

Reservoir & Power Sites
Navajo & Moqui Reservations.

Albuquerque, N. M.

November 15, 1911.

Mr. H. F. Robinson,

Supt. of Irrigation,

Albuquerque, N. M.

Sir:

In pursuance of your instructions to make a reconnaissance for Reservoir and Power Sites on the Navajo and Moqui Reservations, I started on September 12, 1911, from Ganado, Arizona, and in the forty-six days following, covered all the territory showing any likelihood of such possibilities. During this time, I covered eleven hundred miles in distance, traveling through each of the five school divisions.

Power Possibilities.

Power possibilities are nil in the territory through which I traveled, there being no living streams of sufficient magnitude to justify an installation. The few small creeks which rise in the mountainous regions lose themselves in the sand before going any great distance and hence, never unite to form a stream of any size.

Irrigation Development.

Irrigation development is possible in some few places, it being possible to store the flood waters carried by some of

the arroyos.

In examining such sites, I have kept in mind: first, the Feasibility; second, Permanence; and last but not least, the possible benefit to the Indian.

Under Feasibility might come Water Supply, Storage Capacity, Land Available and data leading to cost per acre served.

The Permanence of a project is of great importance in this section where the floods carry such large quantities of sediment in suspension. Some washes appear to carry at least 50% of silt and where there is evidence of any percentage of over 15%, I have invariably rejected the project.

Lastly, there are portions of the Reservations where the soil is such as to render it difficult to make a crop even with irrigation, and the possible benefit to the Indian farmer will be small. These I have rejected.

On the reconnaissance, no surveys were made other than rough hand level measurements, and there is likelihood of the storage capacity being slightly in error.

Taking all these into consideration, I will present the projects I believe to be worth development and tabulate the data for consideration as to withdrawal from entry and allotment.

Classification.

I have for convenience divided the projects into three

classes as follows:

- Class I. Includes projects already surveyed and reported favorably.
- Class II. Includes sites which I would consider worthy of immediate further investigation.
- Class III. Includes sites having some vital defects, but which might be valuable at some future period.

Class I Projects.

(1) Chin Lee.

This project is located in the Chin Lee Valley at the mouth of the Canon de Chelly and about fifty miles northwest of Fort Defiance, as shown on sheet 1 of appendix.

A report was made on this project in 1904, and following is a short abstract of the same.

The water supply is to be derived from the Canon de Chelly from which it is to be diverted by a submerged weir. From here it is to be conducted by canal 8000 feet to a small basin on the south side above the Catholic Mission, where a service reservoir is to be constructed. From this reservoir, the distributing system carries the water directly to the land to be served.

The total estimate on this project was reported as \$20,600. and the acreage served as 3000, giving us a per acre cost of \$6.86.

The Whiskey Creek Reservoir reported later will be in

connection with this project, but merely in the form of an addition.

(2) Ganado Project.

This project is located on the Rio Pueblo Colorado close to Ganado, Arizona, as shown on sheet 2 of appendix, and was reported October 15th, 1910. I will give a short abstract of that report.

This project consists of a reservoir and distributing system taking water from the flood flow of the Rio Pueblo Colorado, and using the stored waters to irrigate the fertile lands along its banks below.

The water is diverted by means of a dam and short canal to the reservoir basin where it is impounded by means of an earth dyke 20 feet high and 1800 feet long.

The water stored here is carried down the north bank to a point above the Presbyterian Mission where it is flumed across the river and carried down the south bank to the lands served.

The total estimate on this project amounts to \$60,100., or \$35. per acre served on a basis of 1775 acres under irrigation.

(3) Round Rock Project.

This project is situated on Carriso Creek about 35 miles due north of Chin Lee, as shown on sheet 1 of appendix, and was reported in 1904.

It consists of a diversion dam and canal to carry the

flood water of Carriso Creek onto the mesa between Carriso and Agua Sal Creeks, no storage being possible.

The dam site consists of a reef of rock projecting from both banks and the form of the dam was reported as rock fill. From the character of the reef and the close approach of the ground water to the surface, I believe that a sub-surface barrier could be placed here and a permanent water supply obtained. It might be advisable to sink a well in the sandy bottom to determine the feasibility of this plan of cutting off the underflow as such a course would also give a supply for stock purposes which is badly needed. If such a plan can be carried out, the value of the project would be doubled. It is impossible to give a definite estimate of the cost of such an addition, however, without further data.

