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NAVAJO SERVICE

LAND MANAGEMENT SURVEY

UNIT - 1

ENGINEERING REPORT

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NAVAJO SERVICE

LAND MANAGEMENT UNIT NO. 1

Engineering Report

UNM 140

C. L. Moyes
Engineering Aide

INDEX

	Page
Boundary	1
Roads and Trails	2
Telephones	3
Trading Posts, Schools and Hospitals	[illegible]
Population	4
Climatological Data	4
Drainage and Runoff	6
Topography and Soils	9
Vegetation	11
Agriculture	13
Rodents and Wildlife	14
Minerals	15
Sketch Map - Cow Springs Irrigation Project	17
Agricultural Projects	18
Cow Springs Irrigation Project	18
Farms #21, 45, 46, 47 Quad. 110°45' 36°30'	23
Farm #1. Quad. 110°45' 36°30'	26
Erosion Control Projects	29
E.C.#1 Quad. 110°45' 36°30'	29
E.C.#2 Quad. 111°00' 36°45'	31
E. C.#1 Quad. 111°00' 36°30'	31a

UN.M 141

CV-6417-201 NN005762

Index, continued

			Page
E. C. #1	Quad. 110°45'	36°45'	32
E. C. #2	Quad. 111°00'	36°30'	33
E. C. #1	Quad. 111°00'	36°45'	34
E. C. #2	Quad. 110°45'	36°30'	35
F. C. #1	Quad. 110°45'	36°15'	35

Water Spreading..... 37

Road Improvements..... 39

Priority List of Projects..... 39

Estimating Procedure..... 40

Future Plans..... 41

List of Work Projects..... 42

Base Map..... 43

UNM 142

CV-6417-201 NN005763

Boundary

Land Management Unit No. 1 is located in the northwestern part of the Navajo Indian Reservation. It lies in Coconino County, Arizona, roughly between 36°15' and 36°45' north latitude and 110° 45' and 111°30' west longitude.

The boundary of the Unit is as follows: Beginning at Old Lee's Ferry it follows southeast along the Echo Cliffs to the Gap Trading Post; it then runs northeast along Crooked Ridge, around Preston Mesa, then southward across Little White Mesa to the Moencopi Wash; then eastward up his wash for about twenty miles, where it turns north, following a drainage divide to a high point on the rim of Black Mesa; it then runs north to Blue Lake, then northwest to the rim of White Mesa, from where it goes north to the edge of Navajo Canyon; it then follows westward along the south rim of this canyon to the Colorado River; from where it goes southwest down the center of the Colorado River to Old Lee's Ferry, the point of origin.

The boundary, as outlined, encloses an area of 1,035,540 acres. Included in this are the following figures:

Inaccessible and barren - - - - - - - -	86,913 acres
Waste - - - - - - - - - - - - - - - - -	54,700 acres
Mountainous - - - - - - - - - - - - - -	95,000 acres
Area producing runoff (Approx.) - - -	375,000 acres

UNM 143

CV-6417-201 NN005764

Roads and Trails

For the purpose of description and identification, the roads of Unit No. 1 have been divided into graveled road, graded dirt road and unimproved road types.

There are no graveled roads within the boundary of the Unit. However, Highway 89, between Cameron, Arizona and Lee's Ferry, Arizona, runs directly west of the Unit. The western portion of the area is easily accessible from this highway.

Graded dirt roads are those which have been bladed and are maintained at more or less regular intervals. Some of these have been well located while others merely follow the old Indian wagon trails. The roads classed as graded dirt roads are as follows:

Tuba City - Red Lake (Tonalea) - Cow Springs - Kayenta road

Red Lake to Inspriptiom House road

Red Lake to Kaibito road

Cow Springs to Shonto road

Kaibito to Inscription House road

The Gap to Kaibito road

The Gap to the Copper Mine road

UNM 144

The classification of unimproved road is given to any road which is passable to cars but not maintained. Such roads cover practically the entire Unit. The E.C.W. has worked short sections of this type of road. A truck trail was constructed over the Echo Cliffs at the Cedar

CV-6417-201 NN005765

Ridge Trading Post. A truck trail was built to the top of Black Mesa east of Cow Springs. This trail lies just outside of the boundary; however, it provides access to part of Black Mesa within the Unit. They have also done some construction on two roads over Black Mesa southeast of the Red Lake Trading Post. A short section of the road across the south end of White Mesa has also been improved.

As no roads within this Unit have been surfaced, all of them will be impassable at times.

There are several stock trails into the more inaccessible parts of Unit No. 1. Navajo Canyon can be reached by stock in several locations. Kaibito Canyon can be crossed close to Klechee Rock. There are two trails across the Echo Cliffs north of Cedar Ridge. Very little work has been done on these trails and they are only slightly used.

Telephones.

Telephones within this Unit are located at Kaibito, Red Lake (Tonalea), and Cow Springs. All of these connect with the Tuba City - Kayenta line and are handled directly by the Tuba City exchange.

Trading Posts, Schools and Hospitals.

There are ten trading posts located within the boundary or close to Unit No. 1. The four inside the boundary are: Kaibito, Red

UNM 145

CV-6417-201 NN005766

Lake (Post Office - Tonalea), Cow Springs, and the Copper Mine. The posts located close to the Unit are: Lee's Ferry, Cedar Ridge and the Gap to the west; Tuba City to the south; and Inscription House and Shonto to the east. Day schools are located at Kaibito and Shonto and a boarding school and hospital at Tuba City. A day school is also located at Old Moe Wave close to Tuba City.

Population.

The population of Unit Number 1 is approximately 1176, or 157 consumption groups. The areas of population concentration are around Red Lake and Cow Springs.

Climatological Data.

Climatological records are available from Lee's Ferry, Tuba City, and Kayenta, as there are no stations located on the Unit. The records of Lee's Ferry and Tuba City will be more applicable than those of Kayenta.

