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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Techniques and data requirements for estimating the water availability on the Mescalero Apache Indian Reservation, Otero County, New Mexico

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Prepared by the Water Resources Division, U.S. Geological Survey (at the request of the Mescalero Apache Indian Tribe and the U.S. Bureau of Indian Affairs)

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Techniques and data requirements for estimating the water availability on the Mescalero Apache Indian Reservation, Otero County, New Mexico

By the U.S. Geological Survey, Water Resources Division,
Albuquerque, New Mexico, District Office

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Not reviewed for conformance with Geological Survey editorial standards and usage of geologic names

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Albuquerque, New Mexico

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Introduction

Request for preliminary information

On December 10 and 11, 1974 representatives of the Mescalero Apache Tribe, the U.S. Bureau of Indian Affairs, and the U.S. Geological Survey discussed the July 1974 proposal by the Geological Survey for studies of the water resources of the Mescalero Reservation (fig. 1). The proposal was designed to estimate surface-water conditions in the Ruidoso-Hondo drainage basins (fig. 2) and ground-water conditions on the Reservation at the end of a two year study. Surface-water flows from the remaining drainage basins on the Reservation (fig. 2) were to be determined after a five-year period of data collection. The Tribe's chief reason for wanting the studies was to obtain hydrologic information that would be of assistance in its concern for water rights and that would be needed for future water use and development.

During the meetings of December 10 and 11, 1974, representatives from two private consulting firms related their capacities to conduct hydrologic and water-use studies of the Reservation as well as defend the Tribe's position in court. Regardless of who might do the studies, the immediate need for certain basic information was recognized. At the request of the Tribe, the Geological Survey agreed to prepare a paper which would include a very general description of what little is known about the quantity and quality of water and the sediment yields from the Reservation, general lists of existing data, techniques for arriving at estimates of the water availability, and a program for obtaining additional data. The following write-up attempts to fill that commitment.

Purpose of request

This paper provides information that hopefully will help a private consulting firm determine the proper scope of work that it might do for the Tribe. In turn, the material will help the Tribe evaluate the proposal of studies submitted by the consultant and arrive at a plan best suited to the needs of the Tribe. The general description of water available on the Reservation, for example, might determine the extent of the water use studies. The list of techniques for estimating the water availability would allow the Tribe to select the appropriate types of data collection and analysis.

General conditions related to water availability

Several studies dwell on or relate to water resources on the Mescalero Apache Indian Reservation. One of the more comprehensive treatments is that by Sloan and Garber (1971). But while this report contributes to a qualitative understanding of the ground-water supply, this and other reports do not treat the water supply from a quantitative viewpoint. Thus, the present need is for a quantitative treatment of the water resources and potential use. But to arrive at a program to acheive this end, a description of general conditions should be helpful.

Drainage

The Mescalero Apache Indian Reservation includes 716 square miles of moderate to densely forested land of the Sacramento Mountains in northeast Otero County, New Mexico (fig. 1). Altitudes in this rugged terrain range from 12,003 feet on Sierra Blanca Peak to about 5,500 feet where Indian Creek leaves the Reservation seven miles west of Sierra Blanca.

Annual precipitation over the Reservation ranges from less than 16 inches on the lowlands to more than 32 inches on the summit of Sierra Blanca. Surface and ground water in the eastern three-fourths of the Reservation (Ruidoso, Hondo, Felix, and Penasco drainages) moves eastward from the Sacramento crest into the Hondo, Penasco, and Roswell underground water basins (fig. 2). The remaining part of the Reservation (Three River, Rinconada, and Tularosa drainages) drain westward into the Tularosa basin.

Geology

Sedimentary rocks crop out on about 90 percent of the Reservation. Outcrops of Tertiary igneous rocks occur in much of the remaining part of the area, mainly around Sierra Blanca Peak, but lesser outcrops of Precambrian igneous rock are found on Pajarita Mountain and Bent Dome. The sedimentary rock cover probably ranges in thickness from 0 to possibly 3,500 feet and consists of about 40 percent carbonate and about 60 percent clastic and evaporitic rocks (fine-grained sandstone, siltstone, clay, shale, gypsum, and anhydrite). Several down-thrown blocks in the west part of the reservation may contain considerably thicker sections of sedimentary rock.

