STOTZEMBERGER REPORT

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REPORT ON THE IRRIGATION OF THE NAVAJO RESERVATION.

The Navajo Reservation is in the northeastern corner of the territory of Arizona, portions extending across the borders into the territories of Utah and New Mexico. Its total area is in round numbers 12,000 square miles, about one-third the area of the State of Indiana, or one-fifth that of Georgia. The general elevation of the valley lands is from 5,000 to 6,000 feet, the mountain rising to heights of from 8,000 to 9,000 feet, and a few peaks attaining an elevation of nearly 9,500 feet. The country is arid, the mean annual rainfall being from 12 to 14 inches, though the precipitation on the high summits may reach 20 inches. In a few localities agriculture can be carried on without irrigation in favorable seasons, but as a rule success each year can be attained only where a perennial supply of water can be obtained for irrigation.

The most important topographic feature of the reservation is the range or system of mountains extending in a general north and south direction across it. From the high peaks and mesas streams issue and flow in all directions, the greater number being upon the westerly side and flowing towards the broad valley known as Chin Lee. Near the head-waters these streams are perennial, but lower down the water disappears into the sands, except in time of flood, when it flows out upon the valley lands, and occasionally

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northward into the San Juan, which flows westerly across or along the northern end of the reservation. The San Juan is a large river compared with others in the arid region, and has never been known to be dry, although its waters diminish considerably during the late summer. As seen by the topographers of the Geological Survey it has usually been scarcely fordable, the pack trains being obliged to swim a hundred yards in crossing.

Portions of Utah, Arizona and New Mexico, including the Navajo Reservation, were mapped by topographers of the Geological Survey during the field seasons of 1882 to 1887 inclusive, all portions of the reservation being traversed. The maps are printed on a scale of four miles to the inch, elevations being shown by contours at intervals of 200 feet. Upon these maps all of the springs known at the time are shown, as well as the water-courses and beds of torrents. During the progress of this work, the topographers, of necessity became well acquainted with the habits of the Indians as well as the character of their country.

At a later date, by request of the Honorable Commissioner of Indian Affairs, three army officers were detailed to make an examination of the water resources of the reservation. From the printed report it appears that these three officers, with assistants and pack trains, made a rapid reconnaissance, and by traveling at a rate of ten to twenty miles per day, completed their examination in about a month and a half. Their report indicated that many of the

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springs shown upon the contour map should be cleaned and walled up, in order to increase the amount of water available, and that at a number of places small irrigation ditches can be constructed. Estimates of the cost of constructing these ditches and of boring wells have also been made. It is probable, however, that a more detailed examination of the ground by men experienced in irrigation construction would lead to a modification as to localities and projects for utilizing the water.

The number of Indians belonging on the reservation is estimated to be 16,000 to 18,000, and of these it is believed that nearly one-half are wandering off of the reservation, mainly in the south and west, to obtaining grazing for their herds and flocks. The Indians own probably more than 1,500,000 sheep and goats, about 125,000 horses and mules, and 10,000 cattle. The number of animals is probably increasing, and on the other hand the good grazing lands are becoming less and less in extent. In the vicinity of the springs in and near the reservation buildings, the best forage plants have been almost destroyed by reason of the excessive number of horses, cattle and sheep grazed thereon. It must be born in mind that in this arid country there is no "turf", the weeds and grasses which serve as food for the cattle being sparsely scattered over the surface. If these are eaten down to the roots many of the more valuable species disappear.

In order that the Navajos who are now off the reservation may

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make a living upon it, it is necessary to provide water in some localities where there is grazing now practically untouched. In some localities this can be done by cleaning out the springs, putting down wells and furnishing suitable pumps to bring the water to the surface. In a few spots it may be that the conditions are favorable for obtaining artesian water, but before attempts are made, it will be necessary to make a careful investigation of the structure of the country. But it is probable that when all of the available stores of water-supply are developed some of the grazing land will still be waterless and cannot be completely utilized. If all portions of the reservation could be grazed, it is doubtful whether the herds of the Indians could always be successfully pastured-- in other words, whether all of the Indians could find profitable employment in raising sheep, cattle and horses; probably it would still be necessary for some of the Indians to engage in agriculture. This, as previously stated, can only be done by the introduction of irrigation. Stock raising requires broad areas and widely distributed springs or pools of water; agriculture by irrigation necessitates a relatively dense settlement by the utilization of large quantities of water at one point.