UNM 146

CV-6417-201 NN005767

CV-6417-201

UNM 147

AVERAGE ANNUAL PRECIPITATION

Location	Period of Records	J	F	M	A	M	J	J	A	S	O	N	D	Avg. Ann'l Prec.	Avg. Length of Growing Season	Date of Last Killing Frost	Date of First Killing Frost
Kayenta	1915-1930	.63	.43	.64	.42	.36	.38	1.45	1.58	.75	.91	.64	.61	8.80	163	6/1	9/21
Tuba City	1897-1930	.55	.54	.54	.43	.53	.19	.34	.93	.84	.68	.78	.58	6.92	179	5/19	9/19
Lee's Ferry	1916-1930	.34	.60	.44	.59	.26	.16	.76	.96	.59	.64	.42	.44	6.20	229	4/18	10/18

TEMPERATURE RECORDS

Station	Record	Period of Records	J	F	M	A	M	J	J	A	S	O	N	D	Year
Tuba City	Mean	1898-1930	32.0	39.2	45.9	53.8	61.7	71.1	76.8	77.8	67.6	55.7	43.4	32.3	54.8
"	Absolute Maximum	"	68	73	85	88	99	104	105	108	100	95	88	70	108
"	Absolute Minimum	"	-15	-3	12	14	22	34	40	44	28	18	8	-13	-15
Lee's Ferry	Mean	1916-1930	34.8	43.9	52.9	61.1	70.5	80.2	86.9	73.7	75.8	62.3	47.2	36.4	61.3
"	Absolute Maximum	"													114
"	Absolute Minimum	"													15
Kayenta	Mean	1915-1930	27.6	37.5	44.2	51.8	61.2	70.5	76.1	73.2	65.9	54.0	40.7	30.0	52.7
"	Absolute Maximum	"													104
"	Absolute Minimum	"													-15

NN005768

CV-6417-201

EVAPORATION IN INCHES
1921 to 1930

Station	J	F	M	A	M	J	J	A	S	O	N	D	Average Annual
Lees Ferry	2.076	3.088	5.773	7.967	11.594	12.773	13.359	11.083	8.917	6.112	2.945	1.928	87.615

WIND MOVEMENT IN MILES
1921 to 1930

Station	J	F	M	A	M	J	J	A	S	O	N	D	Average Annual
Lees Ferry	1,058	1,216	1,975	1,889	1,940	1,737	1,570	1,392	1,267	1,223	1,057	963	17,287

UNM 148

NN005769

From a study of these records the following figures can be applied to Unit No. 1:

Average yearly precipitation - - - - - - - - - 7 inches

Average yearly precipitation (Black Mesa) - - 8.5 inches

Length of growing season - - - - - - 160 to 180 days

Drainage and Runoff

Very little runoff can be expected from about five-eighths of Unit No. 1, as the soil is light textured and highly permeable to water penetration. In this area gullies originate on the steep slopes of mesa edges and fan as they reach the valleys.

A few flood irrigated farms are to be found on the alluvial fans in this portion of the Unit. Estimates of annual runoff expectancy indicate that there is sufficient water for crops. These estimates, however, are misleading, as the dry season of the year coincides with the growing season. Winter runoff will not be retained in the soil long enough to be of any great benefit to growing crops.

About one-third of the Unit drains into the Colorado River thru Navajo Canyon. As this canyon varies from two hundred to one thousand feet deep, with steep side slopes, no use can be made of the flood water for agricultural purposes. Kaibito Canyon, which is a branch of Navajo Canyon, is also useless for flood irrigation purposes.

UNM 149

CV-6417-201 NN005770

The only part of the entire Unit in which any agronomic use can be made of flood water lies between White Mesa and Black Mesa in Begashibito Valley. A relatively high runoff is found here as the drainages head on large areas of exposed rock and on the steep talus slopes.

Most of the farms in Unit No. 1 are located in this area. Flood irrigated farms will produce fair crop yields, as runoff can be expected at the beginning of the growing season and again in the latter part of July. Sub-irrigation of the adjacent farmland is to be found around the edges of a few semi-permanent lakes. There is one location where enough water can be stored to irrigate about one hundred and sixty acres of land.

In numbering the drainages of the Unit, the conventional system was used, as follows:

Colorado River	#1.0
Navajo Canyon	2.0
Moencopi Wash	3.0
Begashibito Valley	4.0

Side drainages of these are given the whole number of the main drainage and a decimal which indicates which side it enters from. Facing upstream on the Moencopi Wash, the first side drainage to enter from the left would be #3.1 and the second #3.3 etc. Those entering from the right would be given consecutive even decimals.

UNM 150

CV-6417-201 NN005771

No attempt has been made to number the numerous drainages which fan and are lost before reaching a main drainage. Any reference to them in this report will be with respect to the farm or project on which the water is to be used.

The amount of annual runoff expected has been figured at all important locations on the Unit. These figures are found in the discussion of the projects and in the following table:

Location	Water Supply			Farm Land		Amt. of Land Available for Agriculture	
	Ann'l Expectancy A/Ft.	Max. Expectancy Sec/Ft	Max. Expectancy A.Ft.	Present	Potential	Irrigated	Flood Irrigated
Present Supply at the Cow Springs Lake	100		400	28	40	30	
Add'l supply made available by the diversion of Wash #4.8 into Cow Springs Lake	250	2500	600		100	100	
Cow Springs Project (Expectancy after completion)	350		1000	20	140	160	
Farm #1 Quad.94 at Red Lake (Tomalea) #44	400	3000	700	120			120
Probable Equalizing Reservoir in Cow Springs Wash #4.0	600	1500	400	30	120	150	
Wash #4.0 + E.C.1, Quad. 94		800		75	10		85

UNM 151

CV-6417-201 NN005772

Topography and Soils.