The project as reported, estimates \$4,600. in total cost to serve an area of 1500 acres, bringing the per acre cost to \$3. for flood irrigation only.

(4) Leupp Project.

This project, reported in November 1908, consists of a storage and canal system at the mouth of the San Francisco wash near the Leupp Indian School.

As reported, the water supply will come from the San Francisco Wash and Canon Diablo watersheds and will be flood waters entirely, those streams being intermittent.

The water will be impounded in a large basin at the

mouth of the wash by means of a combination dam of concrete and earth dykes, such as to give a depth of 37 feet in the reservoir.

This spillway will be over the concrete portion of the dam and is designed to carry the maximum flood and in addition, it is planned to leave one of the smaller dykes two feet low in order that an overwhelming flood could carry it away and automatically relieve the reservoir.

The outlet as planned is through a tunnel, and the distributing system is of gravity type, covering land on both sides of the river.

The estimated cost was given in the report as \$282,800. to reclaim 7584 acres, or a per acre cost of \$35.35.

Class 11 Projects. Unsurveyed.

(1) Whiskey Creek Reservoir.

This site is located on Whiskey Creek, a small perennial stream rising in the Choiska Mountains about thirty miles north of Fort Defiance, and forming the principal head of the Canon de Chelly, as shown on sheet No. 1 of appendix. Just before entering the canon, a tributary comes in from the north side, forming a large basin which narrows as it approaches the canon.

The water supply will be derived from the normal and flood flow of Whiskey Creek, which has a drainage area of approximately 125 square miles, as shown on the Geological Survey Maps. The watershed is steep and rocky, a condition which tends

to give a maximum runoff with a minimum of silt carried in suspension. I estimate the total runoff to be about 40,000 acre feet but this may be larger in wet years.

The reservoir basin is such that a dam 85 feet in height would impound approximately 25,000 acre feet. The basin seems to have a continuous rock bottom and as the outlet is through solid rock walls, the seepage will be small.

The most economical form of dam will be of a rock fill, core-wall type or one of the general type of the Zuni dam. In case of the former type, rock may be quarried immediately adjacent to the dam site and the expense of breaking and putting in place should not exceed 85 cents per cubic yard.

A dam of the Zuni type will be less expensive since it would be possible to obtain water for hydraulic purposes at small cost by gravity. The objection to this type would be the difficulty in obtaining a bond between the earth fill and the solid rock wall.

Whatever type of dam should be adopted would be better determined after a careful survey and estimate.

I would advocate a tunnel outlet with double valves and an open spillway through the solid rock on the south side of the canon. The excavated material could all be used in the dam without extra haul.

Plenty of good concrete material is close at hand but the long haul on the cement will make concrete an expensive

item.

The water stored in this basin will have to be used in connection with the Chin Lee project and when needed, would be turned directly into the Canon de Chelly and picked up by the projected weir above Chin Lee as suggested in report of 1904 on that project. It might be argued that there would be a large seepage loss in the 18 miles run through the canon but indications are that once the sand is saturated, the only loss will be by evaporation.

In the Chin Lee Valley, the amount of land available for irrigation is limited only by the water supply. Fair crops are raised now in wet years but with an established water supply the Navajos will be enabled to raise some hay and small grain as well as corn.

Below is an estimate of the probable cost of this addition to the Chin Lee Project Dam.

100,000 cu. yds. Rock @ \$1.	100,000.
930 cu. yds. Concrete @ \$15.	13,950.
375 lin. ft. Outlet Tunnel @ \$10.	3,750.
Valves and Fittings	3,000.
30% for Transportation, Engineering and Incidentals	<u>36,200.</u>
	156,900.

Amount of water stored	25,000 acre ft.
Losses through seepage, evaporation, etc. 20%	5,000 " "
Available for irrigation at the land	20,000 " "
Duty of water, 2 acre ft. per acre gives us in land reclaimed	10,000 acres
at a per cost of	\$15.69
Add for additional distributing system per acre	5.00
Total per acre	20.59

(2) Baigihotzo Lake.

This project is situated in the upper Chin Lee Valley between Ganado, Arizona, and the Chin Lee Indian School, and about twenty-five miles north of the former place, as shown on sheet 1 of appendix.

It consists of a large natural lake which the Indians have raised about two feet to provide stock water.

As I saw it, there were about 500 acres on the water surface and by a 10 foot dyke at the lower end, the water could be raised 8 feet.

