WORK REPORT

DETAILED RECONNAISSANCE CONSERVATION SURVEY

Land Management Unit 5

Navajo Project

H. F. Johnson (In Charge)
Junior Conservation Specialist

L. A. Hill
Junior Conservation Specialist

D. E. Jensen
Junior Conservation Specialist

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Approved:

District Chief of Soils Division

Regional Head Soils Division

District Manager

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I. INTRODUCTION.

General Information

Land Management Unit 5 occupies the extreme southwestern portion of the Navajo and Hopi Indian Reservations. It lies approximately between 35°15' and 35°45' of latitude, and 110° 35' and 111°15' of longitude, Coconino and Navajo Counties, Arizona. The western and southern boundaries of the Unit are fenced, whereas natural topographic features constitute the eastern and northern boundaries.

The land management reconnaissance survey was completed during the period February 25 to April 8, 1937.

The Unit comprises an area of 811,800 acres.* 193,270 acres of this, lying north of 35°30' latitude and east of 111°00' longitude, is a part of the Hopi Indian Reservation annexed by an executive order December 16, [illegible]. North of 35°30' latitude and west of 111°00' longitude are 306 acres of the Western Navajo Reservation, annexed by an executive order January 8, 1900. The entire Old Leupp Reservation, annexed by an executive order November 14, 1901, is within the Unit. It comprises an area of 415,661 acres located approximately between 35°10' and 35°30' latitude and 110°45' and 111° 15' longitude. Two or three hundred acres of this is railroad land. An act of Congress June 14, 1934, annexed an area south of 35°30' latitude and east of 110°45' longitude; 139,394 acres of it are in Unit 5. Approximately 5,280 acres of it is railroad land, 2,240 acres Indian patented land, and 84,540 acres New Mexico and Arizona Land Company property that has not been re-surveyed. This latter area is the only part of the Unit which has been sectionized.

The Little Colorado River meanders through the Unit in a southeasterly-northwesterly direction via a broad valley to Grand Falls where it enters a canyon. Canyon Diablo Wash, with its tributaries, Canyon Padre and San Francisco Washes, all afford drainage for the level plateau of the southwestern part of the Unit through deep canyons. They carry runoff from flash rains and melting snow.

*Acreage from original Range Management Data.

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The Jeddito, Coyote, Polacca, Oraibi and Dinnebito Washes enter the Unit from the northeast. Their flow is intermittant. The Jeddito Wash fans before it enters the Unit but reentrenches above its confluence with the Polacca. The Oraibi fans at Tolani Lakes, part of its water entering the Polacca and part draining to the Dinnebito. That portion of the Unit north of the Little Colorado River consists of a series of cuestas and rolling mesa remnants dissected by the valleys of these washes.

Population, Roads, Schools, etc.

Four trading posts are located within the Unit: the Leupp Trading Post and the Sunrise Trading Post, one and a half miles west of Leupp in the southern section; the Tolani Trading Post in the central part, and the Dinnebito Trading Post in the extreme northern part. Winslow, Arizona, is located about ten miles south of the eastern edge of the Unit and Flagstaff about 25 miles to the southwest.

The Indian population of Unit 5 is 1186. There are two principal concentrations of population, the larger at Tolani Lakes and the smaller at Leupp Agency.

A hospital and boarding school are located at Leupp Agency and a day school at Tolani Lakes.

The Unit is readily accessible by primary and secondary roads or wagon trails. The Winslow - Oraibi primary road traverses the Unit from north to south. From this, secondary roads branch to Canyon Diablo, Flagstaff, Indian Wells, and Dinnebito Trading Post.

From the exchange at Leupp, telephone lines extend south to Winslow, east to Indian Wells, and north to Tolani Lake Trading Post and day school.

The Atchison, Topeka and Santa Fe railroad traverses the southwestern corner of the Unit. Freight and supplies for Leupp are unloaded at the Canyon Diablo siding. Stockyards are located at Hibbard, in the southwestern portion of the Unit.

Climate

The elevation of Unit 5 varies from about 5,800 feet on the mesas in the north to 4,500 feet where the Little Colorado River leaves the Unit. The elevation at Tolani Lakes is 4,939, Leupp, 4,710, and Tolchico, 4,674 feet.

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No complete climatological data within the Unit are available. Table I gives the records of stations outside the Unit and Table II the estimated precipitation and length of growing season for general elevation ranges within the Unit.

Strong southwesterly winds, low humidity and clear days prevail throughout most of the year. Flash storms supply a large part of the annual precipitation.

The low annual precipitation eliminates the possibilities of dry farming; consequently farming is confined to areas where water is available for irrigation. The long growing season makes the Unit adaptable to a wide variety of cultivated crops.

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TABLE I. Climatological Data from Weather Stations in or near L. M. U. #5 *

(1) Station & Length of record **	(2) Elevation (feet)	(3) Length of Growing Season (Days)	(4) Average Annual Temperature (F°)	(5) Average Maximum Temperature (F°)	(6) Average Minimum Temperature (F°)	(7) Annual Minimum Temperature (F°)
Flagstaff 27	6907	116	60.0	45.4	30.8	-25
Grand Canyon 23	6866	133	62.4	47.3	32.3	-22
Leupp 9	4710	-	-	53.4	-	-12
Tuba City 22	4500	179	-	54.7	-	-15
Winslow 18	4848	165	70.7	54.3	37.8	-10

Table I - Continued.

(8) Annual Maximum Temperature (F°)	(9) Average Annual $P_p t_n$ (inches)	(10) Ave. Date Last Killing Frost	(11) Ave. Date First Killing Frost	(12) Latest Date of Killing Frost	(13) Earliest Date of Killing Frost
92	22.8	June 6	Sep. 20	July 5	Sep. 9
98	18.13	May 21	Oct. 1	June 17	Sep. 5
105	-	-	-	-	-
104	6.94	Apr.23	Oct. 19	May 9	Sep. 19
106	8.73	May 4	Oct. 16	June 2	Sep. 27

*University of Arizona College of Agriculture. Agricultural Experiment Station Bulletin #130. "The Climate of Arizona" by H. V. Smith. Data from establishment of station to 1930, inclusive.

**Represents length of complete record.

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TABLE II. Estimated Climatological Data for Elevation Ranges Within the Unit*

Factor	Southern	Central	Northern & Southwestern
Elevation (feet)	4500-4700	4700-5300	5300-5800
Precipitation (inches)	6-7	7-8	8-9
Growing Season (days)	160-170	150-160	140-150
Temperature (F°)	-10 to 105	-12 to 102	-15 to 100

*Compiled by W. R. McKinney, Chief, Land Management Study Group.

Agriculture

Little cultivation was practiced in the Unit prior to annexation as Indian land. Farm tracts are commonly located on recent alluvial fans where runoff from summer storms can be easily utilized for irrigation purposes.

The practice of abandoning crop land after a few years' use is prevalent here and leads to active wind erosion of abandoned areas.

With the exception of recent annexations, the entire Unit has been subject to heavy range utilization and as a result the native vegetative cover has been critically depleted over large areas. Wind erosion is very active on the light soils in these areas, whereas sheet erosion is severe on the heavier-textured soils, both due to the partial removal of the vegetative cover.

