RECLAMATION OF TABRIZ PLATEAU

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ABSTRACT

This paper presents the key elements of reclamation of Tabriz plateau at east side of Lake Orumiyeh, in East Azerbaijan, Iran. The plateau consists of approximately 230,000 acres (92,600 hectares) of land with saline and saline-alkali soils. The sources of water include surface and ground water. The major watershed draining to the area is Ajichai basin. Ajichai originates from Sabalan Mountain, travels approximately 168 miles (270 km), and falls through 1,887 feet (575 m) and joins the Lake Orumiyeh. Along its route, various tributaries that originate or pass through salt mines join the river and consequently make it saline for irrigation. The reclamation project consists of dealing with sources of salinity for surface water and reclamation of the saline soil in the plateau with due consideration for impact of the project on Lake Orumiyeh. The project features include construction of a series of earth dams, including an impermeable earth core rockfill dam as the main storage and flood control reservoir, water conveyance facilities, drainage systems, and soil amendments. Due to salt transport in irrigation water and its commutative effect on agricultural lands, it is believed that the complex issues of this reclamation project are good examples of the nature of challenges facing irrigation and drainage in the new millennium.

INTRODUCTION

The growing need for land and water for production of food demands well planned utilization of these resources with due consideration to their sustainability. While the issue of sustainability may not have been a prevailing parameter in the past, it certainly appears to be the most important one in the future. Technological advancements of the twentieth century accelerated the use of natural resources. There have been cases where the human awareness of preservation of natural resources has grown parallel to the fast pace of natural resources utilization, and there have been cases where such awareness has lacked significantly. Nevertheless, so far, the vast resources of the earth had been capable to maintain the balance. This may not be the case anymore; i.e. nature may not be able to continue balancing itself without serious consequences to

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humankind, unless we implement serious changes, leading us toward higher level of sustainability.

PROJECT SETTING

Tabriz plateau is located at east side of Lake Orumiyeh, in East Azerbaijan, Iran. The plateau consists of approximately 230,000 acres (92,600 hectares) of land with saline and saline-alkali soils. The area is approximately 4,265 feet (1,300 meters) above sea level. Average annual precipitation is 10 inches (250 millimeters) and potential evapotranspiration is estimated at 37 in. (930 mm). Therefore, the area is arid. The land is generally flat with moderate slopes towards the lake. The soil consists of alluvial sediments with fine to medium texture. Soil permeability ranges from medium to low. The quality of ground water is good near the foothills but its level of salinity increases as it approaches the lake. The lake water is highly saline.

The pre-project agriculture is along the perimeter of the plateau near foothills where the salinity of ground water is low or tolerable. Traditional agriculture covers approximately 1/3 of the area where ½ is irrigated by groundwater and ½ by surface waters. The primary watershed draining to the area is Ajichai basin (Fig. 1). Ajichai originates from Sabalan Mountain, travels approximately 168 miles (270 km), and falls through 1,887 feet (575 m), and joins the Lake Orumiyeh. Along its route, various tributaries that originate or pass through salt mines join the river and consequently make it highly saline for irrigation. Nevertheless, during the wet season the salinity of Ajichai is decreased and its water becomes suitable for irrigation, where, to some degree, it is utilized for traditional agriculture, by river-flow diversions using low weirs into canals.

The complexity of the project stems from the fact that the prime elements of it, i.e., the land and water resources, both require careful reclamation measures in order to support a sustainable development. Moreover, the suitable dam sites for storage reservoirs and routes for water conveyance are complicated by either seismotectonics, or major saline areas scattered throughout the river route. Primarily for these reasons, some earlier attempts dating back to the 1960s were aborted with no material outcome.

Notwithstanding the earlier piece-meal studies, none of which could warrant a sound conclusion, in 1990s the East Azerbaijan Regional Water Authority (EARWA) undertook a series of systematic studies to explore the feasibility of development of water and reclamation of Tabriz Plateau. The initial phase of investigations consisted of reconnaissance studies including meteorology, hydrology, agriculture and geology of the area, and prospect of construction of dams and irrigation systems. The results of these indicated that the Ajichai basin including Tabriz Plateau has a large potential for irrigated agriculture. Further

