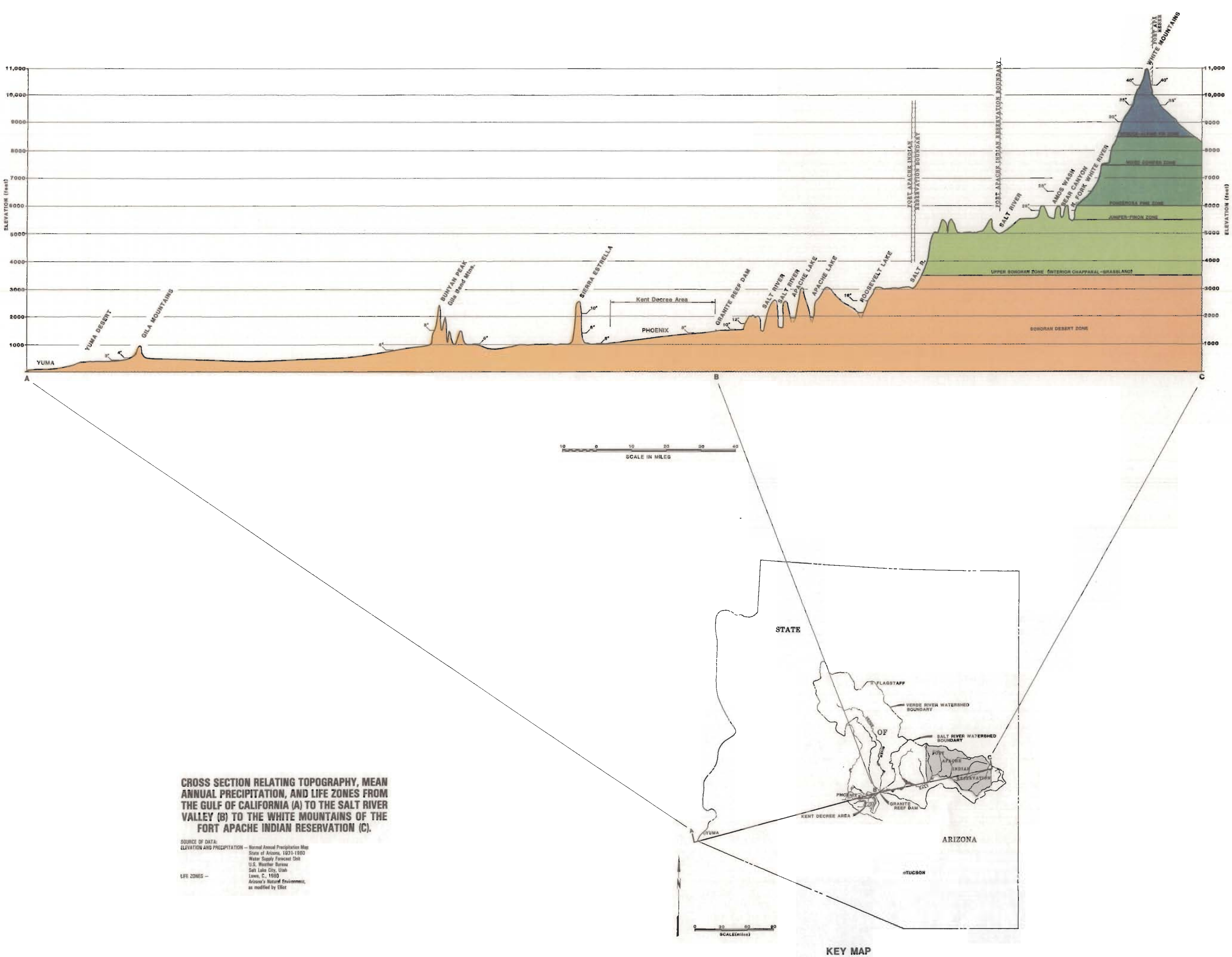
GEOLOGY

- **Qb** — Quaternary basalt of the Springerville Volcanic Field
- **QTb** — Quaternary/Tertiary basalt referred to as "old basalt" in this report
- **Ts** — Tertiary Sediments of Mogollon Rim Formation (Rim Gravels)
- **Tvs** — Tertiary silicic volcanic rocks
- **Ks** — Cretaceous sediments - Mesa Verde Group (?)
- **Pkt** — Permian Kaibab Limestone
- **Pc** — Permian Coconino Sandstone
- **PPPs** — Permian/Pennsylvanian Supai Group
- **PPPnl** — Pennsylvanian Naco Formation
- **MDs** — Mississippian Redwall Limestone and Devonian Martin Formation undifferentiated
- **pCdb** — Precambrian Diabase
- **pCt** — Precambrian Quartzite
- **pCa** — Precambrian Apache Group seimentary rocks and basalt flows
- **pCgr** — Precambrian granitic intrusive rocks
- **pCsc** — Precambrian metamorphosed sedimentary and volcanic rocks
- **Water** — Water

LEGEND

- Irrigation Unit
- Arizona State Boundary
- Reservation Boundary
- Counties

MINER FLAT DAM PROJECT EXTENSION REPORT	FIGURE
GENERALIZED GEOLOGICAL MAP	NUMBER 1-3



CROSS SECTION RELATING TOPOGRAPHY, MEAN ANNUAL PRECIPITATION, AND LIFE ZONES FROM THE GULF OF CALIFORNIA (A) TO THE SALT RIVER VALLEY (B) TO THE WHITE MOUNTAINS OF THE FORT APACHE INDIAN RESERVATION (C).

SOURCE OF DATA:
ELEVATION AND PRECIPITATION — Normal Annual Precipitation Map State of Arizona, 1931-1960 Water Supply Forecast Unit U.S. Weather Bureau Salt Lake City, Utah
LIFE ZONES — Lowe, C., 1960 Arizona's Natural Environment, as modified by Elliot

FIGURE 1-4

Precipitation is variable over the considerable range in elevation across the Reservation. Annual precipitation ranges from about 16 inches in the southwestern corner to above 40 inches on Mount Baldy. Winter snowfall can be heavy at the higher elevations and produces a snow-pack. While not uncommon at the lower elevations, snow does not fall each year, and its persistence is limited to a few days. May and June are generally dry months followed by the "monsoon" season in July, August and September, which produces thunderstorms. Moisture moves upward from the desert and onto the Colorado Plateau, and as elevation is gained, heavy rains can be produced.

The central sections of the reservation, above the arid Upper Sonoran zone are semi-arid. The weather station at Whiteriver (elevation 5,119 feet) assists in characterizing the temperature and precipitation in this central section (Table 1-2).

TABLE 1-2

WHITERIVER CLIMATE
(elevation 5,119)

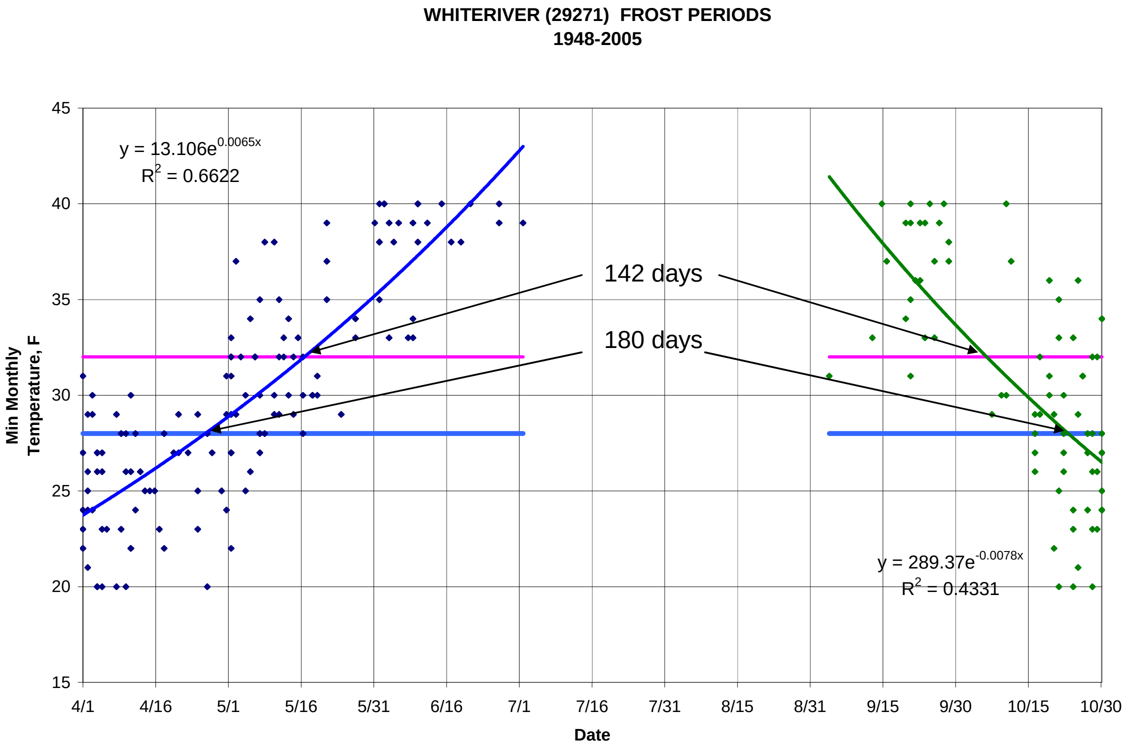
	Normals	
Month	Precipitation (inches)	Temperature (°F)
January	1.80	39.90
February	1.59	42.70
March	2.16	46.70
April	0.82	51.30
May	0.62	58.70
June	0.58	67.90
July	2.44	72.40
August	3.62	70.80
September	1.75	66.50
October	1.83	56.60
November	1.48	46.30
December	1.45	40.00
Annual	20.14	54.98

Normal average annual precipitation at the weather station is 20.14 inches. October through March precipitation is a steady contributor to the annual accumulation. April through June are the driest months, followed by July and August, the wettest months.

Temperatures are moderate, rarely falling below 0°F in winter or rising above 100°F in summer. July and August are the warmest months and average above 70°F. The winter months average near 40°F.

The growing season is dictated by the frost free period. Figure 1-5 displays the frost free period of 142 days beginning on average in mid-May and ending in early October. A killing 28°F frost generally extends from late April through late October, a period of 180 days.

FIGURE 1-5



The growing season shortens with increasing elevation. The Canyon Day and Cibecue irrigation projects are at comparable elevations with the highest areas irrigated lying between elevations 5,300 and 5,400 feet. The Bonito Prairie irrigation project reaches elevations of 5,930 feet. Table 1-3 shows that the growing season on Bonito Prairie is from 10 to 14 days shorter than on the Canyon Day and Cibecue flats.

4. History and People

The White Mountain Apache Tribe, ("Tribe") numbering over 14,000 members, has continuously occupied the lands now known as the Fort Apache Indian Reservation ("reservation"), a remnant of its once vast aboriginal lands, since time immemorial. For centuries the Western Apache, which included the White Mountain Apaches, fought a bitter war of attrition, first against the Spanish, then the Mexicans, and lastly, the Americans.

Prior to establishment of the Fort Apache Indian Reservation, there was little peace between the United States Army and the Apache Indians along the headwaters of the Salt River as the White Mountain Apaches had no interest in being confined to a reservation. The first signs of a change may have been recorded in Lieutenant Colonel John Green's August 20, 1869 report, the "Interesting Scout, White Mountain Apaches", which described numerous Apache crops destroyed and hostile contact. His report states in part:

TABLE 1-3

FROST HISTORY
(1948-2003)

			Average		
Location			28^{0} Frost	32^{0} Frost	Elevation
		Spring			
Whiteriver	28.0	32.0	26-Apr	17-May	5,120
McNary	28.0	32.1	25-May	15-Jun	7,340
		Fall			
Whiteriver	28.0	32.0	23-Oct	6-Oct	5,120
McNary	28.0	32.0	28-Sep	12-Sep	7,340
		Days Between Frosts			
Whiteriver			180	142	5,120
McNary			126	89	7,340
		Spring			
Canyon Day			29-Apr	20-May	5,400
Cibecue			29-Apr	20-May	5,360
Bonito Prairie			6-May	27-May	5,930
		Fall			
Canyon Day			19-Oct	2-Oct	5,400
Cibecue			20-Oct	3-Oct	5,360
Bonito Prairie			13-Oct	27-Sep	5,930
		Days Between Frosts			
Canyon Day			173	135	5,400
Cibecue			174	136	5,360
Bonito Prairie			160	123	5,930

> "*Soon after Captain Barry left, I broke up camp, and moved up White Mountain River about five miles, to where I supposed was the central point of the cornfields, and went into camp; then detailed all of the men, except the a small guard for camp, and commenced to destroy the corn. At least one hundred acres of fine corn, just in silk, were destroyed, and it took the command nearly three days to do it. I was astonished, and could hardly believe the Apache Indians could and would cultivate the soil to such an extent; and when we consider their very crude implements, and the great labor it requires to dig the aceguias for irrigation, one cannot help but wonder at their success. Their fields compare very favorably with those of their more civilized brethren.*"

Lieutenant Colonel Green's experience during his scouting mission caused him to comment that the White Mountain Apaches were peaceful and friendly and that upon approaching one village, he remarked that "if they had fired on them, they would have been guilty of cold blooded murder." Lieutenant Colonel Green reflected:

> "*There seems no settled policy, but a general idea to kill them wherever found. I also am a believer in that, if we go for extermination; but I think – and I am sustained in my opinion by most of the officers accompanying my expedition – that if Miguel and his band were placed on a reservation properly managed, and had a military post to protect them, they would form a nucleus for the civilization of the Apaches, as they seem more susceptible of it than any tribe I have ever seen.*"

The following note was attached at the bottom of Lieutenant Colonel Green's report:

> "*The Department Commander regards this expedition as of great importance. He has forwarded a copy of it to the Adjutant General for the information of the Commission of Indian Affairs, asking that steps be taken to protect and provide for the friendly Apaches in their own country*." (Emphasis added).

In 1870, Indian Commissioner, Vincent Colyer, prepared a report from the Indian Department outlining the injustices imposed upon the Apache Indians in Arizona and the folly of attempting extermination of the Apache Tribes. His report stated in part:

> "*. . . and by acts of inhuman treachery and cruelty made them (the Apaches) our implacable foes: that this policy has resulted in a war which, in the last ten years, has cost us thousands of lives and over Forty Millions of Dollars, and the country is no quieter nor the Indians any nearer extermination that they were at the time of the Gadsden Purchase; that the present "war" will cost the people of the United States between three and four millions of dollars this year; that these Indians still beg for peace, and all of them can be placed on reservations and fed at an expense of less than half a million dollars a year without the loss of life . . .*"

In 1871, peace was finally made with the White Mountain Apache people through the efforts of Indian Commissioner Vincent Colyer, who, at the direction of President Ulysses S. Grant, journeyed to the Arizona-New Mexico territory to "select the White Mountain Reservation, the boundaries of which were defined in a letter from H.M. Robert, Major of Engineers . . . "[1] President Grant's Executive Order of November 9, 1871, established the White Mountain Indian Reservation. *Id.* at 218. Subsequently, in 1877, President Grant withdrew 7500 acres of land from the Tribe's reservation for the Fort Apache Military Post.

The Indian Claims Commission found that May 1, 1873, marked the date on which the United States took from the White Mountain Apache Indians their Indian title

[1] 21 Ind. Cl. Comm. 189 at 198, Docket No. 22-D.

to all of their aboriginal lands located *outside* of the boundaries of the White Mountain Apache Indian Reservation established by President Grant on November 9, 1871 and December 14, 1872. *Id.* at 219. Thus, the White Mountain Apache Tribe has an unbroken chain of aboriginal title, and all of the property rights appurtenant thereto, including property rights to the use of water, *within* the lands of the present day Fort Apache Indian Reservation.

In the years following November 9, 1871, the White Mountain Apache Indian Reservation was diminished by several Acts of Congress. On June 7,1897, the Congress of the United States declared that a separate agency be created to cover and have jurisdiction over all that portion of the White Mountain Indian Reservation lying north of the Salt or Black River, to be known as the Fort Apache Reservation, with headquarters at Fort Apache, Arizona. Importantly, and irrespective of the various reductions in the White Mountain Apache Indian Reservation, the northern boundary of the Tribe's reservation was untouched and remained a segment of the south edge of the Black Mesa, the watershed divide between the Salt and Little Colorado River drainages.

After the Fort Apache Military Post was abandoned in 1922, its lands, comprised of some 7,500 acres and the buildings and other improvements thereon, were transferred to the control and use of the Secretary of Interior and became the Theodore Roosevelt Boarding School for Indians. The School's curriculum focused on an agriculture and livestock education program for the boys and domestic skills training for the girls. Two hundred acres of orchards were planted as part of the School's agriculture program. On March 18, 1960, Congress transferred title to the lands and improvements of the former Fort Apache Military Post (Theodore Roosevelt School) in trust for the benefit of the Tribe, subject to the right of the Secretary of Interior to use the property for school and administrative purposes so long as needed for such purposes. In late 2006, it is anticipated that all but three or four of the 35 buildings within the now designated Fort Apache Historic District will be returned by BIA to the control and use of the Tribe for tourism and other economic development. Future plans include full restoration of the orchards as the main irrigation infrastructure system remains intact.

5. Agriculture Development

From the early 1900's and continuing thereafter, various attempts were made by the Bureau of Indian Affairs to expand, repair and maintain irrigation ditches throughout the Reservation. In 1944-1946, it was estimated by the Bureau of Indian Affairs that the potential dry farming area on the Reservation was 20,000 acres of which only 3,000 were being farmed, and irrigable acreage of approximately 6,000 acres, of which only 1,971 acres were actually being irrigated. Non-development of irrigated agriculture was primarily due to a lack of funding from the Federal government. For example, in a typical letter, dated April 13, 1935, about the chronic lack of federal funding for irrigation, C.A. Engle, the supervising engineer of the Department of Interior Irrigation District, in reference to the White Mountain Apache Tribe, stated:

> *"…There is not another improvement on this reservation so important and so beneficial to the Indians of this reservation as improved irrigation facilities. We are not really in need of expert irrigation assistants, though irrigation engineers are more than welcome, but we do need funds with which to carry on these important repairs….*"

Continuing, Mr. Engle declared:

> *"…I also wish to call your attention to the fact that the Fort Apache Reservation is a watershed for the Salt River Irrigation Project, and the Salt River water users are very jealous of any water used within this reservation, even though the Indians living within the reservation have a prior right through usage and occupation of this territory…."*

Quoted by the court in *White Mountain Apache Tribe of Arizona v. The United States*, 11 Cl. Ct.614, 640 (1987).

6. Livestock Industry

The Fort Apache Indian Reservation contains 1,664,289 acres of land potentially suitable for the grazing of livestock – virtually the entire Reservation. Early correspondence and reports describe the abundance of grass and other forage on the Reservation. For example, the BIA Indian Agent's 1881 Annual Report described the northwestern portion of the reservation as valleys with "excellent grass for grazing purposes. . . " Similarly, a 1901 agriculture lecturer recalled the original condition of the Salt and Verde watersheds where "the great bunch grasses grew luxuriantly. . ., affording an abundance of native hay in the dry season and quickly freshening up into green forage after a rain. . . " Indian harvests and sales of as much as 1,500,000 pounds of native hay (in 1900) to the Fort Apache military post confirm the early productivity of the Tribe's range land. *Id*. at 647. *White Mountain Apache Tribe of Arizona v. United States*, 11 Cl. Ct. 614 (1987) at 647.

Beginning in 1892, there began a history of non-Indian grazing on the Tribe's reservation range land beginning with trespass and ending with a government sponsored system of grazing permits under which the bulk of the Reservation was leased to non-Indian stockmen. Evidence indicates that the government allowed the Tribe's range to be both overstocked and overgrazed. *Id* at 649. The livestock permit system on the Reservation lasted from 1902 until 1953. The number of permitted livestock peaked at 55,000 head in 1920, and then decreased until the permit program ended in 1953. Approximately ten to eleven thousand (10,000-11,000) cattle are now found within the Tribe's lands. With the exception of the Tribe's I.D. herd of approximately 1,400 head, the majority of the cattle, are owned and managed by private tribal member livestock associations.

During the past 25 years, the Tribe has taken aggressive steps to restore its range land. For example, it has removed cattle from environmentally sensitive riparian areas, adopted range management plans in cooperation with the livestock associations with the assistance of the Natural Resources Conservation Service, restored stock ponds, and adopted a permanent Land Restoration Code and Fund in 1998 for restoration of the Tribe's rangeland, wetlands, and riparian areas.

The livestock industry on the Reservation has historically been operated by the Tribe (I.D. Ranch) and by private livestock associations. At one time, the Tribe's prized Hereford herd was well known throughout the region. Today, as it was historically, maintaining a healthy livestock industry remains of paramount interest to the Tribe. Its still abundant grazing lands, the potential for irrigated pasture, as well as the prospects for an organic beef operation, as measured by current and anticipated future consumer demand, bode well for the reservation's livestock industry.

7. Timber Resources

The forest products industry has flourished on the reservation since the early 1900s. The reservation was once forested over 1,061,000 (approximately 60%) of its acres. More than 685,000 acres were considered commercial forest and covered the northern and eastern regions of the reservation from 6,000 feet above sea level to the timberline at 10,000-11,000 feet. The forest currently serves multiple purposes, including, but not limited to, recreation, water, wildlife habitat, grazing and timber production. *Id*. at 667.

A small tribal sawmill and planing mill, originally operated by the Indian Service (BIA) had processed part of the timber harvested from the reservation until 1947 when a fire destroyed the sawmill portion. In 1961, the Fort Apache Timber Company (FATCO) was established and began construction of a sawmill at Whiteriver which began operating in early 1963. Today FATCO processes virtually the entire harvest of the reservation and is among the largest employers of Tribal members. Unfortunately, in 2002, the Rodeo-Chedeski fire burned over 280,000 acres on the western portion of the reservation, leaving just 495,000 acres of commercial forest land in the east management unit of the reservation. The west unit, where the burn took place, has been withdrawn from regulated timber production for the foreseeable future as a result of the fire.

The timber industry remains viable on the reservation. The Tribe's sawmill continues to harvest sawlogs in accordance with the annual allowable cut. Once the Tribe retools its sawmill to harvest and process smaller trees which have become dominant on its forest lands, future prospects for timber harvesting and forest products will be improved substantially while concurrently improving the Tribe's forest stands. The Tribe is exploring the feasibility of developing other wood products that utilize pulp as well as developing a hybrid poplar plantation to supplement the reservation's annual allowable cut as discussed, *infra,* in this Report.

8. Outdoor Recreational Development

The Tribe's Reservation lands are a favorite destination for outdoor recreation enthusiasts. Hundreds of miles of cold water streams and 23 lakes, with several new lakes planned for the future, permeate and dot the reservation's 1.66 million acres. Two federal fish hatcheries stock thousands of trout, including the once endangered Apache trout, in the Tribe's abundant streams and lakes.

The Tribe maintains over 1,200 campsites throughout the reservation designed to support recreation use of the Tribe's lakes and streams. It has also established an internationally renowned guided trophy elk hunt, and has received awards in recognition of its outstanding wildlife management program. Trophy big horn sheep permits on the Fort Apache Indian Reservation are among the most highly prized and rare hunting permits in the region.

The Tribe began extensive development of its recreational lake system in the late 1950's with the construction of Hawley Lake. The potential for expansion of the Tribe's outdoor recreation program is tremendous. Explosive urban development in the state of Arizona has created great demand for the relatively pristine outdoor recreational environment offered by the Tribe. Future plans under consideration include enhancement of existing lake facilities, construction of additional lakes, and condominium and second home development along the Tribe's northern boundary.

In addition to its wildlife and fishing program, the Tribe in the early 1970s developed its Sunrise Ski Park, one of the largest ski areas in the Southwest and the major ski resort in Arizona. The ski area has expanded over the past twenty-five years with the addition of several day lodges, a high speed quad chairlift , additional ski runs, snow boarding areas, and partial snow -making. Plans to expand snow-making capacity in the near future will provide the Ski Park with reliable snow conditions for alpine skiing throughout the winter months regardless of natural precipitation patterns.

9. Commercial Development

The Tribe entered into a gaming compact with the state of Arizona in 1993, which was renewed in 2002 for an additional twenty (20) years, plus three (3) additional years to negotiate a new compact, for a total of twenty-three years. The Tribe established its Hon-dah Casino Resort & Conference Center in 1993 and has continued to expand and upgrade the property with the addition of a sports center for four season outdoor recreation activities, amenities, and a RV center with 258 spaces. In 2006, the RV center has a waiting list for four hundred (400) more spaces and land has been set aside by the Tribal Council for that purpose. The Tribe has a commercial center in Whiteriver, the Tribe's seat of government, several gas stations and mini-markets throughout the reservation and summer cabin rental program for daily and weekly use by reservation tourists.

10. Summary

The White Mountain Apache people have lived within the lands comprising their present day Fort Apache Indian Reservation since time immemorial. In pre-reservation days, the White Mountain Apache people sustained themselves through agriculture, hunting, and warfare. A nomadic people, their territory ranged from the watershed divide of the Little Colorado and the Gila (Salt) River drainage in the north, to Mexico in the south, east to the present State of New Mexico and west, nearly to Flagstaff, Arizona.

Following the Apache wars, the White Mountain Apache people remained on their ancestral lands on what was to become the White Mountain Apache Reservation, established by President Grant by Executive Order on November 9, 1871. Adjusting to the occupation of its homeland by the American Army, the Tribe was compelled to give up its nomadic ways and turn to cattle raising, agriculture, the forest products industry, leasing, and the development of outdoor recreational facilities and lakes to sustain its people.

Beginning in the 1960's with the advent of the Native American movement for Indian self-determination, the White Mountain Apache Tribe gradually took control over reservation affairs from the Bureau of Indian Affairs. In the past 40 years, against great odds, the Tribe has become a leader in wildlife management, outdoor recreation, the forest products industry, and the ski industry in the southwest. It has maintained a viable livestock operation, initiated a range management and land restoration program, has established acclaimed wilderness areas, and has scrutinized the BIA's management of its forest resources. As a result of litigation and government to government negotiations with state and federal agencies, the Tribe has secured its rightful sovereign authority over wildlife and water resource administration and management within its reservation lands.

With a youthful population, over half of whom are under the age of 18, Tribal members have become increasingly educated at a professional level in the areas of forestry, hydrology, education, engineering, law, and other professions. The Tribe's future prospects for entering the organic beef industry, producing organic crops and orchards, expanding outdoor recreation, exploring additional mineral development, and adding new forest products are extremely promising.

The Tribe continues to revitalize itself as it constantly adjusts to a demanding modern world. It is optimistic about a prosperous future for its people. That portion of the Tribe's aboriginal lands comprising the present day Fort Apache Indian Reservation was retained by the White Mountain Apache as a permanent homeland. The Tribe's goals for economic development, self-determination and true self-sufficiency will largely depend upon the protection, development, and use of its aboriginal and otherwise reserved water use rights to the springs, streams, and waters that border, underlie, and traverse its homeland. This Report, the Tribe's water budget, master drinking water infrastructure and needs assessment study, the appointment of a Federal Negotiation Team by the Secretary of Interior at the Tribe's request to assist in the quantification of the Tribe's presently vested and reserved water use rights, among other efforts, represents the Tribe's commitment to its homeland and future generations.

2. DEMOGRAPHIC PROFILE OF THE FORT APACHE INDIAN RESERVATION

2.1 Executive Summary

This demographic profile of the Fort Apache Indian Reservation provides information regarding the total population of the Reservation, the age and sex of the population, and demographic trends within the population. The information is then used to project the Reservation population into the future and develop estimates that may be used in planning. The future housing needs on the Reservation are estimated using these population projections, and the projections also provide estimates of the size of the future labor force, and school enrollment.

2.1.1 Current Population

Results of the demographic analysis of the population based on data from Census 1990 and 2000 reveal a number of interesting features of the Fort Apache Indian Reservation population. These features include:

- The population of the Fort Apache Indian Reservation on April 1, 2000 was 12,429 people, of which 94 percent identified themselves as American Indian or Alaska Native (AIAN).

- 43.8 percent of the AIAN population on the Reservation is comprised of children under the age of 18, and 3.8 percent are seniors over the age of 65. This compares with 25.7 percent of the national population that is under 18 years old, and 12.4 percent of the national population that is over 65 years old.

2.1.2 Population Trends

- The population of the Reservation has grown 19.6 percent in the last decade, implying an annual growth rate of 1.8 percent.

- Overall net migration was small between 1990 and 2000, with several age groups moving onto the Reservation and other age groups moving off of the Reservation. Age cohort analysis suggests that in-migration has occurred among the 5-9 year old cohort, and the 30-74 year age groups. There has been net out-migration among the 0-4 year, the 15-29 year, and the 75-79 year age groups.

- Migration in the 1990s was limited due to a severe housing shortage, with 1,400 people on a housing waitlist by the end of the 1990s. Since 2000, at least 317 homes have been built on the Reservation, as part of the WMAHA "Apache Dawn" housing project, and immigration has increased.

- The current reservation population is estimated to have grown to over 16,000.

- The birth rate for the AIAN Reservation population was been very high throughout the nineties. High birth rates are typical of AIAN populations living on reservations.

- Taken together, these pieces of information suggest that planning to meet the needs of a young and mobile population should be a high priority in the years to come. Also, the middle-aged group that in-migrated during the 1990s will be aging to create a larger senior population in coming years. Hence, the needs of seniors will merit additional consideration in the near future. This will be especially important if the in-migration of this age group represents a trend in migration that continues through the current decade.

2.1.3 Future Population

The Cohort Component projection method is used to estimate the future population of the Fort Apache Indian Reservation. The Cohort Component method used in the analysis is based on the assumption that some age/sex cohorts will encounter out-migration while others will encounter in-migration, but that overall the Reservation will incur a net in-migration. The total number of migrating people is projected to range from 15 and 18 percent of the total population pool in the early projection years, ramping down to 1.5 percent in later years, and ramping further down to 0 percent by the end of the projection period.

The future population of the Fort Apache Indian Reservation is projected based on data regarding the current population. The projections suggest that the population in the coming years will continue to grow, following the schedule shown in Table 2-1. Within the next ten years, the reservation population is expected to grow to 19,423 people. By 2020, this population is expected to reach 28,660 people, and by the year 2100, the population is expected to be 93,833.

Table 2-1
Population Forecast for
the Fort Apache Indian Reservation, 2000-2040

Year	Population Estimate
2000	12,429
2010	19,423
2020	28,660
2030	38,563
2040	48,445
2050	57,409
2075	76,230
2100	93,833

The estimates shown in the table represent a reasonable and expected forecast for the Reservation population. However, these are based on the best data that is currently available and on assumptions about human behavior. If there are significant changes in those assumptions or behaviors, it is possible that the Reservation population may grow faster or slower than currently projected.

2.1.4 Implications for Housing Needs

The housing stock on the Reservation was 3,532 units in the 2000 census. An additional 317 homes were built by 2006 in the Apache Dawn housing project. However, another 13,788 housing units will be needed by 2050 and an additional 19,896 by 2100, bringing the total occupied housing stock needs to 37,533. More housing will be needed to allow for some vacancies among houses due to on-going maintenance and transitions.

2.1.5 Implications for Employment

According to the Bureau of Indian Affairs Indian Labor Force Survey, 3,849 people were employed on the Reservation in 2003. Approximately 62 percent were employed in public sector jobs and the balance was working in the private sector. Another 3,460 people on the Reservation were able to work but were not employed, suggesting a total labor force in 2003 or 7,309. The unemployment rate implied by these figures is of 47 percent underscoring the importance of job creation in coming years. Economic development projects, such as those identified in the report titled, Economic Feasibility of an Irrigated Agriculture Project on the Fort Apache Indian Reservation (ENTRIX, 2006), will be key to sustaining employment on the Reservation.

The Reservation labor force is projected to be 22,444 by 2030, 33,379 by 2050, and reach 58,577 by 2100. This means the labor force is expected nearly to triple over the next 25 years, and this implies a growth rate of just over 4 percent per year through 2030. The rapid growth of the recreation and tourism industry on the Reservation, within the White Mountain region, and in the State of Arizona are anticipated to sustain a rapidly increasing economy in on the Reservation as well as in the local area of Pinetop-Lakeside and Show Low. After the year 2030, the increase in the number of new jobs needed is expected to decrease as a percentage of the whole population, but there will continue to be a requirement of an additional over 5,000 jobs per decade.

2.1.6 Implications for School Enrollment

Presently, the 5-16 year-old population is 4,321 and represents about 35 percent of the total population on the Fort Apache Indian Reservation. By 2010, both the number of school-aged children and the share of the total population represented by those aged 5-16 years are expected to increase to 7,247 and 37 percent, respectively. Following the year 2010, the number of students will continue to grow, but the share of the population represented by this age group will begin to decline. After 2010, the percent of the Reservation population that 5-16 year age group will comprise declines to about 34 percent by 2020, 30 percent by 2030, and to just over 20 percent by 2100. Increasing school-aged students implies increasing needs for schools and other educational facilities.

2.2 Introduction

A demographic profile provides information about the number of people in a population, the composition of the group in terms of age and sex, and insight into any changes that may be occurring within the population numbers and composition. Such information can help develop an understanding of the needs of the group. Planners may then use the information to help direct a planning process designed to meet those needs. In addition, understanding the characteristics of the present population provides a baseline from which to project the future population, and this information may then help direct the planning process for meeting future needs of the community.

This report provides a description of the population on the Fort Apache Indian Reservation (hereinafter referred to as Reservation) of the White Mountain Apache Tribe (hereinafter referred to as Tribe). A very brief description of the population in the State of Arizona as a whole provides a point of comparison within the regional context. Following the presentation of baseline demographic data for the present population, historic data is used to establish any recent trends in the demographics of the group. These trends, combined with the baseline data, are used to project the population for 100 years into the future. Finally, the future population description will be used to derive implications for future housing needs, employment, and school enrollment on the Reservation.

2.3 Current Population

The Reservation is located in east-central Arizona, 194 miles northeast of Phoenix, and comprises approximately 1.6 million acres in Navajo, Apache, and Gila counties. It is the homeland of the Tribe. On April 1, 2000, according to the U.S. Census Bureau, the reservation was home to 12,429 people. Of these, 94.2 percent (or 11,702) of the people identified their race as American Indian or Alaska Native (AIAN), with another 490 identifying as White, 23 identifying as Black, seven identifying as Asian, one identifying as Native Hawaiian or Pacific Islander, 40 reporting some other race, and 166 reporting two or more races.[1]

2.3.1 Census Data

Census data is often the best available data on population. This is especially true in the years immediately following a U.S. decennial census. However, populations in general are living entities that change daily, and even the best available data does not necessarily portray the exact number of people living within a given population (in this case, on the Reservation). Since the 2000 census was conducted, babies have been born, people have died, and others have moved onto and off of the Reservation. Since the population on the Reservation is on the rise, it is probably somewhat larger at present than on April 1, 2000.

2.3.2 IHS Data

In addition to the census data, population information for the Reservation is available from the Indian Health Services (IHS), which maintains a database of patients. The patient database differs from the census data in several ways. First, the patient database includes just those people who are receiving health care from IHS. Second, the patient database serves Indians who live both on and near the Reservation. The first factor suggests that the IHS data may include fewer people than the total Reservation population, since not everyone has health

1 Some other race signifies that the person did not select from the following choices: White, Black or African American (BlackAA), Native American or Alaska Native Asian, or Native Hawaiian or Pacific Islander.

problems. The second suggests that the number of patients is larger than the Reservation population because it also includes people who live near the Reservation and not on it. Furthermore, people who consider the Reservation their home may use IHS Services, though they may be living in Phoenix, or some other larger city for employment or educational purposes. Using data from the IHS Reservation Patient Management System (RPMS), the following Table 2-2 depicts the estimated total population of the IHS service area for the Reservation (including those living on, as well as off the Reservation) as 27,378 in 2005.[2] Furthermore, the total population of still-living patients that reside on the Reservation was tallied at 16,040 in July, 2006 (see Table 2-2).

Table 2-2
Total Indian Health Service Patients by Reservation Division

IHS Division	Number of Patients
Canyon Day	1,359
Carrizo	190
Cibecue	2,279
Diamond Creek	578
Hon-Dah	605
East Fork	1,074
Forestdale	16
Fort Apache	655
McNary	724
Rainbow City	1,985
Seven Mile	870
Whiteriver	5,705
TOTAL	16,040

Source: Personal correspondence from Richard L. Cosen, WRSU-IRM Computer Specialist to Gloria Dayaye, BIA, Memo dated May 9, 2006 Re: Numbers of people in Community.

2.3.3 Age Composition of Population

The age and sex composition of a population plays a major role in determining the future of the population. It is important to note that the population of the Reservation, like most Indian Reservations, is much younger than that of the U.S. as a whole, or than the State of Arizona. Typically, a younger population grows faster than an older population, since there is a greater share of the population that will still grow up and have their own children. Figure 2-1 illustrates the age breakdown of the Reservation population compared with the population of the U.S.

2 Operations Summary provided by Marc Fleetwood, Administrative Officer for the Whiteriver Hospital, IHS in Whiteriver, AZ.

Figure 2-1
Age Composition of the Fort Apache Indian Reservation Population Compared with the U.S. Population, Census 2000

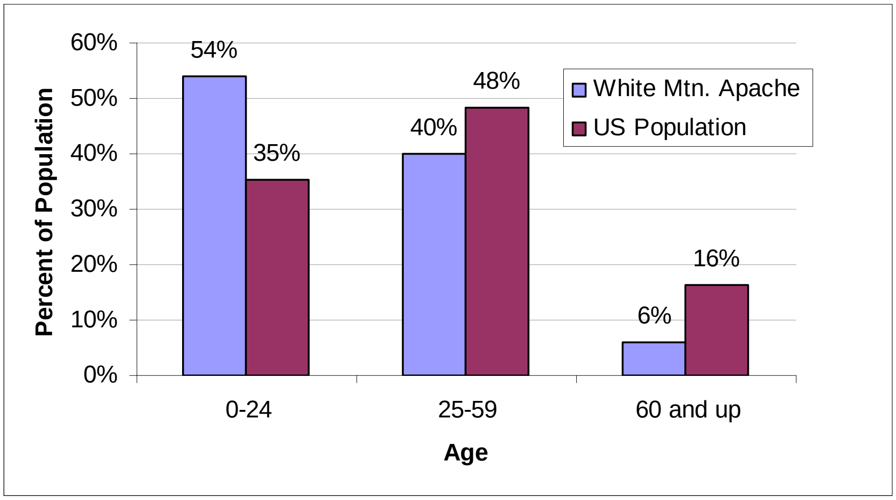
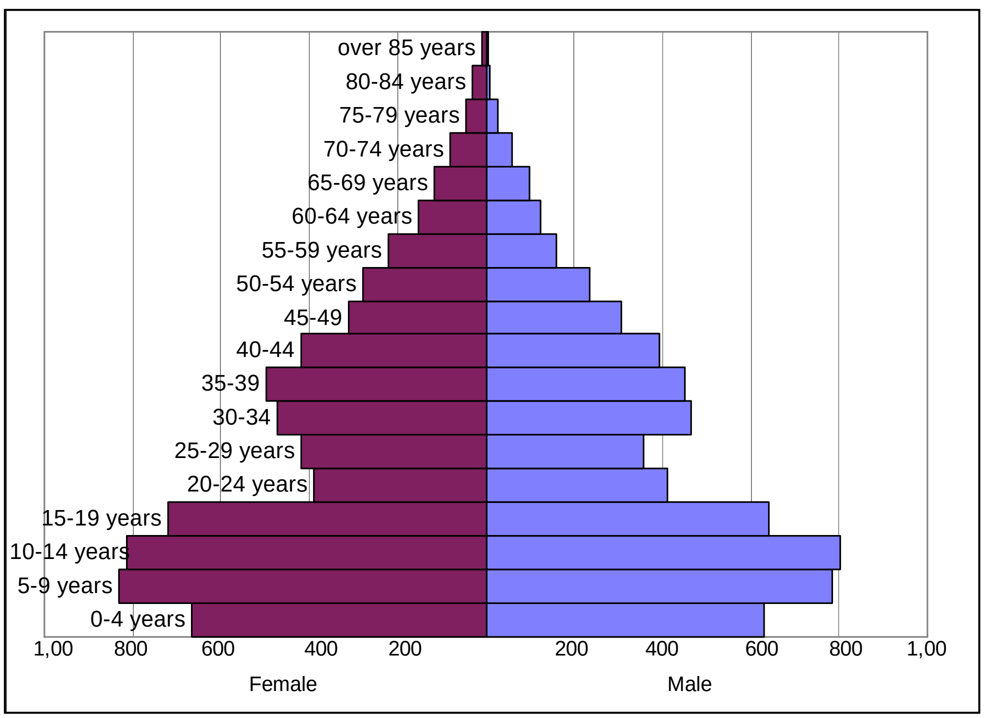


Figure 2-2 shows the composition of the Reservation population in terms of the age and sex of the group. This manner of presenting population data is known as a population pyramid.

Figure 2-2
2000 Population Pyramid for Fort Apache Indian Reservation



Source: Census 2000 Summary Tape File 1 http://factfinder.census.gov.

Figures 2-1 and 2-2 clearly suggest that there are a lot more people in the younger age cohorts on the Reservation than in the older age cohorts. To a certain extent, this is true for all populations because more deaths have occurred in older age cohorts. However, the pattern is particularly pronounced in the Reservation population, with 43.8 percent of the total population of the Reservation being under the age of 18. This compares with the national figure of 25.7 percent of the total U.S. population being under 18 years old. At the other end of the pyramid, while just 9.1 percent of the Reservation population is aged 55 and over, fully 21 percent of the national population falls into this bracket.

The non-AIAN population of Arizona as a whole, surrounding and including the Reservation, provides another context within which to examine the population of the Reservation (see Figure 2-3). The population pyramid reveals a unique feature of the area, that a large portion of the population is over 50 years old (see Figure 2-4). A full 22 percent of the population is over 55 years old, compared with nine percent of the Reservation population and 20 percent of the total U.S. population. It is also worth noting that within the senior population, women outnumber men in all age cohorts. The number of women aged 55 and over in Arizona is 587,032, while the senior men number 497,292, implying about 18 percent more women than men within this group. The population pyramid for Pinetop-Lakeside, a town that borders the Reservation, is similarly skewed toward the older age groups (see Figure 2-5).

Figure 2-3
Arizona State (with Indian Reservations)

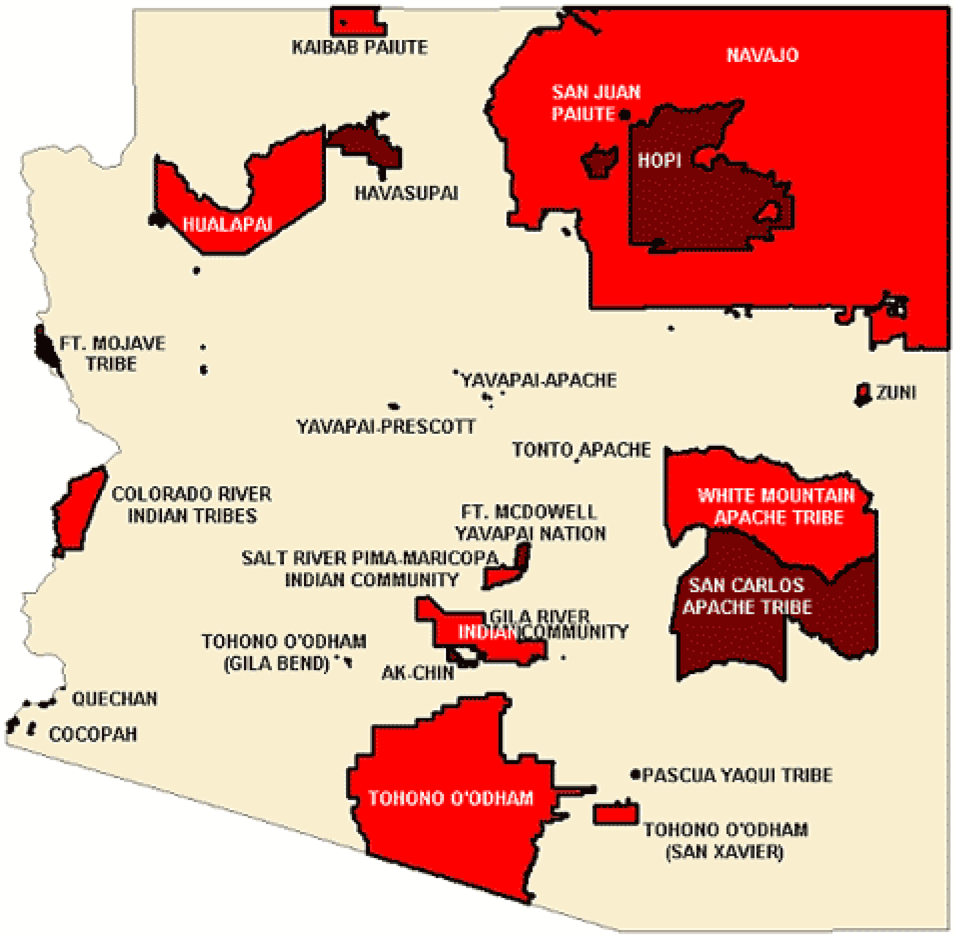
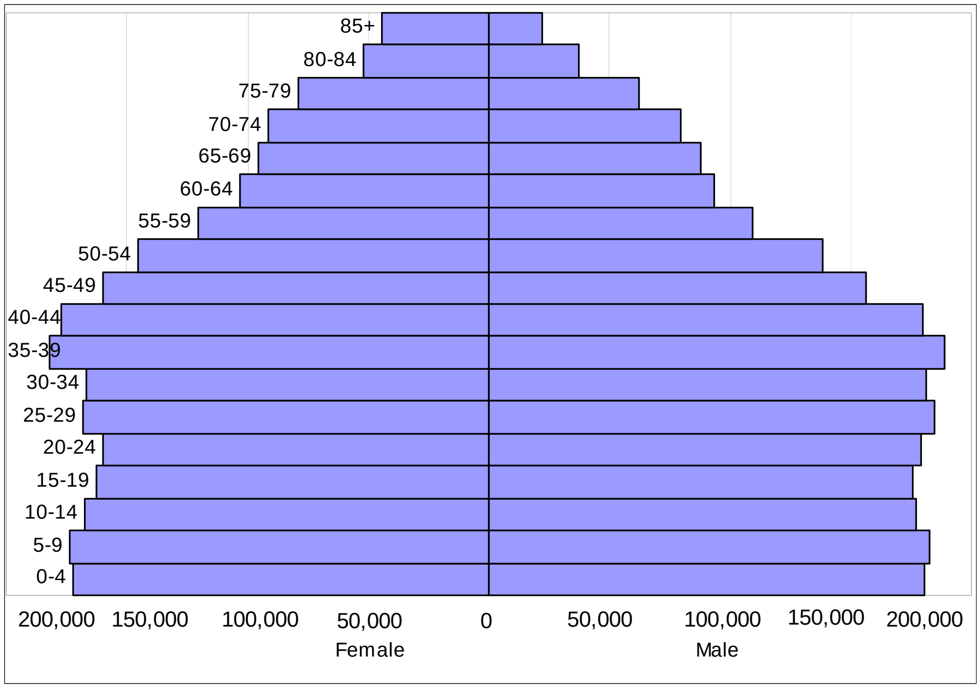
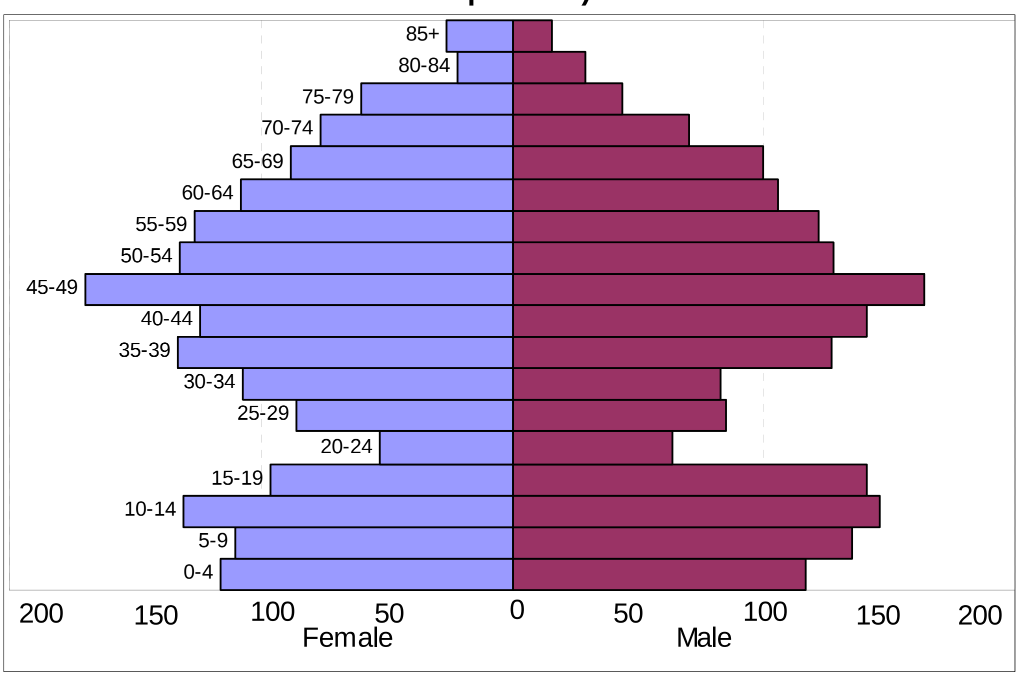


Figure 2-4
2000 Population Pyramid for Arizona Non-AIAN Population



Source: Census 2000 Summary Tape File 1 http://factfinder.census.gov.

Figure 2-5
2000 Population Pyramid for Pinetop-Lakeside (Total Population)



Source: Census 2000 Summary Tape File 1 http://factfinder.census.gov.

2.3.4 Racial Identity

The racial identity of a population is not easily defined, nor is the federal government in the business of classifying people into racial categories by any federally-defined methodology. Rather, the government recognizes that racial identification has to do with a number of cultural and biological factors. For the purpose of the census, each person is asked to identify his or her own race.

In previous censuses, people were asked to check one box to identify their race. This was difficult for many people because they identified with more than one racial group and, therefore, did not always know which box to check. In Census 2000, this was changed so that people could check the box of all races that applied, be that one, two, three, or more. The result of this is important to consider when comparing data from different censuses. There is no way of know whether people who identify themselves as both White and American Indian, for example, marked themselves as White or American Indian on the previous census as well.

One way to classify the race for the population is to look at the population who made just one racial selection. An example would be a group referred to as "AIAN alone," meaning that no other race was selected. Another way to consider the population is to consider the 127 different alternative combinations of race that might be selected. A simpler way to review the data is to look at all of the people who selected a particular race alone or in combination with others.

For example, throughout the U.S., nearly 2.5 million people (0.9 percent of the total population) marked in their 2000 Census forms that they were of one race, and that race was American Indian or Alaska Native. Another 1,643,345 marked that they were AIAN along with some other race. Summing the two produces a grand total of 4,119,301 people (or 1.5 percent of the population of the country) who marked AIAN alone or in combination with others. However, just 152 people on the Reservation, less than two percent, elected AIAN in combination with other races, while 11,702 identified themselves as AIAN alone.

Table 2-3 presents the two ways of classifying race for the population on the Reservation.

Table 2-3
Racial Composition of the
Fort Apache Indian Reservation, Census 2000

Race	Total – Race Alone	Total – Race Alone or in Combination with Others
White	490	622
Black or African American (BlackAA)	23	43
American Indian or Alaska Native (AIAN)	11,702	11,854
Native Hawaiian and Other Pacific Islander (NHPI)	1	4
Asian	7	12
Some Other Race	40	64
Two or More Races	166	N/A
Total	12,429	12,601

Source: Census 2000 Summary Tape File 1 http://factfinder.census.gov.

2.4. Population Trends

Trends in population data are important to understand since these provide information about the way a population is changing. In general, populations change through births, deaths, and migration. Data from Census 2000 can be compared with 1990 census data to provide an estimate of overall population change for the Reservation and the State of Arizona as a whole. A more detailed analysis can provide insight into trends in each of the components (birth, death, and migration).

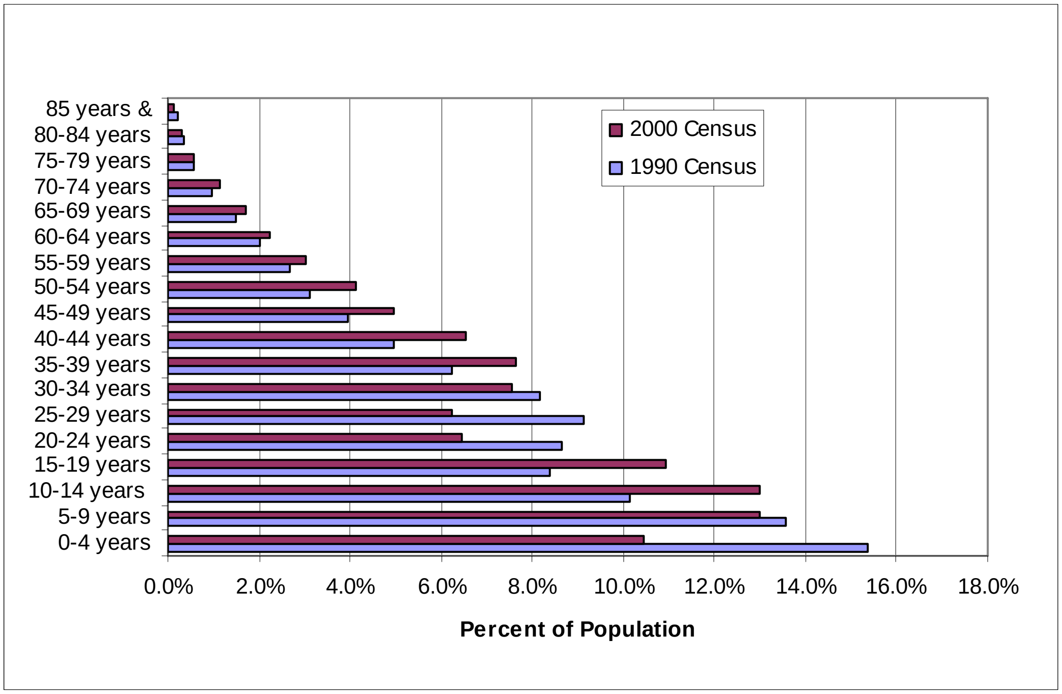
2.4.1 1990 Census Data

Data for the Reservation from the 1990 census suggests that on April 1, 1990, there were 10,394 people living on the Reservation. In 2000, this figure was 12,429 people. This represents an increase of 2,035 people, or about 20 percent increase in population during the decade. The AIAN population also increased from a total of 9,825 people in 1990 to 11,702 people in 2000. This growth also represents an increase of 19 percent, or 1,877 people.

The increase reported is a "net" increase resulting from births, deaths, and migration. It is likely that some people moved onto the Reservation while others moved out if it, but the net result is that more moved out than onto. Also, some people died while others were born, but the net result is that there were more births compared to deaths.

As a population ages, the age composition of the population also changes. This change primarily occurs due to everyone getting older, but it also occurs as a result of migration trends. An analysis of the age cohorts of the AIAN population on the Reservation is shown in Figure 6 that illustrates each age cohort as a percentage of the entire population.

Figure 2-6
Fort Apache Indian Reservation Population by Age, 1990 and 2000



Source: Census 2000 Summary Tape File 1 http://factfinder.census.gov.

Some of the results presented in Figure 6 are expected. For example, the high percentage of 0-4 year olds in the 1990 census translates into a similarly high percentage of 10-14 year olds in the 2000 census. But regardless of whether the people within an age cohort are the same people from the previous census, or whether they migrated onto the Reservation, it is clear that the population composition is changing. The most noticeable trend is that the middle-aged people, between ages 35 and 55 have grown as a percentage of the population. This may be due to increasing job opportunities on the Reservation, whereas this same working-age group in 1990 may have had to live off the Reservation to find employment. In 1990, this group represented 18.2 percent of the population, while in 2000 the group was 23.3 percent of the total population. Other noticeable differences are the increase in the population of the 15-19 year age cohort in 2000, and a decrease in the 20-34 year age group as a percentage of the overall population.

2.4.2 Births and Deaths

Births play an important role in population trends for at least two reasons. First, all expectations of future population sizes depend critically on the number of births that can be expected to occur. Second, birth rates have changed dramatically in the last 30 years, and the most predominant change has been that birth rates (the number of babies born annually per 1,000 people in a given population) have declined steadily among all population groups in the U.S. It is, therefore, imperative to understand not only the birth rates, but also the changes in those birth rates within a given population in order to establish the expected future population.

American Indian populations tend to have higher birth rates than Whites. For example, the 2004 birth rate per 1,000 people for all races in the U.S. is 14.0 births per 1,000 people. The same rate is 13.5 for the White population and 14.0 for the AIAN population, according to National Vital Statistics (Vol. 55, No. 1). But the 1999-2000 birth rates for Indians living on or near reservations (the most recent data available) were much higher, at 22.2 according to Indian Health Services (IHS)[3].

It is difficult to calculate a similar birth rate for the Reservation. Census data provide the number of children less than ten years of age, and while it can safely be assumed that these children were born during the period between 1990 and 2000, it is not clear how large the population base was at the time. This makes it hard to calculate an accurate birth rate. However, a conservative estimate of birth rates on the Reservation may be obtained by assuming the population is as large as the current population for the period, and further assuming that all of the children in the current population are born to members of the current population. The result suggests a birth rate of 23.4 births per 1,000, a rate that is high but not unusual for an AIAN population living on a reservation. The IHS reports that the comparable national birth rate for all IHS areas is 22.2, and that the rate for the regional office in Phoenix is 22.5.[4]

Additional information about the births on the Reservation can be obtained from the IHS database. These data include the births of all patients within their system. Using this approach, the births of current patients include the following total births during recent five-year periods (see Table 2-4):

Table 2-4
Population of Current IHS Patients
by Five-Year Birth Cohorts

Year of Birth	Population
2005-Sept. 2006	712
Jan. 2000 – Dec. 2004	2,019
Jan. 1995 – Dec. 1999	2,035
Jan. 1990 – Dec. 1994	2,785
Jan. 1985 – Dec. 1989	3,008
Total Population 21 and under	10,559

Source: RPMS Query produced by Vanette Endfield, Whiteriver IHS Hospital, personal communication, Oct. 2, 2006.

Changes in longevity (or people living longer) are important to understand because they have strong implications for planning in terms of providing services to an older population. However, changes in these rates are difficult to predict, and have little effect on population projections. Nationally, life expectancy for all races in 1995 was 75.8, while the life expectancy

3 Indian Health Service, *Regional Differences in Indian Health* Table 3.1, Number and Rate of Live Births per Calendar Years 1999-2000, sent electronically to ENTRIX on November 9, 2005.

4 Ibid.

for Indian Health Service area populations was estimated to be 71.1 years.

2.4.3 Migration

Trends in migration of people into an area are often triggered by economic factors such as the proximity to employment, availability of housing, and other cultural and environmental factors. One factor affecting in-migration to Indian reservations throughout the country is that more and more Native Americans are returning to reservation life because they see the reservation as a homeland. This trend has been occurring since the 1970s, and is probably in part a reaction to federal assimilation policies of the 1950s and 1960s that encouraged people to leave reservations.[5] Also, as the AIAN baby-boom population ages, more and more people of that generation are returning to reservation life in retirement.

Migration is made up of many people moving out of an area and others moving in. It is very difficult to know much about these movements in general, but the overall result of such movement is known as “net migration,” which also may either result in net in-migration or net out-migration. Although the net migration between 1990 and 2000 was slightly negative for the Reservation, current net migration appears to be shifting towards a positive trend as more housing has been built. With the growth of the booming regional economy in the neighboring towns of Pinetop-Lakeside and the economic successes of Tribal recreation and gaming industries, job opportunities in the area are increasing. Similarly, as Tribal housing increases, more and more people will be willing to move back from urban areas to live on the Reservation. The sections below cover the recent growth of the local area, and the recent housing improvement efforts developed by the Tribe.

2.4.3.1 Growth in Arizona and White Mountain Area

This analysis covers population and development trends in the State of Arizona, Navajo County, the Reservation, and two communities immediately north of the Reservation, Pinetop-Lakeside and Show Low. In addition to being located near the Reservation, Show Low and Pinetop-Lakeside are selected as these represent two economies driven by tourism and seasonal residents. Demographic trends in Gila and Apache counties are not examined in this report since these do not have significant population centers in the vicinity of the Reservation that may be affected by the proposed project. Additionally, Apache County is primarily comprised of the Navajo and Zuni Indian reservations. Table 2-5 illustrates the population growth in the areas selected for analysis.

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5 Shoemaker, Nancy, 1999, *American Indian Population Recovery in the Twentieth Century*, University of New Mexico Press, Albuquerque, pp. 76-79.

Table 2-5
Population Growth in Arizona, Navajo County,
and Selected Areas in the Vicinity of the Reservation, 1990 - 2050

	1990	2000	2004	2010	2030	2050
Arizona	3,665,228	5,130,632	5,833,685	6,999,810	10,347,543	12,830,829
growth rate	*n/a*	*3.4%*	*3.3%*	*3.1%*	*2.0%*	*1.1%*
Navajo County	77,674	97,470	107,420	123,172	165,647	192,360
growth rate	*n/a*	*2.3%*	*2.5%*	*2.3%*	*1.5%*	*0.8%*
Fort Apache Reservation	10,394	12,429				
growth rate	*n/a*	*1.8%*				
Pinetop-Lakeside	2,422	3,582	4,055			
growth rate	*n/a*	*4.0%*	*3.1%*			
Show Low	5,020	7,695	9,365			
growth rate	*n/a*	*4.4%*	*5.0%*			

Sources: U.S. Census Bureau and Arizona Department of Economic Security.

Arizona is ranked the second fastest growing state in the United States, with an annual population growth rate of just under 3.3 percent between years 2000 and 2004.6 It is the sixteenth largest state in the country in terms of population.[7] Arizona's population is projected to increase by an astounding 120 percent in the next five decades, surpassing twelve million by 2050.

As presented in Table 4, the population of Navajo County has increased by 2.3 percent and 2.5 percent annually between 1990 and 2000 and between 2000 and 2004, respectively. This population is projected to increase at a healthy rate in the coming decades. However, the annual population growth rate in the county is lower compared to that of Arizona as a whole. Navajo County mostly encompasses the Navajo, Hopi, and Fort Apache Indian reservations.

2.4.3.2 Pinetop-Lakeside and Show Low Economies

The Pinetop-Lakeside community and the City of Show Low are located close to the northern border of the Reservation. The population of the 11.3 square mile town of Pinetop-Lakeside was estimated to be 4,055 in 2004. The annual rate of population growth for the town was 4.0 percent between 1990 and 2000 and 3.1 percent between 2000 and 2004. Other

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6 U.S. Census Bureau's annual ranking.

7 Two of Arizona's counties, Maricopa and Pima, are among the hundred largest counties in the U.S., with Maricopa County ranking fourth and Pima County ranking forty-seventh in the July 1, 2004 population estimates by the U.S. Census Bureau. Source: Population Division, U.S. Census Bureau, Table 8: Population Estimates for the 100 Largest U.S. Counties Based on July 1, 2004 Population Estimates – April 1, 2000 to July 1, 2004 (CO-EST2004-08).

indicators of growth for Pinetop-Lakeside, presented in Table 2-6, also reveal an expanding economy. New building permits increased annually by 9.7 percent from 2000 to 2004 while taxable sales expanded by 7.4 percent annually during the same period.

Table 2-6
Growth Indicators for Pinetop-Lakeside and Show Low
1990, 2000, and 2004

	Pinetop-Lakeside		Show Low	
	Permits/Sales/ Net Assets	**Annual Growth Rates**	**Permits/Sales/ Net Assets**	**Annual Growth Rates**
New Building Permits				
1990	93	n/a	259	n/a
2000	129	3.3%	506	6.9%
2004	187	9.7%	646	6.3%
Taxable Sales (in 2004 $s)				
1990	$53,052,800	n/a	$94,853,850	n/a
2000	$88,372,680	5.2%	$310,673,300	12.6%
2004	$117,595,680	7.4%	$384,277,750	5.5%
Net Assessed Valuation (in 2004 $s)				
1990	$30,717,822	n/a	$55,035,976	n/a
2000	$40,953,786	2.9%	$69,922,761	2.4%
2004	$54,706,805	7.5%	$94,162,089	7.7%

Sources: Arizona Department of Commerce, June 2004, "Economy of Pinetop-Lakeside (Zip Codes 85929 and 85935)," and Arizona Department of Commerce, June 2004, "Economy of Show Low (Zip Codes 85901, 85902, and 85912)."

The economy of Pinetop-Lakeside is primarily dependent upon tourism and seasonal residencies. The Hon-Dah Casino, owned by the White Mountain Apache Tribe, is also located near the town. Table 2-7 presents the employment by sector in Pinetop-Lakeside community. Accommodation and food services sectors are the second largest employers in the town after government agencies. Retail trade and construction also provide substantial employment opportunities for the residents, while per capita employment in utilities is much higher compared to both national and state averages. A further analysis of the tourism industry suggests that the per capita employment (employment per 1,000 residents) is 75 percent higher compared to the U.S. average in the accommodation sub-sector in the town, and 25 percent higher in the food services sub-sector. Other tourism related industries also have higher per capita employment compared to the national average. This trend is also reflected in the housing sector, where 42 percent of single-family housing units are seasonal.

Table 2-7 -
Pinetop-Lakeside Employment by Sector

Sector	Number of Establishments	Employment	Relative to Nation: Location Quotient	Relative to Nation: Excess Employment	Relative to Arizona: Location Quotient	Relative to Arizona: Excess Employment
TOTAL	455	3,335	0.60	0	0.66	0
AGRICULTURE	7	50	0.32	0	0.61	0
GOVERNMENT	9	636	0.71	0	0.75	0
TOTAL, NONAGRICULTURE PRIVATE SECTOR	439	2,649	0.59	0	0.64	0
Mining	1	2	0.08	0	0.07	0
Utilities	2	91	3.56	65	4.22	69
Construction	87	456	1.81	204	1.27	97
Manufacturing	11	49	0.08	0	0.12	0
Wholesale Trade	7	67	0.28	0	0.36	0
Retail Trade	68	493	0.85	0	0.87	0
Transportation and Warehousing	4	6	0.04	0	0.04	0
Information	5	68	0.47	0	0.55	0
Finance and Insurance	17	104	0.43	0	0.43	0
Real Estate and Rental and Leasing	28	88	1.13	10	0.99	0
Professional, Scientific and Technical Services	31	116	0.42	0	0.46	0
Management of Companies and Enterprises	2	37	0.33	0	0.41	0
Administrative, Support, Waste Management, Remediation Services	19	85	0.24	0	0.21	0
Educational Services	1	6	0.06	0	0.11	0
Health Care and Social Assistance	43	212	0.37	0	0.50	0
Arts, Entertainment and Recreation	7	67	0.96	0	0.89	0
Accommodation and Food Services	58	510	1.32	123	1.16	72
Other Services (except public administration)	40	185	0.88	0	1.07	12
Auxiliaries (except corporate, subsidiary and regional management)	0	0	0.00	0	0.00	0
Unclassified Establishments	8	5	1.32	1	1.55	2

Table Source: Arizona Department of Commerce, June 2004, "Economy of Pinetop-Lakeside (Zip Codes 85929 and 85935)."

Table 2-8
Show Low Employment by Sector

Sector	Number of Establishments	Employment	Relative to Nation: Location Quotient	Relative to Nation: Excess Employment	Relative to Arizona: Location Quotient	Relative to Arizona: Excess Employment
TOTAL	504	5,409	0.91	0	0.99	0
AGRICULTURE	13	95	0.57	0	1.06	6
GOVERNMENT	10	888	0.91	0	0.97	0
TOTAL, NONAGRICULTURE PRIVATE SECTOR	481	4,426	0.92	0	0.99	0
Mining	1	28	1.39	8	1.23	5
Utilities	4	23	0.82	0	0.97	0
Construction	99	590	2.16	317	1.52	202
Manufacturing	7	87	0.13	0	0.19	0
Wholesale Trade	12	92	0.36	0	0.45	0
Retail Trade	83	1,169	1.87	542	1.91	555
Transportation and Warehousing	22	84	0.53	0	0.50	0
Information	9	117	0.74	0	0.87	0
Finance and Insurance	22	162	0.62	0	0.62	0
Real Estate and Rental and Leasing	21	63	0.74	0	0.65	0
Professional, Scientific and Technical Services	31	106	0.35	0	0.39	0
Management of Companies and Enterprises	2	9	0.07	0	0.09	0
Administrative, Support, Waste Management, Remediation Services	18	86	0.23	0	0.20	0
Educational Services	4	103	0.93	0	1.64	40
Health Care and Social Assistance	46	965	1.58	354	2.09	503
Arts, Entertainment and Recreation	5	61	0.81	0	0.75	0
Accommodation and Food Services	38	453	1.08	33	0.95	0
Other Services (except public administration)	50	223	0.98	0	1.19	36
Auxiliaries (except corporate, subsidiary and regional management)	2	4	0.08	0	0.09	0
Unclassified Establishments	5	3	0.77	0	0.90	0

Table Source: Arizona Department of Commerce, June 2004, "Economy of Show Low (Zip Codes 85901, 85902, and 85912)."

Similar to Pinetop-Lakeside, tourism and recreation also play a significant role in the economy of the City of Show Low. The population of the 27.9-square-mile city grew at a steep annual rate of 5.0 percent between 2000 and 2004. The estimated population of Show Low was 9,365 in 2004 (see Table 2-5). As presented in Table 2-6, economic growth indicators reflect a positive economy with a 6.3 percent annual increase in housing permits and 5.5 percent increase in taxable sales between 2000 and 2004. The city also provides employment to residents of surrounding areas such as Pinetop-Lakeside. Per capita employment in tourism related sectors of accommodation and food services in Show Low is higher than the U.S. average (see Table 2-8). Other sectors where per capita employment in Show Low exceeds the national average are construction, retail trade, health care and social assistance, and mining. In terms of housing, a high 27 percent of single-family housing units are used seasonally in the city.

2.4.3.3 Phoenix and Tucson

The growing city of Phoenix is located southwest of the Reservation in Maricopa County. The county ranks fourth in the U.S. in terms of population according to the July 1, 2004 population estimates by the U.S. Census Bureau and its population is expected to increase over 100 percent by 2050 and reach an astounding 7.7 million.8 The majority of the county population resides in the Phoenix Metropolitan Statistical Area (MSA), which is the fourteenth largest MSA in the U.S., comprising over half of Arizona's population.9 Phoenix is a primary source of the tourism industry in the White Mountain region. Among recreation attributed to individuals traveling to the region from another Arizona county, between 44 and 63 percent of angler and hunter days in the counties of Gila, Navajo and Apache (Reservation is located in all three counties) originate with sportspersons from Maricopa County.[10]

Located south of Phoenix in Pima County, the City of Tucson is also growing rapidly. Tucson's population increased from 666,880 to 843,746 from 1990 to 2000, an annual growth rate of 2.4 percent.[11] Tucson is expected to continue to grow at a quick pace, reaching 1,709,026 persons by 2050; total growth of 103 percent, or 1.4 percent annually.[12] Sportspersons from Pima County account for between 17 and 25 percent of angler and hunter days in Apache, Gila,

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8 U.S. Census Bureau, Population Division, Table 8: Population Estimates for the 100 Largest U.S. Counties Based on July 1, 2004 Population Estimates – April 1, 2000 to July 1, 2004 (CO-EST2004-08).

9 U.S. Census Bureau, Census 2000, Population and Housing Census.

10 Silberman, J. 2003. The Economic Importance of Fishing and Hunting: Economic Data on Fishing and Hunting for the State of Arizona and Each Arizona County. Arizona State University West, School of Management: Phoenix, AZ. Report for the Arizona Department of Game and Fish.

11 U.S. Census Bureau, Census 1990 and 2000, Population and Housing Census.

12 Arizona Department of Economic Security, Research Administration, Population Statistics Unit. Approved by Arizona Department of Economic Security Director, March 31, 2006.

and Navajo Counties.[13]

Phoenix and Tucson's rapid growth is expected to translate into similar expansion in tourism and recreation visitation in the White Mountain region (see Fort Apache Indian Reservation Reservoir Recreation Feasibility Analysis, ENTRIX, 2006 for more details).

2.4.4 Summary of Trends

Some of the trends reported in this section are summarized in Table 2-9. Included in the summary of changes that have occurred between the two census data periods is the percentage change in the value over the ten year period, and also an estimate of the annual percentage change, sometimes referred to as the growth rate. This value provides information that might be used in simple projection exercises, and describes what the annual rate of increase would have been if the increase in the ten-year period had occurred evenly in each of the ten years. Similar information for the State of Arizona's non-AIAN population is provided as a point of comparison (see Table 2-10).

13 Silberman, J. 2003. The Economic Importance of Fishing and Hunting: Economic Data on Fishing and Hunting for the State of Arizona and Each Arizona County. Arizona State University West, School of Management: Phoenix, AZ. Report for the Arizona Department of Game and Fish.

Table 2-9
Trends in Fort Apache Indian Reservation Demographics

Datum	1990 Census	2000 Census	Change Between 1990-2000	Percent Change	Average Annual Growth Rate
AIAN Alone	9,825	11,702	1,877	19%	2%
AIAN Males	4,781	5,572	791	17%	2%
As a Percentage of AIAN Alone	49%	48%			
AIAN Females	5,044	6,130	1,086	22%	2%
As a Percentage of AIAN Alone	51%	52%			
AIAN Alone or in Combination	n/a[a]	11,854	n/a	n/a	n/a
As Percentage of Total	95%	95%			
Non-AIAN	569	575	6	1%	0.1%
Total Reservation Population	10,394	12,429	2,035	20%	2%
AIAN Alone under 18	4,612	5,259	647	14%	1%
As a Percentage of AIAN Alone	39%	45%			
AIAN Alone over 55	744	991	247	33%	3%
As a Percentage of AIAN Alone	6%	8%			
AIAN Alone 18-55 years	4,469	5,452	983	22%	2%
As a Percentage of AIAN Alone	38%	47%			

a Identifying as more than one race was not an option open to respondants prior to Census 2000.

Source: Elaborations from Census 2000 Summary Tape File 1 http://factfinder.census.gov.

Table 2-10
Trends in Arizona State Demographics

Datum	1990 Census	2000 Census	Change Between 1990-2000	Percent Change	Average Annual Growth Rate
AIAN Alone	203,527	255,879	52,352	26%	2%
AIAN as a Percentage of Total AZ Population	6%	5%			
Total AZ Population	3,665,228	5,130,632	1,465,404	40%	3%
Non-AIAN	3,461,701	4,838,080	1,376,379	40%	3%
Males	1,711,557	2,417,729	706,172	41%	4%
Females	1,750,144	2,420,351	670,207	38%	3%
Under 18	895,621	1,366,947	471,326	53%	4%
As a Percentage of Total Non-AIAN	26%	28%			
18-55 years	1,807,950	2,393,598	585,648	32%	3%
As a Percentage of Total Non-AIAN	52%	49%			
Over 55	758,130	1,077,535	319,405	42%	4%
As a Percentage of Total Non-AIAN	22%	22%			

Source: Elaborations from Census 2000 Summary Tape File 1 http://factfinder.census.gov.

2.5 Population Forecast

A population forecast includes an analyst's best estimate of a future population size and sometimes its composition as well. A forecast is the result of the projection of a population into the future. There are various methods of projecting a population that may be used, and the selection of a particular method depends on the purpose of the forecast, the type of data available, the data required by the method, and cost factors. The methodology employed for the projection of the Reservation population is the Cohort Component method, which is described in the paragraphs that follow. Results are reported to provide a population forecast for 100 years, between 2000 and 2100.

2.5.1 Cohort Component Method

The Cohort Component method of population projection uses data on births, deaths, and migration (components) and applies these to each age group (cohort) separately. The data requirements for this type of projection are much larger than that of trend extrapolation, but the results are more detailed, and can provide more information on changes in all of the components of the changing population.

The basic principle of the Cohort Component method is to use a known population separated into age and sex cohorts. Each age and sex group is then "aged" by five years, and death rates are applied subtracting any who might die in the cohort. Applying age specific fertility rates to the female age cohorts of childbearing ages simulates births. Migration is added to the total, and the calculations are repeated for another five years.

2.5.2 Assumptions

For applying the Cohort Component model to the Reservation population, several assumptions are required. These include base data from which to build the population projection, fertility rates, mortality and survival rates, and migration patterns, direction, and magnitude. These are each discussed individually below.

2.5.2.1 Base Data

The Base Population used in this analysis is the 2000 Census of the Reservation and trust lands total population, unadjusted, for all races living on the Reservation.

2.5.2.2 Fertility Rates

Age-specific fertility rates used in the model are based on the Arizona Department of Health Services, Division of Public Health Services age-specific births by county for the year 2000, for Apache, Gila, and Navajo counties. The denominator is the census population for the three counties for AIAN (alone or in combination with other races) women between years 10-49 by 5-year age cohort (same as the Arizona county data). These fertility rates are averaged for the 5-year projection to enable women to move from one cohort to the next within the projection periods (e.g. 10-14 averaged with 15-19 for the 10-14 fertility rate, 45-49 averaged with 0 for 45-49 age group), and are presented in Table 2-11 below.

Table 2-11
Age-Specific Fertility Rates

Age Group	2000	2050	2100
10-14	0.184	0.157	0.129
15-19	0.616	0.524	0.432
20-24	0.822	0.699	0.576
25-29	0.682	0.580	0.478
30-34	0.454	0.386	0.318
35-39	0.196	0.167	0.137
40-44	0.038	0.032	0.027
45-49	0.002	0.001	0.001

The total fertility rate (TFR), the total number of children each woman is assumed to have during her childbearing years, starts at 2.99 and declines steadily to 2.1 by 2100, with each age-specific rate declining proportionately to the total fertility rate (i.e., the fertility rate for the 10-14 age group maintains the same share of the total fertility rate throughout the projection).

2.5.2.3 Mortality and Survival Rates

The age-specific mortality rates used in the model are obtained through the U.S. Department of Health and Human Services, Indian Health Services, and are from the document titled "Trends in Indian Health 1998-1999". The rates used in the analysis are found in Table 10 of the document, column 4, Adjusted Rate for American Indian and Alaska Native in the United States (adjusted for miscoding), using an adjustment factor to break down the age-specific mortality rates by sex using the National Vital Statistics Report, Vol. 50, No. 15, September 16, 2002, Table 3, American Indian and Alaska Native Death Rates, Age-specific for Male, Female, and Both Sexes. A ratio of the rate for each sex over the rate for both sexes for each age cohort is applied to the base mortality rates. Following this, survival rates are calculated for each age/sex cohort (1-mortality rate). Each cohort survival rate, except for the "80-84" and "85+" age cohorts, is then averaged with the next age cohort rate to develop the 2000 age- and sex-specific survival rates. These were "progressed" over time, through 2100, based on the rates of change in the census projection of mortality. The survival rates used in the projections are presented in Table 2-12.

Table 2-12
Individual Survival Rates

Age Group	2000		2050		2100	
	Females	Males	Females	Males	Females	Males
0-4	0.99793	0.99719	0.99942	0.99923	0.99947	0.99954
5-9	0.99962	0.99956	0.99980	0.99985	0.99985	0.99993
10-14	0.99924	0.99839	0.99957	0.99905	0.99968	0.99931
15-19	0.99886	0.99722	0.99932	0.99835	0.99949	0.99888
20-24	0.99851	0.99668	0.99906	0.99816	0.99924	0.99878
25-29	0.99815	0.99614	0.99910	0.99786	0.99935	0.99850
30-34	0.99734	0.99514	0.99868	0.99732	0.99901	0.99807
35-39	0.99652	0.99414	0.99793	0.99689	0.99831	0.99781
40-44	0.99521	0.99143	0.99692	0.99481	0.99746	0.99595
45-49	0.99390	0.98872	0.99646	0.99302	0.99735	0.99456
50-54	0.99039	0.98454	0.99377	0.99030	0.99505	0.99239
55-59	0.98687	0.98035	0.99131	0.98871	0.99310	0.99161
60-64	0.97951	0.97177	0.98607	0.98181	0.98871	0.98575
65-69	0.97214	0.96319	0.97884	0.97111	0.98217	0.97625
70-74	0.95859	0.94725	0.96445	0.95391	0.96835	0.96093
75-79	0.94505	0.93132	0.95206	0.94071	0.95723	0.95097
80-84	0.91327	0.89296	0.95283	0.94257	0.95891	0.95497
85 & OVER	0.88149	0.85461	0.88577	0.88080	0.89466	0.90187

For the Cohort Component model, death rates are assumed to approximate national age-specific death rates for American Indians and Alaska Natives (AIAN). Birth rates are assumed to be related to county birth rates for the AIAN population. Births are also assumed to decline over the period of projection moving to a zero growth rate by 2100.

2.5.2.4 Migration

For the Reservation, the migration component is based on the service area population provided by IHS. This population represents Indians who may live near the Reservation, but who may well move onto the Reservation, if housing were available. This population is estimated at 23,631 for year 2000, and 27,378 for year 2005. After 2005, total IHS service population growth is projected over the forecast period at 1.88 percent annually, 25 percent higher than the growth rate projected for the State of Arizona over the next 50 years. Total movement onto and off of the Reservation is then broken down by age/sex cohorts. The cohorts move in or out based on the migration pattern from 1990-2000, as a percentage of all movers. The 1990-2000 migration is estimated by comparing 2000 census data with an aged 1990 census population. That is, the 1990 population is assumed to age, give birth, and die as expected, and the result is compared with Census 2000 data. Where Census 2000 shows more 20-25 year olds than 10-15 year olds in Census 1990, it can be assumed that some people have moved in. This method is known as the "forward survival method" in demographics.[14]

The percentages of migration included in the model are a percentage of the previous period's total IHS service population that is moving (either on or off the Reservation). It is assumed that 80 percent of the movers are moving "on" and 20 percent are moving "off", resulting in 60 percent net in-migration. The total migration is high through 2020, then declines gradually to 2060, finally reaching zero percent by 2100.

