

GRAZING, RANGE CONTROL, AND WATER DEVELOPMENT

NAVAJO INDIAN COUNTRY

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By

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and

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Fifth Irrigation District
Box 435, Albuquerque, N. M.

August 24, 1931

Commissioner of Indian Affairs
Washington, D. C.

Through Assistant Director of Irrigation

Through Director of Forestry

Dear Sir:

There is submitted herewith our report relative to the range management and water development for the Navajo and Hopi Reservations.

It is believed that the program of development as outlined could be economically completed within five years after the present fiscal year by following the financial set-up as generally outlined in the estimate of funds of the Fifth Irrigation District for the fiscal year 1933.

Respectfully submitted,

H. C. Neuffer,
Supervising Engineer

Enc.

W. H. Zeh,
Forester.

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GRAZING, RANGE CONTROL, AND WATER DEVELOPMENT

NAVAJO INDIAN COUNTRY

The purpose of this report is to set forth the situation in the Navajo country in Arizona and New Mexico, both on and off the reservation, as to grazing, range control, and the development of a water supply which will make possible full use of the grazing facilities and enable the inauguration of range control.

The matters of grazing, range control, and water development in the Navajo country are inseparable in that the full use of the grazing lands is dependent upon both range control and water development while range control is dependent upon a complete water supply. However, it would be futile to completely develop the water for stock purposes without range control, as the entire reservation would soon become a barren waste as now exists in certain overgrazed areas.

The grazing situation on the Navajo Indian Reservation is such that where water now exists the country is very much overgrazed and where areas show good grass production, the development of water is lacking. It is apparent that something must be done to save the range on the reservation where water now exists and insure the proper utilization of the range as a whole. Having this in mind, various conferences were held and a field reconnaissance begun during the month of March, 1931, to study the location and various

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types of water development necessary for grazing and range control. The grazing situation on the Navajo Reservation is covered very fully in the report of December, 1930, by W. H. Zeh, Forester.

The purpose of this new survey was to co-ordinate the water development with the findings of the above report and to bring to light any new information regarding the grazing situation. These studies brought out the fact that a great deal of needed water can be developed at a comparatively nominal cost. Many existing seeps and springs are now practically useless, and are more or less only muddy places in the ground. This is due to the trampling of many hoofs which soon destroys a spring unless it is fenced and the water piped into troughs.

During the trip taken in March, which was practically at the close of the winter season and the beginning of the spring and lambing time, it was found that in many sections the stock was very poor and the range literally eaten into the ground. However, other areas supported an excellent stand of grass which barely had been touched. This was due to the fact that those areas had no natural water and required the most expensive type of development which, due to lack of funds, were never constructed. It is necessary that such areas be grazed during the time when there is snow on the ground or sufficient precipitation so that sheep and stock can get along without an additional supply of water.

During mild winters or years of little or no snow, many areas can not be grazed and, consequently, the areas used as summer range

must also support the stock during the winter. The result is readily visualized.

To travel over the Navajo country and to observe the overgrazed areas, the general shortage of feed and water, and the rapidly progressing stages of erosion, fills one with grave concern about the future of the Navajo livestock industry and the welfare of the Navajo in general, since his life is closely interwoven with the success and failure of his herds. The great urgency of immediate steps to relieve and improve the existing conditions is self-evident to all interested observers.

In order to improve the conditions, the first matter of consideration is that of range management. However, for the purpose of range management certain fundamental requirements are essential. One of the most important is the development of the water on the range so that it can be properly utilized. Without water development, certain areas would be of little or no value in the general scheme of management, as they can not be depended upon for grazing purposes. This is on account of the fact that water is usually available during short periods and that the time when this water is available is not regular and can not be predetermined.

Equally as important as water development is the need of a sufficient force of stockmen, so that each superintendent can regulate and control the movement of the stock on the various ranges in such a way that a definite plan of management can be

followed. In fact, if the time and place of the grazing can not be controlled, there can be no management and any attempt to improve the conditions merely by water development would undoubtedly prove futile.

In making plans for deferred grazing it will be found that tribal customs and usages will have to be considered to a certain degree. During the past years it has often been customary to have certain areas grazed by stock belonging to certain families or clans. It will not be possible to ignore this old, established custom altogether. It will be found that a reduction in the number of stock through people culling the herds will be one of the most important steps leading up to range management which can be inaugurated only by the development of additional water.

