STATE OF COLORADO

DEPARTMENT OF LAW

SOUTHERN UTE & UTE MOUNTAIN UTE INDIAN RESERVATIONS

AGRONOMY STUDY

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SECTION 1

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SECTION 1
PROJECT SUMMARY

1.1 STUDY OBJECTIVE

Boyle Engineering Corporation was retained by the State of Colorado Department of Law to perform agronomic studies to develop data needed to support the State of Colorado's position in the adjudication of reserved water rights on selected lands within the Southern Ute and Ute Mountain Ute Indian Reservations located in southwest Colorado. The overall objective of the Agronomic Studies is to evaluate the ability of these lands to produce economic yields of crops judged suitable for production under site conditions. This evaluation includes investigations to determine the suitability of natural resources and climatic conditions for crop production and the impact of these factors on agronomic considerations such as land development and crop cultural requirements. The results of the Agronomic Study will be used by agricultural economists to develop estimates of crop production costs and returns that reflect prevailing natural resource and climatic conditions.

Prevailing project area natural resource and climatic conditions largely dictate the suitability of a particular site for agricultural development and crop production. The environment for agricultural production is a function of climate, soil physical/chemical characteristics, and water supply quantity/quality. Collectively, these parameters influence the suitability of specific crops to successfully maintain economic levels of production. Generally, the natural resource and environmental characteristics that may be influential in the selection and productivity of crops on reservation lands are similar to those that prevail in adjacent areas currently developed into agricultural enterprises in Colorado (Montezuma, La Plata, and Archuleta counties) and New Mexico (San Juan County).

The prevailing climatic and existing soil/water conditions are known for the reservation area. Climatic and water quality characteristics largely influence the selection of suitable crops since these parameters are often difficult and expensive to modify. Soil characteristics as related to crop suitability are evaluated by land classification reports (prepared by Stoneman & Landers, Inc.). Irrigation suitability land classification studies evaluate the physical/chemical characteristics of lands based on conditions anticipated to occur under irrigation. Reclamation is often required to modify existing soil characteristics to accommodate a specific type of crop and/or irrigation method. These reclamation procedures may include operations such as land leveling, ripping, terracing, and/or soil amendment applications. The feasibility of performing these land reclamation operations must be justified economically. Land reclamation represents an investment which must be added to other costs of production and evaluated against benefits derived from the commodities produced. The evaluation of natural resource and environmental parameters (climate, water quantity/quality, and soil physical/chemical characteristics) enables the quantification of crop yield and agronomic requirements and forms the basis for economic and engineering analyses which are subsequently performed in the adjudication of reserved Indian water rights.

In order to meet the objectives of the Agronomic Study, irrigated and dryland cropping pattern alternatives have been established for the reservation lands. Crop yield and agronomic requirements are based on natural resource and climatic conditions; therefore, cropping pattern alternatives, crop yields, and crop cultural requirements may vary appreciably on the reservations because of the diversity in climatic, soil, and water conditions that occur. The Agronomic Study relied on existing literature to develop base information with field investigations performed to verify and support the data and to gather additional information as needed.

1.2 STUDY APPROACH

The Agronomic Study for subject reservations was performed by collecting and evaluating existing information from sources such as the USGS, USBR, State of Colorado, State of New Mexico, Universities of Colorado and New Mexico, agricultural experiment stations, etc. to develop cropping pattern alternates and crop agronomic requirements as related to specific site conditions. Field evaluations were conducted to verify existing information and to gather additional data necessary to identify crop yield estimates and production requirements under the diverse climatic, soil, and water conditions that occur. The purpose of this approach was to establish agricultural land use alternatives related to specific site capabilities.

Specific data that establish site conditions and crop/yield potential on reservation lands are limited. A land classification investigation was recently performed on reservation lands for the State of Colorado by Stoneman - Landers, Inc. The results of this study provided site specific data on reservation soil characteristics. Existing published information was used along with this and other reservation site specific data to identify natural resource and climatic conditions.

Areas adjacent to reservation lands have been historically farmed. These agricultural operations were studied to determine historic and actual cropping patterns, crop yield, and agronomic practices in contrast to site conditions. These data were then used to project potential cropping pattern alternatives, estimated crop yields, and agronomic requirements for previously determined arable reservation lands.

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1.3 SUMMARY AND FINDINGS

As previously stated, the objective of the Agronomic Study was to determine cropping pattern alternatives, estimated crop yields, and agronomic production requirements for lands located on the Southern Ute and Ute Mountain Ute Indian Reservations based on the natural resource and climatic characteristics of those lands. The Agronomic Study is based on the evaluation of project area climate, water quality, soil physical/chemical, and crop suitability factors. These elements of the study are discussed in the following sections of this report with major considerations briefly summarized as follows.

1.3.1 Climate

Climatic data from weather stations located on Ute reservation lands needed to specifically delineate the climatic characteristics of potential agricultural lands are limited. There are, however, a number of weather stations located on and in the vicinity of the Ute Indian reservations. Data from these weather stations were gathered and used as the basis for performing regression analyses which were then used to project average project area climatic conditions based on the correlation of observed weather data with elevation. A significant correlation was found between precipitation, temperature, and length of frost free season with elevation. Because of the need to develop crop yield estimates consistent with project area natural resource and climatic conditions, it was judged necessary to develop a climatic zone characterization based on the regression analyses to enable a reasonable estimate of crop suitability and potential yield. These climatic zone data also formed the basis for the estimate of crop water requirements which was determined by additional engineering analyses (Agricultural Engineering - Task A). Based on the regression analyses and projected crop suitability, an elevation increment of 400 feet was selected to use in developing climatic zone characterizations. The average annual characteristics of the 10 climatic zones are summarized in Table 1.1. Project area climatic conditions are the major limiting factor to crop suitability and yield. These 10 climatic zones thus form the basis for the determination of crop suitability and yield without restrictions from existing natural resource conditions. The base crop yields for each suitable climatic zone are then modified based on limiting the natural resources (water quality and soil physical/chemical characteristics) under which they are grown.

1.3.2 Irrigation Water Quality

Existing irrigation water quality was evaluated based on reported water quality data for the potential irrigation water sources as reported by the U.S. Geological Survey (USGS). Irrigation water quality was generally evaluated in regard to three potential limiting effects: 1) salinity, 2) soil permeability, and 3) toxic ions. Irrigation water salinity is sufficiently high in La Plata and Mancos River waters to potentially impact the production of salt

TABLE 1.1

SUMMARY OF AVERAGE ANNUAL CLIMATIC ZONE CHARACTERISTICS[1/]
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS

Climatic Zone	Elev. Range (ft)	Length of Growing Season (day)	Mean Annual Precip. (in.)	Mean Annual Min. Temp. (deg.F)	Mean Annual Max. Temp. (deg.F)	Mean Annual Temp. (deg.F)
A	<5,000	>160	7.4	37.1	69.6	53.4
B	5,000-5,400	150-160	8.6	35.9	68.1	52.0
C	5,400-5,800	140-150	10.2	34.7	66.4	50.6
D	5,800-6,200	130-140	11.9	33.5	64.9	49.2
E	6,200-6,600	120-130	13.7	32.2	63.3	47.8
F	6,600-7,000	110-120	15.6	31.0	61.7	46.4
G	7,000-7,400	100-110	17.6	29.8	60.1	45.0
H	7,400-7,800	90-100	19.8	28.6	58.5	43.6
I	7,800-8,200	80-90	22.2	27.4	56.9	42.2
J	>8,200	<80	24.7	26.2	55.3	40.8

1/ See Table 3.9 for detailed climatic zone characteristics.

sensitive crops. Soil permeability may be impacted by adverse sodium concentrations or low irrigation water salinity. Soil permeability problems may occur with irrigation from Piedra River, Vallecito Creek, San Juan and Los Pinos River waters because of low salinity. Irrigation with Mancos River water may also result in soil permability problems because of its sodium content. Toxic ion effects may result from irrigation with Mancos River water which has a sodium concentration sufficiently high to potentially cause crop root and foliage toxicity and subsequent yield reduction in sensitive crops. Potential irrigation water sources for the Ute Indian reservations are generally excellent with the exception of La Plata and Mancos River waters which may reduce the potential yields of salt sensitive crops.

1.3.3 Soil Suitability

An irrigation suitability land classification study was performed by the firm of Stoneman- Landers, Inc. on Ute Indian Reservation lands. Irrigation suitability land classification standards were developed and the mapping was performed using Bureau of Indian Affairs (BIA) land classification mapping standards. Reservation lands were placed into either one of four arable land classes or one non-arable land class. The summary of the irrigation suitability land classification study performed by Stoneman & Landers, Inc. is presented on Table 1.2. The land classification analysis provides the basis for the evaluation of project soil characteristics in relation to crop suitability and production requirements. The

TABLE 1.2

SUMMARY OF IRRIGATION SUITABILITY LAND CLASSIFICATION1/
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS

Reservation	Acreage by Arable Land Class				Total Acreage
	Class 1	Class 2	Class 3	Class 4	
Southern Ute	2,491	16,491	4,021	7,936	30,939
Ute Mt. Ute	23,354	15,951	8,514	2,511	50,330
Total Acreage	25,845	32,442	12,535	10,447	81,269

1/ See Table 5.3 for detailed summary of arable land acreage.

characteristics of project area soils impact the capability of Ute Indian Reservation lands to sustain economic levels of agricultural production by 1) influencing crop yield, 2) increasing annual crop production expense, 3) increasing initial development/reclamation costs, and 4) limiting crop suitability. Soil physical characteristics which impact these factors include soil texture, effective rooting depth, slope, drainage, available water holding capacity, permeability, coarse fragments, and miscellaneous factors such as erosion and overflow hazards, tree canopy, and lime content. Soil chemical characteristics which affect these factors include salinity and sodium concentrations. Based on reported soil characteristics, crop suitability projections were made for each arable land class and subclass. Soil characteristics requiring reclamation were also identified. Increased production costs (equipment, irrigation, or drainage related costs) that would be incurred as a result of soil limitations were also set forth. The following general guidelines were developed to project irrigated/dryland crop suitability to reservation lands.

- Restricted available water holding capacity (<6 inches) will eliminate dryland farming operations.
- Saline/sodic conditions cannot be reclaimed under dryland farming operations which restrict the cropping pattern to crops tolerant of these conditions.
- Very slowly permeable soils (<.06 inches per hour) cannot infiltrate adequate water for dryland farming.
- Soil depth (<40 inches) eliminates alfalfa and apples.

- Very shallow soils (<20 inches) eliminates all crops except grass hay/pasture.
- Steep soils (15 to 20% slope) are not suited to field/row crops or potato/onions.
- Potato/onions are not suited to clayey soils or soils with surface gravel/cobble.
- Soils with very slow permeability (<.06 inches per hour) or high lime content (>25% percent) are suited only to grass hay/pasture.

Based on these general guidelines it was assumed that crop yield potential would not be limited by soil physical factors and that soil salinity/sodicity would limit crop yield only during the soil reclamation period. A reclamation program was developed for soils with adverse saline/sodic concentrations and increased production/development cost considerations were identified based on the observed soil physical characteristics.

1.3.4 Crop Suitability

The suitability and estimated yield of crops judged suitable for production under natural resource and climatic conditions on Ute Indian Reservation lands are summarized in Table 1.3. Table 1.3 summarizes both traditional and non-traditional crops judged to be capable of sustaining economic levels of production under irrigation considering project area natural resource and climatic conditions. Dryland crop suitability and yield are also identified based on the

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TABLE 1.3

SUMMARY OF CROP SUITABILITY AND YIELD BY CLIMATIC ZONE 1/

SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS

Crop (unit/ac.)	A	B	C	D	E	F	G	H	I	J
Irrigated										
Alfalfa (tons)	7.5	7.0	6.5	6.0	5.5	5.0	4.5	4.0	-	-
Pasture (AUM)	18.5	17.5	16.0	15.0	13.5	12.5	11.0	10.0	9.0	7.5
Grass Hay (AUM)	9.5	8.5	7.5	6.0	5.5	4.5	4.0	3.0	2.5	1.5
(tons)	3.5	3.5	3.5	3.5	3.3	3.1	2.9	2.7	2.5	2.3
S.Barley (bu)	100	95	90	86	82	78	74	70	-	-
Corn Grain (bu)	180	165	150	135	-	-	-	-	-	-
Corn Silage (tons)	30	28	26	22	18	14	-	-	-	-
Grain Sorghum (bu)	120	110	90	70	50	-	-	-	-	-
Oats (bu)	100	98	96	94	92	90	-	-	-	-
Oat Hay (tons)	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	4.5	4.0
S.Wheat (bu)	130	120	110	100	90	70	50	-	-	-
W.Wheat (bu)	105	95	85	75	65	55	45	-	-	-
Dry Bean (cwt)	34	32	30	28	26	-	-	-	-	-
Soybean (bu)	45	40	35	-	-	-	-	-	-	-
Dry Onion (cwt)	350	340	330	320	300	280	250	220	-	-
Potato (cwt)	360	340	320	300	280	260	240	220	-	-
Apple (boxes)	1,000	850	-	-	-	-	-	-	-	-
Christmas Tree 2/	1.00	0.96	0.93	0.89	0.86	0.82	0.79	0.75	0.71	0.68
Dryland										
Alfalfa (tons)	-	-	-	0.8	1.0	1.2	1.4	1.6	-	-
Pasture (AUM)	1.0	1.3	1.7	2.0	2.5	3.0	3.5	4.0	3.5	3.0
Dry Beans (cwt)	5 3/	6 3/	7 3/	6	7	-	-	-	-	-
W. Wheat	-	-	20 3/	24 3/	28 3/	32 3/	35 3/	-	-	-

1/ See Section 6 for crop yields and agronomic practices.
2/ Expressed as average annual growth (feet/year).
3/ Crop/fallow system.

climatic zone characterization. Agronomic production requirements for each crop judged suitable to either irrigated or dryland agricultural production were developed based on anticipated agricultural production conditions on the Ute Indian reservations. General cropping pattern alternatives were identified based on the range of crops found suitable for production. An infinite combination of cropping patterns can be developed. The final development of the cropping pattern for Ute Indian Reservation lands will be based on the detailed economic analysis and marketing potential of identified suitable crops as determined by agricultural economic analyses.

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SECTION 2

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SECTION 2

DESCRIPTION OF PROJECT AREA

2.1 PROJECT LOCATION

The Ute Mountain Ute and Southern Ute Indian reservations are located in the southwest corner of the State of Colorado. The geographical relationships are shown on the Vicinity Map, Figure 2.1.

The Ute Mountain Ute Indian Reservation is located adjacent to and west of the Southern Ute Reservation. The state boundaries between Colorado-Utah and Colorado-New Mexico form the western and southern boundaries, respectively. The northern boundary follows an irregular path around Sleeping Ute Mountain south of the City of Cortez extending eastward towards Mesa Verde National Monument which is located near the northeast corner of the reservation. The eastern reservation boundary forms the western boundary of the Southern Ute Indian Reservation and is located approximately 40 miles east of the Colorado-Utah state line. Towac, located about 16 miles southwest of Cortez, is the site of Ute Mountain Ute tribal headquarters and facilities. The total area of the Ute Mountain Ute Indian Reservation encompassed by the exterior reservation boundary is about 415,000 acres.

The Southern Ute Indian Reservation is located adjacent to and east of the Ute Mountain Ute Indian Reservation. The eastern boundary of

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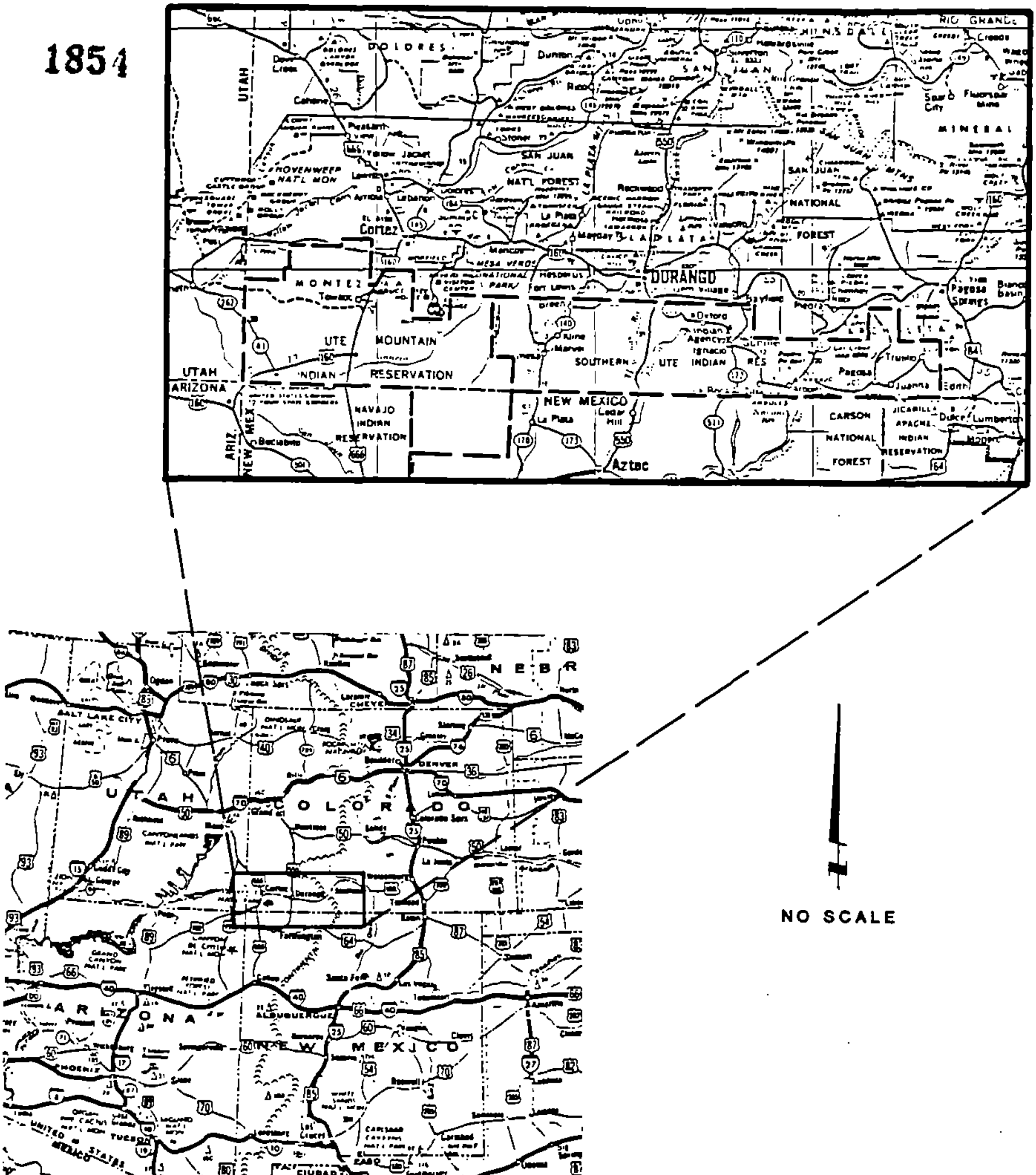

UTE INDIAN RESERVATIONS

VICINITY MAP

Boyle Engineering Corporation — FIGURE 2.1

the Ute Mountain Ute Reservation forms the western boundary of the Southern Ute Reservation. The southern reservation boundary follows the Colorado-New Mexico state line. The northern reservation boundary follows an irregular path south of the cities of Durango and Bayfield. The eastern reservation boundary is located about 70 miles from the western boundary directly south of the city of Pagosa Springs. Ignacio, located about 22 miles southeast of Durango is the site of Southern Ute tribal headquarters and facilities including the local Bureau of Indian Affairs (BIA) office. The total area of the Southern Ute Indian Reservation encompassed by the exterior reservation boundary is about 600,000 acres. However, in the late 1800's parts of the reservation were declared public domain and opened for homesteading. Much of the land located in proximity to existing water supplies was thus obtained by non-Indians. The total area inclusive within the reservation boundaries as shown on Figure 2.1 overstates the actual reservation acreage. The actual reservation area is about 315,000 acres.

Ute Mountain Ute and Southern Ute Reservation lands are further located within the watershed of the Mancos, La Plata, Animas, Florida, Los Pinos, Piedra, and San Juan rivers. These rivers generally flow in a southerly or southwesterly direction across reservation lands. The rivers that flow across the reservations flow into the San Juan River. The San Juan River enters the Southern Ute Reservation in the vicinity of Pagosa Springs near the northeast corner of the reservation. The San Juan flows into the Navajo Reservoir and New Mexico then re-enters Colorado on the Ute Mountain Ute Indian Reservation in the vicinity of Four Corners. The Colorado River ultimately receives San Juan River flows at Lake Powell in southeastern Utah.

2.2 TOPOGRAPHY

The Southern Ute and Ute Mountain Ute Indian reservation lands include mountainous uplands (San Juan Mountains) and high semi-arid mesas that are dissected by active streams and ephemeral washes. The elevation of the project area varies considerably from mountainous uplands with peaks approximately 10,000 feet in elevation to gently sloping mesas with elevations ranging from about 5,000 to 7,000 feet to drainage channels that may be several hundred feet below mesa lands.

The San Juan Mountains occur in the eastern portion of the Southern Ute Reservations east of the City of Ignacio. Sleeping Ute Mountain, which is northwest of Towac, is located on the Ute Mountain Ute Reservation. The San Juan Mountains consist of highly dissected, nearly horizontal sheets of lava and tuff. This area is characterized by high relief, steep topography, and narrow canyons. Arable lands located in the mountainous upland region generally consist of nearly level to gently sloping alluvial deposits located in conjunction with streams and washes.

The remaining area on the two reservations consists of broad gently sloping plateaus and mesas dissected by streams. Plateau and mesa lands are typically gently sloping but some areas may be steep to very steep. These steep soils are often associated with escarpment areas. The alluvial fans and flood plains associated with the streams form a system of level to nearly level benches generally several hundred feet lower than the plateau and mesa lands.

2.3 GENERAL CLIMATIC CHARACTERISTICS

The climate of southwestern Colorado is characterized by large variations often occurring in the same general area. The climatic variation is a result of significant topographic differences as generally characterized by elevation, slope, and aspect.

The climate in the vicinity of the Ute Indian reservations is characterized by warm summers and cold winters. Summertime mean maximum temperatures range from about 80 to 95 degrees F, while wintertime mean minimum temperatures range from nearly 0 to 20 degrees F. The frost free season generally extends from late May to near the end of September. The length of the frost free growing season (32 degrees F base) ranges from less than 100 days at higher elevations to more than 150 days at lower elevations. Precipitation occurs during each month of the year with about 35 to 50 percent of the total annual precipitation occurring during the 6 month period from April to September. The project area climate is generally considered semi-arid. A semi-arid climate is one with average annual precipitation ranging from 10 to 20 inches. The location of the Ute Indian Reservation lands in relation to local mountains influences the climatic conditions. Generally, as elevation increases and as lands become closer to the mountains, precipitation increases and temperature and the length of the frost free season decrease. The types of irrigated agricultural crops that can be economically produced in the project area are limited by prevailing climatic conditions.

2.4 EXISTING AGRICULTURAL PRODUCTION

The historic cropping pattern prevalent in a particular area provides insight in determining the type of crop or crops that can be successfully produced on a long term basis under variable economic and natural resource/climatic conditions. The crops suited to an area are dictated by the influence of soil, water, and climatic characteristics. In an area where many crops can be grown, the economics of crop production often determine the prevalent cropping pattern.

The historic cropping pattern in the vicinity of the Southern Ute and Ute Mountain Ute Indian reservations was evaluated by tabulating crop acreages in La Plata and Montezuma counties, Colorado and San Juan County, New Mexico. The reservations occur in southern La

Plata and Montezuma counties and are adjacent to San Juan County which supports a large acreage of agricultural plantings. Other counties located in the vicinity of the reservations include Archuleta County, Colorado; San Juan County, Utah; and Apache County, Arizona. These counties do not have the diversified cropping pattern which occurs adjacent to reservation lands. Further, because of the large geographic extent of these counties, much of the crop production is probably somewhat removed from reservation lands. The cropping pattern in these counties consists largely of dryland winter wheat and irrigated and dryland alfalfa and other hay crops. These crops are also planted in the vicinity of the reservations.

A summary of the historic cropping pattern during the period 1975 through 1984 is shown on Table 2.1 and 2.2. These data are tabulated based on published agricultural statistics compiled by the states of Colorado and New Mexico.

TABLE 2.1
SUMMARY OF HISTORIC CROP ACREAGE IN
THE VICINITY OF THE SOUTHERN UTE
AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

Crop	Irrigated or Dryland	Year 1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Alfalfa	Irrigated	53,500	56,000	62,500	59,000	54,500	54,500	53,000	45,900	45,300	42,500
	Dryland	20,000	15,000	10,600	8,000	8,000	3,500	3,500	5,600	5,800	5,000
Barley	Irrigated	4,000	4,100	9,050	9,400	14,700	8,900	5,400	1,170	6,000	2,900
	Dryland	700	500	1,100	300	700	300	1,000	1,300	1,300	500
Dry Beans	Irrigated	-0-	-0-	-0-	100	100	-0-	-0-	-0-	-0-	100
	Dryland	34,200	30,700	30,100	38,900	41,400	44,500	44,500	29,200	40,000	42,700
Corn, grain	Irrigated	12,300	15,200	14,600	5,100	1,600	4,000	900	2,600	3,250	2,000
	Dryland	-0-	-0-	-0-	-0-	-0-	-0-	100	-0-	-0-	40
Corn, silage	Irrigated	900	1,100	4,800	3,700	3,700	5,700	5,700	2,900	6,850	6,500
	Dryland	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	10
Oats	Irrigated	1,200	1,500	900	800	600	1,200	1,400	1,000	1,200	1,900
	Dryland	500	1,300	1,400	300	600	200	1,000	200	500	200
Potatoes	Irrigated	1,300	1,300	700	230	-0-	80	80	-0-	120	220
Grain sorghum	Irrigated	11,000	3,400	-0-	-0-	-0-	-0-	900	1,120	4,000	50
Winter wheat	Irrigated	200	700	1,250	1,500	1,700	2,000	1,120	1,200	1,170	2,870
	Dryland	29,300	26,900	29,400	27,400	27,000	31,200	32,100	27,300	29,500	40,500
Spring wheat	Irrigated	50	140	100	200	-0-	100	-0-	100	100	300
	Dryland	200	300	-0-	100	200	200	200	100	200	100
Hay	Irrigated	12,400	19,500	16,850	14,400	13,800	15,300	16,000	12,200	12,400	19,500
	Dryland	800	1,800	1,500	1,600	1,800	1,700	2,000	2,200	2,400	1,200

1/ Includes crop acreage data for La Plata and Montezuma counties, Colorado and San Juan County, New Mexico as published in "Colorado Agricultural Statistics" and "New Mexico Agricultural Statistics" for the years shown.