An abundance of water is available for irrigation purposes in this Unit. The Little Colorado River is semi-permanent and the main washes flow during the spring months and intermittently during the remainder of the year. The only part of this water being used to an appreciable extent at present is that in the Oraibi Wash at Tolani Lakes. Following flash storms and periods of rapidly melting snow, the washes carry large quantities of silt until well after the peak of the flow. One sample taken

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from the Dinnebito Wash following a period of rapid thawing of snow on Black Mesa showed the silt content to be 56.3% by weight. This content is not unusual. After the flood peak has passed, the flow generally continues for some time; this smaller flow is possibly better adapted to irrigation.

The quality of water for irrigation varies from excellent to fair if the silt load is not detrimental. Table VI, showing analyses of water samples from the various sources, follows the alkali tables.

Soils and Geologic Relations

Geologic formations in this Unit are represented by strata of Permian, Triassic and Jurassic ages, together with some recent lava flows in the western margin and an old alluvial terrace east of Leupp Agency. The Permian is represented by the Kaibab Limestone, the Triassic by the Moenkopi, Shinarump, and Chinle formations, and the Jurassic by the Wingate, Navajo(?) and Morrison formations.

These diverse parent materials have imparted to the soils various characteristics which influence their productive capacity and susceptibility to erosion.

The soils of the Springerville and Kaibab series which occur in the extreme southwestern portion of the Unit and derived from basaltic clinkers and lava and Kaibab limestone, are loose, permeable and medium-textured. Erosion in this area is almost lacking.

The Moenkopi series, extending north and east of the soils mentioned above, are derived from the Moenkopi and Chinle formations. Very severe erosion has produced a shallow intermittent soil cover that is slowly permeable to water and has a relatively high water-holding capacity, a combination that actually limits the total amount of available moisture. Geologic erosion is probably responsible for part of this condition.

Small areas of Shavano soil types located on remnants of the Shinarump Conglomerate formation and associated with the Moenkopi series is permeable and deep, and has a high water-holding capacity. Erosion is slight to moderate on this series.

The Todilto series derived from the limestone member of the Chinle formation and the sandstones of the Jurassic period, are found on the Uplands and Mesas of the northern part of the Unit. A loose, sandy, highly permeable and moderately deep surface soil with a moderate water-holding capacity is characteristic of this series. However, these same characteristics

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render them exceedingly susceptible to wind erosion when the vegetative cover is damaged. Active wind cutting and drifting sands prevail over a large part of the area.

A small body of Teec-Nos-Pos sandy loam is located on the old alluvial terrace east of Leupp. This soil has a relatively high water-holding capacity. Otherwise, the characteristics are essentially the same as the Todilto series.

II. EROSION

The level to rolling topography, light-textured, permeable surface soils, low annual rainfall, lack of forest, reduced grass and browse cover, and sweeping southwest winds are factors largely responsible for active wind erosion in this Unit. Wind erosion progresses in degree of severity from essentially none on the coarse-textured Springerville soils in the extreme southwestern portion of the Unit near the San Francisco Peaks, to severe on the Todilto Series in the northern portion of the Unit. As an example of what may be expected when the vegetative cover is impoverished, several square miles of large active dunes on Garces Mesa may be cited.

Sheet erosion is progressing rapidly on areas of heavier-textured soils where the vegetative cover has been damaged until its natural protective effect is reduced. The usual inverse correlation exists between the density of cover and the severity of sheet erosion extant.

Gully erosion in this Unit is largely the result of concentrations of water originating outside the boundary. Deep, side-cutting gullies occur in all principal drainageways. Active gully heads occur on the Jeddito just after it enters the Unit, on the Oraibi below the fan at Tolani Lakes, and below Blue Point. Gully erosion is not of particular significance on other portions of the Unit except as shallow fingers resulting from accelerated sheet erosion.

"The loss of a given amount of surface soil, measured in inches, from an undeveloped profile, i. e., a soil with a deep, friable profile, does not reduce the productive ability of that soil as much as the loss of the same amount of soil from a more mature profile, i. e., one having a compact and heavier-textured sub-soil." *

The ultimate conservation of range land resources devolves upon an adequate grazing control program. A vegetative cover will reduce erosion by retaining a greater proportion of precipitation where it falls, thereby retarding the rate and

*Work Report, Land Management Unit #18

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amount of runoff and subsequent sheet and gully erosion. Wind erosion is reduced by the depletion of wind currents and the binding action of roots. To obtain the maximum immediate conservation results, it would be necessary to aid and supplement the range program with engineering structure and artificial revegetation in such intensity as to be economically impractical in a range country. Specific limitations and recommendations will be taken up in the discussion of Soil Groups.

The value of a range control program in soil conservation practice must not be underestimated. Any erosion control measures employed without it will fall short of their purpose.

Artificial Revegetation

Artificial revegetation should, of course, be employed only where returns will fully justify it. The development of desilting basins or water-spreading areas, prevention of gully cutting, or reduction of wind erosion may require artificial revegetation. The adaptation of the plant to the soil, climate, alkali, etc., should be given due consideration in all instances.

Experiments in range revegation on the extensive flats of Winslow Clay are recommended if the project can be justified on the basis of experimentation and not upon net returns expected. One area which might well lend itself to this purpose, because of the water available as overflow from Tolani Lakes, is located above the confluence of the Craibi Wash with the Dinnebito Wash. This area has a dense surface soil, high salt content and relatively poor physical conditions, undesirable characteristics common to the barren flats so extensive in the Unit. Although the sub-soil of this area is more friable than the typical Winslow clay, results will be comparable.

Structures

The adaptability of various soils for structural purposes is discussed under the respective soil groups. Structures on a slowly permeable soil with consequent rapid run-off and sheet erosion materially increase the moisture content of the soil, thus stimulating plant growth. The grazing potentialities of the soil and the funds available for their development are the principal factors limiting the use of structures on range land.

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III. SOILS

The material presented in this report, including the various maps, is based on information obtained through a detailed reconnaissance soil and erosion survey. When information conflicts with that of more detailed studies, as the agronomic data on individual farms, the latter should be given precedence.

A detailed soil erosion survey and a water table study of the Tolani Lakes project have been previously reported. (1)

A detailed soil survey of the Winslow Area overlaps a portion of this survey. (2)

The soils in Unit 5 are separated according to mode of formation as alluvial or valley fill and residual or upland soils. They are further separated according to profile characteristics into five residual series and six alluvial series. These series are in turn separated into types according to surface texture.

Rough broken and rough stony lands are in reality a part of the residual group. The greater part of this land class is composed of exposed geologic shale and sandstone. Portions of these classes with appreciable areas of shallow, intermittent soil cover are separated from barren rough and rough stony land because they have greater forage potentialities.

Factors to be Considered in Grouping Soils as Range Land

The soil types have been grouped on the basis of their quality as potential grazing land, on the assumption that soil moisture is the most important factor limiting the growth of native vegetation in this region. A soil which is permeable, yet will hold the moisture in the surface twelve or eighteen inches, is the strongest grass land. Whereas, a soil which permits moisture to rapidly penetrate to greater depths is better adapted to less palatable low browse or grass types of vegetation. The very shallow residual soil types vary quite widely in range productivity.

(1) Work Report, Detailed Soil & Erosion Survey, Tolani Lakes Area. R. R. Finley, et al, S. C. S. 1935.

(2) Soil Survey of the Winslow Area. Bur. of Chem. & Soils, 1921.