Alluvial deposits in the stream valleys are poorly sorted and probably range in thickness from 0 to possibly 100 feet.

The structure of the rocks is a broad north-northeast-trending anticlinal fold, the axis of which is just west of the center of the reservation. The Sierra Blanca complex is a deep sedimentary syncline that has been penetrated and covered with relatively younger intrusive and extrusive rocks. Several northwest and north-trending faults and folds are mapped by Sloan and Garber (1971) and Kelley (1971), who give considerable information about the geology of the Reservation. The geology of the Reservation, however, has not yet been mapped in detail.

Hydrology

Surface water

Major perennial streams on the Reservation are the Rio Ruidoso, Rio Tularosa, and Indian Creek (fig. 2). The remainder of the major watercourses are either intermittent or ephemeral. A cursory examination of stream-flow data indicates that the mean annual flow in the Rio Ruidoso part of the Reservation is probably about 7,000 acre-feet and that the flow from the Rio Hondo part is about 2,000 acre-feet. It should be noted that the Rio Hondo drainage contains a large number of sink holes on and adjacent to the Reservation. Because of this it is very uncertain as to how much of the flow leaves the Reservation from the Rio Hondo drainage. Total mean-annual surface-water flow from the Reservation is probably on the order of 20,000 to 30,000 acre-feet (spring flow included).

Ground water

Most of the Reservation is underlain by ground-water. Even the Tertiary igneous rock is likely to contain some water in weathered or fractured zones where the topography is not too steep. The water is generally under water-table conditions, however, semi-artesian conditions might occur at places in the deeper part of the saturated zone where tight beds overlie permeable beds. The Yeso Formation, whose thickness is on the order of 1,000 to 1,500 feet, is probably the most extensive aquifer on the Reservation. The San Andres Limestone, which caps the Yeso formation in most places and is generally dry, might contain substantial amounts of water in several down-faulted blocks in the west part of the Reservation. All but a few of the wells and springs in the area tap either the Yeso or the San Andres formations. The alluvium is water-bearing in Tularosa Canyon west of Mescalero and in the South Fork of the Tularosa southeast of Mescalero for several miles. It might also contain some water in the North Fork of Tularosa Creek and part of the Elk-Silver Canyons. The alluvium in several stream valleys in the east part of the Reservation (Sloan and Garber, 1971) is likely to be drained as water levels appear to be fairly deep, but more information is needed to confirm this situation.

Large quantities of water are stored in the rocks of the area, but large well yields at more than a few select sites may not be possible because of the generally low permeability of the Yeso Formation. Wells drilled near the larger springs and the perennial streams are apt to have higher yields, but depletion of springs and streamflow could be expected.

The principal uses of well water on the Reservation, whose population is about 1,500, are domestic, public supply, and stock. Total ground-water pumpage for these uses probably does not exceed 1,000 acre-feet per year.

In general, a cursory look at the ground-water system of the Reservation indicates a low potential for sustained high well yields; however, additional study is needed to verify this premise.

Chemical quality of water

The quality of ground water from existing wells and springs, for which information is available, ranges from good to poor. Sloan and Garber (1971) cite total dissolved solids of 400 to 4,000 mg/l for wells and springs sampled during their reconnaissance of the Reservation. The quality of surface water, particularly in the vicinity of Sierra Blanca, is probably very good.

Records of chemical analyses of surface water indicate that the quality-of-water is generally good to fair. Surface water in the Rio Ruidoso located in the northwest portion of the Reservation is good with total dissolved solids ranging from about 200 to 800 mg/l. Analyses indicate high concentrations of bicarbonates, sulfates, and chlorides. In other streams the water is of poorer quality with total dissolved solids generally in excess of 1,000 mg/l and concentrations of bicarbonates, sulfates, and chlorides proportionally higher.

Sediment transport by streams

Most of the land surface within the Reservation is well protected by vegetal cover or it is rock. The Reservation's 716 square miles yield an estimated average 5,000 to 15,000 tons per year of sediment. The extremes may be from less than one ton per square mile per year to a few hundred tons per square mile per year.