The water supply will depend on flood water entirely, there being no living stream near. Due to the flat nature of the drainage basin, the runoff will not exceed 10% of the precipitation. Estimating on this basis, with a 12 inch mean rainfall and 200 sq. miles watershed area, we will have a yearly runoff of 155,000 acre ft. The topography of the valley would

not indicate over one fourth of that runoff but it shows what one may expect.

Assuming that the most economical dam will raise the water eight feet, we will have a storage capacity of approximately 5,000 acre feet.

To make this storage, two earth dykes are needed with a maximum height of 10 feet and a total length of 2,000 feet.

The spillway will have to be through a canal preferably on the west side of the dam.

The fall of the valley is so light that about a mile of ditch will be necessary before water can be taken out for irrigation. From there down, however, there should be no trouble in getting the water on the land.

Following is an approximate estimate of the cost of the project.

Reservoir: Dam	10,000 cu. yds. earth @ 20c.		2,000.
	Spillway canal		300.
	Outlet works		200.
Distributing System:	Estimated		10,000.
	20% Engineering and incidentals		<u>2,500.</u>
			15,000.
	Storage capacity	acre feet	5,000
	Seepage loss	20%	" " 1,000
	Available at the land	" "	4,000
	Duty of water	2 acre feet per acre	
	Giving 2,000 acres available for farming, at a cost per		

acre of \$7.50.

The land under this project is fair in quality and will probably grow good corn crops. Alfalfa and small grains would probably be successful, but unless they are carefully worked, the corn would be far the better crop.

There is an immense area of good grazing land to be had in the surrounding country, and a considerably larger population could be supported in the valley were a constant supply of water assured.

(3) White Cone Project.

This project is located on the Moqui Reservation, in a wide wash, 10 miles south of Jettyto Springs and $\frac{1}{2}$ mile east of where the Keams Canon-Holbrook road crosses said wash, as per sheet 3 of appendix.

It consists of a lake bed which is intermittently filled with flood waters and is often dry.

The water supply will come from the flood runoff of a basin with approximately 150 sq. miles of watershed areas shown by the maps of the U. S. Geological Survey. On account of the flat nature of the watershed, the runoff will be light and should not exceed 10% of the precipitation. Estimating on this basis with a 12 inch mean rainfall, we will have an annual runoff of 10,000 acre feet.

An earth dyke 1500 feet long and 20 feet high should store approximately 4000 acre feet, and hence, with the large

runoff could probably be filled twice during the season. In this estimate we will figure on one filling only.

Following is estimated cost:

Reservoir: Dam	35,000 cu. yds. earth fill @ 20c.	7,000.
Spillway		500.
Outlet and control		200.
Distributing System: Estimated		5,000.
30% Transportation, Engineering and Incidentals		<u>3,800.</u>
		16,500.

There is an immense area of good farming land immediately below the dam site and the amount put under cultivation is dependent only on the water supply.

Assuming a duty of water of 2 acre feet per acre which will be ample in the dryest years for corn and small grains, we will have an area of 2000 acres available for settlement. The soil here is such that 10 acres will support a family and hence, we could support 200 families at an outlay of \$82.55 per family or \$8.25 per acre.

The Indians in this vicinity depend on sheep raising for a livelihood, and this project will help to put them in better circumstances. There is no permanent water within 10 miles in any direction so this development will also help the stock industry and open grazing lands not much used now. There are large corn-fields 15 miles below this site which testify

that the Navajo will farm where possible and with an assured water supply I believe a large enough colony could be gathered to make a day school possible.

(4) Beckishibito Springs Project.

This project is located in the Klee Thla valley in the northeast corner of the present Moqui Reservation, and is shown on sheet No. 4 of appendix.

The nearest school is at Tuba, 40 miles to the southwest, although the territory is nominally under the charge of the Superintendent at Keams Canon. The soil is good and the project has no drawbacks except its inaccessibility.

The water supply will depend entirely on flood runoff, the drainage basin having an area of 100 sq. miles as shown by the Geological Survey maps. The watershed is flat and the runoff will not exceed 10%, or a runoff of 6,400 acre feet for a 12 inch rainfall. The sediment carried is negligible.

The reservoir will be situated at a lake 4 miles up the valley from the Beckishibito Springs. A ~~small~~^{20 ft} earth dam here, 600 feet long on top should store approximately 3000 acre feet. With the amount of runoff in the valley, the basin could be filled twice but we will estimate on one filling only.