TABLE 2.2
SUMMARY OF TOTAL ANNUAL PLANTED CROP ACREAGE
IN THE VICINITY OF THE SOUTHERN UTE
AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

County & State	Year 1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
La Plata, Colorado	51,400	53,000	49,300	48,000	49,300	34,000	54,900	49,100	52,600	59,000
Montezuma, Colorado	80,900	81,300	67,800	71,300	74,100	80,300	59,600	83,100	95,800	93,300
San Juan, New Mexico	54,550	53,240	57,300	49,970	43,750	40,730	33,380	28,620	37,210	26,730
TOTAL	186,850	187,540	174,400	169,270	167,150	155,030	147,880	160,820	185,610	179,030

1/ Total planted acreage for La Plata and Montezuma counties, Colorado and San Juan County, New Mexico as published in "Colorado Agricultural Statistics" and "New Mexico Agricultural Statistics" for years shown.

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SECTION 3

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SECTION 3
CLIMATIC CHARACTERISTICS

3.1 GENERAL

Climatic characteristics that prevail on Ute Indian Reservation lands will influence crop suitability and the capability of suited crops to produce economic yields. Specific climatic data which would facilitate the climatic characterization of all reservation areas are lacking. However, weather stations maintained by the National Oceanic and Atmospheric Administration (NOAA) are located on and in the vicinity of subject reservation lands. Data from these stations applied in conjunction with other published weather summaries and reports provide an adequate base to generally establish the prevailing climatic characteristics of reservation lands. The location, years of record, and types of data available from these NOAA stations are summarized in Table 3.1.

The climate of the project area is influenced by its location in relation to surrounding mountains and its remoteness from large bodies of water. Moist air from the Gulf of California area becomes significantly drier as it traverses the low mountains enroute to the project area. The Sierra Nevada Mountains in California and the Wasatch and Uinta Mountains in Utah intercept moisture entering from the west and northwest. The San Juan Mountains also act to shield the project area from precipitation. More importantly, the San

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TABLE 3.1
SUMMARY OF NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) WEATHER STATION LOCATION AND YEARS OF RECORD FOR STATIONS LOCATED IN THE VICINITY OF THE UTE INDIAN RESERVATION LANDS[1]

			Station Location			Years of Record		
Station	County	State	Elevation	Latitude	Longitude	Temp.	Precip.	End of Record Period
Teec Nos Pos	Apache	AZ	5,290	36°54'	109°06'W	18	18	1982
Cortez	Montezuma	CO	6,212	37°22'	108°33'W	52	53	1982
Dolores	Montezuma	CO	6,970	37°29'	108°29'W	0	45	1982
Durango	La Plata	CO	6,600	37°17'	107°53'W	86	88	1982
Fort Lewis	La Plata	CO	7,600	37°14'	108°03'W	71	79	1982
Ignacio	La Plata	CO	6,460	37°08'	107°38'W	58	66	1982
Mancos	Montezuma	CO	6,975	37°21'	108°19'W	0	56	1982
Mesa Verde	Montezuma	CO	7,070	37°12'	108°29'W	56	59	1982
Pagosa Springs	Archuleta	CO	7,105	37°16'	107°01'W	51	55	1982
Vallecito Dam	La Plata	CO	7,650	37°22'	107°35'W	41	41	1982
Yellow Jacket	Montezuma	CO	6,860	37°31'	108°45'W	20	20	1982
Aztec Ruin	San Juan	NM	5,644	36°50'	108°00'W	62	73	1982
Bloomfield	San Juan	NM	5,806	36°40'	107°58'W	64	66	1982

Table 3.1, Continued

			Station Location			Years of Record		
Station	County	State	Elevation	Latitude	Longitude	Temp.	Precip.	End of Record Period
Dulce	Rio Arriba	NM	6,793	36°57'	107°00'W	51	58	1982
Farmington	San Juan	NM	5,625	36°42'	108°15'W	27	60	1982
Fruitland	San Juan	NM	5,145	36°44'	108°21'W	56	59	1982
Shiprock	San Juan	NM	4,870	36°47'	108°42'W	43	47	1982
Aneth	San Juan	UT	4,620	37°15'	109°20'W	20	20	1982
Blanding	San Juan	UT	6,130	37°37'	109°28'W	69	73	1982
Bluff	San Juan	UT	4,315	37°37'	109°33'W	51	57	1982
Hovenweep	San Juan	UT	5,240	37°23'	109°05'W	22	24	1982
Mexican Hat	San Juan	UT	4,120	37°09'	109°52'W	33	34	1982
Monticello	San Juan	UT	6,820	37°52'	109°18'W	58	59	1982
Natural Bridges	San Juan	UT	6,500	37°37'	109°59'W	17	17	1982

1/ Based on data from "Climatological Data Annual Summaries", published by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration for stations shown.

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Juans generally prevent extremely cold polar air masses from reaching the project area. The climate in the vicinity of the Ute Indian Reservations is characterized by warm summers and cold winters. Precipitation occurs year round. Maximum summertime temperatures average approximately 85 degrees F and winter nighttime lows average between 10 to 20 degrees F. The frost free growing season generally extends from late May to near the end of September. The elevation and proximity of reservation lands to local mountains markedly impact climate. Generally, as elevation increases and as lands become closer to the mountains, precipitation increases and temperature decreases with a corresponding decrease in the length of the frost free season.

The purpose of establishing general reservation area climatic conditions is to identify zones with similar climatic characteristics. These zones will be evaluated individually in regard to existing soil/water conditions to develop estimates of crop yield and agronomic requirements. The characteristics of reservation area climate and the identification of the climatic zones are developed in this section.

fluctuations and generally recover from short term temperature stresses.

In addition to direct plant growth effects, temperature also impacts seed germination, dormancy, and flowering. In many plants a cold period is necessary to overcome natural substances which act to prevent or delay germination. Many perennial plants will enter a period of dormancy after the onset of cold temperature. Different varieties have different dormancy requirements. For example, alfalfa dormancy and tolerance to cold are variety dependent. Alfalfa varieties are classed non-dormant, semi-dormant, or dormant. Dormant alfalfa varieties, which have the highest tolerance to winter cold, are probably best suited to reservation conditions.

Deciduous trees have specific cold weather requirements which must be satisfied to promote normal flowering, growth, and fruit production. This cold weather requirement is measured by determining the number of chilling hours that occur over the winter period. Chilling hours refer to the accumulation of time during which the temperature is less than 45 degrees F. Temperatures below 32 degrees F or above 45 degrees F are not considered effective and warm temperatures during the dormant period are thought to have an offsetting effect. Plant species and varieties vary in their chilling requirement.

The diurnal temperature variation, thermal periodicity, has an impact on crop growth response and yield. Plants vary in their response to thermal periodicity. For example, high nighttime temperatures accelerate tomato growth. Night temperature is also the dominate factor for potato production with the optimum temperature about 54 degrees F. Decrease in night temperature has been shown to increase the sucrose content of sugar beets.

Late spring and early autumn frosts can significantly reduce crop yield and in severe cases cause the loss of the entire crop. The critical periods whenfrost can be most damaging during plant growth are germination, flowering, and fruiting. There are marked differences between plant species and physiological development stages and the ability of plants to tolerate freezing temperature conditions. Winter annuals such as wheat, barley, and oats are considerably more tolerant of frost during part of their life cycle than summer annuals such as corn and potatoes. Deciduous trees often tolerate extreme cold when dormant but are very sensitive to frost when in the vegetative stage, especially during flowering.

General temperature conditions depicted by records from several NOAA weather stations located in the vicinity of the reservations are shown on Tables 3.2, 3.3, and 3.4. Figures 3.1, 3.2, 3.3, and 3.4 show isotherms for July and January mean minimum and maximum temperatures. Temperature generally decreases from south to north and from west to east. Temperature is inversely correlated with

TABLE 3.2

SUMMARY OF MEAN MINIMUM MONTHLY TEMPERATURE FOR SELECTED NOAA STATIONS LOCATED IN THE VICINITY OF THE UTE INDIAN RESERVATIONS

Station	Mean Minimum Temperature (°F)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Mean Annual
Cortez CO 1/	12.5	17.8	23.8	30.5	38.2	45.8	53.6	52.2	44.0	33.6	22.3	14.7	32.6
Durango CO 2/	10.4	15.7	22.5	29.0	35.3	41.7	49.9	48.8	40.8	31.2	21.4	12.9	30.0
Fort Lewis CO 3/	8.4	12.0	18.0	25.9	33.0	40.0	48.0	46.4	39.5	30.5	19.2	11.8	27.7
Ignacio CO 3/	6.3	12.5	19.9	26.7	33.8	40.8	49.1	47.9	39.7	30.0	18.3	10.7	28.2
Mesa Verde CO 4/	18.4	22.2	26.3	33.7	42.4	51.8	57.6	55.8	49.3	39.2	27.8	20.8	37.1
Pagosa Springs CO 5/	1.7	6.8	14.9	23.3	30.2	36.3	45.2	44.1	36.4	26.6	15.3	5.8	24.4
Vallecito Dam CO 6/	5.6	8.1	15.7	24.9	32.1	39.3	47.0	45.8	38.9	30.2	19.8	11.5	26.7
Yellow Jacket CO 7/	12.5	17.4	22.8	29.8	39.1	46.9	54.8	52.4	45.5	36.4	25.6	16.4	33.3
Aztec Ruin NM 8/	14.1	19.7	24.6	31.4	39.8	48.0	56.9	55.2	46.9	36.1	23.5	16.3	34.4
Bloomfield NM 8/	15.6	21.8	27.2	34.7	43.9	52.4	59.6	57.6	49.5	38.0	25.7	18.0	37.0
Dulce NM 8/	2.4	8.6	16.9	23.7	30.6	37.1	46.5	45.7	36.5	26.2	15.3	6.4	24.7
Farmington NM 8/	13.7	19.7	24.4	31.0	40.0	48.5	57.2	55.0	46.0	34.4	23.4	15.7	34.1
Fruitland NM 8/	16.1	20.9	26.4	34.0	42.2	50.7	58.2	56.7	47.7	36.5	24.7	17.3	36.0
Shiprock NM 8/	15.2	21.0	27.1	34.9	43.7	51.1	58.8	56.9	47.9	36.3	24.6	16.7	36.2
Blanding UT 9/	16.2	21.5	26.3	32.9	41.4	50.0	57.5	55.3	47.3	37.3	26.2	18.3	35.9

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TABLE 3-3

SUMMARY OF MEAN MAXIMUM MONTHLY TEMPERATURE FOR SELECTED NOAA STATIONS LOCATED IN THE VICINITY OF THE UTE INDIAN RESERVATIONS

Station	Mean Maximum Temperature (°F)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Mean Annual
Cortez CO [1]	40.4	45.6	53.0	63.2	72.8	83.3	88.6	86.4	79.2	67.7	52.8	42.6	64.7
Durango CO [2]	39.4	44.5	51.7	61.0	70.1	80.3	84.4	82.9	76.5	65.5	52.3	41.3	62.5
Fort Lewis CO [3]	36.3	39.7	45.3	55.5	65.2	75.3	80.4	77.8	71.5	61.0	47.5	38.9	57.9
Ignacio CO [3]	38.3	44.0	52.2	52.7	72.1	82.6	87.4	84.7	77.9	66.9	52.2	42.0	63.6
Mesa Verde CO [4]	39.8	44.3	50.3	60.6	71.1	82.5	87.4	84.7	77.2	65.6	50.8	41.5	63.1
Pagosa Springs CO [5]	37.8	42.5	48.8	59.3	68.5	78.6	83.3	80.9	74.7	64.5	49.6	40.2	60.6
Vallecito Dam CO [6]	37.4	41.4	46.5	56.4	65.0	76.0	81.5	78.7	73.2	63.0	49.0	40.5	59.1
Yellow Jacket CO [7]	35.3	41.1	47.0	56.8	68.3	79.6	86.3	83.1	75.1	63.7	48.9	38.3	60.3
Aztec Ruin NM [8]	42.4	49.3	57.6	68.0	76.9	86.7	91.4	88.6	82.0	70.5	55.4	44.5	67.8
Bloomfield NM [8]	41.0	48.0	56.7	67.0	77.3	88.4	92.6	89.6	82.4	69.9	54.4	43.4	67.6
Dulce NM [8]	38.3	43.5	51.1	61.3	70.4	81.4	85.7	83.1	77.6	65.9	51.2	40.7	62.5
Farmington NM [8]	42.0	49.9	58.2	67.7	78.7	88.9	93.5	90.4	83.1	71.1	55.7	43.7	68.6
Fruitland NM [8]	42.1	49.9	58.1	68.5	77.9	88.5	92.9	89.9	83.4	71.9	55.3	44.5	68.6
Shiprock NM [8]	42.3	50.0	59.2	69.7	79.0	89.5	94.5	91.6	84.8	72.3	55.9	43.8	69.4
Blanding UT [9]	38.4	44.5	51.5	61.3	72.3	83.7	89.5	86.2	78.8	66.2	50.6	40.7	63.7

Table 3.2, Continued

Station	Mean Minimum Temperature (°F) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Mean Annual
Bluff UT 9/	16.6	22.8	28.3	35.7	44.2	51.7	59.9	58.1	47.7	35.6	25.0	17.2	37.0
Hovenweep UT 9/	11.8	20.6	25.8	32.0	41.5	49.5	58.4	56.5	47.5	36.7	25.7	15.6	35.1
Mexican Hat UT 9/	18.9	24.8	30.1	38.4	48.1	57.2	65.2	63.1	52.8	40.1	28.7	20.0	40.7
Monticello UT 9/	14.2	17.6	22.6	29.6	37.7	45.4	52.8	50.9	43.4	34.1	23.3	15.8	32.3
Natural Bridges UT 9/	16.1	21.2	26.5	31.3	42.6	51.7	59.0	56.7	48.3	38.2	28.5	17.9	36.5

1/ Colorado Climate Center, period of Record 1911-1980.
2/ Colorado Climate Center, period of Record 1891-1980.
3/ Colorado Climate Center, period of Record 1931-1980.
4/ Colorado Climate Center, period of Record 1922-1980.
5/ Colorado Climate Center, period of Record 1939-1980.
6/ Colorado Climate Center, period of Record 1917-1980.
7/ Colorado Climate Center, period of Record 1962-1980.
8/ New Mexico Agricultural Statistics, period of record 1931-1981.
9/ Utah Weather Guide, period of record 1951-1980.

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Table 3.3, continued

Station	Mean Maximum Temperature (°F) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Mean Annual
Bluff UT 9/	42.5	51.8	60.7	70.5	79.9	90.5	95.9	92.8	85.6	72.7	56.7	44.4	70.4
Hovenweep UT 9/	38.6	47.5	56.4	66.1	77.7	88.4	94.8	91.7	82.7	69.7	54.2	40.8	67.4
Mexican Hat UT 9/	43.4	52.9	61.2	71.1	81.6	93.0	98.4	95.2	87.6	74.4	57.8	45.3	71.9
Monticello UT 9/	35.7	40.4	47.1	57.5	67.6	78.5	84.5	81.3	74.3	63.0	47.9	38.5	59.7
Natural Bridges UT 9/	40.1	45.5	52.4	60.8	75.0	84.2	90.8	87.5	77.9	64.9	50.6	39.9	64.1

1/ Colorado Climate Center, period of Record 1911-1980.
2/ Colorado Climate Center, period of Record 1891-1980.
3/ Colorado Climate Center, period of Record 1931-1980.
4/ Colorado Climate Center, period of Record 1922-1980.
5/ Colorado Climate Center, period of Record 1939-1980.
6/ Colorado Climate Center, period of Record 1917-1980.
7/ Colorado Climate Center, period of Record 1962-1980.
8/ New Mexico Agricultural Statistics, period of record 1931-1981.
9/ Utah Weather Guide, period of record 1951-1980.

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TABLE 3.4

SUMMARY OF MEAN MONTHLY TEMPERATURE FOR SELECTED NOAA STATIONS
LOCATED IN THE VICINITY OF THE UTE INDIAN RESERVATIONS

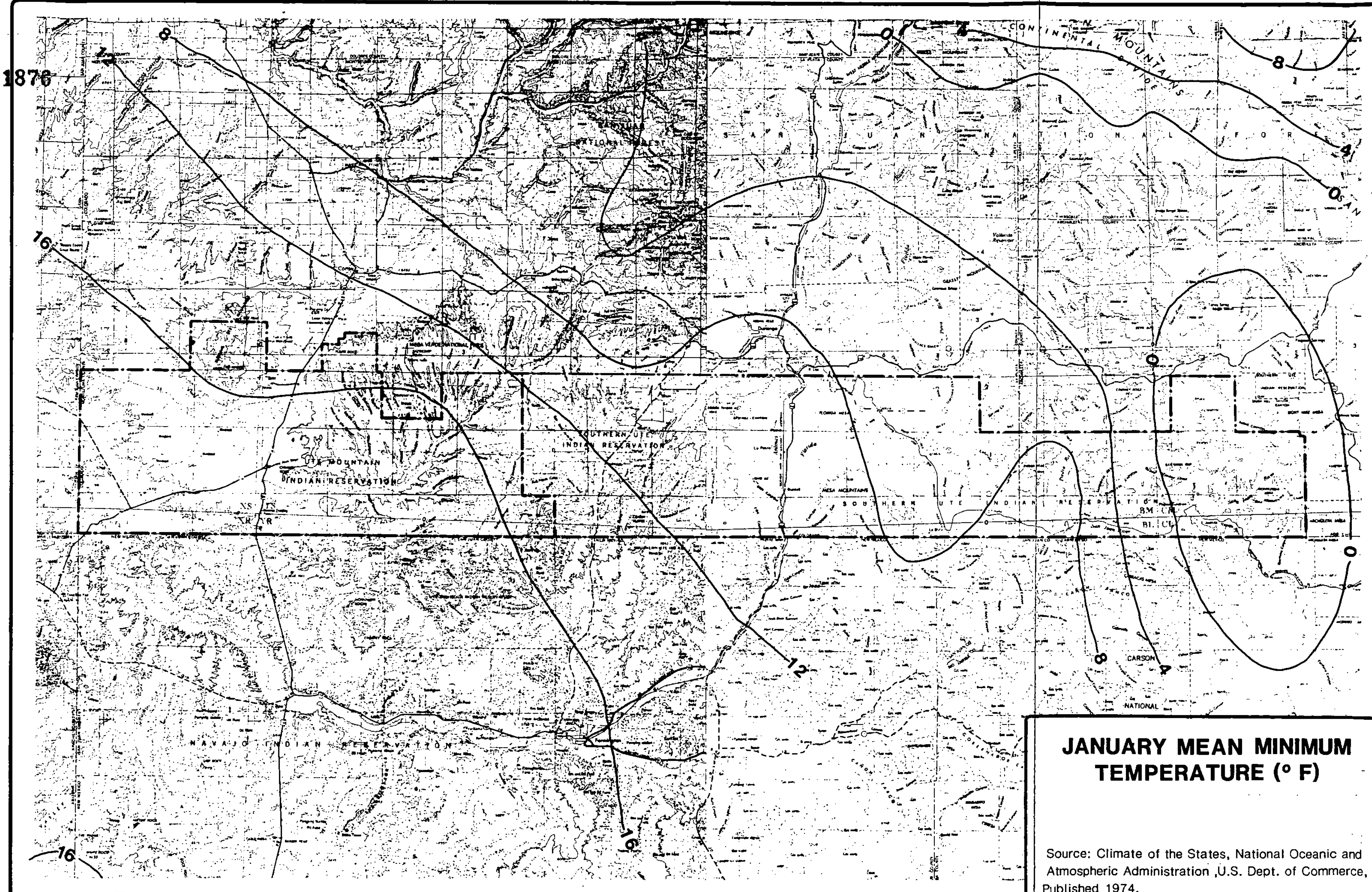
Station	Mean Temperature (°F)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Mean Annual
Cortez CO[1/]	26.5	31.7	38.4	46.9	55.5	64.6	71.1	69.3	61.6	50.7	37.6	28.7	48.6
Durango CO[2/]	24.9	30.1	37.1	45.0	52.7	61.1	67.4	65.9	58.6	48.4	36.8	27.1	46.2
Fort Lewis CO[3/]	22.3	25.9	31.7	40.7	49.1	57.7	64.2	62.1	55.6	45.8	33.3	25.4	42.8
Ignacio CO[3/]	22.3	28.3	36.0	44.7	53.0	61.7	68.3	66.3	58.8	48.4	35.3	26.3	46.0
Mesa Verde CO[4/]	29.2	33.2	38.3	47.1	56.8	67.2	72.5	70.3	63.2	52.4	39.3	31.2	50.1
Pagosa Springs CO[5/]	19.8	24.7	31.8	41.3	49.3	57.5	64.3	62.5	55.5	45.6	32.5	23.1	42.5
Vallecito Dam CO[6/]	21.5	24.8	31.1	40.7	48.6	57.7	64.3	62.2	56.1	46.6	34.4	26.1	42.9
Yellow Jacket CO[7/]	23.9	29.3	35.0	43.3	53.7	63.3	70.6	67.8	60.3	50.1	37.3	27.3	46.8
Aztec Ruin NM[8/]	28.3	34.5	41.1	49.7	58.4	67.4	74.2	71.9	64.4	53.3	39.5	30.5	51.1
Bloomfield NM[8/]	28.1	34.9	42.0	50.9	60.6	70.5	76.1	73.6	65.9	53.9	40.1	30.7	52.3
Dulce NM[8/]	20.2	26.0	33.9	42.4	50.0	58.6	66.1	64.4	57.1	46.1	33.3	23.6	43.5
Farmington NM[8/]	28.0	34.8	41.3	49.4	59.3	68.7	75.4	72.7	64.6	52.8	39.6	29.7	51.3
Fruitland NM[8/]	29.1	35.5	41.5	51.3	60.1	69.8	75.6	73.3	65.6	54.2	40.0	30.9	52.2
Shiprock NM[8/]	28.8	35.5	43.1	52.3	61.3	70.3	76.6	73.5	66.3	54.3	40.3	30.3	52.7
Blanding UT[9/]	27.3	33.0	38.9	47.1	56.9	66.9	73.5	70.8	63.1	51.8	38.4	29.5	49.8

Table 3.4, continued

Station	Mean Temperature (°F)											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Mean Annual
Bluff UT 9/	29.6	37.3	44.5	53.1	62.1	71.1	77.9	75.5	66.7	54.2	40.9	30.8	53.7
Hovenweep UT 9/	25.2	34.1	41.1	49.1	59.6	69.0	76.6	74.1	65.1	53.2	40.0	28.2	51.3
Mexican Hat UT 9/	31.2	38.9	45.7	54.8	64.9	75.1	81.8	79.2	70.2	57.3	43.3	32.7	56.3
Monticello UT 9/	25.0	29.0	34.9	43.6	52.7	62.0	68.7	66.1	58.9	48.6	35.6	27.2	46.0
Natural Bridges UT 9/	28.1	33.4	39.5	46.1	58.8	68.0	74.9	72.1	63.1	51.6	39.6	28.9	50.3

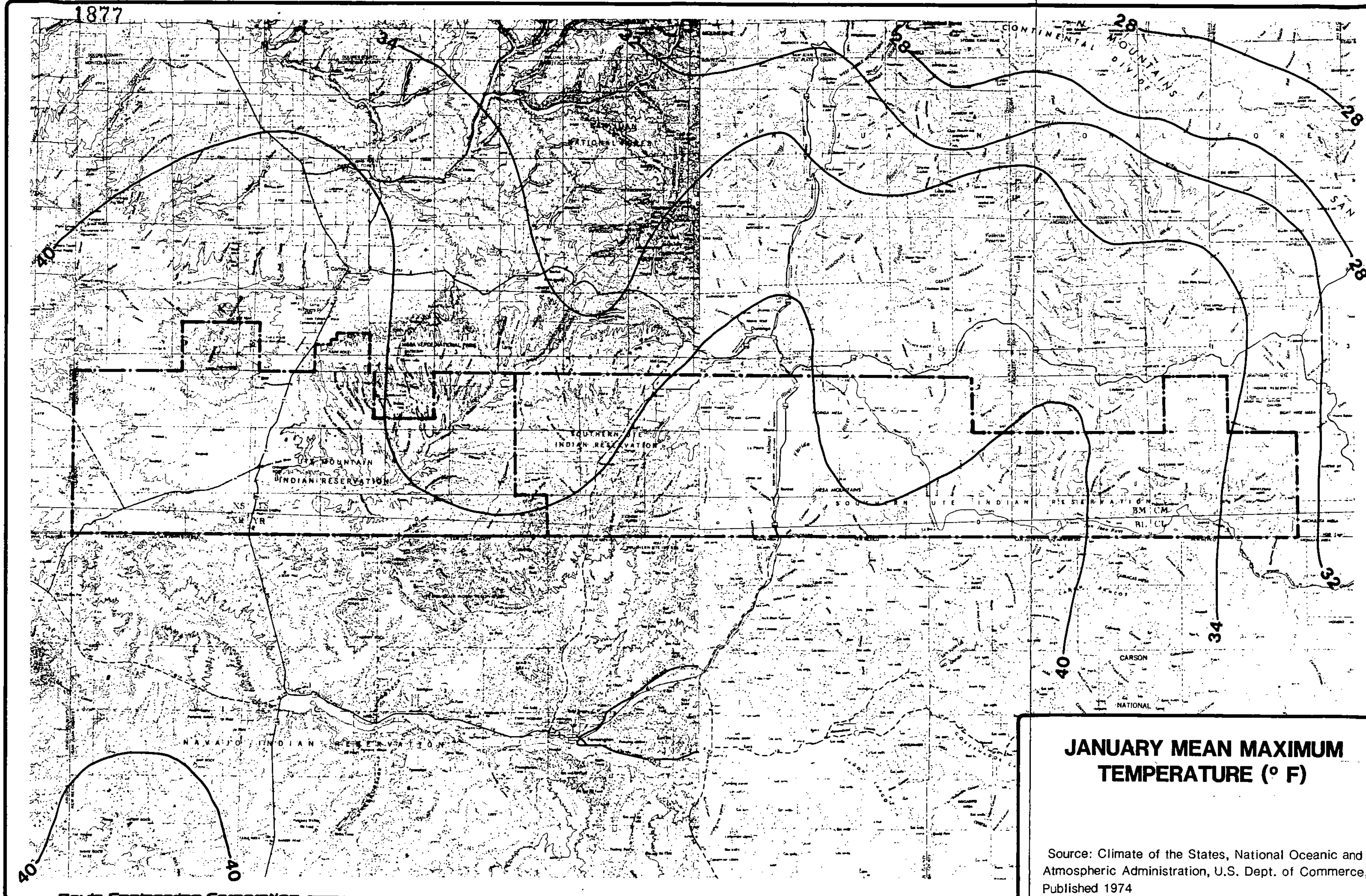
1/ Colorado Climate Center, period of Record 1911-1980.
2/ Colorado Climate Center, period of Record 1891-1980.
3/ Colorado Climate Center, period of Record 1931-1980.
4/ Colorado Climate Center, period of Record 1922-1980.
5/ Colorado Climate Center, period of Record 1939-1980.
6/ Colorado Climate Center, period of Record 1917-1980.
7/ Colorado Climate Center, period of Record 1962-1980.
8/ New Mexico Agricultural Statistics, period of record 1931-1981.
9/ Utah Weather Guide, period of record 1951-1980.