Water for proper range management should be developed so that it will be within a reasonable distance of all feeding grounds so as to avoid wearing out the range by excessive travel.

The following reasons are given to show the necessity for additional water development:

1. Stock moving long distances to water trample out more range and destroy more forage than they eat.
2. Not enough watering places means the concentration of a large number of stock near water, with the result that a large radius of barren and denuded land surrounds each watering place. In the case of surface reservoirs, due to the fact that the soil around them is loosened by many sheep hoofs, it is found that

during heavy rains much silt is washed into the reservoirs and causes them to become shallow and reduced in capacity in a short time. This increases the maintenance cost or even necessitates the construction of a new reservoir after a few years' service.

3. The Indians themselves have made several attempts in many places to construct reservoirs, but these usually washed out after the first heavy flood waters came. Their failures are attributed to the fact that most of these tanks are poorly located and not properly constructed. The Indians try to do this work with their horses which are very small, light, underfed, diseased, and inbred. It is not possible to do a day's work with those teams which have no strength, because of lack of proper feed. The tanks to be constructed must in some cases be quite high, in order that they will be able to hold at least one whole year's supply of water. To move dirt in such quantities and raise it ten to fifteen feet or more requires very good teams or power tractors. To use the Indians' teams for the higher dams not only results in the construction of poor dams, most of them not high enough to be very useful, but also greatly increases the cost of the work. Considerable experience and skill is required to properly construct the dams, and it appears that the whole work of constructing these dams should be placed entirely under the direction and supervision of Irrigation Service and carried on by modern methods. However, where labor is required temporarily, Indian teams can be used in the manner subsequently outlined.

4. The presence of water on some areas naturally makes them available for summer use only; consequently they are grazed year after year, depriving the growing grass of an opportunity to send out sufficient leaves to manufacture and store surplus food in its roots to be used the following season in giving the plants strength to send out new shoots and to propagate itself by means of seed or rootstock. Continual cropping of the grass during its growing season will weaken the plants to such an extent that they will eventually die. The dying out of plants opens up the sod cover and this is the first step in erosion. Soon after the sod cover has been broken and erosion starts, noxious and poisonous weeds soon replace the good forage grasses.

5. The development of water on the ranges now used only during the winter months will enable the stockmen to practice deferred grazing and give the present summer ranges a chance to build up their density and productiveness. As the range is built up, erosion will diminish and many of the noxious and poisonous weeds will die.

6. The Navajo Indian is largely dependent upon his flocks for his living. The welfare and well-being of his entire family is directly influenced by the condition of the range and the forage available for his sheep and goats. The proper management of the range, which includes the development of additional water, therefore, becomes a problem of paramount importance.

7. The development of existing springs and seeps will make more and better water available at places where stock previously obtained only a small amount of very poor water.

8. Small springs and seeps, although barely sufficient for stock watering purposes, should not be overlooked as they will often furnish an additional supply of clean water for domestic purposes, thereby bringing about better health conditions.

The general plan of water development is to bring water within not to exceed three miles of all points, provided the topography is suitable. On account of geographic conditions such as ridges, canyons, and precipitous mesa walls, it is believed that an equal of at least two first-class developments should be placed on each township. In the matter of spring developments it will sometimes be necessary to have them much closer together on account of the small quantity of water supplied. In fact, some springs will be able to supply water only sufficient for stock grazing within one or one and one-half miles radius.

In making the field reconnaissance, various types of water developments, listed as follows, were considered: Springs, dug wells, drilled wells with windmills, artesian wells, surface reservoirs, as well as the matter of recasing and otherwise repairing the existing drilled wells. The type of water development in the Navajo country is chiefly dependant upon the availability of the water. In certain areas there are numerous small springs, and occasionally larger springs, which can be developed and the water conserved so as to

make it available when needed. In other areas, particularly adjacent to some of the large arroyos, it is possible to dig shallow wells from which the water can be pumped. While at other places water is available in the sandstones at depths of 100 to 600 feet. This water can be pumped by windmills. In the region east of the Lukachukai Mountains, in the Northern, Southern, and Eastern Navajo jurisdictions, artesian water can be obtained at depths of 500 to 900 feet. On some of the high, broad mesas where there are no springs, there is no opportunity to drill wells at a reasonable cost and it is essential that surface reservoirs be constructed to store the run-off during the wet seasons. In fact, the type of water development is dependent upon local conditions; and in making the field reconnaissance, these matters were taken into account when determining the type or types of development for any particular area.