The following approximate elevations have been taken from the U.S.G.S. topographical maps edited in 1891 and 1892:

Average elevation..... 6000 feet

Black Mesa..... 7000 feet

White Mesa..... 6800 feet

Preston Mesa..... 6500 feet

Echo Cliffs..... 6500 feet

Copper Mine..... 5800 feet

Kaibito..... 5400 feet

Red Lake (Tonalea)..... 5400 feet

Moenkopi Wash..... 4600 feet

Lee's Ferry (Lonry's Lodge)... 3142 feet

Unit No. 1 includes the Kaibito Plateau, the western end of Black Mesa, and the lower end of Begashibito Valley. The topography is characterized by a broad, gently sloping sandy plateau broken by high mesas and deep canyons. The main topographical features are as follows: The Echo Cliffs and Mormon Ridges in the west; Navajo Canyon and Glen Canyon of the Colorado River in the north; White Mesa, the head of Navajo Canyon, and Kaibito Canyon in the east; and Black Mesa, Blue Canyon of the Moenkopi Wash, and Wildcat Peak in the south.

UNM 152

CV-6417-201 NN005773

The majority of the soils in Unit #1 originate from sandstone and are highly susceptible to wind erosion when the vegetative cover has been partially or wholly destroyed. A better developed soil, less affected by wind, is derived from the Carmel sandstone. Soil developed from the Mancos shale on Black Mesa is heavier textured, and more severely affected by water erosion. The soils are derived from the grayish white Navajo sandstone in the western half of the Unit; from the dark red Carmel formation in the north; from the red Entrada formation in the east; and from scattered areas of the brown to buff Dakota sandstone and the dark bluish gray Mancos shale in the south and southeast.

Residual soils occupy the greater portion of the area and constitute the better classes of grazing land. The Floy, Todilto, Duell and Kaibito series are the most important of the residual series mapped.

A very small part of the Unit is occupied by alluvial soils. Of the eight series mapped, portions of the Ives, Oraibi, Dinnehotso, and Concho are the only ones cultivated.

Strong southwest winds, low rainfall and light textured soils are responsible for the predominance of wind erosion in this Unit. Small active sand dunes are sparsely distributed throughout this Unit but are more frequent in the heavily overgrazed southern part.

UNM 153

CV-6417-201 NN005774

Partially stabilized sand dunes, ranging in depth from thirty-six inches to several feet, are common west of Kaibito.

Extensive areas of barren sandstone dissected by deep canyons are common in the north portion of the Unit. A shallow, severely wind blown, intermittent soil cover, with spotted accumulation of dune sand, occupies the northwestern portion of the Unit.

Sheet and gully erosion prevail on the steep slopes of Black Mesa and White Mesa. The extreme southeastern portion of Black Mesa, because of severe sheet erosion and steep slopes, consists of almost barren geologic material with an intermittent, shallow soil cover.

Vegetation

Vegetation of the Unit is typical of the Upper Sonoran Zone. Certain species typical of the Lower Sonoran Zone were seen in very limited quantities. The altitude is too low for Ponderosa pine and other species of the Transition Zone. The main species occurring in the Unit are as follows:

Grasses - Blue Grama
Galletta grass
Spinny Muhley
Sand dropseed

UNM 154

CV-6417-201 NN005775

Weeds	- Russian Thistle
	Indian Wheat
	Lupine
Shrubs	- Black brush
	Chamise
	Mormon Tea
	Sand Sage
	Snakeweed
	Yellowbrush
Woodland	- Pinon
	Juniper
Poisonous Plants*	- Loco
	Lupine
	Larkspur
	Isocoma
	Greasewood
	Cocklebur

* These poisonous plants are not causing the loss of much stock.

UNM 155

CV-6417-201 NN005776

The condition of the vegetation in the north and western part of the unit is very good. This is due to seasonal usage caused by the lack of permanent water. In the central and southern part of the Unit the vegetation is in poor condition, lacking in vitality and growth due to heavy over-grazing.

Agriculture

Unit Number 1 has very little agricultural possibilities, due primarily to the lack of water. The soil, generally, is quite favorable for crop production, but is quite susceptible to wind erosion.

There are four small agricultural concentrations on the Unit.

(1) Near Cow Springs

(2) At Red Lake

(3) Four miles south of Red Lake

(4) In the vicinity of White Mesa

UNM 156

CV-6417-201 NN005777

During the survey 112 tracts were located, totaling 803 acres of present and 325 acres of potential farm land. Most of the present farm land, and all of the potential, lies in the above named areas. The farm land is divided as follows:

	Present Acreage	Potential Acreage
Irrigated	20	100
Flood Irrigated	725	225
Dry Farm	58	
TOTAL	803	325

Corn is the main drop grown, representing about 70 percent of the acreage farmed. Squash, melons, and beans are planted on the remainder of the land.

Rodents and Wild Life

The most damage to range land by rodents is caused by prairie dogs. The heaviest infestations are found in the open grassland valleys of the central portion of the Unit.

Kangaroo Rats are the most abundant rodent of the Unit. They are found over the entire area. The heaviest infestation is in the vicinity of Red Lake. Other species found on the Unit are Ground Squirrels, pocket gophers, wood rats, and miscellaneous mice. Ground squirrels are causing some damage in agricultural area.

UNM 157

CV-6417-201 NN005778

Coyotes and bobcats are common over the entire Unit, but damage done by them to livestock is negligible. Game species found on the unit are Mourning Doves and a small herd of antelope.

Minerals

Copper is the only known mineral resource of this Unit. The White Mesa copper district was prospected in 1882, and 35 claims located. At the present time there are nine patented claims owned by the Pittsburgh Copper and Mining Company, and totaling 185,609 acres. These claims were last worked about 1918. Only a small amount of ore has been removed, most of it still being on the site where it was taken out. The most abundant ore mineral is chrysocolla but small amounts of malachite and some azurite occur. The copper occurs in the Navajo sandstone disseminated between the quartz grains along joints and bedding planes. In some places malachite is associated with hematite.

The average ore runs from five to eight percent copper with some as high as fourteen percent. The copper is scattered, irregular and of low grade. Due to the distance to a railroad, low grade of the ore, and the lack of water, mining under present conditions would be unprofitable.