2.5.3 Results

The results of the Cohort Component projection suggest that the total population on the Reservation will be 28,660 by the year 2020, 57,409 by the year 2050, and 93,833 by the year 2100. Table 12 illustrates the estimated Reservation population over the full projection period. This estimate shows that over the 100 year period, the Reservation population is expected to grow at an average annual growth rate of 2.0 percent per year. During the current decade, the annual growth rate is anticipated to be 4.6 percent per year, considerably faster compared to other periods. However, the 4.6 percent rate places the 2006 Reservation population at 16,246 in 2006, which is fairly close to the IHS patient population of 16,040 identified as living on the Reservation (see IHS data presented earlier). The annual growth rate in each period declines, associated with an expected decline in fertility coupled with an eventual decline in net in-migration.

As depicted in Table 2-13, the annual growth rate slows to 2.3 percent per year by the year 2040, at which time it is assumed that the housing shortage will have significantly abated,

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14 Cosen, Richard L., WRSU-IRM, Computer Specialist, 2006, Memorandum to Gloria Dayaye, Re: Numbers of People in Community, May 9, 2006.

and tribal members who wish to live on the Reservation will no longer be discouraged to do so by lack of housing. Also, it is assumed that the economic boom of the White Mountain region in general will not continue at its current rapid pace but will have achieved a more sustainable rate of economic development by that time. The growth rates of the population between 2050 and 2100 are all below two percent per year, and in the last decade (between 2090 and 2100) the growth rate is expected to be less than one percent per year. The population is expected to continue increasing after the year 2100, but at slower and slower rates of increase, until ultimately a stable population may develop.

Table 2-13
Fort Apache Indian Reservation
Population Projection Results

Year	Population Estimate	Growth Rate from Previous Period	Cumulative Growth Rate
2000	12,429	n/a	
2010	19,423	4.6%	4.6%
2020	28,660	4.0%	4.3%
2030	38,563	3.0%	3.8%
2040	48,445	2.3%	3.5%
2050	57,409	1.7%	3.1%
2075	76,230	1.1%	2.4%
2100	93,833	0.8%	2.0%

2.6. Implications for Housing, Employment, and Education

The population projection developed in the preceding chapter has implications for future housing needs, future employment, and future educational needs. The Cohort Component method is helpful in planning for such needs since different age groups within a population do not all grow at the same rates. The cohort method allows planners to employ a more detailed estimate of age-based target populations. For example, as a population simultaneously ages and slows fertility, there is a relatively greater need for elder housing, and relatively less need for the construction of elementary schools. Similarly, the population of employed people will depend on the share of people who are over 16 and under 64 years old. So there are implications for the size of the Reservation labor force through time. The following sections cover the expected future housing needs on the Reservation, the expected labor force and employment requirements, and the needs of school aged population.

2.6.1 Housing

As the Reservation population expands, housing will be needed for the increased number of people. The following analysis presents how demographic information is used in the planning process for Reservation housing. As is the case in many Indian reservations across the U.S., there is currently a housing shortage on the Reservation, despite the Tribe's aggressive housing program.

2.6.1.1 Existing Housing on the Reservation

It is difficult to know exactly the current number of housing units on the Reservation and the associated status of the stock. Information is available in Census 2000, which provides a starting point. However, since the time of the census, new housing has been built while other units may have fallen into disuse or been destroyed. According to the Census 2000, the number of housing units on the Reservation was 3,532 in 2000. The occupation rate for the housing stock was close to 90 percent, with 3,063 units reported as occupied (households), and 469 reported as vacant. Of the vacant housing units, 227, or just about 50 percent were identified as vacant because they were for seasonal, occasional, or recreational use. Examples of these include the cabins available for renting along Hawley Lake (see Fort Apache Indian Reservation Reservoir Recreation Analysis for details). The ownership rate for the occupied units was 55 percent.

Table 2-14 shows how the housing stock and housing characteristics on the Reservation changed between 1990 and 2000. In percentage terms, the housing stock increased by nine percent over the decade.

Table 2-14
Trends in Housing on the Fort Apache Indian Reservation

Datum	1990 Census	2000 Census	Percent Change 1990-2000	Average Annual Growth Rate
Total Housing Units	3,240	3,532	9%	0.9%
Occupied Housing Units (Households)	2,480	3,063	24%	2.1%
Occupation Rate	77%	87%	13%	1.2%
AIAN Head of Household	2,232	2,784	25%	2.2%
As a percentage of all Households	90%	91%	1%	0.1%
Non-AIAN Head of Household	248	279	13%	1.2%
Persons per household	4.19	4.01	-4%	-0.4%
Vacant Housing Units	760	469	-38%	-4.7%
Owner-Occupied Units	1,667	1,958	17%	1.6%
Ownership Rate	67%	55%	-18%	-2.0%
Renter-Occupied Units	813	1,105	36%	3.1%

Source: U.S. Bureau of Census, http://factfinder.census.gov

Table 2-15 presents the age of the current housing stock based on data from the 2000 census. This demonstrates that just fewer than 1,000 structures were built in each of the decades of the 1970s, 1980s, and 1990s. It further suggests that, excluding houses that have fallen or have been torn down, housing has increased approximately 100 fold in the 60 years since 1940.

Table 2-15
Year of Construction
Existing Housing Stock, Fort Apache Indian Reservation

Year Built	Number	Percent of 2000 Stock
Built 1999 to March 2000	65	1.9%
Built 1995 to 1998	512	14.6%
Built 1990 to 1994	410	11.7%
Built 1980 to 1989	1,013	28.9%
Built 1970 to 1979	842	24.0%
Built 1960 to 1969	522	14.9%
Built 1950 to 1959	35	1.0%
Built 1940 to 1949	68	1.9%
Built 1939 or earlier	38	1.1%
Total	3,505	100%

Since at least the 1960s, the Tribe has had an active program providing housing development and assistance to tribal members. The White Mountain Apache Housing Authority (WMAHA) has taken the initiative and is now recognized nationwide as a model for Native American housing, especially in the area of developing successful financial strategies. During the 1960s, WMAHA developed 87 new housing units on the Reservation. Another 453 WMAHA units were built during the 1970s, 726 in the 1980s, and 426 new units were built between 1990 and 2000.[15] Thus, the total housing units created by the WMAHA between 1960 and 2000 was 1,692. This growth in housing development is illustrated in Figure 7 (see Section 5.1.3).

More recently, WMAHA has been showcased nationwide with the success of its Apache Dawn housing project, which received commendation from the Assistant Secretary of the Office of Public and Indian Housing at HUD.[16] The planned development of 250 new homes ultimately resulted in the construction of 317 new housing units in Hon Dah. The National American Indian Housing Council (NAIHC) included the project in a case study of six Indian housing projects. This case study highlighted the financing resources the Tribe utilized in its establishment of the project. The Apache Dawn homes are rental units, with the option to purchase after 10 years. The case study conclusion states:

> "One of the most notable attributes of this housing project, outside of bringing the resources together, was a Housing Executive Director's vision for the White Mountain Apache people. This vision, in conjunction with the

15 White Mountain Apache Housing Authority, personal communication, dated October 5, 2006.

16 Cabrera, 2006.

> tribal housing mission and housing needs of the people, was the key ingredient in conceptualizing a project such as "Apache Dawn."
>
> *NAIHC 2001*

The Tribe, including the tribal governing body, demonstrated a strong commitment to the success of Apache Dawn and the project established that a tribe given more control over its housing program can achieve a higher success rate than it has in the past.

Even with the success of this housing project, a large unmet housing need exists on the Reservation. Prior to Apache Dawn, the housing waiting list was more than 1,400, and the addition of the original 250 homes was reported to account for just about 16 percent of the current housing needs.[17] Many families without homes remain on the waiting list. At present, there are 400-500 tribal members on the waiting list for housing, some of whom currently live off the Reservation.[18] The Tribe continues to plan for more housing on the Reservation, including a current plan to develop approximately 100 more units in the Hon-Dah and McNary areas.[19]

2.6.1.2 Persons Per Household

The number of persons per household on the Reservation is calculated by dividing the number of people by the number of occupied houses. The result for the Reservation in the year 2000 is 4.01 people per household, slightly lower than the figure of 4.2 in 1990. In the nearby area of Pinetop-Lakeside, this number is significantly lower, at 2.5 people per household.

The number of persons per household plays an important role in assessing future housing needs. For the Reservation, the higher number of persons per household appears to signify crowding and a need for more houses, as discussed previously. Additionally, part of it may be the much larger percentage of the Reservation population comprised of children, thus bringing up the household average.

The dedication of the Tribe to find funding sources in order to continue building new homes on the Reservation suggests that the number of people per household will decline. Therefore, for the purposes of this report, the housing needs are based on the assumption that the number of persons per household will decline steadily over the projection period, from the current estimate of 4.01 persons per household, to 2.5 by 2100.

2.6.1.3 Future Housing Needs

The future housing needs of the Reservation may be determined by dividing the future population by an appropriate number for the persons per household. In general, planning for

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17 NAIHC, 2001

18 Vernona Dazen, Contracts Manager, White Mountain Apache Housing Authority, personal communication, Oct. 6, 2006.

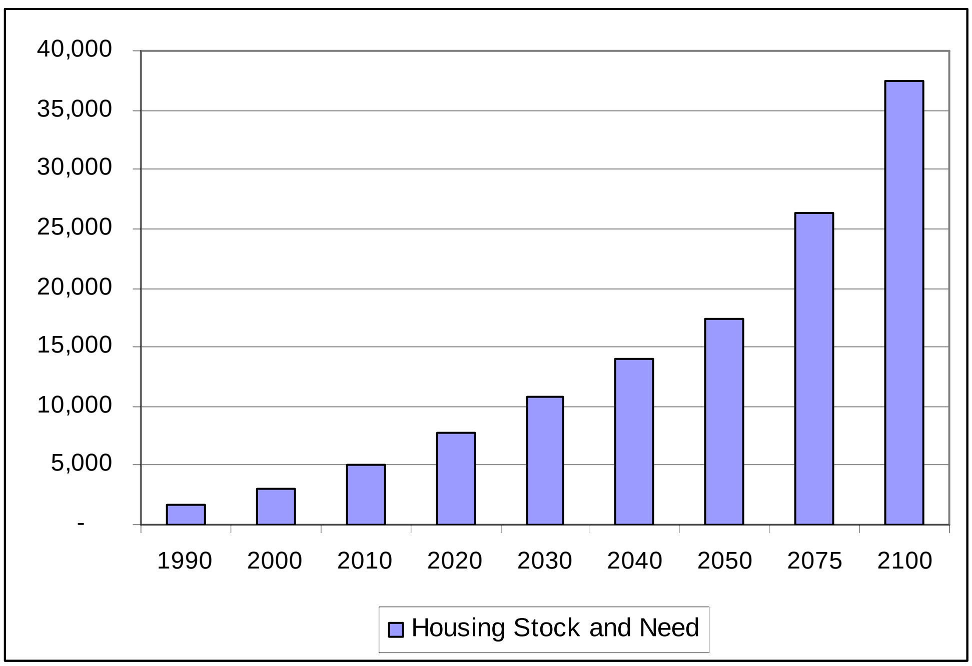
19 Ibid.

housing development should incorporate the expected numbers of houses needed to avoid experiencing a housing shortage. The recommended number of houses will include an effort to move toward less crowded conditions, with the number of persons per household decreasing from the current 4 persons per household to the more common national average of 2.6 persons per household, as reported in Census 2000. This information is presented in Table 2-16 and shown graphically in Figure 2-7.

Table 2-16
Expected Housing Needs
for the Fort Apache Indian Reservation, 2000 - 2100

Year	Population	PPH	Total Units
2000	12,429	4.01	3,100
2025	33,572	3.6	9,242
2050	57,409	3.3	17,637
2075	76,230	2.9	26,492
2100	93,833	2.5	37,533

Figure 2-7
Housing Development and Need, 1990 - 2100



2.6.2 Employment and Labor Force

Lack of employment continues to be a problem for residents of the Reservation. Recent estimates from the Bureau of Indian Affairs, Fort Apache Agency, Officer of Indian Services suggests that there were 3,849 people employed on the Reservation in 2003, and of these people approximately 62 percent were employed in public sector jobs, with the balance working in the private sector.[20] The report also shows that there were another 3,460 people on the Reservation that were able to work but were not employed, suggesting an unemployment rate of 47 percent. It is important to note that the report states that additional resources and technical support will be needed to complete the report. The same report suggests that the total population of the service area was just 12,213 in 2003, which also does not conform to information from IHS and other sources. Thus, it is not clear how accurate the numbers presented in the report are. Furthermore, the economy of the area has been growing rapidly in recent years and, unfortunately, more current data is not available.

Based on the results of the Cohort Component model, with the projected increases in population, the Reservation labor force in the coming years will be as follows:

Table 2-17
Anticipated Number in Labor Force
Fort Apache Indian Reservation, 2000 - 2100

Year	Labor Force	Percent Increase	New Jobs Needed	Growth Rate
2000	7,149			
2010	11,013	54%	3,864	4.4%
2020	16,807	53%	5,794	4.3%
2030	22,444	34%	5,637	2.9%
2040	27,629	23%	5,185	2.1%
2050	33,379	21%	5,751	1.9%
2060	39,269	18%	5,889	1.6%
2070	43,959	12%	4,690	1.1%
2080	49,219	12%	5,261	1.1%
2090	54,598	11%	5,379	1.0%
2100	58,577	7%	3,979	0.7%

These estimates suggest that the Reservation economy and the economy of the neighboring communities will need to increase rapidly until the year 2030 in order to accommodate the labor force of the Reservation. After the year 2030, the increase in the number of new jobs needed is expected to decrease as a percentage of the whole population, but there will continue to be a requirement of an addition of over 5,000 jobs per decade. At present, the nearby communities of Pinetop-Lakeside and Show Low are growing at rates faster than 4.4 percent when sales, assets, and building permits are used as measures of the economy (see earlier section on Growth in Arizona and White Mountain Area). Furthermore, agricultural and tourism

20 Information forwarded from Glorianna H. Dayaye, Indian Services Officer, Indian Labor Force Labor Market Information Survey form for Calendar Year 2003.

employment is expected to grow in the future in conjunction with the new proposed reservoir projects.

2.6.3 Implications for School Enrollment

The school-aged population is expected to grow for the next 100 years, with implications for additional school and educational needs. For the next decade, both the number of school-aged children and the share of the total population represented by those aged 5-16 years will grow. Following the year 2010, the number of students will continue to grow, but the share of the population represented by this age group will begin to decline. At present, the 5-16 age population represents about 35 percent of the total population. This is expected to grow to 37 percent in 2010, then decline again to about 34 percent by 2020, to 30 percent by 2030, and further decrease to just over 20 percent by 2100. However, absolute numbers of school-age individuals will grow significantly over the course of the analysis period, and will require increased educational resources and facilities. The results for this forecast are shown in Table 2-18.

Table 2-18
Anticipated Number of School Aged Children
Fort Apache Indian Reservation, 2000 - 2100

Year	Students	Percent Increase	New Students	Growth Rate
2000	4,321			
2010	7,247	68%	2,926	5.3%
2020	9,868	36%	2,621	3.1%
2030	11,570	17%	1,702	1.6%
2040	13,705	18%	2,135	1.7%
2050	15,413	12%	1,708	1.2%
2060	15,983	4%	569	0.4%
2070	17,465	9%	1,482	0.9%
2080	18,978	9%	1,513	0.8%
2090	19,496	3%	518	0.3%
2100	20,069	3%	573	0.3%

2.7 References

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3. DOMESTIC PROJECT FORMULATION[1]

Development of domestic water supply for the Fort Apache Indian Reservation was the inspiration for the evolution of multi-purpose projects reliant upon the White River with alternative or supplemental projects on Bonito Creek and Cibecue Creek as described further in this report. Miner Flat Dam was the first storage facility identified to regulate White River streamflows (that portion available from the North Fork of the White River). A diversion dam, water treatment plant, pipelines, pumping stations, water tanks and control systems were then planned to distribute domestic water to the present and future population. Irrigation of Canyon Day Flat and recreation development were then considered as multi-purposes additions to the domestic water supply project (Chapter 5). Bonito Creek and Cibecue Creek developments were considered alternatives and supplements to Miner Flat Dam.

The description of the project criteria for domestic water supply from the North Fork of the White River is presented here. Chapter 5 presents the project formulation for irrigation, recreation and other multi-purposes compatible with the project requirements described in this section.

3.1 Summary of Sizing Criteria

Table 3-1 summarizes the application of the sizing criteria for domestic water facilities for those communities within the Reservation that could be reasonably served by the multi-purpose projects, namely the Greater Whiteriver Area, Carrizo and Cibecue. The total population of the reservation in year 2050 and 2100 was projected at 57,409 and 93,833 persons, respectively, (Chapter 2). Water requirements were determined for year 2100, and facilities were sized for year 2030 based on population and maximum daily water use. The design population of 35,907 in year 2030 was used for the communities of the Greater Whiteriver Area, Carrizo and Cibecue or 93% of the Reservation population, (Table 3-1).

Average daily per capita water requirements ranging from 137 to 203 gallons are projected between 2000 and 2050, respectively. This resulted in an average day demand in 2030 for the combined project communities of 6,786,000 gallons. Design for maximum day increased

[1] Domestic water is defined for the purposes of this report as water necessary to meet requirements of the public water systems and individual household needs outside the public water systems. Domestic water needs include in-home purposes, such as cooking, drinking, bathing, and sanitation; outside residential purposes, such as lawns and gardens; schools; institutions, such as offices of the Tribe, offices of other agencies and hospitals; parks; and commercial purposes, such as shopping centers, service stations and other relatively light water uses required by wholesale, retail and service establishments. Domestic water needs do not include heavier water using activities required by the Fort Apache Timber Company, for example, or commercial development along the Tribe‘s Northern Reservation boundary. The term “domestic” in this report is synonymous with terms “municipal and industrial” or “municipal, rural and industrial.” These latter terms are used commonly by the Bureau of Reclamation and Corps of Engineers to describe projects serving metropolitan areas, cities, towns and rural water districts.

TABLE 3-1

CURRENT (2000) AND PROJECTED WATER REQUIREMENTS
FORT APACHE INDIAN RESERVATION

Year	Population	Gallons per Capita per Average Day: Domestic	Commercial Industrial	Schools and Parks	Total	Average Day (gpd)	Peak Factor	PWS Maximum Day Demand: gpd	gpm	Annual af
Fort Apache Indian Reservation										
2000	12,429	82	47	8	137	1,705,880	2.25	3,838,231	2,908	1,911
2010	19,423	92	53	12	157	3,039,700	2.25	6,839,324	5,181	3,405
2020	28,660	101	56	16	173	4,951,015	2.25	11,139,784	8,439	5,546
2030	38,563	110	60	19	189	7,288,407	2.25	16,398,916	12,423	8,165
2040	48,445	110	63	23	196	9,495,220	2.25	21,364,245	16,185	10,637
2050	57,409	110	67	26	203	11,654,027	2.25	26,221,561	19,865	13,055
2060	64,937	110	67	26	203	13,182,292	2.25	29,660,157	22,470	14,767
2070	72,466	110	67	26	203	14,710,557	2.25	33,098,754	25,075	16,479
2080	79,751	110	67	26	203	16,189,372	2.25	36,426,087	27,596	18,136
2090	86,792	110	67	26	203	17,618,735	2.25	39,642,155	30,032	19,737
2100	93,833	110	67	26	203	19,048,099	2.25	42,858,223	32,468	21,338
Whiteriver										
2000	9,889	82	47	8	137	1,357,265	2.25	3,053,847	2,314	1,520
2010	15,454	92	53	12	157	2,418,504	2.25	5,441,634	4,122	2,709
2020	22,803	101	56	16	173	3,939,222	2.25	8,863,249	6,715	4,413
2030	30,682	110	60	19	189	5,798,943	2.25	13,047,621	9,885	6,496
2040	38,545	110	63	23	196	7,554,770	2.25	16,998,231	12,877	8,463
2050	45,677	110	67	26	203	9,272,401	2.25	20,862,902	15,805	10,387
Carrizo										
2000	135	82	47	8	137	18,529	2.25	41,690	32	21
2010	211	92	53	12	157	33,016	2.25	74,287	56	37
2020	311	101	56	16	173	53,776	2.25	120,997	92	60
2030	419	110	60	19	189	79,164	2.25	178,120	135	89
2040	526	110	63	23	196	103,134	2.25	232,052	176	116
2050	624	110	67	26	203	126,582	2.25	284,811	216	142
Cibecue										
2000	1,549	82	47	8	137	212,600	2.25	478,351	362	238
2010	2,421	92	53	12	157	378,831	2.25	852,370	646	424
2020	3,572	101	56	16	173	617,035	2.25	1,388,328	1,052	691
2030	4,806	110	60	19	189	908,339	2.25	2,043,762	1,548	1,018
2040	6,038	110	63	23	196	1,183,369	2.25	2,662,581	2,017	1,326
2050	7,155	110	67	26	203	1,452,417	2.25	3,267,938	2,476	1,627
Combined Project Communities										
2000	11,573	82	47	8	137	1,588,394	2.25	3,573,887	2,707	1,779
2010	18,085	92	53	12	157	2,830,352	2.25	6,368,292	4,824	3,171
2020	26,686	101	56	16	173	4,610,033	2.25	10,372,574	7,858	5,164
2030	35,907	110	60	19	189	6,786,446	2.25	15,269,503	11,568	7,602
2040	45,109	110	63	23	196	8,841,273	2.25	19,892,864	15,070	9,904
2050	53,455	110	67	26	203	10,851,400	2.25	24,415,651	18,497	12,156

the demand to 15,270,000 gallons applying a peaking factor of 2.25. When converted to flow rate, the maximum day demand is equivalent to 11,568 gallons per minute (gpm) based on 22 hours of operation at the water treatment plant or source of supply.

3.2 Residential Water Use Criteria

The introductory remarks in this section place residential water uses in context with non-residential uses. A more detailed discussion of residential water use criteria begins in section 3.2.1. The determinations related to nonresidential purposes are discussed further in section 3.3.

As will be shown below, the U.S. Geological Survey has found that residential water use in Arizona in 1995 averaged 134 gallons per capita per day (gpcd) as contrasted with other regional states where residential water use averaged from 136 to 184 gpcd. EPA finds that normal residential water use, with some lawn and garden watering, averages 60 gpcd nationally, but this value does not compare well with reported experience in the region. Johns Hopkins University, as will be shown, found that residential water use averaged 123 gpcd in the metered West during the mid 1960s.

By the beginning of the 20th century, municipal water use in the United States was 90 gallons per capita per day. In London by 1912, per capita use was 40 gallons per day, suggesting lower water use in Britain than in the United States. By 1955 residential water use averaged 67gpcd in the United States, and total municipal requirements averaged 155 gpcd.[1] Water use in public systems in 1970 averaged 166 gpcd across the United States.

In 1960 and 1970, the U.S. Geological Survey wrote, in marked contrast between the two decades, as follows:

> *... People living in the average electrified farm or urban home in the United States use an average of 60 gpd or more per person for household purposes and watering of lawns. The corresponding average for homes without running water is only 10 gpd per person. Others investigators report that only 50 gpd per person is used in homes with running water. ...*[2]
>
> *The per capita rate for rural domestic use is about 63 gpd; this represents a quantity intermediate between estimated low withdrawal rates in homes without running water and estimated withdrawal rates in rural homes that have running water and are equipped with modern high-water-requirements appliances. ...* [3]

In 1995 the U.S. Geological Survey reported water use from public supplies for domestic, commercial, industrial and thermo-electric power[4] uses at 206 gallons per capita per day in Montana.[5] Other Great Plains states reported as follows:

Arizona	206 gpcpd
New Mexico	225
Utah	269

[1] Linaweaver, 1967, p. 2.

[2] MacKichan, 1960.

[3] Murray, 1970.

[4] Public suppliers in South Dakota do not provide water for thermo-electric power use.

[5] Solley, *et al*, 1998, Circular 1200

Domestic (residential) water use (drinking, food preparation, bathing, washing cloths and dishes, flushing toilets and watering lawns and gardens) from public water supplies was reported in the source states as follows:

Arizona	134 gpcpd
New Mexico	136
Utah	184

Commercial water use for motels, restaurants, office buildings, and civilian and military institutions was reported as follows:

Arizona	34 gpcpd
New Mexico	57
Utah	62

The following sections examine water needs in the project area for residential, school, commercial, industrial and livestock purposes. The water needs may be compared with historic uses presented in Chapter 5 and with water needs identified from other sources.

3.2.1 Residential Water Needs

Residential water is defined as that used inside the household for drinking, cooking, bathing and other purposes and outside the household for gardening or lawn sprinkling. The Environmental Protection Agency (EPA) presents the following levels of residential or domestic water use as a basis for assessing the level of water conservation.[6] Actual domestic water use reported by the U.S. Geological Survey (Section 3-2) in most neighboring states significantly exceeds the "normal" water conservation level given by EPA.

Level of Water Use	gpcd
Very heavy, no conservation evident	100
Heavy, including lawn and garden watering	75
Normal, with some lawn and garden watering	60
Moderately conservative, with little or no lawn watering and some selective garden watering	45
Very conservative, no outside watering	30

Sources for assessing residential water needs provide highly variable statistics. The *guidelines* of EPA, for example, suggest smaller amounts than actual *reports* of water use. U.S. Geological Survey water use statistics by state for residential use range from 134 gpcd (Arizona) to 184 gpcd (Utah), but little date exists to explain reasons for differences. Unknown is the effect of the availability of high quality drinking water on per capita residential consumption.

[6] EPA, 1985. p. 85.

For assessment of this project's needs, *guidelines* were examined, but *reports* of actual water use were also examined. Specifically, the 1967 report of residential water use by Johns Hopkins University for the Department of Housing and Urban Development[7] was relied upon, subject to information from other sources, as will be discussed. Residential water use for the unmetered West (Table 3-2) was considered applicable to this project, assuming that water needs are intended as a measure of reasonable water use in housing that meets national standards for plumbing, fixtures and appliances.

Table 3-2 presents the results of the Johns Hopkins investigation. The metered West had residential water use of 123 gpcpd. Meters are commonly used as a water conservation device. Billing is based on the amount of water used, and water becomes more expensive (in representative rate structures) as more water is used. As shown in Table 3-2, the absence of increasing cost of water for greater use (flat rate) results in more lawn watering and greater residential use (193 gpcpd). Metering does not have as great an effect on household water use (47 to 67 gpcpd, Table 3-2). Household water use is highest in the west and lowest where water users are apparently attempting to increase the longevity of septic tanks.

This project arrives at a residential water requirement of 110 gpcd by 2050: 57 gpcd for in-house use and leaks and 53 gpcd for lawn or garden water for an average yard/garden of 50 by 50 feet per household, including leakage. The chief difference between the residential requirement (110 gpcd) used here and the Johns Hopkins metered west (123 gpcd) is a lower household use (57 gpcd used here and 67 gpcd in the metered West) and lawn watering and gardening(53 gpcd here and 50.5 gpcd for the metered West). Sections 3.2.2 and 3.2.3 describe the findings of residential water needs for this project.

TABLE 3-2

PER CAPITA RESIDENTIAL WATER USE
AS DETERMINED BY JOHNS HOPKINS UNIVERSITY[8]

Residential Component	41 Study Areas	Metered West PWS	Metered East PWS	Metered With Septic	Flat Rate PWS
Household	59.0	67.0	51.0	47.0	66.0
Lawn Watering	43.9	50.5	19.5	10.3	117.5
Leakage	6.1	5.5	5.5	3.7	9.5
Total	109.0	123.0	76.0	61.0	193.0

[7] Linaweaver, 1967.

[8] Linaweaver, 1967.

3.2.2 Household Water Needs

The following are the basic categories of household water use:

Toilet	Clothes washing
Lavatory sinks	Cooking and drinking
Baths and showers	Utility sink
Dish washing	Leakage

Toilets account for the highest water use in the home. For each person in the home, there are an average of 5 flushes per day with water use ranging from 3.5 gallons per flush with water conservative devices to 6.0 gallons per flush without conservative devices. Daily need of 25 gpcd was used for without conservation, and daily need of 18 gpcd was used with conservation.[9]

Lavatory sinks are used an average 3.5 times per day per household. Each use consumes approximately 1.7 gallons. Standard faucets flow at a rate of 4 to 5 gpm, and a faucet with conservation devices flows at 1.5 gpm. Daily water use ranges from 1 gpcd (with conservation) to 7.6 gpcd (without conservation). Need without conservation by sinks for this project was estimated at 3 gpcd.[10]

Baths and showers are taken 2.5 times per day for a family of four. Showers range from 5 to 7.5 minutes in duration and use 20 to 35 gallons per shower. Showers or baths require a flow rate of 3 gpm (with conservation) to 12 gpm (with standard devices). Showers or baths require 8.0 to 21 gpcd.[11] For this project, 20 gpcd was used to estimate shower and bath water needs with standard devices (without conservation) and 15 gpcd was the estimated need with conservation.

Clothes are washed .3 times per day per person or .7 times per day for a family of four. With conservation, clothes washing requires 17.5 gallons per use, and without conservation, clothes washing requires 50 gallons per use. Water requirements for washing clothes ranges from 1.3 to 14 gpcd.[12] A value of 10 gpcd was used for needs without conservation, and a value of 6 gpcd was used with water conservation.

Dish washing events average from .16 to 1 time per day per capita. The frequency of dish washing depends on the presence or absence of a dishwasher. Water used for washing dishes ranges from 7 gallons to 20 gallons per use. Per capita water use for dish washing ranges

[9] EPA, 1980.

[10] *Ibid.*

[11] *Ibid.*

[12] *Ibid.*

from 1.1 to 3.8 gpcd.[13] Values of 4 and 3 gpcd were used for needs without and with water conservation, respectively.

Estimates of per capita use for cooking and drinking range from 3 to 7 gpcd.[14] Values of 5 and 3 gpcd were used for need without and with water conservation, respectively.

A value of 2 gpcd was used for utility sink needs with and without water conservation. [15] Utility sinks may or may not be in use.

Leaks in households fixtures are the largest variable in household water use, irrespective of water conservation measures. The elimination of all leaks is desirable, but may not be practical from the standpoint of planning a comprehensive water system. Kitchens, lavatory faucets, baths, showers and toilets are all sources of leaks. One drop per second will result in a daily water use of 7 gallons. A leak that has developed to a steady stream of 1/16 inch in diameter under 40 pounds of pressure will consume 2,500 gallons per day. Leaks in toilet tanks are estimated to range from 160 to 200 gallons per day. For purposes of estimating the quantity of water required for leaks, a *steady drip* was used. The steady drip will consume 20 gallons per day.[16] Based on a future average 2.69 persons per household, the *steady drip* is equivalent to approximately 7 gpcd.

Total household need, based on the criteria presented above, is 81 and 57 gpcd (without water conservation and with water conservation, respectively) as presented in Table 3-3. The literature presents household water use in the range of 41.9 gpcd (with conservation) to 63.8 gpcd (without conservation devices).[17]

Household water use, studied by Johns Hopkins University for typical conditions in the United States in the 1960's, was in the range of 47 to 67 gpcd (Table 3-4).[18] Lowest household water use was in areas with septic tanks. Residents on septic tanks probably strive to use less water in an effort to lengthen the time required for replacement of drain fields. Highest water use was in areas of the Western United States with meters. While meters are generally considered a water saving device, they apparently had less effect on in-house uses than on lawn sprinkling as discussed earlier (Table 3-2). In public water systems of the Western United States, metered

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[13] *Ibid.*

[14] *Ibid.*

[15] *Ibid.*

[16] *Ibid.*

[17] *Ibid.*

[18] Linaweaver, 1967.

TABLE 3-3

PROJECTED HOUSEHOLD WATER NEED

Activity	Average Daily Water Need (gpcpd W/O Conservation	W Conservation
Toilets	25	18
Lavatory Sinks	8	3
Baths and Showers	20	15
Clothes Washing	10	6
Dish Washing	4	3
Cooking	5	3
Utility Sinks	2	2
Leaks	7	7
Total	81	57

water systems used 247 gallons per household per day (3.69 persons per household). Public water systems in the Eastern United States on meters used 209 gallons per day per household. This compares with average daily household needs of 328 gallons per household per day basedon 81 gpcd from Table 3-3 and an average 4.06 persons per household in 1990 without water conservation. With water conservation, average household water need would total 231 gallons per day. The household water need, in the absence of water conservation devices, is higher than nationwide statistics developed by Johns Hopkins.[19]

Metered public water systems included in the Johns Hopkins studies were the East Bay Municipal Utility District in California, the City of San Diego, Des Moines, Iowa Water Works, City of Fort Worth, Washington D.C., Baltimore City and County, City of Philadelphia, City of Sacramento, City of Great Falls, Montana, and Denver, Colorado, among others. Therefore, the water use estimates were derived from communities representative of conditions in the project area although the project communities are smaller.

Based on the foregoing, an average household water need of 69 gpcd was adopted for this project for year 2000. This reflects the implementation and achievement of some water conservation measures but not all. Additional water conservation measures are reflected in the later decades and reduce household water needs to 57 gpcd by year 2050.

It was considered unrealistic to expect full implementation of water conservation measures and full success with those measures necessary to reduce the household water needs to 57 gpcd until year 2050. It was considered realistic in year 2000 to eliminate leaks in household fixtures to reasonable levels and, with implementation of future plumbing codes and without retrofit of existing fixtures in existing homes, to achieve a reduction in household water use from

[19] *Ibid.*

81 to 69 gallons per capita per day. A high level of water conservation in the household was not adopted until year 2050 for the reason that implementation and enforcement may be unrealistic and, at some point, becomes more costly as greater conservation is achieved.

3.2.3 Gardening and Lawn Sprinkling

In addition to household water use, residential water use includes gardening and lawn sprinkling for the purpose of watering grass, trees, shrubs, flowers and vegetables. Based on the Johns Hopkins study, [20] water needs range from 42 gallons per household in public water systems with septic tanks and meters to 420 gallons per household in public water systems that have a flat rate for the cost of water, (Table 3-4). Clearly, the effect of meters on the use of water for gardening and lawn sprinkling is significant with water use rising by a factor of 10 in public water system without meters. The average water use for public water systems in the Western United States was 186 gallons per day per dwelling. This is significantly greater than in the Eastern United States where average daily water use per dwelling was 80 gallons, (Table 3-4).[21]

The Arizona Irrigation Guide[22] places the project in climate area 2. Grass requires 16.89 inches of net[23] irrigation water annually in climate area 2. Vegetables, such as dry beans, corn and potatoes consistently use less water than grass. For the project area, 22.52 inches of annual lawn watering and gardening need was used. This value was based on 16.89 inches of water use and a watering efficiency of 75 percent. Growing season was assumed to cover the period from April 4 to October 19, a period of 198 days. Therefore, the average water need is equal to 0.114 inches per day.

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[20] *Ibid.*

[21] *Ibid.*

[22] SCS, 1974, p. 3-8.

[23] "Net" irrigation requirement is the "gross" water requirement of the lawn less the "effective" precipitation. All values (net, gross and effective) apply during the growing season only.

Assuming 186 gallons per household per day as a reasonable gardening and lawn sprinkling water requirement (Table 3-4, Metered West PWS), there will be adequate water to irrigate an average area per household of 2,600 square feet (50 feet by 50 feet, for example).

TABLE 3-4

SUMMARY OF RESIDENTIAL WATER USE
JOHNS HOPKINS 1965 STUDY

Use/Area	Date	Average Gallons Per Capita Per Day	Persons Per Dwelling	Average Gallons Per Dwelling Unit
Residential Domestic (Household)				
41 Study Areas	1965	59.0	3.64	215
Metered West PWS	1965	67.0	3.69	247
Metered East PWS	1965	51.0	4.10	209
Metered Septic Tank	1965	47.0	4.06	191
Flat Rate PWS	1965	66.0	3.58	236
Residential Sprinkling, (Lawn Watering)				
41 Study Areas	1965	43.9	3.64	160
Metered West PWS	1965	50.5	3.69	186
Metered East PWS	1965	19.5	4.10	80
Metered Septic Tank	1965	10.3	4.06	42
Flat Rate PWS	1965	117.5	3.58	420
Leakage				
41 Study Areas	1965	6.1	3.64	22
Metered West PWS	1965	5.5	3.69	20
Metered East PWS	1965	5.5	4.10	22
Metered Septic Tank	1965	3.7	4.06	15
Flat Rate PWS	1965	9.5	3.58	34
Residential Total				
41 Study Areas	1965	109.0	3.64	397
Metered West PWS	1965	123.0	3.69	453
Metered East PWS	1965	76.0	4.10	311
Metered Septic Tank	1965	61.0	4.06	248
Flat Rate PWS	1965	193.0	3.58	690

Assuming 4.06 persons per household the need is 46 gpcd. Planned use of 53 gpcd was adopted to permit the watering of 3,000 square feet per household (50 feet by 60 feet).

3.2.4 Total Residential Use

Combining the household and lawn/garden watering, the total residential water need ranges from 82 gpcd in 2000 to 110 gpcd by 2050. The Johns Hopkins study shows residential use ranging from 61 to 193 gpcd, including leakage,[24] (Table 3-4). Western United States public water systems were using an average 123 gpcd, and in the east, 76 gpcd. Within public water system with flat rates, average water use was 193 gpcd. The residential water determined for this project is less than metered public water systems in the Western United States.

3.3 Water Requirements for Non-Residential, Domestic Purposes

This section presents water requirements for communities for purposes other than residential. The section applies only to the communities based on the assumption that the water requirements for the purposes described are only located in the communities. In broad categories, these water uses are for schools, businesses, hospitals and other institutions and government. As in the case of residential water requirements, a standardized method of estimating non-residential water use was sought. However, there are differences in communities with regard to certain types of industry, such as food processing, that will require more water than other communities due to the nature of the industry. Those differences are not addressed in this section. A series of community enterprises or activities, representative of typical water consumers, was analyzed to provide a common base for each community.

As discussed in the introduction to Section 3-2, U.S. Geological Survey data for Arizona show in 1995 that residential, commercial, public and industrial use was an estimated 206 gallons per capita per day, including losses and water not included in public water system accounting.

3.3.1 Schools and Parks

School enrollment in the project area in 1990 was 3,415 persons, 33% of the total population. There were 348 persons in pre-primary education, 2,696 persons in elementary or high schools and 371 persons in regional colleges. In pre-primary ages, 39.19% of the age class on the Reservation was enrolled in public schools compared with 34.08% of the age class in Arizona. In elementary and high school ages, 93.06% of the age class was enrolled compared with 92.97% of the age class in Arizona. In college ages, however, only 35.23% of the age class was enrolled compared with 87.14% of the age class in Arizona. In all age classes, except those of college age, Fort Apache school enrollment was comparable to Arizona. The difference in college age enrollment was significant. Table 3-5 summarizes.[25]

School enrollment in year 2030 was estimated from the projected population resulting in an estimated 14,541 students in pre-primary through college ages. It was assumed that most college enrollment would be located on the Reservation in community colleges. At 15 gallons

[24] Linaweaver, 1967.

[25] Bureau of Census, 1992, Table 225.

TABLE 3-5

STUDENT POPULATION AND WATER REQUIREMENTS
FORT APACHE INDIAN RESERVATION

	1990 Fort Apache	1990 Arizona	2030 Fort Apache
Total Population	10,506	3,665,228	38,563
Age 3 through 5	888	175,697	3,259
Age 6 through 18	2,897	682,718	10,634
Age 19 through 24	1,053	340,283	3,865
	4,838	1,198,698	17,758
School Enrollment			
Pre-Primary	348	59,880	1,277
Elementary and High	2,696	634,705	9,896
College	371	296,537	3,368
	3,415	991,122	14,541
Not Enrolled	7,091	2,674,106	24,022
% School Enrollment			
Pre-Primary	39.19	34.08	39.19
Elementary and High	93.06	92.97	93.06
College	35.23	87.14	87.14
% Not Enrolled	67.49	72.96	62.29
Gallons per Student per Day	15	--	15
School Water Use, gal per day	51,225	--	218,121
Per Capita, gpcd 2030	4.88	--	5.66
Parks Per Capita, gpcd 2030	0	--	13.74
Total Schools and Parks, gpcd 2030	4.88	--	19.40

per student per day, the average daily water requirement would increase from 51,225 gallons in 1990 to 218,121 gallons by year 2030 or from 4.88 to 5.66 gallons per capita per day, respectively.

Community parks are virtually nonexistent on the Fort Apache Indian Reservation at present. However, throughout the state of Arizona, water use for all public purposes, including losses in the distribution systems, averages 21 gallons per capita per day.[26] Public purposes include water for firefighting, street washing, municipal buildings, parks and swimming pools, among other purposes. It was assumed that by years 2030 and 2050, water for parks and other public purposes would increase to 13.5 and 21 gallons per capita per day, respectively.

When combined, the total per capita water requirement for schools and parks was 4.88 gallons per capita per day in 1990 and 19.17 gallons per capita per day by year 2030.

[26]Solley, 1998, Circular 1200, p. 20.

3.3.2 Labor Force and Commercial Requirements

Census data disclose that there were 3,445 persons (male and female) in the civilian labor force on the Reservation in 1990 (Table 3-6). There were an additional 2,705 persons over the age of 16 that were not part of the labor force. Of those in the labor force, 2,313 were employed and 1,130 were unemployed, the latter representing 32.8% of the total labor force.[27]

Table 3-7 summarizes the 1990 employment on the Reservation by industry sector and sub-sector. Employment by industry across the state of Arizona is all so presented.[28] Most of the Fort Apache employment in 1990 was in the service sector (786) followed by employment in public administration (415) and manufacturing (410). Wholesale and retail trade, construction, and agriculture and forestry account for most of the remaining employment, which totaled 2,315 persons (Table 3-6 and Table 3-7).

Projections of future commercial water requirements were based on several assumptions. First, the 1990 proportional distribution of employment between industrial sectors was assumed to remaining constant. Second, unemployment was assumed to diminish uniformly with time

TABLE 3-6

1990 CIVILIAN LABOR FORCE AND EMPLOYMENT

Labor Force Statistic	Fort Apache Indian Reservation
Male:	
In labor force:	
In Armed Forces	0
Civilian:	
Employed	1,307
Unemployed	630
Labor Force	1,937
% Unemployed	32.52
Not in labor force	1,028
Female:	
In labor force:	
In Armed Forces	0
Civilian:	
Employed	1,008
Unemployed	500
Labor Force	1,508
% Unemployed	33.16
Not in labor force	1,677
Total Employed	2,315
Total Unemployed	1,130
Total Labor Force	3,445
Total % Unemployed	32.80
Total Not in labor force	2,705

[27]Bureau of Census, 1990 Summary Tape File 3, Universe: persons 16 years and over, Sex by Employment Status, P070, factfinder.census.gov/home/.

[28]Bureau of Census, 1990 Summary Tape File 3, Universe: persons 16 years and over, Industry, P077, factfinder.census.gov/home/.

from 32.8% in 1990 to 5% in 2050. Finally, water requirements per person employed were derived for each industrial sector based on data from Ada County, Idaho, the only known inter-mountain location that has collected and analyzed commercial water use by industrial sector.

As shown in Table 3-8 and as presented in Chapter 2, population was projected to increase from 10,394 in 1990 to 57,409 in 2050. Similarly, labor force was projected to increase from 3,445 to 19,028 between 1990 and 2050. The projected number of persons employed increased from 2,315 in 1990 to 18,076 in 2050 as the rate of unemployment declined progressively from 32.8% to 5% over the same time frame. Jobs in agriculture and forestry increased from 187 in 1990 to 1,460 in 2050. Similar increases were projected for the other industrial sectors as shown in Table 3-8.

TABLE 3-7

1990 ARIZONA AND FORT APACHE EMPLOYMENT BY INDUSTRY CLASSES

Industry Class and Sub-Class	Arizona	Fort Apache Indian Reservation Sub-Class	Fort Apache Indian Reservation Class
Agriculture, forestry, and fisheries (000-039)	40,210	187	187
Mining (040-059)	13,927	8	8
Construction (060-099)	107,558	190	190
Manufacturing, durable and nondurable (100-399)			410
Manufacturing, nondurable goods (100-229)	50,658	6	
Manufacturing, durable goods (230-399)	155,721	404	
Transport, comm and utilities (400-499)			
Transportation (400-439)	68,369	0	40
Communications and other public utilities (440-499)	48,229	40	
Wholesale/retail trade (500-699)			240
Wholesale trade (500-579)	62,992	14	
Retail trade (580-699)	295,398	226	
Finance, insurance, and real estate (700-720)			
Finance, insurance, and real estate (700-720)	120,141	39	39
Services (721-899)			786
Business and repair services (721-760)	90,571	13	
Personal services (761-799)	70,208	52	
Entertainment and recreation services (800-811)	28,411	32	
Professional and related services (812-899):			
Health services (812-840)	124,998	259	
Educational services (842-860)	133,806	303	
Other professional and related services (841, 861-8	106,196	127	
Public administration (900-939)	86,503	415	415
	1,603,896	2,315	2,315

Water requirements per employee per day by industrial sector were derived from Ada County, Idaho as presented in Table 3-9.[29] The advantage of the analysis conducted by Ada County was the relatively large volume of water required for each industrial sector. This gave

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confidence that the volumes required per employee were representative. Any differences in results of a similar analysis conducted in Arizona might be attributed to geographical differences between areas, but differences in the amounts of water per employee used for wholesale and retail trade, the services industry, construction and other industrial sectors should not vary significantly by geographical region. Differences in manufacturing could be more significant depending upon differences in the types of manufacturing between regions. Water requirements ranged from 0 gallons per capita per day for the agricultural and mining sectors, which do not rely on public water systems, to 330 gallons per person per day in the government sector. Within the government sector, for example, water requirements ranged from as low as 8 to as high as

TABLE 3-8

PROJECTED EMPLOYMENT BY INDUSTRY AND WATER REQUIREMENTS
FORT APACHE INDIAN RESERVATION

		Employment											
Year	Population	Agriculture, forestry, and fisheries (000 039)	Mining (040-059)	Construction (060-099)	Manufacturing, durable and nondurable (100-399)	Transport, comm and utilities (400-499)	Wholesale/ retail trade (500-699)	Finance, insurance, and real estate (700 720)	Services (721 899)	Public administration (900-939)	Total	Unemployment, %	Labor Force
1990	10,394	187	8	190	410	40	240	39	786	415	2,315	32.80	3,445
2000	12,429	224	10	227	490	48	287	47	940	496	2,768	32.80	4,119
2010	19,423	390	17	396	855	83	501	81	1,639	866	4,828	25.00	6,438
2020	28,660	614	26	624	1,346	131	788	128	2,580	1,362	7,599	20.00	9,499
2030	38,563	878	38	892	1,924	188	1,126	183	3,689	1,948	10,864	15.00	12,781
2040	48,445	1,167	50	1,186	2,559	250	1,498	243	4,906	2,591	14,451	10.00	16,057
2050	57,409	1,460	62	1,484	3,201	312	1,874	305	6,137	3,240	18,076	5.00	19,028
		Coefficients, gallons per day per employee											
		0	0	40	285	45	85	186	254	330			
		Water Use, gallons per Day										Per Capita	
1990	10,394	0	0	7,601	116,870	1,819	20,482	7,254	199,277	137,078	490,381	47	
2000	12,429	0	0	9,090	139,754	2,175	24,493	8,675	238,296	163,919	586,401	47	
2010	19,423	0	0	15,853	243,745	3,793	42,718	15,130	415,613	285,892	1,022,744	53	
2020	28,660	0	0	24,952	383,640	5,970	67,235	23,813	654,151	449,978	1,609,740	56	
2030	38,563	0	0	35,672	548,463	8,535	96,122	34,044	935,193	643,301	2,301,332	60	
2040	48,445	0	0	47,449	729,541	11,353	127,857	45,284	1,243,951	855,690	3,061,124	63	
2050	57,409	0	0	59,353	912,560	14,202	159,932	56,644	1,556,020	1,070,356	3,829,068	67	

416 gallons per person per day. The weighted average water requirements in the government sector was 330 gallons per person per day as presented in Table 3-9 and used in Table 3-8.

Based on the foregoing assumptions, water requirements for labor force and commercial purposes were estimated to increase from 490,000 gallons in 1990 to 3,829,068 gallons in 2050, the equivalent of 47 and 67 gallons per capita per day in 1990 and 2050, respectively. These values are higher than the 34 gallons per capita per day commercial use reported by the U.S. Geological Survey for Arizona (34 gpcpd) but comparable to the values reported for New Mexico and Utah (57 and 62 gpcpd, respectively).

TABLE 3-9

WATER REQUIREMENTS PER PERSON EMPLOYED
BY INDUCTRIAL SECTOR
ADA COUNTY, IDAHO

SIC Codes	Coefficients (gal/emp/day)	Gallon per Day Baseline 1997/8	Weighting
1-Construction			
15	72	138,709	9,969,016
16	25	119,086	2,933,088
17	16	105,633	1,637,312
Total	40	363,428	14,539,416
2/3-Manufacture			
20	400	2,377,485	951,588,371
24	40	148,254	5,876,789
25	46	12,557	573,353
26	157	29,767	4,663,596
27	59	117,346	6,902,292
28	20	1,180	23,199
30	10	4,572	46,452
32	44	25,317	1,114,708
34	38	50,559	1,900,513
35	40	336,147	13,324,867
36	260	2,550,843	662,606,978
37	66	125,387	8,252,972
38	157	47,784	7,486,319
other	26	12,840	333,070
Total	285	5,840,038	1,664,693,477
4-TCU			
41	47	32,568	1,526,136
42	36	97,675	3,507,509
43	50	36,948	1,844,814
45	66	72,996	4,822,116
47	26	9,032	236,458
48	46	121,829	5,611,444
49	34	59,470	2,026,738
Total	45	430,518	19,575,214

3.4 Total Domestic Demand

The total domestic water demand is summarized in Table 3-10, including both residential and non-residential demand. Average residential demand for the combined project communities in 2000 was 951,879 gallons per day. Average non-residential demand for the Reservation was 636,515 gallons per day, and the total residential and non-residential demand was 1,588,394 gallons per day.

The values for community demand include leakage in individual households (Table 3-3). The values were also considered adequate to address leakage in the existing community distribution system and the regional water system of 10%. Leakage in the infrastructure delivering water through homes and enterprises would be approximately 13.5 gallons per capita per day for residential purposes and 4.5 gallons per capita per day for community enterprises.

TABLE 3-10

CURRENT (2000) AND PROJECTED WATER REQUIREMENTS
FORT APACHE INDIAN RESERVATION

		Gallons per Average Day					PWS Maximum Day Demand		
Year	Population	Domestic	Commercial Industrial	Schools and Parks	Total	Peak Factor	gpd	gpm	Annual af
Fort Apache Indian Reservation									
2000	12,429	1,022,285	584,163	99,432	1,705,880	2.25	3,838,231	2,908	1,911
2010	19,423	1,777,205	1,029,419	233,076	3,039,700	2.25	6,839,324	5,181	3,405
2020	28,660	2,887,495	1,604,960	458,560	4,951,015	2.25	11,139,784	8,439	5,546
2030	38,563	4,241,930	2,313,780	732,697	7,288,407	2.25	16,398,916	12,423	8,165
2040	48,445	5,328,950	3,052,035	1,114,235	9,495,220	2.25	21,364,245	16,185	10,637
2050	57,409	6,314,990	3,846,403	1,492,634	11,654,027	2.25	26,221,561	19,865	13,055
2060	64,937	7,143,114	4,350,806	1,688,372	13,182,292	2.25	29,660,157	22,470	14,767
2070	72,466	7,971,238	4,855,209	1,884,111	14,710,557	2.25	33,098,754	25,075	16,479
2080	79,751	8,772,566	5,343,290	2,073,516	16,189,372	2.25	36,426,087	27,596	18,136
2090	86,792	9,547,098	5,815,051	2,256,587	17,618,735	2.25	39,642,155	30,032	19,737
2100	93,833	10,321,630	6,286,811	2,439,658	19,048,099	2.25	42,858,223	32,468	21,338
Whiteriver									
2000	9,889	813,370	464,783	79,112	1,357,265	2.25	3,053,847	2,314	1,520
2010	15,454	1,414,014	819,046	185,444	2,418,504	2.25	5,441,634	4,122	2,709
2020	22,803	2,297,404	1,276,969	364,848	3,939,222	2.25	8,863,249	6,715	4,413
2030	30,682	3,375,046	1,840,934	582,962	5,798,943	2.25	13,047,621	9,885	6,496
2040	38,545	4,239,922	2,428,319	886,529	7,554,770	2.25	16,998,231	12,877	8,463
2050	45,677	5,024,454	3,060,349	1,187,598	9,272,401	2.25	20,862,902	15,805	10,387
Carrizo									
2000	135	11,104	6,345	1,080	18,529	2.25	41,690	32	21
2010	211	19,303	11,181	2,532	33,016	2.25	74,287	56	37
2020	311	31,363	17,433	4,981	53,776	2.25	120,997	92	60
2030	419	46,075	25,132	7,958	79,164	2.25	178,120	135	89
2040	526	57,881	33,150	12,102	103,134	2.25	232,052	176	116
2050	624	68,591	41,778	16,213	126,582	2.25	284,811	216	142
Cibecue									
2000	1,549	127,405	72,803	12,392	212,600	2.25	478,351	362	238
2010	2,421	221,489	128,294	29,048	378,831	2.25	852,370	646	424
2020	3,572	359,862	200,023	57,149	617,035	2.25	1,388,328	1,052	691
2030	4,806	528,663	288,362	91,314	908,339	2.25	2,043,762	1,548	1,018
2040	6,038	664,136	380,369	138,865	1,183,369	2.25	2,662,581	2,017	1,326
2050	7,155	787,024	479,369	186,024	1,452,417	2.25	3,267,938	2,476	1,627
Combined Project Communities									
2000	11,573	951,879	543,931	92,584	1,588,394	2.25	3,573,887	2,707	1,779
2010	18,085	1,654,806	958,522	217,024	2,830,352	2.25	6,368,292	4,824	3,171
2020	26,686	2,688,630	1,494,424	426,978	4,610,033	2.25	10,372,574	7,858	5,164
2030	35,907	3,949,783	2,154,427	682,235	6,786,446	2.25	15,269,503	11,568	7,602
2040	45,109	4,961,939	2,841,838	1,037,496	8,841,273	2.25	19,892,864	15,070	9,904
2050	53,455	5,880,069	3,581,497	1,389,835	10,851,400	2.25	24,415,651	18,497	12,156

4. DOMESTIC PROJECT COSTS

Based on the criteria and demands for water presented in Chapter 3, project facilities necessary to provide domestic water to the Greater Whiteriver, Carrizo and Cibecue areas were defined, and cost estimates were prepared as described below.

4-1. North Fork of the White River

The following describes the facilities necessary to serve the Greater Whiteriver, Carrizo and Cibecue areas based on water supply from the north fork of the White River.

4.1.1. North Fork White River Diversion

The Indian Health Service (IHS) has developed preliminary designs for a diversion facility on the North Fork White River to serve a new water treatment facility for the Greater Whiteriver Area. This diversion facility would be located downstream from Diamond Creek near 51st Street to connect to a proposed water treatment plant (WTP). The diversion facility would consist of an intake system and raw water pump station to supply the WTP. The IHS has estimated project costs of the diversion facility and pump station at $1,188,493.[1]

The diversion works for the project proposed here would be the same as the diversion that would exist at the initiation of this project. Therefore, there would be no additional cost if future diversions are taken from the same location on the North Fork White River. Due to the additional demand for the domestic system, construction of a new raw water pump station or expansion of the existing would be necessary. The cost for the new raw water pump station is estimated at $2,500,000. This construction costs estimates has been included in the Total Project Costs presented for the WTP described below.

4.1.2. Water Treatment Plant

The IHS project contemplated the construction of a water treatment plant with associated raw water transmission main settling basins near the diversion site on the North Fork White River below Diamond Creek. The project would provide treatment of 2 million gallons per day (MGD) with room to expand to a potential 4 MGD. Two package treatment plants would be placed in parallel and would be enclosed in a pre-engineered building. Water would then be conventionally treated using polymer injection, flocculation, sedimentation, filtration and chlorination. The project would serve the Greater Whiteriver area. The costs of the IHS water treatment plant, building, and raw water transmission main were estimated at $4,505,807.[2]

The IHS water treatment facility would be supplemented when the project proposed here is implemented, and the costs of the expanded water treatment facility beyond the 2 MGD level

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[1] Stover, Michael A., June 2005, *Preliminary Engineering Report for the White Mountain Apache Tribe, Fort Apache Indian Reservation, Proposed Whiteriver Surface Water Diversion and Treatment Facility*, Indian Health Service, Pinetop Arizona.

[2] Ibid.

are considered here. Micro filtration, media filtration or conventional water treatment are proposed for the project. Pilot studies would be conducted to the extent necessary to make final determinations of the most cost effective water treatment plant. The WTP would be sized to meet project demands for the Greater White River area and the communities of Carrizo and Cibecue in year 2030 as presented in Chapter 3. The future demand of 11,568 gpm would be offset by the continuation of existing sources of supply totaling 2,520 gpm. Therefore, an additional capacity of 9,048 gpm would be required from the water treatment plant proposed here.

4.1.3. Raw Water Quality

Table 4-1 summarizes selected water quality characteristics of the White River near Fort Apache as measured by the U.S. Geological Survey gaging station 9-4910 at considerable distance downstream from the diversion point. Upstream water quality should be superior to samples taken at the gaging station. The characteristics selected are those most relevant to treatment processes designed to bring surface water into compliance with present and future drinking water regulations and to produce a highly aesthetic finished product for the users in the public water system. The streamflow and water quality data points were based on a minimum of 36 common measurements (turbidity) and as many as 45 measurements for other constituents with streamflow ranging from 26 to 1,660 cfs. All measurements were taken between 1976 and 1979.

Some of the water quality constituents are reasonably well correlated with streamflow (R^2 =0.635 to 0.7354, TDS, hardness and sulfate concentration), and others are poorly correlated (R^2 = 0.02 and 0.067, total nitrogen and turbidity, respectively). Some characteristics vary directly with increasing flow (total iron, total organic carbon (TOC), turbidity and total arsenic). Others vary inversely with streamflow (hardness, TDS and sulfate).

Table 4-1 provides predicted values of each constituent for streamflows ranging from 10 to 500 cfs. All predictions fall within acceptable ranges with the exception of hardness at low flows (315 mg/l at 10 cfs) and a maximum observed total arsenic level of 11 µg/l. The latter is an outlier and may represent an error in measurement or analysis. It also represents “total” arsenic, which includes dissolved arsenic and arsenic carried in suspension with sediments. Normally dissolved arsenic is much lower in value than total arsenic. Because sediment is removed in drinking water treatment processes, dissolved arsenic is expected to fall well within ranges of acceptability.

Table 4-1 discloses that finished water quality will be highly satisfactory from both a health and aesthetic perspective. The low concentration of TDS and sulfate make the raw water exceptional from the standpoint of taste and odor. Water quality normally degrades from upstream to downstream in a natural surface water system. The location from which the measurements analyzed in Table 6-6 were taken is downstream from the community of White River, the Canyon Day Farm and the regional wastewater facility. The latter were not in operation, however, during the period of measurement. Water quality at upstream locations on the White River or North Fork White River is expected to be better than data presented in Table 4-1.

TABLE 4-1
TABLE 10.1.1.2.1
SUMMARY OF SELECTED WATER QUALITY CHARACTERISTICS
WHITE RIVER NEAR FORT APACHE

			Regression			Predicted Concentration Flow cfs					Maximum
Constituent	Units	Standard	a	b	R^2	10	25	50	100	500	Observed
Secondary											
Hardness	mg/l	250	2.8571	(0.3592)	0.714	315	226	177	138	77	230
Total Iron	mg/l	0.3	1.2783	0.6605	0.310	0.1	0.2	0.3	0.4	1.2	10.0
TDS	mg/l	500	2.8847	-0.30594	0.635	379	286	232	187	115	294
TOC	mg/l	--	(0.1138)	0.23915	0.155	1.3	1.7	2.0	2.3	3.4	20.0
Turbidity	JTU	--	0.1683	0.34201	0.067	3	4	6	7	12	260
Suspended Sed	mg/l	--	(0.7530)	0.86528	0.819	1	3	5	9	38	217
Primary											
Total Nitrogen	mg/l	10	-0.24377	-0.14224	0.018	0.4	0.4	0.3	0.3	0.2	4.7
Sulfate	mg/l	400	2.5880	(0.4917)	0.735	125	80	57	40	18	87
Total Arsenic	µg/l	10	0.0731	0.0359	0.004	1.29	1.33	1.36	1.40	1.48	11.00

Form of Regression $y_i = 10^K$

Where
y_i = water quality value for constituent "i" in units for that constituent
$K = (a+b(\log_{10}(x_i)))$
x_i = Streamflow, cfs
a and b are coefficients given above

When alkalinity is low (no known measurements of alkalinity were available), TOC removal of 25% and 40%, respectively, is proposed by EPA. Large surface water systems (greater than 10,000 persons) would be required to sample at the plant on a monthly basis for TOC and alkalinity. Conventional filtration treatment systems must monitor (1) source water TOC prior to any treatment and (2) treated TOC at the same time in paired samples.[3] Removal of TOC at the levels proposed by EPA may not be feasible for many public water systems. In the event a public water system cannot provide the necessary percentage TOC removal, jar test procedures are proposed by EPA for determining the point at which addition of alum or an equivalent dose of a ferric coagulant has reached a point of diminishing returns and further removal is infeasible.[4] Jar testing for TOC removal is proposed for this project in final design.

EPA initially disallowed pre-disinfection credit in order to maximize removal of organic precursors prior to the addition of disinfectant However, based on comments from public water systems, the proposed rule does not impose constraints on the practice of pre-disinfection as proposed at the water treatment plant. Credits will be applicable for pre-disinfection.

Suspended sediments, an indicator of turbidity, will also be carried by raw water diverted from the White River. Removal of suspended sediments (turbidity) will remove most arsenic, as discussed above, and some TOC. Suspended sediments averaged 36 mg/l and ranged from 3 mg/l (41 cfs) to 217 mg/l (1,660 cfs) for a limited number (11) samples collected in the late 1970s.

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[3] Federal Register, May 10, 2000, *National Primary Drinking Water Regulations: Ground Water Rules; Proposed Rules*, Vol. 65, No. 91, p. 69422, *et seq*, Environmental Protection Agency.

[4] Ibid., p. 69413

4.1.4. Processes

White River raw water, as described in the previous section, can be treated satisfactorily by several treatment methods to meet federal safe drinking water criteria. These alternatives will be investigated in more detailed design-level studies outside the scope of this document, and a selection will be made based on costs and the ability to produce a high quality dependable finished water supply.

Water treatment at the White River plant will involve the removal, including filtration, of suspended particles from the raw water and disinfection of the filtered water to remove microorganisms. The following processes are potentially available within the proposed treatment plant, subject to requirements to produce a finished product meeting federal safe drinking water standards and public opinion respecting matters such as fluoridation and methods of disinfection:

- potassium permanganate oxidation;
- powdered activated carbon absorption;
- alum (or ferric chloride) and cation coagulation;
- flocculation;
- sedimentation;
- gravity filtration;
- pH modification;
- corrosion inhibitors;
- disinfection (chlorimination with consideration of ozone for partial disinfection);
- fluoridation.

While direct filtration operates without treatment processes involving sediment removal before filtration, this alternative was eliminated from consideration on the basis that suspended sediments in relatively high concentrations are expected during runoff periods. On the other hand, some treatment processes can be bypassed and lower operating costs will result during some periods of the year when raw water quality does not require all the processes associated with sediment removal before filtration and direct treatment can be effective.

The White River treatment plant can provide a product to a future nano-filtration, reverse osmosis or other comparable process to remove contaminants that are not known to have an impact on human health at levels currently regulated.

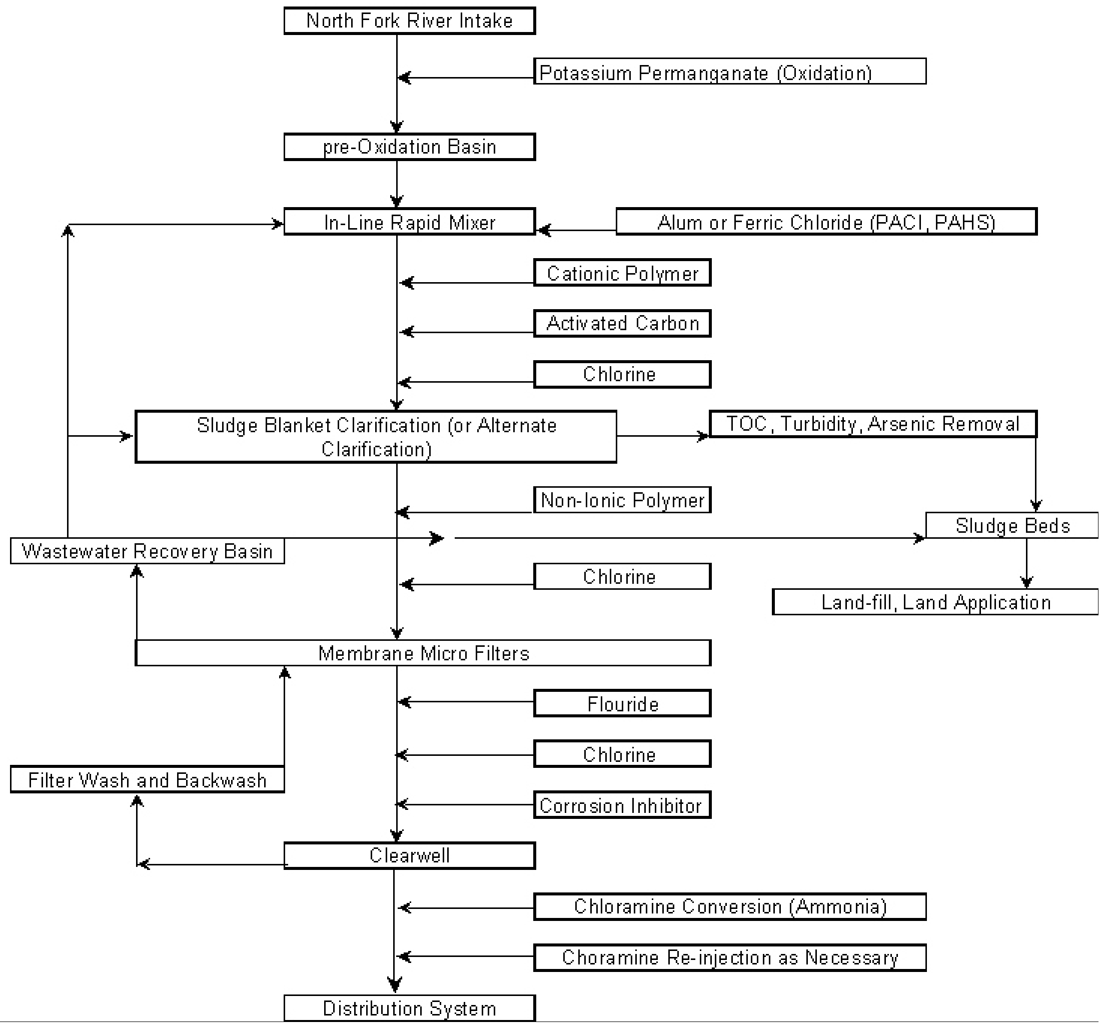
Figure 4-1 summarizes the general process of treating water delivered from the raw water intake on the White River to the finished water in the clear well before entry to the distribution system.

Pre-Oxidation

Potassium permanganate would be added (as necessary) as the initial chemical to promote oxidation and minimize taste and odors. This would be accomplished with the delivery of raw water to a pre-oxidation basin followed by an in-line (or other similar type of) rapid mixer with controls to prohibit backflow of chemicals. Depending on final site conditions, the raw water

FIGURE 4-1

WATER TREATMENT PROCESSES



pipeline from the intake may be used as the "pre-oxidation basin" if an adequate contact time (15 to 30 minutes) can be achieved prior to the water treatment plant rapid mixer.

Mixing, Coagulation and Flocculation

Mixing, as referred to above, is a process to uniformly disperse chemicals added for coagulation through the raw water taken at the intake. Coagulation is the addition of chemicals that destabilizes the forces among particles that keep them apart and promotes their attachment to one another for removal as the treatment process progresses. These particles may be silts, clays and organic matter that remain suspended in the source water. Enhanced coagulation will be designed to remove organic material to comply with the disinfectant byproducts rules. This will be accomplished by increasing chemical dosage and/or pH adjustment. Ferric chloride is the preferred coagulant by other surface water treatment plants in the region as a means of achieving arsenic removal. The most common coagulant, absent the presence of arsenic, is alum (aluminum sulfate). Flocculation is the process that settles suspended particles and follows the addition of coagulation chemicals. In a conventional water treatment plant, flocculation occurs in sedimentation basins prior to the clarification process. Agents that can aid the flocculation process include cationic or anionic polymers, activated silica and bentonite. The rapid mixing, coagulation and flocculation processes may be combined in proprietary devices, such as a Superpulsator™. Pilot studies will be undertaken to determine the whether separate facilities for rapid mixing, coagulation and flocculation consistent with a conventional water treatment plant will be utilized or whether these processes will be combined in a proprietary clarifier. Alum or ferric chloride would be added to the rapid mixer for coagulation. Ferric chloride will be used if needed to enhance arsenic removal. Alum will be used if arsenic can be successfully removed with turbidity. Polyaluminum chloride (PACL) and partially neutralized alum-polyaluminum hydroxy sulfate (PAHS) are alternative coagulants. Selection of a final coagulant will be based on effectiveness of turbidity reduction, arsenic removal, organics removal, impact on disinfection byproduct reduction, sludge production, pH and corrosion impacts, ease of handling and storage, and costs.

Clarification

Clarification will reduce the remaining suspended sediments, including organics, after the coagulation and flocculation processes, or combined with these processes, before filtration. Alternatives for clarification include membrane filtration and media filtration. Membrane filtration may include microfilters or nano filters. The latter will remove particle sizes that are 1,000 times smaller than the particle sizes removed by microfilters. This level of removal is not considered necessary for this project.

Before entering the clarifier, cationic and non-ionic polymers, activated carbon and the first stage of chlorine injection for disinfection will be provided as necessary. The principal difference in the water treatment process discussed here and a conventional treatment process is the substitution of sludge blanket clarification (or another alternative clarification system) for conventional flocculation/sedimentation. The clarifier will remove suspended organic carbon (a precursor to formation of disinfectant byproducts), turbidity and suspended arsenic. These contaminants will be delivered to sludge beds and thereafter to landfill or land application, depending on compliance requirements for the final concentrations of constituents that are produced.

Preliminary cost estimates indicate that a pulsed blanket clarifier may be more cost effective than conventional flocculation/sedimentation. Detailed sizing based on recommendations from manufacturers and a review of other facilities treating similar waters should be performed before this clarifier system is selected. Pilot testing may be warranted since this process does not work well with all types of waters and contaminants. In addition to the pulsed blanket clarifier, other types of alternative flocculation/sedimentation systems should be evaluated, including:

- Solids contact clarification.
- Conventional (not pulsed) sludge blanket clarification.

• Contact clarification.
• Ballasted clarification.

It is not contemplated at present that arsenic in the waste sludge will be of sufficient concentration to cause concern with any disposal method. Emphasized is the fact that arsenic removal is part of the planning process, but removal of turbidity is expected to remove arsenic to the point that the remaining dissolved concentration will be well below a 10 µg/l level.

Filtration

From the clarifier, water will be delivered to gravity micro (membrane) or media filters. Conceptual value engineering of the water treatment plant determined that conventional gravity media filters would be less costly than membrane filters, but both alternatives will be re-examined in final design of the water treatment plant. Before water is delivered to the filters, additional injection of chlorine for disinfection, polymers and corrosion inhibitors is proposed. Beyond the filters, fluoride is proposed for injection, depending on public acceptance, as a beneficial dental treatment. Additional chlorine and conversion to chloramines through addition of ammonia is proposed to finish the treatment of water before and after the clearwell. Part of the finished water delivered to the clear well will be used to wash the surface and backwash the filters. The wash water will then be delivered to a recovery basin and thereafter to sludge drying beds or returned to the front of the treatment process at the in-line rapid mixer or to the clarifier, depending on quality of the wash water. This latter phase in the process will be an operational decision based on conditions that will vary throughout the seasons and the year.

Disinfectants and Disinfectant Byproducts

Alternatives for disinfectants include chlorine, chlorine dioxide, chloramines, ozone, ultraviolet light and combinations thereof. Because residual levels of disinfectant are required in the finished water, any use of ozone or ultraviolet light must be followed by chlorine or chloramines to complete the disinfection process and provide a residual. Ultraviolet light was not considered here. Some consideration may be given to ozone, which is gaining in popularity in combination with chloramines (a secondary disinfectant). This combination generally produces better taste than chlorination. Ozone is particularly effective in achieving log 3 (99.9%) removal or inactivation of *Giardia Lambia* cysts and log 4 (99.99%) removal or inactivation of viruses.[5]

Chloramines are formed from the reaction of chlorine and ammonia in the following steps:

(1)	$Cl_2 + H_2O$	→	$HOCL + H^+ + Cl^-$	
(2)	$NH_3 + HOCl$	→	$NH_2Cl + H_2O$	monochloramine
	$NH_2Cl + HOCl$	→	$NHCl_2 + H_2O$	dichloramine
	$NHCl_2 + HOCl$	→	$NCl_3 + H_2O$	nitrogen trichloramine

[5] US Bureau of Reclamation, January 2000, *Red River Valley Water Needs Assessment, Phase II, Appraisal Of Alternatives to Meet Projected Shortages*, Dakotas Area Office, p 4-1.

The competing reactions in the second step are dependent on pH, the chlorine: ammonia nitrogen (Cl2:N) ratio, temperature and contact time.[6] Monochloramine is the preferred form due to its disinfectant properties and minimal taste and odor.

Chloramine residuals may be maintained for as many as 21 days[7] or significantly longer than chlorine residuals. Thus, chloramines are of considerable interest in regional water projects of the nature here with long distances between the points of initial disinfection and end-users. The number of re-injection points to maintain residual concentrations of disinfectant can be minimized. Chloramines form very few disinfection byproducts and are superior to chlorine in maintaining low levels of total trihalomethanes (TTHMs) and haloacetic acids (HHAs). Trihalomethane reductions of 40% to 80% are reported when chlorination was replaced with chlorimination. Haloacetic acids may not be as effectively controlled by chloramines.[8] Contact time for chloramines is significantly greater than with chlorine.

Disadvantages of chloramines include requirements to remove chloramines before use in kidney dialysis. This will require attention in the project area where diabetes is prevalent. Chloramine will bind to iron in the red blood cells during the dialysis process.[9] Treatment centers can remove chloramines ahead of the dialysis process. Although not considered as aggressive as chlorine, chloramine contributes to bladder and other cancer risks.

Nitrification is a risk, particularly in warmer waters. Ammonia from chloramine is converted to nitrite and then to nitrate. This can deplete the chloramine residual and increase bacterial production. Chloramines can also lead to accelerated corrosion and degradation of gaskets and some metals in distribution systems. Temperature, pH, ammonia concentration, organic compounds, detention time and the time that water may stand in dead-end lines or other parts on the distribution system are among the factors that require attention with use of chloramines.[10]

WTP Alternative Capacities

Additional alternatives were developed for supply of water for communities that would be at the distal end of the rural water system, most notably, the community of Cibecue. Alternative treatment supplies to the community of Cibecue include a conventional filtration or microfiltration WTP with Cibecue Creek/Salt Creek Reservoir (Chapter 5) serving as the source, and a reverse osmosis groundwater treatment facility with the Redwall formation serving as the source.

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[6] EPA, April 1999, *EPA Guidance Manual, Alternative Disinfectants and Oxidants*, p. 6-1, *et seq*.

[7] Bureau of Reclamation, April 30, 2001, *Value Engineering, Fort Peck Assiniboine and Sioux Water Supply System, Dry Prairie Rural Water System, Final Report*, p. 53

[8] AWWA RF, August 1999, *How Chloramines Improve Water Quality*, Research Application: Research in Use, p. 2

[9] Ibid.

[10] Ibid.

Costs estimates for treatment facilities were made by comparison of costs of other similar treatment plants in the Inter-Mountain region, use of the U.S. Bureau of Reclamation's Water Treatment Estimation Routine (WATER),[11] and recent quotes from manufacturer's and suppliers of water treatment equipment. Cost estimates were developed for the following alternatives:

1. 12.3 MGD Conventional Filtration WTP North Fork White River
2. 12.3 MGD Microfiltration WTP North Fork White River
3. 10.2 MGD Conventional Filtration WTP North Fork White River
4. 10.2 MGD Microfiltration WTP North Fork White River
5. 2.1 MGD Conventional Filtration WTP Cibecue Creek/Salt Wash Reservoir
6. 2.1 MGD Microfiltration WTP Cibecue Creek/Salt Wash Reservoir
7. 2.1 MGD Reverse Osmosis WTP Redwall Formation

Interpolating between the developed cost estimates allowed for a comparison of costs to supply the Demand Scenarios described below.

4.1.5. Distribution System

The distribution system for the domestic water system as analyzed under this extension report was to specifically serve the area outside of Whiteriver. The WTP would be connected to the Diamond Creek Tanks to serve the community of White River. The principal areas served outside of Whiteriver by the distribution system are Fort Apache, Canyon Day, Cedar Creek, Carrizo and Cibecue. A pipeline connection already exists between Whiteriver and Cedar Creek. However, cost estimates were based on the construction of a new pipeline between the communities. A small diameter pipeline may prove adequate in final design in the event that the existing 6-inch pipeline is determined to be suitable for a portion of the supply.

Five different distribution system alternatives were modeled and cost estimates prepared. The five alternatives were based on a progressive model to determine the incremental costs to serve each of the five areas outside of Whiteriver. The alternatives analyzed and their corresponding maximum day demands were as follows:

Demand Scenario	Demand, gpm
#1 – Distribution to White River	None, tie into existing system
#2 – Distribution to Fort Apache	1,820
#3 – Distribution to Canyon Day	2,956 (1,136 + 1,820)
#4 – Distribution to Cedar Creek	3,209 (253+1,136+1,820)
#5 – Distribution to Carrizo	3,346 (137+253+1,136+1,820)
#6 – Distribution to Cibecue	4,919 (1,573+137+253+1,136+1,820)

[11] Bureau of Reclamation, August 1999, *Water Treatment Estimation Routine (WATER) User Manual*, Water Desalination Research and Development Program Report number 43, Lower Colorado Regional Office, Boulder City, Nevada.

Each of the alternatives was analyzed to develop the pipe sizes, pressure ratings, pumping requirements and storage requirements for each scenario. Pipelines were generally considered to consist of AWWA rated PVC pipe. Pump stations, tanks, and pressure-reducing stations are discussed in the next section. Standard appurtenances such as isolation valves, air release/vacuum valves, blowoff hydrants, and other items necessary for construction were included in the costs estimates. The cost estimates for the pipeline only address connecting the major communities as discussed above. Branch lines may eventually be developed between the communities to serve new housing project along the main transmission pipeline in the rural areas. The cost estimates for the pipeline do not address any upgrade or improvement of the main transmission system within the existing public water system necessary to accommodate increased demands and flow rates for the future. Because all land crossed by the pipeline between Whiteriver and Cibecue is held in trust by the United States for the White Mountain Apache Tribe, virtually no lands in private or individual ownership would be crossed, and it was assumed that no cost of easements would be incurred.

Modeling results for the five alternatives are discussed below.

4.1.6. Pump Stations, Pressure Reducing Facilities and Tanks

The terrain between Whiteriver and Cibecue is undulating and would require pump stations to overcome static head and friction losses in the pipeline. Most of the pumping requirements between White River and Cibecue would be to cross Cibecue Ridge between Carrizo and Cibecue and to overcome friction losses in the pipeline. Pump stations were estimated based on a package pump station construction that would be delivered to the site and installed on the pipeline. Booster stations would pump between tanks, with the first reservoir in the series providing suction pressure to the booster station, and the second reservoir serving as the discharge point.

Alternatives 1 thru 3 serving the communities of Fort Apache, Canyon Day, and Cedar Creek require no booster station, only the High Service Pump Station at the WTP. Alternative No. 4 with the distribution system serving Carrizo only requires one booster station. Alternative No. 5 serving Cibecue requires four booster stations, with one station at approximately the same location as the Carrizo booster station, and three additional booster stations to cross Cibecue Ridge.

Pressure reducing stations were used to limit the pressure in distribution to a maximum of 200 pounds per square inch (psi), the maximum allowable working pressure for the majority of AWWA C900 rate PVC pipe. Alternatively, pressure reducing stations could be used to limit pressure to a higher pressure, but this would require higher class pipe such as steel or ductile iron. Pressure reducing facilities on the transmission pipeline were modeled in Alternative 1, 2 and 5. A pressure reducing facility was used on Alternatives 1 and 2 to keep the pressure rating of the transmission pipeline below 165 psi. Pressure reducing facilities for Alternative 5 were modeled to limit the pressure in the transmission pipeline on the downstream side of Cibecue Ridge to no greater than 200 psi. The crest elevation of Cibecue Ridge is approximately 6,200 feet msl while the community of Cibecue is at elevation 5,100 feet msl. Intermediate demands at

Fort Apache, Canyon Day, Cedar Creek, and Carrizo for Alternatives 3, 4, and 5 were assumed to have pressure reducing facilities on the central meter taps for those demand points.

Water storage tanks would be provided between pump stations for the distribution system. Tanks were typically located at the highest point between pump stations to provide water in distribution both upstream and downstream under non-pumping conditions. The purpose of the storage tanks is to provide a water source at the suction side of the next pump station in distribution, as well as provide an uninterrupted supply of water during peak use periods, power failure, or loss of a system component. The total capacity of water storage tanks was determined to be the volume of flow between the Greater Whiteriver and Cedar Creek public water supply systems (1,753 gpm) discharging over a 24-hour day. This volume equated to 2,524,000 gallons. It was assumed that the storage tanks would be equally sized between the total number of tanks required between the WTP and Cibecue, including storage at the WTP and Cibecue itself. Alternative No. 5 indicates that four storage tanks along the distribution system between the WTP and Cibecue are necessary along with clearwell storage at the WTP and elevated storage at Cibecue. Six equally sized tanks would equate to approximately 420,000 gallons of storage per reservoir.

4.1.7. Modeling Results

For preparation of the hydraulic model, it was assumed that the WTP would be configured so that two separate pumping facilities would be provided for the High Service Pump Station. These separate facilities would allow one system to pump to the existing Diamond Creek Tanks for the community of Whiteriver. The other system would be used to service Fort Apache and beyond. Separation of the system would allow for different pumping head requirements, different sizes and classes of distribution piping, and the ability to separately monitor the demands on the system.