1876



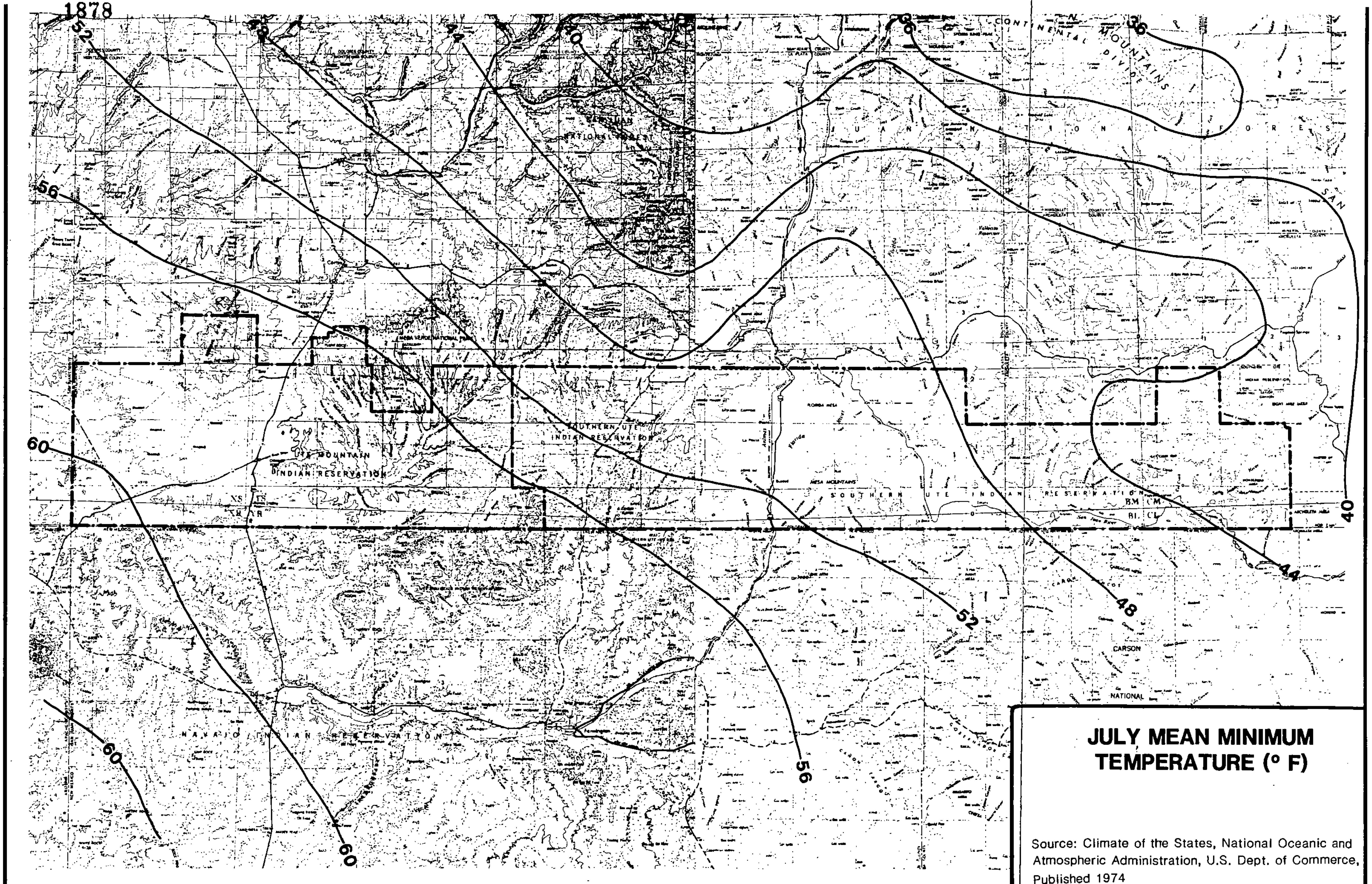
JANUARY MEAN MINIMUM TEMPERATURE (° F)

Source: Climate of the States, National Oceanic and Atmospheric Administration ,U.S. Dept. of Commerce, Published 1974.



JANUARY MEAN MAXIMUM TEMPERATURE (° F)

Source: Climate of the States, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce, Published 1974

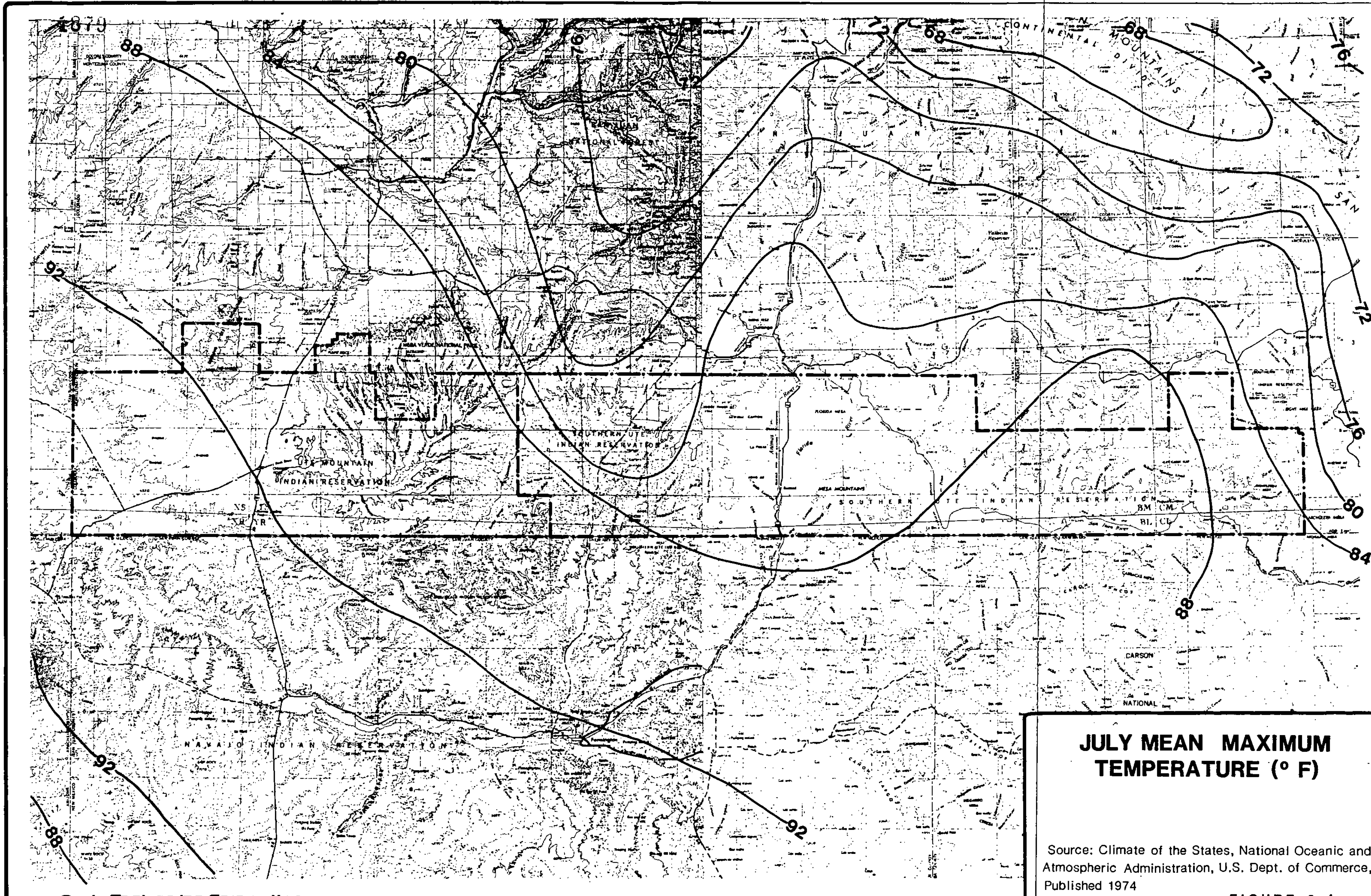


JULY MEAN MINIMUM TEMPERATURE (° F)

Source: Climate of the States, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce, Published 1974

Boyle Engineering Corporation

FIGURE 3.3



JULY MEAN MAXIMUM TEMPERATURE (° F)

Source: Climate of the States, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce, Published 1974 elevation which isothermal lines on Plates 3.1 through 3.4 generally confirm. However, this relationship can be influenced by microclimatic factors such as air flow which impact temperature conditions on a local basis.

Aspect will also significantly affect plant growth and yield potential. Much of the land in the reservation area is hilly to mountainous. Aspect is the general direction of the land slope in a given area. North slopes are usually cooler and moister than south slopes in the same general area and with the same elevation and may provide climatic niches where plants may do much better or much poorer than would be expected otherwise.

3.3 PRECIPITATION

The supply of water available for plant growth, whether from rainfall or irrigation, is another determining factor in evaluating crop suitability and yield. Water is necessary for all plant chemical processes. Further, soil nutrients must be dissolved in water to allow uptake by plant roots. Water availability directly influences the capability of agricultural crops to grow and produce economic yields.

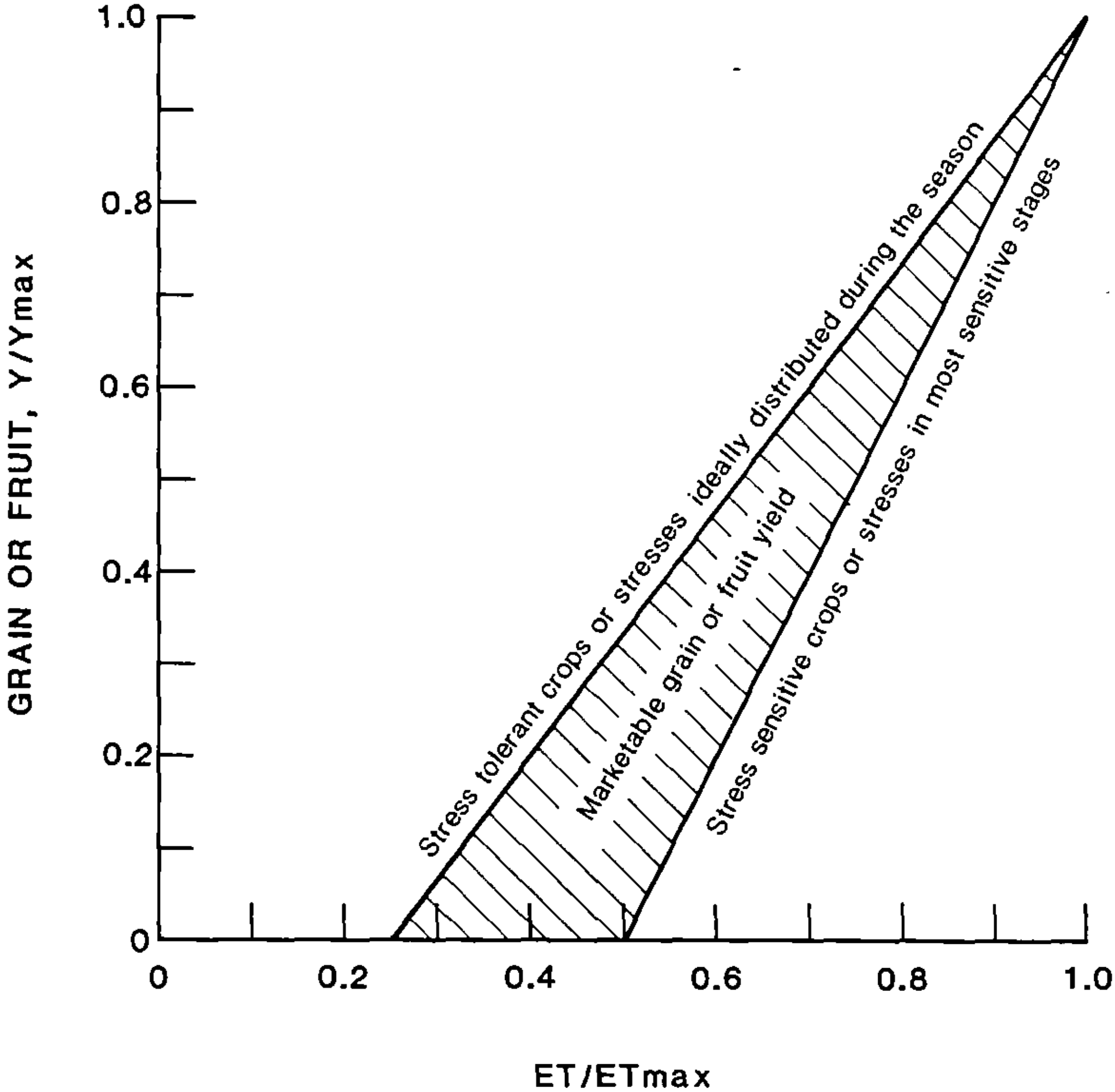
Water enters plants through the root system and exits from the leaf surface in vapor form. This transpirational loss occurs largely through leaf surface structures called stomata. Stomata maintain some degree of control over transpiration losses through their ability to close during climatic periods which favor high evaporative demand. The ability to control excessive transpirational losses through the stomata varies among plant species. The amount of water required by a plant is therefore a function of crop species, environmental and climatic conditions.

Consumptive use (evapotranspiration) is the sum of the water evaporated from the soil and the water transpired by the plants growing thereon. The consumptive use requirement may be derived mathematically using empirical equations or by measuring actual water use with a lysimeter. Measurement of the evaporation from an open pan filled with water may also be used as a basis to estimate the consumptive use requirement for an area. The consumptive use requirement is the amount of water required to meet plant needs when growth is not limited by lack of water. Consumptive use requirements reflect the plant growth environment and vary between different geographic areas and climatic conditions.

Environmental growth conditions which act to reduce crop consumptive use to levels below that needed to achieve full production potential result in crop yield losses. The impact of reduced crop consumptive use on yield is related to the type of crop and the timing and amount of the water shortage. Generally, crops can be separated into two broad groups: 1) those harvested for their vegetative parts and 2) those harvested for their fruiting parts. General relationships shown on Figures 3.5 and 3.6 depict the impact of reduced crop evapotranspiration on yield. Crops harvested for their vegetative parts, such as alfalfa, silage and hay crops, generally have a linear yield relationship to water availability. For example, if consumptive use is reduced 50 percent, crop growth will be reduced to approximately 50 percent of its potential. A different relationship exists for crops grown for their fruiting parts (i.e. dry beans or grain corn). For these plants, water shortages have different effects on yield depending on the time and severity of the shortage. Water shortages usually have the most severe impact during periods of germination, flowering, and pollination. For these crops, a general reduction of water to 50 percent of that required may result in the loss of the entire crop, particularly if water is limited at one of the specific periods mentioned above. However, if adequate water is supplied at the time of flowering and pollination, respectable yields may be obtained. The timing of water availability is often as important as the total supplied.

The total amount of water which must be supplied to achieve optimum crop growth must take into consideration the consumptive use requirements of the chosen crops. In addition, (as discussed in Chapter 4) the quality of the water supplied may require that an additional amount will be needed to satisfy the leaching requirement and prevent the build-up of salts in the irrigated soils.

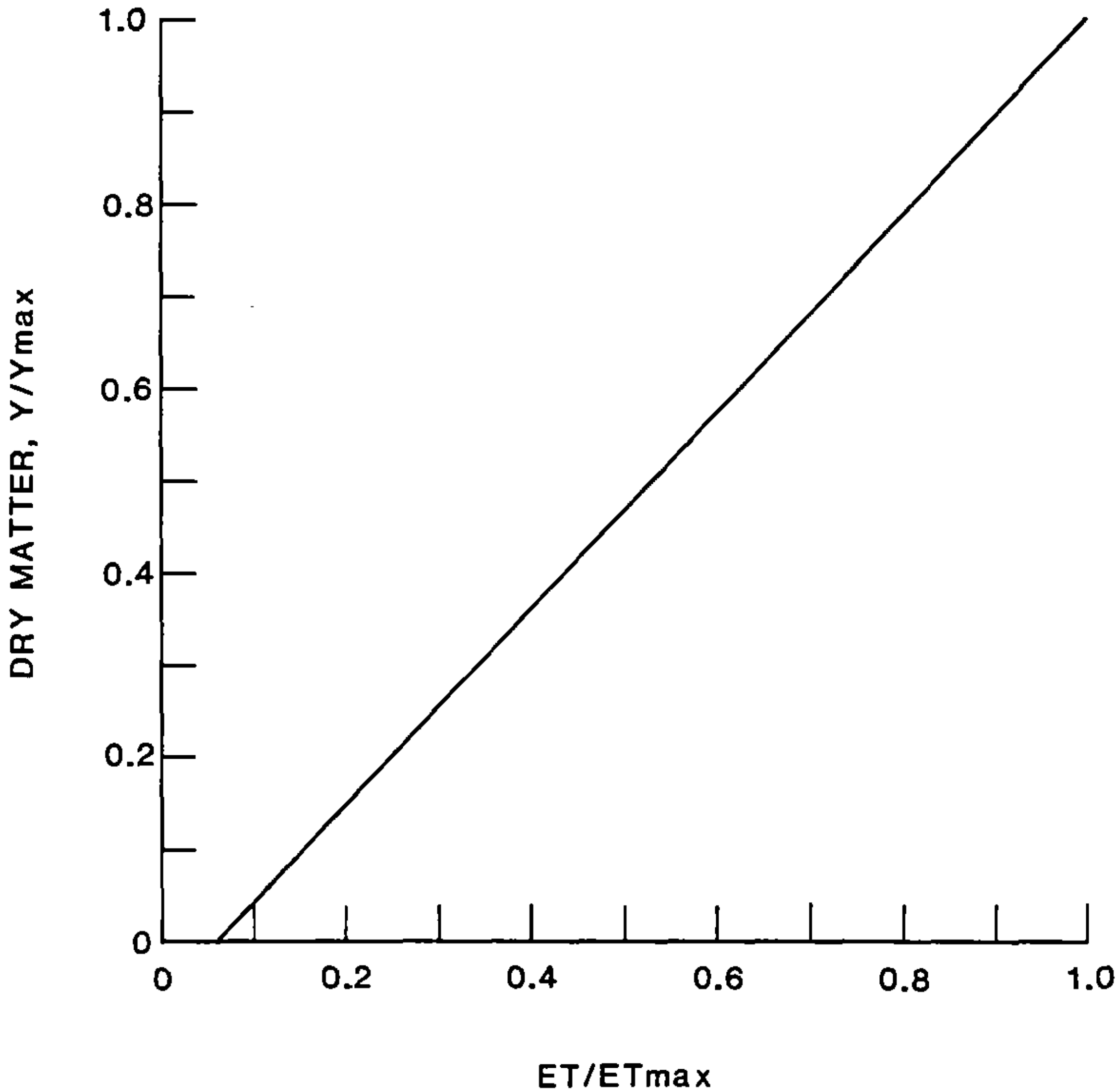
1883



RELATIVE GRAIN OR FRUIT YIELD AS RELATED TO RELATIVE SEASONAL EVAPOTRANSPIRATION

Boyle Engineering Corporation FIGURE 3.5

1884



RELATIVE DRY MATTER YIELD AS RELATED TO RELATIVE SEASONAL EVAPOTRANSPIRATION

Boyle Engineering Corporation — FIGURE 3.6

Precipitation is important for crop production, but if rain falls during certain growth periods, severe crop damage can occur. For example, rainfall during the harvest period of cereal grains or corn can cause lodging which usually makes harvest difficult and increases harvest losses. Dryland crops rely on precipitation to provide their water requirement and crop yield is directly related to the amount of precipitation that occurs both annually and during the growing season. Precipitation during the growing season (generally April through September) is considered the most important; however, precipitation that occurs during the winter also contributes to crop growth by increasing the amount of moisture stored in the soil which is available for future crop uptake. This stored soil moisture is available to the plant for use during the growing season.

Guidelines which specifically relate the amount of annual or seasonal precipitation to crop suitability or yield are lacking. There are several site specific variables that must be evaluated in order to determine the suitability of a particular area to dryland crop production. Not all rainfall is effective in satisfying the crop consumptive use requirement. Water losses occur as a result of evaporation, runoff, and deep percolation. Short, light intensity rainfall does not provide significant effective precipitation since much of this water is lost through evaporation. Conversely, an intense rain is often lost as a result of runoff or deep percolation. Soil conditions also affect the amount of rainfall effective in satisfying crop consumptive use . Soils with low infiltration rates may suffer significant runoff losses. Coarse textured, rapidly permeable soils typically have insignificant runoff losses, but since they have low available water holding capacity, storage capacity is limited and deep percolation losses may occur.

The net crop water requirement is also a factor which must be considered in evaluating potential dryland farming areas. The net crop water requirement takes into account not only the water lost from the soil through evapotranspiration, but also water gained through precipitation. Crop consumptive use requirements vary between plant species and will vary for the same species under different climatic conditions. Thus, under conditions of high evaporative demand, consumptive use will be higher and effective precipitation lower resulting in a higher net crop water requirement. The efficiency of precipitation for dryland farming operations and crop yield is dependent upon the multiple effect of these variable factors.

Precipitation is also important for irrigated farming operations. Effective precipitation acts to reduce the irrigation requirement since it satisfies a part of the crop consumptive use requirement.

The unreliable nature of precipitation in the project area results in crop yield under dryland farming conditions which is usually far from optimum. The timing and amount of rainfall that occurs is seldom adequate to maximize potential crop yield. Conversely, irrigation offers an opportunity to overcome this unreliability and obtain maximum crop yield under the given growing environment. Given the availability of an adequate water supply, it would appear desirable to develop potential or existing dryland farming areas to irrigation. However, careful economic analyses are required to demonstrate the feasibility of such a venture since the cost of developing irrigation water can more than offset the benefits derived from increased crop production.

Precipitation occurs during each month of the year in the project area. The summary of average precipitation at several NOAA weather stations located in the vicinity of reservation lands is shown in Table 3.5. Figure 3.7 shows precipitation isohyets. Average amounts of precipitation increase from south to north and west to east. Approximately 35 to 50 percent of the average annual rainfall occurs in the 6 month period encompassing April to September. The project area is considered semi-arid. A semi-arid region is arbitrarily designated as one with annual precipitation averaging from 10 to 20 inches. An additional characteristic of the semi-arid climate is the wide variability of precipitation and temperature from year to year. Deviations from the average may be as large as the average. For example, the annual precipitation at Mesa Verde varied from less than 13 to more than 30 inches over a 20 year period. Generally, 20 inches is arbitrarily chosen as the dividing line where non-irrigated agriculture is possible. The Four Corners area on the Ute Mountain Ute Indian Reservation averages less than 10 inches of

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TABLE 3.5

SUMMARY OF ANNUAL AVERAGE PRECIPITATION AT SELECTED NOAA WEATHER STATIONS LOCATED IN THE VICINITY OF THE UTE INDIAN RESERVATIONS[1]

Station	Average Precipitation (inches)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Cortez CO	1.04	.82	1.02	1.05	.94	.54	1.14	1.60	1.16	1.54	.84	1.21	12.90
Dolores CO[2]	1.83	1.49	1.73	1.44	1.30	.67	1.32	1.89	1.37	1.86	1.41	1.73	17.88
Durango CO	1.70	1.14	1.47	1.36	1.12	.88	1.85	2.43	1.59	1.94	1.11	2.00	18.59
Fort Lewis CO[3]	1.63	1.56	1.54	1.24	1.16	.80	1.83	2.12	1.75	2.05	1.09	1.58	18.12
Ignacio CO	1.29	1.66	1.07	1.12	.96	.72	1.37	1.68	1.29	1.63	.77	1.31	14.87
Mancos CO[2]	1.48	1.11	1.41	1.15	1.19	.64	1.70	1.86	1.26	1.74	1.11	1.31	15.86
Mesa Verde CO	1.74	1.47	1.57	1.36	.99	.71	1.77	2.13	1.28	1.82	1.12	1.86	17.82
Pagosa Springs CO	1.87	1.15	1.45	1.38	1.12	.96	1.66	2.38	1.66	2.02	1.23	1.89	18.77
Vallecito Dam CO[4]	2.62	1.78	2.34	1.80	1.52	1.02	2.39	2.98	2.12	2.49	1.69	2.46	25.57
Yellow Jacket CO[5]	1.26	1.11	1.06	.85	1.19	.49	1.30	1.70	1.38	1.95	1.24	1.55	15.07
Aztec Ruin NM	.75	1.21	.71	.70	.60	.48	.87	1.29	.90	1.17	.54	.89	10.11
Bloomfield NM	.51	.40	.57	.57	.48	.37	.83	1.43	.79	1.08	.46	.60	8.09
Dulce, NM[6]	1.47	1.35	1.41	1.02	1.08	.71	1.71	2.42	1.48	1.40	1.15	1.38	16.58
Farmington NM[6]	.56	.58	.58	.53	.48	.38	.74	1.06	.95	1.03	.44	.66	7.98
Fruitland NM	.53	.41	.50	.59	.46	.36	.75	1.03	.85	1.03	.47	.66	7.64

Table 3.5, Continued

Station	Average Precipitation (inches)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Shiprock NM 6/	.47	.39	.51	.38	.49	.31	.55	.87	.81	.86	.48	.50	6.62
Blanding UT 7/	1.34	.95	.80	.67	.59	.37	1.04	1.41	.89	1.46	.89	1.29	11.70
Bluff UT 7/	.78	.64	.55	.40	.37	.19	.76	.77	.60	1.15	.61	.79	7.61
Hovenweep UT 7/	.64	.72	.86	.79	.58	.44	.71	1.12	.96	1.65	.97	1.01	10.45
Mexican Hat UT 7/	.50	.43	.38	.31	.35	.19	.66	.65	.54	.96	.51	.61	6.09
Monticello UT 7/	1.34	.97	.96	.86	1.00	.48	1.67	1.89	1.16	1.62	1.08	1.38	14.41
Natural Brides UT 7/	.81	.92	.94	.70	.56	.69	1.76	1.72	.85	1.71	1.00	1.52	13.18

1/ Data are summarized from National Oceanic and Atmospheric Administration (NOAA) climatological data for period of 1941-1970 unless otherwise noted.
2/ Colorado Climate Center, period of record 1947-1980.
3/ Colorado Climate Center, period of record 1931-1980.
4/ Colorado Climate Center, period of record 1917-1980.
5/ Colorado Climate Center, period of record 1962-1980.
6/ New Mexico Agricultural Statistics, Climate of New Mexico, period of record 1931-1981.
7/ Utah Weather Guide, period of record 1951-1980.