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In grouping soils a basic grade is given each type on the basis of its normal profile characteristic representing the maximum ability of the type to produce native vegetation under optimum conditions obtaining in the Unit. The factors of erosion, slope and texture as they affect the rate of water penetration and run-off; alkali, dispersion and drainage in relation to permeability, modify the basic grade of each type. For instance, under normal conditions Todilto loamy sand is rated as Group B range land, but when modified by class S wind erosion it is placed in Group C.

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TABLE III. Grazing Land Soil Groups
Land Management Unit # 5

SOIL Field No.	Basic Grade
21.1	B
25.7	A
42.7	A
42.13	A
44.7	A
44.13	A
46.7	B
46.13	B
60.13	B
60.16	C
66.1	C
66.7	B
66.13	B
66.16	C
68.7	B
68.13	B
70.10	B
70.13	B
71.7	A
79.1	A
79.7	B
79.13	B
79.16	C

MODIFYING FACTORS*

I. Erosion:

Grade A - Less than 25% A horizon removed by sheet or wind; wind accumulations less than 6" deep, or occasional class A gullies.

Grade B - 25 to 75% A horizon removed, less than 12" hummocks, or occasional gullies, B or C.

Grade C - More than 75% A or upper B horizon removed, hummocks 36" deep, or moderately frequent B or C gullies.

Grade D - Removal of lower B and upper C horizon hummocks over 36" deep, or frequent gullies, Class B or C, or geologic erosion.

Grade E - Geologic erosion or class 9 gullies.

II. Permeability Chart:

Slope %	Texture: Sand	Sandy loam	Loam	Clay loam	Clay
0-5	A	A	A	A-B	B-C
5-10	A	A	B	B	B-C
10-20	B	B	C	C	C-D
20-40	C	C	C	D	D-E
40+	D	D-E	D-E	D-E	D-E

III. Water Holding Capacity:

Grade A - High, drainage excellent

Grade B - Moderate to high, drainage adequate

Grade C - Moderate to low, drainage fair to poor

Grade D - Low, drainage poor

Grade E - Essentially none

IV. Alkali:

Grade A - Of no consequence, white less than 0.2%, no carbonates

Grade B - Low, not affecting vegetation

Grade C - May be high enough to affect type of native vegetation

Grade D - High, may limit amount as well as type of native vegetation

Grade E - Excessive

*The modifying erosional factors in Table III are set up for a soil of moderate or mature development; for a less developed soil, a like erosion class is proportionately less detrimental to the grazing potentialities.

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TABLE IV

Total Acreage of Soil Types in Range Land
Soil Groups* - Land Management Unit #5

Soil Types	Group A (Acres)	Group B (Acres)	Group C (Acres)	Group D (Acres)	Group E (Acres)	Totals
Todilto Loamy sand & loam undifferentiated		104,352	98,403	13,182		215,937
Springerville sandy loam	22,158	6,059	14,104			42,321
Shavano sandy loam	4,405	9,730	4,682			18,817
Shavano clay loam			587			587
Kiabab sandy loam		50,917	1,856			52,773
Kiabab clay loam	4,455					4,455
Moenkopi sandy loam		733	2,710	367		3,810
Moenkopi clay loam		1,052	4,140	3,125		8,317
Hunt clay loam			2,245			2,245
Hunt clay			13,071	3,703		16,774
Ives loamy sand			2,354	1,774		4,128
Ives sandy loam			3,537			3,537
Ives clay loam		815	38,114			38,929
Ives clay			15,035	2,335		17,405
Tolani sandy loam		2,367	41,776			44,143
Tolani clay loam		1,245	7,947			9,192
Tolani clay			3,447	5,101		8,548
Gila loam			1,642			1,642
Gila clay loam		1,845	11,849			13,694
Bes Nos Pos sandy loam		9,232				9,232
Winslow loamy sand	182					182
Winslow sandy loam		3,689	2,830			6,519
Winslow clay loam	215	2,075	10,492			12,782
Winslow clay			23,191	48,693		71,884
Dune sand				3,025	1,121	4,146
Urban					722	722
River wash					5,558	5,558
Rough broken & undifferentiated soil remnants				64,204	1,509	65,713
Rough broken				1,272	126,541	127,813
Totals	31,415	184,111	309,143	141,680	135,451	811,800

*Preliminary data by planimeter

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Numeric designation of Soil Series and Types

Soil Series Name	No.	Textural Class Name	No.
Todilto	21	Sand	1
Springerville	25	Sandy loam	7
Shavano	42	Loam	10
Kiabab	44	Clay loam	13
Moenkopi	46	Clay	16
Hunt	60		
Ives	66		
Tolani	68		
Gila	70		
Teec Nos Pos	71		
Winslow	79		

Group A represents soils having the highest potential grazing capacities, Group D, the low grade soils, and Group E those having essentially no value for grazing purposes.

For convenience, the important characteristics of the soil series and types are presented in tabular form. See Table VII.

"A" GROUP RANGE LAND:

In Unit 5 the following limits are recognized in Group A grazing land:

1. Erosion - Class 1, 2, P, F or 7
2. Permeability - High
   Slope generally less than 3%
   Texture average sandy loam, or clay loam
3. Water-holding capacity - High
4. Alkali - Low
   White - less than 0.2%
   Carbonate - none

Portions of the following soil types are included in this grade:

Residual - Springerville sandy loam
Shavano sandy loam
Kiabab clay loam

Alluvial - Teec Nos Pas sandy loam

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Moisture Penetration (No accurate data available)

The estimated relative rate of water penetration is based on field observation of texture, slope and other physical characteristics.

Soils in this group have a readily permeable surface soil and are level enough to absorb normal precipitation.

Sub-soils or substrata are commonly less permeable than the surface soils.

Water-Holding Capacity (No accurate data available)

The water holding capacity of Group A soils is high, either because of the reservoir effect of the sub-soil alone, or the combined surface and sub-soil. Normal precipitation is held within the root zone of native plants.

Vegetative Adaptation

Highly palatable grasses, mainly black grama (Bouteloua eriopida)*, blue grama (Bouteloua gracilis), and galleta (Hilaria jamesii) are adapted to the soils of this group. Shavano sandy loam sometimes supports a growth of sage (Artemisia tridentata). These soils make maximum use of rainfall in the production of native vegetation.

Value of Soil for Structural Purposes

Group A soils may be safely used in earth structures. Statements concerning the value of soils for structural purposes are general, and are based on field observation and laboratory analysis.

Erosion

Erosion on these soils is not at present critical and should never become a problem unless the land is heavily overutilized.

Improvement Program Feasible from Soils Standpoint

Proper range management is recommended.

*Branch of Range Management.

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The topographic position of these soils limits the possibilities of spreading water on them.

Precautions

The coarse texture of the Springerville sandy loam and the porous nature of the underlying cinders render the sealing of tanks almost impossible on this particular type. Furthermore, essentially no run-off is expected from this group.

"B" GROUP:

Group "B" soils have the following maximum limits:

1. Erosion: Class 3 sheet erosion, Class R wind removals, Class K accumulations, occasional gullies, Class B or C.

2. Permeability: Moderate to high. Slope strong enough for given texture to permit some run-off, generally less than 10%.