It has been suggested that it might be possible to drive well points into some of the valley areas and obtain wells in that manner. However, on account of the fact that there are practically no coarse sands and gravel in the Navajo country, this type of water development is not practicable, as the sands are so fine that the inflow through the screen of a driven pipe would be insufficient to give an adequate water supply unless the screen openings were of sufficient size to admit the sand. The latter, of course, would defeat the purpose of the well, as it would soon be filled with sand.

Spring development consists of digging out the spring, walling it up with concrete, and piping the water from the spring to a reinforced trough.

Dug wells consist of open excavations where water is available at shallow depths, which is usually found in the sands adjacent to arroyos. In these cases the sides are walled and a gravel filter, topped with hand-placed stones, is placed in the bottom. The water can be pumped either by windmill or by a hand pump, and it is believed that for most cases a hand diaphragm pump should be installed to pump the water from the well to a reinforced concrete trough.

Spring development and dug wells are the least expensive, and it is planned to use these types wherever possible.

As mentioned above, certain areas are suitable for drilled wells with windmills. The largest area of this type is in the Leupp jurisdiction. These wells will be from 100 to 400 feet deep and are to be equipped with a windmill, a concrete storage tank of 5,000-gallon capacity, and a concrete watering trough 30 feet long.

Artesian development, which when properly done, is the most satisfactory type, although the most expensive. Artesian wells must be capped and piped to a trough with the necessary overflow to take care of excess water.

Most of the developments in the past have been spring developments, windmill wells, and dug wells. For the new work the single type of development, which will likely exceed all others, is that of building surface reservoirs. During the last few years two

reservoir crews have been operating, one in Eastern Navajo and one in Western Navajo. These crews have been operating with crawler-type tractors and rotary scrapers, which have been found to be the most economical types of machinery for this development.

Considerable thought has been given to the matter of having the Indians build these reservoirs with their teams, paying them for this work at the same rate it would cost to do the work with power machinery. The advantage of this method is that the Indians will be doing the work and, also, will be enabled to buy food stuffs and subsistence, although the compensation will be low if the work is to be done without an increase in cost. On account of the fact that the Indian teams are very small and underfed, it is extremely doubtful if this method will prove satisfactory for a general program. However, it is believed that the Indians can build the smaller or shallower reservoirs where water is needed for temporary or seasonal use. The 1932 program is being worked out along this line in certain areas of the Southern and Northern jurisdictions where water is needed for seasonal range only.

The Indians of these two jurisdictions are organized into chapters, and it is planned to contract with the chapter officers for the construction of the dams. The amount of payments will be made on the basis of past costs for reservoir dams constructed with machinery. These costs have been twenty cents a cubic yard for earthwork, one dollar a square yard for embankment riprap, and two dollars a cubic yard for excavation of rock spillways. The

Indians will do the work as a group and, while the compensation will be low, it is believed to be sufficient to purchase food supplies and stock feed while the work is in progress. Distinct advantages of this method of construction will be that the Indians will be able to obtain some money to assist in their support and will develop a keen interest in the projects, which is essential for proper range management.

A study of the present windmills and cased wells now in existence indicates that it is essential in almost every instance that they be recased, and in some cases drilled deeper and developed further. For this work it is planned to purchase a well rig and do the work force account.

The following tables show the developments to date, those required to make the water supply complete for grazing, and the estimated cost of the new work.

TABLE I

Water Development Navajo Country to Date

	Eastern Navajo	Southern Navajo	Leupp	Western Navajo	Hopi	Northern Navajo	Totals
Reservoirs	10	--	4	28	--	--	51
Springs	4	54	23	55	78	107	321
Dug Wells	4	51	6	26	15	59	161
Drilled Wells							
Windmills	--	35	4	4	30	4	77
Artesian Wells	<u>8</u>	<u>4</u>	<u>--</u>	<u>--</u>	<u>4</u>	<u>7</u>	<u>23</u>
Totals	55	144	37	113	127	177	633

TABIE II

Proposed Water Development to Provide for Full Use.
of Grazing Facilities in the Navajo Country.