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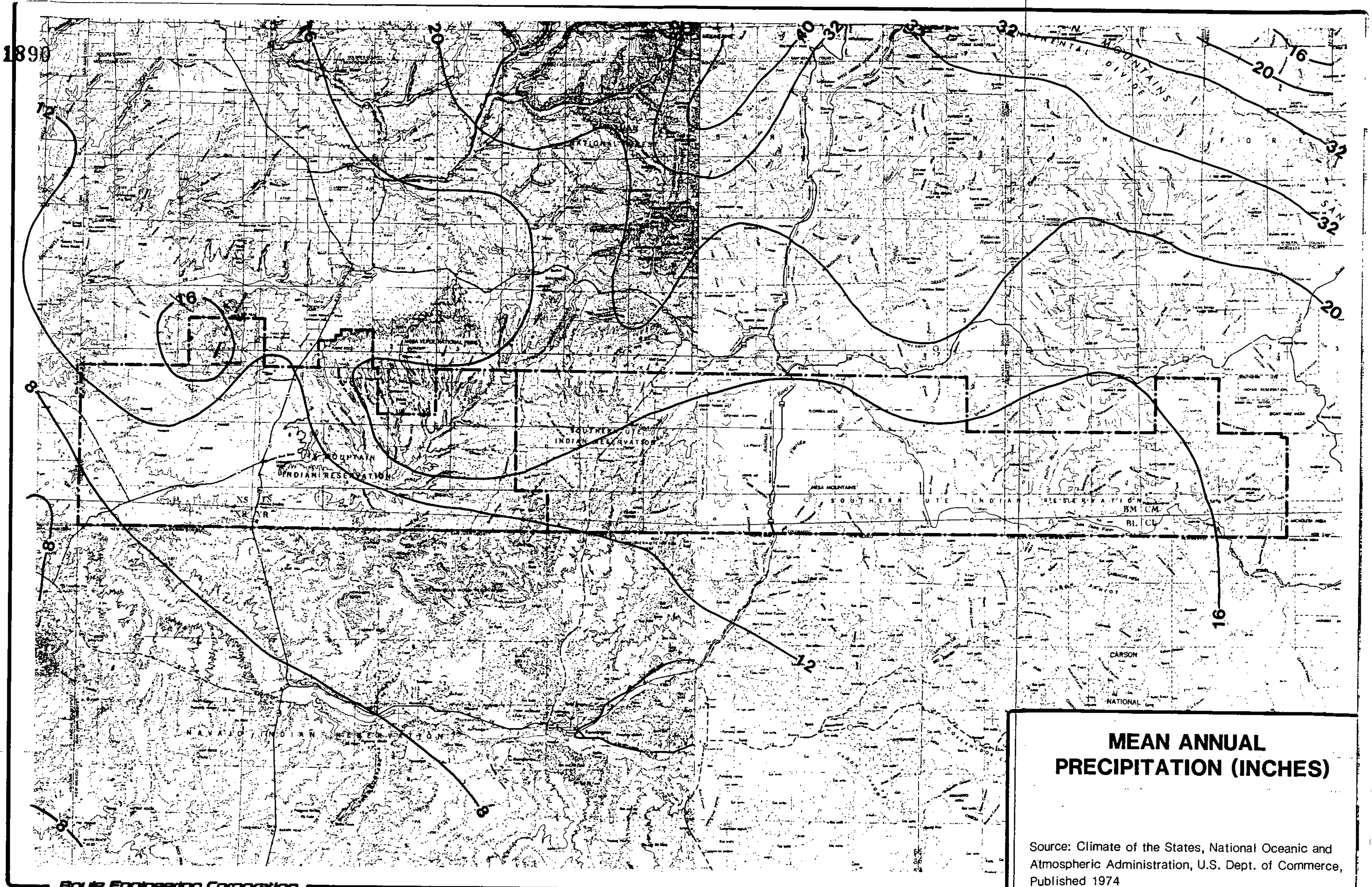

MEAN ANNUAL PRECIPITATION (INCHES)

Source: Climate of the States, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce, Published 1974

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FIGURE 3.7

precipitation a year.

3.4 RELATIVE HUMIDITY

Humidity refers to water vapor in the air. Relative humidity is atmospheric vapor pressure expressed as a percentage. The percentage represents the ratio of actual vapor pressure to the saturation vapor pressure at a particular temperature. Atmospheric moisture at saturation vapor pressure will condense on solid surfaces forming dew. The temperature at which this phenomenon occurs is known as the dew point. The dew point varies with the atmospheric moisture content. Higher amounts of atmospheric moisture result in a higher dew point, while reduced atmospheric moisture will yield a lower dew point.

Relative humidity is another factor which influences the evapotranspiration rate. The air takes up water transpired by the leaf or evaporated from the soil surface more rapidly as the relative humidity decreases at a given temperature. Temperature also affects the evapotranspiration rate. For example, the drying capacity at 95 degrees is 9.2 times that at 32 degrees at the same relative humidity. Evaporation and transpiration increase as a result of high temperature and low relative humidity. High seasonal evaporation from a free water surface is often related to high crop water requirements. Evaporation also affects rainfall efficiency, particularly in areas that receive less than 30 inches

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per year. High evaporation negates the effectiveness of light rains.

Transpiration in plants is the loss of water through the plant stomata. Water vapor pressure inside the stomata is quite high. When relative humidity is low, a large vapor pressure gradient is produced. This vapor pressure gradient is often referred to as the vapor pressure deficit (VPD). Since water vapor moves from areas of high to low vapor pressure, lower relative humidity will increase the VPD and the transpiration rate. Humidity generally impacts crop growth as a result of its effect on the transpiration rate which then influences related plant growth processes.

Site specific relative humidity data are lacking for reservation lands. However, data are available for sites at Cortez, Colorado and Farmington, New Mexico. Since summertime humidity at both Farmington and Cortez is very similar, it is assumed that conditions at these sites will approximate those of the reservations areas. Relative humidity normally ranges from approximately 60 percent during cooler morning hours to less than 30 percent during late afternoon. Summer thunder showers may temporarily increase relative humidity, but such effects are generally localized and short lived.

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3.5 WIND

Favorable wind conditions are important to crop production, but more importantly, wind or air movement significantly influences the climate in an area. Air movement begins over the equator as hot air rises, cools, and looses its moisture through precipitation over the great rain forests. Air moving away from the equator is dry and as it descends at about 30 degrees north and south latitude, it creates arid climatic zones. Semi-arid transitional areas, such as southern Colorado, are associated with this air pattern and generally occur beyond the 30 degree north and south latitudes.

The location of mountain ranges and bodies of water modifies the general weather pattern. As mentioned in the introduction, mountain ranges prevent moist air from the Gulf of Mexico and the Pacific Ocean from reaching the project area. Moisture is lost as the air masses rise to cross the surrounding mountains resulting in a rain shadow effect.

Wind also has an impact on evapotranspiration. As the plant grows, water is lost through the stomata. Transpired water increases the humidity in the plant microclimate. Increased humidity decreases the VPD and the rate of plant transpiration and evaporation from the soil since it reduces the vapor pressure gradient. Wind tends to replace the humidified air with drier air which increases the VPD and the rate of evapotranspiration. The transpiration rate generally

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increases as wind speed increases. Some plant species have the ability to close their stomata as wind velocity increases thus decreasing potential transpiration.

Climatic data required to specifically assess wind conditions in the project area are lacking. Based on project area analyses, including interviews with professional agriculturalists and growers, prevailing wind conditions have an insignificant impact on crop production in the project area.

3.6 SOLAR RADIATION

Sunlight provides energy for the photosynthetic process which makes plant growth possible. Light is necessary for the production of chlorophyl in green plants. Chlorophyl is the green pigment in plant cells necessary for photosynthesis. When illuminated by light of sufficient intensity, chlorophyl produces carbohydrates from carbon dioxide and water.

The photosynthetic rate is dependent on light intensity. Outer leaves of agronomic crops require as much as thirty percent full sunlight to become light saturated or to reach the point where further increase in light intensity does not increase the photosynthetic rate. While outer plant leaves become light saturated early in the day, inner leaves which depend on reflective light may not reach saturation intensity until much later in the day.

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As a result, the total photosynthetic rate can continue to rise as light intensity increases even though an individual leaf may be light saturated at lower intensities. Therefore, unless very high light intensities are available, maximum photosynthetic rates may not be achieved.

The daily number of light hours is known as the photoperiod and the plant development response to a photoperiod is called photoperiodism. Plants which are classified as "long day" require long days to induce flowering. Conversely, plants classified as "short day" are induced to flower by short days. Day neutral plants flower without respect to day length. Photoperiodism governs the distribution of certain crops. For example, onions are cultivar specific to latitude. In the United States each latitude has its own specific cultivars. The various cultivars range in photoperiod requirement from 12 to 16 hours. Predictable bulb size and maturity are predicated on proper cultivar selection. Hours of sunshine (day length) for the Ute Reservation area range from about 14 hours near the start of the growing season (mid-May) to almost 15 hours at the summer solstice (June 22) to approximately 12 hours at the end of the growing season (mid-September). Clouds, dust, water vapor and other pollutants reduce the amount of solar radiation that reaches the earth's surface. Thus, the amount of solar radiation received is usually less than the maximum potential. Barley, oats, potatoes, wheat, and alfalfa are long day species well adapted to southern Colorado's long day conditions. Judicious selection of cultivars, as indicated by the example for onions, can provide appropriate germplasm so that solar radiation is not likely to limit potential yields in the project area.

Solar radiation also affects evaporation. For example, long days with light intensity approaching the maximum potential will result in higher evaporative demand. This relates to higher crop consumptive use requirements. Specific climatic data needed to carefully characterize site solar radiation characteristics are lacking. However, data available from other sites have been used to estimate solar radiation on reservation lands. These data are summarized on Table 3.6.

3.7 GROWING DEGREE DAYS

The concept of degree day dates back over 200 years. It holds that the growth of a plant is dependent on the total amount of heat to which it is subjected during its lifetime. A degree day is the measurement of the mean daily departure from the minimum temperature at which plant growth occurs. If the minimum plant growth temperature is 50 degrees and the mean daily temperature is 60 degrees, that day would accumulate 10 degree days. The minimum plant growth temperature is species dependent, i.e., 40 degrees for peas, 45 degrees for potatoes, 50 degrees for corn, and 55 degrees for citrus. If temperatures exceed a given maximum for the selected crop this can result in a reduction in the degree days for a given area.

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TABLE 3.6
SUMMARY OF SOLAR RADIATION FROM SELECTED LOCATIONS IN THE VICINITY OF THE UTE INDIAN RESERVATIONS

Location	Average Daily Solar Radiation by Month1/												Avg. Daily
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Farmington2/	169	266	335	509	582	683	636	561	466	291	229	266	416
USBR Dolores Report3/	-	-	-	497	575	638	612	535	463	338	-	-	-
USBR Animas-LaPlata Report4/	-	-	-	490	564	624	599	526	459	342	-	-	-
Blanding, UT5/	198	308	429	549	669	744	696	607	508	368	227	212	460
Bluff, UT5/	213	363	481	628	735	830	770	663	587	442	256	257	519
Mexican Hat, UT5/	208	354	472	602	705	779	718	624	549	417	246	239	493
Monticello, UT5/	196	306	424	543	655	734	690	600	501	368	228	215	455

1/ Average daily solar radiation expressed in langleys which are a measure of heat per unit area (gram calories/cm^2).

2/ New Mexico Agricultural Experiment Station, San Juan Branch, Climatological Data summaries 1981-1983.

3/ USBR Dolores Project Report, estimated solar radiation based on climatic data for the period 1952-1973.

4/ USBR Animas-La Plata Project Report, estimated solar radiation based on climatic data for the period 1952-1973.

5/ Utah Weather Guide, 30 year period of record 1951-1980.

The accuracy of the degree day concept is acceptable when it is developed for a specific crop in a specific location. Using degree day information and long range weather forecasts, growers can often predict harvest dates within a few days. Degree days may also be useful in determining general crop suitability. For example, a crop which is known to require 4500 degree days to mature should not be grown in a locality which can only supply 2500 degree days. However, the degree day concept has not been suitably refined to use in making definitive crop recommendations in new agricultural regions or to introduce previously untested crops into existing agricultural areas. This approach is not adapted for making crop suitability judgements in the project area because:

- It makes no allowances for threshold temperature changes with advancing stage of crop development.
- The method gives too much weight to temperatures over 80 degrees F, for such high temperatures may even be detrimental to some crops.
- No consideration is given to the diurnal temperature range which is often more significant than the mean daily value.
- Degree day requirements for the same crop may vary in different geographic areas.

Recently, investigators have begun calculating degree days using crop specific maximum growth temperatures in place of the maximum daily temperatures. This approach is an attempt to improve the reliability and suitability of this concept. Table 3.7 summarizes the number of degree growing days at weather stations in the vicinity of the project area.

3.8 LENGTH OF FROST FREE GROWING SEASON

The length of the frost free growing season and its effect on crop production are closely related to temperature. The growing season or frost free season is the period between the last spring frost and the first fall frost. The length of the frost free season is a major factor in crop selection and cultural practices. Freezing temperatures are hazardous to many plant species during their growing season. Some plant species exhibit greater frost tolerance than others.

Frost damages plants by causing water in the plant to freeze. The ice crystals formed by freezing occupy a larger volume than water which causes the individual plant cells to rupture. As a result, the plant tissue loses turgor pressure and looks limp after thawing from a freeze. Plant tissue which has undergone this freeze-thaw effect does not recover.

In general, optimum production of most crops is accomplished where there is no temperature limitation to crop growth, i.e., where the growing season is long enough to allow completion of physiological

TABLE 3.7

SUMMARY OF GROWING DEGREE DAYS AT SELECTED NOAA WEATHER STATIONS LOCATED IN THE VICINITY OF THE UTE INDIAN RESERVATIONS1/

Station	Growing Degree Days2/ 40 Degree F Base	50 Degree Base
Pagosa Springs, Colorado	2,980	1,240
Durango, Colorado	3,640	1,700
Fort Lewis, Colorado	2,910	1,200
Ignacio, Colorado	3,750	1,800
Vallecito Dam, Colorado	3,000	1,250
Cortez, Colorado	4,300	2,240
Mesa Verde, Colorado	4,600	2,540

1/ Colorado Climate, Colorado Experiment Station, December, 1977.

2/ Growing Degree Days are calculated by subtracting the base temperature (50 degrees F for warm season plants or 40 degrees F for cool season plants) from the average daily temperature.

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processes. A frost free season less than 125 days is an effective limitation to the production of many crops. Not only is the growing season too short, but the growing temperatures adjacent to the outer limits of the growing season generally fall below the minimum temperatures required for plant growth. These early season low temperatures not only slow plant growth, but limit or slow requisite biological activity such as pollenization and microbial action. Certain frost tolerant crops such as spring wheat can be sown before the last spring frost. Spring wheat may survive temperatures as low as 15 degrees F in the early stages of growth. Other examples of crops with some degree of frost resistance are oats and barley. Unseasonal frost can damage perennial deciduous crops such as trees. Once the plant has come out of its hardened winter dormant state, it is quite susceptible to frost damage. Unseasonal late spring freezes will burn back or kill buds and fruiting bodies resulting in significant yield reduction. Apple yields in Colorado were reduced by half as a result of late spring freezes in 1978 and 1982. Early fall frost which occurs before perennials have a chance to harden may affect the ability of the plant to survive the winter and result in increased winter kill losses. While short season annual cultivars can be grown in areas with less than 125 frost free days, the time is generally not long enough to produce acceptable economic yields.

The growing season in the project area ranges from less than 100 days at the eastern side of the project area to over 150 days in the Four Corners area. The summary of growing season length at several NOAA weather stations located in the vicinity of the project site is shown in Table 3.8. Figure 3.8 shows lines of equal growing season length. Length of growing season generally increases from east to west and north to south.

3.9 CLIMATIC ZONES

The climatic data previously summarized provide a base from which to characterize the expected climate of the Ute Reservation lands. The purpose of this climatic characterization is to identify climatic zones in which crop suitability and growth response will be similar under favorable soil and water conditions. The average conditions established for climatic zones will be used as a basis for determining crop production requirements.

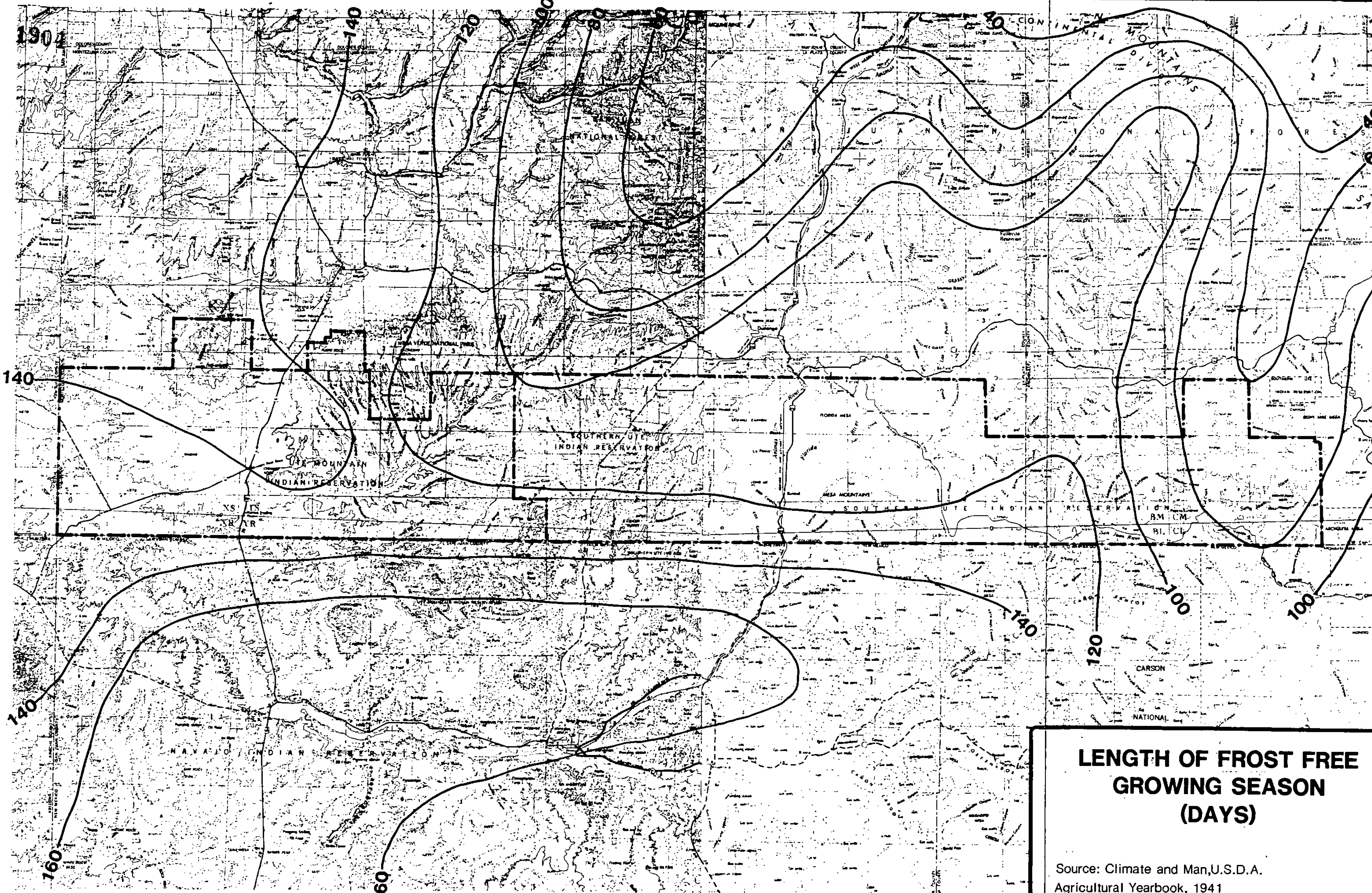
Comprehensive climatic data which could be directly applied to reservation lands in order to delineate climatic zones are lacking. As a result, data from existing NOAA weather stations and other sources previously summarized which are in the vicinity of reservation lands were extended by the use of regression analysis to provide a basis for climatic characterization. Growing season length, temperature, and precipitation were analyzed on a monthly and annual basis to determine their relationship with elevation. The estimated climatic zone characteristics are based on calculations used to extend existing data. Thus, the precision shown is a result of calculation and not actual measured data.

TABLE 3.8

AVERAGE LENGTH OF FREEZE FROST FREE GROWING SEASON
IN THE VICINITY OF THE UTE INDIAN RESERVATIONS
(32° F Base)

Station	Avg.Date of Last Spring Freeze	Avg.Date of First Fall Freeze	Avg.Length of Freeze Free Growing Season
Cortez, CO1/	May 21	September 30	131
Durango, CO2/	June 9	September 20	103
Fort Lewis, CO2/	June 13	September 17	96
Ignacio, CO2/	June 6	September 21	106
Mancos, CO2/	June 6	September 24	110
Mesa Verde, CO1/	May 13	October 16	156
Pagosa Springs, CO2/	June 21	August 18	58
Vallecito Dam, CO1/	June 9	September 18	100
Aztec Ruin, NM3/	May 11	October 9	152
Bloomfield, NM3/	May 4	October 16	164
Dulce, NM3/	June 19	September 2	74
Farmington, NM4/	--	--	150
Fruitland, NM3/	May 10	October 7	151
Shiprock, NM3/	May 6	October 3	149
Blanding, UT5/	May 15	October 6	144
Bluff, UT5/	April 23	October 21	182
Mexican Hat, UT5/	April 18	October 24	190
Monticello, UT5/	May 24	October 3	132

1/ Preliminary climatic data developed for the SCS soil survey of La Plata and Montezuma counties by NOAA.
2/ Colorado Climate, CSU Experiment Station, 1977.
3/ New Mexico Agricultural Statistics.
4/ Personal communication with Jack Jordan, Farmington Experiment Station horticulturist.
5/ Utah Weather Guide.



LENGTH OF FROST FREE GROWING SEASON (DAYS)

Source: Climate and Man, U.S.D.A. Agricultural Yearbook, 1941

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FIGURE 3.8

Because of potential microclimatic effects, actual measured data may or may not exactly fit the estimated climatic zones; however, the extrapolation from known data provides a reasonable characterization which can be used very well for planning purposes. The regression analyses are summarized in Appendix A.

Estimated climatic zones are established based on projected average growing season conditions and the potential suitable cropping pattern which could be implemented. Thus, the initial climatic zone delineations are based primarily on crop suitability considerations. The estimated climatic zones are further divided based on selected incremental temperature and precipitation conditions which have been chosen based on crop agronomic production requirements. The projected average characteristics of estimated climatic zones are summarized in Table 3.9.

TABLE 3.9

SUMMARY OF CLIMATIC ZONE CHARACTERISTICS 1/

Climatic Zone Designation	Elevation Range 2/ (ft.)	Length of Growing Season 3/ (days)	Climatic 4/ Parameter	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total Annual Precip. (in.)	Mean Annual Temperature (degrees F)
A	<5,000	>160	Precipitation	0.6	0.5	0.5	0.5	0.4	0.3	0.7	0.9	0.7	1.1	0.5	0.7	7.4	
			Mean Min.Temp.	16.1	22.4	27.8	34.9	43.9	52.1	60.3	58.4	48.8	37.1	25.8	17.6		37.1
			Mean Max.Temp.	42.1	50.6	59.3	69.0	79.5	90.2	95.3	92.3	84.8	72.2	56.1	44.0		69.6
			Mean Temp.	29.1	35.6	43.6	52.0	61.7	71.2	77.8	75.4	66.8	54.7	41.0	30.8		53.4
B	5,000–5,400	150–160	Precipitation	0.7	0.6	0.6	0.6	0.5	0.3	0.8	1.1	0.8	1.2	0.6	0.8	8.6	
			Mean Min.Temp.	15.1	21.1	26.5	33.6	42.4	50.5	58.6	56.8	47.6	36.4	25.1	16.9		35.9
			Mean Max.Temp.	41.3	49.1	57.4	67.0	77.6	88.2	93.4	90.5	83.1	70.7	55.0	43.3		68.1
			Mean Temp.	28.2	35.1	42.0	50.3	60.0	69.4	76.0	73.7	65.4	53.6	40.1	30.1		52.0
C	5,400–5,800	140–150	Precipitation	0.8	0.7	0.8	0.7	0.6	0.4	1.0	1.3	0.9	1.3	0.7	1.0	10.2	
			Mean Min.Temp.	14.0	19.7	25.3	32.4	41.0	48.9	57.0	55.2	46.4	35.6	24.4	16.2		34.7
			Mean Max.Temp.	40.5	47.6	55.5	64.9	75.6	86.2	91.5	88.6	81.3	69.2	53.8	42.5		66.4
			Mean Temp.	27.3	33.7	40.4	48.7	58.3	67.6	74.3	71.9	63.9	52.4	39.1	29.4		50.6
D	5,800–6,200	130–140	Precipitation	1.0	0.9	0.9	0.8	0.7	0.5	1.1	1.5	1.1	1.5	0.8	1.1	11.9	
			Mean Min.Temp.	13.0	18.3	24.0	31.1	39.5	47.3	55.4	53.6	45.2	34.8	23.7	15.5		33.5
			Mean Max.Temp.	39.6	46.1	53.6	62.9	73.7	84.3	89.6	86.7	79.5	67.7	52.7	41.8		64.9
			Mean Temp.	26.3	32.2	38.8	47.0	56.6	65.8	72.5	70.2	62.4	51.3	38.2	28.7		49.2
E	6,200–6,600	120–130	Precipitation	1.2	1.0	1.1	0.9	0.9	0.6	1.3	1.7	1.2	1.6	0.9	1.3	13.7	
			Mean Min.Temp.	11.9	16.9	22.7	29.8	38.0	45.7	53.7	52.0	44.0	34.0	23.1	14.8		32.2
			Mean Max.Temp.	38.8	44.6	51.7	60.8	71.8	82.3	87.7	84.9	77.8	66.2	51.5	41.1		63.3
			Mean Temp.	25.4	30.8	37.2	45.3	54.9	64.0	70.7	68.5	60.9	50.1	37.3	28.0		47.8
F	6,600–7,000	110–120	Precipitation	1.4	1.2	1.3	1.1	1.0	0.7	1.5	1.9	1.3	1.7	1.0	1.5	15.6	
			Mean Min.Temp.	10.9	15.5	21.5	28.6	36.6	44.2	52.1	50.4	42.8	33.3	22.4	14.2		31.0
			Mean Max.Temp.	38.0	43.1	49.7	58.8	69.8	80.4	85.8	83.0	76.0	64.7	50.3	40.4		61.7
			Mean Temp.	24.5	29.3	35.6	43.7	53.2	62.3	69.0	66.7	59.4	49.0	36.4	27.3		46.4
G	7,000–7,400	100–110	Precipitation	1.6	1.3	1.4	1.2	1.1	0.8	1.7	2.2	1.5	1.9	1.2	1.7	17.6	
			Mean Min.Temp.	9.9	14.1	20.2	27.3	35.1	42.6	50.5	48.8	41.6	32.5	21.7	13.5		29.8
			Mean Max.Temp.	37.2	41.6	47.8	56.7	67.9	78.4	83.8	81.1	74.2	63.2	49.2	39.7		60.1
			Mean Temp.	23.6	27.9	34.0	42.0	51.5	60.5	67.2	65.0	57.9	47.9	35.5	26.6		45.0
H	7,400–7,800	90–100	Precipitation	1.8	1.5	1.7	1.4	1.3	0.9	1.9	2.5	1.6	2.0	1.3	1.9	19.8	
			Mean Min.Temp.	8.8	12.7	19.0	26.1	33.7	41.0	48.9	47.2	40.3	31.7	21.0	12.8		28.6
			Mean Max.Temp.	36.3	40.1	45.9	54.7	66.0	76.4	81.9	79.3	72.4	61.8	48.0	39.0		58.5
			Mean Temp.	22.6	26.4	32.5	40.4	49.9	58.7	65.4	63.3	56.4	46.8	34.5	25.9		43.6

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Table 3.9, Continued

Climatic Zone Designation	Elevation Range2/ (ft.)	Length of Growing Season3/ (days)	Climatic 4/ Parameter	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total Annual Precip. (in.)	Mean Annual Temperature (degrees F)
				Month													
I	7,800–8,200	80–90	Precipitation	2.1	1.7	1.9	1.6	1.4	1.0	2.2	2.8	1.8	2.2	1.4	2.1	22.2	
			Mean Min.Temp.	7.8	11.3	17.7	24.8	32.2	39.4	47.2	45.7	39.1	31.0	20.3	12.1		27.4
			Mean Max.Temp.	35.5	38.6	44.0	52.6	64.0	74.5	80.0	77.4	70.7	60.3	46.9	38.3		56.9
			Mean Temp.	21.7	25.0	30.9	38.7	48.1	57.0	63.6	61.6	54.9	45.7	33.6	25.2		42.2
J	>8,200	<80	Precipitation	2.4	1.9	2.1	1.8	1.6	1.1	2.4	3.1	2.0	2.3	1.6	2.4	24.7	
			Mean Min.Temp.	6.7	9.9	16.5	23.5	30.8	37.8	45.6	44.1	37.9	30.2	19.7	11.4		26.2
			Mean Max.Temp.	34.7	37.1	42.1	50.6	62.1	72.5	78.1	75.5	68.9	58.8	45.7	37.5		55.3
			Mean Temp.	20.7	23.5	29.3	37.1	46.5	55.2	61.9	59.8	53.4	44.5	32.7	24.5		40.8

1/ Estimated climatic zones are based on extrapolated data obtained from regression analyses.