3. Water-holding capacity: Moderately high. Drainage adequate.

4. Alkali: Not affecting the type of native vegetation.

Portions of the following soil types are found in Group "B":

Residual:

Todilto loamy sand
Shavano sandy loam
Kiabab sandy loam

Alluvial:

Winslow sandy loam
Ives sandy loam
Ives clay loam

Moisture Penetration (No accurate date available)

The rate of moisture penetration in some Group "B" soils may be equivalent to or greater than that of "A" soils. That of Todilto loamy sand is more rapid because of the extremely light texture of surface soil permitted in this class.

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Water-Holding Capacity (No accurate date available)

Because of a relatively shallow soil cover, some of the residual soils may be expected to have a lower water holding capacity than Group "A" soils. This is in part offset by the consolidated sub-surface material which holds the moisture at a depth readily accessible to the shallow grass roots. The moisture holding capacity of the alluvial soils is variable because of the several textural grades represented. However, it can be expected to be as high as that of corresponding textural grades of Group "A" soils.

Vegetative Adaptation

This group is capable of producing a good sod of grass with occasional areas of sagebrush and scattered browse. Spiny muhly (Muhlenbergia pungens), and Mormon tea (Ephedra spp.) occupy many of the hummocks. In so far as the low annual rainfall will permit, these soils will respond readily to a range management program.

Value of Soil for Construction Purposes

Soils of this group in general may be safely used for construction purposes. However, caution is recommended in the use of Winslow sandy loam because of the physical condition of the sub-soil.

Erosion

Moderate erosion is prevalent on "B" group soils.

Improvement Program Feasible from Soils Standpoint

Approved range practices will effect a relatively rapid return of normal vegetative cover. Artificial revegetation or structural work are not generally recommended.

Precautions

Cracks in the limestone underlying the Kiabab series necessitates utmost care in selecting sites for water tanks, etc.

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"C" GROUP

"C" Group soils have the following maximum limits:

1. Erosion: Class 4 sheet erosion, Class 8 wind removals, Class L accumulations or moderately frequent gullies.

2. Permeability: Moderate to low.
   Slopes strong enough to induce considerable run-off on heavier-textured types during flash storms; average less than 20%.

3. Water-holding capacity: Moderate to low. Drainage may be poor.

4. Alkali: May be high enough to limit the native vegetation to the more tolerant plants, e. g. greasewood, saccaton and shadscale.

Portions of the following soil types fall in this group:

Residual:

Todilto loamy sand
Shavano sandy loam
Moenkopi sandy loam
Moenkopi clay loam

Alluvial:

Ives loamy sand
Tolani sandy loam
Winslow sandy loam
Ives clay loam
Tolani clay loam
Gila clay loam
Hunt clay loam
Hunt clay
Ives clay

Moisture Penetration (No accurate data available)

The rate of moisture penetration in this group of soils varies considerably because of the wide range of textures. For areas having class 2 sheet erosion or less the rate of penetration is about the same as for Group "B" soils. On areas having more severe sheet erosion, or 77 gullies, the permeability is low below a depth of about 3 inches, due to the heavy texture of the sub-soil. This is especially true of the Winslow and Hunt series.

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Water-holding Capacity (No accurate data available)

Deep gullies, facilitating rapid run-off, are largely responsible for the shortage of available moisture in the soils near the main washes. The water retaining ability of the alluvial sands is low and of the alluvial clays high; that of residual soils is about the same as Group "B" residual soils, except that of the Moenkopi series, which is materially lower because of its shallow profile.

Vegetative Adaptations

The vegetative cover is similar in species but more sparse than those on "B" group residual soils. The alluvial soils are adapted to chamisa (Atriplex canescens), greasewood (Sarcobatus vermiculatus), shadscale (Atriplex confertifolia), and various grasses such as sacaton and galleta.

Various tree species such as cottonwood, tamarisk and Chinese elm are adapted to the alkali-free alluvial soils, such as portions of the Gila series.

Value of Soils for Construction Purposes

Some difficulty may be experienced with structures on the Hunt soils, Winslow sandy loam, and to a lesser extent on the Tolani series because of soil dispersion. The heavy-textured soils are unsuited for structural purposes because a high colloidal clay content makes them subject to excessive heaving and swelling on wetting and cracking on drying.

Erosion

Extensive areas of class S wind erosion are situated in the northern portion of the Unit. The deep gullies referred to in the paragraph on "Water Holding Capacity" reduce the value of the soil through excessive surface drainage.

Improvement Program Feasible from Soils Standpoint

Response to a range control program will be relatively slow on these soils. This is especially true of the eroded Moenkopi soils and the heavier-textured alluvial soils.

Water spreading on these soils, if carefully handled, should aid in the production of native plants. On such areas where

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alkali is not present in harmful amounts, sweetclover, various species of wheatgrasses and almost any of the deciduous tree species adapted to the reservation should thrive.

Precautions

If over-utilization of the light textured residual soils is continued, many areas will revert to waste land of alternate bodies of barren geologic formation and moving sand dunes.

"D" GROUP

This group has the following limits:

1. Erosion: Class 5 sheet, Class T wind removal, Class N or O wind accumulations, Class 9 gully (none mapped in this Unit).

2. Permeability: Low. Slope less than 40% or strong enough to induce excessive run-off.

3. Water-holding capacity: Low.

4. Alkali: High. May affect the density and growth as well as the species of native vegetation. 3.0% white alkali or 0.1% carbonate. May result in highly dispersed condition.

Portions of the following soil types are included in the group:

Residual:

Todilto loamy sand

Alluvial:

Ives sandy loam
Ives clay and
Winslow clay.

Rough broken or rough stony land with intermittent soil areas of Todilto loamy sand or Moenkopi sandy loam and clay loam are also included in this group.

Moisture Penetration (No accurate data available)

The rate of moisture penetration into most Group "D" soils

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is very low because of the heavy texture and high dispersion ratio of the exposed "B" horizon, steep slope, or very shallow soil cover. Exceptions to this are the Ives and Todilto loamy sands on which wind erosion is so active that the productivity is low and confined principally to annuals.

Water Holding Capacity (No accurate data available)

The water retaining capacity of all remaining soils except sand is relatively high. However, the rate of water penetration is so slow as to render the water holding capacity of little value. Where this is not the case the shallow soil cover is the limiting factor.

Vegetative Adaptation

The sparse native vegetative cover on "D" Group soils consists mainly of shadscale, alkali sacaton and browse. Sunflowers (Helianthus spp.) are observed to be thriving on some of the Winslow clay areas. Several species of wheat grass should be adapted to areas of the Ives series.

Value of Soil for Construction

Soils of this group are generally of the lowest value for construction purposes. Erosion has removed large portions of the surface soil and exposed the more dispersed sub-soil.

Improvement Program Feasible from Soils Standpoint

Intensive treatment is not recommended for "D" Group soils. If artificial revegetation is anticipated, the program should evolve from experiments conducted under similar conditions as suggested in paragraph on Artificial Revegetation, page 8.

A strictly enforced range management policy will show the slowest returns upon this group; but a land and water conservation program should depend strongly upon this method of control.

The sand dune area on Garces Mesa, mentioned before, covers some 6,000 acres. Active dunes are moving across an extensive grass land area. The need of effecting stabilization is apparent. In at least one place the water table is within fifteen feet of the surface. If grazing were excluded, either by mutual agreement or by the construction of seven or eight miles of fence, at least partial stabilization might be effected. Among the better adapted species are Russian thistle, spiny muhly, tamarisk and cottonwood.