4.1.7.1. Alternative No. 1 – Distribution to Fort Apache

The hydraulic modeling results for distribution to Fort Apache indicate that the only pumping facilities required would be those at the WTP. Two alternate scenarios could be constructed to provide water for distribution to Fort Apache that are nearly equal. The first scenarios would be to pump from the WTP to a newly constructed water storage reservoir adjacent to the WTP at a roughly similar elevation of 5,600 feet msl. Construction of this reservoir could occur during construction of the WTP. The second scenario would be to pump from the WTP to a newly constructed water storage reservoir near to Fort Apache at an approximate elevation 5,500 feet msl. Both scenarios would be the same in terms of pump size, pipeline size and rating, and water storage reservoir requirements. Fort Apache could also be served directly from gravity by the Clearwell Reservoir at the WTP. However, this type of arrangement would not be suitable in terms of the difficulty of operating the system when the WTP is not in operation or the clearwell needs maintenance.

The hydraulic analysis indicates that the minimum pipe size for this alternative would be 12-inch diameter C900 PVC pipe. Pressure ratings for the pipe would be Class 100, Class 150, or Class 200. One pressure-reducing valve facility was modeled near Fort Apache to limit the pressure in the pipeline to no greater than 200 psi. This pressure limitation allows for the use of lower class pipe, thus with the cost savings inherent with these pipes. Transient pressure would be negligible due to the configuration of the system. Pumping head requirements are essentially zero due to the close proximity of the reservoir. However, a minimum of 50 feet of total dynamic head was used for sizing of the pumps and developing power requirements. The storage reservoir was considered to be the size of one reservoir as described above or 420,000 gallons. The reservoir would be a ground-level storage tank as minimum pressure requirements are fulfilled by topography.

4.1.7.2. Alternative No. 2 – Distribution to Canyon Day

The hydraulic modeling results for this alternative are very similar to Alternative No. 1 in terms of pumping and storage facilities. Similar to Alternative No. 1, a ground level storage tank adjacent to the WTP was chosen as the operational scenario. The hydraulic analysis indicates that the minimum pipe size for this alternative would be 14-inch diameter C905 PVC pipe between the WTP and Fort Apache and 10-inch diameter C900 PVC pipe between Fort Apache and Canyon Day. Pressure ratings for the pipe would be Class 165 for the 14-inch pipe and Class 100 for the 10-inch pipe. One pressure reducing facility near Fort Apache was modeled to limit the pressure in the pipeline to no greater than 165 psi. This pressure limitation allows for the use of lower class pipe. Transient pressure would be negligible due to the configuration of the system. Pumping head requirements are essentially zero due to the close proximity of the reservoir. However, a minimum of 50 feet of total dynamic head was used for sizing of the pumps and developing power requirements. The storage reservoir was considered to be the size of one reservoir as described above or 420,000 gallons. The reservoir would be a ground-level storage tank as minimum pressure requirements are fulfilled by topography.

4.1.7.3. Alternative No. 3 – Distribution to Cedar Creek

Hydraulic modeling for Alternative No. 3 is very similar to Alternatives 1 and 2, however, the ground level storage tank is relocated to the ridge between Canyon Day and Amos Wash. This relocation of the reservoir allows for storage between the demand points of Canyon Day and Cedar Creek. As described in Alternatives 1 and 2, this reservoir is sized at 420,000 gallons. Essentially no pumping requirements are necessary for the system as water can flow by gravity to Reservoir No. 1. An altitude valve at Reservoir No. 1 would be necessary to prevent overflowing the tank. Pressure reducing facilities at the Fort Apache and Canyon Day Taps would be necessary. In addition, a pressure reducing valve at Cedar Creek would be necessary because static pressure would be nearly 250 psi. A small amount (10,000 lf) of Class 250 ASTM PVC pipe would be necessary just upstream of Cedar Creek.

The hydraulic analysis indicates that the minimum pipe size for this alternative would be 16-inch diameter C905 PVC pipe between the WTP and Reservoir No. 1 and 6-inch and 8-inch diameter C900 or ASTM PVC pipe between Reservoir No. 1 and Cedar Creek. Pressure ratings for the pipe would be Class 125 to Class 305 for the 16-inch pipe and Class 100 to Class 20 for the majority of the 6-inch and 8-inch diameter pipe. As previously stated, approximately the last 10,000 feet of 6-inch pipe into Cedar Creek must be Class 250 ASTM PVC pipe due to the high pressures (static head conditions).

4.1.7.4. Alternative No. 4 – Distribution to Carrizo

Hydraulic modeling for Alternative No. 4 indicates that at least one booster pump station and one additional reservoir is required compared to Alternatives 1 thru 3. The reservoir location as described in Alternative 3 at the ridge between Canyon Day and Amos Wash would again be used to provide water to the demand points of Canyon Day and Cedar Creek under non-pumping conditions and would be sized at 420,000 gallons. Essentially, no pumping requirements are necessary between the WTP and Reservoir No. 1 as water can flow by gravity. An altitude valve at the reservoir would be necessary to prevent overflowing.

In addition, this reservoir site would provide the necessary suction pressure to the booster station downstream of Cedar Creek. The booster pump station between Cedar Creek and Carrizo would be located just northeast of Cedar Creek to provide the necessary head to cross the divide between Cedar Creek and Carrizo. This pump station is sized at the maximum day demand of Carrizo of 137 gpm at a total dynamic head of 460 feet. Pump Station No. 1 would pump to Reservoir No. 2 located on the ridge between Cedar Creek and Carrizo. Reservoir No. 2 would be sized at 420,000 gallons.

Pressure reducing facilities would be necessary at the Fort Apache, Canyon Day, and Cedar Creek taps would be necessary due to high pressures. In addition, a pressure reducing valve would be necessary at the Carizzo tap.

The hydraulic analysis indicates that pipe sizes for this alternative would be 16-inch diameter C905 PVC pipe between the WTP and Reservoir No. 1 and 6-inch and 8-inch diameter C900 or ASTM PVC pipe between Reservoir No. 1 and Reservoir No. 2 and 4-inch diameter between Reservoir No. 2 and Carrizo. Pressure ratings for the pipe would be Class 125 to Class 305 for the 16-inch pipe and Class 100 to Class 200 for the majority of the 4, 6 and 8-inch diameter pipe. Small amounts of Class 250 ASTM PVC pipe would be necessary near Cedar Creek and Carrizo due to the high pressures (static head conditions).

4.1.7.5. Alternative No. 5 – Distribution to Cibecue

Hydraulic analysis for Alternative No. 5 indicates that Cibecue Ridge is the main control feature of this Alternative. Reservoir and pump station locations between Carrizo and the WTP are essentially as detailed under Alternative No. 4. However, to cross Cibecue Ridge, three additional pump stations, two additional tanks, and three transmission pipeline pressure reducing facilities are necessary to cross the topographic high. Reservoir No. 1 location and size between Canyon Day and Amos Wash remain the same. Similarly, the location of Pump Station No. 1 just northeast of Cedar Creek is relatively the same, only moving slightly farther downstream. Pump Station No. 1 would be sized at the maximum day demand of Carrizo and Cibecue (1,710 gpm) at a total dynamic head of 300 feet. Reservoir No. 2 between Carrizo and Cibecue would still be located on the ridge between the communities but would be sized at 420,000 gallons.

Downstream of Reservoir No. 2, progressive pump stations would be installed to provide the required head to cross Cibecue Ridge while maintaining the maximum pressure in the pipeline of 200 psi. This 200 psi limitation allows for the use of PVC throughout the system. Alternatively, high pressure pipe such as steel or ductile iron could be used in conjunction with high pressure-rated pump stations to limit the number of booster stations. However, preliminary analyses indicate that lower costs would be associated with additional pump stations and PVC pipe. The progressive pump stations (Nos. 3 thru 5) would each be sized at the maximum day demand of Cibecue at 1,573 gpm at approximately 460 feet of TDH. Tanks are provided between pump stations to provide suction pressure and a discharge point for the pump stations. Matched pump stations utilizing variable frequency drives (VFDs) could be used in place of the tanks, however, it was assumed that a less complex operational scenario would be more desirable. Pumping to the tanks does not require that exact flow matching as with sequential booster stations and their associated operational difficulties and would minimize transient pressure potentials. Reservoir Nos. 3 and 4 between Pump Station Nos. 2 and 3 and 3 and 4 would be sized at 30,000 gallons to provide only for minimum cycle times on the pumps. These 30,000 gallons ground level storage tanks are not too costly and would provide for sufficient pump operation capability. Reservoir No. 5 would be sized at 420,000 gallons to provide the necessary storage for supply to Cibecue.

Downstream of Reservoir No. 5, three pressure-reducing valve stations would be installed to maintain the pressure in the transmission pipeline below 200 psi to allow for the use of Class 200 or less C900 PVC pipe. Alternatively, high pressure pipe such as steel or ductile iron could be used without pressure reducing stations. However, preliminary analyses indicate that lower costs would be associated with pressure reducing stations and PVC pipe.

An elevated storage reservoir would be constructed in Cibecue to provide the minimum pressure requirements for distribution throughout the community. This elevated reservoir would be sized at 420,000 gallons with a minimum head height of 6,105 feet msl.

4.1.7.6. Water Supply Alternatives

An alternate source of supply to the Canyon Day Irrigation Unit (Chapter 5) would be to serve the Unit from a pipeline from the Bonito Creek Reservoir. A large diameter transfer pipeline would be constructed from the Bonito Creek to the Canyon Day transmission pipelines. This alternative source of supply has been designed to operate with two sub-alternative capacities: 1) 100% supply from Bonito Creek and 2) 50% supply from Bonito Creek and 50% supply from Miner Flat. Furthermore, due to the elevation change from the Bonito Prairie Unit to the Canyon Day Irrigation Unit, the transfer pipeline would have hydropower potential. This alternative would eliminate irrigation demands on the North Fork of the White River and make more water available for domestic supply.

The first scenario of 100% supply from Bonito Creek would allow the Canyon Day Irrigation Unit to be operable without the need for Bear Canyon Reservoir or the main irrigation pump station. The 100% alternative would consist of a 60-inch diameter pipeline, booster pump station, mini-hydropower facilities, and associated appurtenances connecting Bonito Creek with the Canyon Day Unit. The pipeline would have the capability of supplying the peak consumptive use of the Canyon Day Unit of 38,400 gpm.

The second scenario of 50% supply from Bonito Creek would similarly allow the Canyon Day Irrigation Unit to be operable without the need for Bear Canyon Reservoir. However, the main irrigation pump station on the White River would still be necessary to divert the necessary irrigation supply from the White River. This additional water may be released from Miner Flat Dam or produced from runoff below the dam. The 50% alternative would require a 42-inch diameter pipeline, booster pump station, mini-hydropower facilities, and associated appurtenances connecting Bonito Creek with the Canyon Day Unit. The pipeline would have the capability of supplying one-half the peak consumptive use of the Canyon Day Unit, the equivalent of 19,200 gpm or 1.66 times the domestic requirement from the North Fork of the White River.

4.1.7.7. Lifecycle Costs

Lifecycle costs for each Alternative consist of the following categories: 1) Initial construction costs, 2) Interest during construction, and 3) Operation, maintenance, and replacement (OM&R) costs. The definitions below summarize the lifecycle cost categories:

- **Initial Construction Costs –** include those cost related to the studies, design, and construction of each of the individual components. Initial construction costs generally consist of the following major items:
    - **Field Costs** - includes project cost accounts normally part of construction contracts for building the project facilities. Each contract for construction would include general items, major contract items, and minor contract items. Contingencies would not be a contract item but are also included in field costs for budget purposes.
    - **General Items** - includes mobilization, de-mobilization, taxes, bonds and insurance costs. Costs related to recordkeeping by the contractor, preparation of as-built drawings and related overhead expenses are also included.
    - **Major Contract Items -** includes the major components of each of the individual facilities. For example, major contract items for a pump station would include the pumps, pump station building, electrical facilities, SCADA system, foundation, but would not include such items as isolation valves, air release valves, pressure transducers, etc.
    - **Minor Contract Items –** includes the minor components of each of the individual facilities. For example, minor contract items for a pipeline would include tees, air relief valves, drains, isolation valves, highway crossings, railroad crossings, stream crossings and upgrades of existing electrical distribution systems to accommodate pumping stations. In this case, an inventory of minor items was conducted but may not have included all minor costs.

- **Contract Costs** - the sum of field costs before including contingencies and intended to represent the full amount of the budget for construction of all project facilities.

- **Contingencies** - Contingencies, in the context of the determination of pre-construction costs, were intended to represent an addition to quantities and unit prices of major and minor field items to provide greater certainty in the cost estimates for budgeting by the sponsors, federal, state and local agencies. Contingencies as used here are comparable, but not equivalent to, design-level contingencies that are intended to account for unforeseen circumstances during construction, such as unusual soil conditions, the discovery of a cultural site or extreme weather.

- **Non-Contract Costs** - Non-contract costs are part of the project costs not related to the construction contracts or construction budgeting. Non-contract costs include the mitigation of environmental impacts to comply with commitments made by the sponsors pursuant to the National Environmental Policy Act (NEPA); federal oversight; project administration; during-construction investigations, such as special studies to evaluate alternatives for reducing construction costs of a particular project component, the preparation of supplemental environmental assessments based on project conditions not initially contemplated or not sufficiently well-defined, and value engineering; geotechnical and other investigations in support of design; preparation of plans and specifications by a design engineer; and field inspection of construction to insure conformance with plans and specifications.

- **Project Costs** - Project costs are the sum of the field and non-contract costs and constitute the total budget for all project activities through the construction phase of the project to be funded by federal, state and local sources. Project costs do not include post-construction activities of operation, maintenance and replacement.

- **Interest During Construction –** includes the cost of money to finance a project during its construction. Interest was calculated during the estimated construction time required for the project.

- **Operation, Maintenance, and Replacement (OM&R) Costs** - are intended to capture a majority of the costs associated with operating the facility. The OM&R costs generally consist of the following major items.
  - **Labor:** This item represents the cost of labor, including fringe benefits, to operate and maintain the facility. Personnel labor estimates were based upon required personnel to operate similar facilities in the Western U.S. The cost of labor including fringe benefits was similarly estimated. Vehicle mileage was included in the labor estimates.

- **Energy:** This item represents the costs for energy to operate the new facility. At this time, the estimated energy costs for the alternatives are based on Navopache Electric Cooperative rates for large commercial installations.

- **Materials and Supplies:** This category represents the parts, supplies, materials and chemicals required for operation and maintenance.

- **Equipment & Material Replacement:** The cost of equipment and material replacement of major components of a system are based on a useful life for each of the facility components. For example a pump station may have different useful lives for pumps and controls (10 years), manifold piping and appurtenances (20 years) and the pump station building (40 years).

- **Life-cycle Costs -** present value of project costs, interest during construction and operation, maintenance and replacement costs discounted at 3% over a 100 year life of project.

Table 4-2 summarizes the costs of the alternatives for the North Fork of the White River domestic supply. Details of the construction, operation, maintenance and replacement costs in support of Table 4-2 are presented in Appendix X. Project costs total $113,236,000 for a project delivering water to the communities of Greater Whiteriver area, Cedar Creek, Carrizo and Cibecue. The marginal costs life-cycle of delivering water of delivering water from the Greater Whiteriver area to Cedar Creek, the first community to the west, was estimated at $11,255,000 (Table 4-2). An additional life-cycle cost of $12,670,000 would be incurred to extend the system to the community of Carrizo, and an additional $64,936,000 would be incurred to extend the system to Cibecue.

4-2. Bonito Creek Alternative

The Bonito Creek alternative includes a large diameter transfer pipeline from the Bonito Creek Reservoir to the recommended site of the WTP. This pipeline would transfer the anticipated future demand of 11,568 gpm to the treatment plant. The pipeline would cross Sevenmile Ridge and proceed down the north side. Due to the extreme change in elevation, multiple pressure reducing stations would be necessary to maintain a suitable pressure within the pipeline. Water would flow by gravity down Sevenmile Ridge, through Whiteriver and to the proposed WTP site. The estimated total project costs of this pipeline are $36,572,000.

Table 4-3 summarizes the costs the alternative of developing Bonito Creek as a domestic supply for the Greater Whiteriver area, Cedar Creek, Carrizo and Cibecue, the alternative that would likely be implemented if the North Fork of the White River were not developed. The Coconino aquifer was considered an alternative to the North Fork of the White River, but the adequacy of the water supply was considered inadequate to meet demands. Inadequacy was based on the unsuccessful history of well exploration within the boundaries of the Reservation and estimates of the amount of water that might be captured by wells based on water issuing from the Coconino sandstone and the Fort Apache limestone.

TABLE 4-2

ALTERNATIVE COSTS FOR NORTH FORK WHITE RIVER DOMESTIC SUPPLY
BY COMMUNITIES SERVED

Discount Rate, %	3%
Interest Rate, %	5%
Project Life, years	100
Substantial Completion, year	3

		Water Source		
Cost Feature		MR&I Cedar Creek (Demand 4)	MR&I Carizzo (Demand 5)	MR&I Cibecue (Demand 6)
Construction				
Total Field Costs				
Miner Flat Dam		24,728,000	24,728,000	24,728,000
Water Treatment Plant		$ 20,442,000	$ 21,442,000	$ 24,437,000
Pipelines & Appurtenances		8,163,000	10,604,000	19,717,000
Pump Stations/PRVs		0	687,000	3,410,000
Reservoirs		1,744,000	2,724,000	6,167,000
Subtotal		55,077,000	60,185,000	78,459,000
Contingency	15%	8,262,000	9,028,000	11,769,000
Total Contract Costs		63,339,000	69,213,000	90,228,000
Non-Contract Costs				
Environmental Mitigation	0.50%	317,000	346,000	451,000
Federal Oversight	2.50%	1,583,000	1,730,000	2,256,000
Contract Administration	6.25%	3,959,000	4,326,000	5,639,000
Pre-Construction Investigations	3.00%	1,900,000	2,076,000	2,707,000
Design, Surveys and Geotechnical	0.75%	475,000	519,000	677,000
Designed Plans and Specifications	5.75%	3,642,000	3,980,000	5,188,000
Construction Observation	6.75%	4,275,000	4,672,000	6,090,000
Sutotal	25.50%	16,151,000	17,649,000	23,008,000
Total Project Costs		79,490,000	86,862,000	113,236,000
Present Value Project Costs		77,197,000	84,357,000	109,970,000
Interest During Construction		7,949,000	8,686,000	11,324,000
PV IDC		7,644,000	8,353,000	10,889,000
Operation, Maintenance and Replacement (OMR)				
Annual Energy				
Water Treatment Plant		155,960	164,340	209,484
Pump Stations		0	3,440	150,767
Subtotal		155,960	167,780	360,251
Annual Operation and Maintenance (OM)				
Labor		389,695	443,030	622,500
Materials and Supplies		163,463	181,669	245,206
Subtotal		553,158	624,699	867,706
Present Value Annual OM		21,121,000	23,604,000	36,575,000
Present Value of Future Replacements		21,312,000	23,289,000	45,886,000
Total Present Value OMR		42,433,000	46,893,000	82,461,000
Present Value Life Cycle Costs		$ 127,274,000	$ 139,603,000	$ 203,320,000
Marginal Increase in Present Value		$ 10,945,000	$ 12,329,000	$ 63,717,000

The life-cycle costs of developing Bonito Creek as a domestic water supply were estimated at $468,707,000. The principal investments with the alternative are $138,650,000 for Bonito Creek dam and $36,572,000 for a pipeline and related facilities from Bonito Creek to the water treatment plant location north of the community of Whiteriver. The lifecycle costs of developing Bonito Creek are $265,387,000 more than the costs of developing the North Fork of the White River.

TABLE 4-3

BONITO CREEK ALTERNATIVE COSTS FOR DOMESTIC SUPPLY
LIFECYCLE COSTS

Discount Rate, %	3%		
Borrowing Rate,%	5%		
Project Life, years	100		
Substantial Completion, year		5	3

Cost Feature		Bonito Prairie WTP Transfer Pipeline	Miner Flat Dam & Diversion
Construction			
Total Field Costs			
Miner Flat Dam		0	24,728,000
Water Treatment Plant		24,437,000	24,437,000
Pipelines & Appurtenances		19,717,000	19,717,000
Pump Stations/PRVs		3,410,000	3,410,000
Reservoirs		6,167,000	6,167,000
Bonito Creek Dam		138,650,000	
Transfer Pipeline		36,572,000	0
Subtotal		228,953,000	78,459,000
Contingency	15%	34,343,000	11,769,000
Total Contract Costs		263,296,000	90,228,000
Non-Contract Costs			
Environmental Mitigation	0.50%	1,316,000	451,000
Federal Oversight	2.50%	6,582,000	2,256,000
Contract Administration	6.25%	16,456,000	5,639,000
Pre-Construction Investigations	3.00%	7,899,000	2,707,000
Design, Surveys and Geotechnical	0.75%	1,975,000	677,000
Designed Plans and Specifications	5.75%	15,140,000	5,188,000
Construction Observation	6.75%	17,772,000	6,090,000
Sutotal	25.50%	67,140,000	23,008,000
Total Project Costs		330,436,000	113,236,000
Present Value Project Costs		311,740,000	109,970,000
Interest During Construction		49,565,000	11,324,000
PV IDC		45,840,000	10,889,000
Operation, Maintenance and Replacement (OMR)			
Annual Energy			
Water Treatment Plant		209,484	209,484
Pump Stations		134,171	150,767
Subtotal		343,655	360,251
Annual Operation and Maintenance (OM)			
Labor		622,500	622,500
Materials and Supplies		245,206	245,206
Subtotal		867,706	867,706
Present Value Annual OM		34,009,000	36,575,000
Present Value of Future Replacements		77,118,000	45,886,000
Total Present Value OMR		111,127,000	82,461,000
Present Value Life Cycle Costs		468,707,000	203,320,000

4-3. <u>Cibecue Creek Alternative</u>

The population of the community of Cibecue is projected to increase from 1,549 persons in year 2000 to 4,806 persons by year 2030 (Table 3-1). Current water needs are estimated at 212,000 gallons per average day. The 2030 population would require 908,000 gallons per average day. Design capacity of facilities to meet future demands is projected at 2,044,000 gallons per day based on a maximum to average day factor of 2.25.

As shown in Table 4-2, the marginal increase in life-cycle cost of delivering water to the community of Cibecue from the North Fork of the White River, assuming completion of a pipeline to the community of Carrizo, is $64,936,000. Because this increment was relatively large, alternatives were examined for the community of Cibecue as summarized below.

- <u>Alternative 1:</u> Diversion from the North Fork White River with total dissolved solids concentration less than 500 milligrams per liter (mg/l.) to a regional water treatment plant near the community of Whiteriver and conveyance by pipeline to Cibecue with intermediate delivery to Cedar Creek and Carrizo (see Table 4-2);

- <u>Alternative 2:</u> Development of deep wells to the Redwall formation in the vicinity of the community of Cibecue and treatment of water pumped from the Redwall formation with reverse osmosis to remove most of the total dissolved solids concentration of the source water, which is greater than 6,000 mg/l

- <u>Alternative 3:</u> Diversion and storage of water from Cibecue Creek with total dissolved solids concentration less than 500 milligrams per liter (mg/l.) to a local treatment plant near the community of Cibecue.

Development of springs upstream from the community of Cibecue and tributary to Cibecue Creek is not considered a viable alternative because diversion of the springs would significantly impact the base flow of Cibecue Creek and adversely affect the riparian habitat. Groundwater in the alluvial of Cibecue Creek in the vicinity of the community is the current source of water but is not considered adequate for short-term increases in population nor is it considered adequate for long-term increases through year 2030.

Alternative 1 would rely on the surface waters of the North Fork White River for raw water. Removal of suspended sediments and disinfection of the source water is the primary purpose of the conventional water treatment plant that would provide safe drinking water to a regional distribution system, including the community of Cibecue. Disinfection would require removal of bacteria, viruses and cysts, such as *giardia* and *cryptosporidium*. Disinfection processes would likely include chloramination and could in the future provide for ultraviolet light to control *cryptosporidium* or other microbiological concerns. Steps to avoid the formation of haloacetic acids and trihalomethanes would be implemented. The chemical composition of the source water is extremely good, and water treatment does not require removal of constituents.

Radiological, volatile organic compounds and synthetic organic compounds have not been detected at levels that would cause concern.

Alternative 2 would rely on water from the Redwall formation approximately 1,000 feet below the surface in the vicinity of Cibecue. The water is high in total dissolved solids with concentrations exceeding 6,000 milligrams per liter. Most of the total dissolved solids concentration is from sodium and chloride. Sulfates are also high. More sampling is needed to determine if arsenic is problematic. Removal of the inorganic chemicals would require reverse osmosis as the treatment process. Water quality in the Redwall formation is based on sampling from a single exploratory well drilled for the community of Cedar Creek. There has been no exploration of the Redwall formation in the Cibecue area.

Alternative 3 would rely on water diverted from Cibecue Creek that is stored in the proposed Salt Creek Reservoir. Removal of suspended sediments and disinfection of the source water is the primary purpose of the conventional water treatment plant that would provide safe drinking water to a community such as Cibecue. Disinfection would require removal of bacteria, viruses and cysts, such as *giardia* and *cryptosporidium*. Disinfection processes would likely include chlorination and could in the future provide for ultraviolet light to control *cryptosporidium* or other microbiological concerns. Steps to avoid the formation of haloacetic acids and trihalomethanes would be implemented. It has been assumed that the chemical composition of the source water is extremely good, similar to other surface water bodies in the region, and water treatment does not require removal of constituents. Tests for radiological, volatile organic compounds and synthetic organic compounds must be conducted to determine if levels of the constituents are present that would cause concern.

Table 4-4 presents a water quality comparison of the source water for Alternatives 1 and 2. Alternative 3 is assumed to have approximately the same water quality as Alternative 1.

4.3.1. Description of Alternative 1

Alternative 1 relies on raw water diverted from the North Fork White River downstream from Diamond Creek and near Gold Gulch. Surface water would be treated with conventional treatment processes to remove suspended sediment, provide disinfection and inhibit the formation of disinfectant byproducts. The type of facility proposed is described more fully in the current plan for surface water treatment by the Indian Health Service for the Greater Whiteriver area[12] and above in discussion of the domestic features for the North Fork White River alternatives. The differential costs of a water treatment plant to meet the needs of Cibecue were assigned to Alternative 1.

Treated water with volume of 922,781 gallons per day would be delivered by pipeline transmission system from the water treatment plant to the community of Cibecue over a distance of 53 miles. The pipeline transmission system would also be designed to carry future water

[12] Stover, Michael A., June 2005, *Preliminary Engineering Report for the White Mountain Apache Tribe, Fort Apache Indian Reservation, Proposed Whiteriver Surface Water Diversion and Treatment Facility*, Indian Health Service, Pinetop Arizona.

TABLE 4-4

COMPARISON OF WATER QUALITY OF ALTERNATIVE SOURCES

Component	Units	MCL (mg/L)	Redwall[1] Water Analysis	Redwall[1] Amount Over MCL	North Fork White River[2] Water Analysis	North Fork White River[2] Amount Over MCL
METALS:						
Aluminum	mg/L	0.05				
Antimony	mg/L	0.006			ND	
Arsenic	mg/L	0.05	0.01		ND	
Barium	mg/L	2	0.02		ND	
Beryllium	mg/L	0.004			ND	
Cadmium	mg/L	0.005	0.00		ND	
Calcium	mg/L	---	200.00		87	
Chromium, total	mg/L	0.1			ND	
Copper	mg/L	1	0.03		0.06	
Iron	mg/L	0.3	37.00	**36.7**		
Lead	mg/L	0.015			ND	
Magnesium	mg/L	---	67.00		13.22	
Manganese	mg/L	0.05				
Mercury	mg/L	0.002	0.00		ND	
Nickel	mg/L	---	0.02		ND	
Potassium	mg/L	---	89.00			
Selenium	mg/L	0.05			ND	
Silver	mg/L	0.1				
Sodium	mg/L	---	2,100.00		3.53	
Strontium	mg/L	---				
Zinc	mg/L	5				
INORGANICS:						
Alkalinity-Bicarbonate		---	630.00		143	
Alkalinity-Carbonate		---				
Carbon Dioxide (aq)		---				
Chloride	mg/L	250	2,800.00	**2550**		
Cyanide, free	mg/L	0.2				
Fluoride	mg/L	4			0.2	
Nitrate (as N)		10	0.10		0.14	
o-Phosphate		---				
Sulfate	mg/L	250	540.00	**290**	77.3	
Silica						
pH	pH	6.5-8.5	7.50		8.5	
Solids (TDS)	mg/L	500	6,232.00	**5732**	290	
Total Suspended Solids:	mg/L	---			304	
Conductivity		---			428	
Temperature		---				

[1] Precision Analytical Laboratories, Inc. May 31, 2000, JFK Deep Well for White Mountain Apache Tribe

[2] Maximum observed from repetitive measurements. Source, Stover, Michael A., June 2005, *Preliminary Engineering Report for the White Mountain Apache Tribe, Fort Apache Indian Reservation*, *Proposed Whiteriver Surface Water Diversion and Treatment Facility*, Indian Health Service, Appendix H.

requirements for Cedar Creek and Carrizo. The transmission system would include polyvinyl chloride (PVC) pipelines with diameter ranging from 12 to 20 inches (see hydraulic grade line) and with pressure classes ranging from DR14 C900 to DR32 C905. The differential costs of the pipeline transmission system between the costs of the transmission system to Cibecue and to Carrizo without Cibecue demand was used for the analysis.

A hydraulic pipeline model was developed for the transmission system. The terrain requires four pumping stations and five tanks from Whiteriver to Cibecue. The pumping stations are required to overcome head losses and elevation differences between Whiteriver and Cibecue and to boost water over high points along the route. The difference in cost of pumping stations to Cibecue and to Carrizo without Cibecue demands was used for the analysis.

Tanks along the transmission system were sized to store 24 hours of maximum day supply. The difference in cost of tanks with Cibecue and with Carrizo but without Cibecue demands was used for the analysis.

Appendix X provides the full detail of the project features and sizes including the minor items in addition to pipelines, pumping stations and tanks. Controls, stream crossings, road crossings and other minor items are listed and included in the cost estimate.

4.3.2. Description of Project Alternative 2

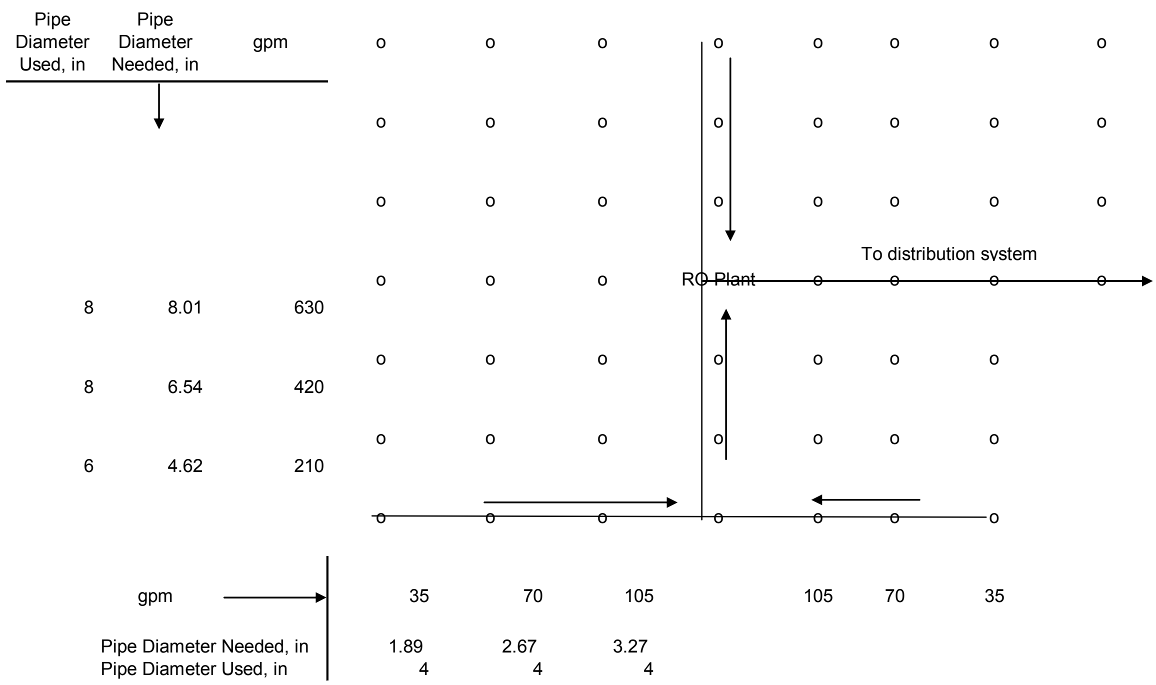
Alternative 2 relies on raw water pumped by 53 wells from the Redwall formation in the vicinity of Cibecue. The number of wells was based on the raw water requirement of a reverse osmosis treatment facility to provide 1,548 gallons per minute discharge on a maximum day in the year 2050. With 85% recovery, the wellfield would be required to produce 1,851 gallons per minute. A six-inch diameter well drilled in year 2000 near the community of Cedar Creek produced between 30 and 40 gallons per minute. For purposes of Alternative 2, wells drilled into the Redwall formation in the vicinity of Cibecue were estimated to yield 35 gallons per minute per well. These criteria would require 53 wells to produce the necessary water supply. Wells would range and depth from 1,380 to 1,475 feet. Well costs would range from an estimated $207,000 to $221,000. Pumping lifts of 900 feet without significant drawdown were assumed. Appendix X provides a more complete description of the factors considered in pumping from the Redwall formation.

In developing costs of the well-field, it was assumed that a well spacing of one half mile would be adequate to prevent interference between wells. The schematic arrangement in Figure 4-1 provides a hypothetical well-field used for cost estimating. The water treatment plant would be located in the center of the grid. The wells on the seven rows of the grid would be connected by pipelines delivering 35, 70 and 105 gpm, respectively, to a central collection pipeline. Each row would include 3.5 miles of 4-inch diameter pipeline. The collection pipeline along the central column of wells would deliver 210, 420 and 630 gpm, respectively, from two opposite directions to the central water treatment plant. This piping would be 6 inch diameter between the outer two rows of wells and 8 inches in diameter for the remaining distance to the water treatment plant.

Finished water would be delivered in a 12-inch diameter pipeline over a distance of 4 miles to the distribution system in Cibecue. This assumes that a well-field could be developed in the immediate vicinity of the community.

FIGURE 4-1

WELLFIELD LAYOUT AND SIZING
ONE HALF MILE GRID



Pumping equipment, including shaft and column, would be installed in each well to an estimated depth of 900 feet. An estimate of $20,000 per well was used in developing project costs. Stimulation of wells to produce the estimated yield of 35 gpm was assumed for half of the wells in the field.

Costs of the reverse osmosis water treatment plant for Cibecue were developed using Bureau of Reclamation procedures and cost estimating techniques for the water quality given in Table 4-4.[13]   Harshness of the water in the Redwall formation required consideration of a shorter life of wells and pumping equipment for Alternative 2 than for equipment proposed for other alternatives, using 25 years for the life of wells and pumping equipment in Alternative 2.

4.3.3. Description of Project Alternative 3

[13] Bureau of Reclamation, August 1999, *Water Treatment Estimation Routine (WATER) User Manual*, Water Desalination Research and Development Program Report number 43, Lower Colorado Regional Office, Boulder City, Nevada.

Alternative 3 relies on raw water diverted from Cibecue Creek upstream from the confluence of Cibecue Creek and Salt Creek and stored in the proposed Salt Creek Reservoir. Surface water would be treated with conventional treatment processes to remove suspended sediment, provide disinfection and inhibit the formation of disinfectant byproducts.

Treated water with would be delivered by pipeline transmission system from the water treatment plant to the community of Cibecue distribution system over a distance of less than 2 miles.

4.3.4. Summary

Table 4-5 summarizes the costs of the three alternatives selected for analysis for the Cibecue Creek Alternative domestic features. Alternative 3 with water supply from Cibecue Creek and a separate water treatment plant is the apparent most favorable option with a lifecycle cost of $26,436,000. This is superior to lifecycle costs of constructing pipelines from the North Fork White River to Carrizo with sufficient capacity to serve Cibecue and constructing the pipeline extension between Carrizo and Cibecue by $15,569,000. Neither alternative 1 nor alternative 3 for Cibecue, however, consider allocation of storage costs to the purpose of domestic supply. Cost allocations will be needed to fully evaluate the alternatives, but it is expected that the alternatives will be more equal given the higher cost of storage on Salt Wash than at Miner Flat Dam on the North Fork of the White River. The governing body of the White Mountain Apache Tribe should select a preference between alternatives 1 and 3 given the near equivalence of the life-cycle costs.

The life-cycle costs of developing a well-field reliant upon the Redwall formation, although presently speculative from the standpoint of adequate water supply, were projected at $90,114,000 or $48,109,000 greater than building pipelines from the North Fork of the White River.

TABLE 4-5

ALTERNATIVE COSTS FOR NORTH FORK WHITE RIVER DOMESTIC SUPPLY

Discount Rate, %	3%
Interest Rate, %	5%
Project Life, years	100
Substantial Completion, year	3

		Water Source		
Cost Feature		North Fork Pipeline (Alternative 1)	Redwall Wells (Alternative 2)	Cibecue Creek WTP (Alternative 3)
Construction				
Total Field Costs				
Water Treatment Plant		2,995,000	11,832,000	9,895,000
Pipelines & Appurtenances		9,113,000		300,000
Pump Stations		2,723,000		
Water Tanks		3,443,000		
Well Field Drillings, Casing, Pumps			14,851,000	
Well Field Piping			980,000	
Well Field Electrical			1,949,000	
Finished Water Piping			369,000	
Subtotal		18,274,000	29,981,000	10,195,000
Contingency	15%	3,655,000	5,996,000	2,039,000
Total Contract Costs		21,929,000	35,977,000	12,234,000
Non-Contract Costs				
Environmental Mitigation	0.50%	110,000	180,000	61,000
Federal Oversight	2.50%	768,000	1,259,000	428,000
Contract Administration	6.25%	1,645,000	2,698,000	918,000
Pre-Construction Investigations	3.00%	768,000	1,259,000	428,000
Design, Surveys and Geotechnical	0.75%	164,000	1,270,000	92,000
Designed Plans and Specifications	5.75%	1,316,000	2,159,000	734,000
Construction Observation	6.75%	1,590,000	2,608,000	887,000
Subtotal	25.50%	6,361,000	11,433,000	3,548,000
Total Project Costs		28,290,000	47,410,000	15,782,000
Present Value Project Costs		26,964,000	45,188,000	15,042,000
Interest During Construction		2,829,000	4,741,000	1,578,000
PV IDC		2,653,000	4,445,000	1,480,000
Operation, Maintenance and Replacement (OMR)				
Annual Energy				
Water Treatment Plant		45,144	650,000	20,201
Pump Stations		147,327		
Well Field Pumping			167,000	
Subtotal		192,471	817,000	20,201
Annual Operation and Maintenance (OM)				
Labor		179,470	393,000	240,090
Materials and Supplies		63,536	142,000	59,370
Well Field Electrical			19,000	
Subtotal		243,006	554,000	299,460
Present Value Annual OM		8,619,000	27,136,000	6,327,000
Present Value of Future Replacements		3,769,000	13,345,000	3,587,000
Total Present Value OMR		12,388,000	40,481,000	9,914,000
Present Value Life Cycle Costs		42,005,000	90,114,000	26,436,000
Marginal Life-Cycle Costs		--	48,109,000	-15,569,000

5. RESERVOIR STORAGE TO FIRM THE WATER SUPPLY

Regulation of streamflows is needed to satisfy future domestic water demands of the White Mountain Apache Tribe. Greater regulation is needed for implementation of multi-purpose projects, including irrigation and recreation. New reservoirs would regulate seasonal variations and store water during the snowmelt runoff and from monsoon and fall rains and release water to during the typical dry season of May and June. Conservation storage at some dam sites would assist in regulating streamflows during protracted drought.

Four damsites were investigated to provide regulation necessary to prevent significant shortage in meeting domestic and irrigation demands. Miner Flat Dam was the first of the damsites investigated. The discussion related to Miner Flat Dam reflects feasibility level investigations founded on geotechnical investigations of the damsite and reservoir area. Cost estimates were based on preliminary designs. Miner Flat Dam has capability to regulate the seasonal stream flows of the North Fork of the White River. It has insufficient capacity to provide storage during extended drought. Bear Canyon damsite was investigated at the appraisal level, absent geotechnical investigations, to provide additional off-stream storage of the White River streamflows, including sufficient conservation storage to eliminate shortages during extended drought.

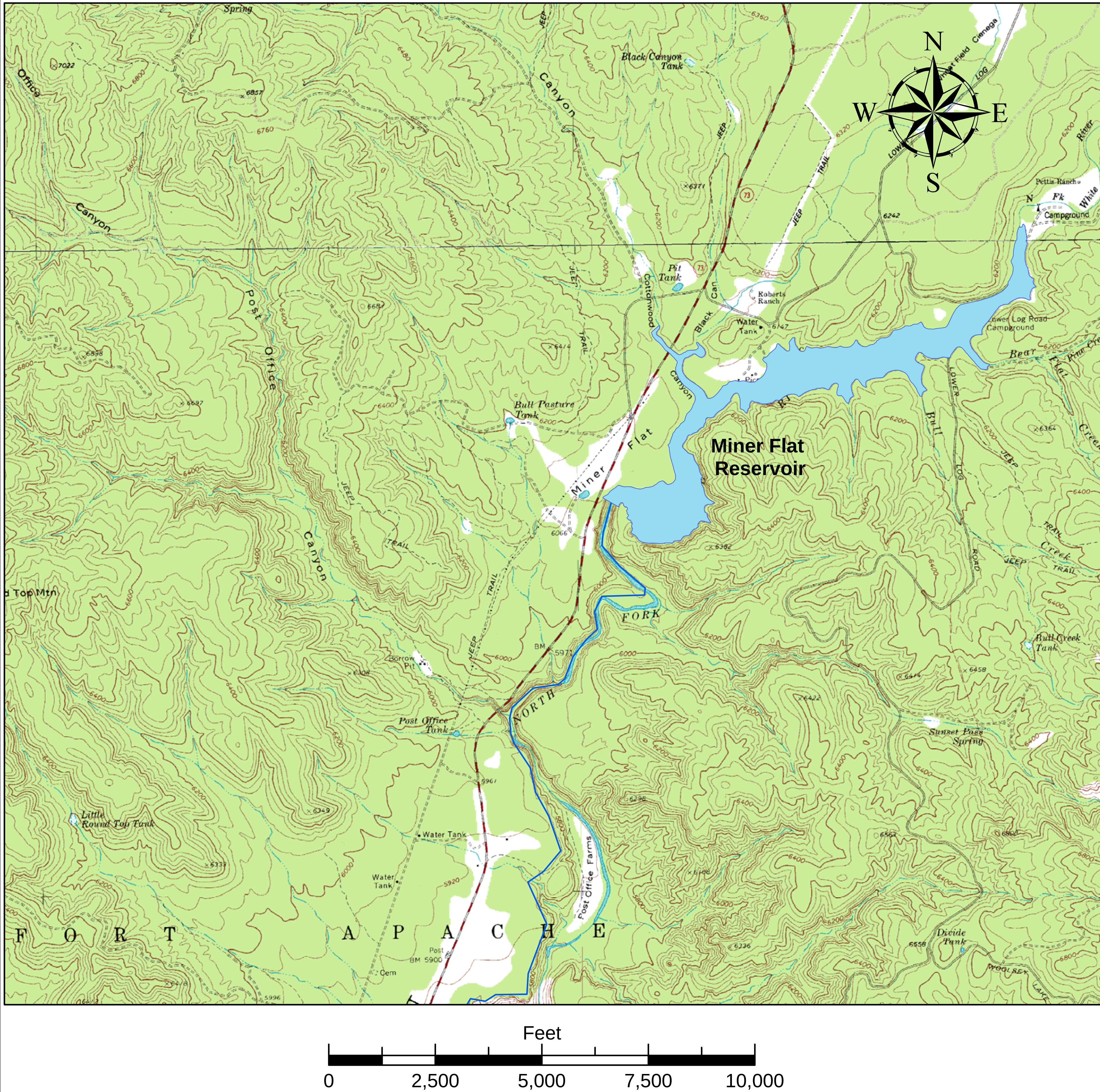
The damsite on Bonito Creek would regulate the streamflows of the Bonito Creek system during seasonal low flows and during extended drought for irrigation and, at the end of the 21st century, as a supplemental supply to the North Fork of the White River for domestic purposes. For irrigation of Bonito Prairie, a re-regulating reservoir created by a small off-stream dam would store water at the Jeep Trail site. Salt Creek is an off-stream damsite that would regulate the streamflows of Cibecue Creek for domestic and irrigation purposes. All investigation of the Bonito Creek and Salt Creek dam sites was conducted at an appraisal level without geotechnical investigations.

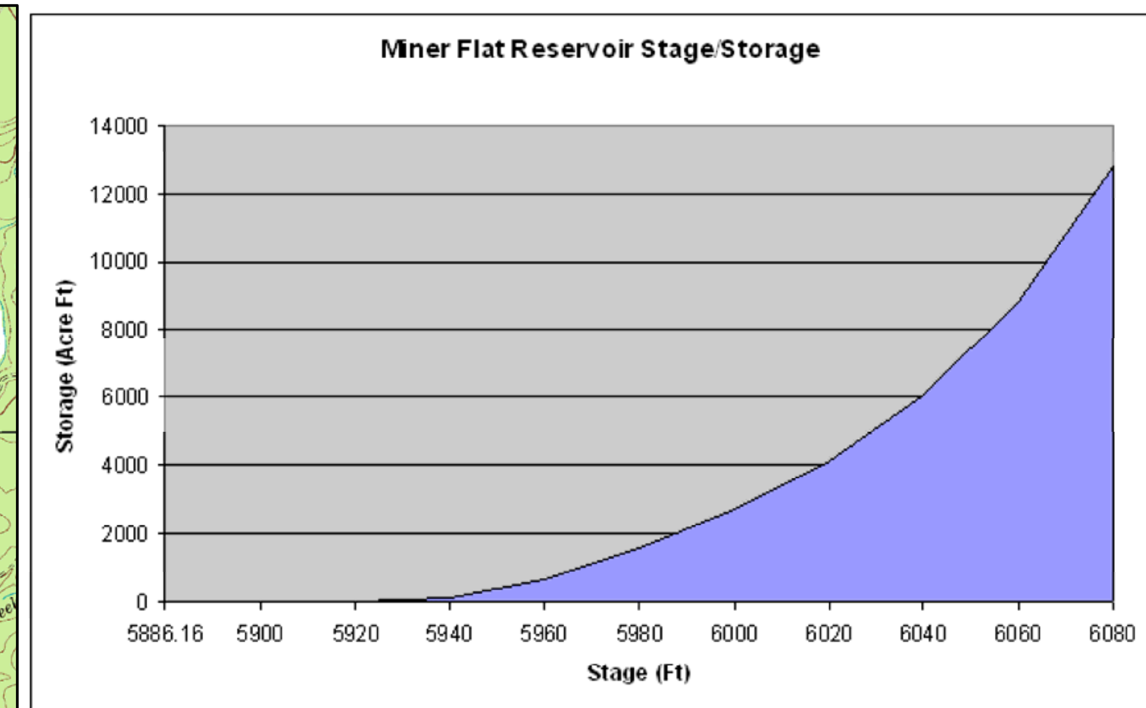
5.1 Miner Flat Dam

Miner Flat Dam on the North Fork of the White River was investigated for the following purposes:

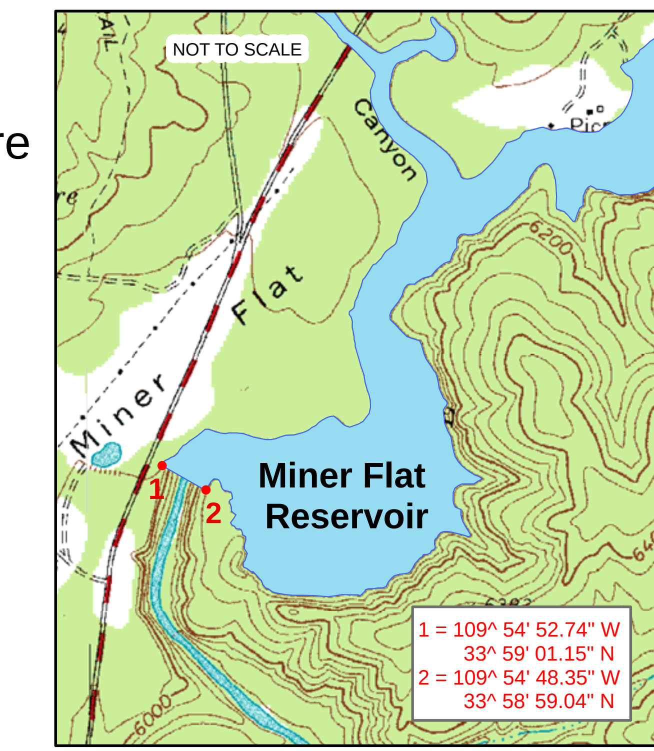
1) Supply for Municipal, Rural, and Industrial (MR&I) water.
2) Storage for irrigation water supply for the Canyon Day Irrigation Project
3) Potential hydropower development
4) Water supply to Alchesay National Fish Hatchery
5) Water-borne recreational opportunities
6) Flood control

The Miner Flat Dam is located upstream from the community of White River, in the SE1/4 of the Section 21, Township 7 North, Range 23 East. The damsite is located at river mile 35.4 as measured from the confluence of the Black River with the White River. The location of Miner Flat Dam is shown on Figure 5-1.





- Canal Structure
- Diversion
- Pump Station
- Canal
- Pipeline
- Reservoir



MINER FLAT DAM PROJECT EXTENSION REPORT	FIGURE
MINER FLAT DAM	NUMBER 5-1

The watershed area above the damsite of 238 square miles provides an estimated 64,000 acre-feet of available water to the project area. The proposed reservoir, with a normal pool elevation of 6,062 feet above mean sea level (msl), creates a surface area of 159 acres and a total storage capacity of 8,400 acre-feet.

The proposed impounding structure (concrete gravity dam) for the reservoir was developed in past studies for Miner Flat Dam, and would be constructed of Roller Compacted Concrete (RCC). The site is suited to a gravity dam, which relies on the weight of the structure to resist the hydrostatic pressure on the upstream face of the dam as distinguished from reliance on the strength of the abutments. The site is narrow, which reduces the volume of material required, and the foundation has bearing strength that can withstand the weight of the facility. RCC construction is based on methods usually associated with earth dam construction. Typically, one-foot thick layers of no-slump concrete are spread horizontally and compacted with construction from abutment to abutment. The lower cost of RCC dams is primarily derived from rapid mechanized construction and reduced labor. [1]

RCC is more of a construction method that relies on a mixture of cement and natural material available at the damsite. Cement and natural material are blended in a pugmill mixer, transported by trucks, large front end loaders or conveyor belts, spread by dozers, and compacted by smooth drum vibratory rollers. In comparing RCC with conventional slump concrete, less water is used and consolidation is achieved externally with steel drum vibrating compactors. Because less water is used, less cement is required to produce an equivalent water/cement ratio. Less water in the mixture leads to less drying shrinkage and less cement results in less heat generation. The reduction in drying shrinkage and heat generation, in combination, reduces cracking potential. Additionally, reduced water content and vibratory roller compaction increases unit weight.[2]

Miner Flat Dam has been extensively studied in the past by the White Mountain Apache Tribe and their respective consultants. The most notable reports and studies on the dam have included the following:

> *Design Memorandum, Miner Flat Dam*, February 1987, Morrison-Maierle, Inc. – This document was a culmination of numerous studies, design approaches, and alternative analyses that provided a framework for the final design of Miner Flat Dam. Included in this work was topographic surveying, geological studies, foundation stability studies, hydrologic/hydraulic analyses, and final design level dam analysis.
>
> *Probable Construction Cost Estimate, Miner Flat Dam*, January 1995, Morrison-Maierle, Inc. – This updated construction cost estimate was developed to include more conventional cost estimating as well as deletion of the hydropower facilities.

[1] Portland Cement Association, 2003, *Design Manual for Small RCC Dams*, EB225, pg. 1
[2] Ibid.

Miner Flat Dam, Left Abutment Ridge Seepage Analysis, April 1997, Golder Associates, Inc. – Conducted in 1995-1996 and completed in 1997, this analysis provided a more detailed analysis of the Miner Flat left abutment.

These documents are located in Appendices S and T.

Specialists were consulted to update costs of Miner Flat Dam. Data and analysis collected since 1987 were reviewed and updated. The technical analyses completed in the past on Miner Flat Dam remain applicable, but improvements in RCC technology require permit refinement of the original design philosophy.

5.1.1 Available Geologic and Soils Information

The geology of the proposed Miner Flat Dam and Reservoir has been studied to determine the feasibility of a dam at the selected site. Initial investigations were conducted by Morrison-Maierle, Inc. and Mineral Systems, Inc. in February and March, 1982. These initial investigation included geotechnical investigations, geologic mapping of the dam site and reservoir and drilling for core samples. Based on these initial investigations, additional geotechnical studies were conducted in 1983 consisting of more detailed geologic mapping, core drilling of additional test borings, logging of core and testing of drill holes, geophysical investigation of the thickness of the basalt flows and gravel deposits, and bulking sampling and testing of the gravel deposits. Recommendations for additional investigations were made as a result of the 1983 investigations. The recommendations were implemented in 1985 and 1986. The investigations included core drilling of 13 additional holes, and more intensive logging and testing of these drill holes including point-load testing, hydraulic conductivity tests, and in-situ elastic moduli tests. Morrison-Maierle, Inc. and Golder Associates, Inc. conducted a detailed seepage analysis of the left abutment, which was reported in 1997.

“Miner Flat” is the top of a basalt flow that moved down an ancestral valley of the North Fork of the White River. The area physiographically is in the transition zone between the Colorado Plateau and the Basin and Range Province. It is about eight miles south of the southern limit of the Colorado Plateau.

The bedrock of the Miner Flat Dam and Reservoir site is in the Supai Formation, which consists predominantly of sandstone at the site, a series of basalt flows, which are capped by partially indurated gravel. Overlying the bedrock are surficial deposits, which include colluvium, including talus, alluvium, alluvial fans, and alluvial terrace deposits.

The bedrock units are exposed in the cliffs along the North Fork of the White River. A valley was cut by the river into the Supai Formation. This valley was filled with a series of basalt lava flows. The river then deposited gravel on the basalt flow before cutting a channel through the flows.

The Supai Formation crops out in steep cliffs south of the dam axis and locally in cliffs along the north and south of the reservoir. In the reservoir area only sandstone of the Limestone and Siltstone Member crops out. The sandstone is pale reddish brown to yellowish brown, fine-grained, and well sorted. In general, the beds strike north-northwest and dip less than 5 degrees to the northeast. Joints and joint sets, spaced at intervals of less than 0.5 to 3.0 feet, at right angles to the bedding and about parallel and at right angles to the strike of the beds, are conspicuous in outcrop.

Basalt crops out and forms conspicuous cliffs at the damsite and along the north side of the reservoir. At the damsite, at least four individual flows have been identified. The flows have filled an ancestral valley of the North Fork of the White River and the surface of the basalt slopes to the south. The basalt is very dark to black, weathering medium to dark grey. Individual flows range from about 20 to 80 feet in thickness. There are thin clay seams that separate flows. Jointing in the flows is irregular. Some flows show crude columnar jointing. In general, the joints are relatively tight.

The contact between the sandstone of the Supai Formation and the basalt is exposed in a cliff east of the dam axis. On the sandstone is less than one to three inches of sandy soil. In the base of the basalt are fragments of sandstone, sand, and breccia fragments of basalt. The disturbed zone at the base of the basalt ranges from about 3 to 18 inches in thickness.

Quarternary/Tertiary gravel deposits occur above the reservoir area along the road cut of State Highway 73, north of the damsite. The gravels overlie basalt. They consist of stratified sand, gravelly sand, and lenses of gravel. The gravel consists of metamorphic and igneous rocks.

The basalt constitutes the abutments and foundation of the Miner Flat Dam. The basalt is a dense rock of high compressive strength. The basalt is jointed, but the joints lack continuity. Portions of the basalt would have a relatively high porosity, provided there was interconnection of vesicules. The vesicules are not interconnected, so the permeability is low. Based on packer tests in various drill holes, the permeability along flow boundaries and along joints is between 10(-3) and 10(-5) centimeters per second.

5.1.2 Hydrological Conditions

The average annual streamflow on the North Fork White River in the vicinity of Miner Flat Dam is approximately 64,000 acre-feet. Streamflow, storage, and monthly simulated operations are described in Chapter 10.

The lowest level in the reservoir behind the proposed Miner Flat Dam would be approximately 5,910 feet at the toe of the upstream face of the dam. The normal water surface elevation in the reservoir at full pool would be at elevation 6,062 feet. Total storage in the reservoir was determined from contour maps generated during the 1985-1986 survey investigations. The storage capacity at full pool of 6,062 is approximately 8,400 acre-feet. At the minimum elevation of 6,000 feet proposed for the reservoir, the storage capacity is 2,500 acre feet, resulting in an active storage content of approximately 6,400 acre-feet. This minimum elevation of 6,000 is proposed as the minimum level in the reservoir in order to provide capacity for the collection of sediment and to maintain a minimum recreation, fish and wildlife pool.

The reservoir behind Miner Flat dam would be approximately 2.4 miles long with a maximum width of 1,200 to 1,400 feet. When the reservoir level is drawn down to elevation 6,000, the upstream end of the reservoir would terminate 1.4 miles from the dam, with a maximum width of approximately 1,000 feet. The surface area of the reservoir at full pool would be 159 acres. The reservoir area at minimum pool would be 62 acres.

Annual sediment yields produced by the watershed that would be trapped behind the dam are estimated at 7.43 acre-feet per year. Over 100 years, accumulated sediment in the dead storage zone allocated for sediment storage would be 743 acre-feet, approximately 30 percent of the dead storage pool of 2,500 acre-feet.

5.1.3 Dam Safety Design Standards

Based upon the reservoir storage capacity of 8,400 acre-feet at normal pool and a reservoir crest height of 155 feet, National Dam Safety Procedures, reflected in Arizona statutes,[3] would apply to Miner Flat Dam, which would be categorized as a "Permanent Storage Reservoir with Low Level Outlet Works." Dams are further classified based on size and hazard potential.

Size determination for Miner Flat Dam would be dictated by the height of the dam. With a crest height of 155 feet, the dam would be classified as "Large." Hazard potential is more difficult to determine and would require a detailed analysis of downstream affects. The Arizona Administrative Code Title 12, Chapter 15, Article 12 states the following:

> *Hazard Potential Classification*
>
> *1. The Department shall base hazard potential classification on an evaluation of the probable present and future incremental adverse consequences that would result from the release of water or stored contents due to failure or improper operation of the dam or appurtenances, regardless of the condition of the dam. The evaluation shall include land use zoning and development projected for the affected area over the 10 year period following classification of the dam. The Department considers all of the following factors in hazard potential classification: probable loss of human life, economic and lifeline losses,*

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[3] Arizona Administrative Code (A.A.C.) Title 12. Natural Resources, Chapter 15. Department of Water Resources, Article 12. Dam Safety Procedures

and intangible losses identified and evaluated by a public resource management or protection agency.

a. The Department bases the probable incremental loss of human life determination primarily on the number of permanent structures for human habitation that would be impacted in the event of failure or improper operation of a dam. The Department considers loss of human life unlikely if:

i. Persons are only temporarily in the potential inundation area;
ii. There are no residences or overnight campsites; and
iii. The owner has control of access to the potential inundation area and provides an emergency action plan with a process for warning in the event of a dam failure or improper operation of a dam.

b. The Department bases the probable economic, lifeline, and intangible loss determinations on the property losses, interruptions of services, and intangible losses that would be likely to result from failure or improper operation of a dam.

2. The 4 hazard potential classification levels are very low, low, significant, and high, listed in order of increasing probable adverse incremental consequences, as prescribed in Table 3. The Director shall classify intangible losses by considering the common or unique nature of features or habitats and temporary or permanent nature of changes.

a. Very Low Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life and would produce no lifeline losses and very low economic and intangible losses. Losses would be limited to the 100 year floodplain or property owned or controlled by the dam owner under long-term lease. The Department considers loss of life unlikely because there are no residences or overnight camp sites.

b. Low Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life, but would produce low economic and intangible losses, and result in no disruption of lifeline services that require more than cosmetic repair. Property losses would be limited to rural or agricultural property, including equipment, and isolated buildings.

c. Significant Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life but may cause significant or high economic loss, intangible damage requiring major mitigation, and disruption or impact on lifeline facilities. Property *losses would occur in a predominantly rural or agricultural area with a transient population but significant infrastructure.*

d. High Hazard Potential. Failure or improper operation of a dam would be likely to cause loss of human life because of residential, commercial, or industrial development. Intangible losses may be major and potentially impossible to mitigate, critical lifeline services may be significantly disrupted, and property losses may be extensive.

The downstream conditions and hazard potential have not been re-surveyed from the criteria in use in the early investigations, which was based on a high hazard classification. Using current criteria, the Miner Flat Dam would remain classified as a Significant or High Hazard Dam.

For a Significant Hazard, Large dam or a High Hazard dam, the minimum inflow design flood (IDF) magnitude for design of the dam and emergency spillway is equal to or greater than 0.5 Probable Maximum Flood (PMF) to a maximum of the PMF, with a minimum factor of safety for stability of 1.5.

Under previous studies, an estimated peak inflow rate for the PMF, was estimated at 113,000 cubic feet per second (cfs) for an August rainfall event and 98,000 cfs for an April snowmelt event. This peak estimate was based on a 72-hour probable maximum precipitation (PMP) point rainfall of 23.2 inches for the month of August and a peak snowmelt in April of 16.9 inches from joint National Oceanic and Atmospheric (NOAA) and Army Corps of Engineers (COE) publication *Hydrometeorological Report (HMR) No. 49, Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages* and hydrological assumptions based on a review of the topographical maps and soils information for the drainage area. [4]

The original design of the Miner Flat Dam utilized these estimates of PMF to size the spillway and structure. Detailed analysis for the dam and spillway are included in the Miner Flat Design Memorandum included in Appendix S.

5.1.4 Assumptions for Dam and Spillway Construction

While the original design is still applicable, advancements in RCC technology require that some minor changes to the original design philosophy be made. On the basis of the following, assumptions on the design and construction that affect the cost analysis for the proposed Miner Flat Dam include:

- Original design quantities developed during the Miner Flat Design Memorandum and refined in the 1995 Probable Construction Cost Estimate were utilized with small allowances for additional material.

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[4] Morrison-Maierle, Inc., December 1986, *Design Memoradum, Miner Flat Dam*, Volume IV, Revised February 1987, pg. 14-20

- Additional costs were associated with items such as jet and curtain grouting, consolidation grouting, plinth construction, adit construction in the abutments, and training wall concrete.

- The outlet tower and outlet works would be isolated from the RCC construction to minimize construction time delays. The outlet tower may be constructed at any time as a stand-alone conventional concrete structure.

- Hydroelectric facilities were considered a turnkey system, with packaged equipment utilized as much as possible.

- Alluvial materials would not be utilized for production of the RCC. A quarry site would be developed to provide the additional aggregate necessary (above the basalt excavated at the dam abutments) for generation of the RCC.

- A conveyor system would be used to transport the RCC from plant to the dam instead of conventional equipment.

- RCC would be spread on the dam prior to rolling by conventional tracked equipment.

- Training walls would be constructed on the overflow section of the RCC dam.

- The emergency spillway would be a stepped spillway with conventional concrete facing for stability.

- The North Fork of the White River would be coffered and diverted around the right abutment during construction of the outlet works on the left abutment. After completion of the outlet works, the water would be diverted through these facilities during the remainder of construction.

Other assumptions and design philosophies used for preparation of the Construction Cost Estimate for the Miner Flat Dam remain the same as those used in previous documents. Detailed construction cost estimate are presented in Appendix Y.

5.2 Bear Canyon Dam

The proposed off-stream Bear Canyon Dam is a unit needed in the development of the White River to provide additional storage for irrigation water supply for the Canyon Irrigation Unit. Deliveries to Bear Canyon Dam would be pumped from the White River below the confluence of the North Fork and East Fork or diverted by gravity upstream. Partial regulation would be provided by Miner Flat Dam.

Bear Canyon Dam is located upstream from the Canyon Day community, just to the north of the proposed Canyon Day Irrigation Unit. The location of Bear Canyon Dam is shown on Figure 5-2.

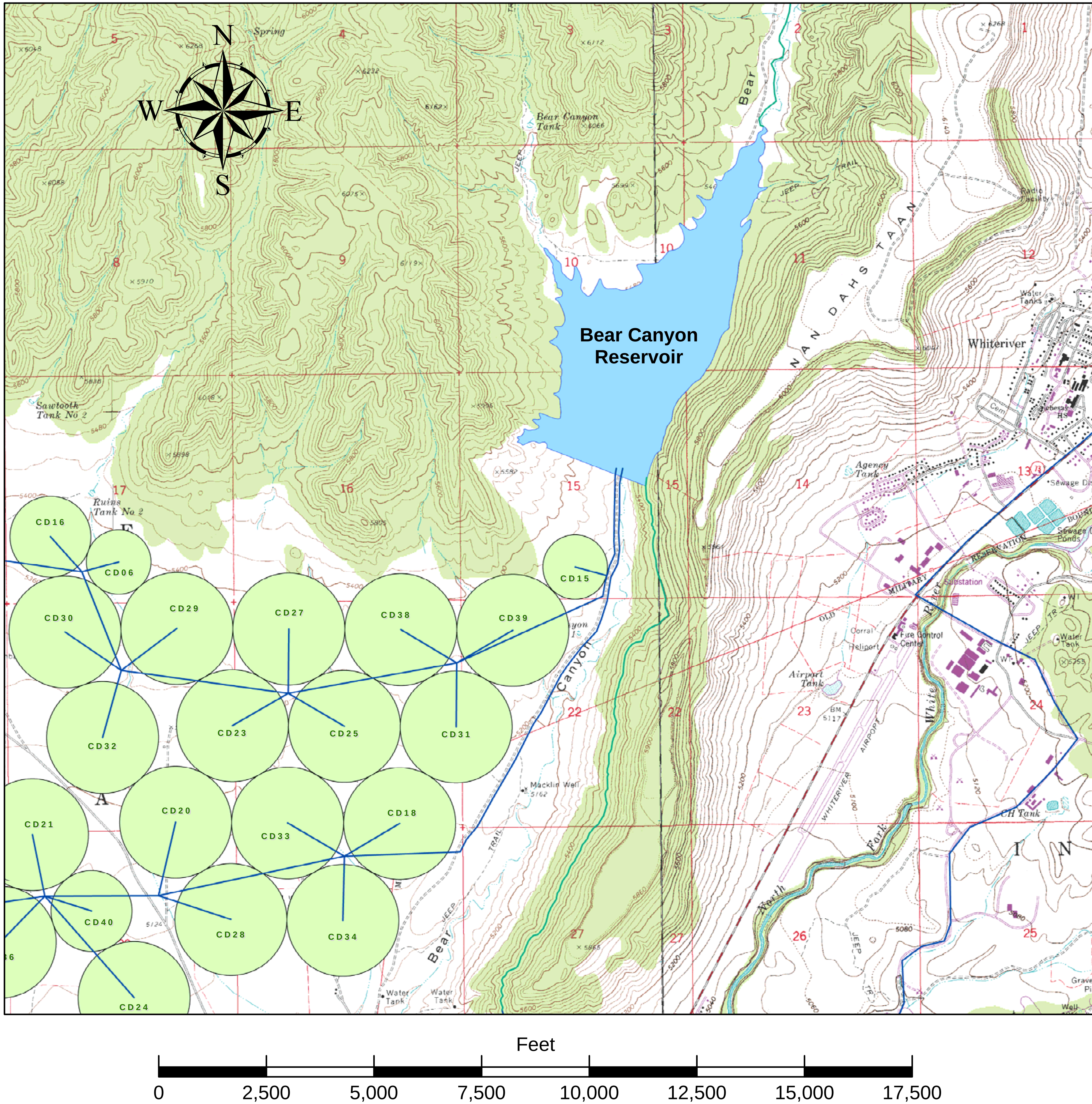
The watershed area above the damsite of 22.8 square miles would provide minimal available water to the project area. Therefore, water would be diverted from the White River and conveyed to the reservoir. The diverted water would be either pumped from the White River into the reservoir or transferred in a pipeline from Miner Flat Dam. In either case, the water conveyed to Bear Canyon Reservoir would be partially regulated by Miner Flat Dam. The Bear Canyon Dam would then provide storage for the Canyon Irrigation Unit. The proposed reservoir, with a normal pool elevation of 5,480 feet above mean sea level (msl), has an area of 350 acres and a total storage capacity of approximately 17,800 acre-feet. The ground elevation in the vicinity of the Bear Canyon Dam is 5,315 feet above msl resulting in a total crest height of about 165 feet.

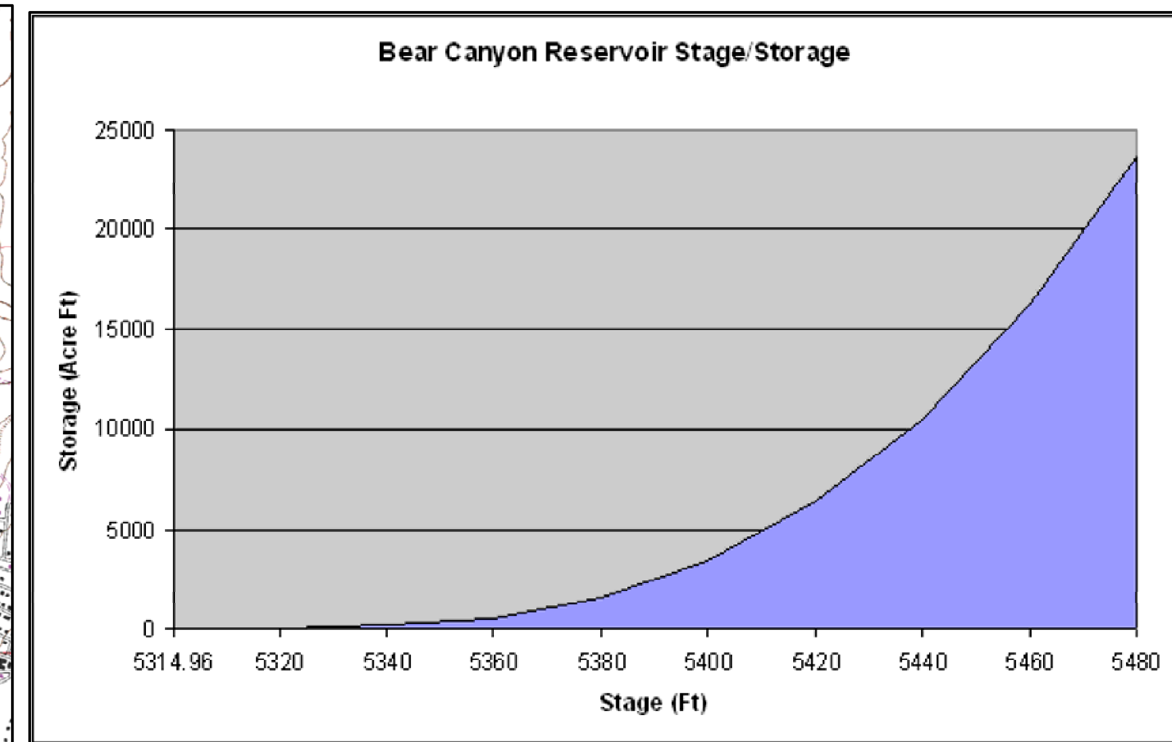
Three alternatives were initially investigated for construction of the Bear Canyon Dam. These alternatives included earth-fill, rock-fill, and concrete gravity. A field reconnaissance in April 2006 determined that a suitable source for impervious materials for an earth-fill dam may be present. The abutment area around the dam site, however, may not be suitable for conventional earth-fill dam. The site was reviewed for potential construction of a rock-fill dam and found to be suitable. The main disadvantage of either an earth-fill dam or rock-fill dam would be the necessity to construct a spillway outside the structure. A conventional or RCC spillway could be constructed over an earth-fill or rock fill structure at a significant.

An RCC gravity dam was suitable at this site and was used as the appraisal-level cost basis for the Bear Canyon Dam. Further analyses are necessary to select the actual dam alternative most applicable to the Bear Canyon Dam site.

5.2.1 Available Geologic and Soils Information

Collection of geotechnical information at the Bear Canyon Dam is needed for future investigations. The parent materials outcropping within the area occur in geological ages ranging through pre-Cambrian to the Tertiary and Quaternary times and are chiefly in the Supai Formation. The most prominent geologic feature of the area is the Nan Dahs Taan Mesa between Whiteriver and Canyon Day. The proposed dam would tie directly into the mesa on the left abutment.





Existing Pivots and Fields

Pump Station

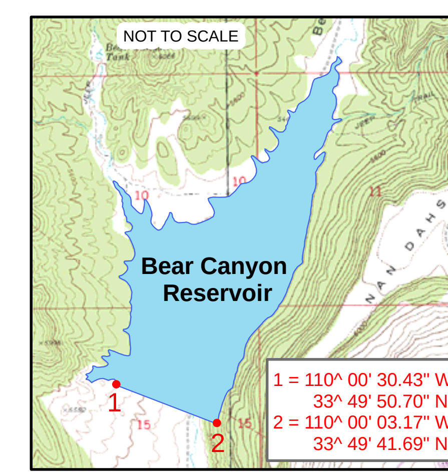
Diversion

Canal

Pipeline

Reservoir

Field



MINER FLAT DAM
PROJECT EXTENSION REPORT

BEAR CANYON DAM

FIGURE

NUMBER
5-2

5.2.2 Hydrological Conditions and Assumptions

As stated previously, the Bear Canyon watershed does not produce a perennial stream and only flows intermittently during high runoff events. No reliance was placed on water derived from the Bear Canyon watershed. Water for storage would be provided by diverting streamflow from the White River and conveying this water for storage to the Bear Canyon Reservoir. Streamflow that would be diverted into Bear Canyon Reservoir would be either pumped from the White River or transferred via a gravity supply pipeline from Miner Flat Dam. These alternatives are discussed further in Chapter 6.

No minimum flows would be provided below the damsite. To prevent constant overtopping of the dam during high flow periods, an uncontrolled principal spillway could be established on the dam to convey flows up to the 25-year event. Flow in excess of the 25-year event would be passed by the emergency spillway.

Estimated sediment yields produced by the watershed that would be trapped behind the dam were projected from gaging stations analyzed previously.[5] These investigations indicate that an expected sediment yield would range from 0.014 to 0.827 acre-feet per square mile per year. A more conservative estimate was used at 0.20 acre-feet per square mile per year. With a watershed area of 22.8 square miles, yearly sediment accumulation would be estimated at 4.57 acre feet per year. Over 100 years, accumulated sediment in the dead storage zone allocated for sediment storage would be approximately 457 acre-feet.

Dead storage of approximately 805 acre feet would be provided below elevation 5,350 feet within the proposed reservoir. The normal water surface elevation in the reservoir at full pool would be at elevation 5,460 feet with a total storage capacity of approximately 17,800 acre-feet. Active storage content for the reservoir would be 17,000 acre-feet. At a crest elevation of 5,480 feet including a freeboard of 20 feet the crest length would be 2,480 feet.

The reservoir behind Bear Canyon Dam would be approximately 1.6 miles long with a maximum width of 3,900 feet. When the reservoir level is drawn down to elevation 5,350 feet, the upstream end of the reservoir would terminate 0.5 miles from the dam, with a maximum width of approximately 800 feet. The surface area of the reservoir at full pool would be 350 acres. The reservoir area at minimum pool would be 40 acres.

5.2.3 Dam Safety Design Standards

Based upon the reservoir storage capacity of 17,800 acre-feet at normal pool and a height of 165 feet, National Dam Safety Procedures would consider Bear Canyon Dam to be a large "Permanent Storage Reservoir with Low Level Outlet Works", high hazard dam, particularly in view of the proximity downstream of the Canyon Day community.

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[5] Morrison-Maierle, Inc., February 1986, *Miner Flat Dam and Canyon Day Irrigation Project*, pg 8-9

Preliminary analysis of the PMP and resultant PMF for the Bear Canyon watershed indicate that the IDF of 1.0 PMF would be approximately 40,000 cfs. Further analysis would be necessary to correctly estimate the probable maximum precipitation (PMP) and probable maximum flood (PMF) for the project site. Initial design concepts and appraisal-level construction costs were based on this inflow designed flood (IDF).

It was assumed that the maximum level of the PMF would be no greater than 15 feet above the normal pool elevation of 5,460 feet leaving an additional 5 feet of freeboard. Low unit discharge rates of 200 cfs per foot or less would be allowed over the crest. Initially sizing would indicate that the emergency spillway crest length would be approximately 200 feet. More detailed analyses are needed before ultimate conclusions can be reached.

5.2.4 Assumptions for Dam and Spillway Construction

On the basis of the following information, assumptions on the design and construction that affect the cost analysis for the proposed Bear Canyon Dam include:

- The silty sandy gravels with cobbles near of the dam site appear to be suitable for aggregate for a low height wide RCC dam. In future investigations test pits are proposed and samples are proposed at different depths and locations for simple bulk gradation, variability evaluation, fines content, absorption, and specific gravity tests.

- For construction of the dam it appears that these materials could be easily excavated by scraper and then screened, re-blended, and used almost as a pit run material to make RCC suitable for this location.

- The foundation would require special attention, especially with regard to potential interbred rock layers and grouting needs.

- For low flows, a vertical outlet near the upstream face could be used, discharging to an apron at the downstream face.

- The dam could be constructed with conventional earth moving equipment or a conveyor system. The use of a conventional concrete slab at the upstream face would provide watertightness and resistance to debris flows. The slab (actually a wall) could be placed prior to (or with) the RCC and act as an upstream form, or it could be placed after the RCC. It would be reinforced concrete with joints and waterstops, and be connected to a grout curtain. Both consolidation grouting and curtain grouting would be necessary for this foundation.

- Because of high unit flows and freeze-thaw conditions, the spillway face should be conventional concrete. A stepped spillway would be most economical to construct. It would also act as an energy dissipater (with a downstream apron or small stilling basin).

- Coring and seismic refraction are part of the future subsurface exploration needed at the site.

5.3 Cibecue Creek (Salt Creek Dam)

The proposed Salt Creek Dam would create an off-stream storage reservoir reliant on Cibecue Creek for the following potential benefits:

1) supply for domestic water for the Community of Cibecue.

2) irrigation water supply for the Cibecue Irrigation Unit.

3) Recreation

The Salt Creek Dam is located upstream from the community of Cibecue, approximately ½ mile upstream of the confluence of Cibecue Creek and Salt Creek. The location of Salt Creek Dam is shown on Figure 5-3.

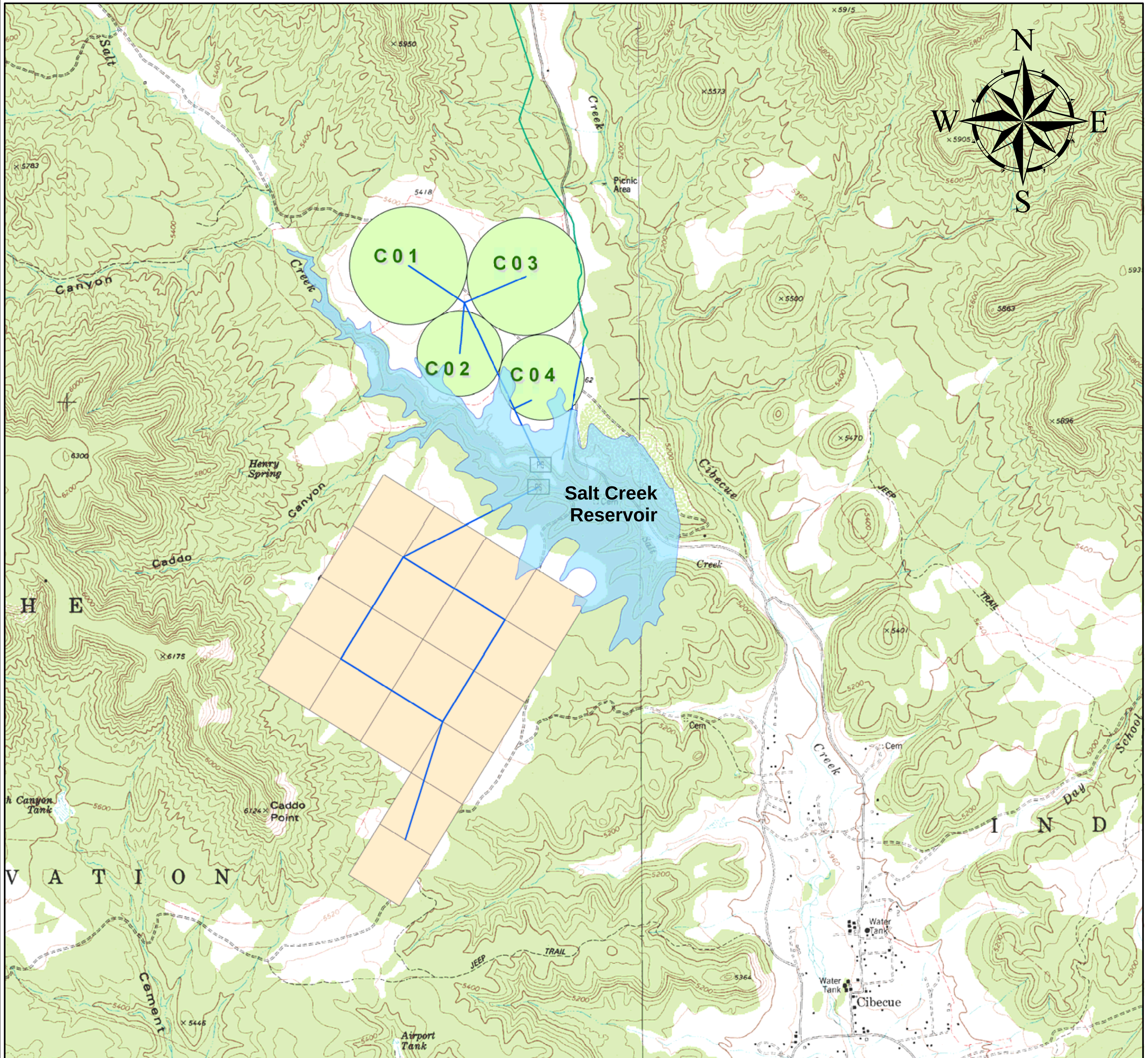
The watershed area above the damsite of 36.7 square miles would provide negligible water supply to the reservoir. Water would be diverted upstream from Cibecue Creek and conveyed to the reservoir by gravity canal. Salt Creek Dam would then provide storage for Cibecue irrigation and potentially to the community of Cibecue. The proposed reservoir, with a normal pool elevation of 5,220 feet above mean sea level (msl), has a surface area of 288 acres and total storage capacity of 14,436 acre-feet. The ground elevation at the damsite is 5,050 feet resulting in a total dam height of 170 feet.