Following is estimated cost of project:

Reservoir: Dam	20,000 cu. yds. earth fill @ 20c.	4,000.
	Spillway	500.
	Outlet and Control	200.

Distributing System:	Estimated	4,000.
30% Transportation, Engineering and Incidentals		<u>2,600.</u>
		11,300.

The reservoir would serve 1500 acres in dry years, making the cost per acre about \$7.55. This is a very reasonable first cost and there is no danger of filling the basin with sediment.

The Indians tried to develop this site themselves for stock purposes but not having provided a spillway, their dam was washed away.

Class III Projects.

(1) Zuni Forest Project.

This site is located on the southern-most of the two roads from St. Michaels to Ganado, Arizona, and lies in a small basin 10 miles west of the former place.

It consists of a small basin almost closed at the lower end by rock walls.

A 50 foot dam of earth fill, core-wall type, will impound possibly 4000 acre feet. The dam would be 100 feet long on the bottom and 300 feet on top.

The drainage basin is very small but there is a small underflow and the indications point to a high runoff.

Considerable silt is carried by the floods and would probably impair the usefulness of the reservoir. This taken together with the cost of the distributing system spoils the project.

The lands which could be irrigated from this project lie inside the Zuni National Forest but the only growth is a scrub pine unfit for commercial purposes.

(2) St. Michaels Project.

This project is located 3 miles above St. Michaels, Arizona, on the road to Fort Defiance and consists of a natural lake which by the erection of a dyke 14 feet high and 1800 feet long, could be made to store probably 3000 acre feet of water.

The water supply will be Black Creek, a stream rising in the Choiska Mountains, and which carries immense floods after the heavy rains prevalent during the summer months. About 750 feet of ditch will be required to get the water into the reservoir and expensive headworks will be necessary to control the intake.

The land to which water can be applied is limited only by the supply and the quality of the soil is not to be excelled.

The cost of this project, together with the possibility of raising corn by dry farming methods makes the present construction impracticable.

(3) Black Creek Project.

This project is located in a large basin on the west side of Black Creek about 5 miles above Fort Defiance. The water supply would come from Black Creek and a mile of ditch with expensive headworks will be required to get the water into the reservoir. The dam will be 1500 feet long and a maximum

of 20 feet in height with a storage capacity of 2000 acre feet. There is an abundance of good land to reclaim but the cost of this makes immediate development undesirable.

(4) Tsalee Project.

This project is located on the Tsalee Creek, a perennial stream coming from the Tunitcha Mountains, about 45 miles north of Fort. Defiance. Its normal flow seems to be close to 3 second feet and this running into the Canon del Muerto loses itself in the sand.

At the crossing of the Ft. Defiance-Round Rock road over Tsalee Creek, a reef of rock crops out forming a canon about 50 feet deep which can be closed with a dam of the rock fill type and about 3000 acre feet of water impounded. The Tsalee Creek has a very steep and rocky drainage basin which has a large runoff after the heavy rains but even so, the silt carried does not seem excessive. The water impounded could be either used on the Chin Lee Project or diverted for use on lands closer to the Reservoir. In the latter case, an expensive distributing system will be required, and it is this which, in my judgment will render the project useless. I would suggest further investigation of this site, however, for the soil of the land along the north side of the Canon del Muerto is very good.

These few sites seem to be the only ones of any value on the Navajo and Hopi Reservations.

There are numerous places where one could put in a dam but such features as heavy silt content in the water, or in-

sufficient water supply, or other causes render them unworthy of consideration.

In some places too, the Indians might build small embankments for themselves, and store enough water for one irrigation of 20 to 40 acres. Such works, however, could never be permanent, and would not justify supervision.