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"E" GROUP

Group E has the following limiting factors:

1. Erosion: Geologic

2. Permeability: Very low. Slopes 40% and over and barren.

3. Water-holding capacity: Very low or droughty.

4. Alkali: Important only as it affects the total salts in run-off or influences silt deposits below.

This troup includes all areas of exposed geologic formations classified as rough stony or rough broken land having essentially no grazing value.

Moisture Penetration and Water Holding Capacity

A large percentage of the precipitation falling on these areas escapes as run-off because of prevailing steep slopes and bare geologic material. The water holding capacity is very low.

Vegetative Adaptation

Sparse growths of shrubs and grasses comprise the vegetative cover of the group.

Value of Soil for Construction Purposes

The only constructional value these areas possess is the available masonry rock supply.

Erosion

Erosion of geologic material is characteristic of these areas.

Improvement Program Feasible from Soils Standpoint and Precautions

No improvement is possible on these areas since the soil cover is so shallow, and the slopes are too steep to support appreciable amounts of vegetation.

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III. AGRICULTURAL SOILS

No attempt to discuss agricultural land groups is made in this report. Instead, the adaptability of each type to irrigation is discussed, and the group or groups into which each type is placed is mentioned.

Agricultural soils are limited to the alluvial deposits in the valleys. Local areas within the residual soil bodies may be cultivated if water is available for irrigation and the hazards of wind erosion are reduced.

The value and limitations of areas which were more carefully investigated in the field are discussed briefly. A map with the agricultural soil grades superimposed on the Range Land Soil Group Map accompanies this report.

The alluvial soils are more or less adapted to agriculture. They are the Hunt, Ives, Tolani, Gila, Tees Nos Pos, and Winslow series.

These soils are graded according to their value for irrigation in a manner similar to that used for the grouping of range soils. Group A is regarded as excellent from the standpoint of quality for irrigation, Group B, good, Group C fair to poor, and Group D as non-irrigable.

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TABLE V. Agricultural Land Soil Groups for Irrigation
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SOIL Field No.	SOIL Basic Grade	LIMITING FACTORS
60.13	B	I. Erosion*
60.16	C	Grade A - Less than 25% A horizon removed by sheet erosion.
66.1	B	Grade B - 25-75% A horizon removed
66.7	A	occasional gullies.
66.13	B	Grade C - More than 75% A horizon or upper
66.16	C	B horizon removed, frequent shallow gullies.
		Grade D - Removal of lower B or C horizon,
68.7	B	frequent deep gullies.
68.13	C	
		II. Moisture Penetration:
		Grade A - rapid.
		Grade B - Moderately rapid.
70.10	B	Grade C - Slow.
70.13	B	Grade D - Very slow.
71.7	A	III. Water Holding Capacity:
		Grade A - High, drainage excellent.
79.7	B	Grade B - Moderate to high, drainage adequate.
79.13	C	Grade C - Moderate to low, drainage fair to poor.
79.16	D	Grade D - Low, drainage poor.
		IV. Alkali:
		Grade A - Of no consequence: White, less than 0.2%, no carbonate.
		Grade B - Low, not affecting vegetation.
		Grade C - May be high enough to limit crops to more tolerant plants.
		Grade C - High, very poor or no crops possible.

Numeric Designation of Soil Series and Types

Soil Series Name	No.	Textural Class Name	No.
Hunt	60	Sand	1
Ives	66	Sandy loam	7
Tolani	68	Loam	10
Gila	70	Clay loam	13
Teec Nos Pos	71	Clay	16
Winslow	79		

*The modifying erosional factors are set up for a soil of moderate or mature development; for a less developed soil, a like erosion class is proportionately less detrimental to the irrigation potentialities. See appendix for description of soil types.

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The Tolani, Hunt and Winslow series have a number of characteristics in common. They are derived primarily from the Chinle and Moenkopi formations which impart to soils appreciable amounts of harmful salts often resulting in a dispersed condition of the soil. They are all susceptible to wind erosion. Shadscale, greasewood, sacaton, and galleta are native plants normally adapted to these soils.

The Tolani Series is usually located on toe slopes bordering valleys. Consequently, subjugation is generally costly. The surface soil is light in texture and the subsoil is loose, open and light-textured and very susceptible to wind erosion. The salt content is usually lower than the other two series derived from the same formations, but because of the severe wind erosion, it is generally rated as "C" or poor agricultural land. Small areas more suited to irrigation occur throughout the series. Two such areas are discussed in detail.

Natani's farm west of the Dinnebito Wash is an area of well-drained, light sandy loam. The dispersion is moderately high but is probably not injurious because of the light texture of the profile.

An area of Tolani light sandy loam or loamy sand is located approximately four miles above the confluence of the Dinnebito Wash and the Little Colorado River. Samples from this area indicate that it is irrigable, but a more detailed investigation is recommended before subjugation.

Both of the above areas are susceptible to wind erosion. Some difficulty may be experienced in sealing irrigation ditches until silt is deposited in them to seal the porous walls.

The Hunt Series differs from the Tolani soils in that the sub-soil is usually heavy and slowly permeable. This is significant, because if the salts are not readily leached when irrigation water is applied, an alkali condition unfavorable to plant growth may develop. If the sub-drainage is adequate the sandy loam and clay loam are well adapted to irrigation and are rated B or C, agricultural land. The clay type is rated as D, non-irrigable, unless drainage is exceptionally favorable and ample water is available for irrigation.

The Winslow Series has a rather dense B horizon. When the friable surface soil is intact, the series is generally adapted to irrigation in an arid climate, because the B horizon serves as a water storing reservoir. However, in this Unit the surface soil has generally been severely eroded following over-utilization by livestock, leaving the unproductive subsoil exposed. The alkali content of many areas is high enough to

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rate this soil as D agricultural land. One area is located north of the Little Colorado River approximately five miles northwest of Leupp Agency. If alkali is not too high at present and wind erosion can be controlled, this area is recommended for irrigation from the water of the Little Colorado River.

The Ives Series is a recent deposit along the drainage channels of main washes and on alluvial fans. A friable surface soil over a medium to heavy-textured subsoil is characteristic. The subsoil is not heavy enough to prevent adequate sub-drainage, except in the heavy-textured types. The sandy loam and clay loam types are rated excellent agricultural land, the loamy sand as good or fair, and the clay as poor or non-irrigable.

An area of 1000 acres or more on the fan of Corn Wash above Leupp Agency appears to be well adapted to the irrigation by water from the Little Colorado River. The reconnaissance indicates it to be the best potential irrigation development, from a soils standpoint, along the Little Colorado River. It will be necessary to provide protection from wind erosion. A more detailed investigation is recommended.

Satisfactory growths of native vegetation can be expected on the proposed water spreading areas along the Jeddito and Polacca Washes. However, the utmost care in handling water along the Polacca Wash is necessary because the deep friable soil is highly susceptible to head cutting and gullying.

The Teec Nos Pos Series is mapped on an old alluvial terrace approximately twelve miles east of Leupp Agency. This soil is a deep friable sandy loam free from alkali which has adequate sub-drainage. Because of exposure it is slighly susceptible to wind erosion. From a soils standpoint it is well adapted to irrigation and is classed B grade land. The distance from the Little Colorado River would increase the cost of subjugation.