UNM 158

CV-6417-201 NN005779

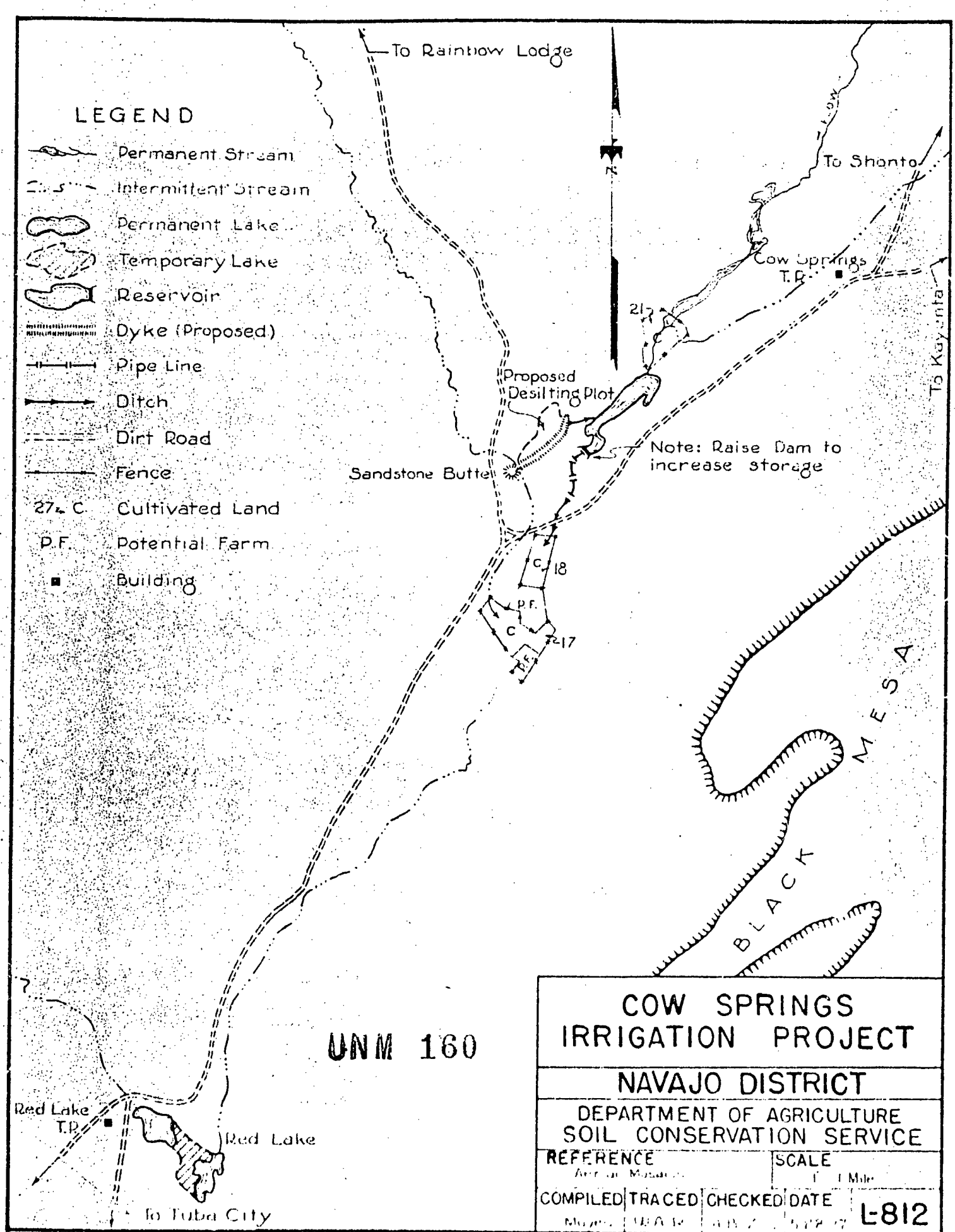
The only coal bearing formations in the Unit are the Mesa Verde and Dakota. The area is confined to Black Mesa. Three sections along the west side of Black Mesa failed to reveal any coal. A few thin beds were found in the Dakota in the vicinity of Blue Canyon; however, these are too thin to be of commercial importance.*

(*Note: The fore-going statements have been condensed from the several branch reports of Unit No. 1. For a more detailed discussion refer to these reports.)

UNM 159

CV-6417-201

NN005780



CV-6417-201
NN005781

Agricultural Projects

The following projects are the most important in the Unit. These are listed in the order of their importance to the income of the population.

The fore-going sketch shows the location and proposed work on the Cow Springs Irrigation Project.

All projects listed in this report can be found by reference to the 1937 Agronomy-Engineering map of Unit No. 1. A small copy of this map can be found on the last page of this report.

The Cow Springs Irrigation Project is located approximately three miles southwest of Cow Springs, Arizona, along the Tuba City-Kayenta road. The storage reservoir lies about one-half mile north of this road and the farm land is directly south of it. A sketch of this area can be found on the preceeding page.

The storage reservoir is a natural lake on the Cow Springs Wash (Drainage #4.0). A dam six feet high and thirty feet long impounds the water in a lake of about 60 surface acres. Although no spillway is provided, there are no signs that the dam has been overtopped. Water is supplied both from flood water and a permanent flow of about one second foot. During the growing season this permanent flow is used on farm land above the lake.

UNM 161

CV-6417-201 NN005782

In 1933 the U.S.I.I.S. provided an outlet from this lake to a potential farm site. The southwest corner of the lake was deepened and a ditch about 2000 feet long was dug from here to the farmland. 1500 feet of wooden pipe was placed in this ditch and back filled. This backfill will allow a maximum depth of six feet of water in the lake. Should the water overtop this small dam there is danger of washing out the wooden pipe and any subjugated farm land on the project would be flooded.