Alternatives for construction of Salt Creek dam included earth-fill and concrete gravity dams. Field reconnaissance in April 2006 determined that a suitable source for impervious materials for an earth-fill dam were absent. An RCC gravity dam was deemed the least costly for the project site.

5.3.1 Available Geologic and Soils Information

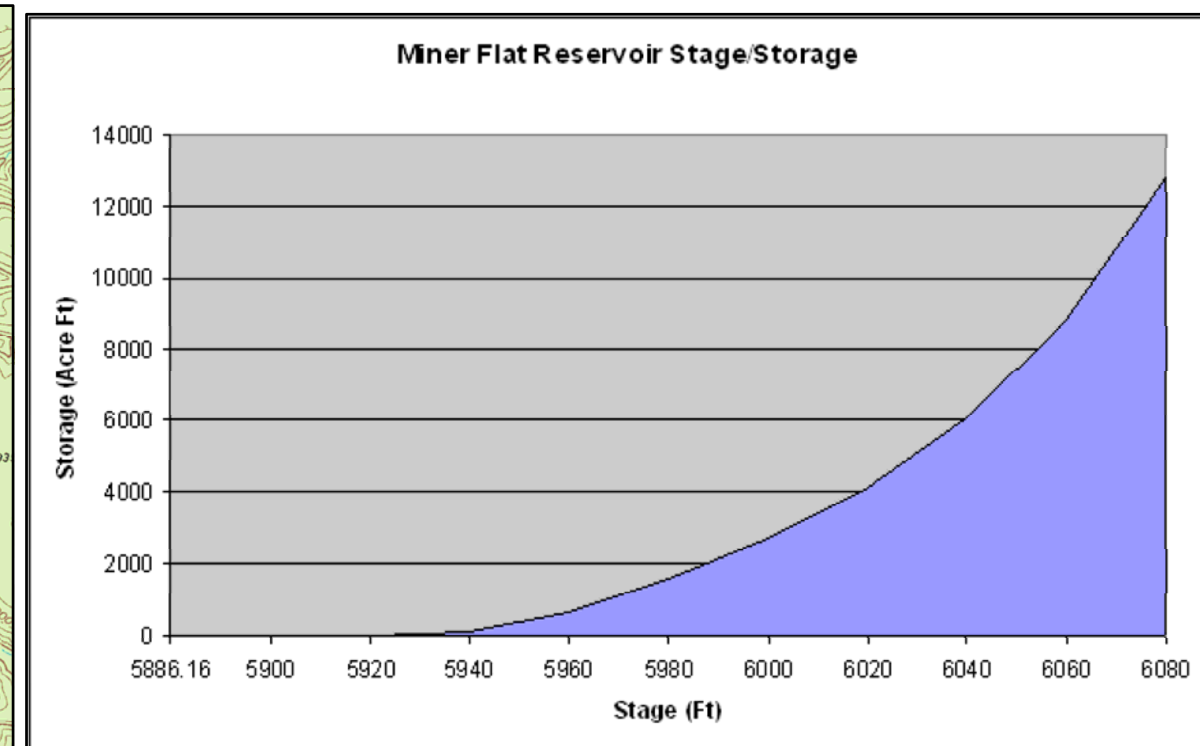
Collection of geotechnical and borrow source data at the Salt Creek Dam is needed for future investigations. The Cibecue Member of the Supai Formation is the predominant foundation material.[6] Overlying alluvium is present in the Salt Creek channel. The Cibecue member is approximately 280-340 feet in thickness and is composed primarily of sandstone and shale. The color is reddish brown with light gray

[6] Finnell, T.L., 1966B, *Geologic Map of the Cibecue Quadrangle, Navajo County, Arizona*: U.S. Geological Survey Geologic Quadrangle Map GQ-545.

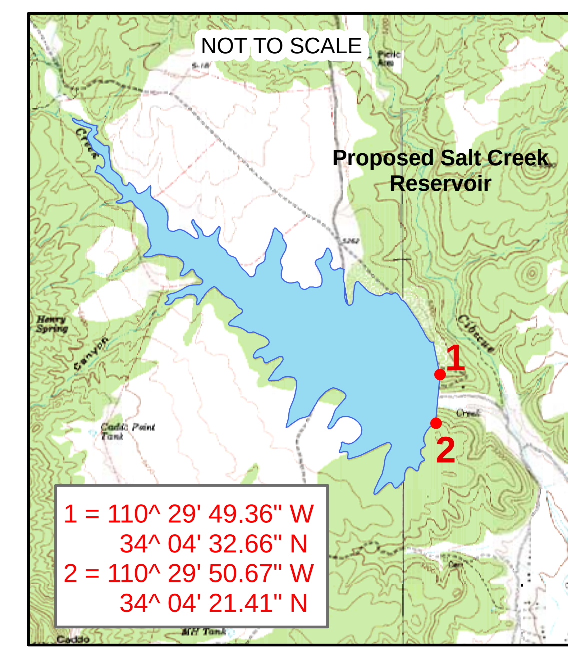


Feet

0 | 2,500 | 5,000 | 7,500 | 10,000 | 12,500 | 15,000 | 17,500 | 20,000



- PS Pump Station
- Diversion
- Canal
- Pipeline
- Apple Orchards
- Reservoir
- Pivots



MINER FLAT DAM PROJECT EXTENSION REPORT	FIGURE
SALT CREEK DAM	NUMBER 5-3

sandstone in some outcrops. The sandstone predominates over shale in the upper half of the unit with shale forming the lower unit. The entire unit is calcareous and one or two nodular limestone beds about a foot thick are commonly present. Lenses of limestone and chert pebbles are locally present at various stratigraphic positions. Sandstone is cross-bedded and fills channels in the underlying units. The lower part of the Cibecue member forms steep slopes that commonly merge upward with cliffs of sandstone. The site reconnaissance confirmed that the abutment area of the proposed damsite is acceptable for RCC dam construction.

5.3.2 Hydrological Conditions and Assumptions

Salt Creek is an intermittent stream. The water supply for the reservoir behind the Salt Creek dam would rely on Cibecue Creek. A gravity system would convey water to the damsite. Derivations of streamflows at the diversion point on Cibecue Creek are presented in Appendix Z.

Minimum flows in Cibecue Creek would be accomplished by providing a low level outlet works with the proposed dam. Since minimum flows are limited to 4 cfs, a relatively small outlet would be provided. A large uncontrolled principal spillway would be built at the dam to address the 25-year event. Flow in excess of the 25-year event would be passed by the emergency spillway.

Estimated sediment yields produced by the watershed that would be trapped behind the dam were based on 0.20 acre-feet per square mile per year. With a watershed area of 36.7 square miles, annual sediment accumulation would be estimated at 7.34 acre-feet per year. Over 100 years, accumulated sediment in the dead storage zone allocated for sediment storage would be approximately 734 acre-feet.

Dead storage of approximately 1,400 acre-feet would provide for sediment accumulation below elevation 5,110 feet. The normal water surface elevation in the reservoir at full pool would be at elevation 5,220 with a total storage capacity of 14,436 acre-feet. Conservation storage contents would be 13,000 acre-feet. The dam would be built to elevation 5,240 feet.

The reservoir behind Salt Creek dam would be approximately 2.2 miles long with a maximum width of lake of 2,800 feet. When the reservoir level is drawn down to elevation 5,110, the upstream end of the reservoir would terminate 0.8 miles from the dam, with a maximum width of approximately 600 feet. The surface area of the reservoir at full pool would be 288 acres. The reservoir area at minimum pool would be 40 acres.

5.3.3 Dam Safety Design Standards

Based upon the reservoir storage capacity of 14,436 acre-feet at normal pool and a reservoir crest height of 170 feet, National Dam Safety Procedures would consider Salt Creek Dam would be categorized as a “Large”, high hazard dam requiring the minimum inflow design flood (IDF) equal to or greater than 0.5 Probable Maximum Flood (PMF) to a maximum of the PMF with a minimum factor of safety for stability of 1.5.

Preliminary analysis of the PMP and resultant PMF for the Salt Creek watershed indicate that the IDF of 1.0 PMF would be approximately 50,000 cfs. Further analysis would be necessary to prepare a final design level estimate of the PMP and PMF for the project site. Initial design concepts and construction costs were based on this IDF.

It was assumed that the maximum level at the PMF would rise no greater than 15 feet above the normal pool elevation of 5,220 feet leaving an additional 5 feet of freeboard. The preliminary emergency spillway width was estimated at 300 feet.

5.3.4 Assumptions for Dam and Spillway Construction

The following information was the basis for the cost estimates prepared for the dam:

- The silty sandy gravels with cobbles upstream of the dam site appear to be suitable for aggregate for a low height wide crest length RCC dam.

- For construction of the dam it appears that this material could be easily excavated by scraper and then screened, re-blended, and used almost as a pit run material to make RCC suitable for this location.

- The foundation would require special attention, especially with regard to potential interbred rock layers and potential voids that could become seepage paths.

- For low flows, a relatively small vertical outlet near the upstream face could be used, discharging to an apron at the downstream face.

- Construction of this dam would be done with conventional earth moving equipment or a conveyor system. The use of a conventional concrete slab at the upstream face would provide water-tightness and resistance to debris flows. The slab (actually a wall) could be placed prior to (or with) the RCC and act as an upstream form, or it could be placed after the RCC. It would be reinforced concrete with joints and waterstops, and be connected to a grout curtain. Both consolidation grouting and curtain grouting would be necessary for this foundation.

- Because of high unit flows and freeze-thaw conditions, the spillway face would be conventional concrete. A stepped spillway would be easiest and most economical to construct. It would also act as an energy dissipater (with a downstream apron or small stilling basin).

- Coring and seismic refraction and other subsurface exploration will be needed prior to design. Test pits should be opened in the proposed aggregate material and samples should be taken at different depths and locations for simple bulk gradation, variability evaluation, fines content, absorption, and specific gravity tests. The samples should be taken by backhoe and placed in sacks, bins , or a series of small trucks loads. Excess material should be saved for later use in RCC mix design studies.

A detailed construction cost estimate is provided in Appendix Y.

5.4 Bonito Creek Dam

The proposed Bonito Creek Dam would provide the following potential benefits:

1) Future supply for domestic purposes beyond the end of the 21st century

2) Irrigation water supply for the Bonito Prairie irrigation project

3) Irrigation water supply for the Canyon Day irrigation project as the growing population on the White River system requires reduction of irrigation to meet domestic needs

4) Recreation

5) Hydropower

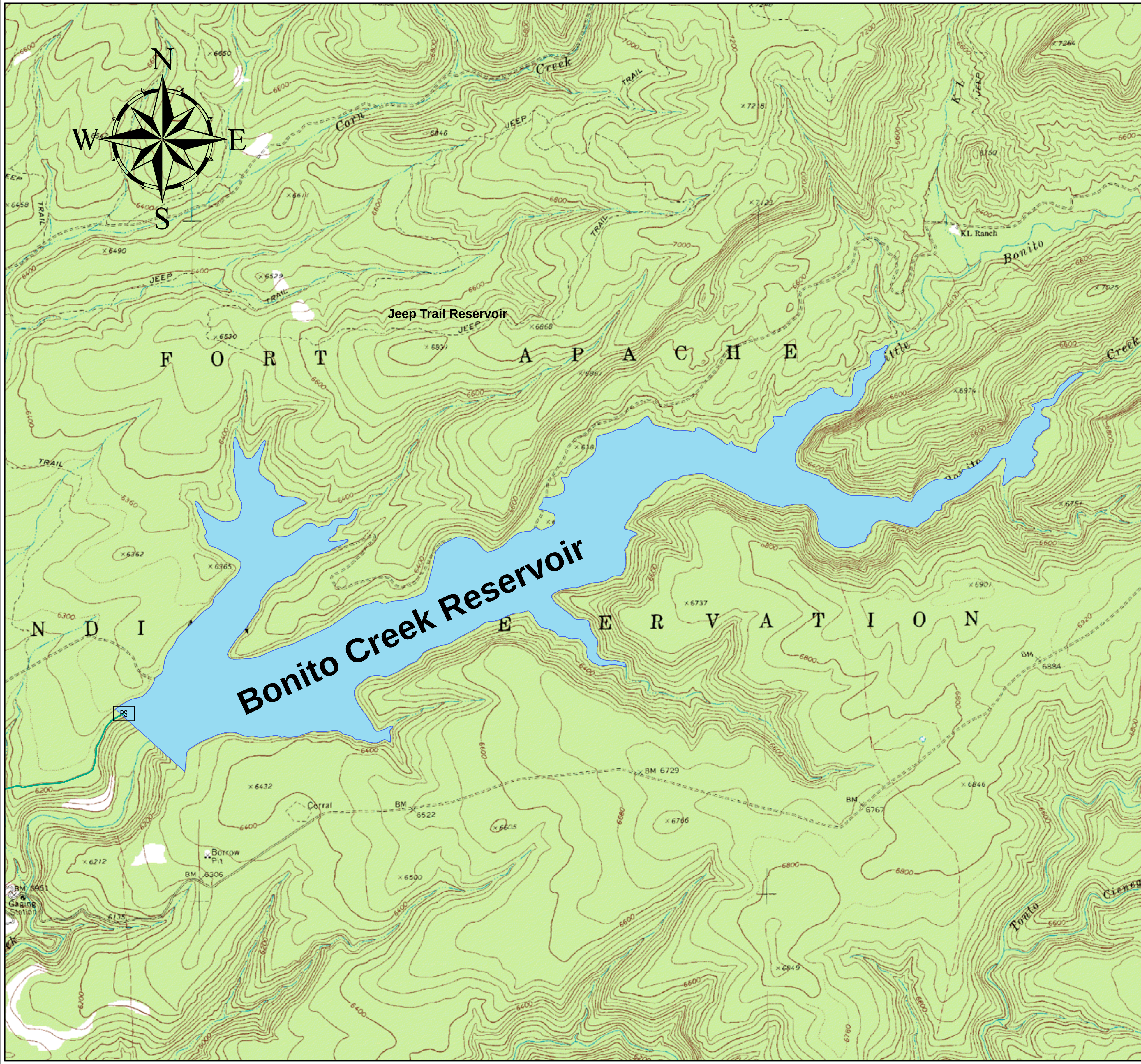
The Bonito Creek Dam is located approximately 3 miles upstream of the confluence of Bonito Creek and Tonto Creek approximately 20 miles southeast of the community of Whiteriver. The location of Bonito Creek Dam is shown on Figure 5-4.

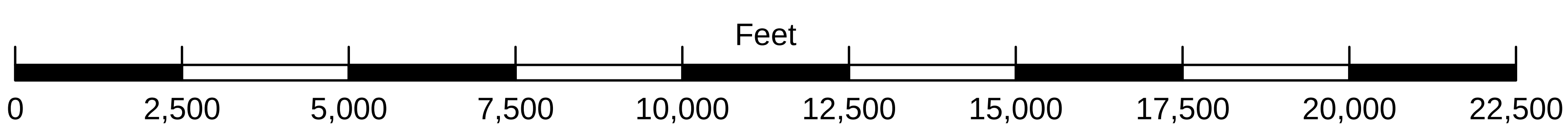
The proposed reservoir, with a normal pool elevation of 6,280 feet above mean sea level (msl), has a surface area of 1,012 acres and a total storage capacity of approximately 115,350 acre-feet. The ground elevation at the damsite is 5,965 feet, and the top of the dam would be at elevation 6,300 feet, resulting in a total dam height of 335 feet.

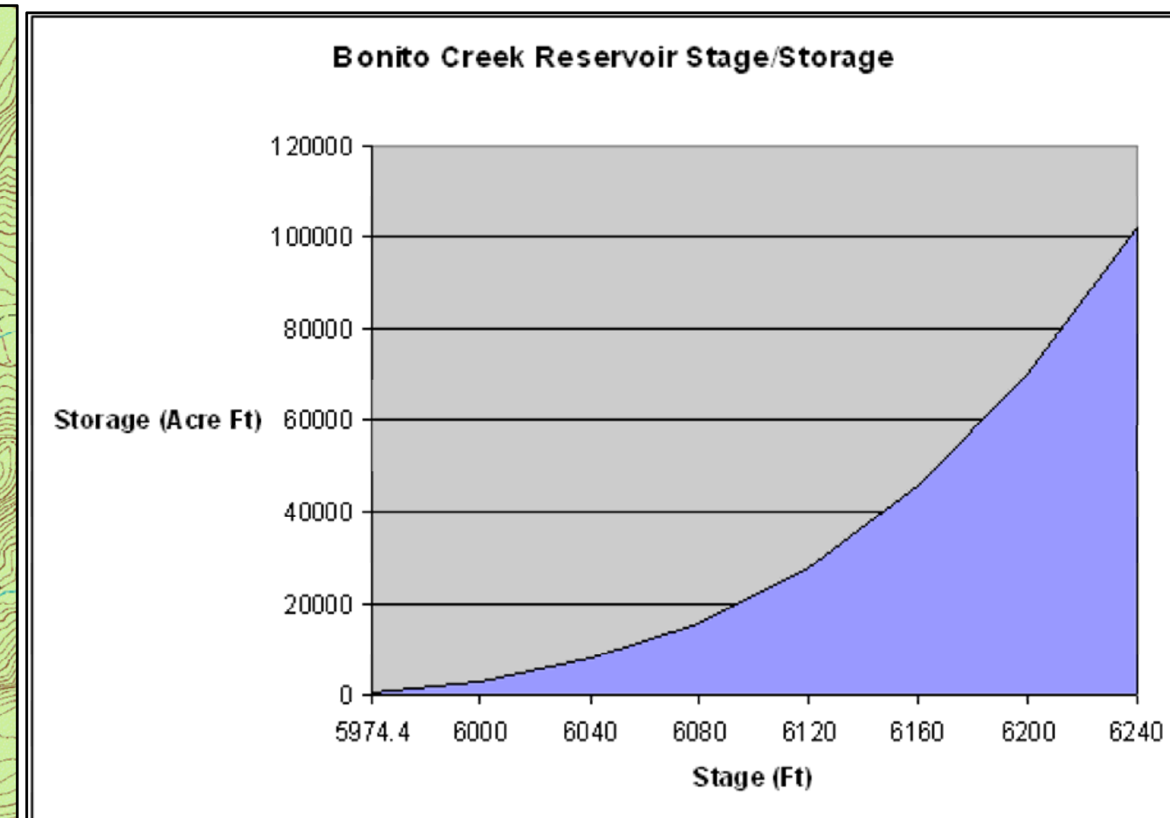
The concrete gravity dam concept was deemed to be the most suitable alternative for the project site.

5.4.1 Available Geologic and Soils Information

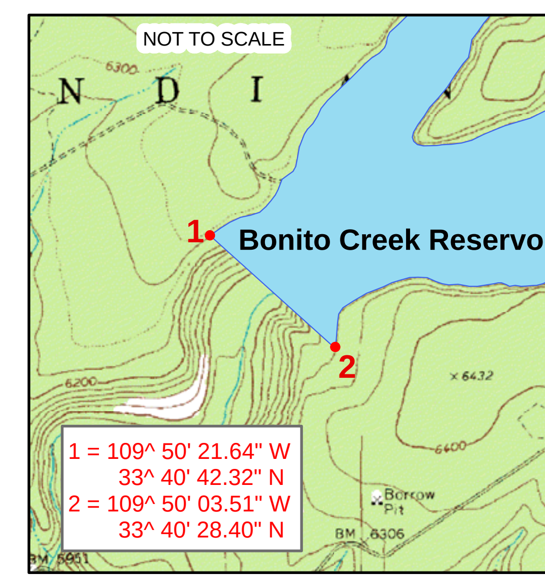
Collection of geotechnical information at the Bear Canyon Dam is needed for future investigations. The damsite is dominated by Quarternary volcanic basaltic flows. The site reconnaissance confirmed that the abutment area of the proposed damsite is suitable for RCC dam construction.







- Christmas Trees
- Poplar Trees
- Pump Station
- Diversion
- Canal
- Pipeline
- Reservoir



MINER FLAT DAM
PROJECT EXTENSION REPORT

BONITO CREEK DAM

FIGURE

NUMBER
5-4

5.4.2 Hydrological Conditions and Assumptions

A USGS stream gaging station located approximately ½ mile downstream of the proposed damsite provided daily streamflows data from October 1957 through March 1981. In addition, the WMAT has been operating the gaging station since April 1997 and has collected data continuously since that date. Based upon water availability studies an average 47,500-acre-feet of water would be available annually for storage in the Bonito Creek Reservoir.

Minimum flows of 10 cfs would be released to Bonito Creek through a low level outlet works with the proposed dam. Minimum flows would be passed through the outlet works and potential hydropower facility.

Estimated sediment yields for the watershed were based on 0.20 acre-feet per square miles per year. With a watershed area of 114 square miles, yearly sediment accumulation would be estimated at 22.8 acre-feet per year. Over 100 years, accumulated sediment in the dead storage zone allocated for sediment storage would be approximately 2,280 acre-feet.

Approximately 6,000 acre-feet of dead storage would be necessary to capture sediment. The top of the dead storage or sediment pool would be at elevation 6,045 feet. The normal water surface elevation in the reservoir at full pool would be at elevation 6,300 feet with a resultant storage capacity of approximately 115,350 acre-feet. Conservation storage contents for the reservoir would be approximately 109,000 acre-feet. The crest length at the top of the dam would be 2,300 feet.

The reservoir behind Bonito Creek dam would be approximately 4.25 miles long with a maximum width of 2,800 feet. When the reservoir level is drawn down to elevation 6,045 feet, the upstream end of the reservoir would terminate 1.25 miles from the dam, with a maximum width of approximately 1,000 feet. The surface area of the reservoir at full pool would be 1,012 acres. The reservoir area at minimum pool would be 85 acres.

5.4.3 Dam Safety Design Standards

Based upon the reservoir storage capacity of 115,350 acre-feet at normal pool and a dam height of 335 feet, the National Dam Safety Standards would classify the dam as "Large." It was assumed that the Bonito Creek Dam would be classified as a Significant or High Hazard Dam, but the primary consideration in failure would be economic loss, not loss of life. There are no downstream housing nor economic development concerns.

Preliminary analysis of the PMP and resultant PMF for the Bonito Creek watershed indicate that the IDF of 1.0 PMF would be approximately 80,000 cfs.

5.4.4 Assumptions for Dam and Spillway Construction

Assumptions for design and construction that affect the cost analysis for the proposed Bonito Creek Dam include:

- Because the RCC dam would be constructed rapidly to a significant height over a single construction season, the cofferdams and stream diversion would be designed to withstand a two- to five-year flood.

- The mix design program would be started at least a year before final design. The data is needed to establish material properties to be used in the detailed design, and to evaluate the most economical mix. Mix optimization is a cost effective mechanism that can impact ultimate construction cost by several million dollars.

- It may be possible to construct the dam without extensive forced cooling. The larger size of the project and probable requirement for higher strength in sections of the dam with higher cement proportions, dictate a detailed and comprehensive thermal study as part of final design.

- A conventional concrete outlet structure and intake constructed on the left abutment is proposed.

- Given the size of dam, schedule, and topography, as well as the required material quality, the RCC should be delivered to the dam by an "all conveyor" system. This would eliminate the need for an otherwise large number of trucks and complex haul roads. It also reduces the number of skilled workers that would be required for the project, the impact of construction crews on the community, and the impact on the environment.

- It is reasonable to assume that approximately one year would be required for mobilization, establishing on-site construction facilities, most of the excavation, the cofferdams, and opening the quarry. All major excavation, including the abutments, would be completed prior to starting the RCC, and at least 40% of the aggregate would be in stockpile, with most acquisition made during the cold winter months.

- During this first year it may be possible to construct the diversion and intake works, as well as most of the "plinth" which is discussed below, but this would require part of the second year. A more detailed assessment of the schedule would be developed during final design.

- Placement of the RCC should ideally start in the early spring or late winter. With a proper "all conveyor" delivery system, and with nothing else to slow production, it is theoretically feasible to complete RCC placement in 12 to 18 months, but it is more realistic to initially anticipate about 24 months because the beginning and ending months would have slower productivity due to the confined work area. Roughly another 6 months would be needed to finish conventional concrete at the spillway, and miscellaneous work. An additional 6 months or more is typically required to finalize construction and demobilize.

- A conventional concrete stair-stepped spillway would be used. This would require careful hydraulic design, and potentially a model study.

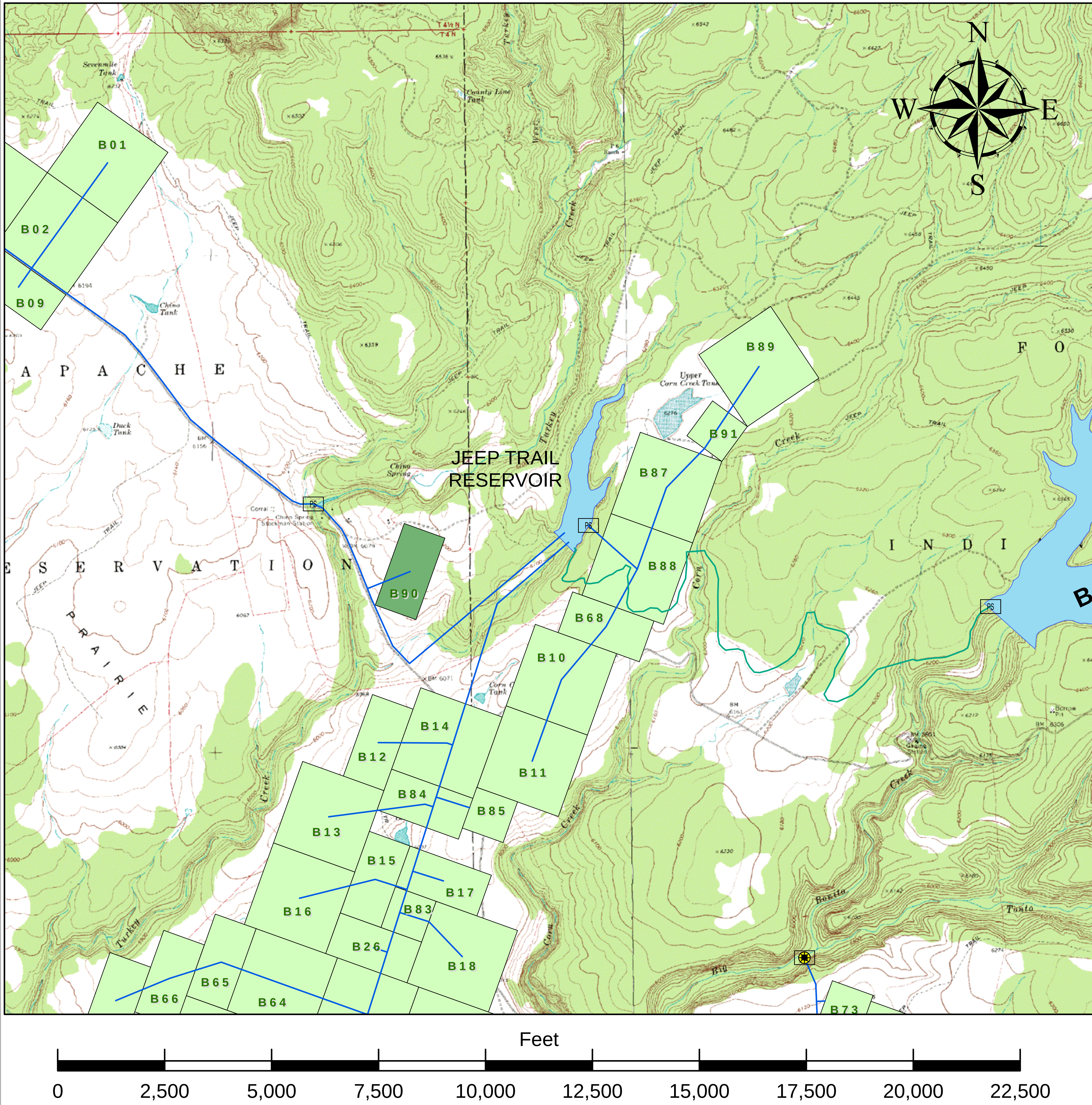
- The upstream face of the dam would contain an impervious PVC membrane. It assures water-tightness assuming some lift joints with less than ideal construction quality, and it assures water-tightness given the development of a thermal crack across the dam. The membrane system would start off the foundation on a conventional concrete "plinth" that connects it to the foundation and grout curtain.

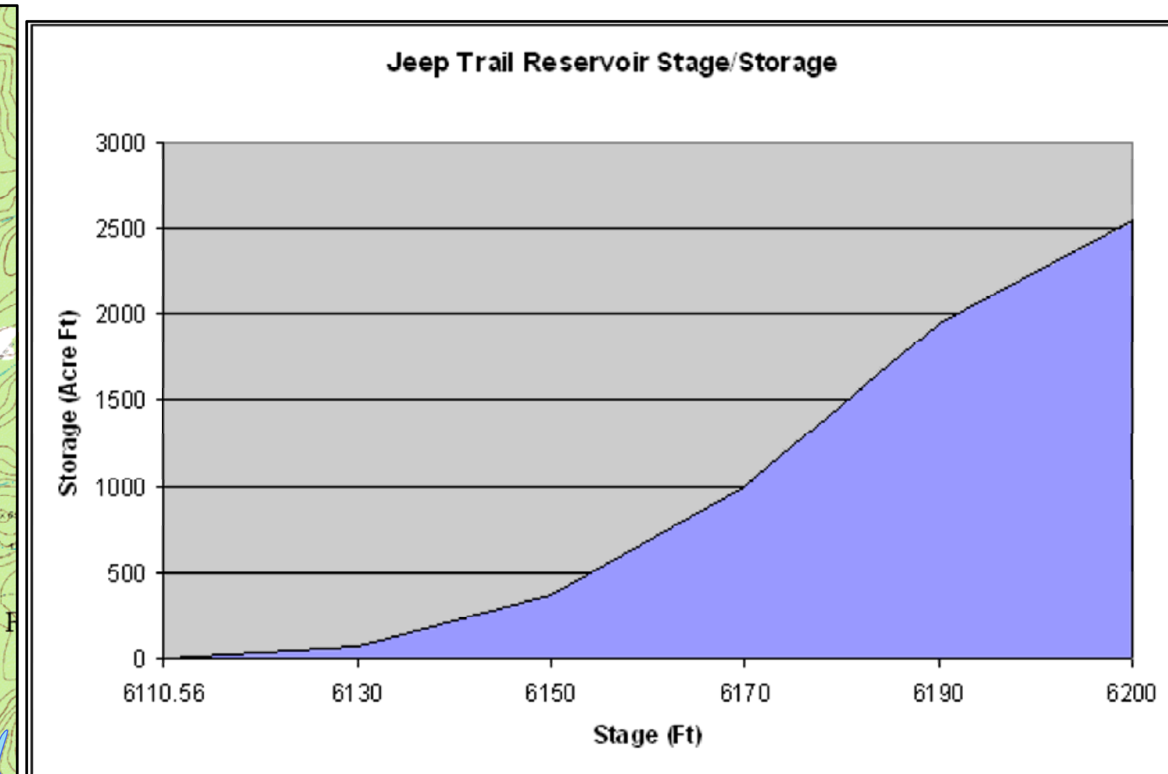
Other assumptions and design philosophies used for preparation of the Construction Cost Estimate for the Bonito Creek Dam are discussed in Chapter 6. A detailed construction cost estimate is provided in Appendix Y.

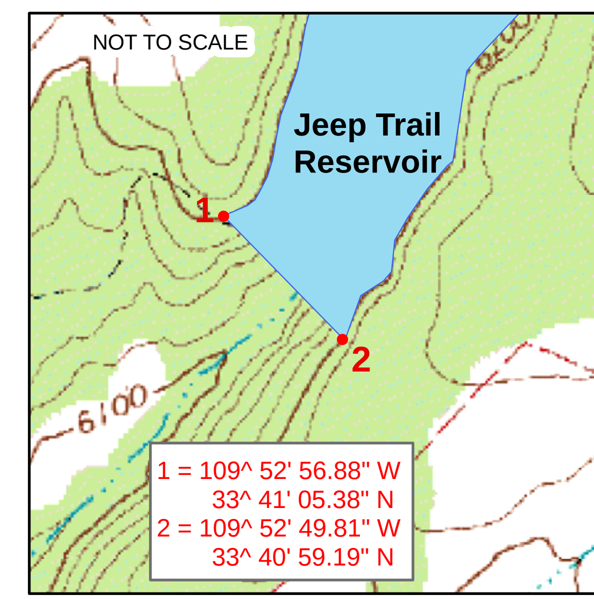
5.5 Jeep Trail Regulating Reservoir

The proposed Jeep Trail Regulating Reservoir serves as the main regulating reservoir for the Bonito Prairie Irrigation Unit. Water would be transferred from the Bonito Creek Reservoir to the Jeep Trail Regulating Reservoir during the irrigation season. The Jeep Trail Regulating Reservoir is located approximately 2.5 miles east of the Bonito Creek Dam. The location of the Jeep Trail Regulating Reservoir is shown in Figure 5-5.

The watershed area above the damsite is 4.0 square miles. The reservoir would provide regulating storage for the West and Middle Subunits of the Bonito Prairie Irrigation Unit. The proposed reservoir, with a normal pool elevation of 6,200 feet above mean sea level (msl), has a water surface area of 67 acres and an operational storage capacity of approximately 2,500 acre-feet. The ground elevation in the vicinity of the dam is 6,110 feet. The dam would be constructed to elevation 6,220 feet making the dam 110 feet high.







MINER FLAT DAM
PROJECT EXTENSION REPORT

JEEP TRAIL REGULATING RESERVOIR

FIGURE
NUMBER
5-5

6. IRRIGATION AND MULTIPURPOSE STORAGE COSTS

6.1 Irrigable Land Base

In the fall of 1979, the White Mountain Apache Tribe initiated an investigation to determine the amount of land on the Fort Apache Indian Reservation that offered physical, chemical, and topographic characteristics suitable for irrigated farming. The 1979 land classification identified some 49,859 acres of land suitable for irrigated farming on the reservation. This report addresses three of the areas of irrigable lands, consisting of 14,178.2 acres located at Canyon Day (including parts of Amos Wash), Cibecue, and Bonito Prairie on the Fort Apache Indian Reservation.

6.1.1. Previous Work

Previous work available to the 1979 investigators was limited to an early 1950's Department of the Interior inventory of historically irrigated lands compiled for California v. Arizona and the 1965 Bureau of Indian Affairs report, "**White River extension of the Fort Apache Indian Project**", as revised February 1966. The latter report addressed 3,200 acres of potentially irrigable land, all in the vicinity of the large alluvial fan at the mouth of Bear Canyon, referred to now as the Canyon Day area. Soil series descriptions were available from the Soil Conservation Service (SCS) based on work done from 1963-1967 with soil names and descriptions approved in 1968; however, the official SCS soil survey was not issued until May 1981, after the Tribe's investigation of irrigable lands was completed. The unpublished SCS soil series descriptions were used in the Tribe's investigations, but the SCS soil survey delineations were not available.

6.1.2. Level of Detail

The 1979 investigation was conducted at a reconnaissance level which, under Bureau of Reclamation (BOR) criteria at the time, required the characterization of each soil group in the area and a minimum of one borehole or test pit to five feet depth per square mile for visual inspection of the soil profile. Soil group characterization was based on the unpublished SCS soil series. The same BOR criteria required five visual inspections with shovel or probe, four boreholes to five feet, and one borehole to 10 feet per square mile for semi-detailed investigations.

The work performed in 1979 included 2.1 soil profiles per section (square mile) at Canyon Day, no soil profiles in Amos Wash, 3.5 soil profiles per section at Cibecue (including lands outside the proposed irrigation project), 1.7 soil profiles per section on the Bonito Prairie, and land area delineations at a scale of 1:24,000. Soil logs are shown in Appendix X. Accordingly, the 1:24,000 mapping scale satisfied criteria for semi-detailed work at that time and the number of auger holes provided a level of detail between a reconnaissance and semi-detailed level of investigation.

Land classification delineations were made in the field, mostly on 7.5-minute U.S. Geological Survey (USGS) topographic quadrangle maps. Ortho-photos were available for parts of the Bonito Prairie, but were of such monotonous tone and image quality that they were not suitable for delineating land classification units. Accordingly, the delineations on the Bonito Prairie were made on 7.5-minute topographic quadrangles, similar to the rest of the land classification.

Table 6-1 below is a summary of the 1979 Land Classification acres delineated as suited for irrigation management, the number of auger holes (and test pits), and the auger holes per section, for each of the three areas comprising the total 14,178.2 acres of irrigable lands identified at Canyon Day, Amos Wash, Cibecue, and Bonito Prairie. The 14,178.2 acres are limited to the lands under consideration for irrigation project development in this report, and do not include all of the lands identified as irrigable in 1979 for each of the areas. The numbers of auger holes and soil pits as well as soil profiles per section are adjusted accordingly to only the lands under consideration for irrigation development in this report.

TABLE 6-1

SUMMARY OF IRRIGABLE ACRES FROM 1979 LAND CLASSIFICATION

Area	**Irrigable Acres**	**Number of Soil Profiles (hand auger holes and soil pits)**	**Soil Profiles per Section**
Canyon Day	5,875.4	19	2.1
Amos Wash	1,072.8	0	0
Bonito Prairie	6,074.0	16	1.7
Cibecue	1,156.0	8	4.4
Totals:	**14,178.2**	**43**	**1.9**

6.1.3. <u>Comparison to SCS Maps</u>

Following completion of the 1979 Land Classification by the White Mountain Apache Tribe, the official SCS cooperative soil survey report for the Fort Apache Indian Reservation was issued in 1981. In the years since 1981, the SCS soil map delineations have been digitized and provided to the public as GIS maps. Table 6-2 below shows the official SCS soil map acreages from the GIS maps for each land area classified as irrigable by the White Mountain Apache Tribe's 1979 Land Classification. The SCS soil acreages from the GIS maps are compared to the irrigable acres identified by the Tribe's 1979 study in each of the same three areas.

The GIS acreages from the SCS soil maps soil are larger than in the acreages from the Tribe's 1979 Land Classification delineations in every case. The SCS acreages indicate potentially more irrigable lands than the 1979 Land Classification investigations with the largest difference at Canyon Day. The difference of nearly 1,200 acres between the 1979 Land Classification and the SCS delineations at Canyon Day is due in part to a relatively large exclusion of lands near the Canyon Day community in the 1979 work for future expansion of the community and due to the SCS mapping units on the west side of Canyon Day extending further up the hillsides than the 1979 Land Classification delineations. The large excluded area in the 1979 Land Classification makes it difficult to directly compare that work to the SCS maps in the Canyon Day area, other than to conclude the Tribe's delineations of irrigable lands was conservative. In the Cibecue area, there is only a two percent difference between the SCS maps and the 1979 Land Classification. The 1979 Land Classification and subsequent work on Bonito Prairie found large differences between areas delineated as land suitable for irrigation and the SCS soils maps; accordingly, there is no attempt to compare the two sources of acreages for Bonito Prairie.

TABLE 6-2

COMPARISON OF 1979 LAND CLASSIFICATION AND SCS ACREAGES.

Area	**1979 Irrigable Land (acres)**	**SCS Soil Units Corresponding to 1979 Irrigable Lands (acres)**
Canyon Day	5,875.4	7,073.33
Amos Wash	2,624.7	2,956.80
Bonito Prairie	Not compared	Not compared
Cibecue	1,156.0	1,170.77
Totals:	**9,656.1**	**11,200.90**

6.1.4. Irrigation Class Definitions

Table 6-3 shows the definitions of irrigable land classes 1, 2, 3, and sprinkler class used for the 1979 Land Classification. The irrigation class definitions pertain to the suitability of the soil for irrigated agriculture, without consideration of economic factors or available water supply. As explained in the footnote, they do not assume unusual irrigation management practices, but they do assume a management level similar to practices at the time of the survey. The 1979 Land Classification did not contemplate application of modern drip irrigation methods to large areas, as is common in contemporary irrigated agriculture. Accordingly, a sprinkler classification was developed for lands with slowly permeable soils, shallow bedrock, or a large percentage of surface rock cover.

TABLE 6-3

IRRIGATION CLASS DEFINITIONS FOR 1979 LAND CLASSIFICATION.

Irrigation Class	Description
Class 1	Suitable for sustained irrigation management. These soils are suitable for growing a wide range of cultivated crops within climatic restrictions, they respond well to fertilization, and they may be cropped intensively under ordinary irrigation management practices. Irrigation return cycles are on a relatively wide-spaced frequency.
Class 2	Suitable for sustained irrigation management. These soils are suitable for growing the same crops as Class 1 soils except where limited by effective soil depth. They respond well to fertilization, and they may be cropped intensively under ordinary irrigation practices. Soils in this class may require more frequent irrigation for shorter application periods than Class 1 soils; however, no limitations or requirements are imposed on types of sprinkler irrigation equipment, irrigation practices, or leaching requirement applications.
Class 3	Suitable for sustained irrigation management. These soils are suitable for growing the same crops as Class 1 and Class 2 soils except where limited by effective soil depth. They respond well to fertilization, and they may be cropped intensively under ordinary irrigation practices. Soils in this class require multiple leaching applications in both spring and fall prior to and following cropping. Artificial drainage may be required in limited areas.
Sprinkler Class	Sprinkler Class soils are restricted to sprinkler irrigation management due to one or more of the following limiting factors: 1. steep slopes 2. high erosion hazard 3. extremely slow permeability 4. thin soil development over slowly permeable substrata 5. very low available moisture holding capacity 6. high alkalinity or salinity hazard

[1/] These classifications assume a moderately high level of soil, water, and cultural management that is practical and within the conventional practices, procedures, and abilities of a majority of contemporary farmers and ranchers operating on privately owned irrigable lands. The fact that soil is classified as non-irrigable under the criteria used to arrive at these classifications does not mean it cannot be irrigated but simply that it has limitations requiring intensive management practices not conventionally used by the majority of agricultural irrigations operators.

6.1.5. Irrigability Criteria

Table 6-44 shows the irrigability criteria used for the 1979 Land Classification. The criteria used in 1979 had been reviewed and approved in the mid-1970s by the Bureau of Indian Affairs with input from the Bureau of Reclamation and some State agencies dealing with irrigation projects and land classification. They are distinctly different from BOR criteria of that time in that economic constraints are not included in the criteria.

6.1.6. Canyon Day Classifications

The 1979 irrigability criteria shown in Table 6-4 were applied to the lands in the Canyon Day area based on hand auger holes to examine the soil profile and ½-mile traverses to inspect the soils and make delineations. Figure 6-1 shows the locations of the hand auger holes and soil logs. Delineations and associated classifications were based on the 1968 soil standardized soil profile descriptions that are now formalized in the SCS cooperative Soil Survey report issued in 1981.

Figure 6-1 is a two-part figure. The left half of Figure 6-1 shows the collective area of SCS soil map units that correspond to the area determined to be suitable for irrigated farming by the 1979 Land Classification with a conceptual irrigation project design superimposed over the irrigable lands. The right half of the figure shows the individual SCS soil mapping units that comprise the irrigable area and include the lands deemed suitable for irrigation in the 1979 Land Classification.

The 1979 Land Classification identified 5,875.4 acres of lands suitable for irrigated farming in the Canyon Day area. This was a conservative delineation of the lands suitable for irrigated farming. The SCS delineation of the same soil types classified as irrigable in the 1979 investigations, now compiled in a GIS database, includes 7,073 acres. The increase in acres from the Tribe's 1979 classification is due to: (1) inclusion of steeper slopes in one of the SCS map units than allowed in the 1979 classification, (2) inclusion of arroyos not included in the 1979 classification, (3) extension of the SCS mapping units up narrow canyons around the periphery of Canyon Day to include land not included in the 1979 classification, and (4) differences in the boundary along lands excluded from the 1979 classification for expansion of housing and the schools at the Canyon Day community.

Descriptions of the typical soil profiles for those units are provided below.

6.1.6.1. Cibecue Series

The SCS soil delineation marked 18D on Figure 6-1 is Cibecue gravelly loam on 8 to 30 percent slopes. The 1979 Land Classification includes quite a bit of this soil unit in the Canyon Day area, but only where the slopes are no more than 8 percent. The fact that this unit includes areas with up to 30 percent slope on the SCS maps explains part of the reason why the SCS soil map units include more acreage than the 1979 Land Classification.

TABLE 6-4:

1979 LAND CLASSIFICATION CRITERIA FOR IRRIGABILITY.

CHARACTERISTICS	CLASS 1	CLASS 2	CLASS 3	SPRINKLER CLASS
SOIL PROPERTIES: Effective Soil Depth[1] Nonrestrictive Substrata[2] Bounded as follows: a. Unconfined Drainage b. Nonsaline Barrier c. Saline Barrier Restrictive Substrata[3] Bounded as follows: a. Unconfined Drainage b. Nonsaline Barrier c. Saline Barrier	 40 inches minimum 96 inches minimum 120 inches minimum 40 inches minimum	 20 to 40 inches 72 to 96 inches 96 to 120 inches 20 to 40 inches	 10 inches minimum 60 to 72 inches 96 inches minimum 10 inches minimum 240 inches minimum 240 inches minimum	 10 inches minimum 60 inches minimum 96 inches minimum 10 inches minimum 60 inches minimum 120 inches minimum
Soil Texture Range in Root Zone	Loamy very fine sand to friable clay loam.	Loamy sand to permeable clay	Loamy sand to slowly permeable clay. Very fine to medium sands with sufficient AMHC are included.	Same as Class 3
Permeability of Undisturbed soil (inches/hour)[4]	Moderately slow to moderate (0.20 - 2.00 inches/hour)	Slow to moderately rapid (0.06 - 6.00 inches/hour)	Very slow to rapid (less than 0.06 to 6.5 inches/hour)	Very slow to rapid (less than 0.06 to 8.0 inches/hour)

[1] Effective soil depth includes both the solum and self-draining or artificially drained substrata. Criteria shown here are for average anticipated soil permeability, internal drainage, and saline/alkaline conditions.

[2] Nonrestrictive substrata are moderately slow to rapid self-draining materials including alluvial sands, sand and gravel, and other self-draining alluvial and colluvial parent materials.

[3] Restrictive substrata are very slow to moderately permeable materials including shallow geologic substrata such as sandstone and siltstone as well as very slowly self-draining surficial deposits such as glacial till and fine-grained alluvial and colluvial silty and clayey sediments.

[4] Permeability may exceed values shown if sufficient available moisture holding capacity (AMHC) is present in upper 48 inches of soil.

Available Moisture Holding Capacity (AMHC) (inches per 48 inches soil depth)	8 inches minimum	6 inches minimum	4 inches minimum	2 inches minimum
Salinity expressed as electrical conductivity (E.C.) in millimhos/cm	4 millimhos/cm maximum under average drainage conditions. 8 millimhos/cm maximum in top 48 inches where good leaching and drainage conditions exist.	4 to 8 millimhos/cm in an individual horizon. May exceed 8 millimhos/cm under good leaching and drainage conditions. Most horizons will have less than 8 millimhos/cm.	8 millimhos/cm maximum in top 24 inches. Maximum of 15 millimhos/cm tolerable at depths below 24 inches **only if adequate leaching and drainage conditions exist.**	Same as Class 3
CHARACTERISTICS	**CLASS 1**	**CLASS 2**	**CLASS 3**	**SPRINKLER CLASS**
Alkalinity[5]	Soil reaction neutral (pH 6.6 - 7.3) and organic content low	Soil reaction neutral to moderately alkaline (pH 6.6 - 8.4); calcareous horizons present, and organic content low.	Soil reaction mildly to mod-erately alkaline (pH 7.4-8.4); no calcareous horizon present, and organic content low. If soil reaction is strongly alkaline or greater (pH 8.5-to more than 9.0), a severe sodic condition probably exists regardless of calcareous horizons or organic matter content.	Same as Class 3

[5] These criteria are not independently sufficient to determine the alkalinity hazard of a soil; however, they are suggested here as a general interpretative tool in evaluating the SCS data which does not contain exchangeable sodium percentages or sodium adsorption ratio data. Criteria for sodium hazard presented here assume reasonably good leaching and drainage conditions (with or without artificial drainage).

Permissible Coarse Fragments[6] Gravel (1.0 - 3.0 inches) Cobble (3.0 - 10.0 inches)	No problem in tillage 15% maximum 5% maximum	Moderate problem in tillage 15 to 55% 15% maximum[7]	Severe problem in tillage 55 to 70% 15 to 35%	Same as Class 3
Rockiness (Proportion of nonsaline bedrock outcrops and shallow nonsaline bedrock)[8]	No bedrock exposures or too few to interfere with tillage. Less than 2% bedrock exposed.	Bedrock exposures interfere with tillage but cultivation is practicable. Rock expo-sures are 100-300 ft. apart and cover 2-10% of surface.	Same as Class 2	Same as Class 2
TOPOGRAPHY Slope[9]	0-4%	4-8%	8-15%[10]	0-15%

[6] Criterion is intended to assess factors limiting tillage. In practice, available moisture holding capacity may become the actual limiting factor before tillage is affected as coarse fragments percent increases.

[7] May be higher % in subsoil for certain shallow rooted crops if surface soil is favorable. Limitations may be reduced somewhat in surface soil by use of modern rock-picking equipment.

[8] No more than 2% saline bedrock outcrops is tolerable in any soil class. The presence of 2% or less saline bedrock outcrops is indicative of inadequate soil depth over a saline substrata or barrier.

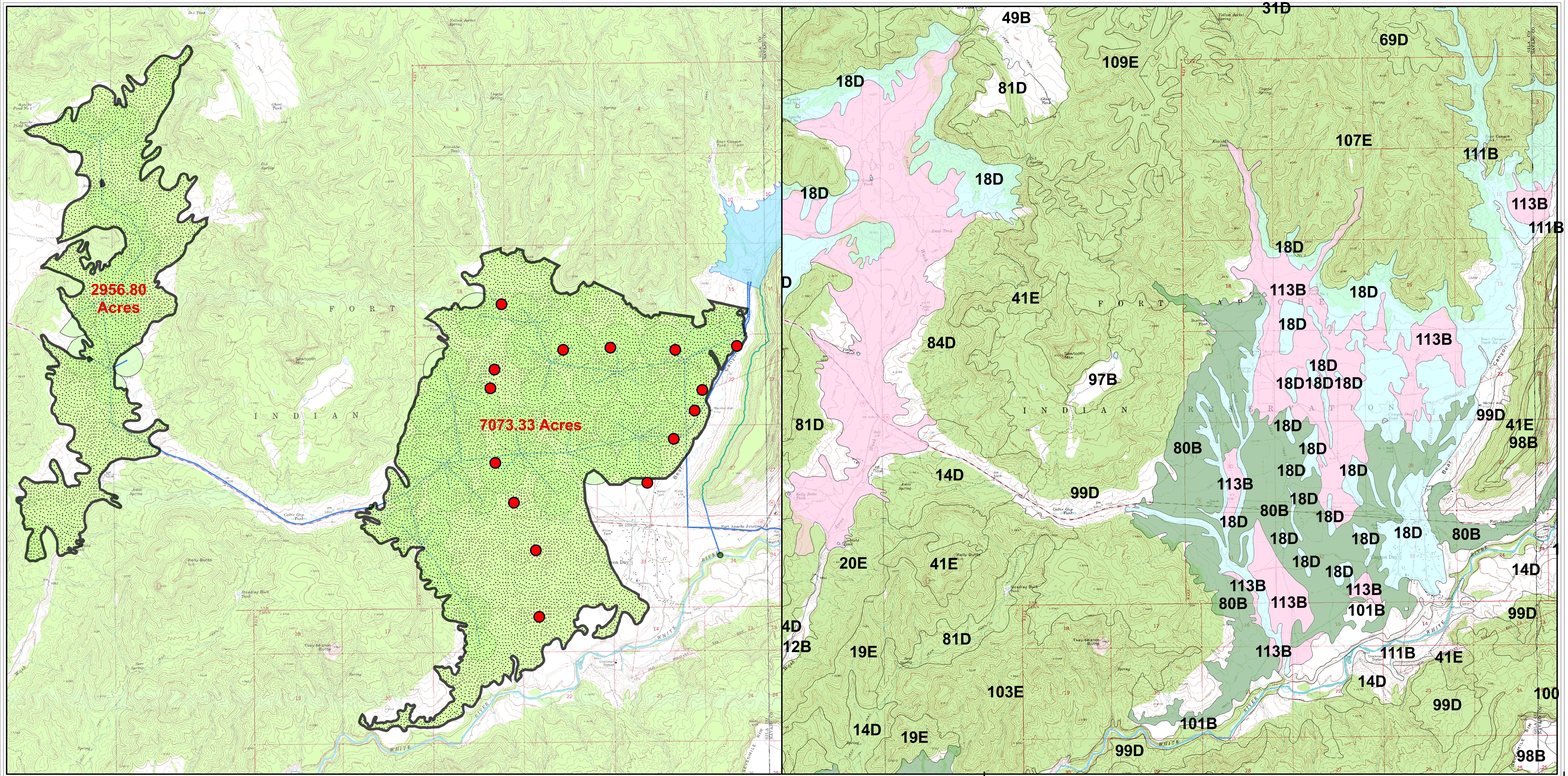
[9] Heavy textured soils in the slope range of 2-4% may be downgraded to Class 2 where an erosion hazard exists under flood irrigation management.

[10] Sprinkler irrigation on slopes greater than 8%.

CHARACTERISTICS	CLASS 1	CLASS 2	CLASS 3	SPRINKLER CLASS
Stone Removal[11]	No stones or too few to inter-fere with tillage. Stones cover less than 0.01% of the area.	Sufficient stones to inter-fere with tillage but not to make cultivation imprac-ticable. Stones cover 0.01 - 0.1% of surface and require removal of 0.15 to 1.5 cubic yards per acre for up-grading Class.	Too stony for practical sustained cultivation. Land can be worked for hay or improved pasture if other soil conditions are favorable. Stones cover 0.1 0 3.0% of surface and require removal of 1.5-5.0 cubic yards per acre for upgrading Class.	Same as Class 3

[11] These criteria are not independently sufficient to determine the alkalinity hazard of a soil; however, they are suggested here as a general interpretative tool in evaluating the SCS data which does not contain exchangeable sodium percentages or sodium adsorption ratio data. Criteria for sodium hazard presented here assume reasonably good leaching and drainage conditions (with or without artificial drainage).

DRAINAGE Water Table (during growing season with or without drainage)	Easily maintained below 60 inches.	Can be maintained between 40 and 60 inches during most of the growing season (may require artificial drains).	Can be maintained below 40 inches during most of the growing season (may require artificial drains).	Same as Class 3
Surface drainage	Good	Good	Restricted	Restricted
Overflow	No overflow	Free of overflow in growing season	Overflow hazard to crops in 2 or 3 years out of 10	Same as Class 3

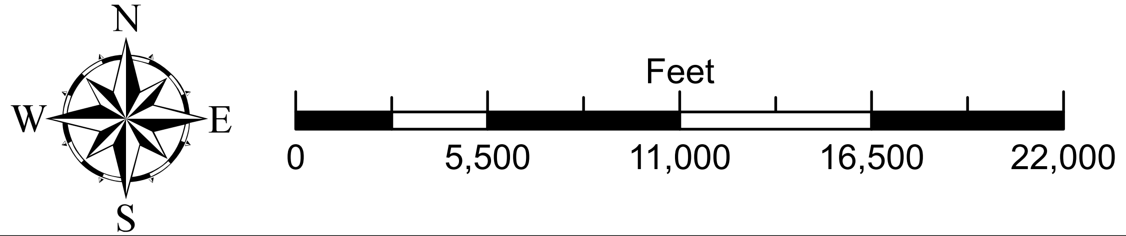


Legend

- Canal Structures
- Diversion
- Pump Stations
- Canals
- Pipeline
- Pivots & Fields
- Bear Canyon Reservoir
- Irrigable Soil

Soil Types

- 113B
- 18D
- 47D
- 80B
- All Other
- Auger Hole



MINER FLAT DAM
PROJECT EXTENSION REPORT

CANYON DAY IRRIGATION UNIT SOILS MAP

FIGURE

NUMBER

6-1

The Cibecue soils have formed in gravelly alluvium on old dissected alluvial fans. They are moderately permeable and well drained with a effective rooting depth of 60 inches or more. These types of soils have been managed under irrigation by the White Mountain Apache Tribe since 1980. All representative soil profile descriptions presented below are taken directly from the 1981 published cooperative Soil Survey of the Fort Apache Indian Reservation.

A representative soil profile of Cibecue gravelly loam is as follows:

A11 0 to 2 inches, dark grayish brown (10YR 4/2) gravelly loam, very dark grayish brown (10YR 3/2) when moist; weak fine granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet, many fine roots; many fine interstitial pores; 25 percent pebbles and 5 percent cobbles; strongly effervescent; mildly alkaline; clear smooth boundary.

A12 2 to 9 inches, dark yellowish brown (10YR 4/4) gravelly loam, dark yellowish brown (10YR 3/4) when moist; massive; soft when dry, friable when moist, nonsticky and nonplastic when wet; many fine and very fine roots; common fine interstitial pores; 25 percent pebbles and 5 percent cobbles; violently effervescent; moderately alkaline; gradual wavy boundary.

C1ca 9 to 18 inches, light yellowish brown (10YR 6/4) gravelly loam, yellowish brown (10YR 5/4) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common very fine and a few tabula pores; 20 percent pebbles and 5 percent cobles; violently effervescent; moderately alkaline; gradual wavy boundary.

C2ca 18 to 42 inches, white (10YR 8/2) and yellowish brown 910YR 5/4) gravelly loam, very pale brown (10YR /3) and yellowish brown (10YR 5/4) when moist; massive; hard when dry, firm when moist; slightly sticky and nonplastic when wet; few very fine and coarse roots; few fine tubular pores; 25 percent pebbles and 5 percent cobbles; violently effervescent; moderately alkaline; gradual wavy boundary.

C3ca 42 to 60 inches, pinkish gray (7.5YR 7/2) and yellowish brown (10YR 5/4) gravelly heavy sandy loam, light brown (7.5YR 6/4) and yellowish brown (10YR 5/4) when moist; massive; slightly hard when dry, firm when moist, nonsticky and nonplastic when wet; very few very fine roots; few fine interstitial pores; 40 percent pebbles and 5 percent cobbles, strongly to violently effervescent; moderately alkaline.

The Cibecue gravelly loam, 8-30 percent slopes shown as 18D on Figure 6-1 is similar to the above profile but contains less gravel and is less eroded. The only part of this unit included in the 1979 Land Classification is at the bottom of slopes and on the tops of small knolls that protrude above the general surface of the Canyon Day alluvial fan. This mapping unit includes about 15 percent Showlow gravelly loam and about 5 percent Tours silt loam.

6.1.6.2. Showlow Series

The SCS soil delineation marked 80B on Figure 6-1 is Showlow gravelly clay loam on 0 to 8 percent slopes. The Showlow series are well drained soils formed on dissected alluvial fans.

They are slowly permeable with low to moderate moisture holding capacity and effective rooting depth of 60 inches or more. A representative soil profile is as follows:

A1 0 to 3 inches, dark reddish brown (5YR 3/2) gravelly clay loam, dark reddish brown (5YR 2/2) when moist; moderate fine granular structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine roots; many fine interstitial pores; 20 percent pebbles and cobbles; slightly acid; clear smooth boundary.

B1t 3 to 9 inches, dark reddish gray (5YR 4/2) gravelly light clay, dark reddish brown (5YR 3/2) when moist; weak medium subangular blocky structure; slightly hard when dry, firm when moist, sticky and plastic when wet; common fine and few coarse roots; few fine interstitial and tubular pores; 25 percent pebbles; common thin clay films on peds; slightly acid; gradual wavy boundary.

B21t 9 to 15 inches, reddish brown (5YR 4/4) gravelly clay, dark reddish brown (5YR 3/4) when moist; moderate medium angular blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; common very fine and coarse roots; few fine interstitial and tubular pores; 25 percent pebbles and cobbles; many moderately thick clay films on peds; neutral; gradual wavy boundary.

B22t 15 to 22 inces, reddish brown (5YR 4/4) gravelly clay, dark reddish brown (5YR 3/4) when moist; moderate medium angular blocky structure; hard when dry, very firm when moist, very sticky and very plastic; many very fine and few coarse roots; 25 percent pebbles and cobbles; continuous moderately thick clay films on pen faces; noneffervescent; moderately alkaline; clear wavy boundary.

C1ca 22 to 36 inches, pink (7.5YR 8/4) and brond (7.5YR 5/4) very gravelly heavy loam, pink (7.5YR 7/4) and brown (7.5YR 4/4) when moist; massive; slightly hard when dry, firm when moist; slightly sticky and nonplastic when wet; few very fine and coarse roots; few fine tubular pores; 50 percent pebbles; violently effervescent; moderately alkaline; gradual wavy boundary.

C2ca 36 to 60 inches, pink (7.5YR 7/4) very gravelly loam, light brown (7.5YR 6/4) when moist; massive; slightly hard when dry, firm when moist, slightly sticky and nonplastic when wet; few very fine roots; few fine tubular pores; 50 percent pebbles; strongly effervescent; moderately alkaline.

The Showlow gravelly clay loam, 0 to 8 percent slopes, SCS map unit 80B on Figure 6-1, is similar to the above representative profile, but with a small accumulation of carbonates in the substratum. A few shallow gullies are present on the surface and about 15 to 20 percent of the surface layer is covered with rounded pebbles and cobbles. Long, narrow stringers of Tours silt loam and Cibecue loam along drainageways comprise up to 10 percent of this mapping unit.

6.1.6.3. Tours Series

The SCS soils delineation marked 113B on Figure 6-1 is Tours silt loam, 0 to 8 percent slopes, eroded. The Tours series consists of well drained soils along long, narrow drainageways and on level to moderately sloping alluvial fans. The Tours soils are moderately to slowly permeable and offer high water holding capacity. Effective rooting depth is 60 inches or more. A representative soil profile is as follows:

A1 0 to 4 inches, reddish brown (5YR 4/4) heavy silt loam, dark reddish brown (5YR 3/4) when moist; weak thick platy structure; soft when dry, friable when moist, slightly sticky and nonplastic when wet; common fine roots; many very fine vesicular pores; slightly effervescent; mildly alkaline; clear smooth boundary.

C1 4 to 9 inches, reddish brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) when moist; weak medium subangular blocky structure; slightly hard when dry, firm when moist, sticky and plastic when wet; common fine roots; common fine interstitial and tubular pores; strongly effervescent; moderately alkaline; gradual wavy boundary.

C2 9 to 21 inches, reddish brown (2.5YR 5/4) silty clay loam, reddish brown (2.5YR 4/4) when moist; weak coarse subangular blocky structure; slightly hard when dry, firm when moist, sticky and plastic when wet; common fine roots; common fine interstitial and tubular pores; violently effervescent; moderately alkaline; gradual wavy boundary.

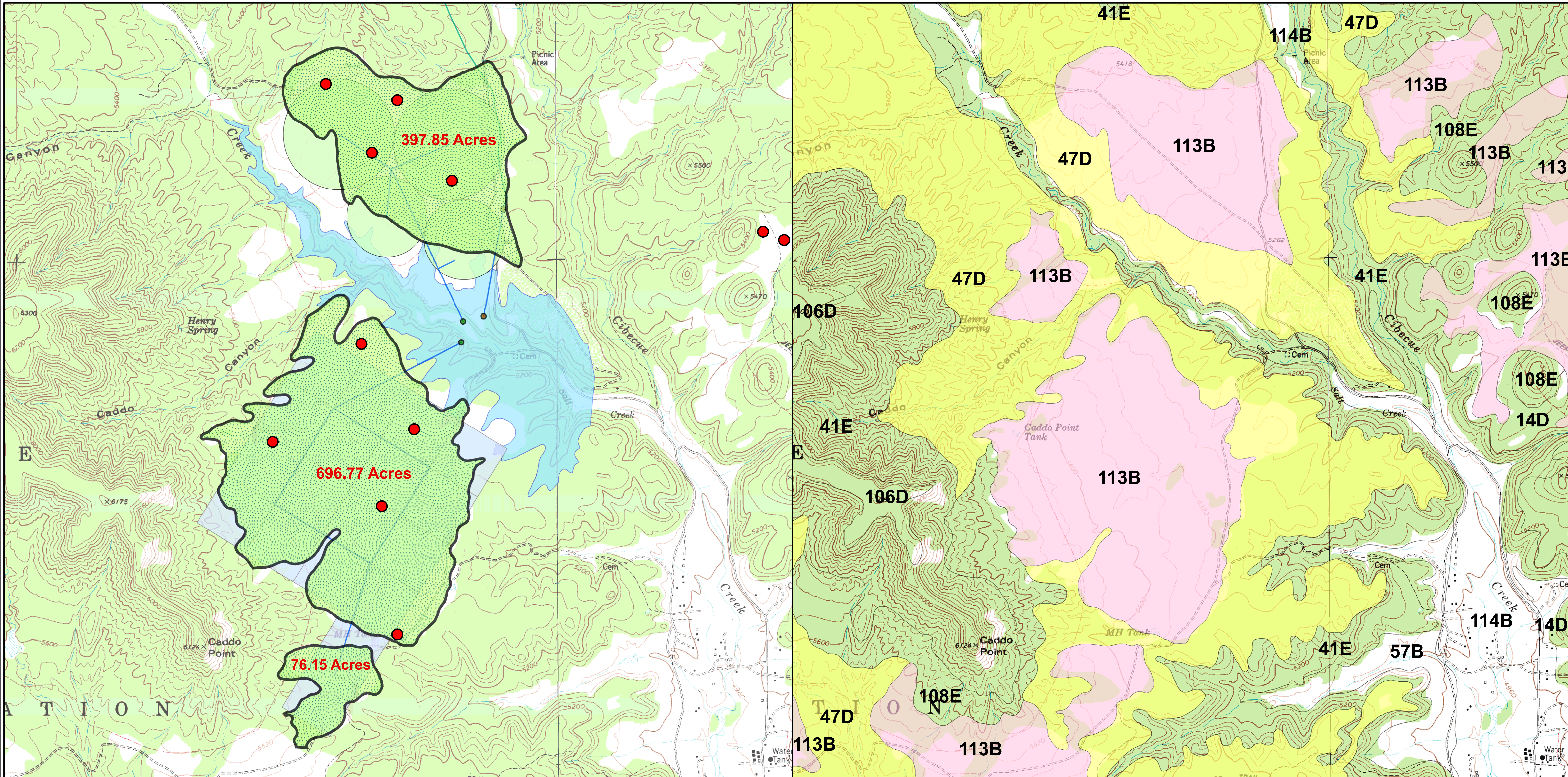
C3 21 to 53 inches, reddish brown (2.5YR 5/4) light silty clay loam, reddish brown (2.5YR 4/4) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine roots; common fine interstitial and tubular pores; violently effervescent; moderately alkaline; gradual wavy boundary.

C4 53 to 70 inches, red (2.5YR 5/6) silt loam, dark red (2.5YR 3/6) when moist; massive, soft when dry, friable when moist, slightly sticky and nonplastic when wet; few very fine roots; common fine tubular and interstitial pores; violently effervescent; moderately alkaline.

The SCS map unit 113B, is as described above and typically dissected by common shallow gullies and a few deep gullies in a dendritic pattern. The unit may include about 10 percent jacks and Chevelon soils in convex areas and 10 percent Navajo clay oam in concave areas.

6.1.7. Cibecue Area Classifications

The 1979 irrigability criteria shown in Table 6-4 were applied to the lands in the Cibecue area based on hand auger holes to examine the soil profile and ½-mile traverses to inspect the soils and make delineations. Figure 6-2 shows the locations of the hand auger holes and soil logs. Delineations and associated classifications were based on the 1968 soil standardized soil profile descriptions that are now formalized in the SCS cooperative Soil Survey report issued in 1981.

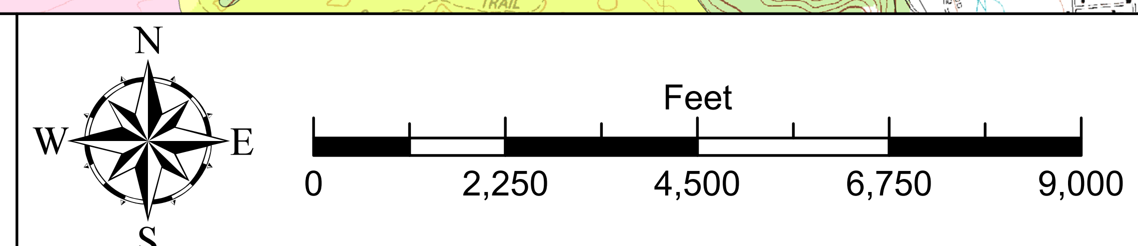


Legend

- Canal Structures
- Diversion
- Pump Stations
- Canals
- Pipeline
- Apple Orchards
- Pivots & Fields
- Salt Creek Reservoir
- Irrigable Soil

Soil Types

- 113B
- 18D
- 47D
- 80B
- All Other
- Auger Hole



MINER FLAT DAM
PROJECT EXTENSION REPORT

CIBECUE IRRIGATION UNIT SOILS MAP

FIGURE

NUMBER

6-2

The left half of Figure 6-2 shows the collective area of SCS soil map units that correspond to the area determined to be suitable for irrigated farming by the 1979 Land Classification with a conceptual irrigation project design superimposed over the irrigable lands. The right half of the figure shows the individual SCS soil mapping units that comprise the irrigable area and include the lands deemed suitable for irrigation in the 1979 Land Classification.

The 1979 Land Classification identified 1,156.0 acres of lands suitable for irrigated farming in the Cibecue area. The acreage and boundaries of irrigable soils delineated in the Cibecue area closely match the boundaries of the SCS delineations of Tours silt loam, 0 to 8 percent slopes, eroded, SCS mapping unit 113B, which includes 1,170.77 acres compared to the 1,156 acres delineated in the Tribe's 1979 classification. The typical soil profile of the Tours silt loam, 0 to 8 percent slopes, eroded, is provided above in the description of soils in the Canyon Day irrigable lands.

6.1.8. Bonito Prairie Classifications

The 1979 irrigability criteria shown in Table 6-4 were applied to the Bonito Prairie lands based on 16 hand auger holes and backhoe test pits to examine the soil profile. As summarized on Table 6-1, these soil profile inspections averaged 1.7 per square mile. Additional inspection was conducted with ½-mile traverses to inspect the soils and make delineations, based on shovel holes, terrain, and surface soils. Figure 6-3 shows the locations of the 1979 soil profile inspections and soil logs. The 1979 work identified 6,074 acres of lands in the Sprinkler Class (Tables 6-3 and 6-4).

The reconnaissance-level classification performed in 1979, consistent with the criteria for irrigation technology of the time, determined that irrigation management of the land on Bonito Prairie was subject to certain limitations. The limitations included areas of land where the soil surface was covered with coarse fragments (gravel through stone sized rocks) on the land surface, areas of unstable clay soil profiles in some of the low areas (particularly in closed depressions), and (to a lesser extent) areas of steep slopes along the margins of broad, flat valleys traversing the upland plains of the Bonito Prairie.

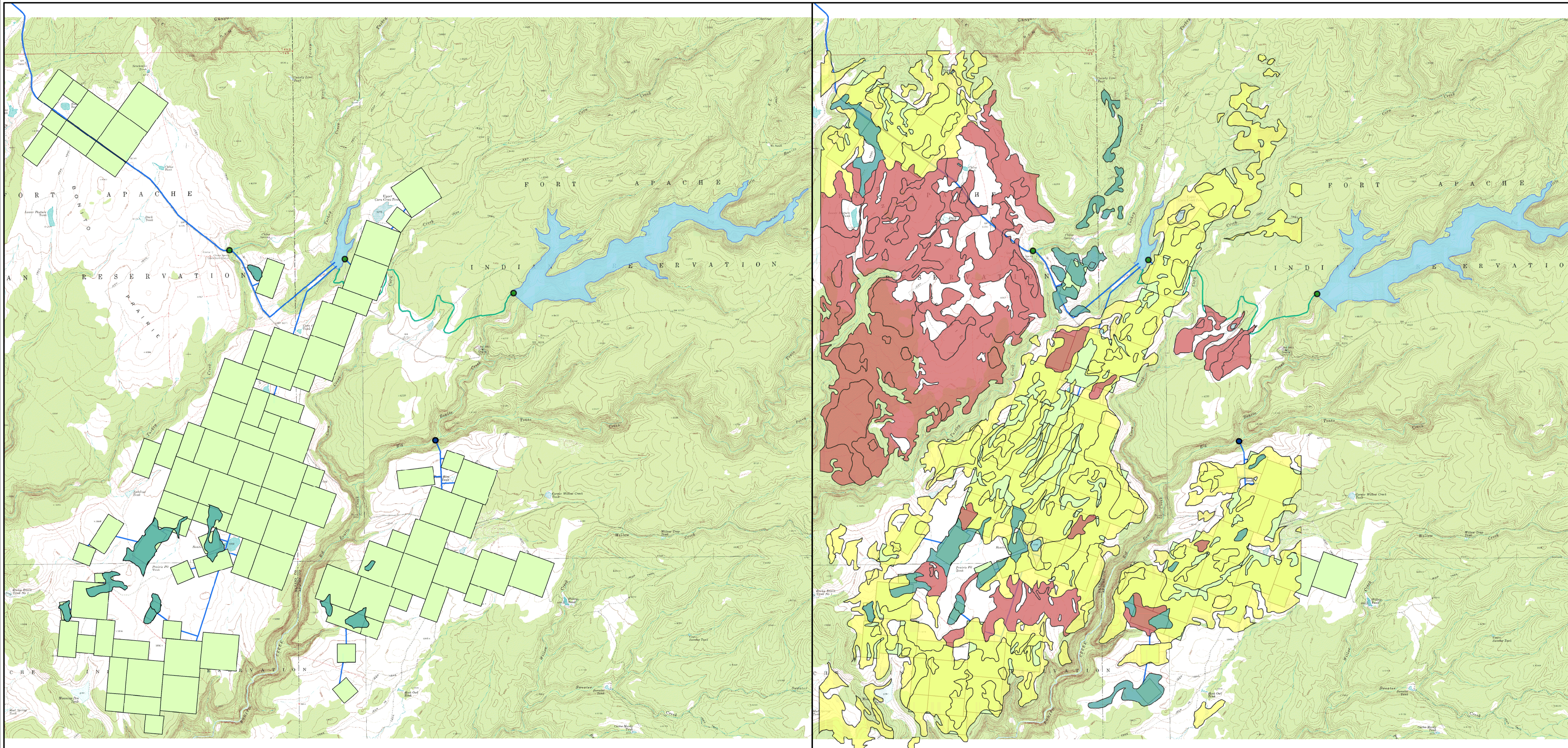
The reconnaissance-level classification identified the portions of the Bonito Prairie where the latter limitations were the least severe, i.e., coarse fragments on the land surface were manageable and reasonable slopes for sprinkler irrigation were present. Areas of excessive slope, lithic soil profiles with shallow bedrock, and heavy clay soils in closed depressions were designated as non-irrigable. The resultant classification designated approximately the northern one-third of the Bonito Prairie as irrigable. It was recognized that land on the southern two-thirds of the Bonito Prairie included areas suitable for irrigation; however, the relationship between suitable and likely unsuitable soils in that area was too complex to delineate at the reconnaissance to semi-detailed level of effort applied at that time.

The SCS Soil Survey published in 1981 indicated that most of the lands determined to be irrigable by the 1979 land classification by the Tribe are located on SCS mapping unit 98B, Thunderbird cobbly clay loam, 0 to 8 percent slopes. Smaller areas of irrigable land are located on mapping unit 97B, Thunderbird gravelly clay loam, 0 to 8 percent slopes. Likewise, the published SCS soil survey indicated that many of the heavy clay soils determined not to be suitable for irrigation with the level of management described in Table 3 were located on SCS mapping unit 92B, Springerville cobbly clay and one large area of 48B, Jaques clay loam around the tank at Georges Basin.

The SCS Soil Survey published in 1981 confirmed the tentative conclusion of the 1979 land classification effort that more than the 6,074 acres of lands identified in the Sprinkler Class were likely suitable for irrigation on the Bonito Prairie, by virtue of the fact the areas of Thunderbird cobbly clay loam with less than 8 percent slopes greatly exceeded the 6,074 acres of irrigable lands identified in 1979. However, it was also evident that the resolution of differences in surface coarse fragments, slopes, clay content, and (in some cases) depths to bedrock in much of the southern two-thirds of the Bonito Prairie is not adequate on the published soil survey maps to provide the level of detail necessary for confidence that the lands are irrigable. It was also evident that the changes in irrigation technology since 1979, particularly the widespread adaptation of drip irrigation methods to large areas of tree plantations, required revision of the irrigability criteria to include the new irrigation methods.

Accordingly, the White Mountain Apache Tribe conducted an additional and more detailed survey of the soils on the Bonito Prairie in early year 2006. The effort included excavation of 172 soil pits and detailed descriptions of the soil profiles. The soil profile descriptions and map delineations of those soils are suitable for classification for various types of cropping and/or irrigability determinations. The year 2006 effort included formulation of classification criteria specifically for plantations of Christmas trees and hybrid Poplar trees to be irrigated with drip irrigation methods. The 2006 soil survey and suitability classifications for irrigated Christmas trees and hybrid Poplar trees are described in Appendix X, "**Soil survey of the Bonito Prairie, White Mountain Indian Reservation**, prepared by Buchanan Consultants, Ltd., 220 West Main, Farmington, New Mexico, for the White Mountain Apache Tribe.

Figure 6-3 shows land classification delineations for suitability for Christmas Trees and Poplar trees. The land classification delineations depicted were developed by Buchanan Consultants, based on application of GIS methods to implement the criteria presented in Table 2 of Appendix X to classify the soil delineations provided by the 2006 field work. Only the most suitable soils for Christmas trees are shown on Figure 6-3, comprising 380 acres of the 18,698 acres ultimately considered in the 2006 study. Additional areas of suitable soils for plantations of irrigated Christmas trees are undoubtedly present, but are not distinguished from other types of soils at the level of detail of the 2006 work.



Legend

- Canal Structures
- Diversion
- Pump Stations
- Canals
- Pipeline
- Pivots & Fields
- Reservoir

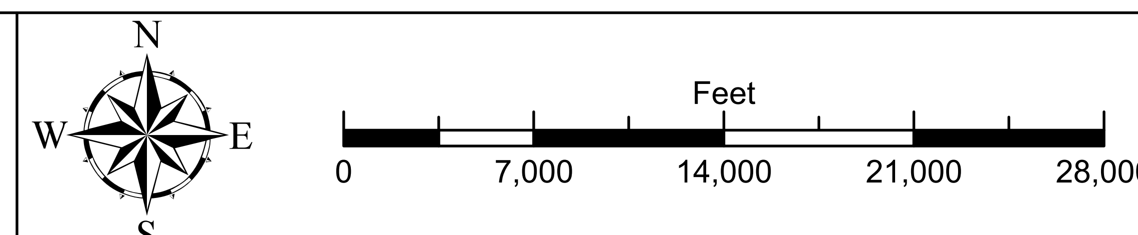
Soils (Suitability for Christmas Trees)

- Slight

Soils (Suitability for Poplar)

- Slight
- Moderate
- Severe

Source: Soil Survey of the Bonito Prairie, White Mountain Indian Reservation,
Buchanan Consultants, LTD, Aug. 2006



MINER FLAT DAM
PROJECT EXTENSION REPORT

BONITO PRAIRIE IRRIGATION MAP SOILS UNIT

FIGURE

NUMBER
6-3

The 2006 investigation considered an area of 41,344 acres that included the Bonito Prairie area. Preliminary exclusion of excessively steep lands and lands underlain by shallow bedrock quickly reduced the size of the area under consideration in the 2006 field work. Application of the irrigability criteria for irrigated Poplar tree plantations to the 2006 soil delineations further reduced the suitable area to 18,698 acres. The land classifications for soils suitable for Poplar trees shown on Figure 6-3 comprise the 18,698 acres. Also shown on Figure 6-3 is a conceptual layout of irrigated Polar tree plantations. The irrigation project layout is limited to those lands with 3 percent or less slope; in other words, those lands with slight to moderate limitations for irrigated Poplar plantations and which comprise 12,139 acres. Although the lands with severe limitations for irrigated Polar plantations are considered suitable under the criteria, most of the 6,559 acres of lands with severe limitations are excluded from the conceptual irrigation project layout depicted on Figure 6-8.

Although Appendix X provides a detailed description of the soil profiles for the soil delineations on the Bonito Prairie, the 2006 investigation revealed some interesting details about the genesis of the soils. These details are of some significance to management of these lands for irrigated Poplar tree plantations.

6.1.8.1. Soil Drainage

For example, the typical soil profile for the SCS Thunderbird soil series is formed in parent material consisting of consolidated volcanic cinders and basalt rock. The basalt bedrock is a potential barrier to drainage if these soils are irrigated. However, soil pits on the Bonito Prairie indicate the portions of Thunderbird soil series constituting the soils with slight to moderate limitations for Poplar tree plantations (and Christmas trees) have formed in a parent material consisting of a thick gravel and boulder pediment that is geologically old and derived mostly from the "old basalts" unit previously described in the chapter of this report about geologic history. The thick gravel and boulder deposits resting on top of the old basalts provide good subsurface drainage conditions on the Bonito Prairie.