The Gila Series is river bottom soils favorably located from the standpoint of water supply. The texture of surface and subsoil is favorable to irrigation. However, a high concentration of alkali in many places limits the utility of this series for cultivated crops. Both loam and clay loam types are similar in adaptations. They are rated as good agricultural soils except where the alkali content or ground-water table does not reduce it to the D Group.

An area approximately thirteen miles east of Leupp Agency is too high in total salts and poor in physical condition to be considered as potential agricultural land.

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Another area of about 200 acres tentatively rated as "B" agricultural soil is located approximately two and one-half miles below the Sunrise Bridge on the north side of the Little Colorado River. The potentialities of this area warrant more detailed investigation.

TABLE VI

Distribution of Soil Types Included in Agricultural Land Soil Groups*

Soil Type	Group A (Acres)	Group B (Acres)	Group C (Acres)	Group D (Acres)	Totals
Gila loam			1,642		1,642
Gila clay loam		2,278	11,416		13,694
Winslow loamy sand		182			182
Winslow sandy loam		3,689	2,830		6,519
Winslow clay loam		541	9,821	2,420	12,782
Winslow clay				71,884	71,884
Ives loamy sand		2,354		1,774	4,128
Ives sandy loam	3,537				3,537
Ives clay loam		35,870	3,069		38,939
Ives clay			4,225	13,175	17,400
Tolani sandy loam	255	2,112	37,576	4,200	44,143
Tolani clay loam			9,192		9,192
Tolani clay				8,548	8,548
Hunt clay loam			2,245		2,245
Hunt clay				16,774	16,774
Tees Nos Pos sandy loam		9,232			9,232
Totals . .	3,792	56,252	82,006	118,775	260,831

*Preliminary data by planimeter

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IV. ALKALI

Accumulations of toxic salts is a factor limiting the utilization of many soil areas in Unit.5. Specific mention of alkali has been made under each group and further discussion has been presented in the description of agricultural soils.

Alkali and profile samples are listed in Table VII which show total salts and mechanical analysis of various samples of the several soil types.

The quality and source of waters available for irrigation are presented in Table VIII.

H. F. Johnson
Junior Conservation Specialist

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TABLE VII. Laboratory Analysis of Soil & Alkali Samples Collected in L. M. U. #5, 1937

Lab. No.	Field No.	Remarks	Depth	% Salts	P.P.M. Na_2CO_3	% Sand	% Silt	% Clay	% Disp.*
3905	S11-05-01	Kiabab	Surface	.02	0	75.1	16.8	8.1	
3907	S11-05-03	"	0-4"	.02	0	76.7	10.9	12.4	
3908	S11-05-04	"	4-20"	.12	Tr.	44.5	23.9	31.6	
3908	S11-05-05	"	20-24"	.125	73	44.0	17.9	38.1	
4003	S11-05-38	Gila	0-12	.075	Tr.	23.2	13.4	63.4	8.0
4004	S11-05-39		12-24	.02	0	93.4	3.1	3.5	28.7
4005	S11-05-40		24-36	.02	0	96.7	0.9	2.4	14.7
[illegible]10	S11-05-06	Gila	0-12"	.125	Tr.	17.7	58.1	24.2	10.7
[illegible]1	S11-05-07		12"24	.165	Tr.	17.9	63.3	18.8	12.9
3912	S11-05-08		24"36"	.54	0	12.7	45.2	42.1	10.3
3913	S11-05-09	Gila	Composite	.15	0	49.7	30.4	19.9	4.6
3979	S11-05-16	Gila	0-12'	0.96	0	37.2	34.8	28.0	19.0
3983	S11-05-17		12-24	.70	0	45.3	34.5	20.2	6.9
3980	S11-05-18		24.36	0.38	0	84.4	7.6	8.0	34.7
3984	S11-05-23	Gila	0-12	.100	83	80.9	9.4	9.7	14.3
3985	S11-05-24		12-24	.170	114	84.1	6.1	9.8	42.8
3986	S11-05-25		24-36	.890	31	26.9	30.6	42.5	55.1
3987	S11-05-26	Gila	0-12	1.80	Tr.	72.1	13.3	14.6	3.5
3988	S11-05-27		12-24	0.60	83	75.4	9.3	15.3	70.2
3989	S11-05-28		24-36	1.39	31	33.6	33.6	32.6	83.6
[illegible]	S11-05-02	Springer-ville	Composite	.02	0	71.3	8.1	20.6	
4009	S11-05-44	Springer-ville	0-12	.06	0	64.2	24.4	11.4	27.5
4010	S11-05-45		12-24	.02	0	66.8	22.6	10.6	12.0
4011	S11-05-46		24-30	.075	200	80.5	15.4	4.1	
4012	S11-05-47	Basaltic Cinders	30-						
4013	S11-05-49	Moenkopi	0-4"	.175	0	54.7	19.9	25.4	64.0
4014	S11-05-50		4-8"	.12	0	42.2	28.3	29.5	21.8
4015	S11-05-51		8-12"	.07	Tr.	46.2	37.2	16.6	32.2
4016	S11-05-52		12-	.37	177	19.6	60.3	20.1	48.5

*%Disp. - Percent clay fraction dispersed by contact with water for fifteen minutes.

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Lab. No.	Field No.*	Remarks	Depth	%** Salts	P.P.M. Na_2CO_3	% Sand	% Silt	% Clay	% Disp.
4000	S11-05-35	Winslow	0-12	.15	Tr.	32.7	13.8	53.5	4.7
4001	S11-05-36		12-24	.20	Tr.	24.4	12.2	63.4	6.8
4002	S11-05-37		24-36	.25	Tr.	73.7	10.5	15.8	31.1
4006	S11-05-41	Winslow	0-12"	.26	108	22.1	15.6	62.3	23.5
4007	S11-05-42		12-24"	1.06	62	20.0	12.9	67.1	38.0
4008	S11-05-43		24-36	1.09	Tr.	47.4	6.1	46.5	
3977	S11-05-14	Navajo	0-15"	2.0	0	15.	28.3	58.2	8.9
3978	S11-05-15		15-48"	2.30	0	11.1	29.4	59.5	4.9
3994	S11-05-29		0-12	1.90	Tr.	28.7	44.3	27.0	58.2
3995	S11-05-30		12-24	2.00	Tr.	19.1	30.9	50.0	16.6
3996	S11-05-31		24-36	2.00	Tr.	15.8	32.6	51.6	8.6
3997	S11-05-32	Ives	0-12	.15	0	74.2	6.4	19.4	23.1
3998	S11-05-33		12-24	.18	0	35.7	32.5	31.8	14.0
3999	S11-05-34		24-36	.02	0	89.6	3.6	6.8	22.9
3990	S11-05-11	Tolani	0-12	.18	74	72.5	4.7	22.8	24.6
3991	S11-05-12	Natani's Farm	12-24"	.17	208	67.7	4.8	27.5	70.0
3992	S11-05-13		24-36"	.145	260	80.5	6.0	13.5	61.0
4084	S11-05-53	Tolani	0"-3"	.02	0	82.4	5.3	12.3	12.3
4085	S11-05-54		4-8"	.11	0	77.9	8.7	13.4	13.0
4086	S11-05-55		10-18"	.105	0	83.8	4.5	11.7	5.1
4087	S11-05-56		20-24	.02	0	87.9	2.5	9.6	9.6
4088	S11-05-57		24-60	.095	0	89.7	3.8	6.5	16.0
3981	S11-05-19	Teec Nos Pas	0-15	.105	0	73.0	7.1	19.9	
3982	S11-05-20		15-30	.080	Tr.	66.0	7.3	26.7	
3983	S11-05-21		30-40	.070	Tr.	67.0	1.4	31.6	

*See map for location.
** Total salts by modified wheatstone bridge.
*** Less than .02%.