At the present time there are only twenty acres of land being irrigated. From a soils standpoint there are about 500 acres of good farm land that could be reached by irrigation water. The area of potential farm land will be limited by the water supply to about 140 acres. All of this land is subject to flooding from White Mesa Wash #4.5, which begins to fan just west of the lake.

At the present time a survey party is working on a map of this area, from which the feasibility and final plans for the project can be accurately determined. The following temporary plans have been made from ocular inspection of the area. Due to the size of the project a more accurate detailed survey will be needed before the project is started.

UNM 162

CV-6417-201 NN005783

In making these estimates it is assumed that heavy equipment will be used on all large excavations and fills. Should the work be done by hand labor and teams the cost should be altered accordingly.

The plans for the project are as follows:

First - Divert the storm flow from the White Mesa Wash, #4.5 into the lake. This will require a dyke of about 10,000 cubic yards for diversion, and a temporary impounding and settling basin. Two 18" corrugated pipes will be needed as outlets from the settling basin. The ditch must be stabilized between the outlets of the desilting plot and the lake, due to excessive grades.

The area of the settling basin will be about fifteen acres. As it will be impossible to impound all of the water in the larger floods, an emergency spillway must be provided - probably at the west end of the dyke.

The estimated cost of this part of the project is $2,500.00.

Second - It is recommended that the dam be raised on the Cow Springs Lake. As the average length of the fill will be about fifty feet, the cost will be small. This dam should be high enough that a spillway can be provided for the lake. It is doubtful if enough water will ever be impounded to reach the elevation of such a spillway; however, one is recommended due to the fact that if the dam should be over-topped, the entire contents of the lake would flow over the irrigated land.

UNM 163

CV-6417-201 NN005784

It is also recommended, before this dam is raised, to replace the first one hundred feet of wooden pipe with a section of steel pipe. This will eliminate the necessity for removal of the dam for replacement of the wooden pipe, a job which will probably have to be done within the next five years. Although it was impossible to inspect the head gate, it will probably not have to be replaced. A trash screen should be constructed around the gate, however.

The estimated cost of this part of the project is $600.00.

The expected annual flow and maximum runoff figures for this project are given below:

Present annual expectancy in the lake - 100 A./Ft.

Maximum expectancy in the lake - 400 A./Ft.

Additional amount added by diversion of Wash #4.5.

Annual expectancy	250 A./Ft.
Maximum Expectancy	2500 Sec./Ft.
Maximum expectancy	600 A./Ft.

Total supply at lake after diversion of Wash #4.5

Annual expectancy	350 A./Ft.
Maximum expectancy	1000 A./Ft.

UNM 164

CV-6417-201 NN005785

This 350 acre feet annual expectancy indicates that there is a possibility of irrigating 160 acres of land. As there are 20 acres already farmed, this will mean that an additional 140 acres can be put into cultivation.

Justification

Total available irrigated farm land.....	160 acres
Estimated cost of proposed work.....	3,100.00
Cost of completed work U.S.I.I.S.....	9,000.00
Total Cost	$12,000.00
Cost per acre of project - approximate -	$ 80.00
Estimated cost per acre of subjugation.....	15.00
Total estimated cost per acre.....	$ 95.00

Probable total cost per acre, using teams and scrapers instead of heavy equipment.

Estimated cost of proposed work.....	$ 6,300.00
Cost of completed work U.S.I.I.S.....	9,000.00
Total cost.....	$15,300.00
Estimated cost per acre of above - approximate - ..	$ 100.00
Estimated cost per acre of subjugation.....	15.00
Total estimated cost per acre.....	$ 115.00

UNM 165

CV-6417-201 NN005786

Farms #21, 45, 46, 47
Quad. 110°45' - 36°30'
In Cow Springs Wash

This project lies about two miles north of the Cow Springs Trading Post on Wash #4.0, and extends up the wash about three miles from the lake of the Cow Springs Irrigation Project. This job may add a slight amount of water to the lake, but otherwise there is no relation between the projects.

It is planned to construct an equalizing reservoir in wash #4.0. This will prevent the flooding of 30 acres of irrigated land and will allow the subjugation of 120 additional acres. A drain must be provided through a part of the land to lower the water table, and to carry the flood water below the equalizing reservoir.

A detailed survey will be needed at the dam site to determine the structural and economic feasibility of the project. The site lies just above farm #46 between sandstone bluffs which are about 200 ft. apart and 25 ft. high. The floor of the canyon is very loose, sandy material. The canyon widens directly above the proposed location, providing a rather large storage basin.

A detailed estimate of the quantity of material required the dam will be needed. The dam will be an earth structure about 200 feet long, and 25 to 30 feet high. A cut-off wall will be required to form a bond between the earth and sandstone cliffs. The

UNM

CV-6417-201

NN005787

spillway can possibly be blasted from the top of the sandstone bluff. This method will probably be much cheaper than the construction of a masonry spill.

It will also be necessary to make a detailed survey of the site. The material is quite sandy and there appears to be a considerable underground flow of water. This survey should determine the possibility of piping through the material, and indicate the necessity for a deep cut-off structure.

Tests should also be run on the material to be used in the fill. A core wall may be required in the dam to check seepage. Tests to find the correct slope required for stability of the material will be needed.

The potential farm land must be drained before it can be farmed. There is a permanent flow of about one second foot in the wash. The water table is high throughout the valley and there are several small shallow lakes. Drainage of this land will probably increase the flow into the Cow Springs Lake.

It is doubtful if the farm land will require irrigation more than twice a year. Sub-irrigation should provide sufficient water for most crops.

In the following estimate no cost has been added for a core wall or cut-off structure under the dam. The estimate is very rough and may contain considerable error.

UNM

CV-6417-201

NN005788

Estimate

200 lin. ft. 30' ft. earth dam 20,000 cu. yd.....	$ 6,000.00
150 lin. ft. of 3' corrugated pipe with inlet structure, outlet structure and collars.....	1,200.00
Spillway.....	1,000.00
Cut-off walls along exposed sandstone.....	300.00
Total Cost.....	$ 8,500.00
Drainage ditch 15,000 cu. yd.....	4,500.00
Total Cost.....	$13,000.00

The use of heavy equipment will lower the Unit cost of moving earth for the structure.