The localities where irrigation can be most promisingly attempted are along the San Juan River and on the eastern side of Chin Lee Valley, utilizing the streams which issue from Chuska, Tunitchc, Lukachukat and Carriso mountains. Along the San Juan there is an

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abundant supply of water for all of the lands which can be brought under irrigation, and while the cost of the first construction of ditches, with suitable headworks will probably be large, the expense of the maintenance of the system will be relatively small. So far as quantity of water is concerned, it is one of the best localities in the arid region for the development of irrigation. In the Chin Lee Valley there are thousands of acres of fertile land, but the water supply is limited, and it will be necessary to construct storage works in or near the mountains in order to furnish a perennial supply. The topographic map has been constructed on a scale too small to reveal suitable natural reservoir sites, but the topographers of the Geological Survey are confident that a more detailed examination will show a number of localities where water can be held at relatively small expense. By constructing suitable irrigating ditches along the San Juan River, or by storing water on the east side of Chin Lee Valley, an area more than sufficient to support all of the Navajos could be brought under irrigation. In fact either of these localities would furnish farms for an equal number of white settlers.

From a consideration of the habits of the Indians and the resources of the reservation, it would seem advisable to give first attention to the development of as many springs and wells as possible, in order that the ungrazed parts of the reservation may be utilized. At the same time several small irrigating systems should be constructed and kept in operation under the direction of competent

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farmers, in order gradually to instruct the Indians in proper methods of irrigation. One large, well constructed system of irrigation would be more economical than a number of small schemes; but owing to the difficulty of bringing any large body of Indians together, it would be best first to construct a few smaller ditches at various points. The plan for these minor projects however, should be so made that they will not interfere with the future development of the water resources, when it becomes necessary to supply a larger number of Indian Farms.

To carry out this idea the following projects are suggested:

1. The development of springs and wells wherever sensible and useful for grazing flocks.

2. The diversion of the perennial flow of Bonito Creek near Fort Defiance, which can be utilized on lands below the agency and would irrigate 200 or 300 acres of land. This project should be so developed as to harmonize with the later construction of a storage reservoir on the same creek, where it enters the narrow gorge west of the agency, if such reservoir is found desirable in the future.

3. The diversion of the perennial waters of the Canyon de Chelly and their use in the Chin Lee Valley, where there is an abundance of irrigable land. This project should also be developed in such a manner as to harmonize with future storage of flood waters. The possibilities of storage and irrigation from Canyon de Chelly are very great.

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4. The diversion of the waters of Carriso Creek, and their use for irrigation in the vicinity.

5. The diversion of the waters of San Juan River to lands in its vicinity. The San Juan is by far the most important of the water resources of the Navajos, and there is fortunately a large tract of excellent land in the vicinity on which to divert it; its proper utilization is therefore the cheapest and best of the irrigation possibilities, in proportion to the resulting water supply. The stream, like all mountain rivers of the west is subject to great floods, and a suitable weir must be provided for controlling and diverting its waters. It would be highly wasteful and injudicious to divert the waters of the San Juan into a small ditch, for three reasons: First, a small ditch requires a steep grade to give the water sufficient velocity to prevent the ditch from filling with silt. A ditch ten feet wide and two feet deep requires a grade more than four feet per mile to give a velocity of two feet per second; While a ditch 20 feet wide and 6 feet deep will give a greater velocity on a grade of one foot per mile. In a length of twenty miles the elevation of the large canal would be sixty feet above that of the smaller, and it is therefore impossible to reach the best lands with the small ditch. Second, evaporation and percolation from a small ditch are proportionately far greater than from a large one. Third, a diversion weir will cost but little more for a large ditch than for a small one; and

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for other reasons, the cost of a large, or moderate sized system is very much less than for a small one, in proportion to the irrigated area.

A canal of an average width of twenty feet and a depth of six feet, on a grade of one foot per mile, will carry a volume of over 200 cubic feet per second, which would irrigate about 20,000 acres of land, or enough to furnish a thousand families twenty acres each. This scheme, with the smaller ones above mentioned, would solve the problem of irrigation for the Navajos.

A suitable point of diversion could probably be found near the mouth of the Animas River.

Before the details of the project can be fixed, or any close approximation to its cost be made, it is necessary to have examinations and surveys made by a competent irrigation engineer, and especially to collect all data regarding the maximum and minimum discharge of the river, and for this purpose a gaging station should at once be established on the river near the probable diversion point, as such observations ought to cover several years before construction is commenced. The San Juan scheme should therefore, be postponed for the present, except that the gaging station should be established and all available information relating to the past history of the river should be collected.

The atlas sheets embracing the Navajo Reservation are transmitted herewith. The irrigating ditches recommended above are indicated thereon by red line.

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