The Rio Ruidoso drainage within the Reservation yields an estimated average 1,000 to 1,500 tons per year of sediment. The Rio Hondo drainage yields an estimated average 1,500 to 2,000 tons per year but most of this probably does not reach the Rio Hondo because of the numerous sink holes.

Techniques for estimating water availability

Existing surface-water data

The Geological Survey has collected streamflow data on several streams whose drainages are associated with the Mescalero Indian Reservation since 1920. These data are of two types:

1. Continuous record of stage and discharge.
2. Periodic measurements of discharge at selected locations.

The continuous records of flow vary in length from two to twenty-seven years. The location of these stations are shown on figure 1. Most of the available streamflow record was collected at locations outside of the reservation boundary. In addition to the records of streamflow collected by the Geological Survey, the Mescalero Indian Tribe has maintained nine non-recording stream-gaging stations for a number of years on streams within the reservation. Although these records have not been published, they are available in the Tribal offices. Location of these gages are indicated in figure 2.

Meteorological data, in particular records of precipitation, have been collected by the National Weather Service and the Mescalero Indian Tribe at various locations on and in the vicinity of the reservation. (See figure 2.)

The following list is a summary of surface-water records collected by the Geological Survey on streams associated with the Mescalero Indian Reservation. The Geological Survey (1930-60, 1961-72) has published all of these data.

Surface-water measurements on or near the Mescalero Apache Indian Reservation

Rio Ruidoso

Gaging Station Number	Name	Type	Period
08386500	Rio Ruidoso near Ruidoso	Low-Flow Partial Record (Quarterly measurements)	1953-Date
08386600	Carrizo Creek at Ruidoso	do	1953-Date
08387000	Rio Ruidoso at Hollywood	continuous	1953-Date
08387600	Eagle Crk blw South Fork nr Alto	do	1969-Date
08387800	Eagle Crk near Alto	do	1969-Date
--	Carrizo Creek at Boundary	Misc. meas.	1961-66

Rio Hondo

08388000	Rio Ruidoso at Hondo	Continuous	1930-55
08389500	Rio Bonito at Hondo	do	1930-55
08390100	Rio Hondo at Picacho	do	1956-62

Rio Penasco

08397600	Rio Penasco near Dunken	Continuous	1956-62
--	Silver Springs Canyon at flume	Misc. meas.	1958-69

Rio Tularosa

08481500	Rio Tularosa near Bent	Continuous	1947-Date

Three Rivers

08480600	Three Rivers near Three Rivers	Continuous	1956-58
08480700	Indian Creek near Three Rivers	do	1956-58
08480800	Indian Creek Flume near Three Rivers	do	1956-58
08480900	Indian Creek at mouth near Three Rivers	do	1956-58

Surface-water techniques based on existing data

The following analysis techniques, utilizing existing data, can be used to estimate runoff from the Reservation:

1. Existing surface-water records can be used to determine mean runoff from the major gaged basins. The means for the period of record can be adjusted to long-term means by use of concurrent and long-term precipitation records. These corrected means can then be used to estimate runoff from the ungaged basins on the basis of drainage area.

2. Define a relation between precipitation and runoff for the basins which are gaged. Compute runoff from ungaged basins by using these relations and existing precipitation data within the ungaged basins.

3. Use existing stream-flow and precipitation records to estimate runoff from 1,000-foot zones of elevation on the Reservation. These estimates can be used to estimate runoff from the same zones of elevation for the ungaged basins (Riggs and Moore, 1965).

4. Use generalized regression relations which were developed to predict streamflow characteristics in New Mexico (Borland, 1970). This would require determining certain basin parameters from topographic maps of the area. The standard error for these relations is quite high. Therefore, results may not be very reliable.

5. A water-budget approach can be used by utilizing existing precipitation data assigning values to losses such as evapotranspiration and ground-water recharge and computing surface-water runoff. However, because of uncertainties in the losses, this technique can probably only be used as a gross check on the answers obtained by other techniques.