Expected flow of wash #4.0.

Average flow (permanent)..... 1 sec./ft.

Annual expectancy flood flow.....600 A./ft.

Maximum expected flood flow.....1500 Sec./ft.

Maximum expected flood..... 400 A./ft.

Justification

Total estimated cost.....	$13,000.00
Acreage effected (Irrigated Land)....150 acres	
Cost per acre.....(Approx.)	87.00
Highest cost per acre that could be justified on this area.....	150.00

UNM 168

CV-6417-201 NN005789

Farm #1 Quad. 110°45' 36°30'

Farm #1 is located along the southwest side of Red Lake on the alluvial fan of wash #4.4. Floods from this wash cause considerable damage to growing crops. The soil is a sandy clay loam and the slope averages 1%. All of the available land, 120 acres, is under cultivation.

There are two plans for controlling the floods on this farm. For the purpose of description these are called plan "A" and plan "B" Plan A is the more desirable; however, it is the opinion of the study group that the estimated cost cannot be justified on the basis of the increased returns. Plan B is suggested if a detailed estimate proves plan A to be economically unfeasible.

Plan A. This plan requires a dyke along the south side of the farm to divert the water from wash #4.4 to the south end of Red Lake. Stabilizers will be needed on the dyke to prevent wind and water erosion. An opening 8 to 10 feet wide should be left at the upper end of the dyke to provide for flood irrigation of the land. Masonry walls are recommended at this opening, and at the end of the dyke to prevent erosion.

This plan will require that approximately 15 acres of land be taken out of cultivation to allow space for the dyke.

UNM 169

CV-6417-201 NN005790

Estimated Costs

3000 lin. ft. of 7 ft. dyke 18,000 cu. yds.	$5,400.00
2000 lin. ft. of sand fence	500.00
300 cu. yd. loose rock	300.00
100 cu. yd. masonry (dyke ends)	1,000.00
80 cu. yd. wire rock sausage	200.00
Total	$7,400.00

It is the opinion of the study group that this project might prove feasible when a more accurate estimate of the cost is made. The maximum cost that can be justified for this farm is $60.00 per acre, or a total of about $6500.00 for the entire project. It is recommended that a detailed estimate be made before any construction plan is approved.

Plan B. The purpose of this plan is to spread the flood water evenly over farm #1. This would decrease the damage from average flows but would have little effect upon maximum floods.

In order to spread the water on this farm it will be necessary to construct four wire rock sausages along the south side of the field. These will control the water which concentrates at this place. A few wire spreader fences will be needed to control the flow at certain other points. No earth structures are recommended due to the cost involved in protection from wind erosion.

CV-6417-201 NN005791

Estimate of above work.

300 cu. yd. wire rock sausage	$ 750.00
2500 lin. ft. wire spreader.....	250.00
Total cost	$1000.00

Justification

Estimated cost	$1000.00
Area effected (farm land).....120 acres	
Average cost per acre.....(Approx.)	$ 8.50

No subjugation will be necessary on this farm. The land is leveled and slopes gently toward Red Lake. Water is provided by floods from wash #4.4 and it is sub-irrigated by underground seepage from Red Lake. Subjugation would be difficult because of the danger of wind erosion on earth structures and because of the quantity of flood water.

A proposal to regulate the flow of wash #4.4, by by-passing the excess flood water to the south, has been rejected by the study group. A rough estimate of the cost provid this proposal to be economically feasible. However, farm #1 is sub-irrigated from Red Lake. Wash #4.4 produces the greater portion of the water supply of this lake. It is believed that the consequent reduction in the valuable water supply would not be justified in order to eliminate the present flooding of the farm.

UNM 171

CV-6417-201 NN005792

Erosion Control Projects

The following erosion control projects are listed in the order of their importance. They should be worked in the order in which they are listed, unless it should be more desirable to complete a few of the smaller jobs at the same time that a large job nearby is being worked.

E.C. #1
Quad 110°45' 36°30'

This project lies about six miles south of Red Lake (Tonalea), along the lower road between Cow Springs and Tuba City.

At the lower end of this valley there are two gully heads about 12 feet deep and 30 feet wide. Head cutting is rather slow, due to heavy soil and the small amount of flood water. The gullies have cut to bed rock throughout most of their length.

Above these heads there are numerous small gullies. The condition of these is not serious and mechanical control can be easily and cheaply done.

It is planned to provide drop structures in the two large gully heads. The cheapest method would be to place a 3 ft. corrugated steel pipe on a 3:1 slope at each drop. A concrete inlet and outlet structure with adequate cut-off walls will be required. About 400 ft. of dyke five feet high in the center and three feet high at the ends

UNM 172

CV-6417-201 NN005793

is needed in order to concentrate the flood water at the drops. The grade of the natural ground at the ends of these dykes should be about six inches above the grade of the top of the culvert. The dyke ends should be open to provide an emergency spillway in the case of clogging of the pipe drops and as a safety factor during maximum floods.

It will be necessary to make tests of the soil in this area. The soil is heavy and it may be that special precautions will be required in the construction of the cut-off walls and in placing the fill.

<u>Estimate on above work</u>

400 lin. ft. of earth dyke - average 4 ft. high 800 cu. yds.....	$ 240.00
Excavation and back fill 75 cu. yds.....	30.00
2 intake structures (concrete) 14 cu. yds.....	280.00
2 outlet structures 10 cu. yds.....	200.00
80 lin. ft. of 36" corrugated pipe.....	250.00
2 masonry dyke ends 10 cu. yds.....	100.00
Total.....	$1100.00

The control of the small gullies above the proposed drop structure is estimated to cost about $400.00. This will include small earth structures and a few wire spreader fences.