2/ Elevation in feet above mean sea level.

3/ Average number of days between last spring and first fall frost.

4/ Precipitation expressed as inches and temperature in degrees Farenheit.

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SECTION 4

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SECTION 4

IRRIGATION WATER QUALITY

4.1 GENERAL

The potential irrigation water sources that can be developed to irrigate subject reservations consist of flows that may be obtained from streams and rivers that provide the means of natural drainage from drainage basins located on and/or above reservation lands. These potential irrigation water sources include the following major rivers and their tributaries: 1) San Juan River, 2) Piedra River, 3) Los Pinos River, 4) Animas River, 5) La Plata River, and 6) Mancos River. The water quality of these potential irrigation water sources was evaluated based on average water quality characteristics as set forth in existing United States Geological Survey reports.

4.2 WATER QUALITY CHARACTERISTICS

The suitability of a particular water source for crop irrigation is based on the concentration and types of constituents present. Water suitability is also impacted by the cropping pattern, soil and climatic conditions under which it is applied. Therefore, water quality must be evaluated in regard to crop, soil, climate, and method of application.

The summary of water quality from surface water sources in the

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project area is shown in Table 4.1. These data generally represent the long term mean for sample sites shown with the exception of Site #0936800 (San Juan River at Shiprock, NM) which includes data for the 1981 water year only. The range of observed concentrations, which occurs primarily as a result of flow variation, is also presented. Under normal flow conditions the long term concentration of constituents will probably occur close to the means and ranges shown on Table 4.1.

Guidelines for evaluating the general impacts of water quality on crops and soils are shown in Table 4.2. Water quality considerations generally fall into four categories as shown on Table 4.2: 1) Salinity, 2) Soil Permeability, 3) Ion Toxicity, and 4) Miscellaneous Impacts.

4.2.1 Salinity

Salinity problems are exhibited if water salinity levels are adequately high to cause an accumulation of soluble salts in the plant root zone which over time exceed crop salt tolerance levels and cause yield reductions. Irrigation water salinity is expressed as Electrical Conductivity (EC_w) which is a measure of the total soluble salt content. Electrical conductivity is measured in millimos per centimeter ($EC_w \times 10^3$) or micromhos per centimeter ($EC_w \times 10^6$) at 25 degrees C. The relationship of irrigation water salinity (EC_w) to plant yield response is shown in Table 4.3. The salinity of

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TABLE 4.1
SUMMARY OF WATER QUALITY FOR SELECTED SITES1/

Water Quality Constituent	Sample Site Location and Station Number											
	San Juan River near Carracas, CO #09346400			Los Pinos River at LaBoca, CO #09354500			Animas River near Cedar Hill, NM #09363500			La Plata River at CO-NM State Line #09366500		
	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High
Elect.Conduct. (ECw x 10)	125	270	460	140	230	331	165	443	710	354	1005	1700
Reaction(pH)	7.1	-	8.9	7.6	-	8.9	7.4	-	8.9	7.1	-	8.8
Bicarbonate (HCO) ppm	53.0	94.5	153.0	76.0	120.2	172.0	79.0	140.8	203.0	140.0	213.8	294.0
Calcium, ppm	14.0	28.3	44.0	20.0	29.0	42.0	34.0	60.9	88.0	54.0	110.3	200.0
Magnesium, ppm	2.7	7.1	13.0	2.9	4.8	7.0	4.8	9.8	22.0	25.0	59.3	99.0
Sodium, ppm	6.0	17.2	30.0	5.3	13.3	24.0	5.0	17.3	35.0	15.0	42.4	75.0
Sodium Absorp. Ratio(SAR)	-	0.7	-	-	0.6	-	-	0.5	-	-	0.8	-
Adj.Sodium Absorp.Ratio (SARadj.)	-	1.1	-	-	0.9	-	-	1.0	-	-	1.9	-
Chloride, ppm	0.2	2.3	5.2	0.4	3.2	6.8	3.1	13.4	29.0	5.8	19.7	43.0
Sulfate, ppm	17.0	55.5	114.0	11.0	19.0	34.0	44.0	94.8	195.0	145.0	392.0	730.0
Nitrate & Nitrite as N, ppm	0.00	0.08	0.28	0.00	0.02	0.10	0.00	0.14	0.48	0.07	0.22	0.56
Boron, ppm	0.01	0.04	0.10	0.00	0.02	0.08	0.02	0.06	0.12	0.04	0.06	0.07

1/ Water quality for sample locations shown except #0936800, Reference: "Summary of Water Quality Data for Selected streams in Colorado", Water Resources Investigations Open File Report 60-682, U.S. Department of Interior, USGS.

Table 4.1, Continued

Water Quality Constituent	Sample Site Location and Station Number: Mancos River near Cortez, CO #09370800			Middle Fork Piedra R. near Pagosa Springs, CO #09347200			Vallecito Creek near Hayfield, CO #09352900			San Juan River at Shiprock, NM 2/ #09368000		
	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High
Elect.Conduct. (ECw x 10)	410	2278	3500	36	63	109	33	73	120	335	519	650
Reaction(pH)	6.2	-	8.7	6.6	-	8.8	6.5	-	9.0	7.3	-	8.3
Bicarbonate (HCO) ppm	92.0	220.4	367.0	17.0	29.3	40.0	14.0	32.3	52.0	98.0	125.6	150.0
Calcium, ppm	44.0	234.5	380.0	4.0	6.6	9.2	3.6	10.2	24.0	39.0	55.2	68.0
Magnesium, ppm	17.0	142.9	270.0	0.3	1.1	2.0	0.5	2.1	4.0	6.3	9.9	13.0
Sodium, ppm	17.0	161.9	310.0	1.5	3.8	5.5	0.0	1.3	6.7	17.0	34.5	53.0
Sodium Absorp. Ratio(SAR)	-	2.0	-	-	0.4	-	-	0.1	-	0.7	1.1	1.7
Adj.Sodium Absorp.Ratio (SARadj.)	-	5.4	-	-	0.1	-	-	<0.1	-	-	1.9	-
Chloride, ppm	3.2	19.1	33.0	0.0	1.0	6.5	0.0	1.0	10.0	5.4	13.9	35.0
Sulfate, ppm	140.0	1304.1	2200.0	3.2	5.8	9.2	3.1	8.7	18.0	71.0	136.7	200.0
Nitrate & Nitrite as N, ppm	0.10	0.61	4.00	0.00	0.03	0.13	0.01	0.12	0.35	0.12	0.32	0.60
Boron, ppm	-	-	-	0.00	0.02	0.08	0.00	0.01	0.06	0.03	0.06	0.07

2/ ."Water Resources Data New Mexico Water Year 1983", USGS Water Data Report NM-82-1, 1983.

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TABLE 4.2

GUIDELINES FOR INTERPRETATION OF WATER QUALITY FOR IRRIGATION

Problem and Related Constituent	No Problem	Increasing Problems	Severe Problems
SALINITY 1/			
EC_w of irrigation water in micromhos per centimeter	750	750 - 3,000	3,000
PERMEABILITY			
EC_W of irrigation water in millimhos per centimeter	0.5	0.5	0.2
Adjusted SAR 2/	6.0	6.0 - 9.0	9.0
SPECIFIC ION TOXICITY 3/ from ROOT ABSORPTION			
Sodium (evaluate by adj.SAR)	3	3.0 - 9.0	9.0 4/
Chloride			
Milliequivalents per liter	4	4.0 -10.0	10
Milligrams per liter or parts per million	142	142 - 355	355
Boron, parts per million	0.5	0.5 - 2.0	2.0 - 10.0
FOLIAR ABSORPTION 5/ sprinklers			
Sodium			
Milliequivalents per liter	3.0	3.0	---
Milligrams per liter or parts per million	69	69	---
Chloride			
Milliequivalents per liter	3.0	3.0	---
Milligrams per liter or parts per million	106	106	---
MISCELLANEOUS 6/			
NH_4 -N and NO_3 -N, in milligrams per liter or parts per million for sensitive crops	5	5 - 30	30
HCO_3 sprinklers			
Milliequivalents per liter	1.5	1.5 - 8.5	8.5
Milligrams per liter or parts per million	90	90 - 520	520
pH	Normal Range = 6.5 - 8.4		---

Table 4.2 continued

1/ Assumes water for crop plus needed water for leaching requirement will be applied. Crops vary in tolerance to salinity. (mmho/cm x 640 = approximate total dissolved solids [tds], in milligrams per liter or parts per million; mmho x 1000 = micromhos).

2/ Adj.SAR (Adjusted Sodium Adsorption Ratio) is calculated from a modified equation developed by U.S. Salinity Laboratory to include added effects of precipitation or dissolution of calcium in soils and related to $CO_3 + HCO_3$ concentrations. Permeability problems, related to low ECw or high adj.SAR of water, can be reduced if necessary by adding gypsum. Usual application rate per acre-foot of applied water is from 200 lb. to about 1,000 lb. Two hundred thirty-four pounds of 100% gypsum added to one acre-foot of water will supply one me/l of calcium and raise the ECw about 0.1 mmho. In many cases a soil application may be needed.

3/ Most tree crops and woody ornamentals are sensitive to sodium and chloride. Most annual crops are not sensitive.

4/ For shrinking-swelling type soils (montmorillonite type clay minerals); for others, higher values apply.

5/ Leaf areas wet by sprinklers may show a leaf burn due to sodium or chloride absorption under low-humidity high-evaporation conditions. (Evaporation increases ion concentration in water films on leaves between rotations of sprinkler heads.)

6/ Excess N may affect production or quality of certain crops, i.e., sugar beets, citrus, avocados, apricots, and grapes. (mg/l NO_3 -N = 2.72 lbs. N/acre-ft of applied water.) HCO_3 with overhead sprinkler irrigation may cause a white carbonate deposit to form on fruit and leaves.

Reference: Ayers, Robert S. Quality of Water for Irrigation, Journal of the Irrigation and Drainage Division, ASCE, June, 1977.

Note: Interpretations are based on possible effects of constituents on crops or soils or both. Guidelines are flexible and should be modified when warranted by local experience or special conditions of crop, soil, and method of irrigation.

TABLE 4.3

POTENTIAL YIELD REDUCTION OF SEVERAL CROPS AS RELATED TO THE SALINITY (EXPRESSED AS ECw) OF THE IRRIGATION WATER1/2/

Crop	Percent Reduction in Yield			
	0% ECw	10% ECw	25% ECw	50% ECw
Alfalfa	1300	2200	3600	5900
Barley	5300	6700	8700	12000
Corn (grain)	1100	1700	2500	3900
Corn (silage)	1200	2100	3500	5700
Dry bean	700	1000	1500	2400
Grain sorghum	2700	3400	4800	7200
Wheat	4000	4900	6400	8700
Onion	800	1200	1800	2900
Potato	1100	1700	2500	3900
Apple	1000	1600	2200	3200
Grape	1000	1700	2700	4500
Peach	1100	1400	1900	2700

1/ Adapted from, "Quality of Water for Irrigation", Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Robert S. Ayers, June, 1977.

2/ Salinity as electrical conductivity ($ECw \times 10^6$) expressed in micromhos/cm at 25 degrees C.

irrigation water sources is not a limiting factor in the selection or production of salt sensitive crops with the exception of La Plata and Mancos River waters (sample locations #09366500 and #09370800) which are more saline than desirable. Lands irrigated with water from these two sources will require consideration for crop selection and management alternatives necessary to mitigate potential adverse crop yield impacts. If salinity is a problem in crop production, irrigation practices require that an additional amount of water called the leaching requirement also be applied (see 4.4 Leaching Requirement). Therefore, salinity influenced soils require more water compared to soils where salinity is not a problem.

4.2.2 Soil Permeability

Soil permeability refers to the capability and rate at which the soil will transmit water. The soluble salt content and the concentration of several specific salts have a direct effect on soil permeability. Very slow soil permeability makes it difficult to provide adequate water in the root zone to satisfy crop consumptive use. Other problems which may occur as a result include poor soil aeration, crusting, surface soil saturation, runoff, soluble salt accumulation, and other related management problems. Soil permeability may be reduced as a result of: 1) low irrigation water salinity, 2) high sodium content in relation to calcium and magnesium concentrations, and 3) high bicarbonate and carbonate concentrations. The impact of these factors is modified based on soil characteristics with fine textured soils affected more than coarse textured soils.

Low salinity irrigation water applied to soils dissolves and leaches soluble salts from the soil surface. The loss of these salts (primarily calcium) results in the deflocculation of surface soils, particularly when sodium is present in the soil. Permeability is reduced because of resultant poor soil structure. Permeability may be reduced by the application of irrigation water from the middle fork of the Piedra River (#09347200) and Vallecito Creek (#09352900). Irrigation water salinity is marginal in the San Juan River (#09346400) and the Los Pinos River (#09354500). Irrigation water application from these two sources may or may not affect soil permeability. The impact will be influenced by soil texture, soil chemistry, irrigation water salinity, and method of irrigation.

A reduction in soil permeability is a major problem that occurs with irrigation water high in sodium. The sodium hazard to crops and soils is evaluated by the sodium adsorption ratio (SAR). The SAR is a calculation that considers the relationship of sodium to calcium and magnesium in the irrigation water. Applying water with an SAR below 6 does not usually result in permeability problems. The SAR of potential irrigation sources should not have a negative impact on soil permeability.

Bicarbonates and carbonates in irrigation water applied to the soil will precipitate calcium from the cation exchange complex as relatively insoluble calcium carbonate. As exchangeable calcium is lost from the soil, the relative proportion of sodium is increased with a corresponding increase in the sodium hazard (SAR). Bicarbonates and carbonates in the irrigation water contribute to the overall salinity, but more importantly, they may result in a previously calcium dominant soil becoming sodium dominant by precipitating the exchangeable calcium. The increased concentration of sodium on the cation exchange complex will reduce soil permeability. A measure of the bicarbonate and carbonate hazard in irrigation water is expressed as the adjusted SAR. The adjusted SAR takes into account the concentration of bicarbonates and carbonates in irrigation water in relation to their effect on soil SAR. When the adjusted SAR is less than 6, soil permeability problems generally do not occur. If the adjusted SAR is between 6 and 9, permeability problems can occur on fine textured soils. An adjusted SAR above 9 will likely result in permeability problems on mineral soils except coarse sandy soils. Generally, permeability problems should not occur at the project site with the possible exception of soils irrigated with water from the Mancos River which has a marginal adjusted SAR.

4.2.3 Ion Toxicity

Some chemical constituents present in irrigation water may have a toxic effect to crop foliage or roots. This toxic effect is usually exhibited as a reduction in crop yield that results from the accumulation of undesirable quantities of these substances in plant tissue. Toxic ions usually responsible include sodium, chloride, and boron.

The crop toxicity hazard from irrigation water sodium is determined by evaluating the adjusted SAR and the sodium concentration (milliequivalents/liter or parts per million). The adjusted SAR is used to evaluate potential root toxicity while the direct concentration is used to evaluate potential foliage toxicity which may occur as a result of foliar absorption from sprinkler irrigation. Sodium levels in all but one of the potential irrigation water sources as evaluated by adjusted SAR and sodium concentration are generally low and should not result in toxicity to sodium sensitive crops. Mancos River water (#09370800) has sodium concentrations which may cause crop root and foliage toxicity with subsequent yield reduction.

Chlorides are necessary for plant growth in relatively small amounts. High concentrations of chloride can cause toxicity by root absorption or by foliar absorption if irrigation water is applied by sprinkler irrigation. Chlorides in irrigation water are specifically toxic to some plant species. The chloride concentration in irrigation water sources is well below potential toxic levels.

Boron occurring in relatively low concentrations in irrigation water can have a toxic effect on sensitive crops. The tolerance of selected crops to boron is shown in Table 4.4. The boron concentration of irrigation water sources is generally less than 0.1 parts per million (ppm). This boron concentration is probably adequately high to supply plant nutrient requirements but is also sufficiently low to irrigate crops at the site without resultant toxicity problems.

4.4.4 Miscellaneous Impacts

High nitrate-nitrogen and bicarbonate concentrations can cause problems which may reduce crop yield and quality. Excessive nitrate-nitrogen levels can cause excessive vegetative growth and delayed crop maturity. High bicarbonate water applied by sprinkler irrigation can leave white deposits on leaves and fruit. This effect usually occurs in arid climatic regions while irrigating during periods of high evaporative demand. The concentration of these constituents in irrigation water sources should not result in negative impacts to crop growth or yield.

4.3 IRRIGATION WATER SUITABILITY

The suitability of potential irrigation water sources is shown on Figure 4.1. The irrigation water quality with regard to salinity measured as electrical conductivity (C) and sodium hazard measured

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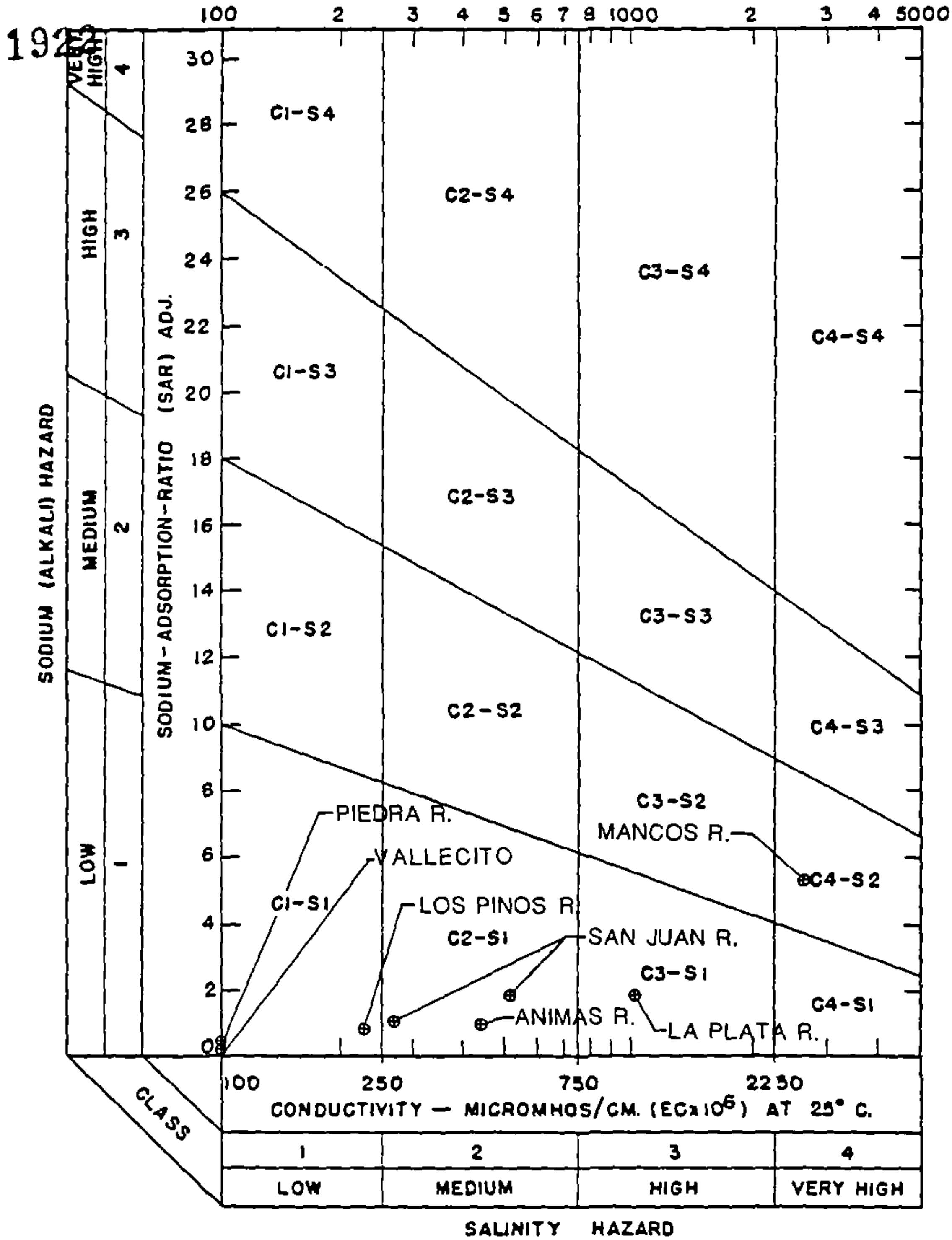
TABLE 4.4

RELATIVE TOLERANCE OF SEVERAL CROPS TO BORON IN IRRIGATION WATER1/2/

Sensitive 0.5 - 1.0 ppm	Semi-Tolerant 1.0 - 2.0 ppm	Tolerant 2.0 - 4.0 ppm
Orange	Bean	Lettuce
Apricot	Sweet Potato	Onion
Peach	Bell Pepper	Melon
Cherry	Tomato	Alfalfa
Grape	Oats	Sugar Beet
Apple	Sorghum	Asparagus
Pear	Corn	
Plum	Wheat	
Navy Bean	Barley	
Walnut	Cotton	
Pecan	Potato	
Almond		
Pistachio		

1/ This table was adapted from USDA Technical Bulletin No. 448.

2/ In each group the plants named first are considered as being more sensitive and those named last more tolerant.



NOTE:

This diagram was adapted from Agricultural Handbook 60, U. S. Dept. of Agriculture.

IRRIGATION WATER SUITABILITY CLASSIFICATION

Boyle Engineering Corporation — FIGURE 4.1

as the adjusted SAR (S) is determined by plotting corresponding values on this figure. Potential soil management and crop production problems that can arise as a result of irrigating with water of a certain quality can thus be determined. The quality of potential irrigation water sources falls into 4 of the general classifications shown in Figure 4.1. Water from the Los Pinos River (#09354500), the Piedra River (#09347200), and Vallecito Creek (#09352900) fall into the C1S1 classification. This water can be applied for irrigation of crops that may be planted at the project site probably without development of future salinity or water penetration problems.

Water from the San Juan River (#09346400 and #09368000) and the Animas River (#09363500) fall into the C2S1 classification. This water can be used to irrigate crops that may be grown at the project site. However, adequate leaching must be provided, especially for salt sensitive crops, to prevent an accumulation of soluble salts in the soil profile.

Water from the La Plata River (#09366500) falls into the C3S1 classification. The salinity of this irrigation water source exceeds the salt tolerance levels of some salt sensitive crops. La Plata River water should be applied to soils with favorable subsoil drainage characteristics to insure adequate leaching of soluble salts.

Water from the Mancos River (#09370800) falls into the C4S2 classification. This irrigation water should be applied only to salt tolerant crops. Coarse textured soils with favorable subsoil drainage characteristics are best suited for irrigation with this water source. Adequate leaching may be difficult to obtain on finer textured soils because of the sodium hazard. Periodic soil amendment applications may be necessary to prevent soil permeability problems which may occur as a result of the sodium hazard of this water source.

4.4 LEACHING REQUIREMENT

Project soils are variable in relation to their soluble salt content. The salinity of potential irrigation water sources is generally acceptable for irrigation with the exception of La Plata and Mancos River waters which are more saline than desirable. Regardless of irrigation water salinity, soluble salts may accumulate in the soil as a result of plant water uptake. This occurs because plants remove stored water allowing soluble salts to accumulate in the root zone. As the salt concentration within the root zone increases, a resulting decrease in plant yield will occur if plant salt tolerance levels are exceeded.

Leaching is a percolation process whereby excess irrigation water passes through the root zone and thus moves soluble salts downward to prevent their accumulation in harmful concentrations. This process maintains a favorable salt balance in the root zone. It requires leaching an equal or greater amount of salt from the soil in the drainage water than that introduced by irrigation water. The leaching requirement is defined as the fraction of irrigation water that must be leached through the root zone to maintain soil salinity at a specified level. The leachate moves out of the root zone as drainage water.

The leaching fraction required to maintain a suitable salt balance can be calculated analytically if the electrical conductivity of both irrigation and drainage water is known. The University of California has published guidelines based on irrigation water electrical conductivity vs. potential yield reduction and leaching fraction which are required to maintain a favorable salt balance in the soil. Table 4.5 shows the estimated leaching requirement for crops that may be planted at the project site for several different irrigation water salinity levels. The leaching requirement is expressed as the percentage of water applied in excess of the net irrigation water requirement that is needed to maintain a favorable salt balance without exceeding crop salt tolerance levels. Crop salt tolerance levels are exceeded when the equilibrium soil salinity can not be maintained below crop tolerance levels.