Surface-water techniques based on five years of additional data

An additional five years of surface-water record at selected sites would improve the estimate of annual runoff considerably. A period of data collection much shorter than five years would probably not be adequate. The techniques of analysis would be the same as described above, however, the reliability would be greater because data would be available on that part of the Reservation which contributes to ephemeral streamflow.

In addition to the techniques described above, the following techniques could be used with additional data:

1. Data on channel-geometry could be utilized to transfer flow estimates from gaged sites to ungaged sites. This technique would require measuring channel characteristics at gaged locations and development of a relation between the channel characteristic and the mean annual flow. Then the same channel characteristic can be measured at the ungaged sites and mean annual flows determined (Hedman, 1970; Hedman and others, 1972; Moore, 1968).

2. Modeling procedures are available for estimating runoff. However, modeling of stream systems generally requires a concurrent record of precipitation and runoff in order to evaluate the model parameters. For the ephemeral stream drainages of the Reservation a long period of record is needed and adequate climatic information is necessary because of frequent snowmelt conditions. This approach is not suggested for use because of these limitations.

Existing ground-water data

Most of the existing ground-water data was examined by Sloan and Garber (1971) in the preparation of their reconnaissance report of the Reservation; they list information on 28 springs and 67 wells. A few additional wells have been drilled in recent years. The original driller's reports and the data collected by Sloan and Garber can be found in the Tribe's files at Mescalero, the office of the Bureau of Indian Affairs in Albuquerque, or the records of the Geological Survey in Denver.

The basic records might include information not reflected in the report by Sloan and Garber. Changes in the water table could be determined if early water levels are available for comparison with more recent ones. Aquifer characteristics might be inferred from driller's test data, which are known to have been made on, at least, some of the wells.

Ground-water techniques based on existing data

1. A general estimate using simple rules of hydrology and geology. Saturated thickness could be assumed from Sloan and Garber's (1971) water-table map and what is known about the thickness of the sedimentary formations. Porosity estimates could be assigned to the various lithologic units based on commonly used porosities of similar units. Driller's logs and surface descriptions would have to be studied to define the lithology. Permeability estimates might be inferred from driller's well test information and the gradients of the water-table map. Ground-water underflow across Reservation boundaries could be estimated from Darcy's law. A general idea of specific yield from the Yeso aquifer could also be estimated.

2. A digital model (Pindar, 1970) of the ground-water system utilizing existing data would probably be an improvement over the above. It might be particularly useful for finding out how the hydrologic system works in general, and in determining the relative magnitudes of the various parameters involved. Review of existing ground-water data would be necessary before the level of efficiency of such a model could be assayed.

Ground-water techniques based on additional data

Although the existing ground-water data have not yet been studied, the report by Sloan and Garber (1971) indicates that data are insufficient to adequately define the following:

1. Thickness, lithology, and structure of the aquifers.
2. Capacity of the aquifers to store and yield water.
3. Direction of ground-water movement in parts of the area.
4. Depth to water in parts of the area and long-term change in the depth to water.
5. Definition of the spring systems.
6. Relation of perched ground water to water below main water table.
7. Relation of ground and surface water.
8. Natural recharge and discharge of aquifers.

Sufficient data could probably be collected to define most of the items listed above if time, funds, and manpower were available for a thorough data collection program. The cost of test drilling would, of course, limit the extent of such a program, but much data could be collected at relatively low cost.

With better data a more realistic digital model could be constructed. The products of a reasonably good model include prediction of the effects on the supply by adjacent water users as well as effects on adjacent users by manipulation of the supply.

In short, the effectiveness of the model would depend upon the number and quality of data that could afford to be collected. The value of the data to the model versus the expense of gathering the data would have to be carefully considered.