The old basalts postdate the fault events that formed the Mogollon Rim. The old basalts appear to rest on a surface that developed after the pre-Mogollon drainage from southwest to northeast, from the ancient Mogollon Highland across the southern Colorado Plateau, was reversed south of the rim and began flowing to the ancestral Gila River drainage. The old basalt ranges in age from about 38 to 12 million years ago. The Mount Baldy volcanic complex, which is silica rich igneous rock in contrast to the silica poor old basalt, rests on top of the old basalts and ranges in age from about 12 to 8 million years ago. Most of the gravel, cobbles, and boulders in the pediment deposit consist of old basalt; however, a few cobbles of silica rich igneous rock were observed in the soil pits on Bonito Prairie, indicating that the gravel and boulder pediment was deposited by streams flowing after the Mount Baldy volcanic complex had formed. Along the north side of the Mogollon Rim, Thunderbird soils are developed in basalt and basaltic cinders of the Springerville Volcanic Field. The basalt in the Springerville Volcanic Field ranges in age from about 2.0 to 0.3 million years ago (Condit, 1991), indicating Thunderbird soils on the Mogollon Rim formed during and after those dates.

The presence of Springerville volcanic rocks in the ancestral valleys of the North Fork of the White River and its tributaries indicates that by the time those volcanic rocks were deposited, the pediment surface on the Bonito Prairie was isolated from the drainages from the Mogollon Rim and, therefore, is highly unlikely to contain any Springerville Volcanics Field rocks. This indicates the pediment formed sometime between 8 and 2 million years ago and that soil forming processes have had a long time to act on the essentially alluvial parent material comprising the dominantly alluvial gravel and boulder pediment deposits.

The soil profiles reveal that the basalt gravel and boulders comprising the uppermost part of the pediment deposits are completely converted to weathering products by the soil forming process to a depth of one to two feet. Basalt gravel and boulders below that depth are highly weathered to depths of more than 60 inches; however, the original rock is still evident. Clays formed by the weathering process in the uppermost part of the deposits, where the original rock fragments are completely weathered away, have been dissolved and transported deeper into the soil profile where they have been redeposited, enriching the area of deposition with clay. This part of the soil profile is referred to as a "textural" horizon. Three to four successive horizons of clay enrichment are typically present in the Thunderbird soils on Bonito Prairie, including enrichment of the uppermost part of the parent materials with clay, as described in the soil profile logs in Appendix X. The degree of soil profile development coupled with the transportation of clay from the upper part of the soil profile and enrichment of clay in the intermediate part of the profile, indicates that during significant amounts of the time during which these soils formed, the precipitation was considerably greater than 16 to 20 inches of annual precipitation received in this area in modern times. The soil profile characteristics indicate that these soils remained well drained, even when annual precipitation significantly exceeded the present 16 to 20 inches per year in the geologic past.

The zones of clay enrichment in the soil profile do not offer a drainage barrier in the soil profile because they exhibit a highly developed and strong prismatic structure. The cracks between the individual columns or prisms of clay enriched soil offer considerable openings for drainage of water through these soils, into the underlying alluvial (pediment) parent material. This is an important management consideration in growing trees on these soils. The cultivation of these soils, including planting of Christmas trees or hybrid Poplars with rippers, should not penetrate into and disrupt the prismatic soil structure of the intermediate horizons. Destruction of the soil structure in the intermediate horizons by plowing or ripping will adversely and irreparably damage the drainage properties of these soils.

6.1.8.2. Coarse Fragments

A fascinating aspect of the soil profiles examined during the 2006 investigations was the paucity of large coarse fragments in the uppermost part of the soil profile, where significant amounts of gravel, cobbles, stones, and even boulders were present on the soil surface. The presence of these coarse fragments was a matter of considerable concern because they were perceived to indicate the probable presence of a large amount of gravel, cobbles, and boulders in the uppermost horizons of the soil. The soil pits revealed that the latter assumption was not true and that, even where significant amounts of coarse fragments were present on the land surface, the uppermost soil horizons were relatively devoid of coarse fragments. This discovery indicated that a blade or rock picker could be used to remove most of the coarse fragments from the land surface and that surface would not develop more coarse fragments because they were not present in the soil immediately below the land surface.

The reason for the above phenomena became evident upon examination of the soil profiles. Contraction and expansion of the uppermost part of the soil during wetting and drying, and probably during freezing and thawing, cause vertical cracks to form in the soil. Eventually, coarse fragments migrate into the cracks where earth pressure during the expansion of the soils causes the coarse fragments to move toward the area of least earth pressure, i.e., the land surface. After the fragments have been expelled onto the land surface, they are mostly too large to fall back down into the vertical soil cracks that form during the contraction of the soil during dry and/or warm conditions. Accordingly, the coarse rock fragments remain on the land surface and the uppermost part of the soil profile, over a long period of time, becomes relatively free of coarse fragments, containing only those that are small enough to fall back into the soil cracks.

This discovery indicates that removal of the coarse fragments from the land surface, where present, will be essentially a one-time operation and expense. Subsequent planting of trees will be confined to the uppermost soil profile, above the zones of clay enrichment and prismatic soil structure, which are in turn above the gravelly, cobbly, and bouldery horizons in the deeper part of the soil profiles.

It is for the above reason that the conceptual irrigation project layout shown on Figure 6-3 is limited to the areas with slight to moderate limitations. Those are the areas of soil where the depth to the coarse fragments in the deeper part of the soil profile is the greatest. In the areas of severe limitations, the uppermost part of the soil profile is suitable for Poplar plantations, but the depth to both the textural horizons with prismatic structure and the horizons with coarse fragments is significantly shallower than in the areas of slight to moderate limitations, and will require considerably more difficult management and control of the plantation process to prevent damage to the soil structure and/or plowing up of undesirable coarse fragments.

6.2 North Fork of the White River Irrigation Development

The following sections summarize the costs of irrigation and multipurpose storage features reliant upon the North Fork of the White River. Life-cycle costs including initial construction, interest during construction, and operation, maintenance and replacement (OMR) are provided.

6.2.1 Canyon Day Irrigation Unit

The Canyon Day Irrigation Unit is located on Bear Flat bounded by the White River (elevation 4,760 to 4,840 feet) on the south, Bear Canyon on the east, Amos Wash on the west and pinyon juniper slopes above elevation 5,400 on the north. The project area is entirely within the White River watershed. The Irrigation Unit is divided into three sub-units depending on location. The Existing Sub-Unit consists of the existing facilities including pump station, pipelines, and sprinkler irrigation system. The Canyon Day Sub-Unit consists of those areas within the Canyon Day delineation, most notably defined by Kinishba Wash on the west. The

Amos Wash Sub-Unit is located to the west of the Canyon Day area, with all lands within the Amos Wash Watershed. The Canyon Day Irrigation Unit is shown on Figure 6-4.

Diversion for irrigation would be approximately 16 miles upstream from the confluence of the White River with the Black River and approximately 1.5 miles downstream from the confluence of the North Fork White River and the East Fork White River.

The Canyon Day community of the White Mountain Apache Tribe is located on the eastern edge of the project. Fort Apache is located approximately 3 miles due east of the project, and the community of Whiteriver is located approximately 6 miles northeast of the project.

Arizona Highway 73 enters the project area from the west and traverses the central portion of the project area from west to east. Highway 73 connects the project lands with the community of Whiteriver and the communities of Pinetop and Show Low beyond the northern boundary of the Fort Apache Indian Reservation.

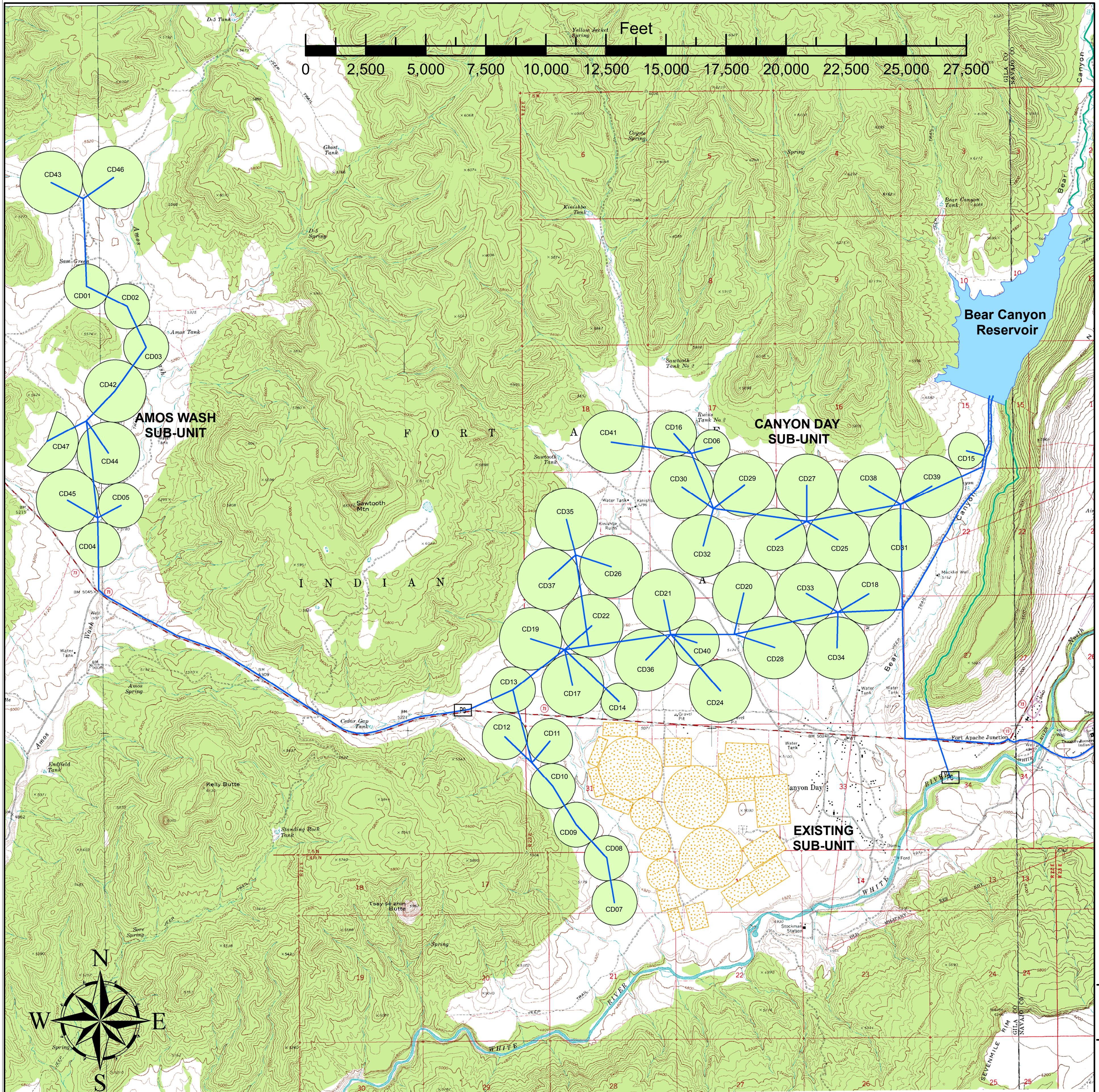
The proposed Miner Flat Dam would create reservoir storage necessary for expansion of the Canyon Day Irrigation Project. The damsite is 19 river miles upstream from the diversion point for expansion of the Canyon Day Irrigation Unit.

6.2.2 Project Lands

The soils of Canyon Day and adjacent areas were derived from erosion of the surrounding hillsides and subsequent deposit by wind and fluvial processes. Older deposits containing gravel are overlaid by finer grained materials. The slope of Bear Flat from north to south is generally uniform and controlled at the southern end by a basalt flow parallel to the modern course of the North Fork White River and White River. High points of the older topography extend through the newer deposition of fine loams. Across Section 29 and 32 of Township 4 ½ N, Range 22 East, the elevation of land declines from 5,200 to 4,960 feet (240 feet over a distance of two miles). This mild slope of approximately 2.5 percent is well suited for irrigation. West of Kinishba Wash, slopes reach 8 percent. This is well below the limit of 15 percent slope generally accepted as limiting for sprinkler irrigation.

The natural slope of the land and the presence of Kinishba Wash on the west and Bear Canyon on the east provide good drainage conditions throughout the project lands. Drainage difficulties have not been experienced in the southern half of the project lands, which have been successfully irrigated since 1979.

Soils in the Canyon Day area consist primarily of NRCS-classified soils Cibeque Gravelly Loam, Showlow Gravelly Clay Loam, and Tours Silt Loam. Soil textures generally include loams, clays, sandy-clay loams and gravelly clay loams. The gravelly soils are older than the more fine grained soils which have been deposited upon them. The soils are deep and do not contain groundwater near the surface. Soils around the edge of Bear Flat are thinner than in the central portion. Soil depths are thin near the contact with the hillsides. Along the southern edge of the Bear Flat area, soil depths above the surface of the basalt flow vary from 24 to 36 inches. Vegetation consists primarily of piñon, juniper, shrubs and grasses.



AMOS WASH SUB-UNIT		CANYON DAY SUB-UNIT					
Field ID	Acreage	Field ID	Acreage	Field ID	Acreage	Field ID	Acreage
CD01	70	CD14	45	CD18	130	CD30	130
CD02	70	CD15	45	CD19	130	CD31	130
CD03	70	CD07	70	CD20	130	CD32	130
CD04	70	CD08	70	CD21	130	CD33	130
CD05	70	CD09	70	CD22	130	CD34	130
CD42	130	CD10	70	CD23	130	CD35	130
CD43	130	CD11	70	CD24	130	CD36	130
CD44	130	CD12	70	CD25	130	CD37	130
CD45	130	CD13	70	CD26	130	CD38	130
CD46	130	CD16	70	CD27	130	CD39	130
CD47	77	CD40	70	CD28	130	CD41	130
Amos Wash 1,077 Total Ac.		CD17	130	CD29	130	CD42	130
					Canyon Day 3,970 Total Acres		

EXISTING SUB-UNIT
884 Total Existing Acres

- Canal Structures
- Diversion
- PS Pump Stations
- Canals
- Pipeline
- Existing Pivots and Fields
- Pivot
- Reservoir

MINER FLAT DAM
PROJECT EXTENSION REPORT

CANYON DAY IRRIGATION UNIT

FIGURE
NUMBER
6-4

Historic permeability tests in the soils indicate that water migrates at rates of 0.05 to 2.0 inches per hour. Generally permeability ranges from slow to moderate. Within the 6-foot root zone of alfalfa crop, water holding capacities generally range from 10 to 12 inches. If filled to capacity, the soils of the Canyon Day Irrigation Project can be expected to supply crop water for a period of two weeks or more during peak water consumption. This characteristic of the soils of the Canyon Day Irrigation Project makes them highly suitable for irrigation.

Salinity of the soils is low. Good water quality from the White River and low salinity soils would help prevent the buildup of salts in the soil profile.

6.2.3 Existing Project Facilities

In 1979, the White Mountain Apache Tribe developed 350 acres of irrigation within the Canyon Day Irrigation Project on Bear Flat. By the end of 1982, 710 acres were under irrigation. The 710 acres of irrigation were integrated with the White River Wastewater Treatment Facility. Treated wastewater is pumped to the irrigation project as a means of achieving zero discharge to the White River. In 1983, the Canyon Day Irrigation Project was increased to 885 acres by construction of an additional 175 acres.

Current irrigation of Canyon Day is accomplished by diversion of the White River in the west half of Section 22, Township 4 ½ N, Range 22 East. From the diversion point, water is conveyed in an open channel to a pumping station approximately 1,000 feet west of the diversion point. A short detention time is provided in settling ponds constructed immediately upstream from the intake to the pumping station.

Two pumps, each with a capacity of 1,100 gallons per minute (gpm) at 440 feet of head discharge from an approximate elevation of 4,780 into a 12-inch pipeline, originally designed to serve center pivots on fields 1 and 2 and side roll sprinkler system on fields 18, 19, 20 and 21. Five additional pumps, capable of delivering approximately 5,000 gpm (1,000 gpm each), discharge into a 14-inch pipeline serving the balance of the irrigated area. The two pipeline systems have reduced diameters as the delivery requirements are reduced.

The two delivery systems are interconnected to provide flexibility in the operation of the pumping station. The pumping station provides a combined capacity of 7,200 gpm at peak capacity.

6.2.4 New Facilities

The expansion of the existing Canyon Day Irrigation Project from 885 acres to 5,875 acres would require irrigation of approximately 4,050 acres in the Canyon Day area lying to the north of Highway 73, to the south of elevation 5,400 feet between Kinishba Wash and Bear Canyon and to the west of Kinishba Wash and approximately 940 acres in the Amos Wash area. For clarity these areas have been labeled as the Canyon Day Sub-Unit and Amos Wash Sub-Unit.

6.2.4.1 Storage Facilities

Irrigation water storage for the Canyon Day Irrigation Unit would be accomplished by constructing Miner Flat Dam and Bear Canyon Dam. Water availability and dam features are discussed in earlier sections. Water would be transferred from Miner Flat to Bear Canyon for regulating storage either by a diversion dam and pump station or an alternative transfer pipeline.

Miner Flat Dam and Bear Canyon Dam were discussed in Chapter 5. Lifecycle cost estimates were based on similar facilities that have been constructed throughout the United States and abroad. Miner Flat Dam has been pre-designed as an RCC dam with an approximate dam height of 155 feet and crest length of 400 linear feet. The Bear Canyon Dam is pre-designed as an RCC dam with a dam height of 165 feet and crest length of 2,280 linear feet.

Sufficient water would be released from storage behind the Miner Flat Dam to provide for the water requirements of the 5,875 acre irrigation project.

6.2.4.2 Diversion Facilities

For diversions via the pump station, releases of water from the Miner Flat Dam would be conveyed in the natural channel of the North Fork White River and White River for a distance of 19 miles. The pumping station for the expansion of the Canyon Day Irrigation Project would be located in the southwest corner of Section 34, Township 5N, Range 22E. The pumping station would be located 0.2 miles upstream from the mouth of the Bear Canyon Creek. The pump station would discharge to a lined canal at elevation 5,480 feet to be conveyed to storage in Bear Canyon Reservoir.

The capacity of the pumping station was based upon a peak consumptive use of 7.5 gallons per minute per acre. Total pumping capacity for the 5,120 acres of expansion was estimated at 38,400 gpm (85.5 cfs). Six pumps, each sized for one-sixth of the design flow of with a maximum head of 320 feet would be installed.

The pumping station would be designed to receive the full level of streamflows in the White River. This would require a diversion works, head works and settling facilities for detention of sediment. Moreover, because the water of the White River retains small particles of suspended sediment for considerable periods of time, consideration would be given to severe duty materials to minimize wear of oil or water lubricated pumps.

An intake manifold connecting all pumps would be constructed. On the discharge side of the pumping units, air release valves, flow control valves, check valves, isolation valves, and surge control facilities would be installed. The pumping units would also be equipped with controls to stop operation under low pressure, high pressure, or high temperature conditions. Flows from the pumping station would be monitored for system pressure, instantaneous flow, and accumulated flow.

Incoming electrical service for the pumping station is available from existing 3 phase, 60 cycle, 7,200 volt distribution lines approximately ½ mile north and parallel to Highway 73.

Extension of overhead electrical facilities to the pumping station would require minimal construction.

For diversions via a transfer pipeline, releases of water from Miner Flat would be conveyed via a 48-inch diameter pipeline that would cross Nan Dahs Taan Mesa and discharge in Bear Canyon. Discharge would be to a canal that would convey the water to Bear Canyon Reservoir. Water would be able to flow by gravity, but would require a tunnel through Nan Dahs Taan Mesa to prevent cavitation at the ridge crossing.

6.2.4.3 Water Conveyance System

Water conveyance for the Canyon Day Irrigation Unit includes the transmission mains and laterals necessary to feed the pivots of the Canyon Day and Amos Wash Sub-Units from Bear Canyon Reservoir. Two separate low level outlets would supply water to the irrigation unit from Bear Canyon Reservoir. One outlet would serve the northern half of Canyon Day, with the other outlet serving the southern half of Canyon Day and Amos Wash.

The northern half of Canyon Day would be supplied through a network of pipes to the individual fields ranging in size from 8-inch to 30-inch Class 100 or Class 125 PIP PVC pipe or Class 165 C905 PVC pipe depending on the pressure. An estimated 10,000 feet of PVC pipe would be installed for the transmission pipeline and branch lines. The transmission pipeline and branch lines would be installed with isolation valves, air valves, and blowoff valves for maintenance. Pressure reducing facilities, where necessary, would be installed to protect the pipeline.

The southern half of Canyon Day and Amos Wash would be supplied through a network of pipes to the individual fields ranging in size from 8-inch to 42-inch Class 100 or Class 125 PIP PVC pipe or Class 165 C905 PVC pipe depending on the pressure. An estimated 10,000 feet of PVC pipe would be installed for the transmission pipeline and branch lines. The transmission pipeline and branch lines would be installed with isolation valves, air valves, and blowoff valves for maintenance. Pressure reducing facilities, where necessary, would be installed to protect the pipeline.

Amos Wash would be supplied from a booster station along Highway 73. The booster pump station would use inlet pressure from the southern transmission pipeline. A packaged booster pump station consisting of three split-case centrifugal pumps or comparable pumps each sized at one-third of the design flow of 7,900 gpm at 250 feet TDH and a discharge manifold would be installed. The pumping unit would also be equipped with controls to stop operation under low pressure, high pressure, or high temperature conditions. Flows from the pumping station would be monitored for system pressure, instantaneous flow, and accumulated flow.

6.2.4.4 Irrigation System

Center pivots in the Canyon Day Irrigation Unit were sized according to available irrigable area and most cost effective pivot spans. Center pivots range in size from smaller pivots (approximately 45 acres) to standard quarter-section pivots (approximately 130 acres).

The majority of the center pivots are positioned in a "nested" arrangement. This nesting maximizes available irrigation acres within the area, while minimizing the costs for the center pivot supply pipelines, controls, and electrical facilities. The area between the nest of center pivots would house the main water supply pipeline, center pivot manifolds, electrical connections, and pivot control panels. Operators would not need access to the center pivot tower unless there is a need for maintenance. The remaining center pivots are located to maximize irrigated area.

Each center pivot would be equipped with a control system that would be transmitted back to the central irrigation control system. The existing 7,200 volt, 3-phase transmission line would be extended from its current location along Highway 73 to interconnect with the center pivots. Overhead lines would be extended to areas that would not interfere with center pivots. Buried cable would be used in areas where overhead lines are not practical.

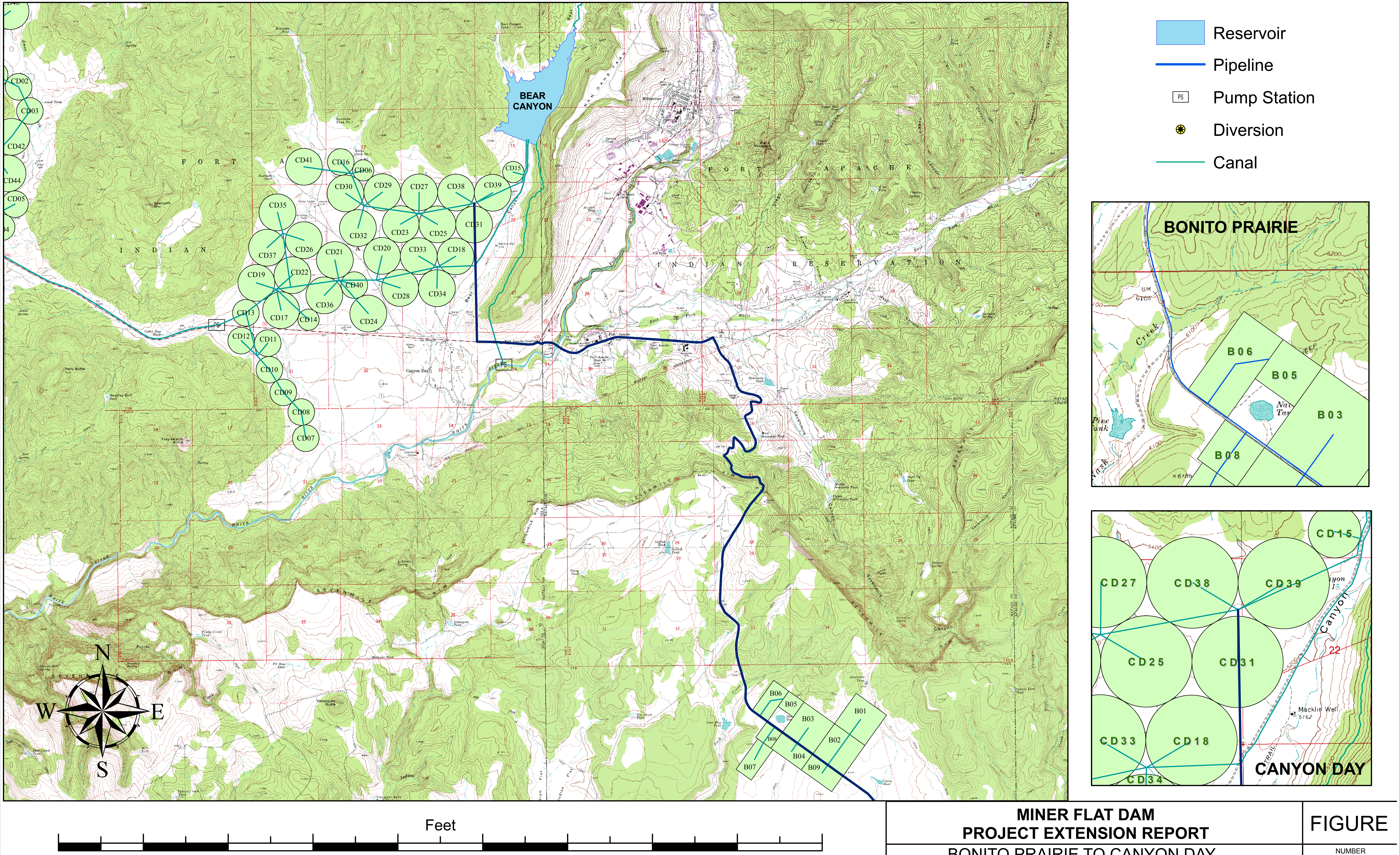
6.2.5 Supply Alternatives

An alternate source of supply to the Canyon Day Irrigation Unit would be to serve the Unit from a pipeline from the Bonito Creek (Figure 6-5). A large diameter transfer pipeline would be constructed from the Bonito Creek Reservoir to the Canyon Day transmission pipelines. This alternative source of supply has been conceptually designed to operate under two different scenarios; 1) 100% supply from Bonito Creek and 2) 50% supply from Bonito Creek and 50% supply from Miner Flat. Furthermore, due to the elevation change from the Bonito Prairie Unit to the Canyon Day Irrigation Unit, the transfer pipeline would have hydropower potential. Potential hydropower revenues are discussed below.

The first scenario of 100% supply from Bonito Creek would allow the Canyon Day Irrigation Unit to be operable without the need for Bear Canyon Reservoir or the main irrigation pump station. The 100% alternative as conceptually designed would consist of a 60-inch diameter pipeline, booster pump station, mini-hydropower facilities, and associated appurtenances connecting the Bonito Prairie Unit with the Canyon Day Unit. The pipeline would have the capability of supplying the peak consumptive use of the Canyon Day Unit of 38,400 gpm.

The second scenario of 50% supply from Bonito Prairie would similarly allow the Canyon Day Irrigation Unit to be operable without the need for Bear Canyon Reservoir. However, the main irrigation pump station on the White River would still be necessary to divert the additional irrigation water from the White River. This additional water may be released from Miner Flat Dam or from normal streamflow in the river. The 50% alternative as conceptually designed would consist of a 42-inch diameter pipeline, booster pump station, mini-hydropower facilities, and associated appurtenances connecting the Bonito Prairie Unit with the Canyon Day Unit. The pipeline would have the capability of supplying one-half the peak consumptive use of the Canyon Day Unit, the equivalent of 19,200 gpm.

An additional alternate supply route to the Canyon Day Irrigation Unit would be to divert water from Miner Flat Dam to Bear Creek Reservoir by gravity (Figure 6 – 6). This alternative would allow Bear Canyon Reservoir to be filled without the use of the main irrigation pump

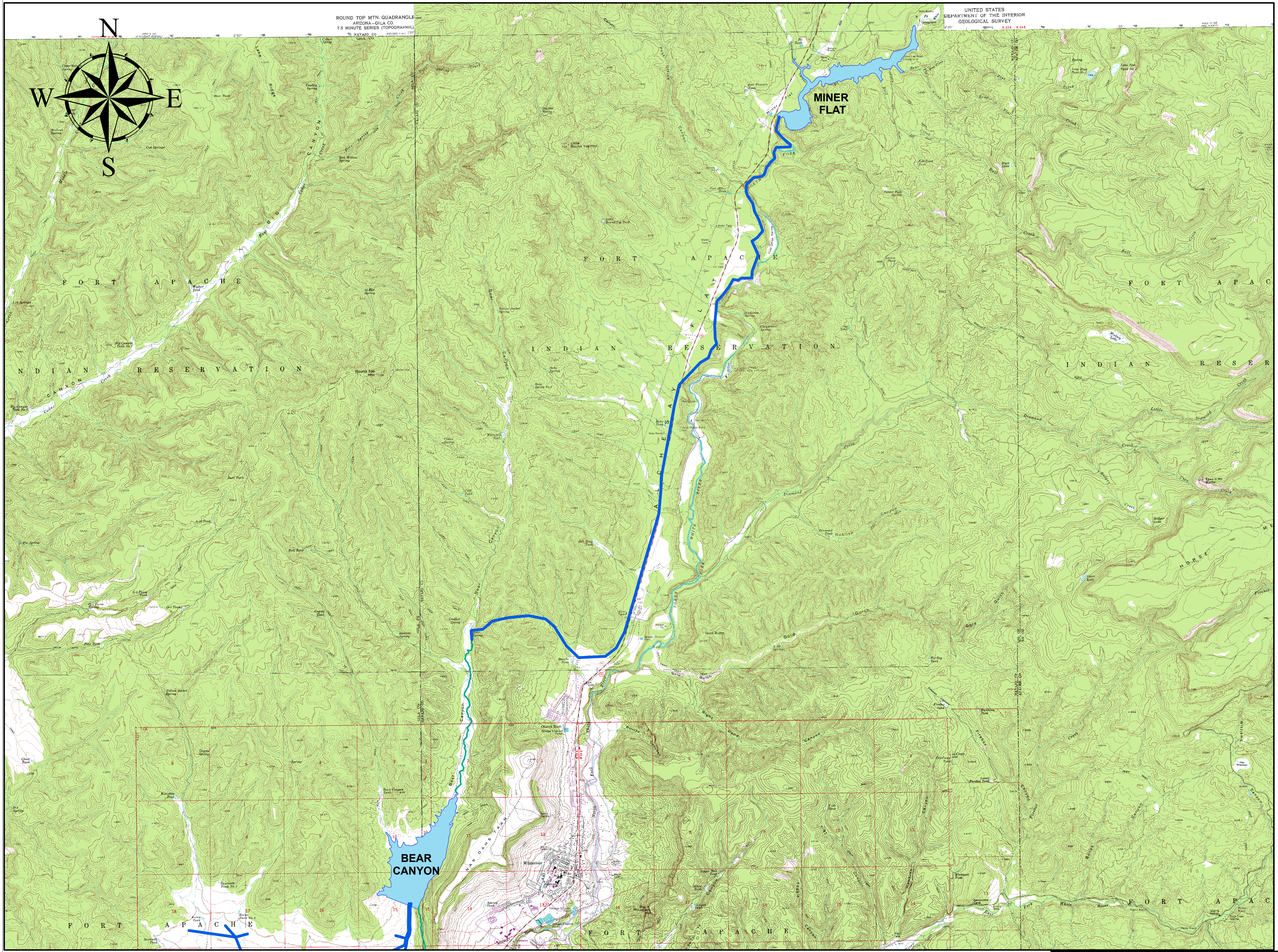


MINER FLAT DAM
PROJECT EXTENSION REPORT

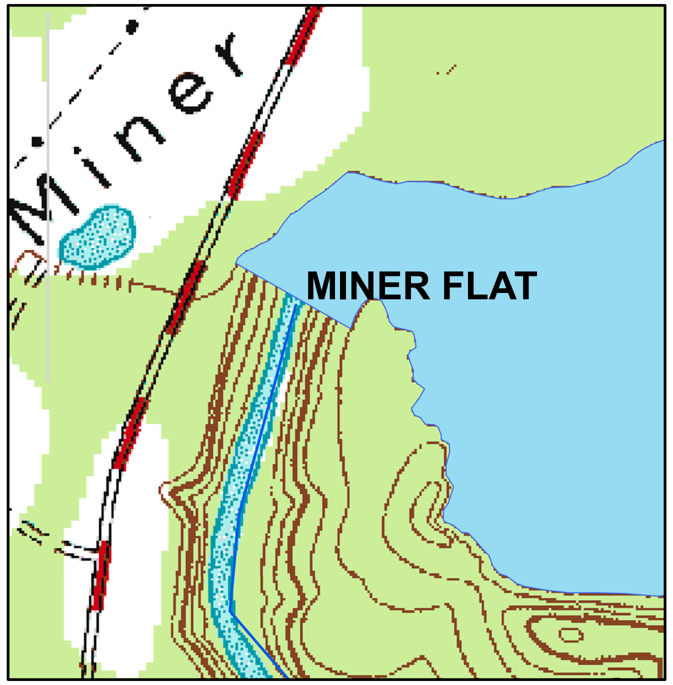
BONITO PRAIRIE TO CANYON DAY
TRANSFER PIPELINE

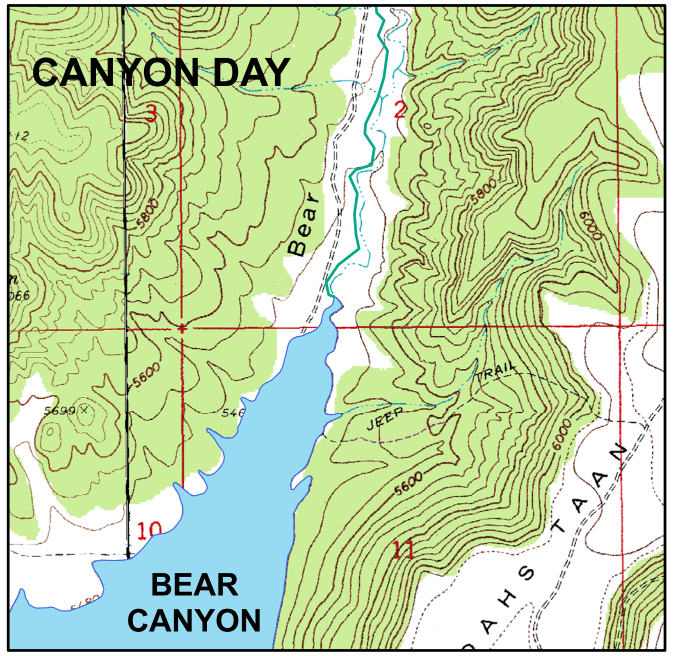
FIGURE

NUMBER
6-5



Reservoir
Pipeline
Pump Station
Diversion
Canal





Feet

0 7,000 14,000 21,000 28,000 35,000 42,000 49,000 56,000 63,000

MINER FLAT DAM
PROJECT EXTENSION REPORT

MINER FLAT DAM TO BEAR CANYON DAM
TRANSFER PIPELINE

FIGURE
NUMBER
6-6

station. This alternative as conceptually designed would consist of a 48-inch diameter pipeline, outlet works from Miner Flat Dam, a tunnel crossing through the ridge between Whiteriver and Bear Canyon, a constructed canal from the tunnel to Bear Canyon Reservoir and associated appurtenances.

6.2.6 Hydropower Potential

Potential hydropower from the North Fork White River is generated from releases from Miner Flat Dam. The Miner Flat damsite is situated immediately to the east of existing 14.4 and 69 kilovolt (kV) transmission lines that are parallel to Highway 73 between Pinetop and Whiteriver, therefore, interconnection of potential hydropower facilities with the transmission system may be minimal.

A hydropower analysis of the Miner Flat Dam indicates that with a design discharge of 200 cubic feet per second, hydropower production at the damsite would average 5,220 megawatts hours per year. At $0.04 per kilowatt hour, annual hydropower revenues would be valued at $208,800 per year or a present value $6,600,000 over a 100 year or project discounted at 3%. Total project costs of the hydropower facilities including construction, non-contract costs, and contingencies were estimated at $8,763,000. Before consideration of annual operation maintenance and replacement costs of hydropower facilities, the costs exceed the benefits. Hydropower was not considered feasible.

6.2.7 Life-Cycle Costs

Table 6-5 summarizes the costs of the alternatives selected for analysis for the Canyon Day irrigation features. Alternative 1, with Miner Flat, Bear Canyon Reservoir and a diversion dam and pump station for transfer of water from Miner Flat Dam to Bear Canyon Reservoir has an estimated lifecycle cost of $318,055,000, the least of the alternatives.

Alternative 2, with Miner Flat Dam, Bear Canyon Dam, and a gravity transfer pipeline from Miner Flat Dam to Bear Canyon Reservoir has an estimated life-cycle cost of $341,047,000. Annual operation, maintenance and replacement costs of $114.063 million are less than the costs for Alternative 1, reflecting the elimination of pumping costs, but the initial construction costs make Alternative 2 less feasible than Alternative 1.

Alternatives 3 and 4, relying upon transfer of water from Bonito Creek to the Canyon Day irrigation project, are not feasible with lifecycle costs of $619 million and $530 million, respectively. While these alternatives may have had greater hydropower potential than alternatives 1 and 2, the benefits are irrelevant considering the higher overall costs.

TABLE 6-5

CANYON DAY IRRIGATION UNIT
LIFECYCLE COSTS

Cost Feature		Canyon Day Irrigation Unit Alternative 1	Canyon Day Irrigation Unit Gravity NF	Canyon Day Irrigation Unit Bonito 50%	Canyon Day Irrigation Unit Bonito 100%
Discount Rate, %	3%				
Interest Rate, %	5%				
Project Life, years	100				
Substantial Completion, year		3	3	3	3
Construction					
Total Field Costs					
Miner Flat Dam		$ 24,728,000	$ 24,728,000	$ 24,728,000	$ 24,728,000
Bear Canyon Dam		71,435,000	71,435,000	71,435,000	0
Bonito Creek Dam				138,650,000	138,650,000
Pump Stations & Diversions		5,510,000	0	2,755,000	0
Conveyance: Pipelines & Canals		12,737,000	12,737,000	12,737,000	12,737,000
Irrigation Application		4,305,000	4,305,000	4,305,000	4,305,000
Hydropower		6,072,000	6,072,000	12,263,000	14,107,000
Alternative Conveyance		0	28,077,000	28,648,000	44,615,000
Subtotal		124,787,000	147,354,000	295,521,000	239,142,000
Contingency	15%	18,718,000	22,103,000	44,328,000	35,871,000
Total Contract Costs		143,505,000	169,457,000	339,849,000	275,013,000
Non-Contract Costs					
Environmental Mitigation	0.50%	718,000	847,000	1,699,000	1,375,000
Federal Oversight	2.50%	3,588,000	4,236,000	8,496,000	6,875,000
Contract Administration	6.25%	8,969,000	10,591,000	21,241,000	17,188,000
Pre-Construction Investigations	3.00%	4,305,000	5,084,000	10,195,000	8,250,000
Design, Surveys and Geotechnical	0.75%	1,076,000	1,271,000	2,549,000	2,063,000
Designed Plans and Specifications	5.75%	8,252,000	9,744,000	19,541,000	15,813,000
Construction Observation	6.75%	9,687,000	11,438,000	22,940,000	18,563,000
Sutotal	25.50%	36,595,000	43,211,000	86,661,000	70,127,000
Total Project Costs		180,100,000	212,668,000	426,510,000	345,140,000
Present Value Project Costs		174,905,000	206,534,000	414,208,000	335,185,000
Interest During Construction		18,010,000	21,267,000	42,651,000	34,514,000
PV IDC		17,318,000	20,450,000	41,013,000	33,188,000
Operation, Maintenance and Replacement (OMR)					
Annual Energy					
Pump Stations		896,674	0	716,592	536,421
Irrigation Application		94,807	94,807	94,807	94,807
Subtotal		991,481	94,807	811,399	631,228
Annual Operation and Maintenance (OM)					
Labor		578,955	675,225	675,225	675,225
Materials and Supplies		623,935	736,770	1,477,605	1,195,710
Subtotal		1,202,890	1,411,995	2,152,830	1,870,935
Present Value Annual OM		65,359,000	44,880,000	88,290,000	74,527,000
Present Value of Future Replacements		60,473,000	69,183,000	75,525,000	87,324,000
Total Present Value OMR		125,832,000	114,063,000	163,815,000	161,851,000
Present Value Life Cycle Costs		$ 318,055,000	$ 341,047,000	$ 619,036,000	$ 530,224,000

6.3 Cibecue Creek Irrigation Development

The Cibecue Irrigation Unit is located northwest of the community of Cibecue on the flat above the confluence of Cibecue Creek and Salt Creek. The project is bounded by Cibecue Creek on the east and Spring Ridge on the west, with the majority of the project lands ranging in elevation from 5200 feet to 5400 feet. Salt Creek runs through the middle of the project area. The project area is entirely within the Cibecue Creek watershed. Diversion for irrigation would be from Cibecue Creek approximately ¾ mile upstream of the project lands on Cibecue Creek. The Cibecue Irrigation Unit is shown in Figure 6-7.

A gravel road enters the project area from the south and traverses the eastern edge of the project area from south to north. This road connects the project lands with the community of Cibecue approximately 1 mile to the south.

The proposed Salt Creek Dam would create reservoir storage necessary for irrigation of the Cibecue Unit. The damsite is located on Salt Creek at the western edge of the project area just upstream of the confluence of Cibecue Creek and Salt Creek.

6.3.1 Project Lands

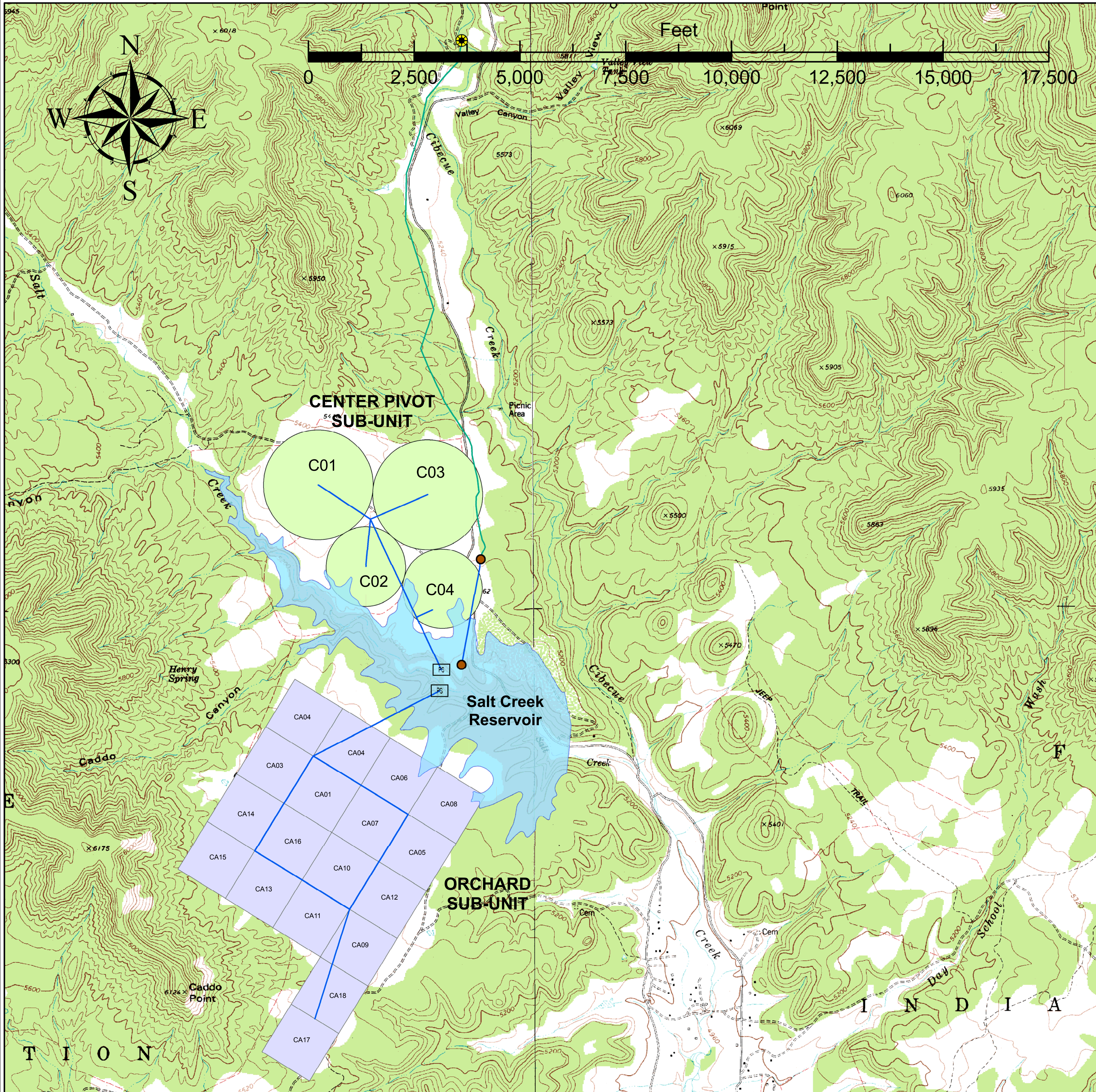
The soils of project area were derived from erosion of the surrounding hillsides and subsequent deposit by wind and fluvial processes. Older deposits containing gravel are overlaid by finer grained materials. The slope of the project area is generally uniform ranging from west to east at 5 percent or less. This mild slope is well suited for irrigation, below the limit of 15 percent slope generally accepted as limiting for sprinkler irrigation.

The natural slope of the land and the presence of Salt Creek through the middle of the site and Cibecue Creek on the east provide good drainage conditions throughout the project lands.

Soils in the Cibecue Unit consist primarily of NRCS-classified soils Jacks Cobbly Clay Loam and Tours Silt Loam. The soils are deep and do not contain groundwater near the surface. Soils around the edge of project site and adjacent to Salt Creek are thinner than in the central portion. Vegetation consists primarily of piñon, juniper, shrubs and grasses.

6.3.2 New Facilities

The Cibecue Unit would irrigate approximately 1,079 acres of land adjacent to Salt Creek, of which 720 acres would be fruit orchards or vineyards and 359 acres would be center pivot irrigation for row crops. The Unit is delineated into two subunits: Orchard and Center Pivot. The Orchard Unit is delineated by Salt Creek on the north and the project extents on the south and the Center Pivot Unit is delineated by Salt Creek on the south and the project extents on the north. Diversion facilities and conveyance systems for these two sub-units are standalone and not interconnected. Salt Creek Reservoir provides storage for both subunits (Figure 6-7).



ORCHARD SUB-UNIT					
Field ID	**Type**	**Acreage**	**Field ID**	**Type**	**Acreage**
CA01	Apple Trees	40	CA10	Apple Trees	40
CA02	Apple Trees	40	CA11	Apple Trees	40
CA03	Apple Trees	40	CA12	Apple Trees	40
CA04	Apple Trees	40	CA13	Apple Trees	40
CA05	Apple Trees	40	CA14	Apple Trees	40
CA06	Apple Trees	40	CA15	Apple Trees	40
CA07	Apple Trees	40	CA16	Apple Trees	40
CA08	Apple Trees	40	CA17	Apple Trees	40
CA09	Apple Trees	40	CA18	Apple Trees	40
720 Total Acres - Apple Orchard					

CENTER PIVOT SUB UNIT		
Field ID	**Irrigation**	**Acreage**
C01	Pivot	130
C02	Pivot	70
C03	Pivot	130
C04	Pivot	70
400 Total Acres		

Canal Structure

Diversion

Pump Station

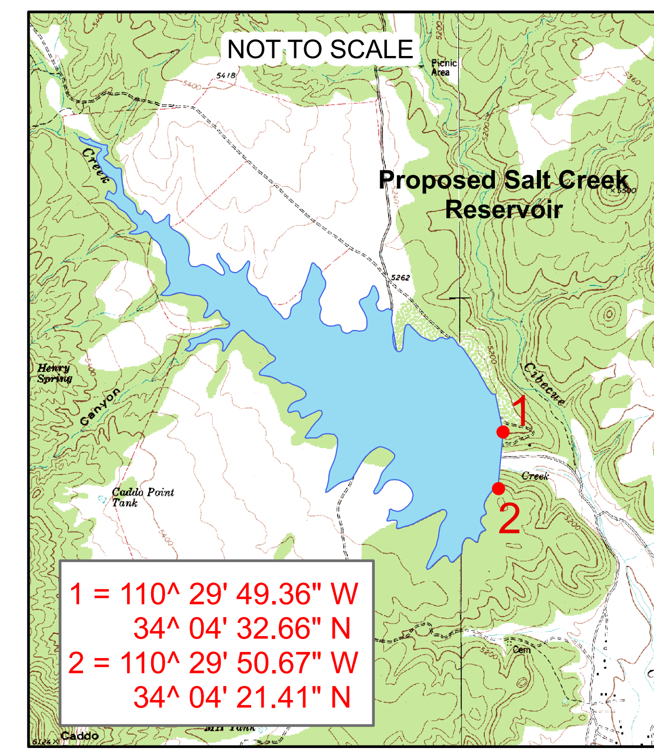
Canals

Pipeline

Orchards

Pivot

Reservoir



MINER FLAT DAM
PROJECT EXTENSION REPORT

CIBECUE IRRIGATION UNIT

FIGURE

NUMBER
6-7

6.3.3 Storage Facilities

Irrigation water storage for the Cibecue Unit would be accomplished by constructing a dam on Salt Creek, just upstream of the confluence of Salt Creek and Cibecue Creek. Water availability and dam features are discussed in earlier sections. The proposed roller-compacted concrete (RCC) concrete dam does not required integrated diversion facilities for the sub-units. The outlets and spillways would only be required to pass minimum flows or flood flows. Diversion facilities for the subunits consist of reservoir intakes and pump stations for each of the individual sub-units constructed down the slopes of the reservoirs. These diversion facilities results in a lower total overall construction costs that constructing one large run of the river diversion facility centrally located within the project area.

Water availability is limited in Salt Creek, therefore, water for the Salt Creek Reservoir would be diverted from Cibecue Creek approximately 1 mile upstream from the project site. This diversion would be accomplished by utilizing a diversion dam/headgate system and an open channel to the Salt Creek Reservoir. Elevation differences would require that the water in the open channel be dropped into the reservoir. It is anticipated that the diversion dam would be a rubber dam system that could be used during the irrigation season and laid flat during the remainder of the year. The diversion dam and appropriate gating systems with automated controls would allow minimum flow requirements in Cibecue Creek and to pass flood flows as well as provide the ability to operate the system remotely.

6.3.4 Diversion Facilities

Diversion facilities discussed below only relate to the individual sub-units. Discussion of the diversion of Cibecue Creek water to the Salt Creek Reservoir is discussed above. Both the Center Pivot Sub-Unit and the Orchard Sub-Unit have their own standalone diversion facilities.

6.3.5 Center Pivot Sub-Unit

A reservoir intake and pump station to supply the Center Pivot Sub-Unit from the Salt Creek Reservoir would also be necessary. It would consist of inclined wetwells/intakes down the reservoir slopes with screened inlets. Three pumps, each sized for one-third of the design flow of 3,000 gpm (6.7 cfs) with a maximum head of 320 feet would be installed in the wetwells/intakes. On the discharge side of the pumping units, air release valves, flow control valves, check valves, isolation valves, and surge control facilities would be installed. The pumping units would also be equipped with controls to stop operation under low pressure, high pressure, or high temperature conditions. Flows from the pumping station would be monitored for system pressure, instantaneous flow, and accumulated flow.

The pump station would be equipped with a SCADA system that would allow for remote operation and monitoring. System information such as instantaneous flow, system pressure, pump operation, and system failure would be transmitted back to the central irrigation control.

Electrical service for the pumping station would be constructed from the 3-phase transmission facilities located near Cibecue.

6.3.6 Orchard Sub-Units

A reservoir intake and pump station to supply the Orchard Sub-Unit from the Salt Creek Reservoir would also be necessary. It would consist of inclined wetwells/intakes down the reservoir slopes with screened inlets. Three pumps, each sized for one-third of the design flow of 5,400 gpm (12.0 cfs) with a maximum head of 250 feet would be installed in the wetwells/intakes. On the discharge side of the pumping units, air release valves, flow control valves, check valves, isolation valves, and surge control facilities would be installed. The pumping units would also be equipped with controls to stop operation under low pressure, high pressure, or high temperature conditions. Flows from the pumping station would be monitored for system pressure, instantaneous flow, and accumulated flow.

The pump station would be equipped with a SCADA system that would allow for remote operation and monitoring. System information such as instantaneous flow, system pressure, pump operation, and system failure would be transmitted back to the central irrigation control.

Electrical service for the pumping station would be constructed from the 3-phase transmission facilities from near Cibecue.

6.3.7 Water Conveyance System

From the Center Pivot Sub-Unit pump station, water would be delivered to the sub-unit through a network of pipes to the individual fields ranging in size from 8-inch to 24-inch Class 100 or Class 125 PIP PVC pipe or Class 165 C905 PVC pipe depending of the pressure. An estimated 10,000 feet of PVC pipe would be installed for the transmission pipeline and branch lines. The transmission pipeline and branch lines would be installed with isolation valves, air valves, and blowoff valves for maintenance. Pressure reducing facilities, where necessary, would be installed to protect the pipeline.

The Orchard Sub-Unit would be supplied from the inclined wetwell/intake pump station in the regulating reservoir. This pump station would discharge to a transmission pipeline to the small regulating reservoir located in the middle of the 160-acre orchard parcel with the highest elevation. Water would be conveyed to the remaining regulating reservoirs for the orchards by the means of buried pipes and headgate control systems. An estimated 3,300 feet of PVC pipe would be installed for the transmission pipeline. The transmission pipeline and branch lines would be installed with isolation valves, air valves, and blowoff valves for maintenance. The buried pipes to the regulating reservoirs would consist of approximately 7,000 feet of 24-inch diameter pipe.

6.3.8 Irrigation System

The sub-units are delineated based upon their irrigation type. To aid in the preliminary design of the orchard irrigation system, the orchards have been laid out on the basis of a quarter-section subdivisions (160 acres).

The concept for the orchard irrigation was to provide undertree sprinkler irrigation for normal irrigation and frost protection, and overtree sprinkler irrigation for required cooling. The undertree and overtree application system require separate manifolds and piping systems due to different spacing and application requirements. In addition, the undertree frost protection demands are approximately 8 times the peak irrigation demand, requiring separate pumping facilities. Since the frost protection demands are significantly greater than the peak irrigation demands, individual regulating reservoirs for each 160-acre parcel would be used during frost protection events. Diesel generators would be included with each pumping facility to provide backup power for the undertree frost protection system in the event of a power outage.

Each 160-acre parcel (or subdivision of smaller size) would consist of a central regulating reservoir, booster pump station, sand filtration system, and zoning facilities. Larger parcels would be zoned to a maximum of 40-acres zones. Distribution manifolds and branch lines consisting of PVC and small diameter HPDE pipe would supply the sprinklers for the over and undertree watering system.

Each parcel would be equipped with its own central electrical and control system. The control system would utilize soils moisture monitoring probes to regulate the supply of water. Information such as pump operation and soil moisture conditions would be transmitted to the nearest SCADA node for relay back to the central irrigation control system.

Center pivots in the Center Pivot Sub-Unit were sized according to available irrigable area and most cost effective pivot spans. The area north of Salt Creek Reservoir was determined to be suitable for center pivot irrigation. The center pivot layout provides two standard quarter section pivots (approximately 130 acres) and two shorter span pivots (approximately 70 acres). Three of the four center pivots are positioned in a "nested" arrangement. This nesting maximizes available irrigation acres within the area, while minimizing the costs for the center pivot supply pipelines, controls, and electrical facilities. The area between the nest of center pivots would house the main water supply pipeline, center pivot manifolds, electrical connections, and pivot control panels. Operators would not need access to the center pivot tower unless there is a need for maintenance. The remaining center pivot is located to maximize irrigated area.

Each center pivot would be equipped with a control system that would be transmitted back to the central irrigation control system.

6.3.9 Life-Cycle Costs

The lifecycle costs of Cibecue irrigation are presented in Table 6-6 totaling $126,908 million.

TABLE 6-6

CIBECUE IRRIGATION UNT
LIFE-CYCLE COSTS

Discount Rate, %	3%	
Interest Rate, %	4.5%	
Project Life, years	100	
Substantial Completion, year	3	
Cost Feature		Cibecue Irrigation Unit
Construction		
Total Field Costs		
Salt Creek Dam		40,320,000
Recreation Facilities		10,000,000
Pump Stations & Diversions		4,286,000
Conveyance: Pipelines & Canals		1,733,000
Irrigation Application		5,255,000
Subtotal		61,594,000
Contingency	15%	9,239,000
Total Contract Costs		70,833,000
Non-Contract Costs		
Environmental Mitigation	0.50%	354,000
Federal Oversight	2.50%	1,771,000
Contract Administration	6.25%	4,427,000
Pre-Construction Investigations	3.00%	2,125,000
Design, Surveys and Geotechnical	0.75%	531,000
Designed Plans and Specifications	5.75%	4,073,000
Construction Observation	6.75%	4,781,000
Sutotal	25.50%	18,062,000
Total Project Costs		88,895,000
Present Value Project Costs		$86,331,000
Interest During Construction		8,001,000
PV IDC		7,693,000
Operation, Maintenance and Replacement (OMR)		
Annual Energy		
Pump Stations		105,000
Irrigation Application		66,000
Subtotal		171,000
Annual Operation and Maintenance (OM)		
Labor		332,000
Materials and Supplies		254,000
Subtotal		586,000
Present Value Annual OM		22,547,000
Present Value of Future Replacements		10,337,000
Total Present Value OMR		32,884,000
Present Value Life Cycle Costs		126,908,000

6.4 Bonito Creek Irrigation

The Bonito Prairie irrigation project is located south of the communities of Fort Apache and Whiteriver on an area known as Bonito Prairie. Project lands are located on three flats. The western most area is bounded by Sevenmile Rim on the northwest and Turkey Creek on the southeast. The middle project area is bounded by Turkey Creek on the Northwest and Bonito Creek on the southeast. The eastern most project area is bounded by Bonito Creek on the northwest and Willow Creek on the southeast. The majority of the project lands range in elevation from 5,800 feet to 6,200 feet. The project area is entirely within the Bonito Creek watershed which discharges to the Black River. The Bonito Prairie Irrigation Unit is shown in Figure 6-8.

Seven Mile Road enters the project area from the northwest and traverses through the middle of the project area from northwest to southeast. This road connects the project lands with the community of Fort Apache which lies approximately 15 miles to the northwest.

The proposed Bonito Creek Dam would create reservoir storage necessary for irrigation of the Bonito Prairie Unit. The damsite is located on Bonito Creek at the northern edge of the project area just upstream of the confluence of Bonito Creek and Tonto Creek.

6.4.1 Project Lands

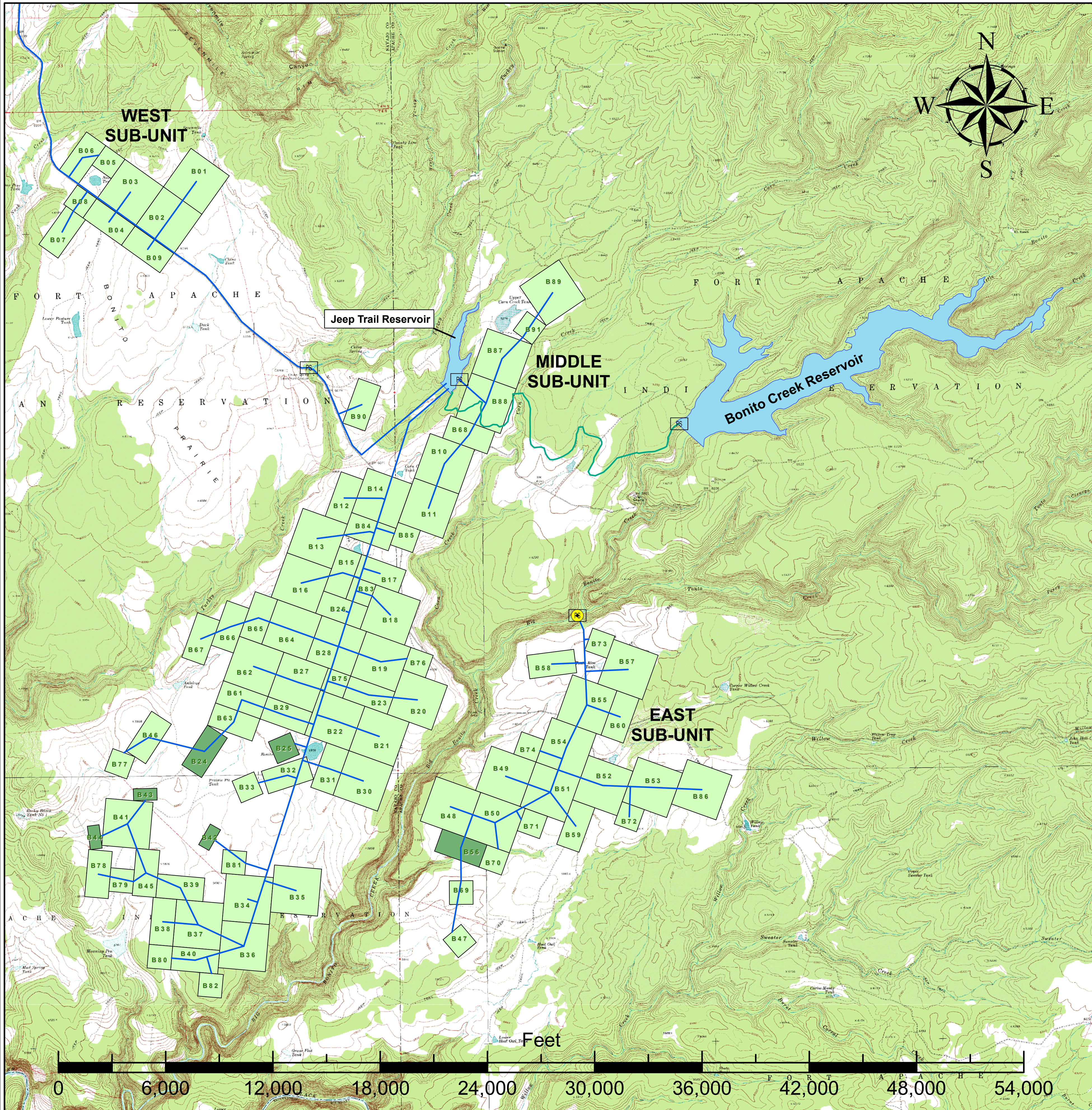
The soils of project area are discussed in the Bonito Prairie Soil Survey included in Appendix X.

The natural slope of the land and the presence of Turkey Creek and Bonito Creek through the middle of the site provide good drainage conditions throughout the project lands.

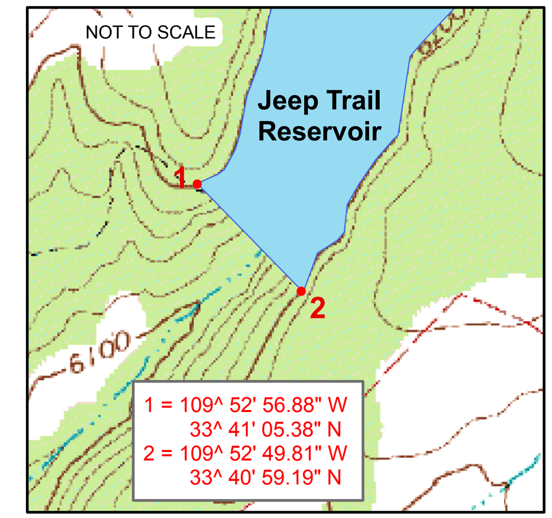
Soils in the Bonito Prairie Unit consist primarily of NRCS-classified soils Springerville Cobbly Clay and Thunderbird Cobbly Clay Loam. The soils are deep and do not contain groundwater near the surface. Soils around the edge of project site and adjacent to Turkey Creek and Bonito Creek are thinner than in the central portion. Vegetation consists primarily of piñon, juniper, shrubs and grasses.

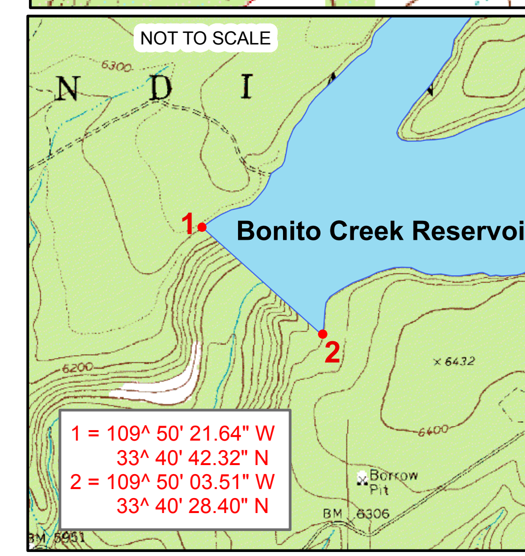
6.4.2 New Facilities

The Bonito Prairie unit would irrigate approximately 9,060 acres of land within the defined project area, off which 8,560 acres would be poplar groves and 500 acres would be Christmas tree groves. The unit is further delineated into three subunits: West, Middle, and East. The West Sub-Unit is delineated by Turkey Creek on the southeast, the Middle Sub-Unit is delineated by Turkey Creek on the northwest and Bonito Creek on the southeast, and the East Sub-Unit is delineated by Bonito Creek on the northwest. Diversion facilities and conveyance systems for these three sub-units are not standalone and are not interconnected. Bonito Creek Reservoir provides storage for all three subunits.



WEST SUB-UNIT			MIDDLE SUB-UNIT						EAST SUB-UNIT		
Field ID	Type	Acreage	Field ID	Irrigation	Acreage	Field ID	Irrigation	Acreage	Field ID	Irrigation	Acreage
B01	Poplar	160	B24	X-Mas Trees	80	B62	Poplar	160	B47	Poplar	40
B02	Poplar	160	B25	X-Mas Trees	40	B63	Poplar	80	B48	Poplar	160
B03	Poplar	160	B26	Poplar	80	B64	Poplar	160	B49	Poplar	160
B04	Poplar	80	B27	Poplar	160	B65	Poplar	80	B50	Poplar	160
B05	Poplar	40	B28	Poplar	160	B66	Poplar	80	B51	Poplar	160
B06	Poplar	80	B29	Poplar	80	B67	Poplar	80	B52	Poplar	160
B07	Poplar	80	B30	Poplar	160	B68	Poplar	80	B53	Poplar	160
B08	Poplar	40	B31	Poplar	80	B75	Poplar	40	B54	Poplar	160
B09	Poplar	80	B32	Poplar	80	B76	Poplar	40	B55	Poplar	160
MIDDLE SUB-UNIT			B33	Poplar	40	B77	Poplar	40	B56	X-Mas Trees	80
B10	Poplar	160	B34	Poplar	160	B78	Poplar	80	B57	Poplar	160
B11	Poplar	160	B35	Poplar	160	B79	Poplar	40	B58	Poplar	80
B12	Poplar	80	B36	Poplar	160	B80	Poplar	40	B59	Poplar	80
B13	Poplar	160	B37	Poplar	160	B81	Poplar	40	B60	Poplar	80
B14	Poplar	160	B38	Poplar	80	B82	Poplar	40	B69	Poplar	40
B15	Poplar	80	B39	Poplar	80	B83	Poplar	40	B70	Poplar	40
B16	Poplar	160	B40	Poplar	80	B84	Poplar	80	B71	Poplar	40
B17	Poplar	80	B41	Poplar	160	B85	Poplar	40	B72	Poplar	40
B18	Poplar	160	B42	X-Mas Trees	20	B87	Poplar	160	B73	Poplar	40
B19	Poplar	160	B43	X-Mas Trees	20	B88	Poplar	160	B74	Poplar	40
B20	Poplar	160	B44	X-Mas Trees	20	B89	Poplar	160	B86	Poplar	160
B21	Poplar	160	B45	Poplar	80	B90	Poplar	80			
B22	Poplar	160	B46	Poplar	80	B91	Poplar	40	TOTAL ACRES = 9140		
B23	Poplar	80	B61	Poplar	80	TOTAL POPLAR TREES = 9080 ACRES			TOTAL CHRISTMAS TREES = 260 ACRES		





Pump Stations — Canal — Pipeline — Christmas Trees

Diversions — Reservoir

Canal Structures — Poplar Trees

MINER FLAT DAM
PROJECT EXTENSION REPORT

BONITO PRAIRIE IRRIGATION UNIT

FIGURE
NUMBER
6-8

6.4.3 Storage Facilities

Irrigation water storage for the Bonito Prairie Unit would be accomplished by constructing a dam on Bonito Creek, just upstream of the confluence of Bonito Creek and Tonto Creek. Dam features are discussed in earlier sections. The proposed roller-compacted concrete (RCC) dam would be constructed to allow for two modes of diversion, with a pumped diversion supplying water to the Jeep Trail Regulating Reservoir for the West and Middle Sub-Units, and a run-of-the-river diversion for the East Sub-Unit. These diversion facilities result in a lower total overall construction costs than constructing one large run-of-the-river diversion facility centrally located within the project area.

The Jeep Trail Regulating Reservoir would be utilized to provide regulating storage for the West and Middle Units. The regulating reservoir would be an earthen embankment dam constructed of nearby impervious materials. Regulating storage would be approximately 2,500 acre-feet between elevation 6,110 and 6,200 feet. Regulating storage would be provided by three separate outlet facilities to the West Sub-Unit and the Middle Sub-Unit. Low level releases located above the anticipated sediment storage level of the regulating reservoir would be used to supply water under gravity to the lower portion of the Middle Sub-Unit and to a booster station that would serve the Western Sub-Unit. A reservoir intake and pump station would be used to serve the upper portion of the Middle Sub-Unit.

6.4.4 Diversion Facilities

As stated previously, two modes of diversion would be used for the Bonito Creek Reservoir, a run-of-the-river release for the East Sub-Unit, and a pumped diversion supply for the West and Middle Sub-Units.

6.4.5 Eastern Sub-Unit

Releases to Bonito Creek for the Eastern Sub-Unit would be from a diversion dam and pump station located on Figures 6-8 on Bonito Creek downstream from the storage dam. The diversion dam would consist of a rubber dam constructed across Bonito Creek adjacent to the northwestern corner of the East Sub-Unit. The rubber dam would be used during the irrigation season and would be lowered during the remainder of the year. A screened inlet pipe would be constructed from the thalweg upstream of the diversion dam to the wetwell of the pump station. Inflow to the wetwell would be controlled by slidegates within the wetwell. The wetwell and pump station would be constructed above the 100-year floodplain of Bonito Creek at the diversion point. The rubber dam would be equipped with controls that would lower the dam in the event of high water events.

The capacity of the pumping station was based upon a peak consumptive use of 7.5 gallons per minute per acre. Total pumping capacity for the 2,200 acre subunit was estimated at 16,500 gpm (36.7 cfs). The pumping station would be capable of sufficient pressure to reach elevation 6,200 feet, to overcome friction losses in conveyance, and to provide sufficient pressure for low pressure center pivots. The total dynamic head was estimated to range between 400 and 500 feet. The pump station would consist of a vertical turbine/wetwell installation. A minimum of four pumps each sized at one-quarter of the design flow that would be installed into the trench-type wetwell. An intake manifold connecting all pumps would be constructed. On the discharge side of the pumping units, air release valves, flow control valves, check valves, isolation valves, and surge control facilities would be installed. The pumping units would also be equipped with controls to stop operation under low pressure, high pressure, or high temperature conditions. Flows from the pumping station would be monitored for system pressure, instantaneous flow, and accumulated flow.

The pump station would be equipped with a SCADA system that would allow for remote operation and monitoring. System information such as instantaneous flow, system pressure, pump operation, and system failure would be transmitted back to the central irrigation control.

Electrical service for the pumping station would either be constructed from the 3-phase transmission facilities along Highway 73 near Fort Apache, or from potential hydropower development at Bonito Creek Dam.

6.4.6 West and Middle Sub-Units

A pump station to supply the canal to the Jeep Trail Regulating Reservoir would be necessary to lift water from the anticipated low water level of the Bonito Creek Reservoir to the canal base elevation of 6,240 feet. If reservoir levels in the reservoir are sufficiently high, the water would be diverted without the necessary lift. At water surface elevations below 6,240 feet in the reservoir, lift pumps equipped with Variable Frequency Drives (VFDs) would provide the necessary input power to supply the canal.

The pump station would be constructed integrally with the RCC dam. It is anticipated that a concrete wetwell with a low level inlet in the reservoir would be constructed with a discharge point into the canal system. Staged axial flow pumps would be installed in the integral wetwell to lift the water. The total capacity of the pump station based on 7.5 gallons per minute per acre would be 52,000 gpm (115.8 cfs) at a maximum head of 200 feet. A minimum of five pumps each sized at one-fifth of the total design capacity would be installed into the wetwell. On the discharge side of the pumping units, air release valves, flow control valves, check valves, isolation valves, and surge control facilities would be installed. The pumping units would also be equipped with controls to stop operation under low pressure, high pressure, or high temperature conditions. Flows from the pumping station would be monitored for system pressure, instantaneous flow, and accumulated flow.

A separate reservoir intake and pump station to supply the northern portion of the Middle Sub-Unit from the Jeep Trail Regulating Reservoir would also be necessary. It would consist of inclined wetwells/intakes down the reservoir slopes with screened inlets. Three pumps, each sized for one-third of the design flow of 6,900 gpm (15.4 cfs) with a maximum head of 250 feet would be installed in the wetwells/intakes. On the discharge side of the pumping units, air release valves, flow control valves, check valves, isolation valves, and surge control facilities would be installed. The pumping units would also be equipped with controls to stop operation under low pressure, high pressure, or high temperature conditions. Flows from the pumping station would be monitored for system pressure, instantaneous flow, and accumulated flow.

A separate booster pump station to supply the West Sub-Unit from the Jeep Trail Regulating Reservoir would also be necessary. The booster pump station would be installed just northwest of Turkey Creek. The booster pump station would have a gravity flow inlet from the Jeep Trail Regulating Reservoir. A packaged booster pump station consisting of three split-case centrifugal pumps or comparable pumps each sized at one-third of the design flow of 7,200 gpm at 250 feet TDH and a discharge manifold would be installed. The low level outlet supply from the Jeep Trail Regulating Reservoir could be combined with the low level outlet for the southern portion of the Middle Sub-Unit or installed separately. The pumping units would also be equipped with controls to stop operation under low pressure, high pressure, or high temperature conditions. Flows from the pumping station would be monitored for system pressure, instantaneous flow, and accumulated flow.

The southern end of the Middle Sub-Unit would be supplied by a gravity pipeline system from a low level outlet on the Jeep Trail Regulating Reservoir. The change in elevation from the minimum water level in the regulating reservoir and the center pivots would provide sufficient static pressure to operate the low pressure pivots. A control valve system to regulate the flows in the gravity pipeline would be installed just downstream from the dam. Flows through the gravity irrigation main would be monitored for system pressure, instantaneous flow, and accumulated flow.

All of the diversion systems, including pump stations and gravity pipelines would be equipped with a SCADA system that would allow for remote operation and monitoring. System information such as instantaneous flow, system pressure, pump operation, and system failure would be transmitted back to the central irrigation control.

Electrical service for the pumping stations would either be constructed from the 3-phase transmission facilities along Highway 73 near Fort Apache, or from potential hydropower development at Bonito Creek Dam.

6.4.7 Water Conveyance System

From the East Sub-Unit pump station, water would be delivered to the East Sub-Unit through a network of pipes, with the initial transmission pipeline consisting of 800 linear feet of Class 250 steel pipe to the top of the flat. From there, the transmission main would branch to the individual fields ranging in size from 6-inch to 36-inch Class 100 or Class 125 PIP PVC pipe depending on the pressure. An estimated 53,000 feet of PVC pipe would be installed for the transmission pipeline and branch lines. The transmission pipeline and branch lines would be installed with isolation valves, air valves, and blowoff valves for maintenance. Pressure reducing facilities, where necessary, would be installed to protect the pipeline.

The northern end of the Middle Sub-Unit would be supplied from the inclined wetwell/intake pump station in the regulating reservoir. This pump station would discharge to a transmission pipeline and branch lines ranging in size from 6-inch to 24-inch Class 100 or Class 125 PIP PVC pipe depending on the pressures. An estimated 15,000 feet of PVC pipe would be installed for the transmission pipeline and branch lines. The transmission pipeline and branch lines would be installed with isolation valves, air valves, and blowoff valves for maintenance.

The southern end of the Middle Sub-Unit would be supplied from a low level outlet from the regulating reservoir. Water would flow by gravity through a transmission pipeline and branch lines ranging in size from 6 inches to 48 inches of Class 100 or Class 125 PIP PVC pipe depending on the pressures. An estimated 107,000 feet of PVC pipe would be installed for the transmission pipeline and branch lines. The transmission pipeline and branch lines would be installed with isolation valves, air valves, and blowoff valves for maintenance. Pressure reducing facilities, where necessary, would be installed to protect the pipeline.

The West Sub-Unit would be supplied from the low level outlet from the regulating reservoir and a booster pump station. Water would flow by gravity to the intake side of the booster pump and then would be delivered from the booster pump to the Sub-Unit. The transmission pipeline and branch lines would range in size from 6-inches to-30 inches of Class 100 or Class 125 PIP PVC pipe depending on the pressures. An estimated 38,000 feet of PVC pipe would be installed for the transmission pipeline and branch lines. The transmission pipeline and branch lines would be installed with isolation valves, air valves, and blowoff valves for maintenance. Pressure reducing facilities, where necessary, would be installed to protect the pipeline.

6.4.8 Irrigation System

The three sub-units all consist of irrigated tree groves. To aid in the preliminary design of the irrigation system, the groves have been laid out on the basis of quarter-section subdivisions (160 acres). Approximately 500 acres of the 9,060 acres would be in Christmas tree groves, and 8,560 acres would be in poplar groves. The Christmas tree groves generally consist of 20 acre parcels with drip irrigation, while the poplar tree groves consist of 40-, 80-, or 160-acres parcels all with drip irrigation.

The drip irrigation facilities for each type of grove are would be served by a central booster pump station, sand filtration system, and zoning facilities. Larger parcels would be zoned to a maximum of 40-acres zones. Smaller parcels would not be individually zoned unless required by elevation change. Distribution manifolds and branch lines consisting of PVC and small diameter HPDE pipe would supply the dripper line for the drip system.

Each parcel would be equipped with its own central electrical and control system. The control system would utilize soils moisture monitoring probes to regulate the supply of water. Information such as pump operation and soil moisture conditions would be transmitted to the nearest SCADA node for relay back to the central irrigation control system. Electrical service for the irrigation system would be constructed from the 3-phase transmission facilities from near Fort Apache.

6.4.9 Hydropower

Potential hydropower for the Bonito Creek project would derive from releases from the Bonito Creek Dam. The Bonito Creek damsite is located nearly 25 miles from existing existing 14.4 and 69 kilovolt (kV) transmission lines near Whiteriver. The costs for interconnection of potential hydropower facilities with the transmission system are estimated at $2,500,000.

A hydropower analysis of the Bonito Creek Dam suggests that with a minimum flow release of 10 cfs plus release to the East Sub-Unit during the irrigation season of 36.7 cfs at an average design head of 180 feet would produce 1200 MWh annually during the irrigation season. Most project water supply, with the exception of releases for the East Sub-Unit, would be pumped from the storage reservoir and would not be available for a hydropower production. At $0.04 per kilowatt hour, annual hydropower revenues would reach $50,500 per year or a present value of $1,596,000 over the project life. Total project costs of the hydropower facilities including construction, non-contract costs, and contingencies were estimated at $7,750,000, and lifecycle costs would be significantly higher. Therefore, hydropower was not considered feasible.

6.4.10 Life-Cycle Costs

Table 6-7 presents lifecycle costs of the Bonito Creek irrigation project totaling $537.756 million.

TABLE 6-7

BONITO PRAIRIE IRRIGATION UNT
LIFECYCLE COSTS

Discount Rate, %	3%
Interest Rate, %	4.5%
Project Life, years	100
Substantial Completion, year	5

Cost Feature		Bonito Prairie Irrigation Unit
Construction		
Total Field Costs		
Bonito Creek Dam		138,650,000
Jeep Trail Regulating Reservoir		7,784,000
Pump Stations & Diversions		14,959,000
Conveyance: Pipelines & Canals		19,565,000
Irrigation Application		38,568,000
Recreation		10,000,000
Subtotal		229,526,000
Contingency	15%	34,429,000
Total Contract Costs		263,955,000
Non-Contract Costs		
Environmental Mitigation	0.50%	1,320,000
Federal Oversight	2.50%	6,599,000
Contract Administration	6.25%	16,497,000
Pre-Construction Investigations	3.00%	7,919,000
Design, Surveys and Geotechnical	0.75%	1,980,000
Designed Plans and Specifications	5.75%	15,177,000
Construction Observation	6.75%	17,817,000
Sutotal	25.50%	67,309,000
Total Project Costs		331,264,000
Present Value Project Costs		312,521,000
Interest During Construction		44,721,000
PV IDC		39,828,000
Operation, Maintenance and Replacement (OMR)		
Annual Energy		
Pump Stations		970,685
Irrigation Application		486,347
Subtotal		1,457,032
Annual Operation and Maintenance (OM)		
Labor		2,001,045
Materials and Supplies		575,589
Subtotal		2,576,634
Present Value Annual OM		113,246,000
Present Value of Future Replacements		72,161,000
Total Present Value OMR		185,407,000
Present Value Life Cycle Costs		537,756,000

7. FUTURE IRRIGATION BENEFITS

7.1 Purpose

The Fort Apache Indian Reservation (the Reservation) is located near the community of Whiteriver, in the eastern portion of Arizona. The Reservation is home to the White Mountain Apache Indian Tribe (the Tribe). Economic development opportunities on the Reservation include, but are not limited to, irrigated agriculture. With a sufficient and reliable water supply, a variety of crops may be produced on the Reservation. The Tribe has expressed interest in pursuing this option; however, many variables must be examined first, to ensure successful implementation of any future irrigated agriculture project on Reservation lands.