	EASTERN NAVAJO		SOUTHERN NAVAJO		LEUPP		WESTERN	HOPI	NORTHERN	TOTALS	
	On Resv.	Off Resv.	On Resv.	Off Resv.	On Resv.	Off Resv.				On Resv.	Off Resv.
Reservoirs	10	60	112	19	27	45	125	68	71	409	142
Springs	4	40	115	14	3	59	33	64	98	517	113
Dug Wells	1	57	36	43	10	23	35	23	27	132	128
Drilled Wells Windmills	0	2	0	0	10	0	1	0	5	16	2
Artesian Wells	3	6	0	0	0	0	4	0	3	10	8
TOTALS	18	167	263	76	50	130	196	153	204	884	393
Summary	205		339		150		196	153	204	1277	

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TABLE III

Estimate of Cost of Proposed Development

Reservoirs, 551 @ \$1200	\$661,200
Springs and Troughs, 430 @ \$465	199,950
Dug Wells and Troughs, 260 @ \$420	109,200
Drilled Wells (tank, trough, and windmill) average 500 ft. deep, 18 @ \$2,500	45,000
Artesian Wells and Troughs average 800 ft. deep, 18 @ \$4,800	86,400
Concrete Tanks and Troughs, 134 @ \$720	96,480
Cap Artesian Wells and Troughs, 5 @ \$400	2,000
Recase Existing Wells, 116 @ \$940	<u>109,040</u>
	\$1,309,270
Eng., Office, and Contingencies, 10%	130,930
O. & M. for 5 years @ \$19,000	95,000
Hopi O. & M. for 1932	<u>6,000</u>
	1,541,200
Less Navajo and Hopi, 1932 \$100,000	
Less Hopi, 1932 <u>6,000</u>	
	<u>106,000</u>
Net Required after 1932	\$1,435,200

TABLE IV

Estimate of Cost of Proposed Development
on Reservation

Reservoirs, 409 @ \$1,200	\$490,800
Springs and Troughs, 317 @ \$465	147,405
Dug Wells and Troughs, 152 @ \$420	55,440
Drilled Wells (tank, trough, and windmill) average 500 ft. deep, 16 @ \$2,500	40,000
Artesian Wells and Trough average 400 ft. deep, 10 @ \$4,800	48,000
Concrete Tanks and Troughs, 134 @ \$720	96,480
Cap Artesian Wells and Troughs, 5 @ \$400	2,000
Recase Existing Wells, 116 @ \$940	<u>109,040</u>
	\$989,165
Eng., Office, and Contingencies, 10%	98,920
O. & M., 5 years @ \$19,000	95,000
Hopi O. & M., 1932	<u>6,000</u>
	1,189,085
Less Navajo and Hopi, 1932 \$100,000	
Less Hopi, 1932 <u>6,000</u>	
	<u>106,000</u>
	\$1,083,085

TABLE V

Estimate of Cost of Proposed Development
on Lands Outside Reservation

Reservoirs, 142 @ \$1,200	\$170,400
Springs and Troughs, 113 @ \$465	52,545
Dug Wells and Troughs, 128 @ \$420	53,760
Drilled Wells (tank, trough, and windmills) average 500 ft. deep, 2 @ \$2,500	5,000
Artesian Wells and Troughs average 800 ft. deep, 8 @ \$4,800	38,400
	<u>320,105</u>
Eng. Office, and Contingencies, 10%	32,010
	<u>\$352,115</u>

The above costs were estimated on the basis of past cost for doing like work. In the case of reservoirs, it is higher than the average cost to date on account of the fact that it will be necessary to have higher dams than in the past in order to hold water during the entire year where the range is for summer grazing.

A study was made of the reservation and the lands outside the reservation boundaries occupied by Indians. It is estimated that there are approximately 14,300,000 acres of Indian lands within the reservation boundaries and at least 4,000,000 acres outside the reservation boundaries occupied by Indians, so that the Navajo country embraces an area in excess of 18,000,000 acres.