Existing quality-of-water and sediment transport data

Chemical analyses

Existing quality-of-water data on streams associated with Mescalero Indian Reservation is limited to that collected since about 1938 in the northwestern portion. Only two quality-of-water stations, Rio Tularosa near Bent (USGS station 08481500) and Rio Ruidoso at Hollywood (USGS station 08387000), have been operated in the immediate area. These stations were established in May 1963, however only the Rio Tularosa station is still in operation. Collection of quality-of-water samples was discontinued at the Rio Ruidoso station in June 1967. These records consist of chemical analyses of water samples collected monthly or more frequently at regular stream-gaging stations located on the respective streams. The majority of the data consist of partial analyses limited to the determination of the major anions (bicarbonates, carbonates and chlorides), hardness, specific conductance and pH. Only about 30 percent of the analyses were complete to include major cations, other anions, total dissolved solids and the sodium absorption ratio. Records of these analyses have been published by the U. S. Geological Survey.

In addition to the quality-of-water records collected at regular stream-gaging stations, numerous samples have been collected at various locations on streams tributary to the Rio Ruidoso. These samples have been collected on a periodic basis since 1938; however, most of the analyses were partially complete. These samples were collected during the periods 1938-40, 1954-55 and in 1961. Records of the analyses are available in the offices of the U. S. Geological Survey in Albuquerque.

Sediment samples

Existing sediment data have all been gathered at points a considerable distance from the Reservation. These data could only be used to state the upper limits of concentrations of sediment in waters expected from the Reservation.

Quality-of-water techniques based on existing data

Chemical quality

Using existing quality-of-water data only the major inorganic constituents can be estimated. No present technique is available with which to extrapolate these estimates beyond the limits of the basin wherein the original determinations were made. Regionalization of major chemical constituents have been attempted in the past with little success.

In that it is extremely expensive to continuously monitor the major chemical constituents in a stream, determinations must be made from samples collected on a periodic basis. Hence conditions which might occur between sampling events are not detected and estimates can be made based only on observed conditions. Techniques of estimating the chemical quality-of-water is based primarily on certain assumptions depending on where the data was collected. These assumptions are as follow:

One-site data.--Concentrations of the major inorganic constituents are presumed to be as low as the best observed condition and should be no worse than the worst observed condition. In the case of spring flows, these assumptions are more reliable than those made at other stream locations as constituents and concentrations vary little.

Data collected at downstream locations.--In order to estimate quality-of-water conditions at a particular site using data collected at a downstream location, it can be assumed that upstream conditions are as good but probably better than the best observed conditions, and are no worse but are probably better than the worst observed conditions at the downstream site.

No data in the drainage.--The probability of estimating conditions in a drainage where no previous data is available is extremely low. However, an approximation can be made by assuming that concentrations of the major inorganic constituents would be about the same as those observed in a similar setting - topographically and geologically.

Sediment

Any effort to determine sediment yields based upon existing data will require an additional reconnaissance-type field effort. The following two techniques could be used to estimate sediment yields with a a minimum of field data:

1. Make reconnaissance of stream channels at points of interest noting channel characteristics and types of sediment deposition. From this reconnaissance estimate sediment concentrations and compute sediment load.

2. Visit watersheds of interest and classify soil type and vegetative cover. Utilize sediment yield formula from Soil Conservation Service to determine sediment loads (Guy, 1970).

Quality-of-water techniques based on five years of additional data

Chemical quality

Techniques for estimating the chemical quality-of-water using data collected during an additional five years would be the same as those previously discussed. By initiating a comprehensive sampling program in all major basins within the reservation, however, the reliability of such estimates would be increased substantially.

Sediment

For definition of sediment yield for small watersheds by the use of ss (single stage) samples: Place ss sampler in the channel at several stages at points of interest. The lowest ss sampler should be as low as possible without digging a hole or submerging the ss sampler (in a perennial stream). Samples would also be taken with each visit when flow is present at the time. With these samples, sample of the bed and banks and the water discharge record by standard means, a fair approximation of the daily sediment yield can be determined by standard computational means. The smaller the watershed and the more uniform in geology, vegetal cover and altitude (uniform precipitation/yr) the better the data.

By adding a few sampled events (samples to define the concentration curve for a storm event) to the above to cover the range of condition and storm magnitude the data for small watersheds with good water discharge records could be improved to about $\pm$ 25 percent.

The larger and more diversity of the water shed the less accuracy of this improvement and the more important ss samples for as many events as possible become for this to attain the accuracy indicated.