The purpose of this chapter is to perform an economic benefit cost analysis for the future irrigation project on the Fort Apache Indian Reservation. This benefit cost analysis is conducted to determine if the project is economically feasible and to quantify the future agricultural irrigation water requirements in support of the water rights claim for the White Mountain Apache Tribe. The study approach is guided by “Practicably Irrigable Acreage” (PIA) criteria, which involve determining the quantity of water sufficient to meet tribal agricultural water needs on the Reservation. The scope of the study is the identification of future irrigated agricultural water needs from tributaries to the Salt River basin on the Reservation.

This chapter also includes a detailed review of the economic analysis of crop production associated with a conceptual irrigation project on the Reservation. The economic analysis has been conducted in support of the economic feasibility study. Some of the objectives of the economic analysis are as follows: 1) to determine the suitability and selection of crops; 2) to analyze and select crop production methods; 3) to determine crop acreage and expected yields for each crop; 4) to develop crop enterprise budgets; 5) to compare crop marketing and management options; and 6) to examine other financial aspects and variables involved with the feasibility of this proposed project. The following section provides an overview of how economic analysis and feasibility tools are used (and the steps involved) to assist the Tribe in determining whether or not to pursue the construction of irrigation units and the production of crops on the Reservation.

7.1.1 Economic Analysis and Related Information

The proposed irrigation project must generate sufficient benefits over its expected life to cover the costs of development and operation. Thus, the use of benefit cost analysis is essential to perform a thorough assessment of the economic feasibility of the project. This economic evaluation is the critical link between what is technically possible and what is practical or economically beneficial for the Tribe.

Economic feasibility incorporates the concept of the time value of money, which means that benefits may accrue over time and be sufficient to cover a large, up-front expenditure of cost. Economic feasibility also includes discounting at an appropriate rate and may include non-marketed benefits as well (that is, benefits for which dollars are not directly exchanged). Economic feasibility allows for other social and economic values to be included in the Tribe's project justification.

Benefits in an economic cost benefit analysis can be defined as project user benefits, personal income, or increased value added produced by the society in terms of output of goods and services (including non-market services).[1] This analysis defines benefits as the net value of additional goods and services produced. Cost benefit analysis also requires defining the standing, or whose costs and benefits are to count in the analysis.[2] Since the Tribe is the jurisdiction or society determining the use of its water right in the best interest of its people, the perspective or standing of this analysis is the Tribe. The costs and benefits to the Tribal society are therefore included in the analysis.

There are a number of steps involved in determining the economic feasibility of an irrigated agriculture project. Each of these steps is listed below and will be developed and analyzed in this analysis.

1. State the goals and purposes of the project;
2. Evaluate basic resource availability;
3. Evaluate and select potential crops and yields;
4. Determine production costs;
5. Determine labor costs and benefits;
6. Determine irrigation costs;
7. Examine potential markets and crop prices;
8. Determine other non agricultural benefits and costs;
9. Establish potential project life;
10. Establish discount rates; and
11. Compute benefit – cost ratios.

7.2 Study Area

7.2.1 Overview

The Reservation spans portions of three different counties, including: Apache, Navajo, and Gila counties in Arizona. Agricultural production in the associated counties is presented below to provide details of the agricultural output in the region. The market value of agricultural products sold in 2002 totaled $8.3 million in Apache County, $2.7 million in Gila County, and $26.8 million in Navajo County.[3]

7.2.2 Agriculture in Apache, Gila, and Navajo Counties

7.2.2.1 Land Use and Crop Production

For each of the of the Arizona counties in the Reservation, the 2002 Census of Agriculture indicates that farms involved with livestock, poultry, and their products have had the

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1 "Assessing the Economic Impact of Transportation Projects: How to Choose the Appropriate Technique for Your Project", Transportation Research Circular, Number 477, October 1997.

2 Economic Valuation of Natural Resources: A Handbook for Coastal Resource Policy Makers, US DOC, NOAA, Coastal Ocean Program Decision Analysis Series No. 5, June 1995.

3 U.S. Department of Agriculture, National Agricultural Statistics Service, 2002, *2002 Census of Agriculture*, Arizona, Table 2: Market Value of Agricultural Products Sold Including Direct and Organic: 2002 and 1997, p. 210.

highest value for agricultural products sold. According to the 2002 Census, forage crops and orchards have been grown on the most acres in the tri-county region.

Table 7-1 shows harvested acres by crop type for Apache, Gila, and Navajo counties in 2002. Apache and Navajo counties had a combined total of approximately 5,500 acres of forage crops in 2002. For this same year, Gila County reported 134 acres in orchards, which represents one-third of the harvested cropland reported for this county.

Table 7-1
Harvested Acres by Crop Type
Apache, Gila, and Navajo Counties, 2002

	Apache	Gila	Navajo	Total
Crops				
Oats for Grain	54	18		72
Forage	4,308		1,281	5,589
Vegetables	25		57	82
Land in Orchards	31	134	47	212
Other	854	475	1,023	2,352
Total	5,272	627	2,408	8,307

Source: U.S. Department of Agriculture, National Agricultural Statistics Service, 2002, *2002 Census of Agriculture*, Arizona. Table 23, pp. 243-246.

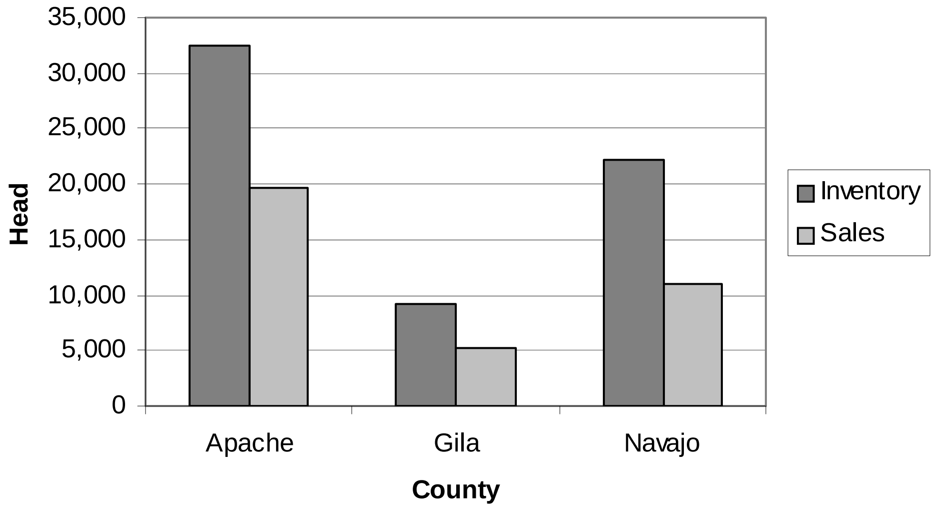
7.2.2.2 Livestock Production

Livestock production is an important part of the regional economy. The combined market value from Apache, Gila, and Navajo counties totaled $36.5 million in 2002. According to the 2002 Census of Agriculture, Apache County had 231 farms, Gila County had 79 farms, and Navajo County had 181 farms involved with livestock, poultry or their products. There were 818 farms reported for the tri-county area in 2002, suggesting that sixty percent of all farms in these counties were involved with livestock, poultry or their products.

Total livestock, poultry and related sales comprised 97 percent of the total agricultural product value in the three counties.[4] According to the 2002 Census of Agriculture, the tri-county area (Apache, Gila, and Navajo counties) accounted for eight percent of Arizona's cattle and calf inventory in 2002. The three counties had a combined total livestock inventory of 63,898 head of cattle and calves, while a total of 36,005 head were sold in 2002.

4 U.S. Department of Agriculture, National Agricultural Statistics Service, 2002, *2002 Census of Agriculture*, Arizona, Table 2, Market Value of Agricultural Products Sold Including Direct and Organic: 2002 and 1997, pp.210.

Figure 7-1
Livestock Inventory and Sales
Apache, Gila, and Navajo Counties, 2002



Source: U.S. Department of Agriculture, National Agricultural Statistics Service, 2002, *2002 Census of Agriculture*, Arizona, Table 11. Cattle and Calves, Inventory and Sales: 2002, p. 230.

7.2.2.3 Farm Size

The 2002 Census of Agriculture also provides farm size data.[5] The average farm size in Navajo County has been recorded as 15,791 acres. The average farm sizes in Gila and Apache counties have been withheld by the National Agricultural Statistics Service (NASS) to protect individual farm data.

7.2.3 Agriculture on the Fort Apache Indian Reservation

Agricultural production on the Reservation is concentrated at the Canyon Day Farm Irrigation Project. The primary use of irrigated lands is as a feed base for livestock; this feed base consists largely of mixed grass, alfalfa, or native meadow hays.[6] The vegetation in the immediate vicinity of Whiteriver, Arizona consists mainly of ponderosa pine forests. Creosote bush and mesquite grass are also in the river valleys and canyons.

7.3 Approach & Methodology

This section of the economic analysis report examines the methodology for using crop budget analysis for feasibility of the irrigation project. The analysis of the irrigation project is conducted in a series of steps. First, crop enterprises (costs and returns from producing a crop, presented on an annual, per-acre basis) are developed for crops under consideration. The crops

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5 U.S. Department of Agriculture, National Agricultural Statistics Service, 2002, *2002 Census of Agriculture,* Arizona, Table 1. County Summary Highlights: 2002, pp.204.

6 Great Western Research, Inc., November 5, 1987, "An Appraisal of the Economic Potential of Irrigable Lands on the White Mountain Apache Indian Reservation."

are reduced in number to a final set used in the conceptual plan based on the findings of the agronomists, horticulturalists, and silviculturalists. These experts determine crop suitability based on numerous factors, including but not limited to: elevation, climate, soil type and frost free days. Next, crop rotations for the selected crops are specified. This specification allows a farm unit's long-term profitability to be analyzed, and reflects its agronomic sustainability. This step is necessary because certain high-valued crops (such as cantaloupe) cannot be grown on the same field year after year; crop rotation is essential to maintain good yields and prevent disease. A minimum rotation of three crops is also a criterion for organic certification by the U.S. Department of Agriculture (USDA) for annual crops.

The set of crop rotations are analyzed in terms of their average annual net revenues, after paying for all costs of production exclusive of irrigation costs. These net revenues are interpreted as the amount of revenue available to pay for the cost of irrigation development, delivery, and application. Several of the suitable crops identified in this report are closely aligned with existing or proposed tribal ventures. These value-added activities include the following: a sawmill (hybrid poplar); an organic beef operation (organic feed crops); a processing/freeze plant (berries); and a U-Cut Christmas tree operation (Christmas trees). The Tribe will ultimately realize the benefits of all proposed projects, as each value-added activity will be organized as a tribal venture. In this analysis, the net revenues from these activities—after paying for processing, storage, and delivery—are used as the net revenues to pay for the cost of irrigation development.

The profitability of producing an agricultural commodity (crop) is dependent upon the conditions of the available market. For each crop considered in the conceptual plan, a market analysis is presented. This analysis includes an examination of the market region, including existing production and competition, and a quantitative determination of the relevant "market limit" for each crop. This market limit is an indication of the quantity, and hence number of acres, of annual production that may be reasonably produced and sold in the market.

7.3.1 Crop Budgets

Enterprise budgets represent the typical cost and returns for producing an agricultural commodity, usually presented on a per-acre basis. Year-to-year variations in actual costs and returns will occur due to weather conditions, labor use efficiencies, and normal crop yield fluctuations. However, crop enterprise budgets represent the annual costs of producing commodities under good management, when averaged over a long period of time.

Published U.S. Agricultural Extension Service budgets have been used and modified for application to the Reservation in this report. Crop yields have been adjusted from the published budgets according to recommendations of the study team's agronomist (Dr. Charles Glover), horticulturalist (Dr. Ron Walser), and silviculturalists (Dr. Jim Fisher and Dr. John Mexal). The budgets typically divide costs into variable and fixed costs, with variable costs further subdivided into pre-harvest, harvest, and post-harvest (as necessary). Variable costs change with the level of production of the commodity and are associated with farm operations such as plowing, harvesting, and applying fertilizer. Fixed costs are those components of the operation that exist independent of commodity production, such as machinery depreciation and interest on debt.

Crops included in the irrigation project are required to meet three basic criteria. These criteria are as follows:

- The crop could be produced commercially under the physical, agronomic, and climatic conditions that exist on the Reservation;
- The commodity could be effectively marketed; and
- The net returns to land, management, and irrigation could contribute significantly to paying for the project.

Each of these criteria is examined in the sections that follow. Section 7.2 of this report provided a description of the current and recent agricultural production in the region and on the Reservation. Section 7.4 presents the crops that have been considered for the project, while Section 7.5 details the results of the market analysis conducted for each commodity.

7.3.2 Discount Rate

Capital investment projects, such as the irrigation project proposed by the Tribe, invariably involve streams of benefits and costs over time. The comparison and ranking of alternative investments necessitates that these benefit and cost streams be expressed consistently. The consistency requirement, in turn, entails the use of present value and discounting methods for financial calculations. Discounting is a method that is essentially the reverse of compounding; discounting involves the expression of future values in present terms. The measure of this "time value of money" is thus the discount rate.

The discount rate has been the subject of a great deal of controversy in the economics literature, for a variety of reasons. One reason is that, in contrast to interest rates, the discount rate is not observable and is therefore subjective. Another reason is that interest rates and discount rates are not interchangeable. An interest rate measures the return that a present investment will provide over time. In contrast, a discount rate refers to the valuation of benefits today versus the future. The discount rate includes an expression of the "social rate of time preference." It reflects that individuals are naturally impatient and generally prefer present to future consumption; hence, individuals typically require more than one dollar in promised future benefits if they are to give up one dollar of consumption today.

In spite of the controversy, there is one aspect of the discount rate for which most economists are in general agreement: a real (as opposed to nominal) rate, which is free of inflation, should be used. A real rate is important because it provides a measure of the value of resources today versus the future, absent inflation. The real rate, therefore, plays an important role in evaluating investments. Similarly, it is logical to use an inflation free discount rate because benefits and costs are measured in real terms and not distorted by inflation in this analysis.

In the "Practicably Irrigable Acreage" (PIA) analysis of Reservation lands, a determination must be made of water needs for the present and all future generations. Previous Indian water rights cases (Wind River, Duck Valley, etc.) have supported real rates of return that are in the range of two percent to four percent. The White Mountain Apache Tribe places a high value on preserving their Reservation as a homeland for living and employment, as well as passing on their culture to future generations of the Tribe. As the Reservation exists for future generations, it is not for sale to private investors. Because the benefits that accrue to future generations are considered as important as any which may accrue to the present generation, a discount rate should weigh these benefits equivalently. The lower the discount rate, the closer future values become to present values.

The U.S. Department of the Interior recommends the use of a discount rate equivalent to the water resources planning discount rate (currently 7.375 percent), as published annually in the Federal Register.[7] This rate is set by a federal planning board and is based on the nominal, or market, interest rate. Therefore, the rate may not be closely related to the true "social time preference" of money. If this rate were adjusted to reflect a real, or inflation free, rate the impact of inflation must be incorporated. Inflation has recently been between 2 and 3.5 percent annually. This results in a calculation of a real discount rate between 1.875 and 3.375 percent. As the policy is only a recommendation and not a requirement, it is not used in this economic feasibility study of the irrigated agriculture project for reasons stated above. However, it is evident that the calculated real rate from the suggested water resource planning discount rate is similar to the suggested discount range of two to four percent.

In this analysis, a discount rate of three percent is applied when discounting future streams of cash flows projected for the proposed irrigation project and associated crop production. This discount rate is approximately equivalent to the following economic measurements:

1. the long-term average of (risk-free) U.S. treasury bonds;
2. the average real (inflation-free) interest rate for commercial loans; and
3. the “pure” rate of time preference across generations, which is not affected by relatively short-term financial risk.

U.S. treasury bonds with long maturities (20 and 30 years) are a good measure for the discount rate for a couple of reasons. First, bonds with long-term maturities reflect the extended period of investment for large water projects (generally over 20 years). Secondly, U.S. treasury securities are considered risk free assets because the U.S. government backs them. Risk is incorporated into this feasibility analysis through the use of conservative estimates on prices and yields in the crop production budgets, as well as conservative estimates of recreation benefits. Further information on the methodology of selecting the prices and yields used in this analysis can be found in Appendix H. Recreation benefits are described further in Chapter 8. The average rate for long term maturing U.S. securities dating back to 1919 is 2.07 percent, as shown in Table 7-2.

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7 *Federal Register*, 2004, Vol. 69, No. 236, p. 71426.

Table 7-2 - Rates for Long Term Maturing Treasury Securities, 1919 – 2006

Year	Nominal	Inflation	Real	Year	Nominal	Inflation	Real	Year	Nominal	Inflation	Real
2006	7.00%	2.71%	2.29%	1976	6.78%	7.76%	1.02%	1946	2.19%	8.33%	-6.14%
2005	4.64%	3.39%	1.25%	1975	6.98%	9.13%	-2.15%	1945	2.37%	2.27%	0.10%
2004	7.04%	2.66%	2.38%	1974	6.99%	11.04%	-4.05%	1944	2.48%	1.73%	0.75%
2003	4.96%	2.28%	2.68%	1973	6.30%	6.22%	0.08%	1943	2.47%	6.13%	-3.66%
2002	7.43%	1.58%	3.85%	1972	7.63%	3.21%	2.42%	1942	2.46%	10.88%	-8.42%
2001	7.63%	2.85%	2.78%	1971	7.74%	4.38%	1.36%	1941	2.05%	7.00%	-2.95%
2000	6.23%	3.36%	2.87%	1970	6.59%	7.72%	0.87%	1940	2.26%	0.72%	1.54%
1999	6.20%	2.21%	3.99%	1969	6.10%	7.46%	0.64%	1939	2.41%	-1.42%	3.83%
1998	7.72%	1.56%	4.16%	1968	7.25%	4.19%	1.06%	1938	2.61%	-2.08%	4.69%
1997	6.69%	2.29%	4.40%	1967	4.85%	3.09%	1.76%	1937	2.74%	3.60%	-0.86%
1996	6.83%	2.95%	3.88%	1966	4.66%	2.86%	1.80%	1936	2.69%	1.46%	1.23%
1995	6.94%	2.83%	4.11%	1965	4.21%	1.61%	2.60%	1935	2.79%	2.24%	0.55%
1994	7.41%	2.56%	4.85%	1964	4.15%	1.31%	2.84%	1934	3.12%	3.08%	0.04%
1993	6.46%	2.99%	3.47%	1963	4.00%	1.32%	2.68%	1933	3.31%	-7.11%	8.42%
1992	7.52%	3.01%	4.51%	1962	3.95%	1.00%	2.95%	1932	3.68%	-9.87%	13.55%
1991	8.16%	4.21%	3.95%	1961	3.90%	1.01%	2.89%	1931	3.34%	-8.98%	12.32%
1990	8.74%	7.40%	3.34%	1960	4.01%	1.72%	2.29%	1930	3.29%	-2.34%	7.63%
1989	8.58%	4.82%	3.76%	1959	4.07%	0.69%	3.38%	1929	3.60%	0.00%	3.60%
1988	8.98%	4.14%	4.84%	1958	3.43%	2.85%	0.58%	1928	3.33%	-1.72%	7.05%
1987	8.64%	3.65%	4.99%	1957	3.47%	3.31%	0.16%	1927	3.34%	-1.69%	7.03%
1986	8.14%	1.86%	6.28%	1956	3.08%	1.49%	1.59%	1926	3.68%	1.14%	2.54%
1985	10.75%	3.56%	7.19%	1955	2.84%	-0.37%	3.21%	1925	3.86%	2.34%	1.52%
1984	11.99%	4.32%	7.67%	1954	2.55%	0.75%	1.80%	1924	4.06%	0.00%	4.06%
1983	10.84%	3.21%	7.63%	1953	2.94%	0.75%	2.19%	1923	4.36%	1.79%	2.57%
1982	12.23%	6.16%	6.07%	1952	2.68%	1.92%	0.76%	1922	4.30%	-6.15%	10.45%
1981	12.87%	10.32%	2.55%	1951	2.57%	7.88%	-7.31%	1921	7.09%	-10.50%	17.59%
1980	10.81%	13.50%	-2.69%	1950	2.32%	1.26%	1.06%	1920	7.32%	17.61%	-10.29%
1979	8.74%	11.35%	-2.61%	1949	2.31%	-1.24%	3.55%	1919	4.73%	14.57%	-9.84%
1978	7.89%	7.59%	0.30%	1948	2.44%	8.07%	-7.63%				
1977	7.06%	6.50%	0.56%	1947	2.25%	14.36%	-12.11%	**Average**	**7.16%**	**3.09%**	**2.07%**

*Sources: US Bureau of Labor Statistics, All Urban Consumers Current Series, accessed online at http://www.bls.gov/cpi/, January 3, 2007.
Northwest Economic Associates (NEA), 1997, Economic Quantification of Nambe Reservation Reserved Water Rights, prepared for U.S. Department of Justice.
Federal Reserve Statistic Releases, Historic Data, accessed online at http://www.federalreserve.gov/RELEASES/h15/data.htm.

7.4 Crop Suitability & Selection

7.4.1 Overview

For organic crop production to be successful for the Tribe, it is imperative that all of the crops selected for cultivation are compatible with the elevation, climate, soil, and water conditions on the Reservation. Therefore, crop suitability analyses have been conducted by Dr. Charles Glover, Dr. John Mexal, Dr. Ron Walser, and Dr. James Fisher to identify specific crops that can be produced on the Reservation, under irrigated growing conditions, given the existing environmental factors. These crop experts have conducted one or more field visits to the Reservation to inspect and examine proposed areas for new irrigation to determine each area's suitability for crop production. Their approach to selecting crops is based upon climatic, soil, and water data assembled by the study team.[8]

The results of the crop suitability study indicate that under irrigated conditions, a wide variety of crops can be grown on the Reservation. This section of the report describes three aspects of the study results: 1) a review of elevation, climate, and soil conditions on the Reservation; 2) a comparative analysis of neighboring geographic areas with similar attributes and crop selections; and 3) a summary of the crops deemed most suitable for organic cultivation on the Reservation.

7.4.2 Climate and Soils Data

Irrigation units are proposed for three areas of the Reservation: Canyon Day, Cibecue, and Bonito Prairie. The best climatic data that exists for the Reservation is that which is available for the Arizona communities of Whiteriver (near Canyon Day), Cibecue, and McNary (also located on the Reservation). The climatic data for these communities has been obtained from the Western Regional Climate Center Division of Atmospheric Sciences, Desert Research Institute and is as described below.

The elevations for the proposed irrigation units at Canyon Day, Cibecue, and Bonito Prairie fall within the range of 5,000 to 6,000 feet. The nearby community of McNary is situated at an elevation of 7,340 feet. The average, annual minimum temperature of these communities ranges from 32.1 degrees Fahrenheit in McNary to 38 degrees Fahrenheit in Whiteriver. The average, annual maximum temperature ranges from 62.4 degrees Fahrenheit in McNary to 72 degrees Fahrenheit in Cibecue.[9]

Additional climate inferences have been drawn from the Arizona Plant Climate Zone Map. This map places the Canyon Day, Cibecue, and Bonito Prairie sites in Zone 2: "Cool Plateau Highlands" (elevation 4,000 to 6,000 feet). In Zone 2, winters are mostly cold, with drying winds. Zone 2 provides a growing season of 150 to 200 frost-free days. The last date of killing frost in spring for Zone 2 usually occurs in late April to mid-May, depending on location.

8 See Appendix A through D.

9 Western Regional Climate Center Division of Atmospheric Sciences, Desert Research Institute, Reno, Nevada, Arizona Climate Summaries web site accessed at http://www.wrcc.dri.edu/.

The soils data for Canyon Day and Cibecue have been gathered from the USDA Soil Conservation Service and reviewed by Dr. Walser and Dr. Glover. Most of the soils in these two areas are deep, silt-like loams intermixed with some clay. Overall, the soils on the proposed irrigation units at Canyon Day and Cibecue are ideal for fruit, vegetable, and grain crops. More detailed information on soils quality is available in Sections 7.7, 7.8 and 7.9 below.

Regarding the Bonito Prairie irrigation site, Dr. Mexal and Dr. Fisher have analyzed soils data provided by Buchanan Consultants from a soils study involving 41,000 acres of Bonito Prairie. The soils study pertained to soil characteristics impacting the suitability of poplar and Christmas tree production at Bonito Prairie. The soils study has concluded that approximately half of that land (20,500 acres) is suitable for irrigated poplar and Christmas trees. More detailed information regarding the soils study is available in the report titled, "Soil Survey of the Bonito Prairie: White Mountain Indian Reservation."

7.4.3 Similar Production Areas

In the agronomy reports prepared by Dr. Walser, Dr. Mexal, Dr. Fisher, and Dr. Glover, reference is made to the cultivation of the proposed crops in similar climatic and geographical areas. The elevation and climatic conditions of the Reservation are similar to other crop production areas in the Four Corners region, including areas within New Mexico and Colorado.

Farmington, New Mexico is approximately 200 miles from Whiteriver, Arizona and is near the Navajo Agriculture Products Industry (NAPI) site. NAPI is the largest, contiguous piece of farmland in the nation, with over 60,000 acres currently under cultivation. The NAPI site is known for high technology crop production and quality agricultural products. The crops grown on NAPI lands include the following: alfalfa, corn, potatoes, beans, hybrid poplars, and small grains.[10]

The climatic conditions of Farmington, New Mexico are very similar to the climatic conditions of the Reservation. The average annual minimum temperature of Farmington is 38.7 degrees Fahrenheit, with an average, annual maximum temperature of 66.6 degrees Fahrenheit. The average growing period for Farmington is approximately 140 to 180 days.[11]

Alcalde, New Mexico, in the neighboring County of Rio Arriba, is another production region in New Mexico that has similar climatic characteristics to the Reservation. Alcalde is home to several agricultural growers of tree fruits and berries. The average, annual minimum temperature in Alcalde is 34 degrees Fahrenheit, and the average, annual maximum temperature is 68.2 degrees Fahrenheit. The average growing period for Alcalde is approximately 130 to 165 days.[12] Both of the communities of

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10 Navajo Agriculture Products Industry web site, http://www.navajopride.com/index.php.

11 Western Regional Climate Center Division of Atmospheric Sciences, Desert Research Institute, Reno, Nevada, Arizona Climate Summaries Web Site.

12 Ibid.

Alcalde and Farmington lie just north of the latitude of the Reservation.

Alamosa, Colorado is located in the San Luis Valley. The San Luis Valley region is another production region with elevation and topographical features that are similar to those of the Reservation. Agricultural production in the San Luis Valley includes field crops such as hay, small grains, canola, seed potatoes, and short-season vegetables. At 23.6 degrees Fahrenheit, the average minimum temperature in the San Luis Valley is significantly lower than the temperature of the Reservation. Similarly, the average maximum temperature of Alamosa, at 59.2 degrees Fahrenheit, is also lower compared to the temperature of the Reservation. The growing season is also shorter at Alamosa, when compared to that of the Reservation. The San Luis Valley has approximately 85 to 110 frost-free days for growing crops, as compared to 150 to 200 frost-free days on the Reservation.

To summarize, crops proposed for irrigation on the Reservation have been proven successful and profitable at the NAPI site in New Mexico and in the agricultural areas of Alcalde, New Mexico and Alamosa, Colorado. These three areas of the Four Corners region are situated in climates that are similar to, or harsher than, the climatic conditions present on the Reservation.

7.4.4 Suitable Crops

The crop suitability analyses conducted by Dr. Charles Glover, Dr. John Mexal, Dr. Ron Walser, and Dr. James Fisher have resulted in the compilation of a list of suitable crops that can be grown under irrigated conditions on the Reservation. The set of suitable crops includes the following: hybrid poplars, Christmas trees, apples, wine grapes, peaches, cherries, raspberries, blackberries, alfalfa hay, corn, blue corn, small grains, onions, chilies, dry beans, cantaloupe, winter squash, and pumpkins. Organic cultivation practices have also been recommended in the agronomy reports for the Cibecue area and undisturbed portions of Canyon Day. See Appendices A through D of this report for a complete analysis of agronomic suitability of the Reservation for crop production.

7.5 Crop Market Summary

7.7.1 Overview

An important consideration in developing an irrigation plan for the Reservation is selecting crops that have long-term viability. Assessing the market viability of crops requires determining the impact that additional regional production will have on prices, as well as analyzing the factors affecting demand for each crop. The market for agricultural products is continually changing. Unlike manufacturing where the conditions of production are controlled, agricultural production is heavily dependent on weather, soil, farm management practices, and even consumer preferences. Demand for agricultural products has been known to shift significantly from year to year, due to the changing diet of the American consumer.

In addition to crop viability, the end use of the crop is an important factor in the analysis of crop markets. Crops can be produced specifically for the fresh market or produced for commercial processing (such as frozen foods and canned goods). If a crop is produced specifically for the fresh market, then the market analysis must focus on the fresh market demand for that specific commodity. Alternatively, crops produced for commercial processing result in a market analysis based on the market demand for commercially processed fruits, vegetables, and grains.

Generally, fresh market crops have shorter shelf lives; thus, the target markets must be relatively close to the agricultural production areas. The proposed cooling and storage facilities associated with crop production affect the shelf life and market window of the fresh market crops. In contrast, crops that are commercially processed, or are grown for processing, generally have longer shelf lives and can be transported to markets located greater distances from the site of agricultural production.

This portion of the economic analysis focuses on the long-term viability of each of the crops selected for inclusion in the Reservation's irrigation plan. (All of the food and feed crops proposed in this analysis are produced via organic methods.) The crop market analysis includes the following components: 1) identification of the market area and characteristics; 2) identification of competing production; 3) analysis of per capita consumption for each of the identified crops; and 4) quantification of reasonable market share to be attained by the Tribe as a result of their crop production. Where necessary, a market limit is determined for each applicable crop. The market limit identifies the maximum production for each crop that can occur on the Reservation without measurably affecting the market price.

To determine market regions for the individual crops proposed for the Reservation, some general criteria have been developed. These criteria are a result of research that includes analyzing specific areas for similarities in production practices, as well as analyzing the location of the individual commodity in relation to the final consumer point-of-purchase or commercial processing plant. For some crops, data is incomplete or nonexistent for a particular state or county. This situation occurs primarily when the crops in question are not tracked by the particular state’s Department of Agriculture.

7.7.2 Produce Market Characteristics

Agricultural products are produced on a seasonal basis. Demand for these products, however, is continuous for the most part. Before modern advances in technology and the transportation of goods, the problem of matching available product to consumer demand was solved through two methods: 1) the growers and shippers would first sell fresh produce during the harvest and shortly thereafter; and 2) the growers and shippers would process the remainder of the agricultural product for later consumption.

Technology advancements in food storage and shipping, coupled with a rise in consumer income, have made it possible for fresh produce to be distributed and sold year round. Today, the American consumer expects to be able to buy fresh produce from the grocery store on any given day throughout the year. Satisfying this consumer expectation requires importing fresh fruits and vegetables from around the world during the non-harvest season in the U.S., as the fresh market window is different in other parts of the world.

In the last decade there has been a shift in the relationship between the grower and shipper (referred hereafter as "grower-shipper") and the retailer. Large, retail supermarket firms have eliminated the wholesaler and are buying directly from the grower-shipper. Conversely, wholesalers are now responsible for a higher proportion of produce that is being distributed to restaurants and institutional customers. The continued growth of nontraditional produce (such as organic and ethnic or gourmet) has been a boost to wholesalers as well. Retail stores do not have the volume or current capabilities to purchase or organize truckloads of these high-margin specialty items. Brokers serve either buyers or sellers of produce by locating supplies and negotiating their sale. Although brokers still figure in the produce market channels, their number and share of sales has dropped significantly.13

In order for the Tribe to maximize market possibilities and sell produce as a wholesaler specializing in organic produce, a packinghouse will need to be built. The costs of such a facility are described below in the "Crop Production Methods and Cost" section of this report. Further information on the market channels available to the Tribe is included in Appendix E.

7.7.3 Competing Production Areas

Production of fresh fruits is largely concentrated in areas of central California, as well as the Northwestern states of Washington and Oregon. The eastern portion of the United States has also been identified as having competing production of peaches and apples. Table 7-3 below shows the distance from various competing production areas, whereas the map on the following page (Figure 2) shows where large concentrations of the fruit crops are grown within the United States. The state of Arizona is known for the production of melon crops, but it does not have a large concentration of tree fruit or berry crops. Colorado is also identified as a melon producing state; however, it is one of the few “interior states” with a significant production of fruit crops.

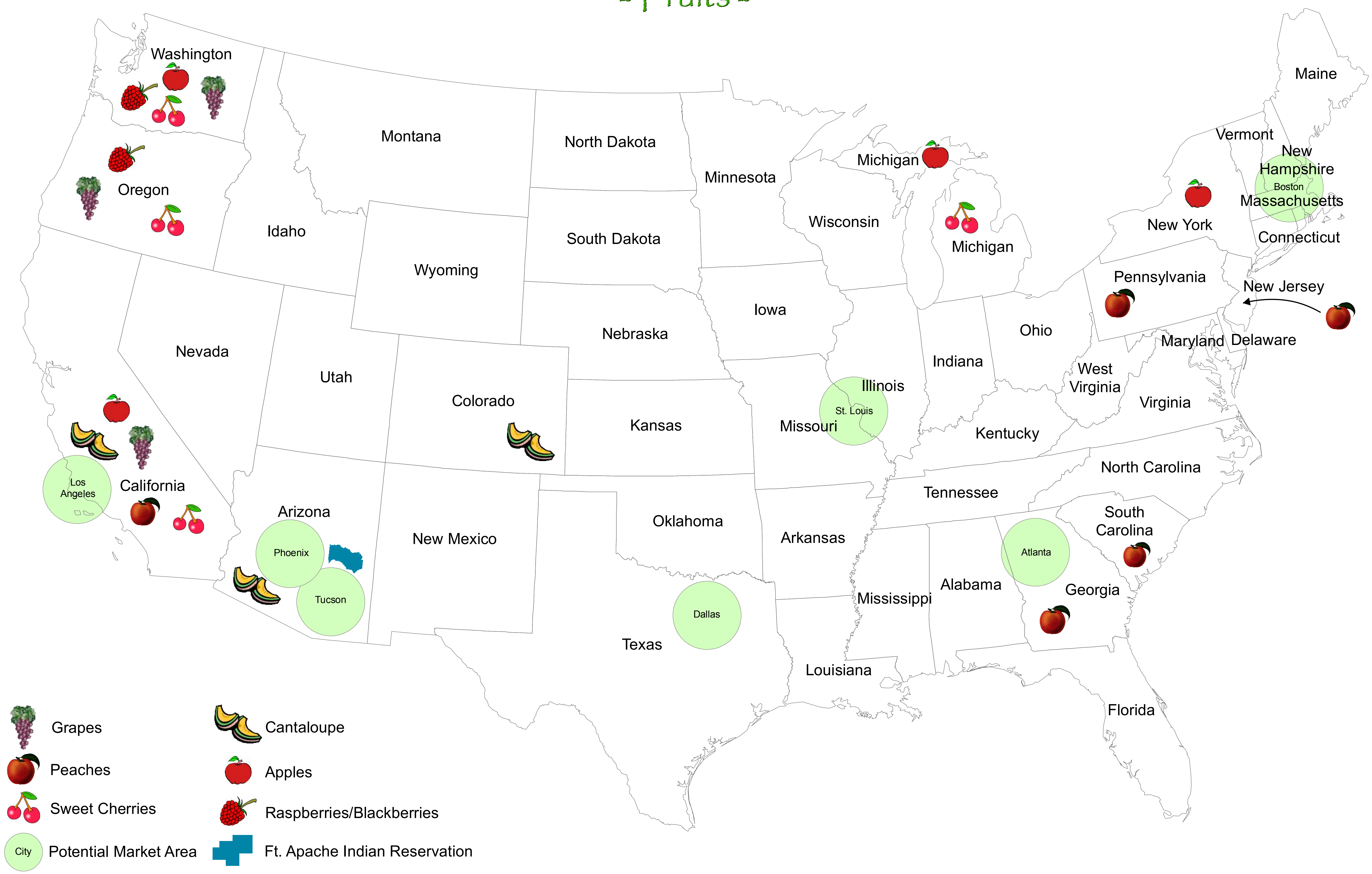
13 Kaufman, Phil, Charles R. Handy, Edward W. McLaughlin, Kristen Park, Geoffrey M. Green, August 2000, "Understanding the Dynamics of Produce Markets: Consumption and Consolidation Grow," *Agriculture Information Bulletin No*. (AIB758) 32 pp.

Table 7-3
Distance to Terminal Markets from Competing Production Areas

	Phoenix	Tucson	Dallas	Atlanta	Boston	Los Angeles	St. Louis
Visalia, CA	552	675	1,517	2,270	3,065	183	1,908
Edgefield, SC	1,966	1,903	947	165	975	2,336	721
Knoxville, GA	1,818	1,832	799	80	1,129	2,189	654
Woodbury, NJ	2,337	2,444	1,451	754	307	2,706	896
Chambersburg, PA	2,183	2,288	1,330	660	432	2,552	742
Walla Walla, WA	1,252	1,409	1,801	2,404	2,724	1,039	1,856
Salem, OR	1,191	1,406	1,993	2,595	3,013	914	2,047
Leland, MI	1,923	2,155	1,227	913	925	2,210	589
Poughkeepsie, NY	2,500	2,548	1,615	950	200	2,830	1,000
El Centro, CA	244	300	1,230	2,012	2,844	208	1,687
Pasco, WA	1,200	1,442	1,838	2,440	2,751	1,058	1,893
Hart, MI	1,812	2,034	1,117	811	915	2,099	488
Bisbee, AZ	209	98	892	1,674	2,555	580	1,391
Salinas, CA	671	790	1,646	2,399	3,153	302	2,037
Deming, NM	301	718	1,499	2,374	702	1,276	215
Sierra Blanca, TX	519	549	1,331	2,345	891	1,152	404
Whiteriver, AZ*	171	875	1,647	2,441	542	1,283	196

*Whiteriver, Arizona is representative of the proposed location of the packinghouse for fresh produce.

Competing Areas & Target Markets
- Fruits -



The states of Washington and California are also large producers of vegetable crops, including asparagus and onions. Chili pepper production is centered in the Southwestern United States, while pinto bean and grain production is scattered throughout the Great Plains region. Christmas trees and hybrid poplar production is centered in the Northwest. The map on the following page (Figure 7-2) shows the competing areas of production for vegetables and other crops proposed for production on the Reservation.

Table 7-3 above and Figure 7-2 indicate that the proposed production of organic fruits, vegetables, and agro forestry crops are located in close proximity to both of the Phoenix and Tucson metropolitan areas in Arizona. It is also apparent from this data that the Reservation is one of the closest production areas for a variety of organic crops that could be supplied to other cities in the Metropolitan Statistical Areas (MSAs) of Dallas, Atlanta, Los Angeles, and St. Louis

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Competing Areas & Target Markets
- Vegetables & Other Crops-

7.7.4 Target Markets

7.7.4.1 Consumers of Organic Products

The demand for organic food has been consumer driven from the start. In early 2000, organic advocates from every walk of life deluged the USDA with over 325,000 comments on its proposed final rules regarding organic production. Due to this outcry of public interest and lobbying efforts, the certified organic label movement is among the most successful labeling campaigns ever initiated for food products. Consumers remain active in the political and regulatory spheres of organic food to this day; for instance, the Organic Consumers Association[14] claims to have over 850,000 members, subscribers, and volunteers.[15]

Numerous consumer studies over the years, including a 2004 study by the Hartman Group, of Bellevue, Washington, have concluded that the number one reason why consumers buy organic foods is that they believe it is healthier than non-organic foods (and therefore superior). Consumers are concerned about the use of pesticides and other chemicals in the production of food crops, as well as the use of antibiotics and hormones in animal food production. Interestingly, the 2004 study has concluded that the second most motivating factor for buying organic foods is taste. Food safety is actually the third motivating factor, followed by environmental concerns.[16]

The 2004 study has also listed the top three reasons as to why consumers do not buy organic foods. The first reason cited is that "they had never really considered them before". Price, often thought to be the primary barrier, is rated as the second most important reason in the study. Rated third as a reason why consumers do not buy organic foods is the availability or lack of availability of these products.[17]

The availability of organic foods is undergoing rapid change. For several years, The Organic Trade Association, of Greenfield, Massachusetts, has estimated that sales of organic food products have increased at an annual rate of 20 percent, since 1990. Large food manufacturers such as Frito-Lay™, The Campbell Soup Company, Unilever, and H.J. Heinz now have organic food lines using their primary label or brand. Other food company giants have organic product lines with alternative names, such as General Mills with its Cascadian Farm® brand. The Cascadian Farm brand sells "Purely O's™," which is the organic alternative to the General Mills Cheerios® brand.[18] Cascadian Farm brand is also active in marketing organic frozen vegetables and berries.

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14 www.organicconsumers.org

15 House, Greg, 2006, "A Primer on Organic Agriculture," California Chapter, American Society of Farm Managers and Rural Appraisers, *2006 Trends in Agricultural & Lease Values.*

16 Howie, Michael, March 29, 2004, "Industry Study on Why Millions of Americans Are Buying Organic Foods," accessed online at http://www.organicconsumers.org/organic/millions033004.cfm.

17 Ibid.

18 House, Greg, 2006, "A Primer on Organic Agriculture," California Chapter, American Society of Farm Managers and Rural Appraisers, *2006 Trends in Agricultural & Lease Values.*

7.7.5 Potential Metropolitan Statistical Areas

Seven MSAs have been identified in various regions throughout the U.S. as potential marketing areas for the Tribe's harvested crops. These locations have been chosen based on one or more of the following reasons: close proximity to the Tribe's proposed production area; lack of competing agricultural production nearby; easy transportation to terminal market(s); and/or a significant market opportunity for exports. The seven MSAs used in this analysis include: Los Angeles, Phoenix, Tucson, Dallas, St. Louis, Atlanta, and Boston.

As indicated by the 2004 U.S. Census, there are a total of 35 million people living in the select MSAs of the identified terminal markets shown in Table 7-4. These MSAs represent a potentially lucrative marketing opportunity for organic fruit, vegetable, and grain sales by the Tribe, given the large population of the MSAs and the Reservation's proximity advantage to terminal markets. Table 7-4 below shows the population of each MSA under consideration.

Table 7-4
Population of Select Metropolitan Statistical Areas

City	Population
Phoenix	3,715,360
Tucson	907,059
Dallas	5,700,256
Atlanta	4,708,297
Boston	4,424,649
Los Angeles	12,925,330
St. Louis	2,764,054
Total	35,145,005

Source: Annual Estimates of the Population of Metropolitan and Micropolitan Statistical Areas: April 1, 2000 to July 1, 2004 (CBSA-EST2004-01), Population Division, U.S. Census Bureau.

7.7.7.1 Population Growth in MSAs

The 2005 population figures shown in Table 7-4 above have been obtained from the Population Division of the U.S. Census Bureau, which publishes annual estimates of the population in metropolitan and micropolitan statistical areas. In this analysis, it is important to determine the growth rate of each of the seven MSAs identified as target markets for the Tribe's crop production; these predictions will enable the Tribe to select only those target markets with the most potential for growth, which is an indicator of market demand. Therefore, the 2005 U.S. population data, as well as the state and county population estimates from the U.S. Census Bureau, have been used as reference points for making derived population projections (in 5-year increments) from the year 2010 up to the year 2030 for each of the Tribe's potential target markets (see Table 7-5).

Table 7-5
Population Projections for Target Markets

	2005	2010	2015	2020	2025	2030
Phoenix	3,715,360	4,202,495	4,745,652	5,354,248	6,034,947	6,782,615
Tucson	907,059	979,765	1,058,300	1,143,129	1,234,758	1,333,731
Dallas	5,700,256	6,169,251	6,654,032	7,166,890	7,725,086	8,338,938
Atlanta	4,708,297	5,058,175	5,396,561	5,720,006	6,033,796	6,339,328
Boston	4,424,649	4,513,275	4,587,352	4,653,168	4,709,564	4,759,366
Los Angeles	12,925,330	13,652,770	14,390,190	15,137,440	15,890,043	16,657,441
St. Louis	2,764,054	2,839,284	2,909,991	2,972,474	3,027,842	3,082,885

Source: Derived from state and county population projections in addition to 2005 census population data for Metropolitan Statistical Areas (MSA), U.S. Census Bureau, April 2006.

Table 7-5 shows that the highest growth rates are anticipated in the Phoenix and Atlanta metropolitan areas, respectively. The Tribe may have a market advantage in the Phoenix metropolitan area; the Reservation's proposed crop production is located just a few hundred miles away from this target market, which is estimated to almost double in population size by the year 2030.

The projected size of the U.S. population in these target markets is used in this analysis as a general gauge of the market demand for agricultural commodities in the years to come. Given the anticipated growth in the populations of each of the seven target markets and their varied locations across the U.S., there appears to be an increasing market demand for agricultural commodities in the U.S. As the Tribe plans to cultivate 10 edible types of organic crops and sell them to wholesalers or retailers in one or more of these target markets, it is necessary to quantify the aggregate demand for agricultural commodities, on a per capita consumption basis, for each of these proposed crops. This next segment of the report addresses per capita consumption rates in more detail.

7.7.7.2 Per Capita Consumption Rates

The per capita consumption rate used in this analysis is published annually in the "Fruit and Nut Yearbook" and "Vegetable and Melon Yearbooks", all of which are publications of the Economic Research Service (ERS) of the USDA. The per capita consumption rate is used as the basis for calculating an adjusted, per capita consumption rate that is indicative of the estimated size of the market demand (in the target markets) for the edible crops produced by the Tribe. In other words, the size of commodities demanded in the target market has been derived through the use of an adjusted per capita consumption rate. The adjusted rate is calculated by collecting data from the past seven years, subtracting the high and low rates, and then averaging the remaining five years of data. Table 7-6 below shows the adjusted per capita consumption rates of the edible agricultural commodities proposed for production on the Reservation.

Table 7-6
Per Capita Consumption Rates, Adjusted for 1998 – 2005

Crop	Consumption
Apple	17.6
Asparagus	0.96
Cherry	0.72
Cantaloupe	10.9
Chili Pepper	7.2
Onion	20.7
Peach	7.3
Raspberry (processed)	0.17
Blackberry (processed)	0.08
Raspberry (fresh)	0.33
Blackberry (fresh)	n/a
Dry Bean	6.9

Source: Fruit and Nut Yearbook, Vegetable and Melon Yearbooks, Economic Research Service (ERS), USDA, 2005

7.7.7.3 Wholesale Market Prices for Fresh Produce

An historical look at average wholesale market prices can assist the Tribe in estimating revenue projections for organic fruits, vegetables, and grains that are to be sold in the identified target markets. Therefore, wholesale market price data has been obtained for the proposed crops in the select terminal market regions. This data is collected by the Agricultural Marketing Service (AMS), which is a division of the USDA; the data is published in the AMA's Fruit and Vegetable Market News reports and is also posted on the AMS web site.

In this analysis, a ten percent price premium for certified organic produce has been applied to the wholesale prices gathered through AMS for conventional fresh produce. (See Appendix E for additional information regarding price premiums of organic crops.) Table 7-7 below is a compilation of average wholesale market prices for fresh produce for the past three years; these prices have been taken during the harvest periods of the various crops and include the ten percent organic price premium as described above.

Table 7-7
Average Wholesale Market Prices, Per Cwt, 2003 – 2005**

	Apple	Asparagus	Cherry	Cantaloupe	Chili	Onion	Peach
Atlanta	$60.14	$172.37	$212.12	$34.43	$127.90	$30.83	$69.03
Boston	$69.28	$173.96	$298.01	$36.84	$183.01	$29.49	$94.32
Dallas	$63.91	$187.28	$249.11	$33.71	$166.03	$27.97	$77.44
Los Angeles	$56.61	$177.50	$253.37	$21.58	$67.66	$27.43	$99.59
St. Louis	$58.98	$163.21	$261.10	$32.45	$113.67	$29.20	$77.03
Phoenix & Tucson*	$56.61	$177.50	$253.37	$21.58	$67.66	$27.43	$99.59

Source: Market News Portal, Agriculture Marketing Service, USDA, accessed online at http://marketnews.usda.gov/portal/fv

Phoenix & Tucson Price data is assumed to be the same as Los Angeles, no data specific to Phoenix or Tucson is tracked by AMS. **No wholesale price data is available for Dry Bean in the select terminal markets, as it is listed as a food grain instead of produce.

7.7.7.4 Transportation Costs

The proposed location of the irrigation units on the Reservation will be in the heart of the Four Corners region. Transportation of products from this site will most likely be accomplished through semi-trailer, flat bed, or refrigerated truck. Access to Route 60, a state route which runs through the Reservation, will enable freight to be transported through any of the major interstates in the Southwest. Freight charges for a refrigerated truck are assumed to be $1.90 per mile for a 10,000 pound load.[19] This is a conservative estimate, as some refrigerated truckloads are 40,000 pounds. The cost of transportation in this analysis is, therefore, $0.019 per hundredweight per mile. The table below shows the transportation costs of a refrigerated truck service from Whiteriver, Arizona to the potential target market MSAs.

Table 7-8
Transportation Costs (per Cwt) from Whiteriver, Arizona to Terminal Markets

	Phoenix	Tucson	Dallas	Atlanta	Boston	Los Angeles	St. Louis
Cwt	$3.25	$3.72	$16.63	$31.28	$46.37	$10.29	$24.38
Truck	$325	$372	$1,663	$3,128	$4,637	$1,029	$2,438

Assumptions: $0.019 per cwt per mile, a truckload is 10,000 pounds

7.7.7.5 Derived Farm Price

The derived farm prices shown in Table 7-9 below are representative of net prices that the Tribe could expect to receive if they were to market their fresh produce from the Reservation in Whiteriver, Arizona to various wholesale terminal markets. A comparison

19 Fruit and Vegetable Truck Rate Report, Washington DC, WA_FV190, www.ams.usda.gov/mnreports/wa_fv190.txt.

of these figures is helpful in identifying target markets with the most potential revenue for marketing the crops produced on the Reservation.

These derived farm prices per commodity are calculated using the average wholesale price reported over the past three years and include a ten percent price premium for certified organic produce (described previously and shown in Table 7-8 above). Additionally, the derived farm prices for the select terminal markets are accounted for after paying freight expenses.

Table 7-9
Derived Farm Prices, Per Cwt Select Terminal Markets

	Apple	Asparagus	Cherry	Cantaloupe	Chili	Onion	Peach
Atlanta	$28.85	$141.09	$180.83	-	$94.62	-	-
Boston	-	$127.59	$251.63	-	$136.64	-	$47.95
Dallas	$47.28	$170.66	$232.48	$17.08	$149.41	$11.34	$60.81
Los Angeles	$46.32	$167.21	$243.09	$11.29	$57.37	$17.14	$89.30
St. Louis	$34.60	$138.83	$236.72	-	$89.29	-	$50.65
Phoenix	$53.36	$174.25	$250.12	$18.33	$64.41	$22.18	$96.34
Tucson	$52.89	$173.78	$249.65	$17.86	$63.94	$21.71	$97.87

Prices marked by "-" have not been included in this analysis because the returns to the derived farm prices have not been adequate to justify marketing efforts.

The blank cells in Table 7-9 indicate the locations where derived farm prices have resulted in returns to the crop that are not adequate to justify marketing efforts. Only the locations with derived farm prices high enough to justify marketing efforts are included as target markets for the individual crops produced on the Reservation. As Table 7-9 shows, the Tribe is expected to receive the highest apple, asparagus, cantaloupe, onion, and peach prices in the terminal markets of Phoenix and Tucson, both of which are located in close proximity to crop production areas on the Reservation. Cherry prices are also the second highest in these markets as well.

7.7.6 Market Limits

The determination of market limits is an important consideration in planning for irrigation units on the Reservation. Essentially, the market limit is the maximum amount of an agricultural commodity that can be grown, without adversely impacting the market price for that product. Multiple agronomy reports have concluded that many crops can be grown organically on the Reservation (see "Crop Suitability and Selection" section). Therefore, an understanding of the specific crop markets and their market limits is a necessary prerequisite to developing crop plans, crop rotations, and the associated irrigation units for the Tribe's proposed organic farm.

7.7.6.1 Methodology

The methodology used to derive the market limits for produce crops in this analysis is based on a series of five analytical steps. First, the MSAs are identified as possible markets where produce could be sold on the wholesale level. Second, derived farm gate prices are estimated using wholesale price data from the terminal markets under consideration to the market area. As stated previously, these derived prices are net of transportation costs but include a price premium for certified organic produce. The most profitable MSAs are identified as the target markets for organic produce grown on the Reservation (see Table 7-9 above). Third, the per capita consumption rates for edible agricultural commodities are used to quantify the total annual demand for the Tribe's produce in the target markets. The fourth step in the determination of market limits is the development of assumptions as to market share. Finally, market limit acreage is derived. Steps one through three have been described previously; steps four and five are addressed in further detail below.

7.7.6.2 Market Share

It is assumed that the Tribe could capture a small percentage of this market share without impacting the market price. The specific market share percentage is based upon the distance from the Reservation to the terminal markets. This analysis also assumes that the Tribe's harvested crops could capture five percent of the existing market demand in MSAs within five hundred miles of the Reservation. The closest MSAs to the Reservation include Phoenix and Tucson. A four percent market share is assumed for the MSAs located between 500 and 1,000 miles from Whiteriver, Arizona; this market share percentage is assumed to decrease by a percentage point for every 500-mile increment that the MSA is located farther away from the pre-determined 500 to 1,000 mile radius around Whiteriver.

Table 7-10 below shows the assumptions regarding market share percentage that can be captured by crop production on the Reservation for each potential target market. The berry crops, wine grapes, beef inputs, and food grain crops are handled separate of this methodology, as explained below.

Table 7-10
Market Share Captured by Tribal Produce

Market	Share
Phoenix	5%
Tucson	5%
Dallas	4%
Atlanta	2%
Boston	1%
Los Angeles	4%
St. Louis	3%

7.7.6.3 Market Limits for Produce

The market limit acreage for each proposed crop is derived based on two factors: 1) total market demand; and 2) the yield assumptions generated by the aforementioned agronomists. Table 7-11 below shows the market limits for the bulk of the Tribe's organic fruit and vegetable crops under consideration. The yield for permanent crops is averaged over the expected life of the plants in the determination of market limits. Agricultural yield data, specific to these organic crops, are identified in the agronomist reports included in Appendix A through Appendix D of this analysis.

Table 7-11
Market Limit for Fresh Fruit and Vegetables

Crop	Market Limit
Apple	615
Asparagus	338
Cherry	96
Cantaloupe	532
Chili	566
Onion	475
Peach	310

The market limits for organic berries are handled in a separate manner from that of other proposed fruits and vegetables, due to the unique characteristics of the raspberry and blackberry markets. The closest competing berry production area to the Southwest region is California, which produces berries almost entirely for fresh market consumption. This is the only main competing area for fresh berry production in the United States. Due to the escalating demand for fresh market berries, and the Tribe's location within a short drive from Phoenix and Tucson, and the ability to distribute to a national market with the assistance of a grower's agent, it is assumed in this analysis that the Tribe can capture a significant share of fresh market demand in theUnited States. Based on these assumptions, the market limit for the fresh market raspberries and blackberries is 100 acres and 70 acres, respectively. Conversations with various organic produce marketers have supported these market limit assumptions. The organic marketers that provided useful market information included Organic Harvest Network (San Francisco, California), New Harvest Organics (Rio Rico Arizona), and Whole Foods Market (both Austin, Texas and Sherman Oaks, California).

The proposed packinghouse and freezing facility on the Reservation will maintain the freshness and quality of the harvested berries, which in turn will allow for the operation of an on-site, processed berry production plant. Processed berries can then be stored for a much longer time period before they are shipped to terminal markets throughout the U.S. In this analysis, it is assumed that the Tribe can capture five percent of the market demand for processed berries in the U.S. This market share figure translates into a market limit of 340 acres of machine- picked red raspberries and an additional 180 acres of machine-picked blackberries.

The market limit for organic wine grapes is derived through personal communication with various wineries in the state of Arizona. The largest organic winery in the Southwest is the Kokopelli Winery, located in Arizona. The owner of the Kokopelli Winery has expressed interest in buying organic wine grapes in the future from outside sources (such as the Tribe), even though all of the grapes they use today are grown on location. Based on this information, additional communication with the Arizona Wine Growers Association, and other published data on wine grapes, it is apparent that there is an increasing demand for organic wine grapes grown in Arizona. Yield data from Appendix A is used in this analysis to derive a market limit of 200 acres for organic wine grapes produced on the Reservation. Appendix E of this report provides further information on the market for wine grapes in Arizona.

7.7.6.4 Market Limits for Grains and Dry Beans

The market limits for organic forage and grain crops are tied to the needs of the proposed organic beef operation on the Reservation. In this analysis, it is assumed that all forage and feed grain crops will be produced solely for the organic beef operation. This assumption is likely an underestimation of the actual market demand for forage and feed grains. The crop needs of the Tribe's organic beef operation include annual production estimates as follows: 207 acres of alfalfa; 179 acres of corn for grain; 85 acres of corn silage; and 219 acres of oats. Further information on the Tribe's proposed organic beef operation can be found in Appendix F.

The market limit for food grains such as organic blue corn, organic soybeans, and organic wheat are tied to the stated demand of Clarkson Grain Company, a merchandiser of these crops. Clarkson Grain Company has indicated that they would be interested in developing crop production contracts with the Tribe in the near future. These production contracts could be as large as 1,500 acres for any of the organic food grain crops.

The dry bean market limit is derived in a separate manner from the market limits calculated for the blue corn, soybean, and wheat as the Clarkson Grain Company's business does not include the production or marketing of pinto beans. In this analysis it is assumed that a partnership can be formed with the NAPI to market the Tribe's organic pinto beans, along with the conventionally produced pinto beans from the NAPI site. The elevators currently used to store pinto beans at the NAPI project site in Farmington, New Mexico have been identified as a possible storage facility for the Tribe's organic pinto beans.

Southern California is identified as being the main target market for the Tribe's organic pinto beans. It is assumed that production of pinto beans in New Mexico and Arizona could increase by five percent without impacting the market price for this commodity. This assumption results in a market limit of 387 acres for pinto beans produced on the Reservation. Appendix E of this report provides more information on the market for pinto beans.

7.7.6.5 Market Limits for Christmas Trees and Poplars

In addition to producing organic fruits, vegetables, grains, and dry beans, the Tribe also proposes to grow Douglas fir trees; these trees would be sold annually as "Christmas trees" in the months of November and December. In this analysis, the market limit for Christmas trees is determined by a review of the wholesale and "choose and cut" (U-Cut) markets, as both of these types of operations are planned for the Reservation.

Presently, the supply for Christmas trees in the state of Arizona is comprised almost entirely of Douglas fir trees that are imported from Oregon and Washington State. It is assumed in this analysis that up to 500 acres of Christmas trees can be planted on Reservation lands without impacting local prices. This assumption results in an annual harvest of 81,000 trees, or 0.3 percent of the trees sold nationwide. Of this total projected harvest, ninety-five percent of the trees will be shipped to wholesale market destinations and sold there, and five percent will be sold on-site by the Tribe as U-Cut trees. The market analysis for Christmas tree production on the Reservation is located in Appendix E.

As the proposed hybrid poplar production will be for commercial and industrial uses only, the market limit assessment for hybrid poplars is strongly correlated with the lumber mill evaluation at the Fort Apache Timber Company (FATCO). The FATCO mill is located on the Reservation and is operated by the Tribe. Appendix K of this report contains a detailed market analysis for the proposed hybrid poplar growing and harvesting operations. Specifically, the market analysis in Appendix K evaluates the demand for hybrid poplars derived from the existing customer base of the FATCO mill on the Reservation. Appendix J also describes production capacity that is specific to hybrid poplar operations at the mill. The mill is currently operating under the maximum capacity by an amount that cannot be supplied by the hybrid poplars on an annual basis at the proposed site on Bonito Prairie; therefore no market limit is imposed for hybrid poplars.

7.6 Crop Production Methods and Costs

7.6.1 Sustainable Agriculture with Organic Production Methods

Sustainable agriculture is a farming method that produces abundant food without depleting the earth's resources or polluting the environment. Agricultural producers who practice sustainability follow principles of nature to develop systems for raising crops and livestock that are, like nature, self-sustaining. These sustainable farming systems have various titles, including: natural, organic, low-input, alternative, regenerative, holistic, biodynamic, bio-intensive, and biological.[20]

The USDA introduced national organic standards on October 21, 2002. The organic certification process requires meticulous record keeping. Records are essentially kept of everything coming into the farm and leaving the farm, as well as everything that is done on the farm. Required records include, but may not be limited to: inputs purchased; crops planted, nourished, harvested, stored, trucked, and sold; animals bought, sold, born, bred, treated, fed, deceased; equipment care and cleaning; animal products sold; any manure spread; water tests; and actions taken in regard to the crop field buffer zone—as required by National Organic Practices (NOP). Each certified farm needs all of these records in order to complete the organic farm plan, which includes a lengthy application for certification.[21]

The production of certified organic crops must meet specific requirements. The standards for all certified organic crops include these five stipulations:

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20 Earles, Richard, 2005, "Sustainable Agriculture: An Introduction," National Sustainable Agriculture Information Service, ATTRA.

21 Arnold, Kathie, 2006, "Making the Leap to Organic Dairy Production," Available online at: http://www.organicmilk.org/transitioning.html, accessed July 11, 2006.

1. Land will have no prohibited substances applied to it for at least three years before the harvest of an organic crop.
2. Use of genetic engineering, ionizing radiation, and sewage sludge is prohibited.
3. Soil fertility and crop nutrients will be managed through tillage and cultivation practices, crop rotations, and cover crops, with soil to be supplemented with animal and crop waste materials and allowed synthetic materials.
4. Preference will be given to the use of organic seeds and other planting stock.
5. Crop pests, weeds, and diseases will be controlled primarily through management practices which include physical, mechanical, and biological controls. When these practices are not sufficient, a biological, botanical, or synthetic substance (approved for use as pursuant to the National Organic Practices List) may be used.[22]

All of the production budgets developed for fruit, vegetable, and field crops in this analysis are prepared with organic standards in mind. In this analysis, it is assumed that Oregon Tilth, Inc. is used as the certifying agency for the Tribe's crop production as no organic certifiers are currently located in the state of Arizona. The cost of organic certification is set at 0.5 percent of gross revenue and is based on the Oregon Tilth fee schedule.[23]

7.6.1.1 Soil Composition Treatments

In order to attain the soil fertility levels required for optimal production of organic crops, a variety of sustainable agricultural practices are planned for use on the Reservation's farmland. One of these practices is the use of a green manure or clover cover crop. The green manure cover crop is a sweet clover that is seeded at the same time as the field crops. After the main crops are harvested, both the residue and the clover are "disked" (tilled) into the soil. The process of disking the sweet clover into the soil results in an enrichment of the soil with nitrogen and organic matter. In permanent tree fruit crops, New Zealand white clover (Trifolium repens) is seeded and maintained between rows as a permanent cover crop. After the third year of growth, the clover is able to add enough nitrogen to the soil to meet the nutrient enrichment requirement of the fruit trees.[24]

The application of composted manures is another method the Tribe can implement to adjust the nitrogen composition of the farmland soil to the level of fertility required. In this analysis, it is assumed that manure will be available from the proposed organic beef cattle operation on the Reservation (or other regional livestock operation) at

22 "Transitioning to Organic Agriculture," Sustainable Agriculture Research Education (SARE), accessed online at www.sare.org/bulletin/organic 2003.

23 Oregon Tilth Certified Organic Fee Schedule, Oregon Tilth Inc., July 1, 2006.

24 See Appendix A

a cost of $24.50 per ton.[25] The application of one ton of manure per acre will provide approximately 20 pounds of nitrogen per acre.

Fish fertilizer is another sustainable agricultural practice that can be used on the Reservation to boost the fertility of the soil by organic means. There are various forms of fish fertilizer available on the market; several of these are certified organic, including the product line of Alaska® Fish Fertilizers from Lilly Miller®. The different brands of fertilizer on the market provide varying levels of nitrogen, phosphorus, and potassium content, thereby allowing agricultural producers to select the most suitable fertilizer for their soil and crop situations.

Other organic soil amendments that provide phosphorus and/or potassium are soft rock phosphate, sulfate of potash, and bone meal. These amendments are added when the composted manure, or green manure crop does not provide the recommended level of these nutrients.

7.6.1.2 Crop Care and Treatments

The proposed crop production areas on the Reservation are isolated from large commercial agriculture and are located in a favorable climate zone. Therefore, the occurrence of crop pests and diseases should be very limited. If organic pest control is needed, organic insecticides available for use in certified organic systems include the following: insecticidal soap; spinosad (Saccharopolyspora spinosa, a soil actinomycete organism); summer oils (a paraffinic insecticide); pyrethrum (a synthetic insecticide); and neem oil (a bio pesticide).

Potential crop diseases on the Reservation can be controlled with the application of natural metal and non-metal elements, bacterium, and mineral oils that are also approved for use in certified organic systems. Examples of crop disease treatments include: copper, sulfur, potassium bicarbonate, lime sulfur, Streptomycin sulfate, Serenade (Bacillus subtilis, a bio fungicide) and stylet oil, to name a few. Appendices A and B of this report provide more information on the organic production practices intended for the Tribe's organically produced crops.

7.6.2 Christmas Trees and Poplars

The Douglas fir ("Christmas trees") and hybrid poplar tree farms proposed for development on the Bonito Prairie site of the Reservation will be produced by conventional tillage operations. The Tribe will employ a drip irrigation system to grow these agroforestry crops. Appendices C, D, H, and I provide more detail on crop requirements, production methods, and the costs associated with the production of, Christmas trees and hybrid poplars.

Both crops require a heavy investment in trees over an extended period of time before harvest. For Christmas trees this time period is between six and seven years, while it is approximately 12 years for hybrid poplars. In order to finance the production

25 Bolda, Mark, and Laura Tourte, Karen Klonsky and Richard De Moura, 2005, “Sample Costs to Produce Fresh Market Raspberries,” University of California Cooperative Extension.

expenses during the establishment period it is assumed that the Tribe will use a combination of debt and equity in equal amounts. Interest charges on this method of financing is included in the Christmas tree budget presented in Appendix H, and discussed in Section 7.9 for the hybrid poplars. Another financing option specific to hybrid poplars that the Tribe may consider is a partnership with a Timber Investment Management Organization (TIMO). While a discussion of TIMOs is included below, it is not incorporated into the production budget as the selected financing option.

7.6.3 Labor Rates and Hours Required

Organic crops are more labor-intensive than conventionally produced crops, as hand weeding and mechanical weeding require more time than the use of synthetic herbicides. The per-acre estimates on the hours required for manual labor and machine labor are included in the crop production budgets prepared for the Tribe (see Appendix H). The table below (Table 7-12) shows the labor hours required by labor type, based on the final cropping pattern that is addressed in Sections 7.7, 7.8, and 7.9 of this analysis.

Table 7-12
Labor Hour Estimates by Labor Type

Crop	Harvest Time	Harvest Labor	Other Manual Labor	Other Machine Labor	Total Hrs
Cherries	June	16,689	7,513	1,377	25,579
Peaches	July -Sept.	24,955	50,932	5,999	81,886
Blackberry*	July, Aug.	21,827	21,395	1,527	44,749
Raspberry*	July - Sept.	92,273	6,109	2,182	100,564
Blackberries	July, Aug.	2,972	51,905	3,927	58,805
Raspberries	July - Sept.	9,235	20,771	7,418	37,424
Apple	August - October	81,488	149,874	32,667	264,029
Grape	September - October	7,720	19,050	0	26,770
Asparagus	Late April - June	24,462	2,903	1,935	29,300
Alfalfa	May - July	828	842	370	2,040
Cantaloupe	July - August	53,200	3,168	2,375	58,743
Wheat	August	937	937	937	2,812
Onion	June	17,813	11,020	3,211	32,044
Chili	October	1,900	8,028	3,083	13,010
Dry Bean	October	217	283	670	1,170
Blue Corn	September	937	1,000	1,500	3,437
Soy	October	937	625	937	2,500
Corn for Grain	September	176	188	281	645
Silage	July - August	252	94	241	587
Oats	July - September	175	117	175	467
Christmas Trees (U-Cut)	December	2,075	781	330	3,186
Christmas Trees (Wholesale)	December	13,455	14,147	6,274	33,876
Poplars (Production only)	May - September	7,200	36,480	0	43,680
Total Hours		381,630	409,212	78,311	869,152
Full Time Equivalent**			205	39	244

*Hand Picked for the fresh market

**Full time workforce equivalent assumes a work year is about 50 weeks.

The wage rates assumed in this analysis have been collected from the U.S. Bureau of Labor Statistics for the state of Arizona. Hourly, manual labor rates in this analysis are $6.71 per hour, and machine labor rates are $7.85 per hour.[26] In the crop production budgets (see Appendix H), the wage rates are increased by 30 percent to account for other employee benefits and employment costs.[27]

Harvest labor for these crops will require the use of a seasonal labor force. As indicated in Table 7-12 above, many of the Tribe's fresh fruit and vegetable crops (such as apples, cantaloupes, and onions) will require a larger seasonal labor force than is needed for other crops harvested on the Reservation. Table 7-13 below shows the hours required and estimated number of jobs generated from seasonal harvest labor on the Reservation.

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26 U.S. Bureau of Labor Statistics website on October 3, 2006, *May 2005 State Occupational Employment and Wage Estimates: Arizona*. Information available for viewing at: http://www.bls.gov/oes/current/oes_az.htm#b45-0000

27 Based on "Employer Costs for Employee Compensation," 2006, Bureau of Labor Statistics.

Table 7-13
Seasonal Harvest Labor Force,
Estimates by Crop Type, in Hours

Crop	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Cherries			16,689						
Peaches				8,318	8,318	8,318			
Blackberry*				10,914	10,914				
Raspberry*				30,758	30,758	30,758			
Blackberries				1,486	1,486				
Raspberries				3,078	3,078	3,078			
Apple					27,163	27,163	27,163		
Grape						3,860	3,860		
Asparagus	2,718	10,872	10,872						
Alfalfa		276	276	276					
Cantaloupe				26,600	26,600				
Wheat					937				
Onion			17,813						
Chili							1,900		
Dry Bean							217		
Blue Corn						937			
Soybean							937		
Corn for Grain						176			
Silage				84	84	84			
Oats					175				
Christmas Trees (U-Cut)								1,038	1,038
Christmas Trees (Wholesale)								4,485	8,970
Poplars		1,440	1,440	1,440	1,440	1,440			
Total Hours	2,718	12,588	47,090	82,954	110,653	75,514	34,078	5,523	10,008
Full Time Equivalent**	17	79	294	518	692	472	213	35	63

*Hand Picked for the fresh market **Full time seasonal workforce equivalent assumes a work year is about 50 weeks.

The seasonal requirements for the harvest of agricultural crops proposed in this analysis range from 17 people in April to a peak of 554 people in August. The harvest season extends through December, to include harvesting of wholesale and U-Cut Christmas trees for holiday sales.

In addition to the labor requirement for the proposed crops, the packinghouse is expected to require the full time equivalent of 13 employees per year.[28] The seasonality of the agricultural products moving through the packinghouse will result in a varying labor requirement throughout the year. The amount of labor could vary from a low of three people in the off-season to a peak of forty or more in the peak season.[29]

7.6.4 Management

In this analysis, it is assumed that the Tribe will not directly manage the production of the proposed agricultural crops; rather, the Tribe is expected to choose one of the following options: 1) form joint ventures with outside entities that specialize in agriculture crop management; or 2) hire experienced farm managers. It is anticipated that with either option, the management team will train tribal employees in the production practices of the specific crops. It is also assumed that the tribal workforce (employed by these farm managers) will learn new skills regarding organic production practices and the marketing of crops.

Pertaining to the first option, Lynn Clarkson (founder of Clarkson Grain Company) and an experienced grain merchandiser has assisted in identifying several farm management entities that may be interested in working with the Tribe. These companies include Grimmway Farms, and Earthbound Farm, to name a few.

The second option for the Tribe is to hire outside managers to work for a tribal business on the Reservation. Experienced agriculture professionals such as Ron Walser, have expressed interest in managing an organic farm for the Tribe. Ron Walser is an extension specialist for organic fruit and vegetable crops at New Mexico State University. While the specific cost of farm management is dependant on contract negotiations and other financial variables, this analysis assigns management fees based on the estimated number of managers likely required for the agricultural venture.

One general farm manager is proposed to oversee the entire agricultural operations on all three units. The salary and benefits of this general farm manager are anticipated to be $100,000. Four other crop specific assistant managers assist the general manager. One manager will lead each of the following sectors of the operation; berries, fruits, packinghouse, and other crops. The salary and benefits of these assistant farm managers are anticipated to be $75,000 per manager. The financial costs of management

28 Estimate based on 766 square feet per worker, obtained from Energy Information Administration, Official Energy Statistics from the U.S. Government, accessed online at http://www.eia.doe.gov/emeu/consumptionbriefs/cbecs/pbawebsite/foodserv/foodserv_howmanyempl.htm.

29 Personal Communication with Ron Walser, NMSU extension specialist for organic fruit and vegetable crops.

are included in the production budgets under the line item titled, “management.” A separate management fee was designed for the crops on the Bonito Prairie.

For the Tribe's proposed hybrid poplar tree farm, it is assumed that an outside company, such as GreenWood Resources, will collaborate with the Tribe in the planting and growing of hybrid poplars. At the time of harvest, it is assumed that FATCO will then assume responsibilities for further processing of the hybrid poplars. It is anticipated that employees at FATCO and GreenWood Resources will work together in cooperation to determine business criteria such as the specific size of logs, volume of logs, and the timing of harvested logs. No production management duties, however, will be required of FATCO. The management fee assigned for such a firm as GreenWood Resources is set in this analysis at $50 per acre. It is anticipated that the tribal farm manager discussed above will manage the Christmas tree plantation. However, the management fee for the Christmas tree plantation on Bonito Prairie is also modeled at $50 per acre. The management fee for hybrid poplars is explained further in Appendix J.

The total cost of management incorporated into the production budgets is slightly over $850,000 per year for all three units, encompassing 16,014 acres. The management fees on a per acre basis range from a high of $191 per acre for berries to a low of $22 per acre for rotational crops. The average of all management fees across all units is $57 per acre.

7.6.5 Machinery

While much of the labor requirements are for manual labor in organic production systems, there are machinery requirements for some of the crops to be produced on the Reservation. For example, mechanical berry picking equipment will be required to harvest the berries that are designated for processing. A combine will be indispensable to harvest the organic food grain crops and oats. Flat bed trailers will be necessary at harvest time for hauling field bins of fruit crops to the packinghouse. A flat bed trailer or farm truck will also be required to haul alfalfa from the field to the organic beef operation elsewhere on the Reservation. Along with the trailer, machinery designed for swathing and baling of alfalfa will be requisite equipment on the Tribe's organic farm.

Additionally, field preparation tasks will require the use of additional farm equipment, including but not limited to: tractors, discs, bed shapers, and manure spreaders. The Tribe will need other general farm machinery as well, such as all-terrain vehicles (ATVs), pickup trucks, mechanical sprayers, and etcetera.

All of the machinery costs for the specific crops are included in the enterprise crop budgets prepared for the Tribe's proposed irrigated agriculture project. The crop budgets are presented in Appendix H of this report.

7.6.6 Packinghouse

The construction of a packinghouse and cooling facility on the Reservation will meet three objectives: 1) to prepare harvested fruits and vegetables for shipping and end use consumption (e.g. fresh or frozen); 2) to provide adequate space for storing produce between shipments; and 3) to maintain overall freshness and quality of the produce. The proposed packinghouse will be an organic certified handler of produce and provide support for organic crop production on the Reservation.

A packinghouse for fruits and vegetables will be the site where freshly picked produce is delivered straight from the Tribe's organic farm. This produce arrives at the packinghouse in picking containers immediately after harvest. The packers employed at the packinghouse then begin the tasks of sorting, grading, sizing, and packing the produce directly into the appropriate transport containers for shipping. Each worker must be knowledgeable regarding defects in the produce, grade and size requirements by produce type, and packing methods for reduce bruising and spoilage. As the size and complexity of the packinghouse operations increase, more operations (and thus more workers trained in specific tasks) might be added.[30]

The required size of the packinghouse (which will include a cooler) is estimated at 9,600 ft2.[31] A building of this size on the Reservation will be able to handle the proposed volume of harvested apples, peaches, cherries, berries, cantaloupe, and vegetable crops such as asparagus. The current construction cost that is projected for a facility similar in scope is $82.50 per square foot.[32] Therefore, the estimated construction cost of the Tribe's packinghouse and cooling facility is $792,000. It is assumed in this analysis that the packinghouse has a useful life of 25 years.

Inside the packinghouse, a fruit-packing production line will be required for preparing the apples, peaches, asparagus, fresh berries, and cherries. A packing production line will include a receiving belt, spray washer, and sorting table. Equipment designed for packing produce is available from several manufacturers and suppliers, including TEW Manufacturing Corp., Orchard Equipment and Supply Co., and Market Farm Implement. The packing line equipment can be purchased for approximately $6,000 per line.[33] Given the proposed scale of crop production on the Reservation, it is anticipated that five of these lines will be required.

In addition to a fresh fruit packing line, a plant geared to Individually Quick Frozen (IQF) production methods will be added; this plant operation will prepare the processed berries and any vegetables for these processed markets. There are two different production methods used by IQF plants in practice today to freeze berries: 1) the "crusting" method, and 2) the "air spray" method. The first IQF method involves crusting the berry with liquid nitrogen or carbon dioxide to freeze the individual berries. The equipment needed for the crusting method costs approximately $100,000. Although this purchase price appears relatively inexpensive, the equipment operating expenses are

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30 Packinghouse Operations, FAO Corporate Document Repository, www.fao.org/Wairdocs/X5403E/x5403e05.htm.

31 Personal Communication with Ron Walser, NMSU extension specialist for organic fruit and vegetable crops.

32 Brushett, Lynda and Stephen Lacasse, January 2006, “Market Analysis for Fresh Cut Apple Slices,” AMS, USDA.

33 Appendix A: Manufacturers and suppliers of post harvest technology materials and equipment for small-scale horticultural handlers, FAO Corporate Document Repository, www.fao.org/Wairdocs/X5403E/x5403e0e.htm.

relatively high (an estimated fifteen cents per pound). The second IQF method involves an ammonia freezer air spray; a high-powered blast of cool air quickly freezes the individual berries. The equipment needed for the air spray method can be purchased for about one million dollars; however, its operational costs are only pennies per pound.[34]

Given the anticipated yields and production capabilities of the proposed berry plants on the Reservation and the large difference in operational costs between the crusting and air spraying IQF methods, it is more economical in the long run for the Tribe to invest in an IQF plant that employs the air spray production method (see Table 7-14 below). Operational costs of two cents per pound for air spray and fifteen cents per pound for crusting are also considered in the value added activity of individually quick-freezing the berries. The cull berries (e.g. berries that do not make the IQF grade) will be frozen by the box (box frozen) and sold for use in juices, purées, baking goods, or other commercially prepared foods.

Table 7-14
Comparison of Freezing Methods, Costs per Pound

Method	Yield	Operational Costs	Amortized Purchase	Annual Investment	Total Costs
	Lbs per acre	$ per lb	$ per yr	$ per lb	$ per lb
Crusting - IQF	5,866	$0.15	$4,655	$0.0018	$0.15
Air Spray - IQF	5,866	$0.02	$46,550	$0.0178	$0.04
Box Freeze - Cull	3,911	$0.01	$16,293	$0.0094	$0.02

The total purchase price for the Tribe's proposed packinghouse, which includes the cooler, packing lines, and IQF plant, is over $1.8 million dollars. When this cost is amortized over the 25-year expected life of the packinghouse at the appropriate interest rate, the total annual cost is $139,161 annually. This cost is then distributed as a fixed production expense, on a per crop basis, among the 3,437 acres of proposed crops that will use the packinghouse in some way. Therefore, the annual cost of the packinghouse is estimated at $40.49 per acre for apples, peaches, cherries, asparagus, berries, cantaloupe, and other vegetable crops grown on Reservation lands. This per acre figure appears as a fixed cost in the associated crop budgets in Appendix H of this report. The variable, or operational expenses, of the packinghouse vary by crop; therefore, variable expenses are also included in the appropriate crop budgets under such line items as, "packing," "cooling," "storage" and / or "selling."

7.6.7 Fencing

The proposed organic farm on the Reservation is in a renowned hunting location. Every year trophy elk are taken from the Reservation. Other game animals periodically hunted on the Reservation include the following: deer, antelope, bear, and turkey. While these magnificent animals are a welcome part of the Reservation, they can be detrimental to crops of all kinds. In order to protect the crops from damage caused by wildlife, a

34 Personal Communication with Rod Cook, Overlake Foods, Inc., October 2005.

game fence will be installed around the perimeter of the proposed irrigation units.

Fence construction costs have two components: labor and materials. It takes approximately 0.35 hours of labor to construct one foot of fencing in the White Mountain region.[35] With an assumed, non-machine labor rate of $8.72 per hour, the labor costs for fence construction will amount to $3.05 per foot of fencing. The materials used in fence construction will consist of two metal tee posts and galvanized steel, fixed-knot game fence; the game fence is expected to measure eight feet in height and contain vertical wires that are spaced six inches apart. Metal fence posts are recommended for longevity and sturdiness, although their use adds an extra expense of $0.10 to $0.12 per foot of fencing to the construction costs. Overall, the materials alone add up to a cost of around $1.52 per foot of fencing. This particular type of fence, as described above, is guaranteed for twenty-five years.[36]

The total cost of constructing a game fence in the proposed project area on the Reservation will amount to over $1.5 million dollars, or $4.57 per foot of fencing. Allocating the entire construction expense across the three project areas results in the following costs per project area: $218,000 for Cibecue; $583,200 for Canyon Day; and $771,300 for Bonito Prairie. As stated earlier, the proposed fence has a 25-year warranted life; therefore, fence construction costs must be amortized over the expected life of the fence in order to obtain the total, annual cost of the fence project. Amortizing these costs over the life of the fence at the appropriate interest rate results in annual costs per area as follows: $16,650 for Cibecue; $44,550 for Canyon Day; and $58,910 for Bonito Prairie. As Table 7-15 illustrates, the total, amortized annual cost of the proposed game fence construction will be approximately $120,110.