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TABLE VIII. Laboratory Analysis of Water for Irrigation Purposes L. M. U.#5

Lab. No.	Field No.	Description	Total Salts	Ca	Mg	Na	Cl	SO_4	CO_3	HCO_3	Alkali** Coefficient	% Silt by Wt.	% Silt by Vol.
986	S11-05-10	Dinnebito Wash, normal spring flow.	2260	209	34	458	47	1400	14	134	Fair	Very low	
987	S11-05-11	3-26-37 Little Colorado River ****	312	15	6	85	83	50	0	94	Good	1.42	.60
988	S11-05-44	Little Colorado River	328	17	6	95	77	85	0	95	Good	2.40	.92
989	S11-05-52	Little Colorado River	292	17	2	87	65	50	0	115	Good	2.22	.85
990	S11-05-53	Canyon Diablo Wash	70	9	6	0	6	Tr*	0	51	Excellent	Very little	
991	S11-05-22	Dinnebito Wash, Flood from melting snow	-	-	-	-	-	-	-	-	-	56.3	35.1
***	-	Oraibi Wash	3430	136	44	716	105	2000	0	110	Fair	-	-
***	-	Polacca Wash	3632	228	50	868	247	2125	6	112	Fair	-	-

* Tra. - Trace

** Alkali Coefficient and Irrigation Classification from the "Quality of the Waters of Southeastern Nevada, Drainage Basins and Water Resources" by George Hardman and Meredith R. Miller. The University of Nevada Agricultural Experiment Station, Bulletin No. 156, P 20. The alkali coefficient is defined as being the depth in inches of water which, on evaporation, would yield sufficient alkali to render a four foot depth of soil injurious to the most sensitive plants.

*** Detailed Erosion Survey Tolani Lakes Survey, Tolani Lakes, Arizona, 1938, R. R. Finley.

**** Samples from Little Colorado River at approximately two week intervals.

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TABLE IX. General Characteristics of Soils of L. M. U. # 5

Residual Soils

Series Type	Field No.	1. Surface 2. Subsoil 3. Substratum or Parent Material	Topography, Erodibility, Alkali (if present), Vegetation, Depth
Todilto loamy sand (sandy loam undifferentiated)	21.1	1. Light brown, loose, highly permeable, loamy sand with sandy loam undifferentiated, low water holding capacity. 2. Slightly compact, permeable, moderate water holding capacity. 3. Limestone or sandstone more or less impervious.	Gently rolling cuesta or mesa topography. Susceptible to wind erosion. Grass and low browse. Average depth 24" or more.
Springerville sandy loam	25.7	1. Brown, friable, very permeable, often approaching loam, moderate water holding capacity. 2. Grey cast, more firm, permeable, moderate water holding capacity. 3. Lava or loose basaltic ash, highly permeable, very low water holding capacity.	Gently sloping plateau topography not susceptible to erosion. Grass 24" to 36" deep.
Shavano Sandy loam	42.7	1. Brown, friable, permeable, moderate water holding capacity. 2. Firm, permeable, water holding capacity good. 3. Weakly consolidated arenaceous material, relatively impervious.	Topography gently rolling. Moderately susceptible to wind erosion. Grass and sagebrush, 36" or more deep.
clay loam	42.15	1. More slowly permeable, slightly compact, high water holding capacity. 2. & 3. Same as 42.7	Slightly subject to sheet erosion.
Kiabab sandy loam	43.7	1. Light brown, friable, moderately permeable, rock outcrops and shallow spots common, moderate water holding capacity. 2. Slightly compact, less permeable, moderate water holding capacity. 3. Limestone impervious.	Gently sloping plateau. Susceptible to slight sheet erosion. Grass. Average 12" or less. Shallow.
Clay loam	43.15	As above except higher water holding capacity.	Depth 30"

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Series Type	Field No.	1. Surface 2. Subsoil 3. Substratum or Parent Material	Topography, Erodibility, Alkali (if present,) Vegetation, Depth
Moenkopi sandy loam	46.7	1. Maroon, loose, moderately permeable, moderately high water holding capacity. 2. Slightly compact, slowly permeable, moderately high water holding capacity. 3. Arenaceous shale and sandstone, relatively impervious.	Sloping to broken topography susceptible to sheet, shallow gully and wind erosion. Harmful salts present resulting in poor physical condition. Sacaton, shadscale. Average depth 12" or less.
Moenkopi	46.13	Similar to above except slightly less permeable and of firm consistency.	Slightly less susceptible to wind and more susceptible to sheet erosion.
		Alluvial Soils	
Hunt clay loam	60.13	1. Purplish-brown, moderately compact, moderately permeable, high water holding capacity. 2. Very compact, slowly permeable, high water holding capacity. 3. Dense, compact, stratified clay. Slowly permeable, high water holding capacity.	Valley fill topography, susceptible to sheet, wind and gully. Alkali high. Shadscale. Deep alluvium.
Hunt clay	60.16	1. Compact, slowly permeable. 2. & 3. Same	Same
Ives loamy sand	66.1	Uniform profile. Grey. Loose or friable, blocky loamy sand, readily permeable, low to moderately low water holding capacity.	Valley fill topography, hummocky, wind erosion. Camise, annuals, deep alluvium.
sandy loam	66.7	Same - higher water holding capacity.	Same - slightly erodible by water and wind.
clay loam	66.13	Same - moderately permeable, high water holding capacity. Moderately compact.	Same.
clay	66.16	Same - slowly permeable, compact.	Same.
Tolani sandy loam	68.7	Uniform profile reddish brown, loose, blocky structure, permeable, moderately low water holding capacity.	Valley fill and toe slope, hummocky. Susceptible to wind erosion. Grass, browse. Deep, sometimes partly wind deposited.
clay loam	68.13	Same, moderately high water holding capacity, more compact.	Same - slightly susceptible to water erosion.

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Series Type	Field No.	1. Surface 2. Subsoil 3. Substratum or Parent Material	Topography, Erodibility, Alkali (if present) Vegetation, Depth
Winslow sandy loam	79.7	1. Reddish brown, loose massive, permeable, moderately low water holding capacity. 2. Heavier-textured, compact, slowly permeable, moderate to high water holding capacity. 3. Loose, light-textured material, readily permeable, water holding capacity low.	Gently sloping valley floor. Susceptible to wind erosion; grass, deep.
clay loam	79.13	1. As above, moderately permeable, high water holding capacity. 2. As above. 3. Slightly compact, slowly permeable, high to moderate water holding capacity.	Same - susceptible to sheet and wind; grass and atroptoxos, alkali high.
clay	79.16	1. Slowly permeable below 3 or 4 inches, high water holding capacity. Compact below surface mulch. 2. Similar to 1, very compact. 3. Compact.	Same.
Teec Nos Pos sandy loam	71.7	1. Light brown to reddish brown, permeable, moderately high water holding capacity, friable. 2. Moderately compact, moderately permeable, high water holding capacity. 3. Slightly compact, permeable, moderately high water holding capacity, friable.	Gently sloping to broken old terrace, slightly susceptible to wind erosion; grass.
Gila loam	70.10	1. Uniform profile, light brown to purplish brown, permeable, moderately high water holding capacity, loose to slightly compact, statified material. Intermittently high water table, often considerable amount of organic matter present.	Gently sloping river bottom soil subject to overflow and wind erosion, alkali spotted by high grasses, greasewood, and cottonwood.
clay loam	70.13	Same.	Same.