The major outflows should have a daily station record which can be obtained by: (1) If an observer is available this along with ss samples for large changes in stage during the night should be adequate. (2) If an observer is not available an automatic pump sampler may be used. Some calibration will be necessary for the expected range in concentration and size distribution. (3) The other alternative is a USGS employee on site when deemed necessary by annual runoff patterns.

Program for the collection of additional data

Surface-water

In order to refine the estimates of surface-water on the Reservation, an additional five years of streamflow data should be collected on watersheds located within the reservation. It is recommended that seven continuous-record stations be established on major streams within the Reservation and that monthly measurements of streamflow be made at six other locations. These data would be used in conjunction with the existing long-term records to estimate surface-water yields on the Reservation. The location of the proposed sites is indicated on figure 1. In addition to the records of streamflow, channel geometry parameters would be collected at gaged and ungaged sites. As previously discussed, these measurements would be used to extend streamflow data to ungaged streams within the Reservation.

At the end of the five-year period, all data would be analyzed and estimates made of streamflow conditions on the entire Reservation. A final report would be prepared to include these analyses.

Ground water

The program for collection of additional ground-water data recommended here is somewhat similar to the one described on pages 13 and 14 of the Geological Survey's July 1974 proposal. Additional effort suggested here would include the verification of the available geologic maps, drilling of several shallow test holes, and some seismic work.

An outline of the recommended ground-water program follows:

1. Analyze all existing well data to learn as much as possible about the character of the producing zones, aquifer, coefficients, historical changes in water level, etc. This includes drillers' pumping tests and lithologic logs, and the examination of well cuttings.
2. Map the surface geology in sufficient detail to verify existing maps and improve where needed. Particular attention should be given to the downthrown blocks in the west part of the Reservation and the vicinities of the major springs and wells.
3. Run gamma-ray, neutron electric logs on 15 or 20 existing wells to determine the continuity, thickness, and possibly the porosity of the producing zones.
4. Conduct aquifer tests at five to ten select existing well sites to determine yields and aquifer characteristics.
5. Drill about ten wells to depths of about 200± feet to determine the geology and hydrology in the vicinity of the major springs and high yielding wells, and the thickness of alluvial deposits.
6. Drill three wells to depths of 700± feet to test the hydrologic potential of the downthrown blocks in the west part of the Reservation.
7. Drill three strategically located deep test holes to determine the thickness and character of sedimentary rocks overlying the Precambrian basement rock. Locations of the holes will be

made after much of the above work is completed. These holes, which might have to be drilled to depths of 2,000 or 3,000 feet, could be completed as production wells for use on the Reservation. Because drilling and testing can be done faster with a rotary drilling rig, rotary type equipment should be used.

Twenty-foot sections of a special type core at several depth intervals should be taken in each hole for the purpose of obtaining samples from which laboratory porosities can be determined. A minimum core diameter size of 3 inches is needed. Packer testing in the cored intervals is recommended and any other zones that might yield relatively large quantities of water.

A complete set of geophysical logs should be run in the holes to gain as much information as possible about the porosity, density, fluid content, and lithology. Any information that could be gained about the extent of fractures in the rock would be useful.

8. Run three seismic profiles in the vicinity of the deep test holes to determine the depth to granite basement rock. Also run a number of cross profiles along the major stream valleys to outline the thickness of the alluvium.
9. Measure the yields of all wells and springs to determine the ground-water discharge from these sources.
10. Set up an observation-well network to monitor water-level changes in future years.

11. Simulate the hydrologic system with a digital model and determine the effects at the Reservation boundary of increased water usage both inside and outside of the area. Hydrologic conditions at the end of given periods of time might also be simulated.

12. Write a report that will include the basic data, analysis, and conclusions regarding the ground-water potential of the reservoir. This will be part of the final report that will also include surface water, quality of water, and sediment yields.

Quality of water

Chemical analyses

The initiation of a comprehensive sampling program on streams located within the Reservation boundaries would help to increase the reliability of estimates of chemical quality considerably. Such a program should be coordinated with the surface water data collection program on both perennial and ephemeral streams.