UNM 173

CV-6417-201 NN005794

Justification

Area effected (range land)..... 1,000 Acres

Area effected (farm land - flood irrigated)..... 85 Acres

Total estimated cost..... $1,500.00

Average cost per acre (farm land only) approx..... 18.00

Maximum flood expectancy at the drop..... 300 Sec. Ft.

E. C. #2
Quad. 111°00' 36°45'

This project lies seven miles south of Kaibito about 1/4 mile up the wash from farm #7. It is on the same wash as E. C. #1, Quad. 111°00' 36°30' and three and one-half miles down stream from this job.

The project consists of controlling a gully which is progressing up the valley from farm #7. The gully head is about 10 feet deep at the head and 3,000 feet long. About two hundred feet below the head there is a secondary vertical drop of 3 feet. The gully head is endangering 2,500 acres of range land and 20 acres of flood irrigated farm land.

Treatment suggested is as follows:

Construct a 3-foot dyke around the head of the gully and divert the water along both sides of the gully to farm #7. This will require about 250 lineal feet of 4.5' dyke and 4,000 lineal feet of 3.0' dyke.

Construct wire and rock stabilizers at placed along the dyke where erosion may become serious.

Cost Estimate:

5,250 cu. yds. of earth.....	$1,575.00
100 cu. yds. of wire-rock sausage.....	325.00
Total Estimated Cost.....	$1,900.00

UNM 174

CV-6417-201 NN005795

Justification

Area of flood irrigated farm land affected..... 20 Acres

Area of range land affected..... 2,500 Acres

1 Stock Water Tank

(Note: The project cannot be justified by its effect on this tank as it is of little use as a stock water supply; however, the tank has some value in checking erosion.)

Maximum flood expectancy 500 Sec. Ft.

E. C. #1
Quad. 111°00' 36°30'

This project lies about eight miles south of Kaibito close to the road to Red Lake.

The project consists of controlling a gully about 2,000 feet long and eight feet deep at the head. Cutting begins directly above farm #4 and ends below a small Indian stock tank. The gully is endangering 25 acres of farm land, the stock tank, and about 2,000 acres of range land.

Treatment suggested is as follows:

Raise the stock tank an additional nine feet to make an equalizing reservoir.

Provide an 18" culvert through the dyke at the present spillway elevation.

Provide a spill around one end of the dyke.

Dig a ditch from the culvert to farm #4.

UNM 175

CV-6417-201 NN005796

Place a trash rock at the inlet of the culvert.

Cost Estimate

2200 cu. yds. earth - - - - - - - - - - - - - - -	$660.00
80 lin. ft. of 18" corrugated steel pipe - - - -	80.00
Inlet structure and cut-off collars - - - - - -	80.00
2500 lin. ft. of ditch 1500 cu. yds. earth - - -	450.00
Total estimated cost - - - - - - - - - - - - - -	$1170.00

Justification

25 acres of flood irrigated land

2500 acres of range land

1 small temporary stock tank

Maximum flood expectancy - - - - - - - - - - - - 350 sec/ft.

EC. #1
Quad. 110°45' 36°45'

This project is located on drainage #2.6 about ten miles northeast of Kaibito.

There are several small active gullies in this area. The largest gully noted on the survey was about three feet deep and five feet wide. In some places they are stabilized at shallow depth by the sandstone bed rock.

UNM 176

CV-6417-201 NN005797

Those gullies lying above farms #27 and #28 are destroying range land by erosion, and are harming the farms by the deposition of silt. These gullies can be controlled by the use of small earth diversion structures. Some spreader fences will be needed and it is possible that a few wire rock sausages should be used.

The gully below the farm, although quite small, carries a large flow of water. It is recommended that no small earth structures be used here. Small overflow structures of the wire spreader fence and wire rock sausage type will be more satisfactory.

Estimated cost of project..... $1 00.00

Area effected - range land..... 900 Acres

Area effected - farm land..... 38 Acres

E. C. #2
Quad. 111°00' 36°30'

This job consists of erosion control work along the road between Kaibito and Red Lake. About five miles of this road, near Kaibito, has been completed. The remaining fifteen miles needs drains and thank-you-mams in several locations. The estimated cost of the project is $450.00.

UNM 177

CV-6417-201 NN005798

E. C. #1
Quad. 11°00' 36°45'

This is a small erosion control project along the Kaibito to Gap road. It extends along one and one-half miles of the road and is located about two miles southwest of Kaibito.

This road has been re-located several times, due to gully erosion. As the soil is quite sandy, the runoff evidently comes from the road itself. This condition was caused by blading a straight road down a long gentle slope.

It is proposed to divert the water from both the old and new roads. Most of the work will be drains and thank-you-mams. Possibly a few wire spreader fences will be required. As the run-off is slight, no estimates have been made of the expected flow.

Total estimate for the job is..... $300.00

Area effected..... 1½ miles of road

Area effected - range land - .....1000 acres

UNM 178

CV-6417-201 NN005799

E. C. #2
Quad. 110°45' 36°30'

This project lies directly north of the Cow Springs Trading Post on Wash #4.10. Several small gully heads have developed in the rather broad valley above farm #22.

The proposed work consists of wire rock sausages and wire spreaders to check and stabilize the small gullies.

Estimated Cost $600.00

Justification

Protection of 4 acres of irrigated farm land.

Protection of 1000 acres of range land.

E. C. #1
Quad. 110°45' 36°18'

This project is located at a small gully head about 7 miles south of the Red Lake Trading Post.

The gully head is 3 feet deep and 10 to 12 feet wide and is cutting into a relatively flat valley. The proposed treatment is a wire rock sausage type drop with an earth dyke at each end to divert the water to the drop.

Estimate

10 cu. yds. wire rock sausage	$35.00
200 cu. yds. earth	60.00
Total	$95.00

UNM 179

CV-6417-201 NN005800

Area effected - range land ..... 300 acres

Cost per acre.....(Approx.) $0.32

As E. C. #2 is a rather small job it is suggested that it be worked at the same time as other construction in this part of the Unit. This will allow better and easier supervision of the construction.