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TABLE X. Distribution of Soil Types in Range Land Soil Groups by Sub-Units.

Soil Type	Group A (Acres)	Group B (Acres)	Group C (Acres)	Group D (Acres)
SUB-UNIT I				
Rough Broken Land and undifferentiated Moenkopi sandy loam				14,285
Kiabab sandy loam	12858			
Moenkopi sandy loam	589	2788		
Moenkopi clay loam		218		3,194
Winslow clay loam	461			
Winslow clay				352
TOTALS	13908	3006	000	17,831
TOTAL GROUPS A B C & D				34,745
OTHER				
AREA SUB-UNIT I				
SUB-UNIT II				
Rough Broken Land				~~2,918~~ 1,977
Rough Broken Land & undifferentiated Moenkopi sandy loam				1,730
Shavano sandy loam	3942			
Shavano clay loam		550		
Kiabab sandy loam			1235	
Moenkopi clay loam			2099	
Gila loam			102	
Gila clay loam			4467	
Winslow clay loam		1338	608	
Gila clay			4909	17,830
TOTALS	3942	1888	13,634	~~22,478~~ 21
TOTAL GROUPS A B C & D				~~41,722~~
OTHER				
AREA SUB-UNIT II				
SUB-UNIT III				
Rough Broken land				2,278
Rough Broken Land & undifferentiated Todilto series				2,221
Todilto sand		28748	1498	
Hunt clay loam		2106		
Hunt clay				3,689
Hunt clay loam and clay, undiff.			13440	
Ives sandy loam			1171	
Tolani sandy loam			17402	
Tolani clay			2790	
Gila loam			1446	
Gila clay loam			5312	

(Cont'd)

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TABLE X. Continued.

Soil Type	Group A (Acres)	Group B (Acres)	Group C (Acres)	Group D (Acres)
SUB-UNIT III-Continued.				
Teec Nos Pos sandy loam		8,915		
Winslow sandy loam			8,448	
Winslow clay loam			760	
Winslow clay				1,952
Winslow clay and clay loam, Undiff.				12,614
TOTALS	00	37,663	34,381	22,694
TOTAL GROUP A B C AND D				114,738
OTHER				
AREA SUB-UNIT III -				
SUB-UNIT IV				
Rough Broken Land & Undifferentiated soil remnants		6,253		2,198
Todilto sand		63,722	84,890	12,877
Todilto sandy loam		435		
Ives sand			2,227	1,683
Ives sandy loam			1,082	
Ives clay loam		730	37,216	
Ives clay			22,445	2,777
Tolani sandy loam		2,291	10,451	
Tolani clay loam		1,310	4,800	
Tolani clay			5,242	
Winslow clay loam	435	275	77	
Winslow clay			8,294	2,170
Winslow undiff. clay & clay loam				3,379
TOTALS	435	74,916	184,144	21,084
TOTAL OF GROUPS A B C & D				280,144
OTHER				
AREA OF SUB-UNIT IV -				
SUB-UNIT V				
Rough Broken Land and Undiff. soil remnants				~~16,702~~
Winslow undiff. clay & clay loam				3,586
Todilto sand		3,130	7,745	9,511
Shavano sandy loam		9,069	2,937	
Moenkopi sandy loam			1,408	576
Moenkopi clay loam			141	2,035
Ives sandy loam				1,338
Tolani sandy loam			3,962	
Tolani clay loam			4,480	
Gila loam		173		
Gila clay loam		1,376	826	
Winslow sandy loam		3,546	608	

(Cont'd)

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TABLE X. Continued.

Soil Type	Group A (Acres)	Group B (Acres)	Group C (Acres)	Group D (Acres)
	SUB-UNIT V (Cont'd.)			
Winslow clay loam			7,507	
Winslow clay			250	15,559
TOTALS	000	39,808	31,182	47,099
TOTAL GROUPS A B C & D				112,089
OTHER				
AREA SUB-UNIT V -				
	SUB-UNIT VI			
Rough Broken Land & Undiff. soil remnants				27,987
Springerville sandy loam	22,291	6,189	14,272	
Kiabab sandy loam		28,770	1,926	
Kiabab clay loam	4,282			
Moenkopi clay loam			2,586	
Gila loam		64		
Gila clay loam		83	429	
Winslow clay				1,683
TOTALS	26,573	45,106	19,213	29,670
TOTAL GROUPS A B C & D				120,562
OTHERS				
AREA SUB-UNIT VI -				
TOTAL AREA SURVEYED - - - - - - - - - - - - - - - - - - -				811,870

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TABLE XI

Acreage of Soil Types by Sub-Units in Agricultural Land Soil Groups.

Soil Types	Group A (Acres)	Group B (Acres)	Group C (Acres)	Group D (Acres)	Totals
SUB-UNIT #I					
Winslow clay loam				269	269
Winslow clay				422	422
Totals				691	691
SUB-UNIT #II					
Gila loam			159		159
Gila clay loam			4,942		4,942
Winslow clay loam				2,151	2,151
Winslow clay				25,124	25,124
Totals			5,101	27,275	32,376
SUB-UNIT #III					
Tees Nos Pos sandy loam		9,232			9,232
Winslow sandy loam			2,114		2,114
Winslow clay loam			919		919
Winslow clay				8,738	8,738
Hunt clay loam			2,245		2,245
Hunt clay				16,774	16,774
Ives sandy loam	722				722
Tolani sandy loam			18,100		18,100
Tolani clay				3,447	3,447
Gila loam			1,483		1,483
Gila clay loam			5,575		5,575
Totals	722	9,232	30,436	28,959	69,349
SUB-UNIT #IV					
Winslow loamy sand		182			182
Winslow clay loam		541			541
Winslow clay				15,237	15,237
Ives loamy sand		2,354		1,774	4,128
Ives sandy loam	1,109				1,109
Ives clay loam		35,870	3,059		38,929
Ives clay			4,225	13,175	17,400
Tolani sandy loam	255	2,112	19,476		21,843
Tolani clay loam			4,565		4,565
Tolani clay				5,101	5,101
Totals	1,364	41,059	31,325	35,287	109,035

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TABLE XI (Cont'd)

Soil Types	Group A (Acres)	Group B (Acres)	Group C (Acres)	Group D (Acres)	Totals
		SUB-UNIT #V			
Gila clay loam		1,706	899		2,605
Winslow sandy loam		3,689	716		4,405
Winslow clay loam			8,902		8,902
Winslow clay				20,676	20,676
Ives sandy loam	1,706				1,706
Tolani sandy loam				4,200	4,200
Tolani clay loam			4,627		4,627
Totals	1,706	5,395	15,144	24,876	47,081
		SUB-UNIT #VI			
Gila clay loam		572			572
Winslow clay				1,727	1,727
Totals		572		1,727	2,299
UNIT TOTALS . .	3,792	56,253	82,006	118,775	260,831

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