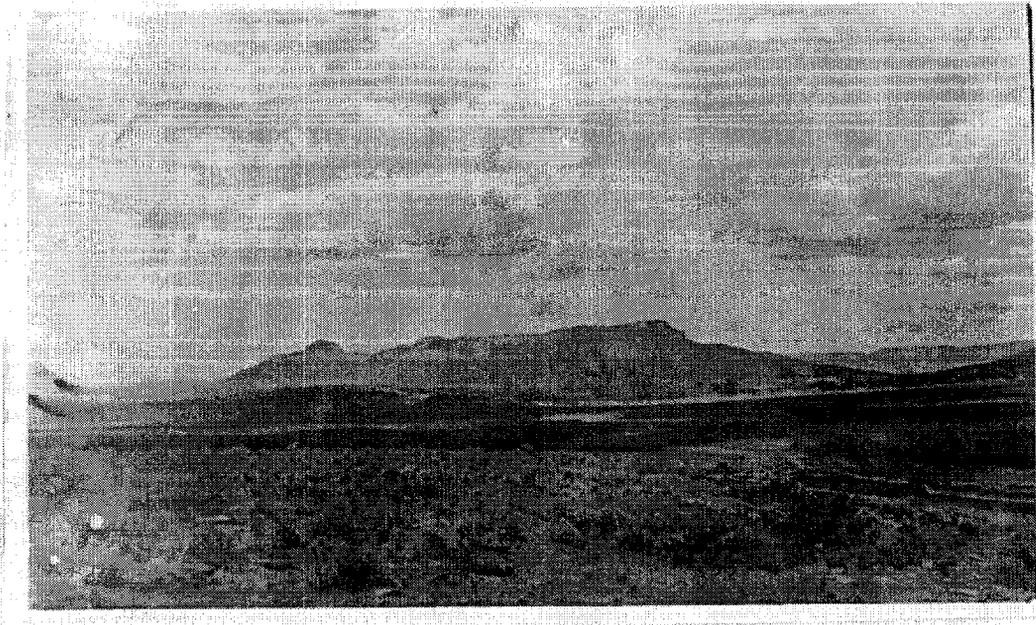
I believe the foregoing projects contain everything of any value and submit them for your consideration.

Yours respectfully,

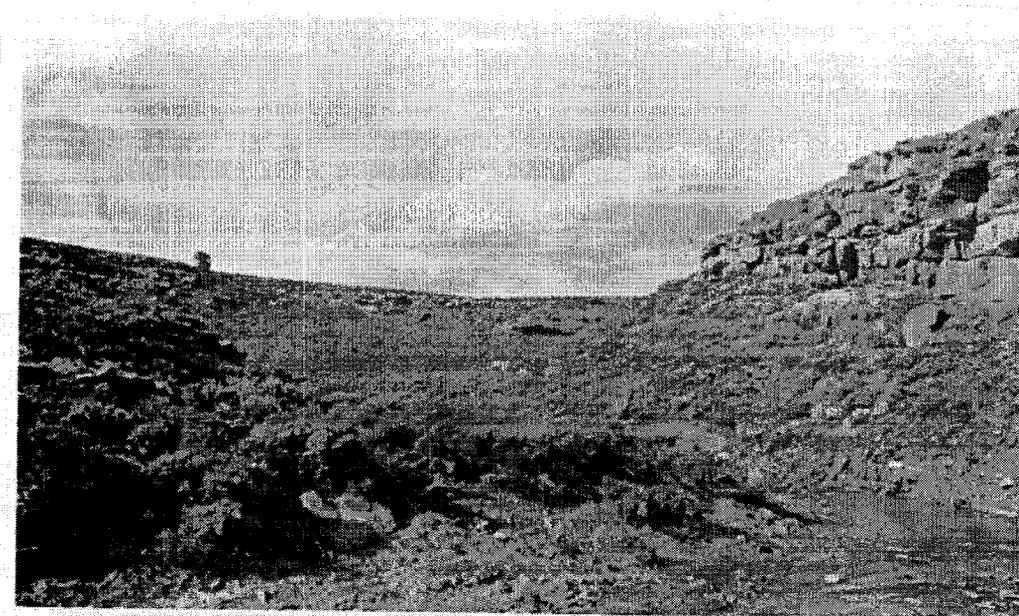
Edl Kinney
Assistant Engineer.

SUMMARY.