TABLE 4.5

LEACHING REQUIREMENT (%) OF SELECTED CROPS
IN RELATION TO IRRIGATION WATER SALINITY 1/

	Additional Water Required for Leaching (%) at Selected Irrigation Water Salinity ($EC_w \times 10^6$) 2/ Concentrations							
Crop	100	350	500	750	1,000	1,250	1,750	2,250
Alfalfa	0.3 3/	1.1	1.6	2.4	3.2	4.0	E 4/	E
Barley	0.2	0.6	0.9	1.3	1.8	2.2	3.1	4.0
Corn (grain)	0.5	1.8	2.5	3.8	5.0	E	E	E
Corn (silage)	0.3	1.1	1.6	2.4	3.2	E	E	E
Apple	0.6	2.2	3.1	4.7	6.3	E	E	E
Dry Bean	0.8	2.7	3.8	E	E	E	E	E
Grain Sorghum	0.3	1.0	1.4	2.1	2.8	3.5	4.9	6.3
Wheat	0.3	0.9	1.3	1.9	2.5	3.1	4.4	5.6
Onion	0.7	2.3	3.3	5.0	E	E	E	E
Potato	0.5	1.8	2.5	3.8	5.0	E	E	E

1/ Reference: Robert S. Ayers, "Quality of Water for Irrigation:, Journal of the Irrigation and Drainage Division, ASCE, June, 1977.

2/ Electrical conductivity of irrigation water (EC_w) expressed as micromhos per centimeter at 25 degrees C.

3/ Leaching requirement is the amount of water that must be applied to keep salt concentrations below crop salt tolerances. Leaching requirement is expressed as a percentage of the net irrigation water requirement and assumes 0% allowable yield reduction from irrigation water salinity.

4/ E designates that crop salt tolerance levels have been exceeded which may result in potential crop yield reduction.

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SECTION 5

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SECTION 5

SOIL RESOURCES

5.1 GENERAL

Native soil characteristics are products of the environment in which they occur. Differences in the degree and intensity of abiotic and biotic (environmental) factor interactions will result in significantly different soil characteristics. At any given point in time, soil characteristics and/or properties are dependent on:

- o Physical and mineralogical composition of the parent material.
- o Climatic conditions.
- o Plant and animal life in and on the soil.
- o Length of time these developmental forces have acted on the soil.
- o Relief or topography under which the soil is developing.

Ute Indian Reservation lands generally occur in the San Juan Basin within the Colorado Plateau Province with the exception of easterly portions of the Southern Ute Reservation which occur in the San Juan Mountains. The project area expresses a wide diversity in physiography including flat to moderately sloping mesas, highly dissected hilly badland areas, large glacial outwash and alluvial fans, and significant areas of valley lands which include flood plains of the major rivers, low terraces, and toe slopes.

The geology and current landforms of the project area are the result of numerous episodes of sediment deposition, uplifting, faulting, erosional events, and local glaciation from the nearby San Juan Mountains. During Upper Cretaceous and Tertiary periods much of the near surface sedimentary beds was deposited and formed in various fresh and salt water environments. In many instances, Mesa lands formed from these sedimentary rocks are covered with Quaternary alluvial deposits that result from glacial meltwater action, river deposits, and aeolian sediments transported and deposited from areas throughout the southwestern United States. Together, these sedimentary rocks and various alluvial and aeolian deposits have provided a parent source of material for soil development. Combined with physical and chemical weathering of the mineral constituents, this has given rise to the soils of the project area.

The extreme easterly portion of the Southern Ute Reservation encompasses areas within the San Juan Mountains. These mountains consist of maturely dissected nearly horizontal layers of lava and tuff. Soils in this area consist of Quaternary alluvial sediments deposited in river valleys and soils forming residually in the igneous parent material.

5.2 LAND CLASSIFICATION

The objective of land classification is to define soil physical and chemical characteristics affecting crop growth and productivity. The suitability of land to support agricultural production is typically evaluated through land classification procedures that consider soil texture, slope/topography, erosion, drainage, salinity/alkalinity, and other parameters. Visual inspection of site conditions combined with soil sampling and laboratory analyses of soil characteristics at selected locations generates factual information as to which land can be categorized in a specific "class" based on parameters pre-established under a particular land classification system. The land classification study conducted on Ute Indian Reservation lands was performed by the firm of Stoneman - Landers, Inc. using slightly modified BIA standards. The BIA land classification standards and criteria are shown in Tables 5.1 and 5.2, respectively.

Project area soil characteristics may influence land development and crop production costs. Soil conditions that are adverse to crop growth requirements will reduce crop yields below those that can be achieved under non-restrictive conditions. The land classification study performed by Stoneman - Landers, Inc. applied BIA standards to classify reservation lands. These standards are adapted from and very similar to those developed by the USBR. The BIA classification uses a six class system with Classes 1 through 4 designating arable lands and Class 6 representing non-arable lands. Class 5 is used to designate lands that require further study to determine arability and was not used in the land classification study on the Ute Reservations. The land classes applied in the Stoneman - Landers study are generally defined as follows:

TABLE 5.1
SPECIFICATIONS FOR IRRIGATION LAND CLASSES[1]
SPRINKLER IRRIGATION

Land Characteristics	Class 1 Arable	Class 2 Arable	Class 3 Arable	Class 4 Arable	Class 6 Non-Arable
Soils[2]					
Texture(surface 10")	lvfs-cl	ls-c	ms to c	ms to c	All other lands not meeting criteria for arability
Moisture Retention AWHC-48"(120cm)	6"(15cm)	4.5"(11cm)	2.5"(6cm)	2.0"(5cm)	
Effective Depth	40"(1m)[3]	30"(75cm)	20"(50cm)	10"(25cm)	
Salinity ($ECx10^3$) (at irrig. equilibrium)	0 - 4	<8	<12	<16[4]	
Sodic Conditions					
Surface area affected(%)	5	5-15	15-25	25-35	
Severity in Control Section[5]	Slight	Slight	Moderate[6]	Moderate[7]	
Severity in Substratum (1m to 1.5m)	Slight	Moderate	Moderate	Moderate	
Permeability, Control Sect. (10-40") slowest	Mod.sl.to mod.rap. 02.-6.0 in/hr	Slow to mod.rap. 0.06-6.0 in/hr.	Slow to rapid 0.06-20 in/hr	Any	
Coarse fragments, surface 10"					
Gravel (% by volume)	<15	15-35[9]	35-55[10]	55-70[11]	
Cobbles (% by volume)	5	5-10	10-15	15-35	
Rock Outcrops(distance apart)	200'(60cm)	100'(30m)	50'(15m)	30'(10m)	
Frequency of Overflow/yrs.	None	Rare(1 in 10)	Occasional(2/10)	Frequent(3 to 5 in 10)	
Depth to $CaCO_3$ (>25%)	>20"	>20"	<20"	<20"	
Soil Erosion(for all classes)	Severely eroded soils will be downgraded one class. Less severely eroded soils may be downgraded one class depending on other conditions. Very severely eroded soils are Class 6.				
Topography (or Land Development Items)					
Stone for Removal (cu.yd/ac)	10	25	50	70	
Slope(%), Sprinkler	0-5	5-8	8-15	15-25	
Surface Grading[12] or Tree Removal (amount of cover)[13]	Light	Medium	Medium Heavy	Medium Heavy	

Table 5.1, Continued

Land Characteristics	Class 1 Arable	Class 2 Arable	Class 3 Arable	Class 4 Arable	Class 6 Non-Arable
Drainage					
Depth to Water Table (During Growing Season with or without Drainage)					
Med or Finer Subsoil Text.	60"(150cm)	40-60"(100-150cm)	20-40"(50-100cm)	10-20"(25-50cm)	
Mod Coarse or Coarser	50"(125cm)	30-50"(75-125cm)	20-30"(50-75cm)	10-20"(25-50cm)	
Surface Drainage	Min.improve.req'd.	Mod.improve.req'd at low cost	Consid.improve. req'd at mod.cost	Restricted	
Depth to Drainage Barrier 14/	8'(245cm)	8'(245cm)	8'(245cm)	8' (245 cm)	
Air Drainage	No problem	Minor problem	Restricted	Restricted	

1/ Each individual factor represents a minimum requirement. Unless all other factors are near optimum, two or more interacting deficiencies may result in land being placed in lower class or designated Class 6-Nonarable.

2/ Specifications are representative of conditions after land is developed for irrigation.

3/ Depth of 60" (1.5m) required where deep rooted crops are important in crop pattern.

4/ Class 6 on slopes steeper than 15% if EC x 10^3 is above 12.

5/ Severity of conditions: Slight - SAR less than 13.
Moderate - SAR 13 to 37.5, and permeability after leaching slow (0.06-0.2 in/hr)(0.15-0.5 cm/hr) or better.

6/ Class 4 maximum on slopes of 8-15%.

7/ Class 6 on slopes steeper than 15%.

8/ Class 6 on slopes steeper than 15% if permeability is very slow (0.06 in/hr, 0.15 cm/hr).

9/ Less than 15% gravel and cobbles if texture is moderately coarse or coarse.

10/ (a) Less than 15% gravel and cobbles if texture is coarse.
(b) Less than 35% gravel and cobbles if texture is moderately coarse.

11/ (a) Less than 35% gravel and cobbles if texture is coarse.
(b) Less than 55% gravel and cobbles if texture is moderately coarse.

12/ (a) Land is further downgraded if surface grading reduces effective depth or otherwise permanently reduces soil fertility.
(b) Degrees of leveling: light - less than 0.5 foot cut and fill on slopes, less than 1.0 foot cut and fill on hummocky areas; medium - 0.5 to 1 foot cut and fill on slopes, 1 to 2 foot cut and fill on hummocky areas; medium heavy - 1 to 1.5 foot cut and fill on slopes, 2 to 3 foot cut and fill on hummocky areas.

Table 5.1, Continued

13/ (a) Amount of cover: light - canopy density 10%; medium - canopy density 10-50%; medium heavy - canopy density 40-70%.
(b) Tree cover may be partially or totally discounted if falue of the trees would offset part or all of the clearing cost, if terrain and cover lend themselves to inexpensive clearing, or if removal would be justified for other purposes.

14/ "Drainage barrier" includes (1) any layer below 5' (1.5m) with hydraulic conductivity less than 1/5 the weighted average H.C. of materials between the layer and a depth of 4' (1.25m) below the surface.

15/ Air drainage is a consideration when (a) the area is otherwise adapted to fruit or to early or late vegetables, or (b) it restricts the growing of other crops otherwise adapted to the area.

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TABLE 5.2
SUMMARY OF CRITERIA FOR IRRIGATION LAND CLASSES

Texture (Surface 10")	AWC	Soil Depth	Salinity (ECx105)	Sodium Affected Surface
LVFS-CL = 1P	>6" = 1C	>40" = 1D	0-4 = 1E	<5% = 1F
C = 2P	4.5-6.0 = 2C	30-40" = 2D	4-8 = 2E	5-15% = 2F
LS = 2R	2.5-4.5 = 3C	20-30" = 3D	8-12= 3E	15-25% = 3F
MS = 3R	2.0-2.5 = 4C	10-20" = 4D	12-16= 4E	25-35% = 4F
	<2.0 = 6C	<10" = 6D	>16= 6E	>35% = 6F

SAR (10-40")	SAR (40-60")	% CaCO3 (0-20")	Permeab. (10-40")	% Gravel (0-10")
<13 = 1X	<13 = 1Y	0-25 = 1T	MS-MR = 1A	<15 = 1U
13-37.5 = 2X	13-37.5 = 2Y	>25 = 3T	SL = 2A	15-35 = 2U
>37.5 = 6X			R = 3A	35-55 = 3U
			VS-VR = 4A	55-70 = 4U

% Cobble (0-10")	Erosion Hazard	Overflow Hazard	% Slope	Stones (Cu.Yd/Acre)
<5 = 1N	Slight = HM	None = 1L	0-5 = 1B	<10 = 1M
5-10 = 2N	Mod. = HM	Rare = 2L	5-8 = 2B	10-25 = 2M
10-15 = 3N	Severe = H-1	Occ. = 3L	8-15= 3B	25-50 = 3M
15-35 = 4N	V.Sev. = 6H	Freq. = 4L	15-25= 4B	50-70 = 4M
>35 = 6N		V.Freq= 6L	>25= 6B	>70 = 6M

% Cobble/Stone (10-20")	Trees(Canopy)	Depth to Water Table	Drainage Barrier (Ft.)
0-35 = 1R	<10% = 1G	>60" = 1K	
>35 = 3R	10-40% = 2G	40-60" = 2K	>8' = 1J
	>40% = 3G	20-40" = 3K	<8' = 6J
		10-20" = 4K	
		<10" = 6K	

Class 1 - Particularly suited to irrigated farming with few or no limitations. Relatively high payment capacity.

Class 2 - Moderately suited to irrigated farming with one or more limitations. Lower productive capacity than Class 1 lands and intermediate payment capacity.

Class 3 - Distinctly restricted suitability, approaching marginal suitability for irrigated farming. More extreme deficiencies than Class 2 lands, but with proper management these lands have an adequate payment capacity.

Class 4 - Limited arable or special use lands that have an excessive specific deficiency or deficiencies that can be corrected at high cost, but are suitable for irrigation because of present or contemplated intensive cropping such as vegetables and fruits. They may have one or more excessive noncorrectable deficiencies that limit their use to meadow, pasture, orchard, or other relatively permanent crops. The magnitude of the correctable deficiency is sufficient to require outlays of capital in excess of those permissible for Class 3. The Class 4 lands may have a range in payment capacity greater than that of the associated arable lands.

Class 6 - Considered non-arable lands for irrigation development because of failure to meet minimum requirements for the other classes of land. Arable areas definitely not susceptible to delivery of irrigation water. Class 4 lands, when their extent does not warrant segregation, are included in Class 6.

The classification of the Ute Indian Reservation lands into the four arable and one non-arable classes involved evaluation of the following parameters:

1) Soil characteristics including - depth, texture, structure, consistence, AWC, infiltration, hydraulic conductivity, stoniness, fertility, salinity, and alkalinity.
2) Topographic characteristics including - slope, surface, irrigation pattern, brush or tree cover, and rock cover.
3) Drainage characteristics including - flooding, water table, and drainage outlet.
4) Land use.
5) Productivity and land development.
6) Farm water requirement.
7) Land drainability.

The land classes have subclass designations which identify the parameter or factors which cause lands to be rated other than Class 1. The type and severity of these factors influence the arable land classification; however, factors which result in lands being placed in a classification other than Class 1 may or may not cause reductions in crop yield. The resulting land classification indicates the type and severity of the limiting factors based on reduction in potential payment capacity relative to payment capacity received from Class 1 lands. The payment capacity is a function of crop yield and development/production costs. Therefore, land classed other than Class 1 has limitations which may reduce crop yield and increase development/production costs. The resultant decrease in the payment capacity may be caused by either factor or by the combined impact of lower yield and higher costs. The summary of arable land acreage by irrigation suitability land class for the Southern Ute and Ute Mountain Ute Indian Reservations is shown on Table 5.3.

The summary of the Irrigation Suitability Land Classification Study performed by Stoneman - Landers, Inc. is shown in Table 5.4. The data shown in Table 5.4 and the land classification mapping sheets prepared by Stoneman - Landers, Inc. are used as the basis for determining land suitability and reclamation requirements for this report.

5.3 PHYSICAL CHARACTERISTICS OF THE LAND

Physical land characteristics (Table 5.4) that may affect crop selection and productivity at the project site include soil, topographic, and drainage features. The interpretation and effect of these physical characteristics on land suitability and subsequent crop selection and productivity are discussed in the following paragraphs.

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TABLE 5.3
SUMMARY OF ARABLE LAND ACREAGE
BY IRRIGATION SUITABILITY LAND CLASS,
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

Reservation	Watershed	Irrigation Suitability Land Class				
		Class 1	Class 2	Class 3	Class 4	Class 5
Southern Ute	Animas	183	776	503	990	2,452
	Florida	-0-	1,150	123	95	1,368
	Los Pinos	414	5,902	521	4,521	11,358
	La Plata	1,331	6,790	1,945	1,599	11,665
	Mancos	-0-	86	310	16	412
	Navajo	-0-	-0-	-0-	156	156
	Piedra	244	524	307	50	1,125
	San Juan	319	1,263	312	509	2,403
Subtotal		2,491	16,491	4,021	7,936	30,939
Ute Mountain Ute	La Plata	1,891	1,517	1,018	-0-	4,426
	Mancos	15,278	11,309	3,826	1,587	32,000
	McElmo	20	452	101	212	785
	San Juan (East)	1,810	18	-0-	-0-	1,828
	San Juan (West)	4,355	2,655	3,569	712	11,291
Subtotal		23,354	15,951	8,514	2,511	50,330
TOTAL		25,845	32,442	12,535	10,447	81,269

1/ Source: Irrigation land suitability study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

TABLE 5.4
SUMMARY OF GENERAL SOIL CHARACTERISTICS BY CLASS AND SUBCLASS[1/]

Class and Sub-class	Surface Texture (top 10") [2/]	AWHC (in.) [3/]	Soil Depth (in.)	Salinity (ECx10)	Sodicity [4/] % Area Affect.	Sodicity [4/] Sever.	Permea-bility (in/hr)	% Gravel [5/]	% Cobble [6/]	Ero-sion Haz.	Over-flow Haz.	% Slope	Stones (cu.yd/ac) [7/]	% Tree Canopy	Depth to Water Tbl. (in.)	Acreage [8/] South.Ute	Acreage [8/] Ute Mt.Ute
1	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	2,491	23,354
2A	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	0-5	<5	<10	>60	9,590	7,015
2AB	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	5-8	<5	<10	>60	2,920	130
2ABG	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	5-8	<5	10-40	>60	52	-0-
2ABH	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Severe	None	5-8	<5	<10	>60	33	-0-
2ABN	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	5-10	Slight	None	5-8	<5	<10	>60	58	-0-
2AC	lvfs-cl	4.5-6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	0-5	<5	<10	>60	25	-0-
2AE	lvfs-cl	>6	>40	4-8	<5	Slight	.06-.2	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	613
2AEX	lvfs-cl	>6	>40	4-8	<5	SAR 13-37.5	.06-.2	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	105
2AG	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	0-5	<5	10-40	>60	123	87
2AK	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	0-5	<5	<10	40-60	8	-0-
2B	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	5-8	<5	<10	>60	2,347	1,227
2BC	lvfs-cl	4.5-6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	5-8	<5	<10	>60	164	-0-
2BG	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	5-8	<5	10-40	>60	-0-	859
2C	lvfs-cl	4.5-6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	447	181
2D	lvfs-cl	>6	30-40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	20	-0-
2DC	lvfs-cl	4.5-6	30-40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	36
2DG	lvfs-cl	>6	30-40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	10-40	>60	58	-0-
2E	lvfs-cl	>6	>40	4-8	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	105
2EAX	lvfs-cl	>6	>40	4-8	<5	SAR 13-37.5	.06-.2	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	2,178
2EX	lvfs-cl	>6	>40	4-8	<5	SAR 13-37.5	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	20

Table 5.4 Continued, Page 2

Class and Sub-class	Surface Texture 2/ (top 10")	AWHC (in.)	3/ Soil Depth (in.)	Salinity (ECx10)	Sodicity 4/ % Area Affect.	Sodicity 4/ Sever.	Permea-bility (in/hr)	% Gravel 5/	% Cobble 6/	Ero-sion Haz.	Over-flow Haz.	% Slope	Stones 7/ (cu.yd/ac)	% Tree Canopy	Depth to Water Tbl. (in.)	Acreage 8/ South.Ute	Acreage 8/ Ute Mt.Ute
2EXY	lvfs-cl	>6	>40	4-8	<5	SAR 13-37.5	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	Occurs in complex	
2EXY-2AE (Complex of two soils, see individual symbol listings for descriptions)																-0-	108
2G	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	10-40	>60	325	1,094
2GA	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	0-5	<5	10-40	>60	-0-	41
2GD	lvfs-cl	>6	30-40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	10-40	>60	-0-	8
2H	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	272	134
2K	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	40-60	44	-0-
2N	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	5-10	Slight	None	0-5	<5	<10	>60	5	-0-
2Y	lvfs-cl	>6	>40	<4	<5	SAR 13-37.5	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	338
3A	lvfs-cl	>6	>40	<4	<5	Slight	6-20	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	403
3AB	lvfs-cl	>6	>40	<4	<5	Slight	6-20	<15	<5	Slight	None	5-8	<5	<10	>60	20	9
3ABC	lvfs-cl	4.5-6	>40	<4	<5	Slight	6-20	<15	<5	Slight	None	5-8	<5	<10	>60	42	-0-
3ABD	lvfs-cl	>6	30-40	<4	<5	Slight	6-20	<15	<5	Slight	None	5-8	<5	<10	>60	203	-0-
3ABG	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	5-8	<5	10-40	>60	612	-0-
3AC	lvfs-cl	4.5-6	>40	<4	<5	Slight	6-20	<15	<5	Slight	None	0-5	<5	<10	>60	29	296
3AE	lvfs-cl	>6	>40	4-8	<5	Slight	.06-.2	<15	<5	Slight	None	0-5	<5	<10	>60	48	-0-
3AG	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	0-5	<5	10-40	>60	489	69
3AH	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Severe	None	0-5	<5	<10	>60	73	-0-
3AHB	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	5-8	<5	<10	>60	50	-0-
3B	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	8-15	<5	<10	>60	175	122
3BA	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	8-15	<5	<10	>60	124	-0-
3BAG	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	8-15	<5	10-40	>60	116	-0-

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Table 5.4 Continued, Page 3

Class and Sub-class	Surface Texture (top 10") 2/	AWHC (in.) 3/	Soil Depth (in.)	Salinity (ECx10)	Sodicity 4/ % Area Affect.	Sodicity Sever.	Permea-bility (in/hr)	% Gravel 5/	% Cobble 6/	Ero-sion Haz.	Over-flow Haz.	% Slope	Stones (cu.yd/ac) 7/	% Tree Canopy	Depth to Water Tbl. (in.)	Acreage 8/ South.Ute	Acreage 8/ Ute Mt.Ute
3BH	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Severe	None	5-8	<5	<10	>60	74	-0-
3BG	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	5-8	<5	10-40	>60	73	-0-
3BN	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	10-15	Slight	None	8-15	<5	<10	>60	22	-0-
3BNGA	lvfs-cl	>6	>40	<4	<5	Slight	.06-2	<15	10-15	Slight	None	8-15	<5	10-40	>60	12	-0-
3C	lvfs-cl	2.5-4.5	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	73	-0-
3CH	sl	4.5-6	>40	<4	<5	Slight	.2-6	<15	<5	Severe	None	0-5	<5	<10	>60	120	-0-
3CNT	lvfs-cl	2.5-4.5	>40	<4	<5	Slight	.2-6	<15	10-15	Slight	None	0-5	<5	<10	>60	-0-	209 9/
3CR	ls	2.5-4.5	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	23	-0-
3E	lvfs-cl	>6	>40	8-12	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	>40	>60	-0-	487
3EA	lvfs-cl	>6	>40	8-12	<5	Slight	.06-.2	<15	<5	Slight	None	0-5	<5	>40	>60	-0-	114
3EAX	lvfs-cl	>6	>40	8-12	<5	SAR 13-37.5	.06-.2	<15	<5	Slight	None	0-5	<5	>40	>60	-0-	76
3EF	lvfs-cl	>6	>40	8-12	5-15	Slight	.2-6	<15	<5	Slight	None	0-5	<5	>40	>60	-0-	98
3EX	lvfs-cl	>6	>40	8-12	<5	SAR 13-37.5	.2-6	<15	<5	Slight	None	0-5	<5	>40	>60	-0-	21
3G	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	>40	>60	228	2,225
3GA	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	0-5	<5	>40	>60	415	852
3GAB	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	5-8	<5	10-40	>60	385	391
3GAC	lvfs-cl	4.5-6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	0-5	<5	>40	>60	61	-0-
3GAD	lvfs-cl	>6	30-40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	0-5	<5	>40	>60	-0-	56
3GB	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	5-8	<5	>40	>60	17	-0-
3GD	lvfs-cl	>6	30-40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	>40	>60	118	-0-
3GK	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	0-5	<5	>40	40-60	179	-0-
3K	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	20-40	47	-0-

Class and Subclass	Surface Texture 2/ (top 10")	AWHC 3/ (in.)	Soil Depth (in.)	Salinity (ECx10)	Sodicity 4/ % Area Affect.	Sodicity 4/ Sever.	Permeability (in/hr)	% Gravel 5/	% Cobble 6/	Erosion Haz.	Overflow Haz.	% Slope	Stones 7/ (cu.yd/ac)	% Tree Canopy	Depth to Water Tbl. (in.)	Acreage 8/ South.Ute	Acreage 8/ Ute Mt.Ute
3KG	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	10-40	40-60	5	-0-
3N	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	10-15	Slight	None	0-5	<5	<10	>60	115	166
3NA	lvfs-cl	>6	>40	<4	<5	Slight	6-20	<15	10-15	Slight	None	0-5	<5	<10	>60	22	-0-
3NB	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	10-15	Slight	None	5-8	<5	<10	>60	41	-0-
3NH	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	10-15	Severe	None	5-8	<5	<10	>60	10	-0-
3T	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	1,748 9/
3TC	lvfs-cl	4.5-6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	818 9/
3TE	lvfs-cl	>6	>40	4-8	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	147 9/
3TN	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	5-10	Slight	None	0-5	<5	<10	>60	-0-	27 9/
3TNC	lvfs-cl	4.5-6	>40	<4	<5	Slight	.2-6	<15	5-10	Slight	None	0-5	<5	<10	>60	-0-	90 9/
3UNT	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	35-55	5-10	Slight	None	0-5	<5	<10	>60	-0-	90 9/
4A	lvfs-cl	>6	>40	<4	<5	Slight	<.06	<15	<5	Slight	None	0-5	<5	<10	>60	4,954	535
4AB	c,sic	>6	>40	<4	<5	Slight	<.06	<15	<5	Slight	None	5-8	<5	<10	>60	252	-0-
4ABCD	lvfs-cl	4.5-6	30-40	<4	<5	Slight	<.06	<15	<5	Slight	None	5-8	<5	<10	>60	53	-0-
4ABDG	lvfs-cl	4.5-6	30-40	<4	<5	Slight	<.06	<15	<5	Slight	None	5-8	<5	<10	>60	90	-0-
4ABEF	lvfs-cl	>6	>40	4-8	5-15	SAR 13-37.5	<.06	<15	<5	Slight	None	5-8	<5	<10	>60	12	-0-
4ABG	lvfs-cl	>6	>40	<4	<5	Slight	<.06	<15	<5	Slight	None	8-15	<5	10-40	>60	19	-0-
4ABP	c	>6	>40	<4	<5	Slight	<.06	<15	<5	Slight	None	5-8	<5	<10	>60	18	-0-
4AE	lvfs-cl	>6	>40	4-8	<5	Slight	<.06	<15	<5	Slight	None	0-5	<5	<10	>60	105	498
4AEB	lvfs-cl	>6	>40	4-8	<5	Slight	<.06	<15	<5	Slight	None	5-8	<5	<10	>60	31	-0-
4AEF	lvfs-cl	>6	>40	4-8	5-15	Slight	<.06	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	85
4AEFX	lvfs-cl	>6	>40	4-8	5-15	SAR 13-37.5	<.06	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	174