This land outside the reservation which the Indians occupy is chiefly public domain and railroad land; however, there are a number of Indian allotments and a few Indian homesteads within these areas. While there is no authority under the present appropriation bills to develop water outside the reservation, except under letter Irrigation 6353-30 of March 7, 1930, which gives authority to develop water on lands purchased for the Navajos, it is felt that some arrangement should be made to supply water to this land as well as to that on the reservation. It is suggested that in case of allotments the individual Indians deed to the tribe that area required for the water development and give an easement for the necessary crossing of this land by other Indians in the vicinity using the water. This will place the allotted and homestead lands on the same footing as the lands on the reservation.

It is believed that water development is an extremely important consideration in the development of the grazing resources of the Navajo country.

The critical point in the management of the Indian ranges will come at the time when new areas are opened for summer grazing by the development of additional water through the construction of the large number of tanks contemplated and necessary. Past experience has shown that where a new area has been developed it has soon been overgrazed. In fact, in some instances where a development has been completed, as many as 15,000 head of sheep have immediately moved into the territory. This naturally is

very detrimental to the grazing and practically ruins it for a number of years. To permit the Indian to graze his stock as he chooses will result in the complete grazing of the entire range within one season.

It is, therefore, essential that each superintendent exercise his authority and influence toward controlling the movement of the Indian stock by whatever means may be at his disposal, with a view of the Indians themselves realizing the advantages of deferred grazing and voluntarily assisting the superintendents in this task. To develop additional water without controlling the movements of the stock will defeat the very purpose desired, and unless every effort is made by the superintendents to regulate the movement of the stock, it will be better to discontinue all efforts to develop water, as at least a few areas will still support grass and even though they can not be properly utilized they will tend to prevent erosion destroying the entire country.

Means of controlling the grazing in certain overgrazed areas might be brought about by partly dismantling windmills where they supply the water, thus putting them out of commission, and in the case of dug wells and springs, tightly fencing the area to prevent the use of the water. In the case of reservoirs it would be necessary to fence the entire reservoir area; however, as many existing reservoirs are not deep, the country adjacent is not so badly overgrazed, as the stock can graze in these areas only during a part of the year, thus making an automatic saving in the range.

All of the Navajo superintendents were interviewed by Mr. A. H. Womack and Mr. W. H. Zeh in order to obtain their opinion as to the probability of controlling Indian stock after water has been developed, and it was found that they all believed that this could be accomplished, although some qualified their statement by saying that they would need additional stockmen. This opinion is also shared by the writers. Exhibit A, hereto attached, presents copies of the letters addressed to Mr. Neuffer covering this and other points discussed.

With the development of more water it is very important to stress the reduction in the number of unprofitable stock. An active educational campaign directed to teach the Indians the advantages of deferred grazing and of culling their herds must precede or at least concur with the development of water. Unless the Indian is a willing co-operator in this project, it will not be possible for the already inadequate personnel to cope with the problem and regulate the movement of the Indian stock and prevent them from grazing the areas reserved for winter grazing under plans of management prepared for the respective areas.

It is believed that this whole program can be more readily accomplished if the construction program each year can be concentrated in certain regions or districts so that the efforts of those charged with the carrying out of the grazing management plan can likewise concentrate their efforts upon a comparatively small area each year and thereby be more positive of success in carrying out their proposed plan of range management.

In making plans for the improvement of the Indian ranges on the Navajo Reservation, the discussion is not complete without mentioning rodent control, elimination of useless horses, and the education of the Indian in improved methods of stock raising and methods of handling them on the range, so that the range will improve as time goes on instead of deteriorating as at the present time.

Water development, culling of herds--thereby reducing the excess numbers, rodent control, education, and the elimination of useless horses are the principal factors to be considered in any plan designed to improve the stock industry of the Navajo. Each of these factors furnishes enough material for an independent report; however, they are mentioned here as they are closely allied and must also be considered in order that the entire plan will be successful and the desired end accomplished.