On perennial streams the program would consist of: 1) daily measurements of specific conductance, 2) monthly collection and analysis of samples for concentrations of major inorganic constituents, and 3) quarterly sampling to analyze for trace elements, nutrients, organics, field, bacteria, and biological constituents in addition to major inorganic concentrations. On ephemeral streams sampling should be accomplished during as many events as possible and complete analysis conducted to determine major inorganic constituents only. Sampling of such events should include samples taken at or near the occurrence of the peak runoff and another taken on the recession.

Miscellaneous collection of samples should be limited to those taken upstream and downstream from potential development sites.

A 5 year program for chemical quality of ground-water should include an initial reconnaissance of all known wells and springs on the reservation and samples collected for a comprehensive analysis of major inorganic, trace elements, nutrients, organics, bacteria, biological and field constituents. This should then be followed with a program consisting of annual collection of samples from selected wells and springs for analyses of major inorganics and field constituents only.

Standard techniques for the collection of chemical-quality samples should be followed. Of primary importance is that the sample be representative of actual conditions at the time that the sample was collected. This is accomplished in the case of stream- and spring-flows by integrating the sample with water from all portions of the cross-sectional flow pattern. In the case of ground-water samples, the well should be pumped a sufficient length of time in order to ensure that all water previously standing in the well column has been expelled. All samples should contain at least one litre of raw water and certain portions of the sample treated according to the type of analysis which is to be conducted.

Treatment of samples should be as follows:

one-fourth (250 ml) - filtered and fixed with the addition of nitric acid

one-half (500 ml) - filtered only

one-fourth (250 ml) - left unfiltered and untreated

In the case of samples collected for comprehensive analysis, one-half (250 ml) of the filtered only sample should be packed in ice and kept chilled.

Field determinations of alkalinity, pH, specific conductance and ambient air and water temperatures will be made at the time that all samples are collected.

Sampling and analyses techniques are further described in the references (Brown, Skougstad, and Fishman, 1970; Goerlitz and Brown, 1972; and Slack, Averett, Greeson, and Lipscomb, 1973).

Sediment stations

In order to refine the estimates of sediment yield from the Reservation, an additional five years of sediment data should be collected on watersheds located within the Reservation. It is recommended that automatic pump samplers (PS-69's) be installed at each of the seven recommended surface-water gaging stations and one at the existing station. Periodic sediment discharge measurements should be made directly downstream of probable development or problem areas to be used in conjunction with single stage samples (SS samples) at the site to establish a base to identify change due to the later developments or treatment.

Evapotranspiration

Although the precipitation records (fig. 2) have not yet been examined, it appears that there may be an adequate number of stations in the area. No data, however, have been collected on the evaporation or transpiration rates in the region. This type of information could be very important in planning for additional surface-water reservoirs or irrigation development, and in ascertaining a realistic ground-water recharge rate.

It is suggested here that the appropriate Government agency consider the installation of one of more evaporation pans and possibly the instigation of a transpiration study of the area.

Conclusions

1. A cursory examination of the readily available water data for the Reservation and vicinity indicates that the surface runoff from the Reservation might be on the order of 20,000 to 30,000 acre-feet per year, and that the potential for obtaining high yielding wells is generally low except possibly in a few select areas.
2. Existing surface-and ground-water data are not sufficient to obtain more than a very general assessment of the water availability of the Reservation, except in the Ruidoso, Hondo, and Tularosa drainages, and possibly the Three Rivers drainage.
3. Techniques for estimating water availability will be more successful if additional data are collected. At least two and one-half years for ground-water and five years for surface-water and quality-of-water data collections are suggested.

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TECHNIQUES AND DATA REQUIREMENTS FOR
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OTERO COUNTY, NEW MEXICO

Figure 1.--Map showing location of Mescalero Apache Indian Reservation, and pertinent existing (▲) and former (△) stream-gaging sites.

2.--Map of the Mescalero Apache Indian Reservation showing principal drainage basins, tribe operated surface-water flumes (▲), precipitation stations (Department of Commerce (■) and Tribe (□), and tentative proposed surface-water gaging sites (♦).