Table 5.4 Continued, Page 5

Class and Sub-class	Surface Texture 2/ (top 10")	AWHC 3/ (in.)	Soil Depth (in.)	Salinity (ECx10)	Sodicity 4/ % Area Affect.	Sodicity 4/ Sever.	Permea-bility (in/hr)	% Gravel 5/	% Cobble 6/	Ero-sion Haz.	Over-flow Haz.	% Slope	Stones 7/ (cu.yd/ac)	% Tree Canopy	Depth to Water Tbl. (in.)	Acreage 8/ South.Ute	Acreage 8/ Ute Mt.Ute
4AEP	c, sic	>6	>40	4-8	<5	Slight	<.06	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	211
4AEXY	lvfs-cl	>6	>40	4-8	<5	SAR 13-37.5	<.06	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	174
4AF	lvfs-cl	>6	>40	<4	5-15	Slight	<.06	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	9
4AG	lvfs-cl	>6	>40	<4	<5	Slight	<.06	<15	<5	Slight	None	0-5	<5	10-40	>60	30	139
4AH	lvfs-cl	>6	>40	<4	<5	Slight	<.06	<15	<5	Severe	None	0-5	<5	<10	>60	14	-0-
4AKD	lvfs-cl	>6	30-40	<4	<5	Slight	<.06	<15	<5	Slight	None	0-5	<5	<10	20-40	71	-0-
4AP	c, sic	>6	>40	<4	<5	Slight	<.06	<15	<5	Slight	None	0-5	<5	<10	>60	1,038	12
4APE	c,sic	>6	>40	4-8	<5	Slight	<.06	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	339
4B	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	15-20	<5	<10	>60	27	-0-
4BAG	lvfs-cl	>60	>40	<4	<5	Slight	.06-.2	<15	<5	Slight	None	8-15	<5	10-40	>60	147	-0-
4C	lvfs-cl	2-2.5	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	16	-0-
4CN	lvfs-cl	2.5-4.5	>40	<4	<5	Slight	.2-6	15-35	10-15	Slight	None	0-5	<5	<10	>60	79	-0-
4D	lvfs-cl	2.5-4.5	10-20	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	92	-0-
4DC	lvfs-cl	2.5-4.5	10-20	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	22
4E	lvfs-cl	>6	>40	12-16	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	59
4EAPX	c, sicl	>6	>40	12-16	<5	SAR 13-37.5	.06-.2	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	27
4EAX	lvfs-cl	>6	>40	12-16	<5	SAR 13-37.5	.06-.2	<15	<5	Slight	None	0-5	<5	<10	>60	-0-	136
4GAB	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	10-15	Slight	None	5-8	<5	>40	>60	14	-0-
4FKC	lvfs-cl	4.5-6	>40	<4	25-35	SAR 13-37.5	.2-6	<15	<5	Slight	None	0-5	<5	<10	20-40	53	-0-
4K	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	None	0-5	<5	<10	10-20	592	-0-
4KLP	c	>6	>40	<4	<5	Slight	.2-6	<15	<5	Slight	Occ.	0-5	<5	<10	10-20	54	-0-
4KNA	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	15-35	Slight	None	0-5	<5	<10	10-20	13	-0-

Table 5.4 Continued, Page 6

Class and Sub-class	Surface Texture (top 10") 2/	AWHC (in.) 3/	Soil Depth (in.)	Salinity (ECx10)	Sodicity 4/ % Area Affect.	Sodicity 4/ Sever.	Permea-bility (in/hr)	% Gravel 5/	% Cobble 6/	Ero-sion Haz.	Over-flow Haz.	% Slope	Stones 7/ (cu.yd/ac)	% Tree Canopy	Depth to Water Tbl. (in.)	Acreage 8/ South.Ute	Acreage 8/ Ute Mt.Ute
4LE	lvfs-cl	>6	>40	4-8	<5	Slight	.2-6	<15	<5	Slight	Freq.	0-5	<5	<10	>60	-0-	25
4MGB	lvfs-cl	>6	>40	4-8	<5	Slight	.2-6	<15	<5	Slight	None	5-8	50-70	>40	11	-0-	49
4MN	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	15-35	Slight	None	0-5	50-70	<10	>60	4	-0-
4N	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	<15	15-35	Slight	None	0-5	<5	>40	>60	-0-	17
4NHAB	lvfs-cl	>6	>40	<4	<5	Slight	.06-.2	<15	10-15	Severe	None	5-8	<5	<10	>60	32	-0-
4NU	lvfs-cl	>6	>40	<4	<5	Slight	.2-6	15-35	15-35	Slight	None	0-5	<5	<10	>60	126	-0-

1/ Irrigation land suitability study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

2/ Soil texture of the surface 10 inches.

3/ Available water holding capacity expressed as inches in a 4 foot profile.

4/ Sodicity evaluated by sodium adsorption ratio (SAR): Slight <13, Moderate 13-37.5, Severe >37.5.

5/ Rounded or angular fragments up to 3 inches in diameter in the surface 10 inches of soil.

6/ Rounded or partially rounded fragments of rock ranging from 3 to 10 inches in diameter in the surface 10 inches of soil.

7/ Rock fragments larger than 10 inches in diameter if rounded and longer than 15 inches along the longer axis if flattened.

8/ Total arable acreage equals 30,939 on Southern Ute and 50,330 on Ute Mountain Ute.

9/ Surface 20 inches contains >25% lime.

5.3.1 Soil Texture

Soil texture refers to the relative composition of the soil as to its percentage of sand, silt, and clay. These mineral particles, less than 2 mm in diameter, are often referred to as soil separates. A textural class is assigned a soil based on the relative proportion of these particles in the soil. A summary of the soil textural classes is shown on Table 5.5.

Soil texture is an important parameter for evaluating crop suitability and yield potential since it directly affects water holding capacity, aeration, drainage, and nutrient retention capacity. Typically, sandy soils have a low water holding capacity and lack the exchange sites necessary to effectively retain nutrients needed for optimum plant growth. Internal drainage of these soils is very good but tends to be excessive in situations where little or no clay is found in the rooting zone. In many instances, sandy soils require intensive management inputs to maintain productivity and obtain economic crop yields.

Conversely, clayey soils have a high water holding capacity and nutrient retention capability. These soils are sometimes imperfectly drained and poorly aerated and may require intensive management inputs for successful crop production.

Soils with intermediate amounts of all three soil separates are generally considered most desirable for farming since they reflect

TABLE 5.5
SUMMARY OF SOIL TEXTURAL CLASSES[1]

Soil Textural Class	General Soil Textural Terminology	
Sands (s) Loamy sands (ls)	Coarse-Textured Soils	Sandy Soils
Sandy loam (sl) Find sandy loam (fsl)	Moderately Coarse-Textured Soils	Loamy Soils
Very fine sandy loam (vfsl) Loam (l) Silt loam (sil) Silt (si)	Medium-Textured Soils	Loamy Soils
Clay loam (cl) Sandy clay loam (scl) Silty clay loam (sicl)	Moderately fine-Textured Soils	Loamy Soils
Sandy clay (sc) Silty clay (sic) Clay (c)	Fine-Textured Soils	Clayey Soils

1/ Source: National Soils Handbook, Appendix 1, Soil Survey Manual, Chapter 4, pp. 4-56 and 4-57, Soil Survey Staff, USDA/SCS, May, 1981.

properties intermediate between the sandy and clayey soils. Good drainage and aeration, along with favorable water holding and nutrient retention capacity are typical of a loamy soil.

Land classification criteria applied to Ute Indian reservation lands assumed that loamy very fine sand to clay loams were the most desirable for crop production. Coarser and finer textured soils were downgraded in the classification system. This indicates that soils with these textures will likely have below average crop yields and/or higher production costs which will result in reduced crop payment capacity; however, soil texture is only generally related to crop yield since many other soil and management factors can influence crop production. Soil texture as a single physical property will not seriously impact crop suitability or yield since only about 2.6 percent of the area has either clayey or sandy soils (see Table 5.6).

5.3.2 Soil Depth

Soil depth refers to the depth of soil that plant roots can readily penetrate to obtain water and soil nutrients. Shallow soils will limit moisture and nutrient retention capabilities and may decrease the yield potential of selected crops. Soil depth may be limited by a layer that differs in physical or chemical properties from the overlying material as to prevent or seriously retard root growth. Crops such as alfalfa and apples require deep soils for economically profitable crop production. Thus, shallow soil depth will limit the crops that can be grown and may even reduce the yield of those crops

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TABLE 5.6
SUMMARY OF SURFACE SOIL TEXTURE,
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

Soil Surface Texture 2/	Acreage by Reservation		
	Southern Ute	Ute Mt. Ute	Total
Loamy soils	29,434	49,741	79,175
Clayey soils	1,362	589	1,951
Sandy soils	143	-0-	143
TOTAL	30,939	50,330	81,269

1/ Source: Irrigation suitability land classification study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

2/ Loamy soils include those from sandy loam to silty clay loam. Clayey soils include sandy clay and those of finer texture. Sandy soils include loamy sand and those of coarser texture.

considered suitable. Even though soil depth is an important factor in crop selection and yield, soil depth as summarized on Table 5.7 is not a significant limiting factor on reservation lands since less than one percent of lands classified had soils shallower than 40 inches.

5.3.3 Soil Slope

Soil slope or grade refers to the degree of deviation of the soil surface from horizontal and is usually expressed in percentage or degrees. The slope of the soil has a marked effect on its suitability for crop production and irrigation. Soils with excessive slope cannot be successfully flood or furrow irrigated because of physical limitations and potential erosion. These conditions require the use of a carefully designed and managed sprinkler system with surface drainage provisions to control runoff.

Soils with slopes less than 8 percent are generally suited to mechanically harvested field, row, and permanent crops. Steeper soils are often planted to permanent tree crops; however, in the project area these soils, where developed, are planted to field and row crops but production/harvest costs are generally significantly higher than more gently sloping soils. Soils with slopes as high as 8 percent can be successfully irrigated by gravity techniques; however, irrigation costs usually increase appreciably on slopes above about 5 percent. Soils with slopes above 8 percent are usually sprinkler irrigated. Generally as slope increases, a concurrent

TABLE 5.7
SUMMARY OF SOIL DEPTH, SOUTHERN UTE AND
UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

Soil Depth(in.) 2/	Acreage by Reservation		
	Southern Ute	Ute Mt. Ute	Total
> 40	30,352	50,208	80,560
30 - 40	495	100	595
20 - 30	-0-	-0-	-0-
10 - 20	92	22	114
TOTAL	30,939	50,330	81,269

1/ Source: Irrigation suitability land classification study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

2/ Soil depth refers to the depth of soil material that plant roots can readily penetrate to obtain water and plant nutrients.

increase in irrigation, crop production, and harvesting costs occurs. Soils with slopes in excess of about 25 percent are usually considered unsuited for the production of most field and row crops. Permeability is an important factor in irrigating steeper soils since irrigation water applied at rates higher than soil intake capabilities will result in runoff and potential erosion. A summary of acreage at the reservations in relation to soil slope is shown on Table 5.8. Soil slope is predominantly less than 8 percent with about 87 percent of the area classified less than 5 percent.

5.3.4 Drainage

Drainage refers to the frequency and duration of soil saturation or partial saturation that occurs after irrigation or precipitation. Soils at the project site are generally well drained. This indicates that the soil profile is generally free of mottles and prolonged periods of saturation generally do not occur. Water is removed from the soil readily but not rapidly. Well drained soils are commonly intermediate in texture although soils of other textural classes may also be well drained. These soils generally retain optimum amounts of moisture for plant growth after irrigation or precipitation.

Some soils in the reservation areas are underlain by materials that act as drainage barriers restricting downward water movement. Often, excess applied irrigation water or precipitation lost to deep percolation accumulates above these barriers forming seasonal or

TABLE 5.8
SUMMARY OF SOIL SLOPE, SOUTHERN UTE AND
UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

% Slope 2/	Acreage by Reservation		
	Southern Ute	Ute Mt. Ute	Total
0 - 5	22,957	47,543	70,500
5 - 8	7,340	2,665	10,005
8 - 15	615	122	737
15 - 25	27	-0-	27
TOTAL	30,939	50,330	81,269

1/ Source: Irrigation suitability land classification study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

2/ Soil slope is the incline of the soil surface from horizontal expressed as a percentage.

permanent perched water tables. The perched water tables may influence the suitability and yield of crops grown on affected soils. These soils will require special reclamation/management inputs and irrigation techniques. Often these soils are suited only to irrigated pasture which is somewhat tolerant to impeded drainage conditions. The successful production of other crops will usually require the installation of subsurface drainage facilities to provide relief from saturated subsoil conditions. The construction of drainage facilities is an on-farm development cost which must be paid for by increased crop revenue. Table 5.9 summarizes shallow water table conditions on reservation lands. Shallow water tables currently exist beneath about 1.3 percent of classified lands.

5.3.5 Available Water Holding Capacity

The available water holding capacity is a measure of a soil's capability to store moisture that is available for plant uptake. It is commonly expressed as inches of water per inch or foot of soil. Soil texture and depth influence the available water holding capacity. Soils within the project area that have greater than 40 inch depth are generally capable of holding in excess of 6 inches of available water. Shallow or coarse textured soils may have a total water holding capacity as low as 2 to 2.5 inches.

Soil water holding capacity dictates irrigation frequency when compared to crop evapotranspiration requirements. A 50 percent depletion of available soil moisture is generally allowable between

TABLE 5.9
SUMMARY OF SHALLOW WATER TABLE CONDITIONS,
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

Water Table Depth(in.) 2/	Acreage by Reservation		
	Southern Ute	Ute Mt. Ute	Total
> 60	29,873	50,330	80,203
40 - 60	236	-0-	236
20 - 40	171	-0-	171
10 - 20	659	-0-	659
TOTAL	30,939	50,330	81,269

1/ Source: Irrigation suitability land classification study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

2/ The depth from the soil surface to the upper surface of groundwater or that level below which the soil is saturated with water.

1955 irrigations. For example, a soil with a total 6.0 inch water holding capacity requires a 10 day irrigation cycle if the average daily evapotranspiration is 0.30. Depletion of soil moisture in excess of the allowable 50 percent usually results in plant water stress and reduced yields. Intensive irrigation water management is required to prevent plant water stress that may occur to crops planted on shallow soils or those with low available moisture holding capacity. Irrigation system cost is an important factor when developing soils with low available water holding capacity. These soils require more frequent irrigations to maintain soil moisture. Thus, more intensive management or extensive facilities are required which usually increase irrigation operational and capital costs. The summary of available water holding capacity for classified reservation lands is shown on Table 5.10. Approximately 3.6 percent of the area has restricted available water holding capacity which will influence irrigation system design, operation and cost.

5.3.6 Permeability

Permeability is that quality of soil which enables it to transmit water or air. It is generally measured quantitatively by determining the flow rate of water through a unit cross section of saturated soil in unit time. The permeability of classified reservation lands is summarized on Table 5.11. Generally, permeability rates increase with a decrease in the amount of clay. Clayey soils have slow permeability while sandy soils approach rapid permeability. Sodium and salt concentrations within a soil may also

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TABLE 5.10
SUMMARY OF AVAILABLE WATER HOLDING CAPACITY (AWHC), SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

AWHC (in.) 2/	Acreage by Reservation: Southern Ute	Acreage by Reservation: Ute Mt. Ute	Total
> 6.0	29,638	48,678	78,316
4.5 - 6.0	1,084	1,421	2,505
2.5 - 4.5	201	231	432
2.0 - 2.5	16	-0-	16
TOTAL	30,939	50,330	81,269

1/ Source: Irrigation suitability land classification study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

2/ Available water holding capacity is the capacity of the soil to store water available for use by plants expressed as inches of water in a 48 inch soil depth.

TABLE 5.11
SUMMARY OF SOIL PERMEABILITY,
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

Permeability(in/hr) 2/	Acreage by Reservation Southern Ute	Ute Mt. Ute	Total
6 - 20	316	833	1,149
.2 - 6	8,537	37,714	46,251
.06 -.2	15,399	9,607	25,006
< .06	6,687	2,176	8,863
TOTAL	30,939	50,330	81,269

1/ Source: Irrigation suitability land classification study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

2/ Permeability is the rate at which water penetrates or passes through a soil.

influence permeability.

Intensive irrigation management is required on soils with slow permeability (<.2 inches per hour) to infiltrate sufficient water into the root zone to satisfy plant consumptive use while preventing surface runoff and potential erosion. Further, slowly permeable subsoil conditions require reclamation or careful irrigation water management to prevent periodic shallow perched water table conditions. Soil permeability is an important consideration in irrigation system design. Slowly permeable soils usually require lower application rates which necessitate more extensive irrigation facilities. Very rapid permeability often results in excessive leaching of applied crop nutrients which increases fertilizer requirements and cost.

Soil permeability directly affects crop selection and management. Intensive management may be required for soils at the site with low (less than 0.2 in/hr.) or high (more than 6.0 in/hr.) permeability rates depending on the crop grown and method of irrigation. Low infiltration rates significantly affect the selection and efficiency of sprinkler irrigation equipment. Under these circumstances, special management and design considerations are often needed to prevent serious surface water runoff and subsequent soil erosion.

5.3.7 Coarse Fragments

The occurrence of gravel and cobble in the soil profile reduces moisture and nutrient retention and in some instances may act as a barrier to water movement and root growth. If these fragments occur on the soil surface, soil tillage becomes more difficult and expensive. Further, seed germination is often a problem, especially if the coarse fragments are associated with sandy soils. Crops planted on beds or root/tuber crops are generally not suited to these soils. In addition to added annual production costs, crop suitability limitations, and potential yield reductions, development/reclamation costs may be incurred in the removal of these fragments. Removal is usally needed if larger stone fragments are present on or near the soil surface. The occurrence of coarse fragments on reservation soils is summarized on Table 5.12. Approximately 1.3 percent of the area classified is affected by coarse fragments with about 53 acres needing removal of 50 to 70 cubic yards of stone.

5.3.8 Miscellaneous Factors

Several other factors related to physical land conditions that impact crop suitability, land reclamation/development, and crop production costs occur on reservation lands. These factors involve soil erosion, overflow hazard, tree canopy, and shallow carbonate accumulations. The occurrence of these conditions is summarized on Tables 5.13, 5.14, and 5.15. Generally, these conditions, with the exception of the carbonate accumulations, do not impact crop

TABLE 5.12
SUMMARY OF SOIL COARSE FRAGMENT CONTENT
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

	Acreage by Reservation		
% Cobble	Southern Ute 2/	Ute Mt. Ute 3/	Total
< 5	30,452	49,731	80,183
5 - 10	63	207	277
10 - 15	281	375	656
15 - 35	143	17	160
TOTAL	30,939	50,330	81,269

1/ Source: Irrigation suitability land classification study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

2/ Lands affected by cobble (487 acres) include 139 acres affected by 15-35% gravel and 4 acres which require removal of 50-70 cubic yards of stone.

3/ Land affected by cobble (599 acres) include 90 acres affected by 35-55% gravel. An additional 49 acres not affected by cobble or gravel require removal of 50-70 cubic yards of stone.

1961

TABLE 5.13
SUMMARY OF SOIL EROSION,
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

Erosion Hazard 2/	Acreage by Reservation		
	Southern Ute	Ute Mt. Ute	Total
Slight	30,261	50,330	80,591
Moderate	-0-	-0-	-0-
Severe	678	-0-	678
Very Severe	-0-	-0-	-0-
TOTAL	30,939	50,330	81,269

1/ Source: Irrigation suitability land classification study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

2/ The potential for soil loss as a result of the wearing away of the land surface by wind, running water, or other geological agents.

TABLE 5.14
SUMMARY OF OVERFLOW HAZARD,
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

Overflow Hazard	Acreage by Reservation Southern Ute	Ute Mt. Ute	Total
None	30,885	50,305	81,190
Rare	-0-	-0-	-0-
Occasional	54	-0-	54
Very Frequent	-0-	-0-	-0-
TOTAL	30,939	50,330	81,269

1/ Source: Irrigation suitability land classification study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

1963

TABLE 5.15
SUMMARY OF TREE CANOPY CONDITIONS,
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

% Tree Canopy	Acreage by Reservation		Total
	Southern Ute	Ute Mt. Ute	
< 10	28,069	44,443	72,512
10 - 40	2,446	2,619	5,065
> 40	424	3,268	3,692
TOTAL	30,939	50,330	81,269

1/ Source: Irrigation suitability land classification study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

suitability or yield, but rather have a direct influence on land development and crop production costs. Shallow carbonate accumulations occur on about 3,129 acres of classified reservation land. These lands are generally suited to improved permanent pasture only because of their susceptibility to wind erosion and potential crop nutritional deficiencies.

5.4 SOIL CHEMICAL CHARACTERISTICS

Soil chemical characteristics that may affect the selection and productivity of crops at the project site include salinity and sodicity. The interpretation and effect of these constituents on soil suitability (Table 5.16) and subsequent crop selection and productivity are discussed as follows.

5.4.1 <u>Salinity</u>

Salinity refers to the concentration of soluble salts and is expressed as the electrical conductivity of the saturation extract (ECe) as measured in mmhos/cm (ECe x 103) 25 degrees C. Soils with an ECe of 0 to 4.0 mmhos/cm are considered low in salt content. Soils with an ECe of 4.0 to 8.0 mmhos/cm are considered slightly affected. Soils with an ECe of 8.0 to 16.0 mmhos/cm are considered moderately affected, and soils with ECe above 16.0 mmhos/cm are considered strongly affected. The productivity of salt sensitive crops can be materially reduced with soil soluble salt concentrations above approximately 2.0 mmhos/cm.

TABLE 5.16
GENERAL GUIDELINES
FOR INTERPRETATION OF SOIL SUITABILITY

ELECTRICAL CONDUCTIVITY - Salinity - (ECe)

Below 2	No salinity problem.
2 to 4	Restricts growth of very salt sensitive crops.
4 to 8	Restricts growth of many crops.
8 to 16	Restricts growth of all but salt tolerant crops.
Above 16	Only a few very salt tolerant crops make satisfactory yields.

SODIUM ADSORPTION RATIO (SAR)

The degree the soil exchange complex is saturated with sodium. Exchangeable sodium has two effects: (1) permeability, (2) toxicity to sensitive crops.

Below 8.5	Generally no permeability problem due to sodium; however, sodium sensitive crops may show leaf burn at SAR below 8.5.
8.5 - 13	Possible permeability problems with clay loams and clays.
Above 13	Permeability problems are likely on all mineral soils with possible exceptions of sands and loamy sands.

Reference: TMT Chemical Company, Soil Fertility Assay Interpretaton Guide, 1971, based on University of California, Department of Soils and Plant Nutrition data.

Note: Interpretations are based on possible effects of constituents on crops or soil, or both. Guidelines are flexible and should be modified when warranted by local experience or special conditions of crop, soil and method of irrigation.

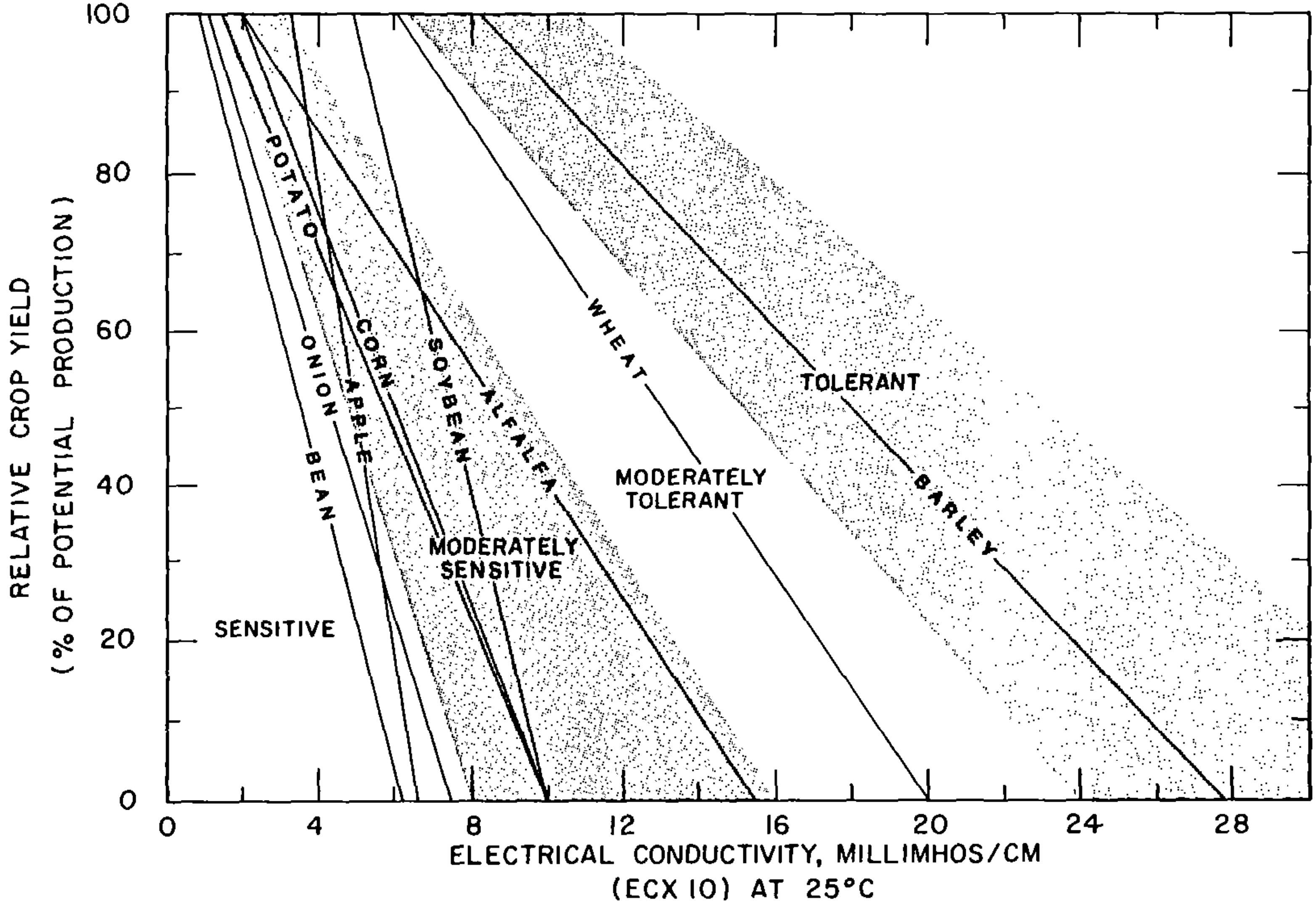
The salt content of the soil profile is used to predict soil potential for a specific crop and yield. Productivity may be affected by salt concentrations in the surface soil or in any other horizon within the root zone. Generally, the zone of highest salt concentration within the rooting zone is used to evaluate soil suitability in regard to salinity.

Crop tolerance levels relating potential yield reduction percentages to soil salinity (ECe) for selected crops that may be grown at the site are shown in Figure 5.1. The salinity of project soils as summarized on Table 5.17 is generally less than 4.0 mmhos/cm; however, the salt content of some soils on the Ute Mountain Ute Reservation may be a restrictive factor in the selection or productivity of salt sensitive crops.