Table 7-15
Total Game Fence Construction Costs

Area	Acres	Perimeter (miles)	Total Cost	Amortized Cost	Cost per Acre
Cibecue	1,079	9.03	$218,000	$16,650	$17.43
Canyon Day	5,875	24.16	$583,200	$44,550	$7.58
Bonito Prairie	9,060	31.95	$771,300	$58,910	$6.50
Total	16,014	67.14	$1,572,500	$120,110	$7.50

The figures in Table 7-15 also show that fence repair and maintenance will likely cost $7.50 per acre annually on a Reservation wide basis. This cost per acre for fencing in the appropriate irrigation unit is included in the associated crop budgets in the line item, “game fence.” Crop budgets are included in Appendix H of this report.

7.6.8 Opportunity Cost

At present, the majority of the land included in the conceptual irrigation project

35 Personal communication with Robert Johnson, owner, Aaron Fence Company, Lakeside, Arizona, October 4, 2006.

36 Personal communication with Howard Athas, Stay-Tuff Fence Manufacturing, Inc., New Braunfels, Texas, October 4, 2006.

can be used for open-range grazing to serve the Tribe's existing livestock operations. This land, however, will not be available for grazing following development of the irrigation project. Therefore, the value of the lost opportunity to graze must be included as a cost to the project. A rangeland specialist for the Natural Resource Conservation Service (NRCS) in Holbrook, Arizona advises that between 4 and 14 acres[37] would typically be required in order to provide one Animal Unit Month (AUM) of forage in the region. In this analysis, the AUM yield is anticipated to be 1/10 AUM per acre.

Net returns to be used as the opportunity cost of land are equivalent to the annual returns from grazing. The average grazing fee in Arizona during 2004 was $8.00 per AUM.[38] Therefore, the per-acre opportunity cost for this project is assumed to be $0.80 per acre.

7.6.9 Interest Rates

The interest rate on operating capital used in this analysis is 7.65 percent.[39] This rate represents the market cost of borrowed funds. In this analysis, interest is charged to a portion of the variable costs during the production of the crop, before harvest. Generally, the operating loan is only carried for half a year but varies from crop to crop. Crop production budgets are presented in Appendix H.

Long-term interest rates are applied to capital projects requiring financing for over one year. Similarly, this interest rate is applied to production loans on permanent crops such as tree fruits, poplars, and Christmas tree. The long-term interest rate in this analysis is approximately equal to the 30-year mortgage rate, or 6.5 percent.

It is assumed that in order to borrow money for operations the Tribe will have to finance half of the expenses through equity. Furthermore, capital investments such as game fencing and a packinghouse are to be financed through equity. The cost of equity is assumed to be approximately equal to the lost rate that the Tribe could have received if it were to invest that money into a risk free, 30-year treasury security. The rate used in this analysis is five percent.

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37 Personal Communication with Rachael Lure, NRCS, March 3, 2006. Range for the area is about 4 – 15 Animal Units / section, which is equivalent to 3.6 – 13.3 acres required for one AUM.

38 USDA, July 2005, "Private Non-Irrigated Grazing Fee Rates For Cattle, Selected States and Regions," *Agricultural Prices 2004 Summary*, Agricultural Statistics Board, NASS.

39 Based on Operating Cost Calculations used in University of California Davis Publications for 2005.

7.7 Canyon Day

7.7.1 Project Lands (Irrigation Layout)

See Chapter 6.

7.7.2 Land Classification

See Chapter 6.

7.7.3 Cropping Pattern

The Canyon Day area has been farmed under conventional practices in the past, and small parts of it continue to be farmed conventionally today. The proposed irrigation plan described below analyzes only the future irrigation acres; however if plans are put in place to certify the existing acreage as organic, it may be beneficial to plant that existing acreage with permanent crops such as apples, berries, and wine grapes. This option would give the Tribe time to certify the crops as organic before the plants begin producing full yields. It is expected, that the new land proposed for crop production will be able to be certified within the first year.

Permanent crops identified for the Canyon Day area include raspberries, blackberries, apples, and wine grapes. Crop rotations for the individual annual crops proposed in the irrigation units were analyzed, and are presented in Table 7-16. Note that the amount of land in each of the proposed rotations in the final irrigation plan is dependent on factors such as agronomic criteria, field size, water availability, irrigation requirements, and economic returns—among other influences.

Table 7-16
Rotations Considered for the Proposed Irrigation Project

Rotation	Crops (years)	Irrigation Type
1	Blue Corn (1), Soybean (1), Wheat (1), Soybean (1)	Sprinkler
2	Grain Corn (1),Dry Bean (1), Oats (1), Dry Bean (1)	Sprinkler
3	Alfalfa (3), Grain Corn (1), Dry Bean (1) Oats (1)	Sprinkler
4	Corn Silage (1), Dry Bean (1), Grain Corn (1), Dry Bean (1)	Sprinkler
5	Onion (1) , Cantaloupe (1), Dry Bean (1)	Drip
6	Dry Bean (1),Corn Silage (1), Alfalfa (3), Oats (1)	Sprinkler
7	Cantaloupe (1), Onion (1), Chili (1), Cantaloupe (1), Onion (1)	Drip

Rotations 1, 2, 3, 4 and 6 include grass crops (corn, wheat, oats) followed by legume crops (soybean, dry bean, and alfalfa). By rotating the crops in this manner the nitrogen fixed in the soil from the legume crops will directly benefit the grass crops, thereby reducing the dependence on fertility requirements from soil amendments alone. Rotations 5 and 7 diversify the overall crop mix to include chili, onions, and cantaloupe. These crops will likely require soil amendments to achieve optimal production, as described in the proposed crop budgets.

7.7.4 Gross Returns

Gross returns are calculated as a function of yields and prices. The price data used in this analysis originates from published sources for the region encompassing the Reservation. If regional price data is not available, national statistics on prices received by growers is substituted. In this analysis, a market premium of ten percent is added to the conventional prices to account for organically produced crops. This premium is a conservative estimate based on price premium studies that have been previously conducted and published.[40] Appendix H has more information on crop prices used in this analysis.

Permanent crops such as tree fruits, asparagus, and Christmas trees have an establishment period characterized by a heavy initial investment with little to no production. Generally, positive returns on these crops are not realized until after the establishment period when full production is reached. The production costs and returns for these crops are annualized by amortizing the present value of the stream of cash flows over the life of the crop, using a discount rate of three percent. Due to the fact that the gross returns are discounted in this analysis, the yields in the table below appear as discounted yields. For a description of yields used in this analysis, see Appendices A, B, and H. The table below shows the discounted yields, prices, and gross returns on a per acre basis for the proposed crops.

40 See Appendix H for price premium discussion, and reference to past studies conducted by the USDA (2003), Vandeman (1998), Glaser et al (1998), Greene and Calvin (1997), and Sok and Glaser.

Table 7-17
Annualized Gross Returns, per Acre, Canyon Day

Crop	Yield / Unit	Unit	Price / Unit	Total Gross Revenue
Organic Apple	15	Ton	$709.10	$11,070
Organic Grape	4	Ton	$2,000	$8,410
Blackberry (processed)	9,495	Pounds	$1.15	$11,020
Blackberry (fresh)	9,495	Pounds	$3.90	$37,360
Raspberry (processed)	9,893	Pounds	$1.09	$10,900
Raspberry (fresh)	9,893	Pounds	$3.08	$30,680
Chili	1,100	Boxes	$3.31	$3,640
Onion	425	Cwt	$12.56	$5,340
Cantaloupe	200	Cwt	$19.06	$3,810
Organic Wheat	75	Bushels	$6.00	$450
Dry Bean	1,900	Pounds	$0.25	$470
Organic Blue Corn	115	Bushels	$7.40	$850
Organic Soybeans	50	Bushels	$12.00	$600
Organic Oats	100	Bushels	$6.53	$650
Organic Alfalfa	3.56	Ton	$210.19	$750
Organic Grain Corn	138	Bushels	$7.75	$790
Organic Silage	20	Ton	$43.42	$870

Numbers in the above table may not sum due to rounding

The gross returns on organic feed crops, such as oats, alfalfa, grain corn, and corn silage are tied to the expected revenues from the proposed organic beef operation on the Reservation. Details and data regarding the organic beef operation are included in Appendix G.

7.7.5 Net Returns to Irrigation

The returns to pay for the proposed irrigation system on the Reservation are calculated as gross returns, net of all production and marketing expenses. Appendix H describes the returns and costs of production on a crop specific basis. The table below provides a summary of the costs and returns of the proposed crop production, as well as the proposed crop mix for the irrigation unit at Canyon Day.

Table 7-18
Annualized Net Returns to Irrigation, per Acre, Canyon Day

	Net Return/Acre	Acres	Total Net Returns
Organic Apple	$3,920	280	$1,098,000
Organic Grape	$4,520	200	$904,000
Blackberry (processed)	$980	180	$177,000
Blackberry (fresh)	$22,070	70	$1,545,000
Raspberry (processed)	$3,090	340	$1,052,000
Raspberry (fresh)	$17,390	100	$1,739,000
Blue Corn (1), Soybean (1), Wheat (1), Soybean (1)	$313	2,549	$799,000
Grain Corn (1),Dry Bean (1), Oats (1), Dry Bean (1)	$193	503	$97,000
Alfalfa (3), Grain Corn (1), Dry Bean (1) Oats (1)	$287	47	$13,000
Corn Silage (1), Dry Bean (1), Grain Corn (1), Dry Bean (1)	$193	170	$33,000
Onion (1) , Cantaloupe (1), Dry Bean (1)	$442	-	$0
Dry Bean (1),Corn Silage (1), Alfalfa (3), Oats (1)	$287	249	$71,000
Cantaloupe (1), Onion (1), Chili (1), Cantaloupe (1), Onion (1)	$610	1,188	$724,000
Total	**$1,405**	**5,875**	**$8,252,000**

Numbers in the above table may not sum due to rounding

The crop mix represented in the Table 7-18 above includes acreage for organic food grain crops such as blue corn, wheat, and soybeans. The remaining crop rotations include organic vegetable crops, as well as inputs for the proposed organic beef operation on the Reservation. The proposed acreage of the organic beef inputs will supply enough forage and feed grain for an organic beef operation comprised of 1,000 head of beef cattle. Permanent crop acreage proposed for the Canyon Day area includes 280 acres of apples, 200 acres of wine grapes, and 690 acres of raspberry and blackberry crops. The proposed crop mix for Canyon Day utilizes all of the market limit constraints for the organic berry crops and the organic wine grape crop. There is, however, still acreage available under the market limits for organic apples and other organic vegetable crops described earlier in this report.

Total annual net returns to pay for irrigation are over $8.25 million dollars for the proposed crops in the Canyon Day unit. This figure results in a net return to irrigation of $1,405 per acre annually.

7.8 Cibecue

7.8.1 Project Lands (Irrigation Layout)

See Chapter 6.

7.8.2 Land Classification

See Chapter 6.

7.8.3 Cropping Pattern

The Cibecue area has never been farmed; therefore this area would transition easily to organic production for any of the crops mentioned above. The only crops that would not be suitable for this area are hybrid poplars and Christmas trees. The hybrid poplar and Christmas tree crops would require more intensive cultivation practices that are not accepted by the USDA's organic standards. The organic crops proposed for the irrigation unit at Cibecue include apples, peaches, cherries, and asparagus.

7.8.4 Gross Returns

The production costs and returns for the crops proposed at the Cibecue area of the Reservation are annualized by amortizing the present value of the stream of cash flows over the life of the crop, using a discount rate of three percent. As the gross returns are discounted in this analysis, the yields in the table below appear as discounted yields. For a description of yields used in this analysis, see Appendices A, B, and H.

The table below shows the yields, prices and gross returns on a per acre basis for the proposed organic crops at Cibecue. The price data used in this analysis comes from published sources for the region encompassing the Reservation. If regional price data is not available, national statistics on prices received by growers is substituted. A market premium of ten percent is added to the conventional prices to account for organically produced crops. This premium is a conservative estimate based on price premium studies that have been previously conducted and published.[41] Appendix H has more information on crop prices used in this analysis. The table below shows the yields, prices and gross returns on a per acre basis for the proposed crops.

41 See Appendix H for price premium discussion and reference to past studies conducted by the USDA (2003), Vandeman (1998), Glaser et al (1998), Greene and Calvin (1997), and Sok and Glaser.

Table 7-19
Annualized Gross Returns, per Acre, Cibecue

Crop	Yield / Unit	Unit	Price / Unit	Total Gross Revenue
Organic Apple	15	Ton	$709.10	$11,070
Organic Peach	704	Box	$12.55	$9,000
Organic Cherry	10,502	Pound	$0.88	$9,390
Asparagus	3,243	Pound	$1.42	$4,650

Numbers in the above table may not sum due to rounding

The tree fruit and vegetable crops proposed at Cibecue will be produced organically. The produce will be sold through the marketing efforts of the proposed packinghouse operation on the Reservation.

7.8.5 Net Returns to Irrigation

The net returns to pay for an irrigation system on the Reservation are calculated as gross returns, net of all production and marketing expenses. Harvesting the crops is the major expense to be incurred from the proposed organic crop production at Cibecue. Many labor hours (using both manual labor and machine labor) are required to harvest the fruits and vegetables proposed for the Tribe's agricultural irrigation project. See Section 7.6 above for a detailed analysis of the harvest labor required for these crops. Other production and marketing expenses associated with crop production in the Cibecue area are addressed in Appendix H.

Table 7-20
Annualized Net Returns to Irrigation, per Acre, Cibecue

	Net Return/Acre	Acres	Total Net Returns
Organic Apple	$3,920	335	$1,314,000
Organic Peach	$2,400	310	$744,000
Organic Cherry	$1,660	96	$160,000
Asparagus	$1,150	338	$389,000
Total	**$2,420**	**1,079**	

Numbers in the above table may not sum due to rounding

As Table 7-20 indicates, the net returns per acre range from $1,150 to $3,920 on the proposed Cibecue acreage. This range results in a total annual net return of over $2.6 million to pay for infrastructure, operation and maintenance of an irrigation system on the Reservation.

7.9 Bonito Prairie

7.9.1 Project Lands (Irrigation Layout)

See Chapter 6.

7.9.2 Land Classification

See Chapter 6.

7.9.3 Poplar Plantation and Christmas Trees

The Bonito Prairie area consists of a soils class that is suitable for hybrid poplars and Christmas trees, as discussed above. These two crops are the focus of this portion of the analysis. The hybrid poplar plantation will serve the market needs of FATCO, and supplement the inventory of timber from the forests on the Reservation. Hybrid poplar is a high valued hardwood that is being used as a substitute for pine, with many features that make it ideal for a wide range of applications.

In this analysis, the management scenario analyzed for the plantation is specific for the optimization of saw log production. The poplar plantation has a 13-year production period (establishment period) before harvest. The establishment period is characterized by a substantial investment into the plantation before the trees are harvested. The harvest of the trees creates a large sum of revenue generation toward the plantation (stumpage value) and at the mill (returns to mill operation). Other management scenarios can be implemented with shorter establishment periods. For example, hybrid poplars grown solely for chips are harvested four to seven years after planting. There is also a management scenario that would allow the thinning of the trees in year six, for use as chips, and then harvesting the remaining trees in year twelve for saw logs. These other management scenarios would likely be feasible options if the biofuels market expands, or chips become more valuable. These scenarios are discussed further in Appendices J and K. The scenario optimal for saw logs was chosen because FATCO is able to process hybrid poplar and has an existing customer base with interest in poplar lumber.

It will be necessary for the Tribe to cover the cash flow requirements of the plantation during the establishment period. While multiple financing options are available, the financing option assumed for this analysis is a traditional combination of debt and equity. This financing option is used for budgeting purposes in this analysis and includes a mix of 50 percent debt and 50 percent equity. It is assumed that the Tribe is able to borrow money from a bank at an interest rate of 6.5 percent for half of the required investment during establishment, and tribal monies from the casino or other tribal income source will provide the equity portion of the required investment. The equity portion of the financing is budgeted a rate of 5 percent, which reflects the lost opportunity of investing that money in a risk free investment.

Timber Investment Management Organizations (TIMOs) are another financing option that the Tribe could potentially use to fund the development of the proposed poplar plantation. TIMOs were first established in the 1980s to aid institutional investors in managing timberland investments. TIMOs find, analyze and acquire investment properties that best suit their clients' objectives. TIMOs are also given the responsibility of actively managing the timberland on an ongoing basis.

The ownership of timberlands in the U.S. has undergone a dramatic shift over the last ten years. Institutional investors such as pension funds, endowments and foundations have seen timberlands as an attractive way to diversify their portfolios. At the same time, large integrated forest products companies have seen a need to sell their land assets and restructure their balance sheets. As a result, according to recent estimates 18 of the largest TIMOs manage nearly $24 billion in invested capital and 38 percent of all US timberlands.[42]

The consensus is that TIMOs will continue to have access to capital for investment into timberlands. However, the pool of relatively simple transactions involving large tracts of timberland from forest products companies has been depleted. This means that future transactions will be more complex, more competitive, and perhaps involve more intensive forestry, including hybrid poplar tree farms. In fact, over the past five years Greenwood Resources has been successful in attracting TIMO investment into hybrid poplar tree farms in the Pacific Northwest.[43]

This climate indicates that TIMO investment is a viable option for financing the development of the proposed tree farm. Greenwood Resources would be prepared to assist the Tribe in gaining access to this source of investment capital.[44]

A fir and spruce Christmas tree plantation, including a U-cut operation, is also proposed for the Bonito Prairie. The White Mountain region in Arizona is an ideal place for a Christmas tree plantation, as almost all of the Christmas trees sold in the state are imported from Oregon. Similar to a poplar plantation, Christmas trees will require investment in production expenses for six to seven years before revenues are realized at harvest. The financing of the Christmas tree plantation is handled in the same manner as the poplar plantation for budgeting purposes in this analysis.

7.9.4 Net Returns to Irrigation

A hybrid poplar plantation will provide four economic benefits to the Reservation. First, the value of the stumpage will be a revenue source for the Tribe. This value represents the worth of the trees in the plantation, and can be thought of as the value of the tree before it is milled. In this analysis, delivered log prices from FATCO were used to calculate the stumpage value of the hybrid poplar. After paying for production expenses, the annualized net returns to stumpage are calculated at $253 per acre. Appendix J provides details on the analysis behind this calculation. However, this figure does not consider the financing costs described in Section 7.9.3 above. After accounting for a mix of debt and equity financing on the plantation, the annualized net returns to stumpage drop to $158 per acre.

The second benefit to the Tribe will also be the high quality product that will be milled and sold to FATCO's existing customer base. Appendix K has more information on the market demand for hybrid poplars. In this analysis, it is assumed that the sawmill overrun is 150 percent.[45] The marketing strategy for hybrid poplars developed by Mater

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42 Personal Communication with Cory Boswell, GreenWood Resources, October 18, 2006.

43 Ibid.

44 Ibid.

45 See Appendix K.

Engineering proposes a product mix consisting of 30 percent dimension lumber, and 70 percent select or better lumber. The price for dimension lumber is assumed to be $400 per mbm (thousand board feet, lumber scale), while the expected price for select or better lumber is assumed to be $1,000 per mbm.[46] There is also a small amount of residual that could be sold as biomass. The net price for residual biomass is assumed to be $16 per bone dry ton (BDT). Table 7-21 below shows the operating cash flow of hybrid poplar on a per acre basis in a representative mill operation. The production cost data contained in this table is not specific to FATCO, but is used in this analysis to represent the likely operating cash flow resulting from processing hybrid poplars at FATCO.

46 See Appendix K

Table 7-21
Operating Cash Flow from Processing Hybrid Poplars, per Acre

			$ / Unit	Unit	Volume	Income	
Production							
Sawlog Volume (mbf / ac)		23.86					
Chip Volume (bdt / ac)		32.4					
Shaving Volume (bdt / ac)		4.6					
Net Recovery							
Grade Lumber		1.5					
Grade Recovery			**$ / Unit**	**Unit**	**Volume**	**Income**	
Select or Better		70%	$1,000	mbm	25.05	$25,050	
Dimension		30%	$400	mbm	10.74	$4,290	
All lumber					35.79	$29,350	
Residual			$16.00	BDT	32.4	$520	
Shavings			$0.00	BDT	4.6	$0	
Total Income from Sawmill Operations							$29,870
Cost of Sales							
Commissions		1%		mbm			
Discounts		3%		mbm			
Gross Profit							**$28,740**
Expenses			**$ / Unit**	**Unit**	**Volume**	**Expense**	
Log Costs							
	Hybrid poplar log basis		$450	mbf	23.86	$10,740	
	Hybrid poplar lumber basis		$300	mbm	35.79	$10,740	
Direct Manufacturing							
	Sawmill		$85	mbm	35.79	$3,040	
	Kiln		$30	mbm	35.79	$1,070	
	Planer		$45	mbm	35.79	$1,610	
	Shipping		$15	mbm	35.79	$540	
	All Direct Manufacturing		$475	mbm		$17,000	
Indirect							
	General & Administrative		$12	mbm	35.79	$430	
	Depreciation		$40	mbm	35.79	$1,430	
	All Indirect Manufacturing		$52			$1,860	
Total Expenses			**$527**	**mbm**	**35.79**		**$18,860**
Operating Income						$9,870	
	Add back depreciation		$40	mbm	35.79	$1,430	
Operating Cash Flow							**$11,310**

Source: The cash flow to the mill was derived from the study results of Greenwood Resources, and Mater Engineering.
*Numbers may not sum properly due to rounding

The cost of labor is incorporated into the expenses described in Table 7-21 above. According to Mater Engineering the existing workforce of FATCO will be able to handle the additional volume from the hybrid poplar plantation, as described in Appendix K. Labor accounts for 16.4 percent of the total expenses described in Table 7-21. For a complete list of labor expenses see Table 7-22 below.

Table 7-22
Labor Costs by Activity

	$ / Unit	Unit	Percentage	Labor Cost
Log Costs	$300	mbm		
Sawmill	$85	mbm	47.0%	$38.25
Kiln	$30	mbm	38.5%	$11.55
Planer	$45	mbm	47.5%	$21.38
Shipping	$15	mbm	59.5%	$8.93
All Direct Manufacturing	**$475**			**$80.10**
General & Administrative	$12	mbm	54.0%	$6.48
Depreciation	$40	mbm		
All Indirect Manufacturing	**$52**			**$6.48**
Total Expenses	**$527**			**$86.58**

Source: Personal Communication with Catherine Mater, Mater Engineering, January 3, 2007.

It is not appropriate to include labor expenses as a cost in this analysis due to the fact that no additional labor will be required to handle the volume from the proposed poplar plantation. Subtracting the labor cost of $87 from the total per unit cost of $527 leads to a cost per unit of approximately $440. Therefore, the total expenses of processing 37.79 mbm of poplar drops from $18,860 to $15,763 resulting in a net operating cash flow from the mill of $14,405 per acre. This operating cash flow is incorporated into the final year of production for the cash flow analysis for the plantation.

A third benefit of the hybrid poplar plantation is that the guaranteed supply of product as well as the guaranteed revenue stream from the poplar plantation will allow the Tribe to conduct more pre commercial thinning (PCT) in the forest. The PCT will result in greater growth of marketable trees in the existing stand as well as reduce the fire risk in the forest. Because of the guaranteed supply of poplar timber expected in the twelfth year, it is assumed that the Tribe will be able to increase the allowable cut in its forests in the years leading up to the first poplar harvest, then scale back when the hybrid poplar plantation begins producing marketable timber. In present value terms, the net impact of the hybrid poplar plantation on the forest is expected to be $30.8 million, using a discount rate of three percent and a one hundred-year time frame.[47] Appendix L provides details on the benefits of the plantation to the forest.

47 See Appendix L

As a fourth and final benefit, the hybrid poplar plantation will sequester carbon both above and below ground. Carbon sequestration is the process by which atmospheric carbon dioxide (CO2) is captured by the trees through photosynthesis, and stored as carbon in the woody biomass and soils. It is anticipated that a total of 222,259 metric tons of elemental carbon could be stored on a sustainable basis in the proposed poplar plantation. At a baseline of 1.8 metric tons and a leakage rate of 24 percent, the net carbon storage is estimated at 153,599 metric tons, or 45,714 metric tons of atmospheric carbon dioxide. This amount of carbon sequestration will create a potential for the Tribe to trade carbon credits on the Chicago Climate Exchange (CCX) or other carbon market. Currently, carbon is trading at $4.14 per metric ton on the CCX. By applying this value to the carbon sequestered on the proposed hybrid poplar plantation, the annualized per acre value of carbon sequestration is $63.44. Therefore, the four benefits (stumpage, mill, forest, and carbon) of the hybrid poplar plantation total $1,052 per acre on an annualized basis, after accounting for the phased in establishment period of the plantation.

Christmas tree production on the Reservation is analyzed as both a wholesale farm and as a U-cut operation. The wholesale farm operation comprises most of the acreage for Christmas trees (450 acres) and the net returns on trees are expected to total $770 per acre on an annual basis, after accounting for the seven-year phase in period of the Christmas tree plantation. While the U-cut, or choose and cut, operation is much smaller (50 acres) it is more profitable with expected annualized net returns of $2,510 per acre after accounting for the phase in period. Appendix H contains the production budgets used to derive the Christmas tree net return figures.

Table 7-21 below outlines the net returns per acre of irrigated land on the Bonito Prairie irrigation unit.

Table 7-21
Annualized Net Returns to Irrigation, Bonito Prairie

	Acres	Net Return per acre	Total Return
Hybrid Poplar	8,560	$1,052	$9,003,000
Christmas tree (wholesale)	450	$770	$346,000
Christmas tree (U-cut)	50	$2,510	$126,000
Total	**9,060**	**$1,046**	**$9,475,000**

The Table above shows the weighted average of the net returns for crops proposed on the Bonito Prairie unit is $1,046 pre acre on an annual basis. Total annualized returns from the crops are expected to be over $9.4 million for the entire unit.

7.9.6 Integration with FATCO

Hybrid poplars are used in a variety of applications ranging from pallet stock to high valued molding. The milling and remanufacturing plants on the Reservations will enable the Tribe to add value to the poplars using their existing infrastructure, milling lines, and personnel. The findings of Catherine Mater, of Mater Engineering indicate that the small log line at FATCO will be able to process the expected volume from the plantation with no modification. Appendix K describes the mill capacity as well as the hybrid poplar milling capabilities of the existing FATCO sawmill.

The introduction of poplar into the product mix will give FATCO increased control over the log quality and supply coming into the mill, thereby enabling them to increase both external and internal sales. The proposed sales strategy for hybrid poplars identified in Appendix K has 30 percent of the poplar volume being sold as dimension lumber, and the remainder being sold as select or better lumber. Mater Engineering surveyed approximately half of FATCO's existing customer base. The findings of the survey show a high level of interest for purchasing hybrid poplar from FATCO. These findings point to a strong market demand for hybrid poplar and a potentially lucrative business opportunity for FATCO.

While FATCO will be the market destination for the poplars from the plantation, it is assumed in this analysis that FATCO will forgo the responsibility of managing the plantation. Instead, it is assumed that the Tribe will hire an outside entity, like GreenWood Resources, to manage the plantation. A management fee of $50 per acre has been assessed in the production budgets. This is consistent with GreenWood's current management fee on the lands that they currently manage.

7.9.7 Integration with Pine Mixed Conifer Forest Management

Using a forest growth model, Mason, Bruce & Girard estimate that approximately 75 percent of the forest on the east side of the Reservation is over-stocked and susceptible to catastrophic wildfire. One method of reducing fire risk is to increase the level of PCT in the forest. Thinning the forest will reduce fire risk and generate greater growth in the remaining marketable lumber. In this analysis, it is assumed that the net revenue generated from the hybrid poplar plantation will allow the Tribe to perform more PCT.

It is further assumed that the harvest of the natural forest can be increased in the short-term (i.e., until year 12) in anticipation that hybrid poplar volume will then be available to replace some of the timber volume previously cut from the natural forest. The net benefits of the integration of plantation and forest management all of these impacts to the forest are described in Appendix L.

7.10 Labor Benefits

7.10.1 Introduction

This section includes an analysis of the levels of unemployment on the Reservation and project benefits associated with creating Tribal employment opportunities. The principal purpose of this section is to determine the extent of unemployed labor resources, and therefore the available unemployed labor for potential agricultural crop production and water developments on the Reservation. Furthermore, this analysis quantifies the economic benefits of the project in terms of reduced Tribal unemployment. Table 7-23 below provides labor force statistics for the White Mountain Apache Reservation and other Indian reservations in Arizona, including the size of the labor force and the level of unemployment. The unemployment rate in the Tribe averages approximately 47 percent and is comparable to the statewide unemployment average for all Tribes in Arizona (55 percent). A similar high level of unemployment has persisted on the White Mountain Apache Reservation for several decades.

Table 7-23
Labor Force and Unemployment
for the State of Arizona, Western Region,
and White Mountain Apache Tribe in 2001, 2003

Entity	Tribal Enrollment[2]	Total Workforce[48]	Number Employed	Number Not Employed	Unemployed as % of Labor Force
State of Arizona*	214,271	89,564	40,233	49,331	55%
Western Region – BIA*	120,753	62,129	24,901	37,228	60%
White Mountain Apache Tribe**	13,230	7,309	3,849	3,460	47%

*Source: U.S. Department of the Interior, Bureau of Indian Affairs, Office of Tribal Services, 2001, ***American Indian Population and Labor Force Report.***
**Source: U.S. Department of the Interior, Bureau of Indian Affairs, Office of Tribal Services, 2003, Labor Market Information on the Indian Labor Force.

7.10.2 Economic Labor Benefits

In benefit - cost analysis there is a distinction between financial and economic costs. The costs and benefits of the proposed agricultural project presented thus far have been quantified using financial analysis, which indicates the profit potential of the various crops. In contrast to financial analysis, economic analysis includes all net gains or losses of a project from a society's perspective. Benefits of a project to society can be defined as user benefits of a project, increased wage income to the society, or increased value added produced by the society in terms of output of goods and services[49]; this analysis defines benefits according to the increased value added of goods and services produced on the Reservation. Therefore, in economic analysis, benefits of a project may include employment of otherwise unemployed workers since the net value added produced in the society rises due to their employment.

In economic analysis the cost of a resource such as labor is equivalent to the opportunity cost of using the labor in the proposed project.[50] The opportunity cost of a resource is defined as the value of the resource to the society in its next best alternative use. In other words, opportunity cost is what society must give up in order to use the resource in the proposed project. For example, the opportunity cost to the Tribe of labor

48 The potential labor force consists of persons who are 16 years old or older who are not students, disabled, or unable to work because of lack of childcare alternatives.

49 "Assessing the Economic Impact of Transportation Projects: How to Choose the Appropriate Technique for Your Project", Transportation Research Circular, Number 477, October 1997.

50 Office of Management and Budget, "Regulatory Analysis", Circular A-4. September 17, 2003. Gittinger, J. Price, "Economic Analysis of Agricultural Projects," Second Edition, Economic Development Institute (EDI) of the World Bank, The Johns Hopkins University Press, 1982.

is the value of the output produced by the labor, typically measured by a market wage, in the absence of the proposed project.

Since an unemployed person may produce little of value to society, the opportunity cost, or economic cost, of employing an otherwise unemployed laborer is typically much less than the wage rate (financial cost). The opportunity cost to society of an unemployed person may be greater than zero due to the value of leisure time foregone by such workers. However, because society typically does not give up any alternative production of goods and services and because it would be difficult to measure the value of leisure time foregone, a zero opportunity cost is often used for unemployed labor.[51] Instead of adjusting costs to account for the use of unemployed labor, for accounting reasons the use of unemployed labor is documented as a benefit in many benefit - cost analyses. This is the methodology utilized in this benefit - cost analysis.

The employment benefits to the Tribe of the proposed agricultural projects depend on the proportion of Tribal project workers that would be unemployed in the absence of the project. First, it is important to note that the number of unemployed Tribal members (3,900 people) far outnumber the employment requirement of the proposed agricultural project (less than 500 full time equivalents, and less than 2,200 employees in any given month). In fact, the number of unemployed Tribal members outnumbers the employee requirements of all components of the project, including construction and recreation (see Table 7-24). In addition to considering the availability of unemployed Tribal members, it is necessary to consider their skill level. Jobs that will be created by the proposed projects will primarily be for unskilled labor, but will also require some skilled management labor. It is assumed that skilled labor jobs created by the project will be filled by otherwise employed workers. However, given the priority of the Tribe to create employment opportunities for Tribal members and the Tribe's policy of employment preference for any enrolled member of the Tribe, combined with the persistent high availability of unemployed workers on the Reservation, it is assumed in this analysis that all unskilled labor will be provided by otherwise unemployed Tribal members.[52]

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51 U.S. Water Resources Council, "Economic and Environmental Principles and Guidelines for Water and Land Related Resources Implementation Studies", March 10, 1983.

52 White Mountain Apache Code: Revised Edition, Labor code, "Chapter One: Labor Relations", 2000, accessed at http://wmat.nsn.us/Legal/labor.html.

Table 7-24
Unskilled Labor Requirements as a Proportion of Unemployed Labor Force

Project Component	Maximum Unskilled Labor Requirement[1]
Construction Phase	<2,200
Operation Phase	
Agriculture & Related Production	<1,000
Recreation[2]	<135

1/ Maximum labor required at any one time. For example, for certain agricultural operations, seasonal labor requirements may be higher, and this higher seasonal number is presented.

2/ Additional recreation services are estimated to require approximately 85 employees the first year of the project, and rise up to 135 employees in year 50 of the project.

By increasing Tribal employment on the Reservation, the project will be increasing the value of goods and services on the Reservation equivalent to the wage value of the otherwise unemployed workers. Therefore, full labor benefits equivalent to the wage value of unskilled workers are attributed to the Project. Applications of this reasoning are included in the works of several leading authorities of benefit - cost analysis. Five quotations from this literature are cited below;

- "We now turn to the question of how to value the services of workers who before the project were unemployed. If the gains in jobs can be counted as a benefit of the project, its social profitability increases" … "The social cost of hiring a person who before the project was unemployed is his reservation wage. There is no loss of production in other sectors of the economy since the person hired is drawn from the pool of unemployed not from the production of goods and services." **(**Per-Olov Johannson Cost Benefit Analysis of Environmental Change, p. 84.) "Benefits from use of otherwise unemployed or underemployed labor resources may be recognized as a project benefit if the area has substantial and persistent unemployment at the time the plan is submitted for authorization and for appropriations to begin construction." (Army Corps of Engineers ER 1105-2-100 Planning Guidance Notebook, 2004, p. D-32.)

- "The extent to which [employment effects] matter for the CBA depends on the nature of the economy. If there is significant unemployment, the labor should be shadow priced on the basis of its opportunity cost. In turn this may be very low, *i.e.* if not used for the policy or project in question, the labor might otherwise be unemployed." (Organization for Economic Development, "Cost Benefit Analysis and the Environment: Recent Developments", 2006, p. 19.)

- "But suppose our project called for growing maize, which is planted in May when there is little other agricultural work available and harvest in August before the peak harvest season for rice and cotton. Then we might find that, on the margin, many agricultural laborers were either unemployed or not very productively engaged at that season and that to draw them into maize planting might entail an opportunity cost considerably less than the going wage, although it would perhaps not be zero." (J. Price Gittinger, Economic Analysis of Agricultural Projects, p. 262.)

- "Thus, a money payment made by the project-operating entity for, say, wages is by definition a financial cost. But it will be an economic cost only to the extent that the use of labor is this project implies some sacrifice elsewhere in the economy with respect to output and other objectives of the country." (Lyn Squire, and Herman G. Van der Tak, Economic Analysis of Projects (World Bank Research Publications, 1981, p. 16.)

7.10.3 Labor Cost Benefits

Labor costs have been financially accounted for in several areas of the proposed project, including labor for crop production, packinghouse, organic beef operation, and pre-commercial thinning (PCT). Section 7.6.3 above provides a summary of the farm labor hours required as well as the financial labor costs of the crops in the proposed project. Table 7-25 below provides details on the total farm labor wages of the proposed project on a per unit basis. As farm labor is unskilled and is expected to be drawn from the Reservation unemployed labor pool, farm labor wages will be included as project benefits to account for the economic benefits of employment.

Table 7-25
Farm Labor Benefits

Unit	Farm Labor Benefit	Present Value*
Canyon Day	$4,917,000	$142,178,000
Cibecue	$2,633,000	$78,419,000
Bonito Prairie	$1,183,000	$33,205,000
Total	**$8,732,000**	**$253,802,000**

* Present Value is calculated using a 3 percent discount rate, and a 100-year time period.

The highest farm labor benefit is found in the Canyon Day unit, mainly due to the high labor intensity crops proposed in that unit. Additional labor benefits are associated with the Canyon Day unit due to the employment of workers to operate the organic beef venture. The organic beef will require grains and forages produced on the Canyon Day unit. Appendix G provides more information on the costs and benefits involved with the proposed organic beef operation. The labor requirements include the full time equivalent of 2.5 laborers and one manager. It is assumed that the laborers for the proposed beef venture will come from the unemployed pool of labor on the Reservation. The beef manager is also likely to be a tribal employee. However, because of the management responsibilities required of him or her, the assumption in this analysis is that the beef manager will not be taken from the unemployed pool of labor. Therefore, only the additional annual employment of 2.5 FTE laborers, or $44,650 is added to the benefits in the Canyon Day unit. [53]

Another labor benefit associated with the Bonito Prairie unit is the PCT that will be funded through the revenue from the poplar plantation. The additional PCT will add value to the forest, as described in Appendix L. The cost of PCT in the analysis of forest benefits is $150 per acre. It is further calculated in the forest growth model described in Appendix L that 3,078 additional acres will be pre-commercially thinned every year with revenue from the poplar plantation. Therefore, the annual labor benefit of $461,700 is added to the Bonito Prairie unit.

The crops produced on Cibecue and Canyon Day will require the operation of a packinghouse in order to timely market the proposed crops. The operation of the packinghouse will have different seasonally labor requirements: in the off season the packinghouse will require three employees while in the peak season the labor requirement will be 40 or more. In total it is estimated that 26,000 hours of labor will be required in the packinghouse, or the equivalent of 13 full time employees. The financial cost of these employees is $232,180.[54] This unskilled labor is assumed to be supplied from the unemployed labor pool on the Reservation; therefore, it is accounted for as a labor benefit to the respective irrigation units. Of the 3,340 acres of proposed production that will use the packinghouse, 69 percent of the acreage is proposed in Canyon Day and the remaining 31 percent is proposed for Cibecue. The labor benefits of the packinghouse are attributed to each unit based on these proportions. Therefore, an additional $159,280 in annual labor benefits is attributed to Canyon Day, and an additional $72,900 in annual labor benefits is attributed to Cibecue. Table 7-26 below provides a summary of the labor adjustments by irrigation unit.

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53 2.5 FTE x 2,000 hrs = 5,000 hrs x $8.93 (weighted average financial cost of employment) = $44,650

54 26,000 hrs x $8.93 (weighted average financial cost of employment) = $232,180

Table 7-26
Labor Benefits of the Proposed Project

Unit	Farm Labor Benefit	Beef Labor Benefit	PCT Labor Benefit	Packinghouse Labor Benefit	Present Value*
Canyon Day	$4,712,750	$44,650		$159,280	$142,178,000
Cibecue	$2,559,920			$72,900	$78,419,000
Bonito Prairie	$721,030		$461,700		$33,205,000
Total	**$7,993,700**	**$44,650**	**$461,700**	**$232,180**	**$253,802,000**

* Present Value is calculated using a 3 percent discount rate, and a 100-year time period.

8. ECONOMIC BENEFITS OF RESERVOIR RECREATION

The White Mountain Apache Tribe (WMAT or Tribe), located in east central Arizona, is considering the construction of several reservoirs for multiple uses. These reservoirs will not only allow for greater economic development on the Fort Apache Indian Reservation (Reservation) in the form of improved water supplies for irrigation of agricultural crops, but will also provide additional recreational resources for the many visitors that come to the Reservation to seek a wide variety of recreational opportunities. For example, the Reservation is also the only location where anglers can catch the indigenous Apache Trout. The Tribe derives significant benefits from its existing recreational tourism in the form of permit revenue, expenditures at Tribally-owned food and lodging establishments, and programs such as the world renowned trophy elk hunts.

The objective of this report is to estimate the anticipated recreational benefit associated with the development of the proposed reservoirs. The report details existing recreational benefits and the potential future of this growing industry on the Reservation without the water storage project. This scenario, without the water storage project, is called the Baseline scenario or condition. Expected future recreational benefits with the proposed reservoirs in place are then estimated and compared with the Baseline scenario to derive the benefit associated with the project.

8.1 Proposed Reservoirs

Four reservoirs are proposed for the Reservation. Three of these are expected to generate the most recreational interest: Miner Flat Reservoir, Bonito Creek Reservoir, and Salt Creek Reservoir. The Miner Flat Reservoir is located just off the main highway on the White River (or White Creek) near two of the most popular fishing locations. Bonito Creek Reservoir is located on Bonito Creek and constitutes a much larger reservoir, while the Salt Creek Reservoir is located near Cibecue. The proposed construction of the associated dams is described in greater detail in Chapter 5. The construction of the proposed reservoirs is collectively referred to as the project.

8.2 Approach

The recreation resources created by the new reservoirs will result in numerous types of economic benefits. These include benefits to Tribal members who regularly recreate on the Reservation, benefits to tourists visiting the Reservation, and benefits to the Tribe from revenues generated by tourists. The reservoirs will provide additional water resources for recreational activities such as fishing, boating, and camping. In addition to the benefits related to greater access to recreation, water from the proposed Miner Flat Reservoir will provide the Alchesay-Williams Creek National Fish Hatchery (A-WC) complex with improved water quality and quantity, thus enabling the hatchery to increase fish production. The hatchery currently supplies several species of trout for stocking lakes on the Reservation, and is a critical element in the success of the recreational tourism industry on the Reservation. In addition to attracting more visits due to more water and more stocked fish, the region immediately downstream from the proposed reservoirs is expected to generate interest as a “blue ribbon” Trout fishery, appealing to high end fly-fishing enthusiasts.

In economics, benefits to recreationists, and the benefits from increased tourism revenues can be used in benefit-cost analysis to help decision-makers determine the economic feasibility of a project. Federal agencies such as the Bureau of Reclamation, the Army Corps of Engineers, and the U.S. Fish and Wildlife Service use such measures when deciding whether to adopt or not adopt a project.[1] Producer surplus (commonly referred to as profits), consumer surplus, and labor income benefits are three types of economic benefits associated with the proposed project. Producer surpluses consist of the revenue generated by businesses in excess of costs. The proposed reservoirs are expected to generate producer surpluses for the Tribe through permit revenues generated by the additional tourism, and through additional profits at Tribal facilities that provide lodging, food, bait, and gas to recreationists.

Consumer surpluses are also included in benefit analysis. These are the economic values that recreationists gain from taking a recreational trip. These values are measured as the difference between what someone was willing to pay for a trip and what the individual actually paid. In the case of outdoor recreational experiences, since these are often provided at little cost to the recreationist, the actual values, or consumer surpluses can be substantial. The proposed project will create consumer surplus for both Tribal members and tourists visiting the Reservation.

Labor income benefits are benefits to the Tribe from the additional employment associated with the project. Since there is a high degree of unemployment on the Reservation, job creation is considered a valuable objective of the project. Additional employment is expected through increased demand for lodging, food, and other services as a result of the expanded tourism sector.

This report will develop estimates of the benefits of increased profits, labor income, and economic value to recreationists based on increased recreation visitation anticipated with the construction of the reservoirs. Recreation visitation has been estimated for a baseline scenario which assumes that the water storage project is not built (Baseline), and again for the "with project" scenario. Using these two scenarios, the value of the project may be considered the additional benefit associated with the project over and above the Baseline. Net permit revenues from the project, profits and labor income from the expenditures of visitors, and economic value to Tribal members are estimated in the analysis that follows.

In addition to the economic benefits that will accrue to the Tribe through additional recreation at the proposed reservoirs, benefits for some non-Tribal groups will also increase. Specifically, through the additional recreational expenditures, profits or producer surpluses and possibly labor income will accrue to non-Tribal local businesses that provide food, lodging, and

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1 Several Federal guidelines exist to guide the development of benefit-cost analysis such as, U.S. Water Council, 1983, *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*; and U.S. Army Corps of Engineers, 1990, *Policy and Planning – guidance for Conducting Civil Works Planning Studies*, Engineer Regulation 1105-2-100.

other goods and services to anglers. As a result of the improved fish production at A-WC, some of the benefits will also accrue to tribes on other reservations that receive fish stocks from the hatchery. Finally, economic benefits will accrue to recreationists who come to the Reservation for fishing. Where possible, each of these benefits has been described and quantified, though only the benefits to the Tribe will be included in the benefit-cost analysis (see Chapter 11).

8.3 Background and Literature

There is a substantial recreational industry present in the White Mountain region of Arizona in general, and on the Reservation in particular, with recreation ranking second only to gaming in terms of Tribal revenue. Visitation estimates were collected from a variety of data sources in an effort to identify and evaluate the baseline scenario that may be expected on the Reservation if the proposed reservoirs are not constructed. The existing recreational facility base, the hatchery, and sizeable managerial infrastructure all support the notion that recreation benefits will be realized when the reservoirs are constructed. Evidence from a survey of anglers and other recreationists[2] provides evidence that people enjoy the current recreational experience on the Reservation and, above all, would like to have more fish stocked in the lakes. Furthermore, the number of anglers, boaters, and campers is rapidly growing with expanding populations in all the major geographic areas of origin for visitors to the Reservation, including Phoenix, Tucson, and the local Pinetop-Lakeside area.

Several recent reports have focused on the economic potential of the recreation industry on the Reservation. Together, these reports document the magnitude and importance of the industry to the Tribe's economic development strategy, as well as identify areas of improvement. These documents are reviewed individually below.

White Mountain Apache Tribe Recreation and Planning Study, April, 2003. Authors: Tribe and Bureau of Reclamation. This report documents the existing recreation facilities on the Reservation, identifying $20 million in recommended reconstruction costs and $153,000 in recommended annual maintenance costs. There are 18 lakes and nine rivers analyzed in the study area. The principal argument presented in the report is that infrastructure maintenance is badly needed for existing facilities to continue operating. The study does not provide documentation on recreation demand issues for the area or address the possible development of new facilities, such as the new reservoirs.

The study also presents a table of facts about tourists to Arizona, and notes how the Reservation can capitalize on these facts. Strategies for the Reservation include planning and designing recreational facilities for groups and families, emphasizing the unaltered natural settings to appeal to out of state visitors, and improving recreational infrastructure to attract in-state tourists.

White Mountain Winter Tourism Study: Evaluating the Efficacy of Regional

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2 The Wildlife and Outdoor Recreation Division of the White Mountain Apache Tribe annually collects data from visitors on the length of their stay, the number of fish they catch, their overall satisfaction, and any other comments. These data (referred to as "creel data") are reported in detail in Appendix O, *Survey of Current Recreationists*.

Investment Opportunity - Prepared for the White Mountain Winter Tourism Advisory Committee, supported by Rural Economic Development Initiative, Arizona Department of Commerce, October, 2001. Authors: Evans Grogan Gibson and Students, Dept. of Geography and Regional Development, University of Arizona. This report discusses the economic importance of the winter tourism industry for the communities of Show Low, Pinetop-Lakeside, Springerville, Eagar, Snowflake, Taylor, and Greer, and for the Tribe. The central draw for winter activity in the area is the Apache Sunrise Ski Area (Sunrise), located on the Reservation. The study is based on a survey of staff at local RV parks, motels, sporting goods stores, real estate offices, gift stores, restaurants, and grocery stores that collected information on the proportion of business revenue that stems from tourism and also information on baseline employment. The study focuses on the Winter season and the dependence on Sunrise. For example, nearly 50 percent of employment in Pinetop-Lakeside is tourism dependent. Overall, 70 percent of respondents agreed that Sunrise benefits their business, and 57 percent felt that if Sunrise were to shut down, it would hurt their businesses. Winter tourism represents about 20 percent of overall revenue in the study area.

The tourism study also analyzes the Arizona Department of Revenue city bed tax collections for hotels and motels by quarter for Pinetop-Lakeside, Show Low, and Springerville. These findings suggest that 30 percent of all hotel and motel revenues come in the summer, and the figure is even higher for Pinetop/Show Low at 40 percent.

Control of the Hatchery, an economic Benefit for the Future. Confidential report to the Tribe produced by the John F. Kennedy School of Government, Harvard University, 2000. Authors: Stephen Brimley and Josh Flax. The report focuses on the value and market for various farmed trout products including sport fishing. The document explores the revenue-generating potential of the A-WC fish hatchery if it were to become a for-profit aquaculture production facility owned and operated by the Tribe. At present, the hatchery is a federal operation run collaboratively between the Tribe and the federal government. However, the report argues that growing demand for stocker fish and food fish throughout the Southwest supports the possibility of developing the hatchery as a successful economic enterprise. The analysis concludes that production at the hatchery at 1999 levels could generate just under $1.2 million per year (in 2000 $).

The report also examines the recreation permit sales for the period 1997 to 1999, showing that fishing, boating, and camping revenue totaled over $800,000 dollars in each of those years (in nominal dollars, or the value of the dollar in the year reported). The number of fishing permits and camping licenses issued in 2000 on the Reservation is reported to total 75,000 and nearly 20,000, respectively. The report states,

> *The data supports the conclusion that a small effort will enable the Tribe to establish a world-class reputation for sport fishing that is equal to its hunting expedition renown. (p.8)*

Specific recommendations of the study include: Offering high-end, comprehensive fishing expeditions; offering integrated hunting and fishing expeditions; raising expedition prices to regional levels; creating unique fishing expeditions for Apache Trout; and restructuring sport fishing business to resemble elk-hunting operations. Furthermore, the authors point out that an additional $141,000 could be earned by merely raising daily fishing permit prices. At the time of report development, the daily fishing permit price was $8 per day, and the recommendation was to consider increasing this price to $10 per day. Current daily fishing permits are priced at $6 per day.

The Economic Effects of Recreational Use of Alchesay-Williams Creek National Fish Hatchery 2004 Stocking, February, 2006.

This report estimates the value of the fish that are produced at the A-WC located on the Reservation. The author evaluates the economic role of the hatchery for raising five species of trout for stocking in Indian waters in Arizona, New Mexico, and Colorado. The average total number of fish stocked over the 2002 to 2004 period was about 1 million, with over two-thirds of these being Rainbow Trout. The hatchery has led the recovery effort for Apache Trout, a rare trout native only to Arizona. A-WC produces 160,000 Apache Trout on average per year, or just over 16 percent of the total production. The report identifies a number of important goods and services provided by the hatchery, including recreation, information, ecological use, and federal spending.

This study distinguishes between economic value and economic impacts, both of which are quantified in the report. Economic value is the maximum amount people would be willing to pay in order to obtain a good, minus the cost of acquiring the good. As stated previously, this is known as the consumer surplus. Economic impacts cover the economic ripple effects of spending on recreation and business operations that are attributable to the project.

In order to estimate impacts, the report first calculates angler days for the years 2003 and 2004. The total angler days were estimated at over 84,000 on average for non-member anglers, and over 22,000 for tribal members. The total average for both tribal members and non-members was over 106,000 angler days. Of the non-member angler days, 80 percent were estimated to come from outside the area, defined as more than 50 miles away. Expenditures were estimated for both resident anglers and non-resident anglers. A total of $8.9 million was estimated to have been spent in the local area (within 50 miles) on angling-related goods and services associated with fish produced and stocked by the A-WC. Another $1.1 million was spent by Arizona residents fishing for A-WC fish stocked in Arizona, but outside the local area, while $2.38 million was spent in New Mexico on hatchery fish-related angling, and over $69,700 was spent in Colorado. Total expenditures were just under $12.4 million.

Net economic value, or the consumer surplus, of the fish stocked by the A-WC totaled over $15.2 million annually, with $9.8 million of that value associated with the fish stocked on the Reservation. Finally, the study compares the hatchery budget expenditures per fish stocked ($0.60) with retail sales per fish stocked ($10.08) and net economic value per fish stocked ($12.39).

8.4 Recreation Visitation and Expenditures

As indicated by the reports reviewed in the previous section, recreation is a key economic industry for the Tribe as well as the regional economies of Pinetop-Lakeside, Show Low, Taylor, and

Snowflake.[3] Sunrise, which is owned and operated by the Tribe, has been linked to major economic activity in the area during the winter season. The White Mountain area is popular during the rest of year as well, especially with retirees, a group that continues to grow as a share of the Arizona population (see Demographic Profile of the Fort Apache Indian Reservation for more information). Regional recreation attractions that bring visitors to the area include two national forests bordering the Reservation; the Hon-Dah Casino, which is owned and operated by the Tribe; the Apache Cultural Center on the Reservation; and numerous restaurants and amenities that have developed to serve the visitor populations in the local towns.

Recreation revenues for the Tribe stem from the many recreational programs, including the world famous Trophy Elk hunts and Sunrise. Details of these programs are provided in Appendix N. The A-WC plays a unique role in supporting fishing-related recreation on the Reservation. Table 8-1 presents the revenue from permit sales for all types of recreation on the Reservation during the year 2005. The rows shown in the bold font – fishing, camping, boating, and special uses, are those that are expected to be affected by the project.

Table 8-1
Summary of Visitors and Revenues, 2005

Activity	Estimated Number of Visitors	Revenue	Permit Price
*Fishing**	*92,517*	*$687,455*	*$6*
Camping	*30,710*	*$245,678*	*$8*
Boating	*9,903*	*$49,515*	*$5*
Rafting	***14,421***	***$223,815***	***$15***
Special Use	*7,883*	*$118,245*	*$15*
Hunting	***1,114***	***$2,025,030***	***variable***
Skiing	***172,912***	***$7,089,392***	***$41***
TOTAL	*351,519*	*$10,439,130*	

*Fishing includes fish camp revenues

8.4.1 Baseline Visitation and Expenditures

Under Baseline conditions, angling on the Reservation is expected to grow at a rate proportionate to, but slightly less than, regional population growth. While regional population growth is estimated at two percent per year for the next 30 years, growth of angling would be one percent or less. The reduction is due to losses in angling-related visitation that would be associated with decreased catch rates as the regional population increases and places greater demands on the existing fishery resource. Table 2 shows angler trips under Baseline conditions.

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3 Gibson, Lay James, Bryant Evans, Andrew Grogan, October 2001, *White Mountain Winter Tourism Study: Evaluating the Efficacy of Regional Investment Opportunity,* University of Arizona, Economic Development Research Program.

Based on permit revenue data provided by the Tribal Wildlife and Outdoor Recreation Department, it is estimated that 109,563 angler days were enjoyed by non-tribal member recreationists in 2005. Under existing conditions, the number of non-member angler-trips is estimated to grow to 178,407 over the next 50 years. It is estimated that 22,557 visits were made by Tribal members in 2005. Over a 50 year period, this number is expected to grow to 36,730 trips. Given that both Tribal and non-Tribal populations are expected to continue growing after fifty years, fishing trips may continue to increase in the subsequent 50 years. However, due to uncertainties surrounding trends in recreational preferences, the assumption that the level of visitation remains constant after the first 50 years represents a reasonable and conservative approach.

Over the 100-year lifetime of the project, a total of 19,273,672 trips are expected under Baseline conditions. This total is made up of just under 16 million non-member trips and 3.3 million trips from members of the Tribe.

Permit revenues include permit sales for camping, boating, fishing, and special use permits. It is assumed that angling-related permit prices (presented in bold font, in Table 1), which presently average about $10 per angler-day, will be increased to the more typical prices in Arizona for fishing. The increase is based on State fees, which are now about 80 percent higher than those on the Reservation. Thus, for these Baseline calculations, it is assumed that approximately $18 on average will be paid per angler day for fishing, including some camping and boating fees. For details of these calculations, see Appendix P. The annual Baseline permit revenue under these assumptions is expected to be just under $2.0 million in Year 1, growing to $3.2 million in 2005 dollars by Year 50. Following Year 50, due to the assumption above, permit revenue is expected to continue at $3,226,747 per year (in 2005 dollars).

Tribal facility revenues from these recreationists are assumed to include expenditures on gas, food, lodging, and bait. Expenditures by tribal members are not included in the total values, because these expenditures are not considered an economic benefit to the Tribe. Table 8-2 also shows the Baseline expenditures beginning in Year 1 of the proposed project. Expenditure data is based on data on average daily expenditures from a 2005 creel survey.

Table 8-2
Baseline Angler Days and Expenditures

	Non-Member	Member	Non-Member	
Year	Angler Days	Angler Days	Permit Revenue	Expenditures
1	109,563	22,557	$1,981,607	$9,287,040
2	110,659	22,782	$2,001,423	$9,379,910
3	111,765	23,010	$2,021,438	$9,473,709
4	112,883	23,240	$2,041,652	$9,568,446
5	114,012	23,472	$2,062,069	$9,664,131
6	115,152	23,707	$2,082,689	$9,760,772
7	116,303	23,944	$2,103,516	$9,858,380
8	117,466	24,184	$2,124,551	$9,956,963
9	118,641	24,425	$2,145,797	$10,056,533
10	119,827	24,670	$2,167,255	$10,157,098
11	121,026	24,916	$2,188,927	$10,258,669
12	122,236	25,166	$2,210,817	$10,361,256
13	123,458	25,417	$2,232,925	$10,464,869
14	124,693	25,671	$2,255,254	$10,569,517
15	125,940	25,928	$2,277,807	$10,675,213
16	127,199	26,187	$2,300,585	$10,781,965
17	128,471	26,449	$2,323,591	$10,889,784
18	129,756	26,714	$2,346,826	$10,998,682
19	131,054	26,981	$2,370,295	$11,108,669
20	132,364	27,251	$2,393,998	$11,219,756
21	133,688	27,523	$2,417,938	$11,331,953
22	135,025	27,798	$2,442,117	$11,445,273
23	136,375	28,076	$2,466,538	$11,559,725
24	137,739	28,357	$2,491,204	$11,675,323
25	139,116	28,641	$2,516,116	$11,792,076
26	140,507	28,927	$2,541,277	$11,909,997
27	141,912	29,216	$2,566,689	$12,029,097
28	143,331	29,509	$2,592,356	$12,149,388
29	144,765	29,804	$2,618,280	$12,270,881
30	146,212	30,102	$2,644,463	$12,393,590
31	147,674	30,403	$2,670,907	$12,517,526
32	149,151	30,707	$2,697,616	$12,642,701
33	150,643	31,014	$2,724,593	$12,769,128
34	152,149	31,324	$2,751,839	$12,896,820
35	153,671	31,637	$2,779,357	$13,025,788
36	155,207	31,954	$2,807,151	$13,156,046
37	156,759	32,273	$2,835,222	$13,287,606
38	158,327	32,596	$2,863,574	$13,420,482
39	159,910	32,922	$2,892,210	$13,554,687
40	161,509	33,251	$2,921,132	$13,690,234
41	163,124	33,584	$2,950,343	$13,827,136
42	164,756	33,919	$2,979,847	$13,965,408
43	166,403	34,259	$3,009,645	$14,105,062
44	168,067	34,601	$3,039,742	$14,246,112
45	169,748	34,947	$3,070,139	$14,388,574
46	171,445	35,297	$3,100,841	$14,532,459
47	173,160	35,650	$3,131,849	$14,677,784
48	174,891	36,006	$3,163,167	$14,824,562
49	176,640	36,366	$3,194,799	$14,972,807
50 - 100	178,407	36,730	$3,226,747	$15,122,535

8.4.2 Visitation and Expenditures with Project

Based on current year estimates, angling visitation in year one with the project is estimated to increase to 306,493 trips (compared to 132,120 in baseline) and rise to 499,078 trips by Year 50. Angler trips are expected to increase as a result of increased reservoir surface area and the improved fish stocking program. This will result in an additional average annual 111,889 trips from non-members per year through the first 50 years, and 117,259 after that. Trips by Tribal members would increase annually by 38,382 trips per year on average over the first 50 years and by 42,389 additional trips annually during the latter 50 years.

The Tribe would also undertake a marketing effort directed towards non-member families with young children who have not experienced fishing on the Reservation. These marketing efforts would promote fishing derbies at the new reservoirs, resulting in expected additional increase of 22,167 trips annually by families on average over the first 50 years, and 34,426 trips annually on average over the latter 50 years of the project. Finally, project improvements would result in improved habitat conditions for trout, particularly downstream of the proposed reservoir dams. These improved habitat conditions would allow the Tribe to market an improved “Blue Ribbon” trout fishery resource to fly anglers, resulting in an additional 23,294 angler trips for the first 50 years, and 26,358 annually after that.

In total, project improvements would result in an estimated additional 25,437,537 angler trips over the 100-year lifetime of the project compared to Baseline conditions. Of these additional trips, approximately 21.1 million are expected from non-members, and 4.3 million are expected from members of the Tribe. Tribal member and non-member trip numbers by project year are shown in Table 8-3, along with total estimated permit revenues and total expenditures from non-members. With the project in place, permit revenue and expenditures are expected to remain essentially as they are at Baseline, with a few exceptions. With the project in place, it is assumed that the Reservation would be comparable to other Arizona State Parks, which all charge an entry fee in addition to permit fees. A $5.00 per vehicle, charge is therefore included, or a $2.50 charge per person. Also, fly fishing is expected to result in higher permit fees, and these anglers are expected to generate about $40 per person per day in permit fees. Such higher fees are consistent with market rates for these trips.

Expenditures are assumed to be the same with the project as in the Baseline scenario except that the fly fishing portion of visitors are assumed to spend an additional $100 per capita per day on guide services and other items specific to fly fishing. This approach is justified in more detail in Appendix P.

Table 8-3
Annual Angler Days and Expenditures with Project

Year	Member Angler Days	Angler Days	Non-Member Permit Revenue	Expenditures
1	52,327	254,166	$4,247,525	$19,906,532
2	52,850	256,708	$4,277,150	$20,045,373
3	53,379	259,275	$4,307,071	$20,185,601
4	53,913	261,868	$4,337,291	$20,327,232
5	54,452	264,486	$4,367,813	$20,470,279
6	54,996	267,131	$4,398,641	$20,614,757
7	55,546	269,803	$4,429,777	$20,760,679
8	56,102	272,501	$4,461,224	$20,908,061
9	56,663	275,226	$4,492,986	$21,056,916
10	57,229	277,978	$4,525,066	$21,207,260
11	57,802	280,758	$4,557,466	$21,359,108
12	58,380	283,565	$4,590,190	$21,512,473
13	58,963	286,401	$4,623,241	$21,667,373
14	59,553	289,265	$4,656,623	$21,823,822
15	60,149	292,158	$4,690,339	$21,981,835
16	60,750	295,079	$4,724,392	$22,141,428
17	61,358	298,030	$4,758,786	$22,302,617
18	61,971	301,010	$4,793,523	$22,465,418
19	62,591	304,020	$4,828,608	$22,629,847
20	63,217	307,061	$4,864,043	$22,795,920
21	63,849	310,131	$4,899,833	$22,963,654
22	64,487	313,233	$4,935,981	$23,133,066
23	65,132	316,365	$4,972,491	$23,304,171
24	65,784	319,528	$5,009,365	$23,476,988
25	66,441	322,724	$5,046,608	$23,651,532
26	67,106	325,951	$5,084,224	$23,827,823
27	67,777	329,211	$5,122,216	$24,005,876
28	68,455	332,503	$5,160,587	$24,185,709
29	69,139	335,828	$5,199,343	$24,367,341
30	69,831	339,186	$5,238,486	$24,550,789
31	70,529	342,578	$5,278,020	$24,736,072
32	71,234	346,004	$5,317,950	$24,923,208
33	71,947	349,464	$5,358,279	$25,112,214
34	72,666	352,958	$5,399,011	$25,303,111
35	73,393	356,488	$5,440,151	$25,495,917
36	74,127	360,053	$5,481,702	$25,690,651
37	74,868	363,653	$5,523,669	$25,887,333
38	75,617	367,290	$5,566,055	$26,085,981
39	76,373	370,963	$5,608,865	$26,286,616
40	77,136	374,672	$5,652,103	$26,489,257
41	77,908	378,419	$5,695,774	$26,693,924
42	78,687	382,203	$5,739,881	$26,900,638
43	79,474	386,025	$5,784,430	$27,109,419
44	80,268	389,885	$5,829,423	$27,320,288
45	81,071	393,784	$5,874,867	$27,533,266
46	81,882	397,722	$5,920,765	$27,748,373
47	82,701	401,699	$5,967,123	$27,965,632
48	83,528	405,716	$6,013,943	$28,185,063
49	84,363	409,774	$6,061,232	$28,406,689
50 – 100	85,207	413,871	$6,108,994	$28,630,530

8.5 Project Benefits

Three types of project benefits have been quantified for this analysis. These include permit revenues; profits and labor benefits (stemming from angler expenditures); and economic value to recreationists (consumer surplus). Each benefit is described below.

8.5.1 Permit Revenue Benefits

Permit revenues shown in Table 8-4 constitute the total annual revenues from sales of daily and annual fishing licenses, as well as camping and boating permits since most of the boaters and campers are drawn to the Reservation to fish. Net permit revenue is the dollar value of permit fees collected, minus the cost of running the program. Costs for the fishing program were calculated using budget data from the Tribal Wildlife and Outdoor Recreation Division. Program costs totaled 47 percent of revenues. Because permit fees are assumed to increase by 80 percent to be compatible with Arizona market prices under the Baseline conditions while program costs will remain the same, costs will then represent a smaller percent of the total revenue – just 23 percent of permit revenues. This 23 percent is expected to remain constant throughout the expansion of the recreation sector on the Reservation, implying that program costs will increase in proportion to visitation.

Table 8-4
Net Permit Revenue Project Benefit

Average Annual Time Period	Baseline Net Revenue	With Project Net Revenue	Project Benefit
1 – 50 years	$1,887,724	$5,321,336	$3,433,612
51-100 years	$2,384,208	$6,720,881	$4,336,674
Project Life Total	**$213,596,577**	**$602,110,852**	**$388,514,275**

In the Baseline scenario, the average annual net permit revenue is expected to reach just under $1.9 million for the first 50 years of the project, based on the assumed increase in permit fees. For the subsequent 50 year period, the annual Baseline net revenue is expected to be $2,384,208. With the project, average net revenue for the first 50 years is expected to be $5,321,366, and then remain constant at $6,720,881 for the remainder of the project life. The benefit derived from the project (the difference between Baseline and project conditions) is an average of $3,433,612 for the first 50 years, and then remains at $4,336,674 for the remainder of the project life. Over the 100 year project life, the expected total (undiscounted) project benefit in terms of permit sale revenue is $388,514,275.

8.5.2 Recreation Expenditures Benefits

In addition to permit revenues, recreation activity also generates economic benefits for the Tribe as a result of recreationists purchasing goods and services on the Reservation. These benefits come in the form of profits earned by Tribal businesses and labor income earned by otherwise unemployed Tribal employees. Increases in recreation use levels translate into increased recreation spending on the Reservation, primarily at Tribal businesses, and thus, economic benefits for the Tribe.

Recreation spending benefits were estimated based on projected recreation use levels by non-Tribal members,[4] representative spending patterns, unemployed labor force capacity, and economic relationships for recreation-serving industries derived from regional data. For more information on the methodology used to estimate the economic benefits attributed to recreation spending, please refer to Appendix Q.2.

It is estimated that recreation visitors spend approximately $84.76 per day, consisting primarily of spending on food followed by expenditures on lodging, gas, and bait.[5] In addition, it is anticipated that fly fisherman would spend an additional $100 per day on guide and outfitting services. Of the total spending by non-Tribal members, it is further estimated that approximately 63 percent of these expenditures are captured on the Reservation at Tribe-operated businesses. Based on these data, an estimated $2.24 billion in recreation spending would be generated by non-Tribal member visitation over the project lifetime, which represents an additional $1.39 billion than the Baseline scenario without the project.

Only a portion of recreational spending may be considered as project benefits, because much of the spending goes to businesses that must use the revenue to buy inventories and supplies. However, the profits that businesses make from sales may be considered as project benefits. Using the economic relationships between spending, economic output, income and profits, which were derived from a regional economic (i.e., input-output) model for the Navajo County area, recreation expenditures were translated into estimated profits and labor benefits to the Tribe.

The estimated economic benefits associated with recreation spending are summarized in Table 8-5. The annual average recreation spending benefits realized by the Tribe during the first 50 years of the project are estimated at $6.7 million with the project, and at $2.3 million in the Baseline scenario. Hence, during the first 50 years, the annual benefit attributable to the project is $4.4 million. In the subsequent 50 year period, the analogous annual benefit of the project is $5.6 million. Over the lifetime of the project, these estimates total just under $500 million for the Tribe. In terms of the types of recreation spending benefits, approximately 45 percent of the increased benefits come in the form of net labor income earned by otherwise unemployed Tribal employees, with the remaining 55 percent representing the business profits of Tribal enterprises that serve recreation visitors.

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4 Economic benefits are based on recreation spending by non-Tribal members only. Spending by Tribal members represents a shift in money from one Tribal entity to another, with no net change in the overall economic well being of the Tribe, while non-Tribal spending represents new money from outside the region that would likely not otherwise be captured in absence of the recreation opportunities provided on the Reservation

5 Permit costs were excluded from the spending data as permit revenue benefits are estimated separately.

Table 8-5
Recreation Spending Benefits of Proposed Reservoirs to the Tribe

Average Annual Time Period	Baseline Net Revenue	With Project Net Revenue	Project Benefit
1 – 50 years	$2,320,328	$6,731,541	$4,411,213
51-100 years	$2,930,590	$8,501,980	$5,571,390
Project Life Total	**$262,545,887**	**$761,676,012**	**$499,130,125**

Since only 63 percent of expenditures are expected to occur on the Reservation at Tribe- owned businesses, the remaining 37 percent of expenditures will generate similar types of benefits in the local communities and governments. These benefits to the local area are expected to total $204.0 million in profits, labor income, and businesses taxes over the next 100 years (see Table 8-6).

Table 8-6
Recreation Spending Benefits of Proposed Reservoirs to the Community

Average Annual Time Period	Baseline Net Revenue	With Project Net Revenue	Project Benefit
1 – 50 years	$1,366,171	$3,169,269	$1,803,098
51-100 years	$1,725,482	$4,002,807	$2,277,324
Project Life Total	**$154,582,653**	**$358,603,763**	**$204,021,110**

8.5.3 Economic Value with Project

The net economic value from recreation is consumer surplus that recreationists enjoy. In order to quantify the economic value of the recreation opportunities provided by the proposed reservoirs, the amount recreationists are willing-to-pay to fish in Arizona is used. Based on a 2003 report from the U.S. Fish and Wildlife Service, the average values for recreation in Arizona are $57.35 for in-state residents and $100.36 for out-of-state residents.[6] Since non-Tribal members are both in-state and out-of-state residents, a weighted average economic value of $61.44 is derived for non-Tribal members. Using the reservation angler days reported by the U.S. Fish and Wildlife Service[7], an economic value of $1.3 million for the current year is found for Tribal members. The estimated additional economic value Tribal members will gain over and above the Baseline would be 1.7 million. Over the first 50 years, the total annual economic value to Tribal

6 Aiken, Richard and Genevieve Pullis La Rouche. *Net economic Values for Wildlife-Related Recreation in 2001*. Addendum to the 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Report 2001-3. Division of Federal Aid, U.S. Fish and Wildlife Service. Washington DC. September 2003.

7 See Caudill, 2006.

members due to the project averages over $2.2 million per year, and for the subsequent years averages nearly a total of $2.8 million. Over the life of the project, the total benefit is just under $250 million (see Table 8-7).

Table 8-7
Tribal Economic Value Benefits of Project

Average Annual Time Period	Baseline Net Revenue	With Project Net Revenue	Project Benefit
1 – 50 years	$1,667,811	$3,869,020	$2,201,209
51-100 years	$2,106,456	$4,886,597	$2,780,141
Project Life Total	**$188,713,371**	**$437,780,849**	**$249,067,477**

Although the value to non-member recreationists does not directly benefit the Tribe, it is an economic benefit to the greater American society. For this reason, the value to non-member anglers that is anticipated to result from the project is summarized below in Table 8-8. Total net benefits to non-member recreationists over the life of the project are expected to reach almost $1.3 billion.

Table 8-8
Non-Member Economic Value Benefits of Project

Average Annual Time Period	Baseline Net Revenue	With Project Net Revenue	Project Benefit
1 – 50 years	$8,647,795	$20,061,317	$11,413,523
51-100 years	$10,922,221	$25,337,574	$14,415,353
Project Life Total	**$978,500,751**	**$2,269,944,553**	**$1,291,443,802**

8.6 Appendices

This report includes several appendices that provide more detailed information supporting the recreation benefit analysis. Appendix M covers the status of recreation in the White Mountain Region. Appendix N covers the current status of the recreation industry on the Reservation. The purpose of these two appendices is to demonstrate that economic benefits from recreation at the proposed water storage projects will build on the well-established and rapidly expanding recreational sector in the area. The enhancement will complement existing strengths in terms of the natural assets of the Recreation as well as the managerial and physical infrastructures already in place, such as the A-WC. The current recreation sector is growing in the local area of Pinetop-Lakeside as well as in Arizona in general, and is forecasted to continue to grow for some time, fueled by population increases throughout the state. Appendix O also includes the results from an annual survey of Reservation visitors demonstrating that a) visitors love the beauty of the Reservation, and b) they would like to have more fish stocked on the Reservation.

Recreation participation and expenditures, both under Baseline conditions and with the project are developed more fully in Appendix P. Details of the benefit estimation results are presented in Appendix Q. Appendix R includes a review of similar research on estimating reservoir visitation from a variety of state and federal agencies. Using one strategy recommended by the U.S. Army Corps of Engineers (USCOE) alternative participation estimates are derived for the Reservation water storage project. As a point of comparison, these alternate estimates demonstrate that the results presented in this report may be considered conservative.

8.7 Summary and Discussion

There are multiple types of economic benefits associated with recreation. A summary of the total benefits that will accrue to the Tribe as a result of the proposed water storage project is provided in Table 8-9. The summary shows that over the project life of 100 years, the annual value of permit revenue benefits is expected to be just under $3.9 million. The average annual benefit in terms of profits and labor income to the Tribe is expected to be just under $5.0 million, while the economic value to the Tribe is estimated at an annual rate of just under $2.5 million. Overall, the average annual value of recreation benefits will be over $11 million (in 2005 dollars). Detailed year-by-year values are available in Appendices M through R.

Benefits from the storage project will also accrue to the local communities and to non-Tribal recreationists who visit the Reservation. The local communities are expected to benefit in terms of profits and labor income, stemming from the expenditures from the additional visitors to the area. The expenditures are conservatively estimated to average an additional $2,040,211 per year that will accrue to the local community over the project life. The benefit to recreationists in terms of the economic value of additional fishing trips is estimated to be over $12.9 million per year over the 100-year life of the project.

Table 8-9
Summary of Total Benefits

Type of Benefit	*Average Annual*
Revenue from Permit Sales	***$3,885,143***
Expenditure Profits and Labor Benefits	***$4,991,301***
Economic Value to Tribal Members	***$2,490,675***
Total	*$11,367,119*

With the proposed project in place, it is also likely that even more businesses will develop on the Reservation to service the additional visitors. For example, lodging facilities will likely be built near Miner Flat and Bonito Creek Reservoirs. A host of other industries are also likely to develop, such as arts and crafts sales, photography services, and related recreational activities. Facilities such as nicer restaurants and gear shops are also expected to increase expenditures over and above the current amount.

Another benefit not quantified in this analysis is the economic value of the increased fish produced by the A-WC that are stocked outside the Reservation. This analysis assumes that not all of the production increases of hatchery fish go to the

Reservation, but that some of the other fish are distributed to off-Reservation locations currently receiving fish. Because it is not clear how or where these fish may be used, these project benefits are not included.

In summary, the proposed reservoir construction project is expected to provide, at a minimum, the increased permit revenues, increased profit and labor income, and economic value to recreationists described in this report. The water storage project will strengthen the existing recreation industry on the Reservation and capitalize on the opportunities presented by the currently expanding market, thereby enhancing the economic well-being of the Reservation. The project is also consistent with the current economic development strategy for the Tribe. This strategy was expressed in a recent grant application related to improving cabins on Hawley Lake:

> *The WMA CDC intends to capitalize on the tourism trade by improving the quality of current cabin rentals offerings and increasing the availability of high quality vacation cabin accommodations. By providing quality accommodations, the WMA CDC will lengthen visitor stays and will enable visitors to purchase goods and services that will enhance the economic well-being of the reservation. Cultural resources, outdoor recreation, and tourism marketing can provide additional reservation attractions that further enhance job creation and market growth in the retail and service trade sectors of the local economy. The WMA CDC will act diligently to channel a significant share of that economic impact to tribally managed resources and facilities. In addition, the expansion of arts and crafts marketing will positively impact local craftspeople and small home-based entrepreneurs.*
>
> *Given the significant increase in the tourist trade to the White Mountain regional area, the WMA CDC envisions the development of a resort complex catering to the thousands of tourists who visit the area each year. The Project will enhance a "controlled" tourism and outdoor recreation environment that protects environmental and cultural values, while providing avenues for visitors to appreciate the qualities of the White Mountain Apache lands, resources, and traditions. In addition, the proper strategic positioning of the Hawley Lake area in the market should greatly enhance the economic potential of the White Mountain Apache Reservation.*
>
> *The proposed Project will lead to increased economic development opportunities for the White Mountain regional community, as a whole, and for the individual entrepreneurs, by not only providing an expanded market for the arts and crafts of the tribal members by increasing the tourism base on the reservation, but also by providing job opportunities within the expanded outdoor recreation, hospitality, and retail trade sectors of the local economy.*[8]

8 White Mountain Apache Community Development Corporation, Rural Housing and Economic Development Grant Application dated April 25, 2002.

9. GROUNDWATER MODELING

By the end of 1996, investigations conducted by the White Mountain Apache Tribe revealed that one principal source of the baseflow in streams on the Fort Apache Indian Reservation is discharge of groundwater from the Fort Apache Limestone, a rock unit in the upper part of the Supai Group. The groundwater discharged through historically well-known springs such as Alchesay Spring and White Spring as well as lesser known springs such as Big Spring near White Spring, diffuse inflow where Carrizo Creek crosses the Fort Apache Limestone outcrop, and an unnamed spring where Corduroy Creek crosses the Fort Apache Limestone outcrop in a box canyon upstream from the community of Carrizo.

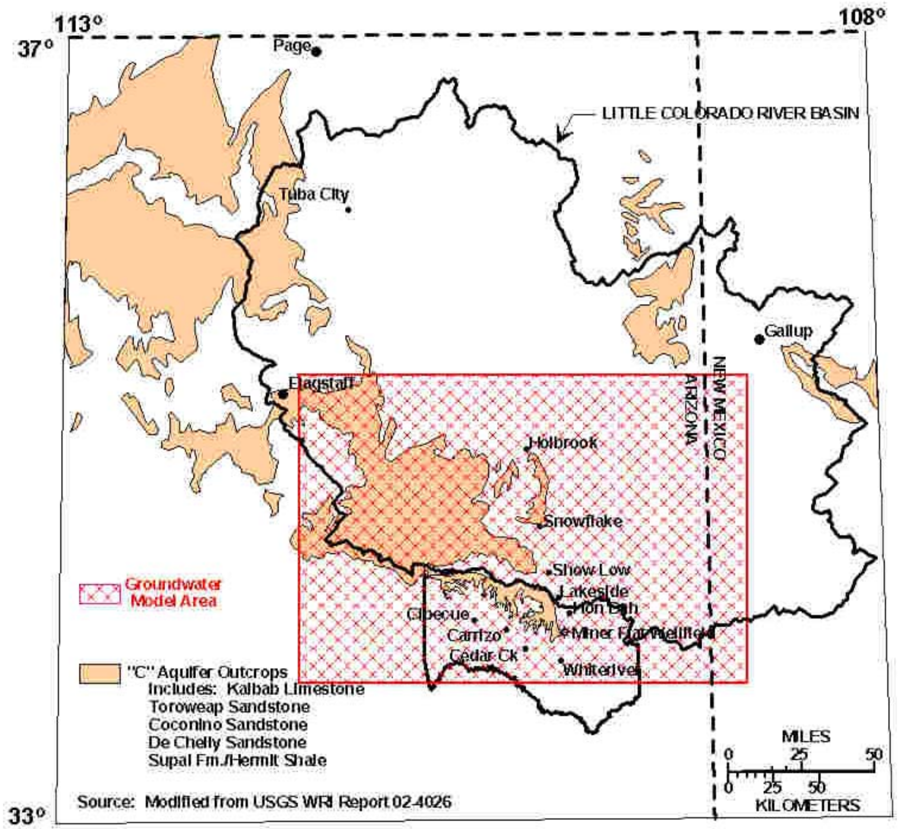
The Tribe's investigations also indicated that the source of the groundwater discharging to the surface water baseflow was the C-aquifer system along the northern boundary of the Indian reservation, with two exceptions. One exception is at Alchesay Spring where a component of the discharge consists of surface water from the North Fork of the White River that infiltrates into the Fort Apache Limestone in the vicinity of Post Office Flats and resurges, mixed with groundwater, at Alchesay Spring. The other exception is discharge from Big Spring tributary to Cibecue Creek that does not exhibit the water chemistry typical of groundwater discharging from the Fort Apache Limestone along the toe of the Mogollon Rim, but instead, exhibits the water chemistry of groundwater with a local recharge source from surface water within the groundwater basin drained by the spring.

Subsequent investigations indicated additional baseflow is provided by groundwater discharge from the Redwall Limestone near the southern boundary of the reservation. The Redwall Limestone springs include Warm Spring on the White River just upstream from its confluence with the Black River, Soda Spring where Carrizo Creek crosses the Redwall, and a large unnamed spring where Cibecue Creek crosses the Redwall. Additional unidentified inflow from the Redwall Limestone to the bed of the Salt River is likely where the Salt River crosses the outcrop of the Redwall. The Canyon Creek valley is incised below the level of the Redwall and does not receive baseflow from that source.

Upon recognizing that the principal source of most of the baseflow in streams on the reservation was discharge of groundwater from the C-aquifer strata that extend into the Fort Apache Indian Reservation from the north, the Tribe became concerned about the potential for wells completed in the C-aquifer north of the reservation lands to reduce the C-aquifer groundwater supporting baseflow in the reservation streams. The Tribe therefore decided to evaluate the potential for reduction of baseflow in the reservation streams with a groundwater model. The main objective was to develop a model which would allow predictions of the potential impacts of groundwater development on private lands along the Mogollon Rim to springs that discharge groundwater to the surface flow on the Fort Apache Indian Reservation.