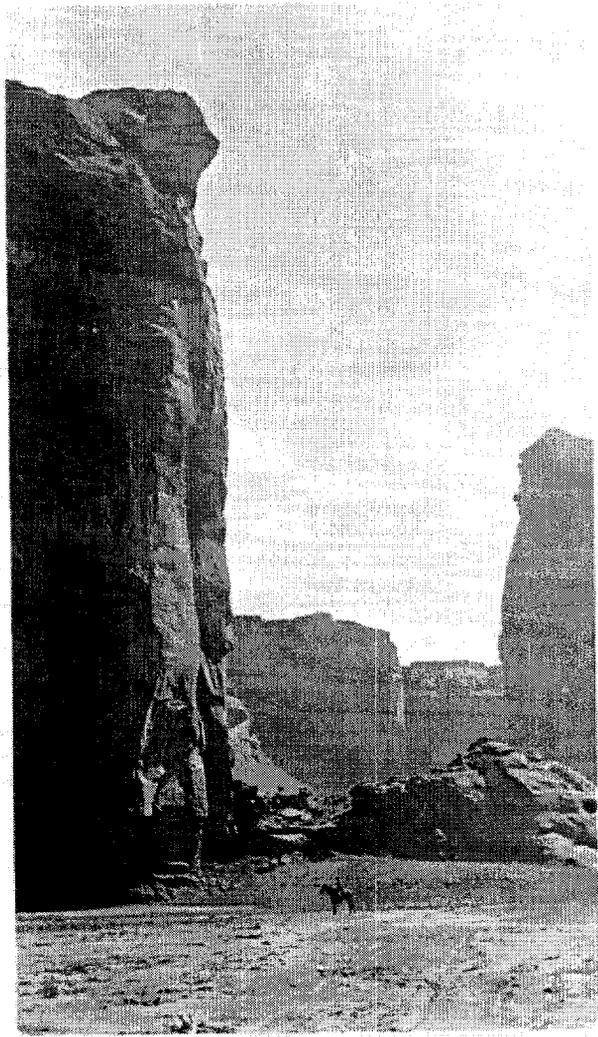
Project	Kind	Storage acre ft.	Land seized	Cost	Cost per acre
Chin Lee	Class 1	1050	3000	\$20.600.	\$ 6.86
Ganado	Class 1	4440	1775	60.100.	35.
Round Rock	Class 1	none	1500	4.600.	3.
Leupp	Class 1	11600	7384	282.800	35.35
Whiskey Creek	Class 11	25000	10000	206.900.	20.69
Baigihotzo Lake	Class 11	5000	2000	15.000.	7.50
White Cone	Class 11	4000	1000	16.500.	8.25
Beckishibito	Class 11	3000	1500	11.300.	7.55
Zuni Forest	Class 111	4000	2000	25.000.	12.50
S. Michaels	Class 111	3000	1500	15.000.	10.
Black Creek	Class 111	2000	1000	22.000	22.
Tsabee Creek	Class 111	3000	1500	no estimates without surveys.	