5.4.2 Sodium Adsorption Ratio

The sodium adsorption ratio (SAR) is a measure of the exchangeable sodium concentration in relation to other cations. Sodum is unique among the cations in its effect upon the soil. When present in the soil in exchangeable form, even at low concentrations compared with other cations, it causes adverse chemical and physical conditions to develop. Clay particle dispersion, which is a result of sodic soil conditions, causes reduced permeability that may result in lower yields. Dispersion does not generally occur when the SAR is less than 8.5. The permeability of fine textured soils may be reduced

YIELD POTENTIAL OF SELECTED CROPS IN RELATION TO SOIL SALINITY



Reference: E. V. Maas and G. J. Hoffman, Crop Salt Tolerance - Current Assessment, Journal of the American Society of Civil Engineering, June, 1977.

FIGURE 5.1

1967

1968

TABLE 5.17
SUMMARY OF SOIL SALINITY,
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

Salinity 2/	Acreage by Reservation		
	Southern Ute	Ute Mt. Ute	Total
< 4	30,743	42,858	73,601
4 - 8	196	6,454	6,650
8 - 12	-0-	796	796
12 - 16	-0-	222	222
> 16	-0-	-0-	-0-
TOTAL	30,939	50,330	81,269

1/ Source: Irrigation suitability land classification study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

2/ The soluble salt content of the soil based on the electrical conductivity of the saturation extract as expressed in millimhos per centimeter (mmhos/cm) at 25 degrees C.

with an SAR between 8.5 and 13. Permeability problems are likely on all mineral soils with an SAR above 13 with the exception of sands and loamy sands.

In addition to potential soil permeability problems caused by clay dispersion, many crops are sensitive to soil sodium concentrations. Table 5.18 shows crop tolerance to sodium concentrations. Sensitive crops such as deciduous trees may show injury symptoms with the SAR ranging from 2.3 to 8.5. Field crops such as cereal grains and alfalfa are more tolerant to sodium and generally do not show injury unless the SAR is above 18. The sodium concentration as summarized on Table 5.19 in soils at the reservations as expressed by the SAR is generally below levels that result in soil dispersion or toxicity to sensitive crops.

Soil amendment (gypsum) applications may be required to mitigate sodium problems in some areas. Applications of soil amendments needed to correct sodic conditions are a development cost needed to facilitate crop suitability and yield.

5.5 LAND SUITABILITY

The capability of Ute Indian Reservation lands to provide economic levels of crop production under irrigated or dryland conditions is largely based on the suitability of project lands to adapted crops. Class 1 reservation lands are those which have the most favorable

1970

TABLE 5.18
SODIUM TOLERANCE OF VARIOUS CROPS
SODIUM ADSORPTION RATIO (SAR)

Extremely Sensitive (SAR=2.3-8.5)	Sensitive (SAR=8.5-18)	Moderately Tolerant (SAR=18-46)	Tolerant (SAR=46-100)	Most Tolerant (SAR=100)
Deciduous fruits	Beans	Clover	Wheat	Crested & Fairway wheatgrass
		Oats		Tall wheat-grass
		Tall fescue	Alfalfa	Rhodes grass
		Rice	Barley	
		Dallisgrass		

Reference: This table was adapted from Agriculture Information Bulletin 216, USDA, 1960.

Note: Stunted growth of more tolerant crops may be due more to adverse soil physical conditions than nutritional factors as the SAR increases above 46.

1971

TABLE 5.19
SUMMARY OF SOIL SODICITY,
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

Sodicity 2/	Acreage by Reservation		
	Southern Ute	Ute Mt. Ute	Total
Slight	30,874	49,964	80,838
Moderate	65	366	431
Severe	-0-	-0-	-0-
TOTAL	30,939	50,330	81,269

1/ Source: Irrigation suitability land classification study performed by Stoneman - Landers, Inc., 10701 Lomas NE, Suite 103, Albuquerque, New Mexico 87112.

2/ Sodicity refers to the amount of area of a particular soil that is adversely affected by sodic or alkaline conditions:

1) Slightly affected - 0 to 5 % of the area has alkali soil unsuited to most crops.

2) Moderately affected - 5 to 35% of the area has alkali soil unsuited to most crops.

3) Severely affected - More than 35% of the area has alkali soil unsuited to most crops.

1973

TABLE 5.20
SUMMARY OF LAND RECLAMATION REQUIREMENTS
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

	Land Characteristics Requiring Reclamation					
Class & Subclass	Salinity	Sodicity	Over flow Hazard	Stone Removal	Tree Canopy	Sub-surface Drainage
2 ABG					X	
2 AE	X					
2 AEX	X	X				
2 AG					X	
2 AK						X
2 BK					X	
2 DG					X	
2 E	X					
2 EAX	X	X				
2 EX	X	X				
2 EXY	X	X				
2 G					X	
2 GA					X	
2 GD					X	
2 K						X
2 Y		X				
3 ABG					X	
3 AE	X					
3 AG					X	
3 BAG					X	
3 BG					X	

Table 5.20 continued, Page 2

Class & Subclass	Salinity	Sodicity	Over flow Hazard	Stone Removal	Tree Canopy	Sub-surface Drainage
	Land Characteristics Requiring Reclamation					
3 BNGA					X	
3 E	X					
3 EA	X					
3 EAX	X	X				
3 EF	X					
3 EX	X	X				
3 G					X	
3 GA					X	
3 GAB					X	
3 GAC					X	
3 GAD					X	
3 GB					X	
3 GD					X	
3 GK					X	X
3 K						X
3 KG					X	X
3 TE	X					
4 ABEF 2/	X	X				
4 ABG					X	
4 AE 2/	X					
4 AEB 2/	X					
4 AEF 2/	X					

1975

Table 5.20 continued, Page 3

Class & Subclass	Salinity	Sodicity	Over flow Hazard	Stone Removal	Tree Canopy	Sub-surface Drainage
	Land Characteristics Requiring Reclamation					
4 AEFX 2/	X	X				
4 AEP 2/	X					
4 AEXY 2/	X	X				
4 AG					X	
4 AKD 2/						X
4 APE 2/	X					
4 BAG					X	
4 E	X					
4 EAPX	X	X				
4 EAX	X	X				
4 GAB					X	
4 FKC		X				X
4 K						X
4 KLP			X			X
4 KNA						X
4 LE	X		X			
4 MGB				X	X	
4 MN				X		
4 N					X	

Table 5.20 continued, Page 4

1/ Summarizes reclamation needed prior to crop development or to facilitate maximum potential crop yield. See Table 5.4 for specific soil characteristics related to reclamation requirements.

2/ Other limitations make reclamation of these lands impractical or unnecessary. Limiting characteristics make these lands suited only to irrigated pasture.

(see Table 5.17 for the Summary of Soil Salinity). Without reclamation, the salinity concentrations in these lands have a negative impact on crop payment capacity by reducing potential yields or restricting crop suitability/selection.

Saline soils are reclaimed by applying excess irrigation water for leaching purposes. Ideally, excess soluble salts move below the root zone in the leachate. The ability to reclaim saline soils is largely dependent on soil permeability and the availability and quality of irrigation water. Very slowly permeable soils and saline irrigation water make reclamation difficult if not impossible. For example, very slowly permeable (<.06 in/hr.) Class 4 lands are considered impractical to reclaim because of the relative inability to perform adequate leaching. These lands, when salt affected, would be suited only to salt tolerant crops. Further, lands irrigated with Mancos River water, which is saline (average salinity of about 2,278 micromohs/cm), will accumulate soluble salt concentrations that exceed the tolerance level of many crops. Thus, Mancos River water is not suitable for reclamation of saline soils. If alternative water sources are available, mixing of Mancos River water with higher quality water will dilute the total salt content thus making the water better suited for reclamation purposes. However, if this irrigation water source is the only one available, the cropping pattern will be limited to more salt tolerant crops such as barley, grain sorghum, and wheat. La Plata River water quality is somewhat limited for successfully reclaiming saline soils because of its relatively high salt load. Lands leached with this water will remain too high in salinity to grow salt sensitive crops such as onion and dry bean without resultant yield losses. The salinity reclamation program (assumes no water quality limitations) recommended for planning purposes is as follows:

1) Soil ECe <4 - Reclamation not required (73,601 acres).

2) Soil ECe 4 to 8 - Plant salt tolerant crops first year (barley -100% yield potential) and leach with 1.5 acre-feet. Normal cropping pattern beginning second year (6,650 acres).

3) Soil ECe 8 to 12 - Plant salt tolerant crop first year (barley - 90% yield potential) and leach with 1.5 acre-feet. Normal cropping pattern beginning second year with spring planting preceeded by leaching with .5 acre-feet (796 acres).

4) Soil ECe 12 to 16- Plant salt tolerant crop first year (barley - 70% yield potential) and leach with 1.5 acre-feet. Plant salt tolerant crop second year (barley - 100% yield potential) and leach with 1.5 acre-feet. Normal cropping pattern beginning third year (222 acres).

Several arable land classification units in the project area have varying sodicity levels. Sodicity problems result from the accumulation of sodium on the soil exchange complex. Excessive adsorbed sodium reduces the overall integrity of the soil and adversely affects soil/plant/water relationships. Adsorbed sodium is not subject to removal by leaching. Sodium is difficult to remove from the soil because its presence causes dispersion of the soil particles which reduces water movement through the soil. A soil amendment which contains soluble calcium (gypsum) or which can produce soluble calcium by reacting with calcium carbonate (sulfur or sulfuric acid) must be applied. Soluble calcium replaces the sodium on the exchange complex and promotes soil flocculation. Water is then able to move through the soil and remove detrimental sodium. Gypsum and sulfuric acid are faster acting than sulfur since sulfur must be oxidized before it can react with calcium carbonate. Soil amendments (gypsum, sulfur, and sulfuric acid) are incorporated into the soil after application. Incorporation of the amendment is followed by irrigation to facilitate the leaching of these excess sodium salts from the root zone. The duration of the reclamation program is dependent on initial sodium levels, soil amendment material/application rate, and the ability to leach soluble sodium salts formed during the reclamation process.

Thirteen arable land classification units have moderate sodicity (SAR 13 to 37.5). Ten of these land classification units have less than five percent of their area affected. The limited extent of sodic areas in these ten land classification units eliminates them from further consideration. The remaining three land classification units have from 5 to 35 percent of their total area affected. Two of these units (4 ABEF and 4 AEFX) have permeability rates of <.06 inches per hour. This condition severely impedes their reclaimability and sodium tolerant crops must be grown on these soils. The remaining unit (4FKC) can also be planted to sodium tolerant crops or can be reclaimed by chemical amendment (gypsum) application/incorporation followed by leaching. The amount of gypsum needed to effectively reduce exchangeable sodium concentrations to acceptable levels can be estimated based on methodology developed by the USDA Salinity Laboratory (USDA Agricultural Handbook 60). Approximately 12 tons of gypsum (100% calcium sulfate) per acre is needed to reclaim this land. This gypsum application rate will allow the planting of identified suitable crops; however, the planting of deep rooted sodium sensitive crops such as apples should be delayed until subsoil sodic conditions are improved. The recommended reclamation program for the 4FKC land for planning purposes is as follows:

1) Year 1- Apply/incorporate 6 tons per acre gypsum, plant small grain (100% yield potential), and leach with 1.5 acre-feet.
2) Year 2- Same as year 1 except apply 3 tons per acre gypsum.
3) Year 3- Same as year 2.
4) Year 4- Leach with 0.5 acre-feet in spring, begin normal cropping pattern.

The reclamation of sodic soils requires leaching with irrigation water having both low salinity and sodium hazards. Water quality as it impacts leaching was previously discussed. Generally, the potential irrigation water sources have a low sodium hazard except Mancos River water. The sodium content of Mancos River water is acceptable for reclamation purposes (of sodic soil); however, irrigation with this water source may result in sodium accumulations in soils over an extended time period.

Overflow hazards are associated with two project land classification units (4KLP and 4LE). Facilities are needed to control potential flood flows across these areas (see Table 5.1 for flood frequency). Without control the cropping pattern is limited to adapted annual crops or irrigated pasture with consideration for potential crop loss resulting from unanticipated overflow conditions. Total area affected is about 79 acres (54 acres on Southern Ute and 25 acres on Ute Mountain Ute Reservations).

Stone removal is required for reclamation of two Class 4 lands (4 MGB and 4 MN). Both of these land classification units have about 50 to 70 cubic yards of surface stone which need to be removed for reclamation. Total area affected is about 53 acres (4 acres on the Southern Ute and 49 acres on the Ute Mountain Ute Reservations).

Tree canopy conditions were summarized in Table 5.15. The area with tree canopy requiring clearing totals about 8,757 acres. This area is divided into two classes: 1) 10 - 40% tree canopy (5,065 acres) and 2) >40% tree canopy (3,692 acres). Clearing cost estimates need to be developed to address this reclamation requirement.

Approximately 1,066 acres of lands on the Southern Ute Indian Reservation have shallow perched water tables. The installation of subsurface drainage facilities may lower the elevation of shallow perched water tables. Without reclamation these lands are generally limited to the production of grass hay/pasture crops.

5.5.2 Annual Crop Production Costs

The physical characteristics of selected project lands will act to increase annual crop production costs. The summary of increased production cost inputs for classified Ute Indian Reservation lands is shown in Table 5.21. Crop production cost considerations are: 1) Equipment costs; 2) Irrigation costs; and 3) Drainage costs.

Equipment costs are influenced by soil texture, coarse fragment content, and slope. Clayey textured soils affect equipment costs by increasing draft requirements which influences horsepower requirements and operational costs. About 1,951 acres have clayey textured soils (see Table 5.6). About 1,093 acres have gravel/cobble near the soil surface (see Table 5.12). Steeply sloping soils may affect equipment costs and increase the time needed to perform crop cultural/harvest operations. About 10,769 acres have sloping soils that will increase equipment operational costs (see Table 5.8).

TABLE 5.21
SUMMARY OF INCREASED PRODUCTION COST INPUTS
RESULTING FROM IDENTIFIED SOIL LIMITATIONS
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS 1/

	Equipment Costs 2/			Irrigation Costs 3/						Drainage Cost 4/
Class & Subclass	Soil Texture	Coarse Fragments	Slope	AWHC	Permeability	Slope	Grading	Tail-water Return	Erosion Control	Operation/ Maintenance
2A					X					
2AB			X		X	X				
2ABG			X		X	X				
2ABH		X	X		X	X				
2ABN			X		X	X				
2AC				X	X					
2AE					X					
2AEX					X					
2AG					X					
2AK					X					X
2B			X			X				
2BC			X	X		X				
2BG			X			X				
2C				X						
2DC				X						
2EXY-2AE					X					
2GA					X					
2K										X
2N		X								
3A					X					
3AB			X		X	X				
3ABC			X	X	X	X				
3ABD			X		X	X				
3ABG			X		X	X				
3AC				X	X					
3AE					X					
3AG					X					
3AH					X				X	
3AHB			X		X	X				
3B			X			X				
3BA			X		X	X				
3BAG			X		X	X				
3BH			X			X			X	
3BG			X			X				
3BN		X	X			X				
3BNGA		X	X		X	X				
3C				X						
3CH				X					X	
3CNT		X		X						
3CR				X						
3EA					X					
3EAX					X					

1983

Table 5.21 continued, Page 2

Class & Subclass	Equipment Costs [2/] Soil Texture	Coarse Fragments	Slope	Irrigation Costs [3/] AWHC	Perme-ability	Slope	Grading	Tail-water Return	Erosion Control	Drainage Cost [4/] Operation/ Maintenance
3GA					X					
3GAB			X		X	X				
3GAC				X	X					
3GAD					X					
3GB			X			X				
3GK					X					X
3K										X
3KG										X
3N		X								
3NA		X			X					
3NB		X	X			X				
3NH		X	X			X			X	
3TC					X					
3TN		X								
3TNC		X		X						
3UNT		X								
4A					X		X	X		
4AB	X		X		X	X	X	X		
4ABCD			X	X	X	X	X	X		
4ABDG			X	X	X	X	X	X		
4ABEF			X		X	X	X	X		
4ABG			X		X	X	X	X		
4ABP	X		X		X	X	X	X		
4AE					X		X	X		
4AEB			X		X	X	X	X		
4AEF					X		X	X		
4AEFX					X		X	X		
4AEP	X				X		X	X		
4AEXY					X		X	X		
4AF					X		X	X		
4AG					X		X	X		
4AH					X		X	X	X	
4AKD					X		X	X		
4AP	X				X		X	X		
4APE	X				X		X	X		
4B			X			X				
4BAG			X		X	X				
4C				X						
4CN		X		X						
4D				X						
4DC				X						
4EAPX	X				X					
4EAX					X					
4GAB		X	X		X	X				
4FKC				X						X

1984

Table 5.21 continued, Page 3

	Equipment Costs 2/			Irrigation Costs 3/						Drainage Cost 4/
Class & Subclass	Soil Texture	Coarse Fragments	Slope	AWHC	Permeability	Slope	Grading	Tail-water Return	Erosion Control	Operation/ Maintenance
4K										X
4KLP	X									X
4KNZ		X			X					X
4MGB			X			X				
4MN		X								
4N		X								
4NHAB		X	X		X	X			X	
4NU		X								

1/ Reflects added production cost inputs required as a result of soil limitations. See Table 5.1 for specific soil characteristics related to crop production costs.

2/ Added equipment costs reflect operation and maintenance related to draft requirements (soil texture), coarse fragments, and slope.

3/ Added irrigation costs reflect capital, operational and maintenance related to irrigation methodology, energy requirements, irrigation frequency, and other soil physical factors.

4/ Drainage costs reflect operation and maintenance of installed systems.

1985

Irrigation costs are influenced by available water holding capacity (AWHC), permeability, slope, grading requirements, tailwater return requirements, and erosion control (see Table 5.8, 5.10, 5.11, and 5.13). Lands will probably be sprinkler irrigated with the exception of Class 4 lands with very slow (<.06 in/hr.) permeability. These Class 4 lands will be irrigated by gravity methods which will necessitate grading and installation of tailwater return facilities. Increasing slope will increase capital, operation, and maintenance costs of irrigating these Class 4 lands. Sprinkler irrigation system capital and operational and maintenance costs are increased by low AWHC, slow or rapid permeability, slope (above 5%), and erosion control considerations. The magnitude of these factors on annual system costs must be addressed by engineering analyses which are beyond the scope of this study.

Annual drainage system costs will be incurred for operation and maintenance of subsurface drainage facilities installed to ameliorate shallow perched water table conditions. Cost will be based on system design, drainage flow volume, and methods of disposal as determined by an engineering analysis.

5.5.3 Crop Suitability and Yield

Crop suitability related to Ute Indian Reservation land conditions is summarized in Table 5.22. Crop suitability projections are based on soil characteristics summarized in Table 5.4 and assume that

1987

TABLE 5.22
SUMMARY OF CROP SUITABILITY TO PROJECT LANDS
SOUTHERN UTE AND UTE MOUNTAIN UTE INDIAN RESERVATIONS1/

	Irrigated Crops						Dryland Crops			
Subclass	Field/ Row	Alfalfa	Grass Hay/ Pasture	Potato/ Onion	Apple	Christ-mas Tree	Alfalfa	Dry Bean	Pasture	Winter Wheat
1	X	X	X	X	X	X	X	X	X	X
2A	X	X	X	X	X	X	X	X	X	X
2AB	X	X	X	X	X	X	X	X	X	X
2ABG	X	X	X	X	X	X	X	X	X	X
2ABH	X	X	X	X	X	X	X	X	X	X
2ABN	X	X	X		X	X	X	X	X	X
2AC	X	X	X	X	X	X				
2AE	X	X	X	X	X	X			X	
2AEX	X	X	X	X	X	X			X	
2AG	X	X	X	X	X	X	X	X	X	X
2AK	X	X	X	X	X	X	X	X	X	X
2B	X	X	X	X	X	X	X	X	X	X
2BC	X	X	X	X	X	X				
2BG	X	X	X	X	X	X	X	X	X	X
2C	X	X	X	X	X	X				
2D	X		X	X		X		X	X	X
2DC	X		X	X		X				
2DG	X		X	X		X		X	X	X
2E	X	X	X	X	X	X			X	
2EAX	X	X	X	X	X	X			X	
2EX	X	X	X	X	X	X			X	
2EXY	X	X	X	X	X	X			X	
2EXY-2AE	X	X	X	X	X	X			X	
2G	X	X	X	X	X	X	X	X	X	X
2GA	X	X	X	X	X	X	X	X	X	X
2GD	X		X	X		X		X	X	X
2H	X	X	X	X	X	X	X	X	X	X

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Table 5.22, continued, Page 2

	Irrigated Crops						Dryland Crops			
Subclass	Field/ Row	Alfalfa	Grass Hay/ Pasture	Potato/ Onion	Apple	Christ- mas Tree	Alfalfa	Dry Bean	Pasture	Winter Wheat
2K	X	X	X	X	X	X	X	X	X	X
2N	X	X	X		X	X	X	X	X	X
2Y	X	X	X	X	X	X	X		X	X
3A	X	X	X	X	X	X	X	X	X	X
3AB	X	X	X	X	X	X	X	X	X	X
3ABC	X	X	X	X	X	X				
3ABD	X		X	X		X		X	X	X
3ABG	X	X	X	X	X	X	X	X	X	X
3AC	X	X	X	X	X	X				
3AE	X	X	X	X	X	X			X	
3AG	X	X	X	X	X	X	X	X	X	X
3AH	X	X	X	X	X	X	X	X	X	X
3AHB	X	X	X	X	X	X	X	X	X	X
3B	X	X	X	X	X	X	X	X	X	X
3BA	X	X	X	X	X	X	X	X	X	X
3BAG	X	X	X	X	X	X	X	X	X	X
3BH	X	X	X	X	X	X	X	X	X	X
3BG	X	X	X	X	X	X	X	X	X	X
3BN	X	X	X		X	X	X	X	X	X
3BNGA	X	X	X		X	X	X	X	X	X
3C	X	X	X	X	X	X				
3CH	X	X	X	X	X	X				
3CNT	X	X	X	X	X	X	X	X	X	X
3CR	X	X	X	X	X	X				
3E	X	X	X	X	X	X				
3EA	X	X	X	X	X	X				
3EAX	X	X	X	X	X	X				
3EF	X	X	X	X	X	X				

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Table 5.22, continued, Page 3

Subclass	Irrigated Crops: Field/ Row	Irrigated Crops: Alfalfa	Irrigated Crops: Grass Hay/ Pasture	Irrigated Crops: Potato/ Onion	Irrigated Crops: Apple	Irrigated Crops: Christ-mas Tree	Dryland Crops: Alfalfa	Dryland Crops: Dry Bean	Dryland Crops: Pasture	Dryland Crops: Winter Wheat
3EX	X	X	X	X	X	X				
3G	X	X	X	X	X	X	X	X	X	X
3GA	X	X	X	X	X	X	X	X	X	X
3GAB	X	X	X	X	X	X	X	X	X	X
3GAC	X	X	X	X	X	X				
3GAD	X		X	X		X		X	X	X
3GB	X	X	X	X	X	X	X	X	X	X
3GD	X		X	X		X		X	X	X
3GK	X	X	X	X	X	X			X	
3K	X	X	X	X	X	X			X	
3KG	X	X	X	X	X	X			X	
3N	X	X	X		X	X	X	X	X	X
3NA	X	X	X		X	X	X	X	X	X
3NB	X	X	X		X	X	X	X	X	X
3NH	X	X	X		X	X	X	X	X	X
3T			X						X	
3TC			X							
3TE			X						X	
3TN			X						X	
3TNC			X							
3UNT			X						X	
4A			X							
4AB			X							
4ABCD			X							
4ABDG			X							
4ABEF			X							
4ABG			X							
4ABP			X							

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Table 5.22, continued, Page 4

	Irrigated Crops						Dryland Crops			
Subclass	Field/ Row	Alfalfa	Grass Hay/ Pasture	Potato/ Onion	Apple	Christ-mas Tree	Alfalfa	Dry Bean	Pasture	Winter Wheat
4AE			X							
4AEB			X							
4AEF			X							
4AEFX			X							
4AEP			X							
4AEXY			X							
4AF			X							
4AG			X							
4AH			X							
4AKD			X							
4AP			X							
4APE			X							
4B		X	X		X	X	X		X	
4BAG	X	X	X		X	X	X	X	X	X
4C	X	X	X	X	X	X				
4CN	X	X	X		X	X				
4D			X							
4DC			X							
4E	X	X	X	X	X	X				
4EAPX	X	X	X		X	X				
4EAX	X	X	X	X	X	X				
4GAB	X	X	X		X	X	X	X	X	X
4FKC	X	X	X	X	X	X				
4K	X	X	X	X	X	X				
4KLP	X	X	X		X	X			X	
4KNA	X	X	X		X	X			X	
4LE	X	X	X	X	X	X			X	
4MGB	X	X	X	X	X	X	X	X	X	X

Table 5.22, continued, Page 5

	Irrigated Crops						Dryland Crops			
Subclass	Field/ Row	Alfalfa	Grass Hay/ Pasture	Potato/ Onion	Apple	Christ-mas Tree	Alfalfa	Dry Bean	Pasture	Winter Wheat
4MN	X	X	X		X	X	X	X	X	X
4N	X	X	X		X	X	X	X	X	X
4NHAB	X	X	X		X	X	X	X	X	X
4NU	X	X	X		X	X	X	X	X	X

1/ Crop Suitability projections are based on land classification data summarized in Table 5.1 assuming appropriate land reclamation is performed as required.

necessary reclamation practices and crop production inputs will be provided in accordance with requirements previously discussed. Crop suitability projections assume that maximum potential yields can be obtained as discussed in Section 6 and that reduced payment capacity will result from a combination of restricted crop suitability, reclamation cost, and increased crop production cost. The only projected yield reductions are associated with the reclamation of saline soils as previously discussed. Since it is assumed that adverse saline/sodic conditions and the shallow perched water table are reclaimed, crop suitability projections are largely based on predominant soil physical conditions. These projections are based on the following general guidelines:

1) Restricted AWHC (<6 inches) will eliminate dryland farming operations.
2) Saline/sodic conditions cannot be reclaimed under dryland farming operations which restricts the cropping pattern to crops tolerant of these conditions.
3) Very slowly permeable soils (<.06 in/hr.) cannot infiltrate adequate water for dryland farming.
4) Soil depth (<40 inches) eliminates alfalfa and apples.
5) Very shallow soils (<20 inches) eliminates all crops except grass hay/pasture.
6) Steep soils (15-20% slope) are not suited to field/row crops or potato/onions.
7) Potatoes/Onions are not suited to clayey soils or soils with surface gravel/cobble.

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8) Soils with very slow permeability (<.06 in/hr.) or high carbonate content (>25%) are suited only to grass hay/pasture.

Crop suitability/yield is also influenced by climatic and water quality factors as previously discussed. Section 6 summarizes potential crop yield and production requirements in relation to variable project land, water quality, and climatic factors.