During the last visit to the various superintendents of the Navajo and Hopi Reservations, plans were considered for the development of water, and the areas were marked out on which the development work was to take place during the fiscal year 1932. These areas were laid out to fit in with the plan of further developments during the succeeding years in the hope that additional funds will be available to carry on an extended program for the entire region inhabited by Navajo Indians.

On the Southern Navajo Reservation, first consideration will be given the southwest region. This area is supporting a fair

stand of grass at the present time but has no water for the stock. Only during the time that some snow is on the ground is it possible to utilize the grass in this area. Due to the topography and the geological structure of this area it will be necessary to construct surface reservoirs at the higher elevations, as well-drilling will be too expensive. Along the Pueblo Colorado and some of the smaller washes it will be possible to dig shallow wells and obtain water at a depth of six to ten feet. Numerous attempts have been made by Indians in this area to construct tanks in order to have water for their stock, but in all cases noticed, these tanks had washed out due to improper location and construction.

After this area in the southwest corner of the Southern Navajo jurisdiction has received the necessary tanks and shallow wells, it is planned to proceed with the development in a northerly direction, working toward Chin Lee and then eastward.

The 1932 program now under way provides for one well and one spring crew to operate during the year and for the construction of twelve dams for reservoirs to be built by the Indians in the manner previously outlined. It will be noted on the tabulation of proposed work that 76 of the proposed developments are outside the reservation boundaries and within the area which it is proposed to consolidate. The work outside can be done in the same yearly program as that on adjacent reservation lands.

In the Eastern Navajo jurisdiction within the reservation

boundaries and the purchased areas it is found that the drilling of three Artesian wells, one spring and dug well crew working one-half year and one reservoir crew working one year will complete the program. However, as shown on the table of developments for all jurisdictions, there are but 18 developments on the reservation and 187 outside on lands occupied by the Indians. These outside areas are east and south of the reservation.

The Ramah district east of Zuni Reservation, the Canyoncito district about ten miles northeast of Laguna Indian lands, and the Puertocito district about forty miles south of Laguna lands are considered in the complete plan of development. It is understood that negotiations are under way for the purchase and consolidation of these areas. At the culmination of the purchase and consolidation, steps can be taken immediately to carry on the development. There are approximately 7,000 Navajos under Eastern Navajo jurisdiction living outside the reservation boundaries.

The 1932 program for Northern Navajo jurisdiction contemplates work in that area north and east of the Chaco and west of the reservation boundary. It is planned to build seven dams for reservoirs and complete ten dug wells. After 1932, to complete the development of this area will require thirteen additional reservoirs and five drilled wells with wind pumps. This is to be the second year's work. The third year's program provides for the development of that area in Arizona west of the Garrisso Mountain. The fourth year provides for the area in Utah, and the fifth year the country

in New Mexico north of the San Juan River and the area in Arizona and New Mexico south of the San Juan River, west of the Chaco, and east of the Carrizo Mountains.

The Western Navajo will require two tractor crews to carry on the necessary reservoir construction. The 1952 program provides for one tractor crew for a full year and one spring crew for three months to begin work north of Tuba City and develop the necessary reservoirs, shallow wells, and springs as they work north toward the Copper Mine country. In the following years the development will link with the 1952 program and be carried on toward the north boundary of the reservation and then east and south-east until the whole reservation is covered. Most of the Western Navajo area is quite sandy, and careful consideration must be given the location of each tank to insure a sufficient run-off to fill the tank during the rainy season. Some shallow well construction and spring development will also be carried on during the first year and subsequent years wherever it is feasible to do so. There is not much chance for the drilling of wells and for Artesian water on the Western Navajo, except in the northeastern part about 15 miles northeast of Kayenta, since much of this area is drained by the Colorado River Canyon.

The Loupp Reservation proper can best be served by the drilling of wells which will vary in depth from 100 to about 600 feet. Wherever feasible, drilled wells will give better service than reservoirs since they will furnish a dependable supply of clean fresh water. However, the drilled wells will need to be supplemented

by a few well-constructed reservoirs and shallow wells along the washes. Under the present authority it is not possible to go beyond the boundary of the Leupp Reservation proper and, except for the area purchased in the Castle Butte country, there exists a problem very similar to that in Eastern Navajo, in that a large area outside the reservation boundary is occupied by Navajos. It is understood that plans are being formulated to consolidate this area by exchange and purchase.