UNM 180

CV-6417-201 NN005801

Water Spreading

The only water spreading area recommended within this Unit lies south of White Mesa. It is #50, Quad. 10°45' 36°45'. We have re-located this area to a point up the drainage about one mile, and plan to divert the water onto a flat area in which about five acres can be farmed. The project will require an earth dyke to divert the flow and subjugation of the land.

Estimated Cost

Diversion structure - 500 cu. yds.....	$150.00
Subjugation cost (Agronomy notes).....	100.00
Total	$250.00
Area effected - farm land -	5 Acres
Area effected - range land -	200 Acres
Cost per acre of farm land.....	$ 40.00
Cost per acre of range land.....	0.25
Maximum flood expectancy.....	25 cfs/ft.
Annual expectancy to farm.....	30 A/ft.

UNM 181

CV-6417-201 NN005802

A list of the water spreading areas located on the 1935 water spreading survey, with a few notes about each, follows:

Quad. 110°45' 36°30'

Water Spreading Area #36 - The survey party has recommended that the water be used on the Cow Springs Irrigation Project rather than on this area.

Water Spreading Area #37 - More economical use can be made of the water on Farm #1 than on the area indicated.

Water Spreading Area #38 - This project was completed in 1935.

Water Spreading Area #39 - Recommendations have been made to work this area as an erosion control measure - See E. C. #1, Quad. 110°45' 36°30' in this report. The heavy soil in this valley will not readily absorb any water spread on it.

Quad. 111°00' 36°45'

Water Spreading Area #8 - Work completed on this area in 1937. Worked on farm #6.

Quad. 110°45' 36°15'

Water Spreading Area #17- Not recommended as the soil is very heavy and water spreads over the entire valley at the present time.

Water Spreading Area #18 - Not feasible to spread the water from a gully two hundred and fifty feet wide and twenty feet deep onto an area of fifteen hundred acres of heavy soil.

UNM 182

CV-6417-201 NN005803

Road Improvements

Plans have been made by the Roads Department for improvement of the road between Tuba City, Red Lake, Cow Springs, and Kayenta. Some work has been done on this near both Tuba City and Kayenta. No work has been started as yet within the boundary of this Unit. The final plans call for an improved grade and a gravel surface.

It is recommended that the road be improved between Red Lake and Kaibito. At the present time the road is quite crooked and there are several places where it is very sandy. A blade would be required to provide a ditch at each side and to level the hummocks. A gravel surface should be placed across the sand dunes, although the road is not important enough to require surfacing over the entire length.

Priority List of Projects

The following projects are recommended for immediate work, and are listed in the order of priority:

1. Cow Springs Irrigation Project
2. Farms #21, 45, 46, 47. Quad. 110°45' 36°30'
3. Farm #1. Quad. 110°45' 36°30'
4. E. C. #1. Quad. 110°45' 36°30'
5. E. C. #2. Quad. 111°00' 36°45'

UNM 183

CV-6417-201 NN005804

The remainder of the projects are of minor importance and can be worked as desired. It makes little difference which of these are worked first; however, the following order is suggested:

Water Spreading Area #50.	Quad. 110°45 36°45'
E. C. #1	Quad. 111°00' 36°30'
E. C. #1	Quad. 110°45' 36°45'
E. C. #2	Quad. 111°00' 36°30'
E. C. #1	Quad. 111°00' 36°45'
E. C. #2	Quad. 110°45' 36°30'
E. C. #1	Quad. 110°45' 36°15'

Estimating Procedure

Any estimates found in this report are made from optical inspection of the location and by comparison with similar projects on the Reservation. No accurate estimate could be made on the quantity of materials required for any project. The cost should serve as a guide as to the size and feasibility of the projects. The following unit costs were used:

Earth (heavy equipment). ..... 15¢ per cubic yard

Earth (team work)..... 30¢ per cubic yard

Spreader fences (wire) ..... 9¢ per lin. foot

UNM 184

CV-6417-201 NN005805

Wire - Rock Sausages ..... $ 3.45 per cubic yard

Masonry ..... $10.00 per cubic yard

Reinforced Concrete ..... $20.00 per cubic yard

Future Plans

Plans for future work to be done after the work outlined by this survey is completed include the following:

1. Maintenance of all construction.

2. Control of any gullies which were missed by this survey or should develop at a later date. In this connection a survey should be made on Black Mesa at periodical intervals to determine the necessity for the control of any active gullies which may develop here.

3. Maintenance of all improved roads.

4. Get a more efficient use of the water on irrigation projects.

UNM 185

CV-6417-201 NN005806

CV-6417-201

LIST OF WORK PROJECTS

Quad	Job	Type of Work	Priority Primary	Priority Secondary	Acreage Effected Cultivated	Acreage Effected Range	Estimated Cost Engineering	Estimated Cost Subjugation
110°45' 36°30'	Cow Springs Irrigation Project	Farm Development	x		160	0	$ 6,300.00	$2,100.00
110°45' 36°30'	Farms 21, 45, 46, 47	Farm Development	x		150	0	13,000.00	
110°45' 36°30'	Farm #1	Farm Development	x		120	0	7,400.00	None
110°45' 36°30'	E. C. #1	Erosion Control	x		85	1000	1,500.00	
110°45' 36°45'	W. S. #50	Water Spreading		x	5	200	150.00	100.00
111°00' 36°30'	E. C. #1	Erosion Control		x	25	2000	750.00	
110°45' 36°45'	E. C. #1	Erosion Control		x	38	900	1,200.00	
111°00' 36°30'	E. C. #2	Erosion Control		x		2500	450.00	
111°00' 36°45'	E. C. #1	Erosion Control		x		1000	300.00	
110°45' 36°30'	E. C. #2	Erosion Control		x	4	1000	600.00	
110°45' 36°15'	E. C. #1	Erosion Control		x		300	95.00	
111°00' 36°45'	E. C. #2	Erosion Control	x		20	2500	1,900.00	

UNM 1186
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NN005807