Reservoir Site At Whiskey Creek

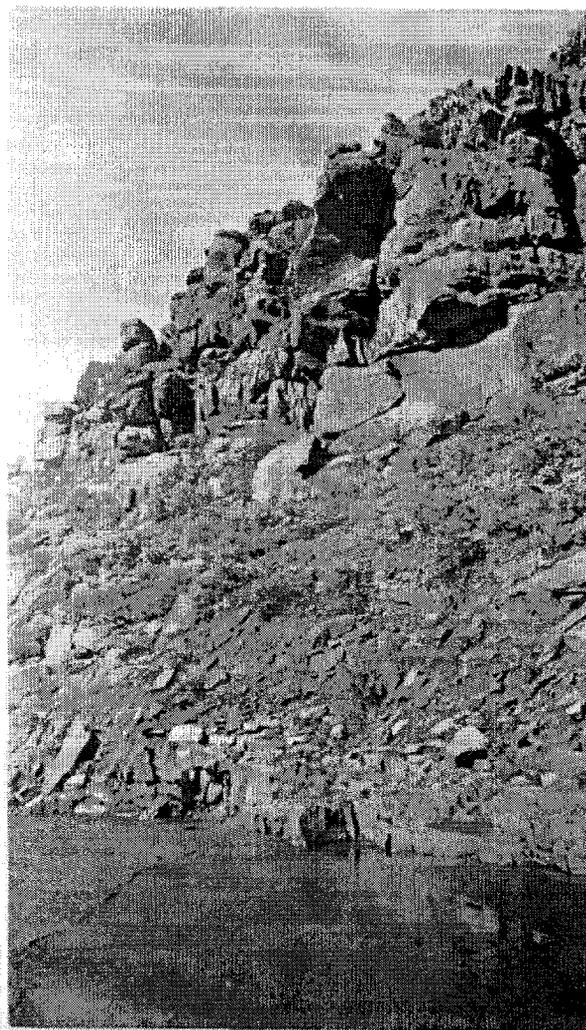


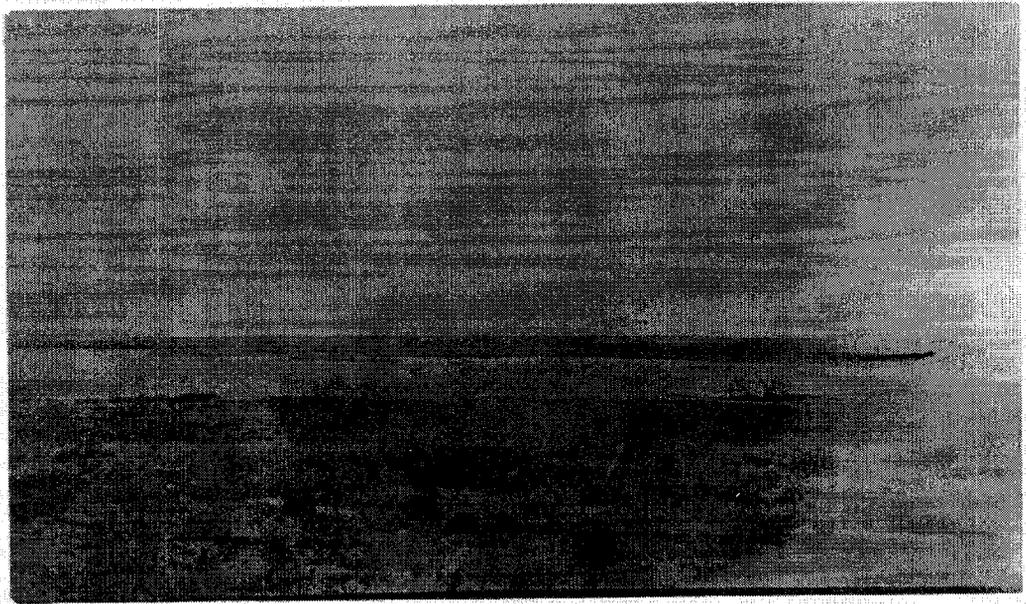
Dam Site Of Above Looking Down Stream



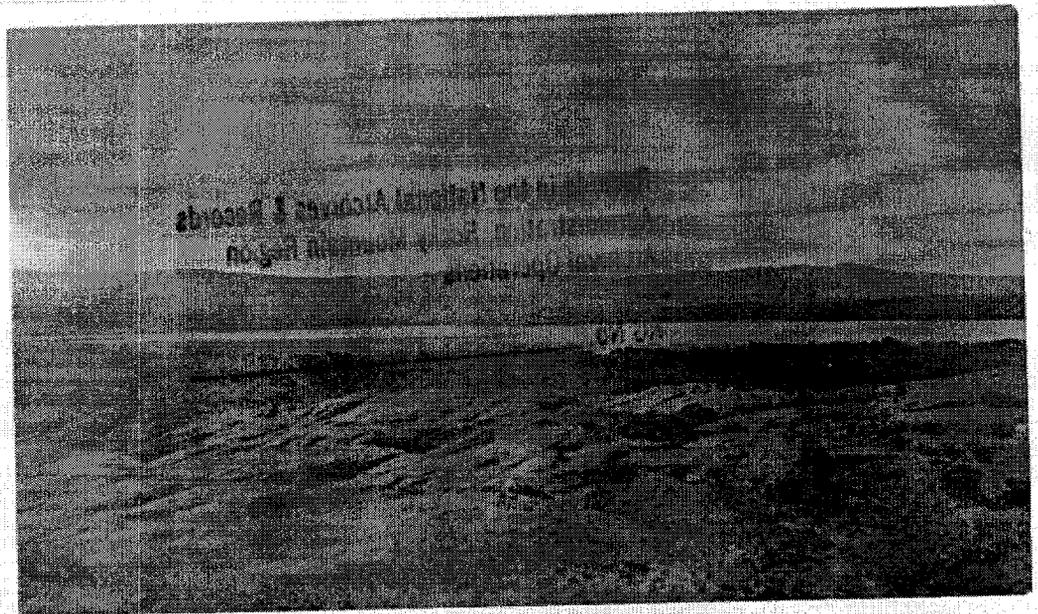
Canyon de Chelly

South Wall Of Dam Site
Whiskey Creek Reservoir





Proposed Baigihotzo Lake Reservoir



Proposed Beckishibito Springs Reservoir