The 1932 program contemplates the drilling of one well to be equipped with a wind pump in the Canyon Diablo territory and one well and spring crew to operate in the Castle Butte country. The entire area of the Leupp jurisdiction is included in the general program; however, except for the reservation and purchased area, no definite program can be outlined until the purchases and consolidations are consummated.

The second year's program proposes the drilling of wind pump wells and digging of shallow wells on the reservation proper. The third year's work is to consist of the drilling of wells and the construction of surface reservoirs. The fourth and fifth years the work is to be confined to construction of surface reservoirs. When the areas outside the reservation are consolidated, the work will be extended and carried on simultaneously with that on the reservation.

The water development for the Hopi Reservation will be concentrated during the fiscal year 1932 in the area northwest from

Pinon toward Blue Canyon and north to the reservation boundary. This is a large area without water and after this area is developed the work in the succeeding years should advance in a southwesterly direction and then swing east across the south boundary of the reservation.

During 1932 one reservoir crew will operate for a period of nine months and a spring crew for two months in the area occupied by Hopi Indians.

Maps

The accompanying maps show the locations and types of the completed and proposed water developments. These locations are plotted on U. S. Geological Survey sheets and are numbered one to ten and listed as follows:

Sheet No.	Title
1	Wingate, New Mexico
2	Chaco, New Mexico
3	Abajo, Utah
4	Canyon De Chelly, Arizona
5	Ft. Defiance, Arizona
6	Tusayan, Arizona

Sheet No.	Title
7	Marsh Pass, Arizona
8	Henry Mountains, Utah
9	Echo Cliffs, Arizona
10	San Francisco Mts., Arizona

These sheets show the entire Navajo and Hopi Reservations and considerable territory outside the reservations occupied by the Navajos. However, there is a considerable area outside the reservation in which the Indians reside that is not shown, as the Canyoncito, Puertocito, and Star Lake districts of Eastern Navajo. Provision is made in the program for these areas.

The legend for the class of development is shown on the back of each sheet. All proposed development except springs is shown in red. In the case of springs those without reference numbers are undeveloped.

Summary

The grazing resources on the Navajo Reservation are being rapidly depleted through overgrazing and improper range practices.

The shortage of water is one of the principal factors which prevent the proper utilization of the range.

Overstocking of the used areas is a primary cause of erosion.

Water development and culling of the herds are the essentials around which to build and formulate a plan for the proper utilization and management of the range.

Since the welfare and existence of the Navajo is directly dependent, to a very large degree, upon his flocks, the problem of proper range management becomes a primary issue in the administration of the Navajo Reservation.

In order to reap any advantage and benefit from the development of water it is necessary that the superintendents exercise control over the movement of stock within their jurisdiction in accordance with a predetermined plan adopted with a view of practicing range control or deferred grazing. All superintendents expressed their opinion that such a procedure was entirely possible; however, some qualified their statement by saying that additional stockmen are needed in order to teach the Indians better range practices and methods of handling their herds and to help in the carrying out of a definite plan of range management.

The types of water development considered are the following: Springs with troughs; dug wells with troughs; drilled wells with windmill, trough, and storage tank; Artesian wells; surface reservoirs; and the repair and improvement of existing water developments. The type used will depend entirely upon its suitability and effectiveness, taking into consideration climatic, geologic, topographic, and economic conditions.

Types of water development which can be constructed by Indians are to be contracted to them in order to help them in obtaining a livelihood. The larger dams for reservoirs can be con-

structed most profitably and efficiently by use of machinery.

At present water can be developed only on the Indian Reservation proper, although the plan submitted includes such lands as are occupied and used by the Indians but which are not tribal at the present time. It is hoped that before long these areas will be included in the reservation through purchases or exchange.

The outlined plan of water development for the Navajo Indian calls for the following:

551 Reservoirs

430 Springs and Troughs

260 Dug Wells and Troughs

18 Drilled Wells and Troughs

18 Artesian Wells and Troughs

134 Concrete Tanks and Troughs

5 Artesian Wells to be Capped

116 Existing Wells to be Recapped

The construction of the above developments is spread over a period of five years, and the estimated cost is \$1,541,200.