Figure 1 shows the extent of the groundwater model with respect to the Little Colorado River Basin, the Fort Apache Indian Reservation, and C-aquifer rock outcrops.

Figure 1: Location and extent of WMAT groundwater model.



The model is a "true layer" model wherein the individual layers are constructed to represent the actual thicknesses, dip, and geologic structure of the rock units within the model domain as closely as possible. The geometry of the rock strata in the model are based on well records from ADWR and structural contours published in literature by previous investigators.

9.1. Model Code Selection

The modeling effort was conducted using MODFLOW-SURFACT (SURFACT) which is an enhanced version of the modular three-dimensional finite difference ground-water flow model (MODFLOW) developed by the United States Geological Survey [USGS] (McDonald and Harbaugh, 1988). SURFACT was developed by HydroGeoLogic, Inc. of Herndon, Virginia.

Much of the model domain involves rock units which possess unsaturated zones over portions of the area established for the project. MODFLOW is not well designed to represent unsaturated flow conditions. One of the main reasons it is not well suited is that it is difficult to obtain numerical convergence owing to limitations in the solution procedures employed in MODFLOW in representing desaturated model cells that occur when conducting "true layer" modeling. SURFACT was designed to simulate both saturated and unsaturated flow conditions. Hence, SURFACT is better suited for simulating the type of conditions encountered for the project.

9.2. Development of Model Structure

9.2.1. Simulation Tools

The initial model structure and model files were created by applying Golden Software Surfer® to x,y,z files containing data representing the elevations along the contacts between the different rock units comprising the model layers. The regular one-mile spacing grid files thus created were then edited for conflicts between layers and/or surface topography and layers and then entered initially into Visual Modflow. After convergence problems were experienced in Modflow due to dewatering and rewetting problems in the transiently unsaturated parts of the model, the model files were subsequently imported into GWVistas (GWV). Both Visual Modflow and GWV are Graphical User Interfaces (GUIs). The primary way these GUIs were used as follows:

- Assist in creation of initial model structure and input files;
- Revise the model structure as necessary during the course of the modeling effort;
- Create and modify parametric zones;
- Modify parameters within zones during calibration;
- Provide calibration statistics during model calibration; and
- Develop presentation graphics for model visualization.

GWV is a GUI developed by Environmental Simulations, Inc. of Herndon, Virginia. It serves as an interface for conducting ground-water simulations including MODFLOW and MODFLOW-SURFACT as well as other model codes.

9.2.2. Model Grid Structure

The areal domain of the ground-water model is shown in Figure 1. The model grid consists of 107 rows and 155 columns each one-mile by one-mile and the following seven layers:

Layer 1:	Confining Layer (not present everywhere in the model domain)
Layer 2:	Coconino Sandstone & Related Strata - Major Aquifer
Layer 3:	Upper Supai
Layer 4:	Fort Apache Limestone - Aquifer - Major source of baseflow.
Layer 5:	Lower Supai
Layer 6:	Redwall Limestone - Major aquifer - discharges through large springs.
Layer 7:	Base of Model

9.2.3. Boundary Conditions

Model boundaries consisted of the following:

1. Constant head boundaries were used to represent the north/northeastern perimeter of the model domain which generally coincides with the axis of the Little Colorado

River. Drain cell boundaries were applied to southwestern boundary cells for model layers 6 and 7 to allow for water flux out of that portion of the model domain. Drain cell boundaries were also applied to the southernmost cells for Layer 1. No flow boundaries were assumed at the perimeter of the model for areas not represented by either constant head boundaries or by drain cells.

2. Drain cells were used to represent baseflow springs, specifically, those present in the Fort Apache Limestone (Layer 4) and in the Redwall Limestone (Layer 6).

3. During the application phase, well cells were used to simulate ground-water demands associated with projected growth from census data.

9.2.4. Areal Sources

Recharge was used as the primary source of flux into the model domain. Initial recharge rates were estimated as a percentage of annual precipitation averaged per unit area between isohyets.

9.3. Model Calibration Process

The model calibration process was as follows:

Step 1: Establishing calibration targets which included well water levels and spring discharges (shown in Table 1).

Step 2: Horizontal and vertical hydraulic conductivities were modified iteratively until no improvement in model fit could be attained.

Step 3: The model fits were evaluated through the course of calibration using the statistical evaluation packages.

Table 1: Model calibration targets.

ADWR Well Identifier	X Coordinate	Y Coordinate	Water Level (meters)	Model Layer
A-19-16-06CDB	78036	152531	1459.70	2
A-19-15-26DAD	75952	146149	1477.69	2
A-18-17-14AAD	95343	140618	1495.34	2
A-18-14-09AAC	62931	142117	1497.74	2
A-20-13-17DDC	51670	158803	1442.94	2
A-18-15-30BCC	68215	136889	1505.82	2
A-18-19-28CCD1	110563	136301	1528.29	2

A-17-19-12CBD	115389	132022	1540.87	2
A-17-14-23BCD	65235	128782	1563.95	2
A-17-13-02BBA	55558	134254	1557.24	2
A-16-18-09ACD1	101532	122446	1550.54	2
A-16-19-04BBC	110233	124686	1554.01	2
A-16-15-17ABC	70409	120075	1595.68	2
A-17-20-26DBC	124314	127099	1543.16	2
A-18-12-13BBD	42619	138876	1549.93	2
A-15-15-12BBC	76227	112050	1584.86	2
A-16-20-28BDB	120295	117949	1556.02	2
A-15-16-15DDC	83791	109642	1579.01	2
A-15-18-19AAA	98702	109770	1608.05	2
A-15-14-03BBB	63098	113870	1615.46	2
A-16-21-17ABD	128425	121588	1555.81	2
A-15-17-34DAC	93634	105278	1622.95	2
A-14-18-05ADC	100309	104357	1631.00	2
A-15-20-19DDA	118227	108785	1585.59	2
A-14-17-18BBB	87438	101524	1665.02	2
A-14-16-08DCB	80254	101898	1683.55	2
A-15-21-08DDC	128912	112289	1572.41	2
A-15-13W18CAA	48855	109980	1723.21	2
A-14-19-30AAA	108519	98614	1665.45	2
A-15-12-15DDC	44631	109396	1777.65	2
A-13-17-05CAA	89762	94110	1701.57	2
A-15-22-10DBA	141652	112962	1579.92	2
A-13-18-02DAA	105257	94497	1686.48	2
A-14-20-30CAA	117517	97936	1664.62	2
A-14-21-19BBA	126720	100472	1658.13	2
A-15-11-05BDC	30593	113266	1850.07	2
A-14-22-07BDC	136476	103331	1615.93	2
A-14-12-08ADD	41622	102222	1907.46	2
A-13-16-34BDB2	83136	86599	1773.96	2
A-15-23-22ABB	151369	110753	1619.42	2
A-13-19-27CDC	112542	87521	1705.16	2
ADWR Well Identifier	**X Coordinate**	**Y Coordinate**	**Water Level (meters)**	**Model Layer**
A-14-11-12BCD	36707	101889	1942.09	2
A-13-21-08DBB	128946	93314	1676.69	2
A-13-20-29CCD	118689	87718	1698.67	2
A-14-23-19DAD	147629	101039	1632.83	2
A-13-22-03BBA	141311	95922	1652.65	2
A-14-10-07CDB	19387	101283	1930.17	2

A-12-21-22BBC	130838	81039	1722.04	2
A-14-24-29DCC	156910	98122	1664.23	2
A-12-22-02ADB	144186	86340	1709.31	2
A-11-20-02AAD	124088	75992	1751.89	2
A-13-23-23DAB	153655	90692	1714.43	2
A-11-19-24DDA	117230	70642	1837.97	2
A-11-18-36DAC	107309	67527	1878.20	2
A-11-21-17BAC	128937	73383	1759.02	2
A-12-23-03CCB	151034	85456	1713.73	2
A-11-22-06BCD	136829	76410	1748.96	2
A-13-24-22BBD	160305	91261	1705.56	2
A-13-25-07DCD	165811	93547	1695.04	2
A-14-26-19ADA	176592	101328	1664.13	2
A-10-21-06DCB	127798	65981	1822.88	2
A-11-23-03BBA	151454	77328	1763.59	2
A-12-24-14DCC	163192	82423	1757.50	2
A-13-26-07BAD	176294	95162	1692.27	2
A-10-22-09CBD	140186	64644	1801.27	2
A-12-25-16CCC	168630	82429	1782.80	2
A-12-26-04BBD	178342	87180	1803.65	2
A-11-24-28CDC	159797	69444	1917.22	2
A-13-27-28ABC	189691	91010	1724.43	2
A-12-27-19BCD	185234	81731	1808.88	2
A-09-22-26CBC	143243	50381	1857.47	2
A-11-27-23AAA	193159	72822	1828.67	2
Arbitrary Spring Number		**Spring Flow Observed (m3/d)**	**Flow (cfs)**	**Model Layer**
Fort Apache Limestone Springs				
1 - Alchesay Spring		-56281	-23.0	4
2 - Corduroy Creek		-4160	-1.7	4
3 - Carrizo Creek		-6460	-2.6	4
4 - Blue Spring		-6460	-2.6	4
5 - Limestone Canyon		-3206	-1.3	4
6 & 7- White Spring & Big Spring		-18989	-7.8	4
Redwall Limestone Springs				
8 - Warm Springs		-11085	4.5	6
9 - Cibecue Creek		-13459	5.5	6

The early focus of the modeling effort was to match well water levels. Later efforts focused on matching spring discharges. Several hundred simulations were performed until no further improvement could be meaningfully attained in the modeling effort.

The other main parameter modified during the model calibration effort was recharge distribution for selected zones. During early phases of the modeling effort, initial recharge distribution rates were assumed to be fixed as a percentage of annual precipitation distribution. Use of these estimates tended to yield over-predictions in potentiometric head in eastern portions of the model domain and under-predictions in head in southwestern portions of model layer 2. Some modifications were eventually made to improve potentiometric head fits. The main modification performed was to reduce recharge rates for selected zones in southeastern portions of the model while increasing recharge rates for selected zones in southwestern portions of the model overlying layer 1.

Figures 2 through 7 summarize the final model zonation for hydraulic conductivity.

Figure 2: Model layer 1 hydraulic conductivity zonation.

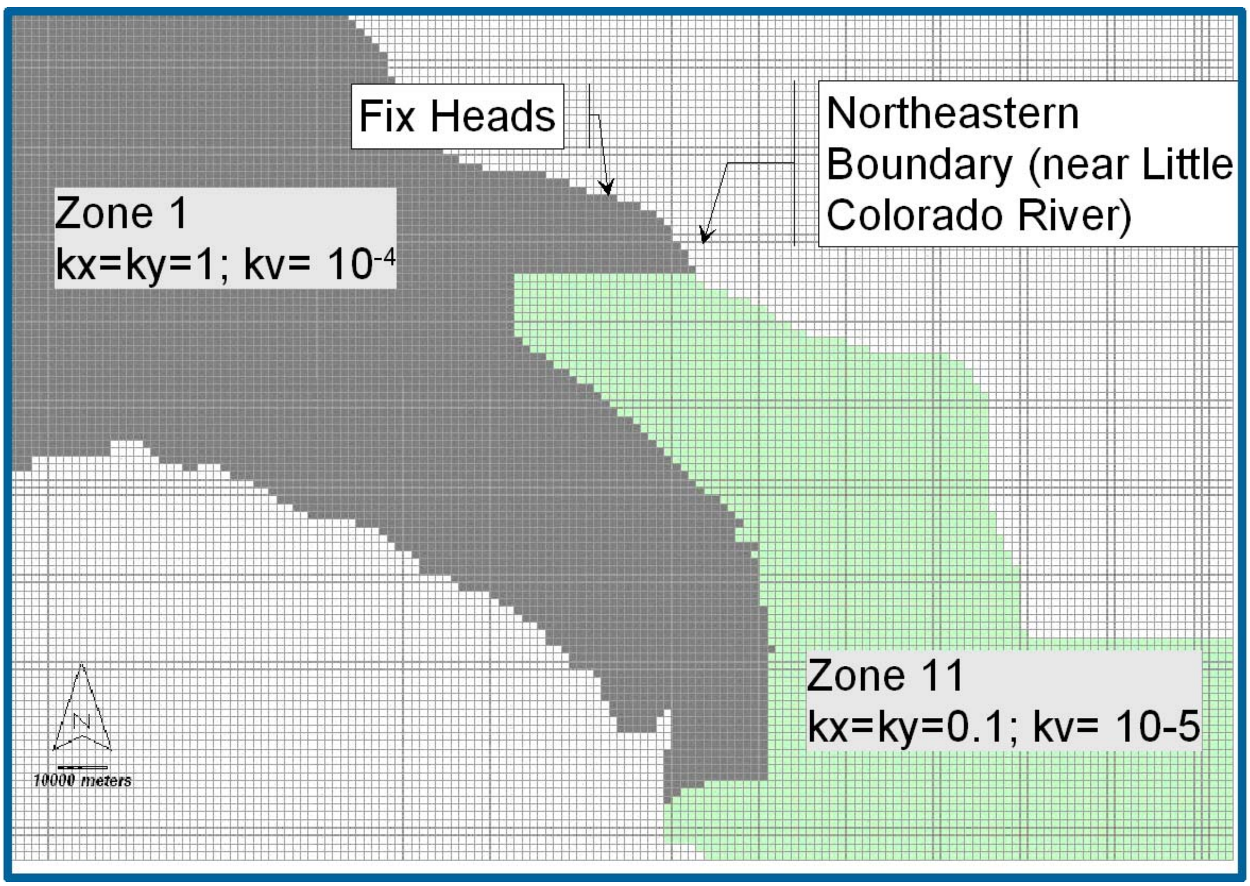


Figure 3: Model layer 2 hydraulic conductivity zonation.

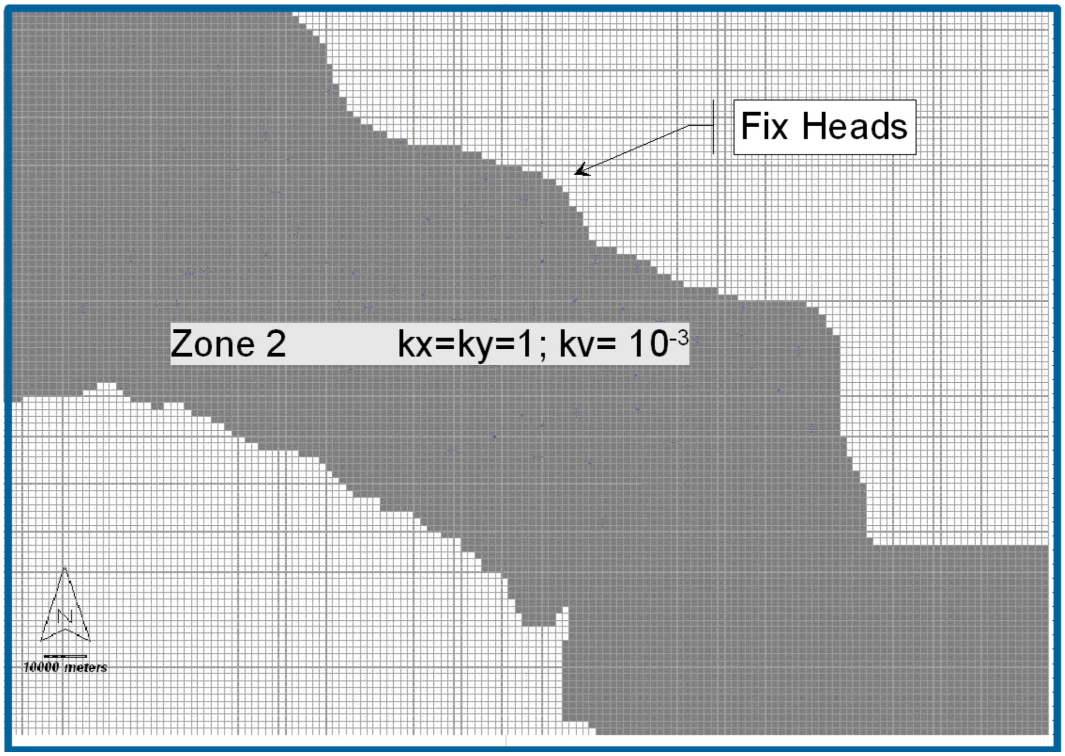


Figure 4: Model layer 3 hydraulic conductivity zonation.

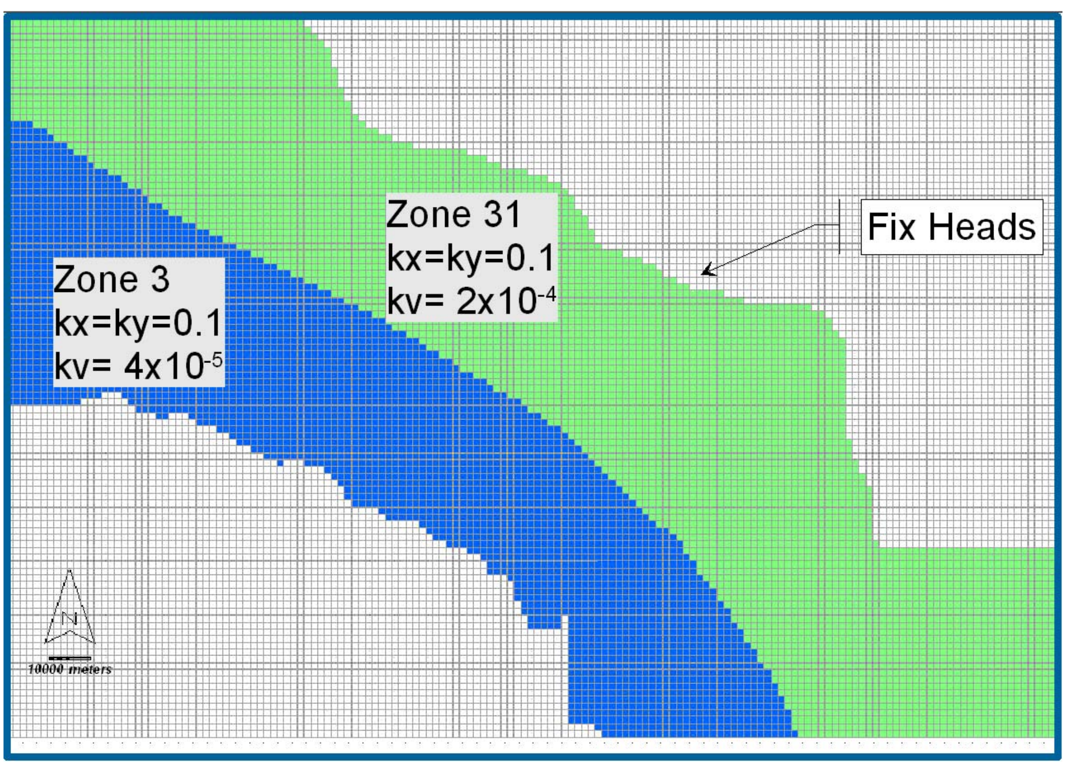


Figure 5: Model layer 4 hydraulic conductivity zonation.

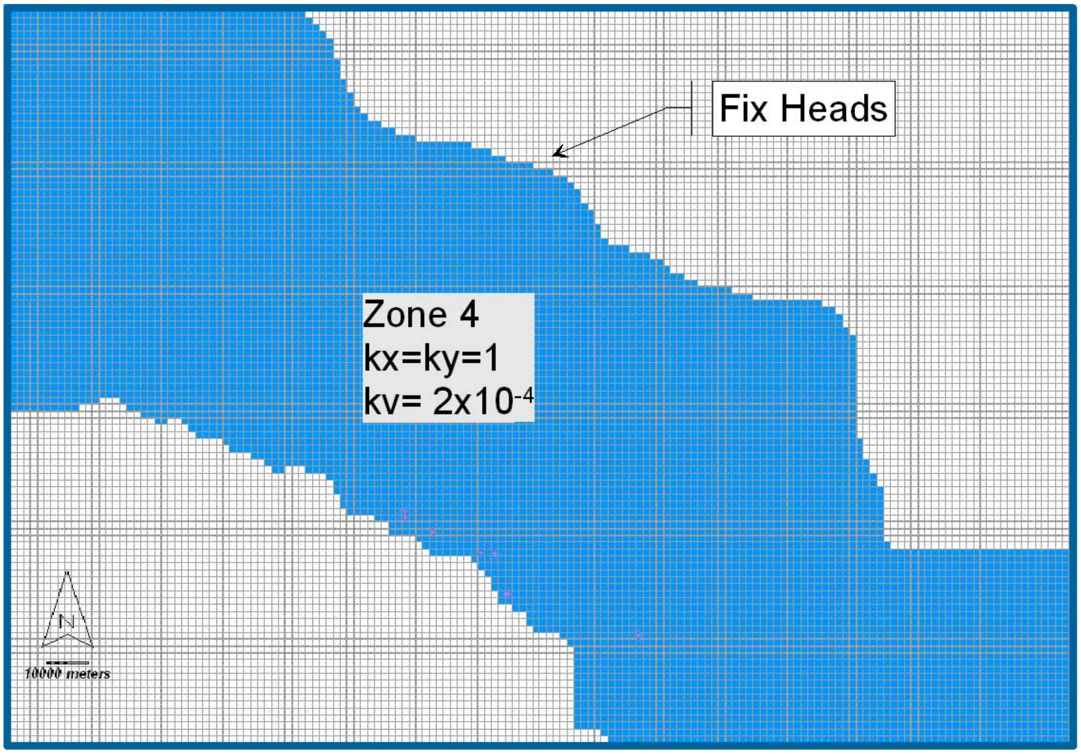


Figure 6: Model layer 5 hydraulic conductivity zonation.

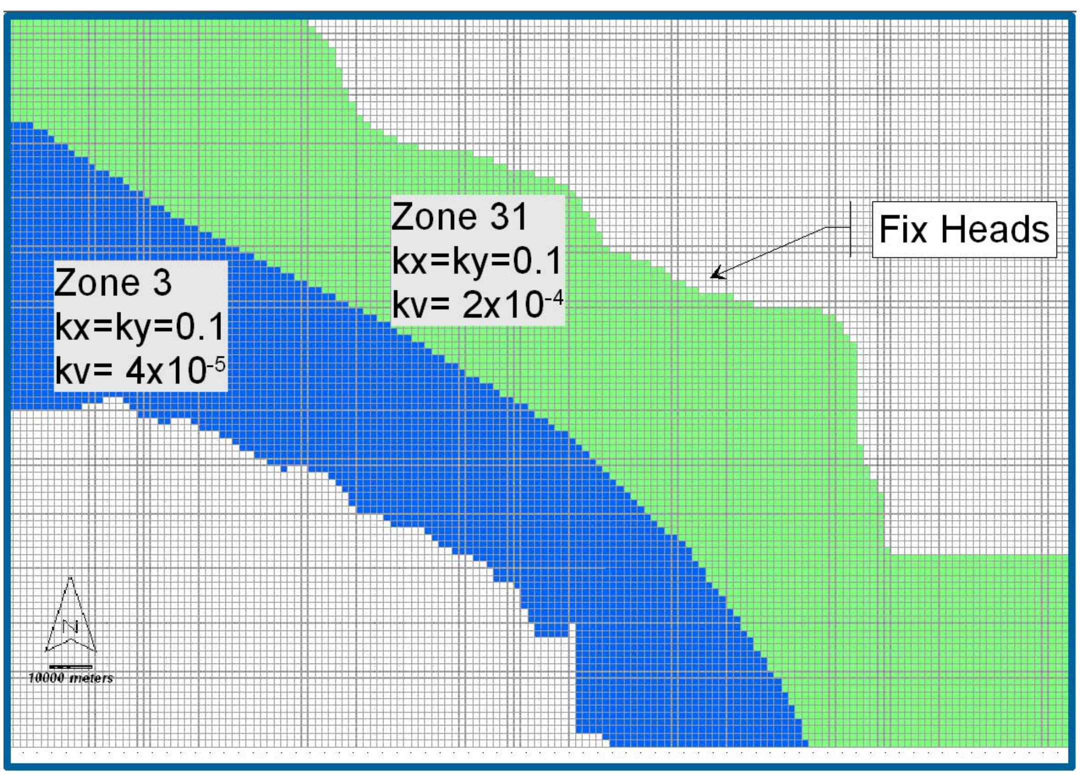


Figure 6: Model layer 6 hydraulic conductivity zonation.

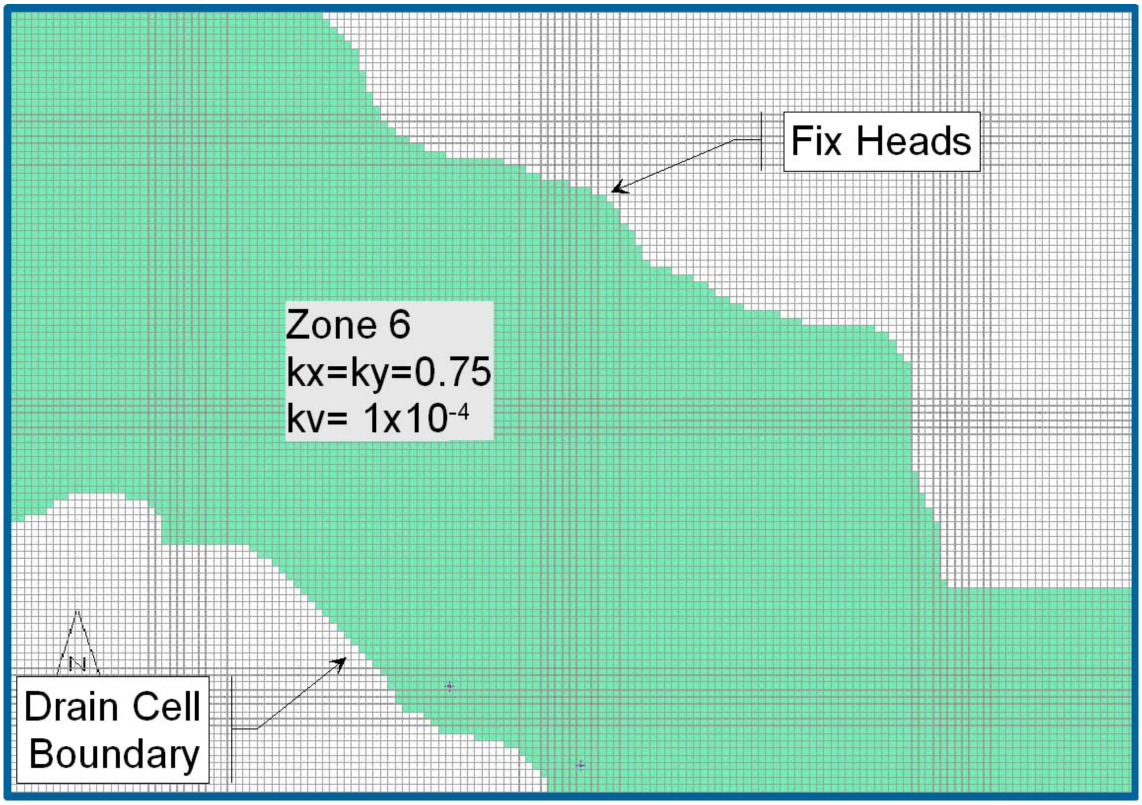


Table 2 summarizes the calibration statistics for potentiometric heads and for spring flows. Figures 7 and 8 present some comparisons of simulated heads with observed heads.

The following summarizes the model domain mass balance[1]:

<u>Inflows</u>

Recharge (represents areal recharge)	534,800 m^3/d	
Constant Head Flux		350,800 m^3/d
	Total Inflow	885,600 m^3/d

<u>Outflows</u>

Constant Head Flux		524,100 m^3/d
Drain Flux (model perimeter cells and spring cells)	261,500 m^3/d	
	Total Outflow	885,600 m^3/d

Table 2: Calibration statistics for water levels and spring flows.

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[1]The mass balance values were rounded off. The mass balance error was 0.003 per cent.

ADWR Well Name	X Coord.	Y Coord.	Model Layer	Observed Water Elevation (meters)	Computed Water Elevation (meters)	Residual Water Elevation (meters)
A-19-16-06CDB	78036	152531	2	1459.70	1450.32	9.39
A-19-15-26DAD	75952	146149	2	1477.69	1486.60	-7.61
A-18-17-14AAD	95343	140618	2	1495.34	1496.23	-0.89
A-18-14-09AAC	62931	142117	2	1497.74	1533.00	-31.66
A-20-13-17DDC	51670	158803	2	1442.94	1502.51	-55.38
A-18-15-30BCC	68215	136889	2	1505.82	1540.37	-31.28
A-18-19-28CCD1	110563	136301	2	1528.29	1521.12	7.23
A-17-19-12CBD	115389	132022	2	1540.87	1534.50	6.54
A-17-14-23BCD	65235	128782	2	1563.95	1579.37	-11.46
A-17-13-02BBA	55558	134254	2	1557.24	1588.40	-26.59
A-16-18-09ACD1	101532	122446	2	1550.54	1551.97	-0.17
A-16-19-04BBC	110233	124686	2	1554.01	1545.29	9.44
A-16-15-17ABC	70409	120075	2	1595.68	1597.88	1.54
A-17-20-26DBC	124314	127099	2	1543.16	1533.51	9.91
A-18-12-13BBD	42619	138876	2	1549.93	1614.48	-59.26
A-15-15-12BBC	76227	112050	2	1584.86	1618.15	-30.29
A-16-20-28BDB	120295	117949	2	1556.02	1570.35	-13.68
A-15-16-15DDC	83791	109642	2	1579.01	1617.89	-36.59
A-15-18-19AAA	98702	109770	2	1608.05	1629.78	-20.04

A-15-14-03BBB	63098	113870	2	1615.46	1643.96	-24.54
A-16-21-17ABD	128425	121588	2	1555.81	1551.30	4.94
A-15-17-34DAC	93634	105278	2	1622.95	1638.54	-14.44
ADWR Well Name	**X Coord.**	**Y Coord.**	**Model Layer**	**Observed Water Elevation (meters)**	**Computed Water Elevation (meters)**	**Residual Water Elevation (meters)**
A-14-18-05ADC	100309	104357	2	1631.00	1648.52	-16.87
A-15-20-19DDA	118227	108785	2	1585.59	1613.74	-27.71
A-14-17-18BBB	87438	101524	2	1665.02	1664.82	0.76
A-14-16-08DCB	80254	101898	2	1683.55	1677.79	7.71
A-15-21-08DDC	128912	112289	2	1572.41	1592.44	-19.19
A-15-13W18CAA	48855	109980	2	1723.21	1741.45	-14.56
A-14-19-30AAA	108519	98614	2	1665.45	1668.73	-3.33
A-15-12-15DDC	44631	109396	2	1777.65	1773.46	7.41
A-13-17-05CAA	89762	94110	2	1701.57	1700.83	1.39
A-15-22-10DBA	141652	112962	2	1579.92	1565.45	16.46
A-13-18-02DAA	105257	94497	2	1686.48	1678.97	7.27
A-14-20-30CAA	117517	97936	2	1664.62	1675.80	-11.34
A-14-21-19BBA	126720	100472	2	1658.13	1659.57	-0.92
A-15-11-05BDC	30593	113266	2	1850.07	1862.54	-10.37
A-14-22-07BDC	136476	103331	2	1615.93	1637.99	-20.11
A-14-12-08ADD	41622	102222	2	1907.46	1848.01	61.97
A-13-16-34BDB2	83136	86599	2	1773.96	1753.76	20.73

A-15-23-22ABB	151369	110753	2	1619.42	1568.06	52.18
A-13-19-27CDC	112542	87521	2	1705.16	1702.61	1.86
A-14-11-12BCD	36707	101889	2	1942.09	1884.37	59.97
A-13-21-08DBB	128946	93314	2	1676.69	1702.31	-25.29
A-13-20-29CCD	118689	87718	2	1698.67	1709.75	-11.56
A-14-23-19DAD	147629	101039	2	1632.83	1643.95	-5.61
A-13-22-03BBA	141311	95922	2	1652.65	1680.80	-25.64

ADWR Well Name	X Coord.	Y Coord.	Model Layer	Observed Water Elevation (meters)	Computed Water Elevation (meters)	Residual Water Elevation (meters)
A-14-10-07CDB	19387	101283	2	1930.17	1955.75	-23.36
A-12-21-22BBC	130838	81039	2	1722.04	1749.95	-27.81
A-14-24-29DCC	156910	98122	2	1664.23	1660.98	9.83
A-12-22-02ADB	144186	86340	2	1709.31	1745.69	-34.76
A-11-20-02AAD	124088	75992	2	1751.89	1763.03	-11.52
A-13-23-23DAB	153655	90692	2	1714.43	1720.52	-1.04
A-11-19-24DDA	117230	70642	2	1837.97	1777.36	58.77
A-11-18-36DAC	107309	67527	2	1878.20	1789.98	85.38
A-11-21-17BAC	128937	73383	2	1759.02	1783.49	-24.49
A-12-23-03CCB	151034	85456	2	1713.73	1758.25	-41.69
A-11-22-06BCD	136829	76410	2	1748.96	1782.66	-33.16
A-13-24-22BBD	160305	91261	2	1705.56	1718.50	-5.99

A-13-25-07DCD	165811	93547	2	1695.04	1702.72	-0.90
A-14-26-19ADA	176592	101328	2	1664.13	1643.49	21.60
A-10-21-06DCB	127798	65981	2	1822.88	1816.72	6.08
A-11-23-03BBA	151454	77328	2	1763.59	1802.89	-37.28
A-12-24-14DCC	163192	82423	2	1757.50	1785.58	-23.88
A-13-26-07BAD	176294	95162	2	1692.27	1699.17	-1.51
A-10-22-09CBD	140186	64644	2	1801.27	1849.48	-47.11
A-12-25-16CCC	168630	82429	2	1782.80	1785.59	2.44
A-12-26-04BBD	178342	87180	2	1803.65	1756.82	52.63
A-11-24-28CDC	159797	69444	2	1917.22	1844.59	75.54
A-13-27-28ABC	189691	91010	2	1724.43	1734.91	-6.75
A-12-27-19BCD	185234	81731	2	1808.88	1791.19	24.41
ADWR Well Name	**X Coord.**	**Y Coord.**	**Model Layer**	**Observed Water Elevation (meters)**	**Computed Water Elevation (meters)**	**Residual Water Elevation (meters)**
A-09-22-26CBC	143243	50381	2	1857.47	1911.94	-52.61
A-11-27-23AAA	193159	72822	2	1828.67	1840.66	-7.33
Residual Mean						-4.36
Res. Std. Dev.						28.99
Sum of Squares						61895
Abs. Res. Mean						21.68
Min. Residual						-59.26
Max. Residual						85.38
Range						499.15
Std/Range						0.0581

Arbitrary Spring Number	Model Layer	Observed Spring Flow (m^3/d)	Flow (cfs)	Steady State Model Flow (m^3/d)
Fort Apache Limestone Springs				
1	4	-56281	-22.99	-51107
2	4	-4160	-1.70	-5214
3	4	-6460	-2.64	-10429
4	4	-6460	-2.64	-4706
5	4	-3206	-1.31	-9066
6	4	-15313	-6.26	-16104
Redwall Limestone Springs				
8	6	-11085	-4.53	-11266
9	6	-13459	-5.50	-17047

Note: Spring 7 was not shown as model simulation efforts were unsuccessful in emulating its flow.

9.4. Model Application Phase

The next phase of the modeling effort was to project the impacts of off-reservation population growth and the corresponding ground-water resource demands upon water levels and upon spring flows. The projected off-reservation water demands were developed from year 2000 and earlier census data by determining housing units per acre, residency per housing unit, and projecting them to full build-out on the available private lands in the narrow strip of private holdings between the northern boundary of the reservation south of the private holdings and the National Forest lands north of the private holdings.

Figure 9 illustrates how census block data were used to assign water demand allocations over the projected private holdings in the census blocks of interest. Table 3 summarizes the water demand assignments made for the model.
Figure 7: Groundwater elevation calibration residuals map view.

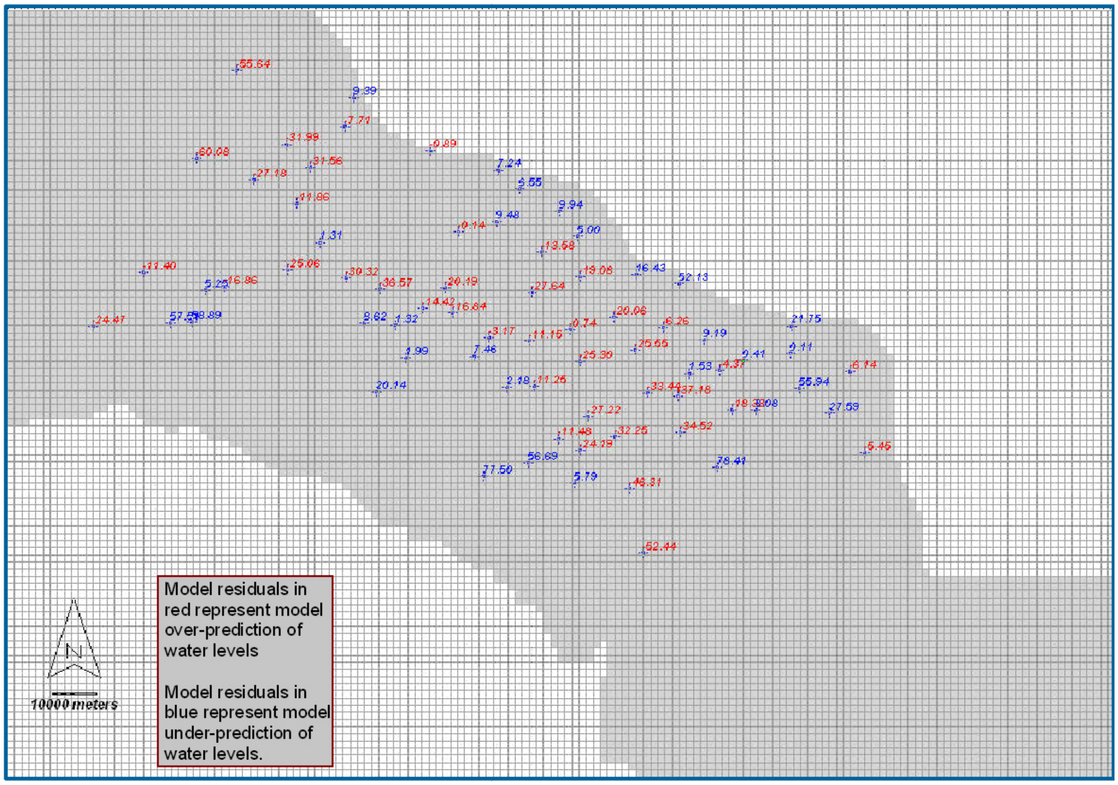


Figure 8: Modeled groundwater elevations versus observed elevations.

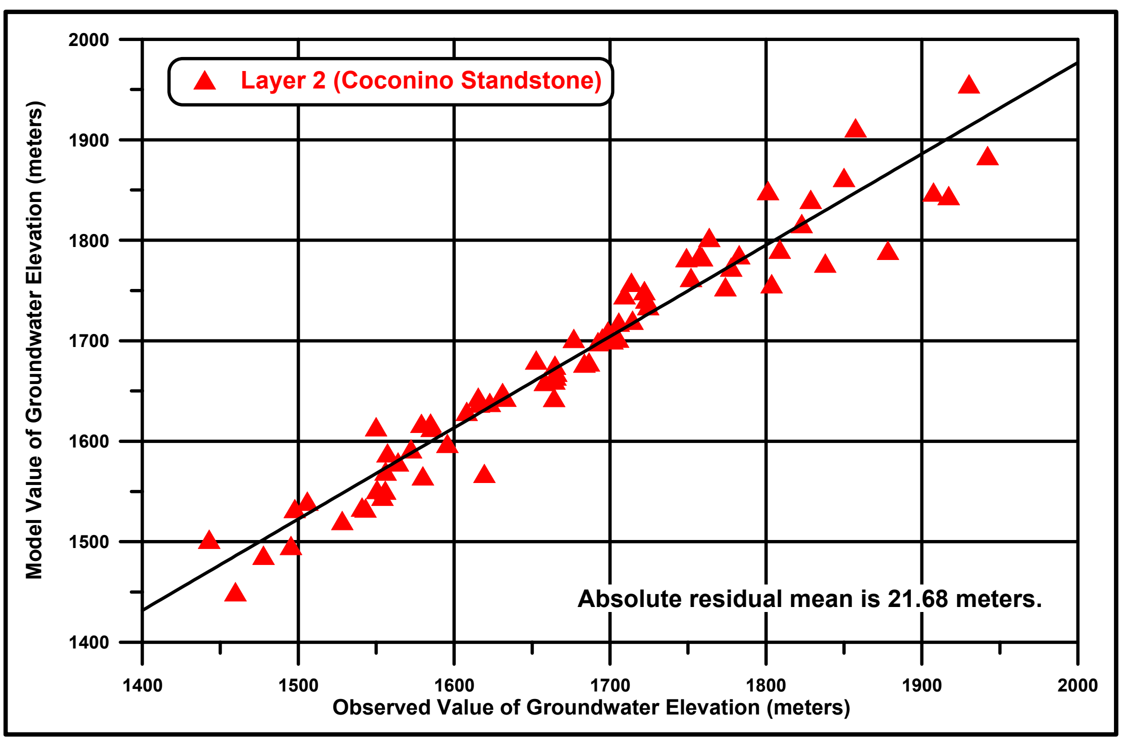
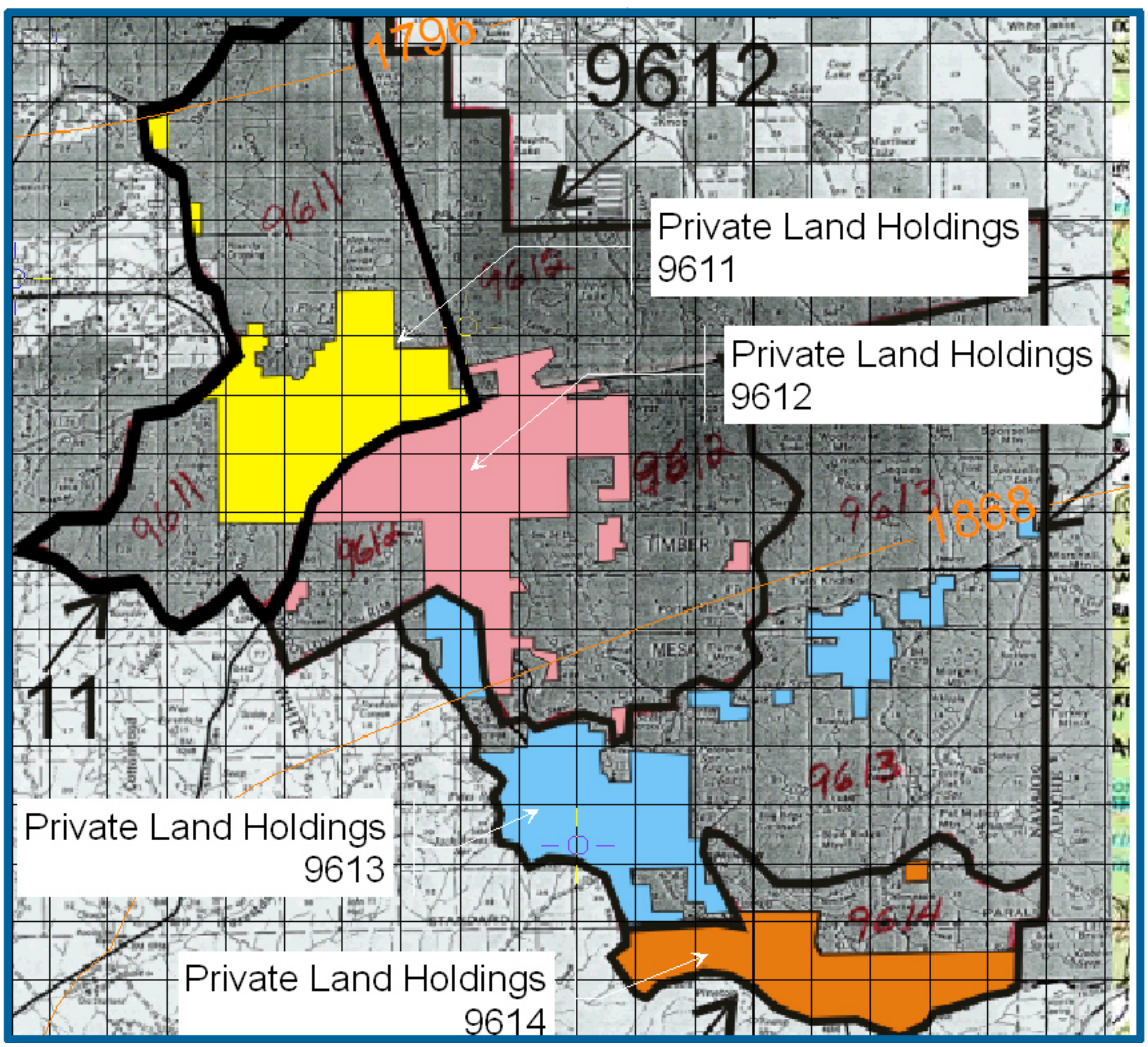


Table 3: Projected off-reservation water demand to year 2050.

Census Tract	Year 2000 Demands Annual Withdrawal (ac-ft/yr)	Year 2050 Annual Withdrawal (ac-ft/yr)
9,611	1,005	5,052
9,612	945	4,751
9,613	1,351	6,795
9,614	734	3,695
Totals:	**4,035**	**20,293**

Note: Refer to Figure 5 for information on water distribution methods for ground-water model.

Figure 9: Projected water demands evenly distributed on private land holdings.



Two model application scenarios were run using year 2000 through year 2050 estimated water demands. In the first simulation, the water demands though year 2050 were imposed as a steady-state demand and the model was allowed to operate to steady-state. Since changes in water use are very gradual over time, it was assumed that steady-state model simulations provide for a reasonable approximation of the transitions in water levels and in spring discharges in the future.

In the second model application, a transient flow analysis was performed in which the year 2000 through year 2050 estimated water demands were increased in equal increments through year 2050 and then held constant at the year 2050 level thereafter.

9.5. Model Results

9.5.1. Simulated Impact to Overall Water Balance

Inflows

	Steady-State	Steady State 2050
Recharge (represents areal recharge)	534,800 m^3/d	534,800 m^3/d
Constant Head Flux	350,800	361,900
Total Inflow	885,600 m^3/d	896,700 m^3/d

Outflows

	Steady-State	Steady State 2050
Constant Head Flux	624,100 m^3/d	589,000 m^3/d
Drain Flux (model perimeter cells and spring cells)	261,500 m^3/d	241,100
Wells		66,600
Total Outflow	885,600 m^3/d	896,700 m^3/d

In effect, the next flux exiting the constant head boundary is reduced from (624,100 minus 350,800) under steady-state model (no well usage) to (589,000 minus 361,900) in year 2050. This equates to a net reduction in flow to the northeast of 46,200 m^3/d

Similarly, the drain flux is reduced about 20,400 m^3/d.

9.5.2. Simulated Spring Flows and Drawdown

Based upon the assumptions inherent in the model and the projected future water demands, the model simulates a 5.32 cfs reduction in collective spring flow discharge to surface water baseflow on the reservation or a reduction of about 12.9 percent after the groundwater system adjusts to the projected demands and achieves a new steady-state condition. Significant dewatering of the upper layers in the model occur before the new steady-state condition is reached, resulting in projection of substantial drawdown in the Coconino Sandstone, upper Supai, and the Fort Apache Limestone under the area of private land holdings. However, it must be recognized that achievement of new steady-state conditions in the aquifer in response to the year 2050 demands requires more than 1,000 years of simulated pumping, and therefore is not an indication of potential impacts on reservation stream baseflows in year 2050.

The transient simulation through year 2050 does provide an indication of potential impacts on reservation stream baseflows in year 2050. The most likely two scenarios over a range of 16 transient simulations for sensitivity testing indicate a reduction of collective baseflow discharge to reservation streams of 0.92 to 1.05 cfs or 1.8 to 2.1 percent by year 2050. These results suggest that little or no significant impact to spring discharge to baseflow in the reservation streams will occur due to off-reservation pumping by year 2050.

However, the results do not evaluate the impact that future off-reservation pumping through year 2050 may have on the very small amount of existing natural discharge from the recharge area and groundwater divide along the rim to the small contact springs issuing from the base of the Coconino Sandstone, such as those near Forestdale Trading Post. Simulated drawdown at year 2050 may be considered significant under the private land holdings, but based on a regional one-mile grid, cannot be considered representative of actual groundwater conditions that might exist along the northern boundary of the Fort Apache Indian Reservation by year 2050 and therefore is not depicted herein. However, the simulated drawdown distributed around one-mile pumping centers in the private land holdings is significant enough to indicate that the small amount of natural discharge onto the reservation through small contact springs at the base of the Coconino Sandstone on the Fort Apache Indian Reservation may be significantly impacted by year 2050.

9.6. Summary

The results of the model simulation provide evidence that substantial ground-water development in the private holdings along the northern boundary of the Fort Apache Indian Reservation are likely to cause significant reductions in spring flow emanating from the Coconino Sandstone to the south. This will reduce the sustainable yield available to wells that might be drilled into the Coconino Sandstone aquifer in the future.

The results of the model simulation indicated that significant reduction of flow from springs in the Fort Apache Limestone to surface water baseflow in the reservation streams is unlikely in the foreseeable future.

It is unclear that sufficient ground water is available to meet the future demands of the private holdings without causing substantial dewatering of the Coconino Sandstone and upper Supai strata, the principal rock units comprising the C-aquifer system in this area. At the present time, large groundwater users for golf course irrigation that have traditionally developed groundwater in the Volcanic aquifer as a source of water supply are now extending wells down to the C-aquifer strata because the Volcanic aquifer source is becoming unreliable under a combination of increased use by more wells and diminishment of recharge by drought. New high-capacity wells for golf course irrigation and municipal water supplies are being completed in the C-aquifer system, not in the shallower Volcanic and Pinetop-Lakeside aquifers.

Although individual wells producing from fractures in the crystalline basalt may offer locally high yields, the amount of groundwater stored in the fractures per volume of rock is tremendously less than that in a porous rock such as the Coconino Sandstone. The limited groundwater storage in the Volcanic aquifer therefore makes it sensitive to drought and/or excessive groundwater abstraction.

The latter considerations support the approach used in the groundwater model, namely, imposing future demands on the C-aquifer system, not the Volcanic or Pinetop-Lakeside aquifer in the Cretaceous. The latter conclusion is supported by the Indian Health Service's experience in drilling a number of unproductive test wells into the Cretaceous rock strata in the Pinetop-Hondah area. The model results leave little doubt that the natural discharge from the Coconino Sandstone to the reservation will be reduced in the future by increased off-reservation pumping of the C-aquifer system. Since that natural discharge is the measure of the potential sustainable yield of the C-aquifer to wells drilled on the reservation lands, it is clear that the sustainable yield available to wells on the reservation lands will be decreased by future off-reservation use of the C-aquifer system.

9.7. Limiting Assumptions of Modeling Effort

There are limiting assumptions that should be noted when applying this flow model including the following:

- Models are predictive tools and they represent simplifications of complex systems.
- There is considerable uncertainty about the magnitude of various formation parameters including hydraulic conductivity, vertical hydraulic conductivity, and recharge rates.
- There is no unique solution to a complex natural system. In essence, there are alternative conceptual and hydraulic models which could be applied to the project.
- Future population growth and water demands involve significant uncertainty.

In view of the limiting assumptions, it is necessary to keep some practical considerations in mind when assessing the meaning of the groundwater modeling effort. The discharge of groundwater from the Fort Apache Limestone to the streams on the Fort Apache Indian Reservation takes place at an elevation above which there is a very large volume of groundwater storage, extending well back under the C-aquifer system north of the Mogollon Rim. The volume of groundwater storage above the Fort Apache Limestone, potentially in a position to flow to springs in the Fort Apache Limestone on the Indian reservation, is very large with respect to the projected off-reservation use of water though year 2050. It therefore is expected that the projected groundwater use will not have much impact on the flow of groundwater from the Fort Apache Limestone into the baseflow of the reservation streams, just as predicted by the model.

On the other hand, the volume of groundwater stored in the Coconino Sandstone, between the groundwater divide along the Mogollon Rim and the southern edge of the sandstone in the Fort Apache Indian Reservation is relatively small. Therefore, the groundwater system is sensitive to withdrawal of water through pumped wells and to fluctuations in recharge. The natural discharge from this part of the C-aquifer system onto the Fort Apache Indian Reservation is historically small, and as shown by measurements and observations by the White Mountain Apache Tribe in the past ten years, has diminished during drought with many locations exhibiting flow in the 1980s through the mid 1990s not flowing at present. Because these flows have historically been so small as to not contribute to continuous baseflow on the reservation, they were not included in the modeling effort. However, they suggest that wells drilled into the C-aquifer system on the reservation might possibly capture up to a few hundred gallons per minute of sustainable flow away from the natural discharge areas. This is a much different situation than that of the springs issuing from the Fort Apache Limestone below large amounts of stored groundwater. The small amount of groundwater storage in the C-aquifer system on the reservation lands will therefore be highly sensitive to the effects of off-reservation pumping extending under the reservation lands and the already small sustainable supply available from the resource under the reservation lands will be diminished accordingly.

10. WATER AVAILABILITY TO MEET PRESENT AND FUTURE DEMANDS FORT APACHE INDIAN RESERVATION AND DOWNSTREAM IMPACTS

10.1. Streamflows

The water availability study was based upon streamflows of the White River, Cibecue Creek and Bonito Creek within the Fort Apache Indian Reservation Monthly increments of streamflow on the various surface water sources from the record of the White Mountain Apache Tribe, US geological survey and synthetic data derived from correlation were used to fill proposed reservoirs, release water from proposed reservoirs and meet present and future diversion demands for irrigation, domestic, commercial, recreation, fish hatchery, livestock, industrial and mineral purposes.

The impact of present and future depletions within the Fort Apache Indian Reservation on the Salt River below Stewart Mountain Dam, the principal source of water for the Salt River Valley and the Phoenix metropolitan area, were determined.

The period of record used to simulate future demands on the Fort Apache Indian Reservation and future impacts on water available to the Salt River Valley was 1958 through 2003 using a monthly increment for analysis. The following describes the basic streamflow data used in the analysis.

10.1.1 White River

Appendix Z-A provides the streamflow record used in the analysis generally described above. Units are in acre-feet for each month. The locations of streamflow and descriptions of the published and/or synthesized record are as follows:

LLR -- North Fork White River at Lower Log Road. This station is upstream from the reservoir created by Miner Flat Dam and is located on the bridge crossing the stream. The station is operated by the White Mountain Apache Tribe. Daily record from February 16, 1983, through August 27, 1984, was correlated with corresponding daily streamflow of the White River near Fort Apache and the East Fort near Fort Apache during winter and summer as follows:

(1) if month is October through April: LLR = .28585+.42152 x WRNFA +.02569 x EFNFA; R^2 = .945

(2) if month is May through September: LLR = 16.9246+.36647 x WRNFA + -0.009042 x EFNFA; R^2 = .976

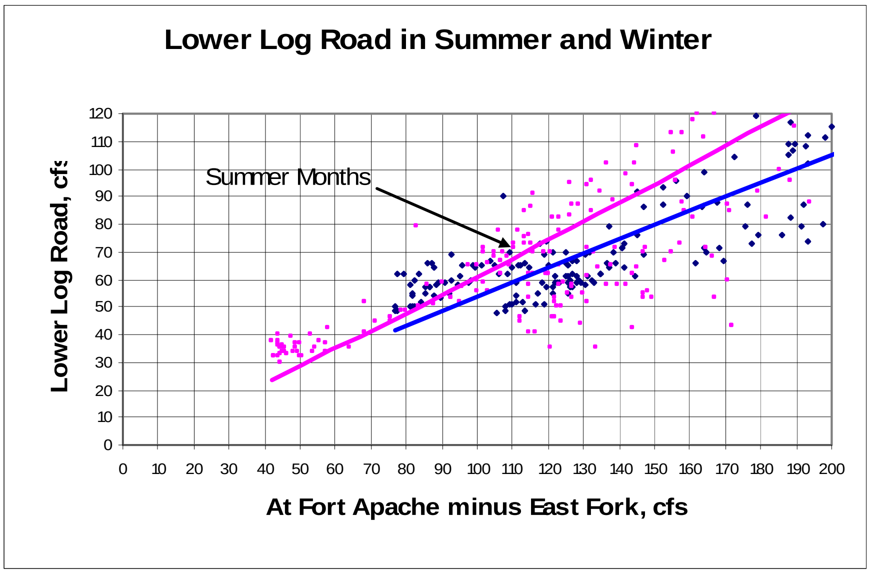
Where

LLR	=	daily streamflow at Lower Log Road, cfs
WRNFA	=	daily streamflow of the White River near Fort Apache, cfs
EFNFA	=	daily streamflow of the East Fork White River near Fort Apache, cfs

Figure 1 shows the difference between summer and winter streamflows at Lower Log Road in relation to the White River at Fort Apache after deduction of the East Fork. During the summer months, a streamflow at Lower Log Road of 50 cfs correlates to a streamflow at Fort Apache of approximately 82 cfs. During the winter months, a streamflow at Lower Log Road of 50 cfs corresponds to a streamflow at Fort Apache (less the East Fork) of approximately 91 cfs. Evapotranspiration from riparian vegetation, including a cottonwood forest, during the summer months accounts for lower streamflows at the downstream location during the summer months.

Domestic Diversion -- North Fork White River at the site of the domestic diversion now contemplated by the Indian Health Service downstream from Diamond Creek and near Gold Gulch. A gauging station is now operated by the White Mountain Apache Tribe, but at the time of the analysis, only miscellaneous measurements were available. Streamflows at the location were synthesized as follows:

FIGURE 10-1



(1) if month is October through April: $NFDD_{Trial} = ((WRAFA - EFNFA) + LLR))/2$

Where

$NFDD_{Trial}$ =	trial daily streamflow of North Fork White River at domestic diversion site, cfs
NFDD =	final daily streamflow of North Fork White River at domestic diversion site, cfs
LLR =	daily streamflow at Lower Log Road, cfs
WRAFA =	daily streamflow of the White River at Fort Apache and downstream from the East Fork, cfs

EFNFA = daily streamflow of the East Fork White River near Fort Apache, cfs

If $NFDD_{Trial}$ was less than 23.4 cfs + LLR, cfs, then NFDD = 23.4 + LLR.

If $NFDD_{Trial}$ was greater than 23.4 cfs + LLR, cfs, then NFDD = $NFDD_{Trial.}$

(2) if month is May through September: $NFDD_{Trial}$ = ((WRAFA –EFNFA) + LLR))/2

Where

$NFDD_{Trial}$ = trial daily streamflow of North Fork White River at domestic diversion site, cfs

NFDD = final daily streamflow of North Fork White River at domestic diversion site, cfs

LLR = daily streamflow at Lower Log Road, cfs

WRAFA = daily streamflow of the White River at Fort Apache and downstream from the East Fork, cfs

EFNFA = daily streamflow of the East Fork White River near Fort Apache, cfs

If $NFDD_{Trial}$ was less than 23.4/2 + LLR, cfs, then NFDD = 23.4/2 + LLR.

If $NFDD_{Trial}$ was greater than 23.4/2 cfs + LLR, cfs, then NFDD = $NFDD_{Trial.}$

Measurements of minimum flow of the North Fork White River were taken by the White Mountain Apache Tribe at the Lower Log Road (LLR) and the domestic diversion site (NFDD) in November 2004. At the time of measurement it was determined that the streamflow at Lower Log Road was 14.8 cfs, and the corresponding streamflow at the domestic diversion site was 38.2 cfs. The contribution to streamflow from Diamond Creek (estimated at 3.0 cfs) and from spring zone discharges from the Alchesay/Columbine complex (estimated at 20.4 cfs) were the principal contributors between Lower Log Road at the upstream location and the domestic diversion at the downstream location. The Alchesay/Columbine spring complex November 2004 contribution of 20.4 cfs compares reasonably with the June 1952 measurement by the US Geological Survey of 17.0 cfs in a season when evapotranspiration could influence the measurement.[1]

[1] Feth, J. H. and J. D. Hem, June 1954, Preliminary Report of Investigations of Springs in the Mogollon Rim Region, Arizona, Open-File Report, US Geological Survey, Table 8, Columbine Terrace Springs (measured June 1952).; Feth, J. H. and J. D. Hem, 1954, Reconnaissance of Headwater Springs in the Gila River Drainage Basin

The difference between the streamflow determinations in the summer and winter months at the domestic diversion site (step 2 above) was the halving of the 23.4 cfs contribution from Diamond Creek and the Alchesay/Columbine spring complex in the summer months to acknowledge evapotranspiration. Continuous record now being collected by the Tribe will permit improvement in the determination of water available at the domestic diversion site.

East Fork White River near Fort Apache -- Streamflows have been measured by the US Geological Survey during the full period of record (Station number 9-4924, 1958 through 2003). No synthetic data was necessary.

White River at Fort Apache -- Streamflows were measured and recorded by the US Geological Survey from October 24, 1912, through June 30, 1922, (Station number 9-4935). Corresponding streamflows were measured and recorded by the US Geological Survey from October 1, 1917, through August 31, 1918, permitting correlation with the latter station having additional record throughout the period of investigation (Station number 9-4940, 1958 through 2003). The following equations correlate the streamflows of the White River *at* Fort Apache with the streamflows of the White River *near* Fort Apache:

(1) if month is October through April: $WRAFA = 1.4515 \times WRNFR^{.9262}$; $R^2 = .958$

(3) if month is May through September: $WRAFA = 4.043 \times WRNFR^{.739}$; $R^2 = .574$

Where

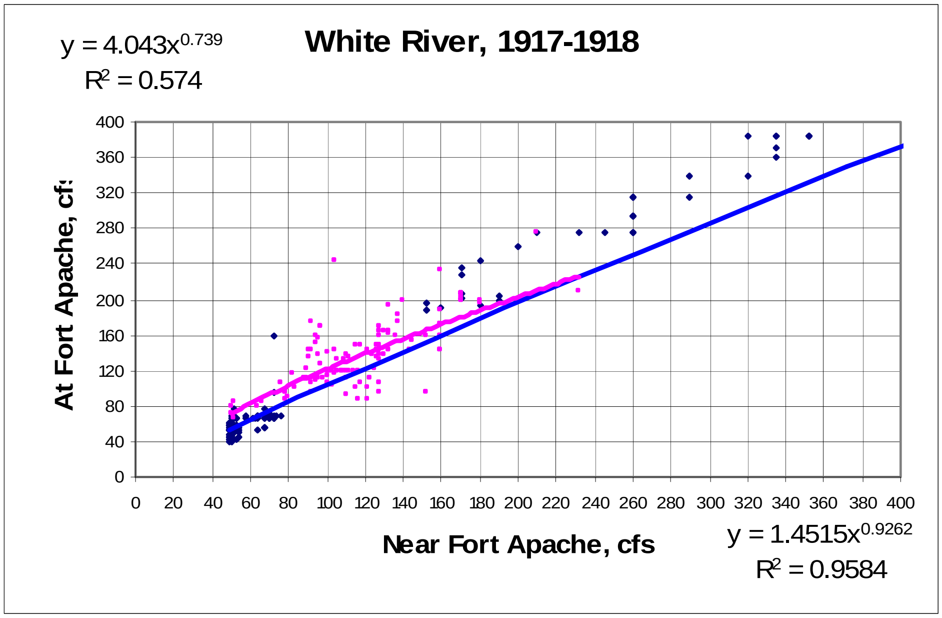
WRAFA = White River *at* Fort Apache, Station number 9-4935, cfs

WRAFA = White River *near* Fort Apache, Station number 9-4940, cfs.

The gauging station record at Fort Apache reflects drainage from 499 square miles of watershed, and the gauging station near Fort Apache reflects drainage from 632 square miles. The correlation between the two stations is relatively good in the winter ($R^2 = .958$) and poor in the summer ($R^2 = .574$). Evapotranspiration from the cottonwood forest between the gauging stations and summer thunderstorms account for the greater variability in the correlation during the summer months as shown graphically in Figure 2. At lower streamflows, evapotranspiration in summer accounts for a loss of approximately 20 cfs between the stations.

Arizona, Geological Survey Water-Supply Paper 1619-H, Table 5, page H47, Alchesay Spring, discharge measured June 1952, 7,650 gpm.

FIGURE 10-2



White River near Fort Apache -- Streamflows have been measured by the US Geological Survey during the full period of record (Station number 9-4940, 1958 through 2003). No synthetic data was necessary.

Salt River near Chrysotile -- Streamflows have been measured by the US Geological Survey during the full period of record (Station number 9-4975, 1958 through 2003). Continuous record is available from September 1924 to present. No synthetic data was necessary.
Salt River near Roosevelt -- Streamflows have been measured by the US Geological Survey during the full period of record (Station number 9-4985, 1958 through 2003). Continuous record is available from September 1913 to present. The streamflows at this location represent the inflow contributions of the Salt River, not including Tonto Creek, to Lake Roosevelt. No synthetic data was necessary.

Salt River below Stewart Mountain Dam -- Streamflows have been measured by the US Geological Survey during the full period of record (Station number 9-5020, 1958 through 2003). Continuous record is available from October 1934 to present. The streamflows at this location represent the releases from the Salt River system of four reservoirs, not including the Verde River system, to SRP and the Salt River Valley. No synthetic data was necessary.

10.1.2 Black River and its Tributary, Bonito Creek

Appendix Z-B provides the streamflow record used in the analysis of Bonito Creek and the Black River. Units are in acre-feet for each month. The locations of streamflow and descriptions of the published and/or synthesized record are as follows:

Big Bonito Creek near Fort Apache -- Streamflows have been measured by the US Geological Survey during water years 1958 through 1981 (Station number 9-4897). The White Mountain Apache Tribe now operates the station and maintains additional data. It was necessary to synthesize at the record during water years 1982 through 2003. The following relationship was developed:

$$BBNFA = -2.7381 + 1.15194 \times EFNFA + .080066 \times BRNFA; R^2 = 0.866$$

Where

BBNFA = Big Bonito Creek near Fort Apache, Station number 9-4897, cfs

EFNFA = East Fork White River near Fort Apache, Station number 9-4924, cfs

BRNFA = Black River near Fort Apache, Station number of 9-4905, cfs

10.1.3 Cibecue Creek

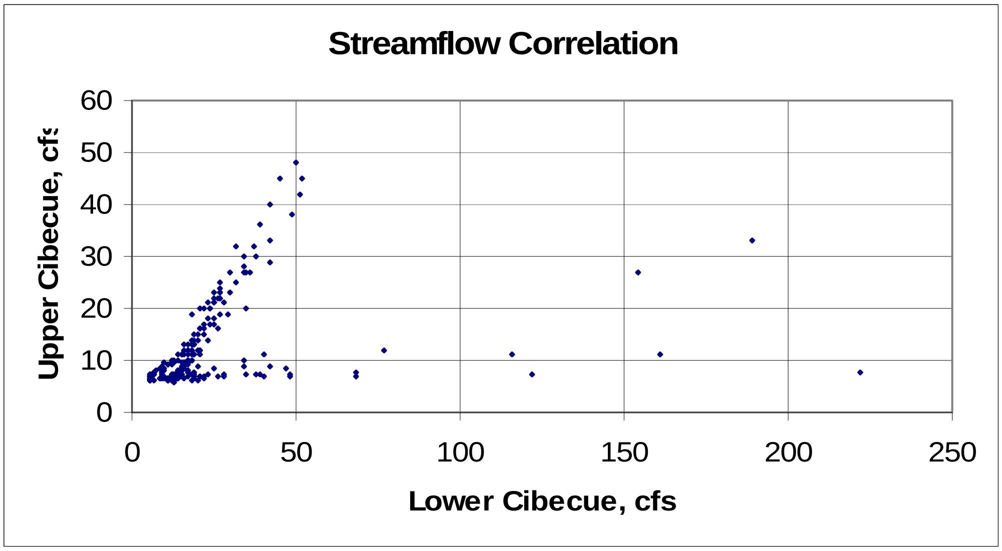
Appendix Z-C provides the streamflow record for Cibecue Creek used in the analysis. Units are in acre-feet for each month. The locations of streamflow and descriptions of the published and/or synthesized record are as follows:

Cibecue Creek near Chrysotile -- Streamflows have been measured by the US Geological Survey during most of the period of record near the confluence of Cibecue Creek with the Salt River (Station number 9-4978). Record began in May 1959 and continued through water year 2004. No synthetic data was necessary, but the period of record from October 2002 (beginning of water year 2003) through April 2004 was substituted for the October 1957 (beginning of water year 1958) through April 1959.

Cibecue Creek near Overgaard -- Streamflows had been measured by the US Geological Survey from October 2003 through September 2004, a period of two years (Station number 9-4977). The station is located approximately 5 miles upstream from the community of Cibecue at the diversion point for present and future irrigation from Cibecue Creek. The White Mountain Apache Tribe now operates the gauging station.

Synthetic data were developed for the upstream station on Cibecue Creek based on the downstream station. Figure 3 shows the scatter of the data, which seems to trend in two different directions. A streamflow of 20 cfs, for example, at the upper station corresponds to approximately 25 cfs at the lower station in the absence of runoff events, but during thunderstorms, the lower station streamflows can reflect 150 to 200 cfs with 20 cfs at the upper station. The large watershed area between stations produces significant differences during runoff events.

FIGURE 10-3



Equations to synthesize data at the upstream gauging station were developed as follows:

CCNOU = A + B x CCNCD

Where

CCNOU = Cibecue Creek near Overgaard (upstream from Cibecue community)

CCNCD = Cibecue Creek near Chrysotile (near confluence with Salt River)

For streamflows at CCNCD	A	B
less than 13 cfs	.4426	.9418
less than 30 cfs	.7806	-4.9793
less than 72 cfs	.5559	3.0835
greater than 72 cfs	CCNOU was capped at 10 cfs.	

10.2. Regulation of Supply

The Tribe's future demands from the White River, Bonito Creek and Cibecue Creek for domestic and irrigation purposes can be met with regulatory storage. Conclusions have been based on simulated operation of the reservoirs the period of record from 1958 through 2003. This is the period that the U.S. Geological Survey and White Mountain Apache Hydrology collected and published streamflow records. There are no significant records on the Fort Apache Indian Reservation prior to 1958 except on the Salt River near Chrysotile.

The preliminary conclusions were based on simulation (modeling) of month by month streamflow, reservoir operation and demand for water based on historic temperature and precipitation. Table 10-1 summarizes the results.

Three reservation streams are proposed for development of surface water: the White River, Bonito Creek and Cibecue Creek. The combined average annual streamflow of these three streams during the period of record was 207,064 acre-feet. Irrigation of 16,014 acres is proposed for future development. Domestic water requirements were based on year 2100 population estimates

Depletions from historic irrigation, livestock consumption, existing stock ponds and existing recreation lakes are reflected in the historic streamflow record.

Not included in the current analysis are future annual depletions for new recreation lakes (1,544 acre-feet), industrial development (9,023 acre-feet) and mineral development (5,000 acre feet). These additional depletions totaling 15,566 acre-feet bring totals to 87,594 acre-feet annually.

Streamflows based on the 1958 through 2003 hydrology are sufficient to meet year 2100 demands without shortage when combined with storage facilities. This requires regulation of pumping north of the Fort Apache Indian Reservation to insure that the hydrology is not artificially diminished by withdrawals from the Coconino Aquifer system. The results of groundwater modeling by others demonstrate that significant, long-term reduction of base flow is probable if population growth continues in the Show Low/Pinetop/Lakeside areas at historic rates.

10.3. Impact on Downstream Users

The lower half of Table 10-1 presents the impact of depletions on the downstream parties (SRP, RWCD and others) from surface water sources on the Fort Apache Indian Reservation for future irrigation and domestic purposes. The analysis was based on two scenarios: before enlargement and after enlargement of Roosevelt Dam.

After enlargement of Roosevelt Dam and with historic and future depletions on the Fort Apache Indian Reservation, the average water level in Lake Roosevelt will be 0.61 feet higher than historic water levels resulting in an increase in evaporation of 1,160 acre-feet annually. The enlargement of Roosevelt Dam permits the conservation storage level to increase from 2,136 to 2,151 feet, which provides for an additional 304,000 acre feet of usable storage. CAP water supply of 41,800 acre feet is required to deliver the historic demands of downstream users. Because water levels would be slightly higher than historically, hydropower production would increase by 0.3%.

TABLE 10-1

FUTURE WATER USE BY WMAT BY SOURCE AND IMPACT ON DOWNSTREAM WATER USERS
(Period of Record: 1958-2003)

Statistic	White River	Bonito Creek	Cibecue Creek	Total
Streamflow				
Historic, af/yr	147,133	50,854	9,077	207,064
Proposed Minimum Flow, cfs	10	10	4	--
Future Irrigation				
Acres	5,875	9,060	1,079	16,014
Diversion, af/yr	21,608	27,080	3,231	51,919
Depletion, af/yr	19,637	24,576	2,932	47,145
Future Domestic (through the year 2100)				
Population	93,833	0	0	93,833
Diversion, af/yr	21,338	0	0	21,338
Depletion, ayr	15,751	0	0	15,751
Totals				
Diversion, af/yr	42,946	27,080	3,231	73,257
Depletion, af/yr	35,388	24,576	2,932	62,896
WMAT Shortage, af/yr	0	0	0	-
SRP Impact (Without Gila River Indian Community Demand)				
Before Enlargement of Roosevelt Dam				
Reduction in Evaporation, af/yr				-5,707
Trigger CAP Delivery, af				950,000
CAP Delivery, af/yr				42,782
SRP Shortage, af/yr				0
Average Annual Drawdown by Tribe, ft				-9.97
Hydropower w/o WMAT Water Use, MWH/yr				462,644
Hydropower w/ WMAT Water Use, MWH/yr				458,012
Hydropower Reduction, %				1.001%
After Enlargement of Roosevelt Dam				
Reduction in Evaporation, af/yr				1,160
Trigger CAP Delivery, af				950,000
Average Annual Drawdown by Tribe, ft				0.61
Hydropower w/o WMAT Water Use, MWH/yr				459,735
Hydropower w/ WMAT Water Use, MWH/yr				461,121
Hydropower Reduction, %				-0.301%

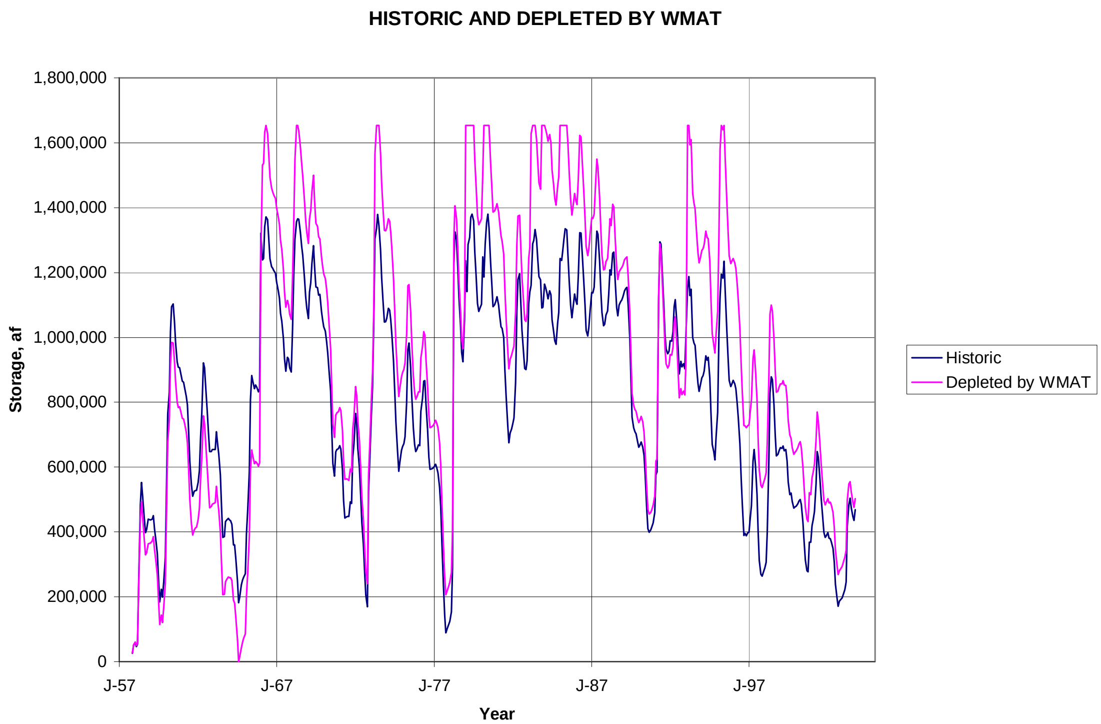
Notes:

[1] Historic depletions for irrigation, livestock consumption, existing stock ponds and existing recreation lakes are reflected in the streamflow record.

Figure 10-4 shows the Lake Roosevelt storage levels without future depletions by the Tribe and before enlargement of Roosevelt Dam and compares with storage levels with future depletions by the Tribe and after enlargement of Roosevelt Dam. The net impact of the enlargement of the dam and future depletions by the Tribe is increased storage levels in Lake Roosevelt. Figure 10-5 shows the impact on hydropower of future depletions by the Tribe with enlargement of Lake Roosevelt.

FIGURE 10-4

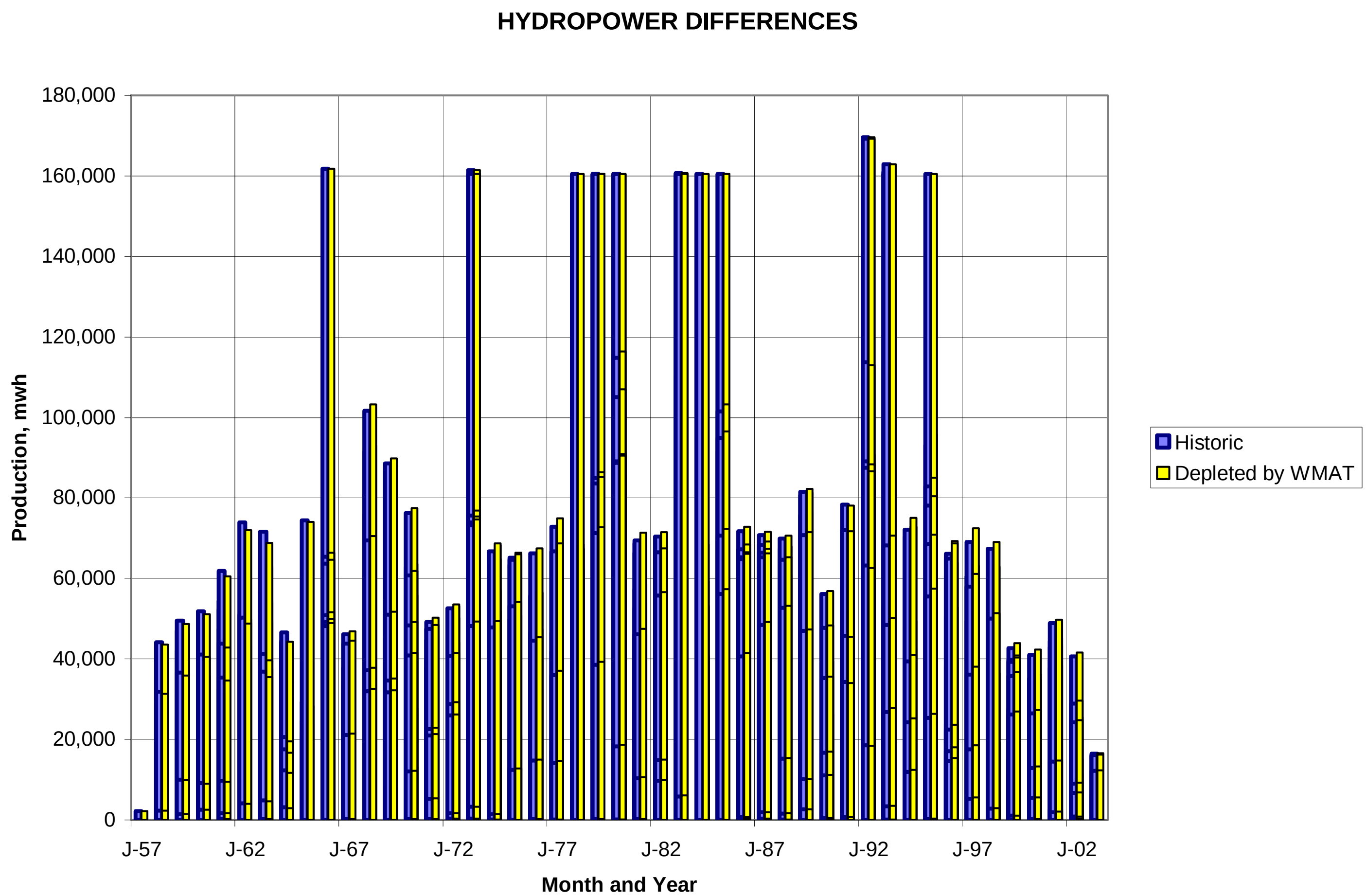
LAKE ROOSEVELT STORAGE
(1) BEFORE ENLARGEMENT WITHOUT FUTURE WMAT DEPLETIONS (HISTORIC) AND (2) AFTER ENLARGEMENT WITH FUTURE WMAT DEPLETIONS



It was assumed that demands on Lake Roosevelt of 35,000 acre feet annually by the Gila River Indian Community when lake levels are at a specified elevation in the spring of each year will be supplied from historic SRP demands.

In summary, future depletions claimed by the Tribe can be achieved without shortage on the Fort Apache Indian Reservation. With the enlargement of Roosevelt Dam, the White Mountain Apache Tribe will not cause a reduction in the historic level of supply from Lake Roosevelt by SRP, the Roosevelt Water Conservation District or other parties dependent on the Salt River system.

FIGURE 10-5


HYDROPOWER DIFFERENCES
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Production, mwh
J-57
J-62
J-67
J-72
J-77
J-82
J-87
J-92
J-97
J-02
Month and Year
Historic
Depleted by WMAT