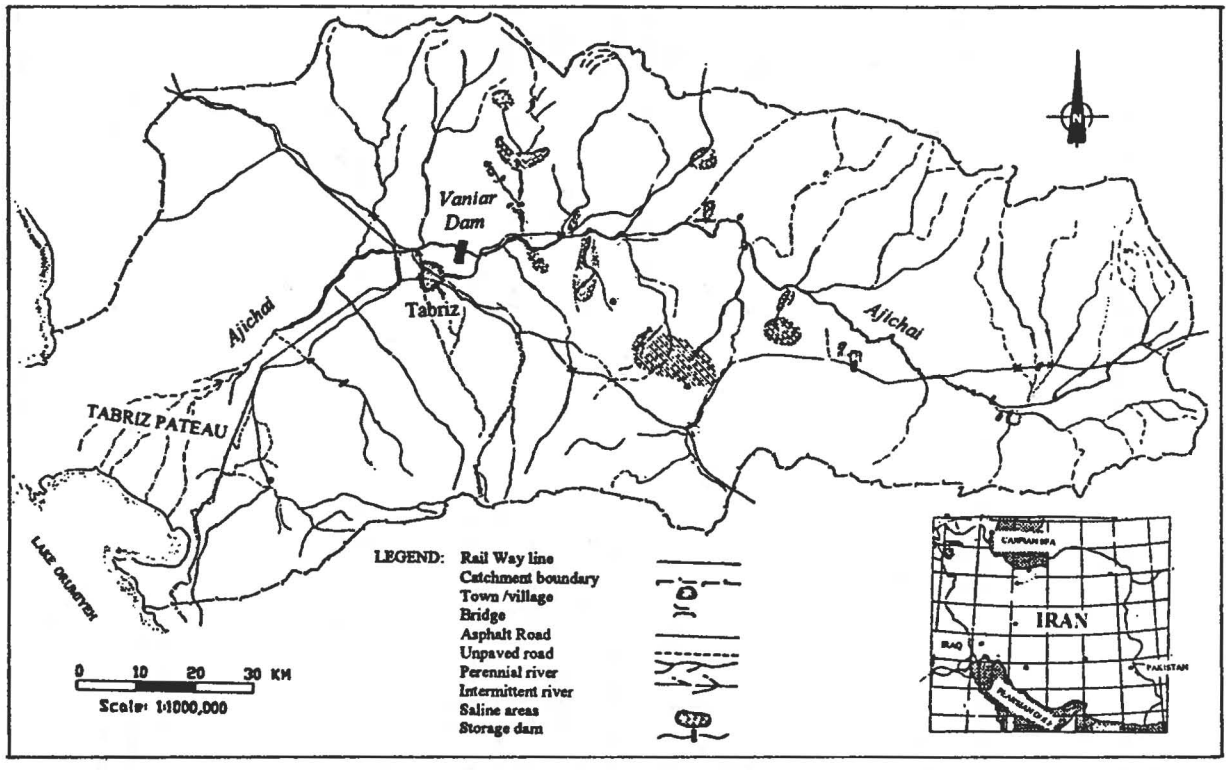

Fig. 1.- Ajichai River Basin and Major Saline Zones above Vaniar Dame Site

investigations were initiated to study the soil characteristics. Presentation of approaches taken for design of dam and appurtenant structures is beyond the scope of this paper. The highlights of these studies relative to the quantity and quality of water, soil characteristics, and irrigation and drainage principles in connection with reclamation of Tabriz Plateau are given in the following sections.

HYDROLOGY OF WATERSHED

As mentioned earlier, the primary watershed draining to Tabriz Plateau is the Ajichai basin. The highest elevation of upper catchment is 11,000 feet (3,352 m) on the south-western slopes of Sabalan mountains, which sharply drops to about elevation 6,000 feet (1,828 m) and travels a distance of about 173 miles (279 kilometers) and joins Lake Orumiyeh at elevation of 4,183 feet (1,275 m), (Fig. 2).

The average annual precipitation ranges from 10 inches to 18 inches (250 to 450 millimeters) within the watershed as indicated in Fig. 3, isohyetal map of the basin. The mean annual run-off of the basin is about 373,697 acre-feet (461 million cubic meters), based on forty years observed flow data. About 80% of the flow occur during the period of February to June, i.e., during four months, and 20% in the balance of the year, where the irrigation season in the area is between June and September. Please refer to Figures 4 & 5 for river flow variations. Such a major disparity requires some means of flow regulation, such as a dam. For further characterization of the river flow it should be mentioned that, depending on the time of the year, the river flow may range from zero to 13,450 cubic feet per second (0 to 381 cubic meter per second). However, based on a flow duration analysis, 50% of the time the mean daily flow in a typical year may equal or exceed 636 cfs (18 cm/s).

A dam site was selected near Vaniar as shown in Figure 1. Because of proximity of this site to an active fault, a rockfill type dam with impermeable earth core was selected for the project. Rockfill dam is more suitable for seismically active areas.

QUALITY OF WATER DEVELOPED IN THE WATERSHED

The primary source of surface water for the project area is Ajichai River. This river originates from the mountains with fresh water but is seriously degraded by saline reaches along its route and tributaries from saline springs, originating from salt domes or saline ground water (Fig. 1). Under such condition, the salinity of the river is in reverse proportion to the amount of flow and its Total Dissolved Solids (TDS) generally range from 1,100 PPM to 3,000 PPM in high flow season, and 3,000 PPM to 4,600 PPM in low flow season. Due to contamination by

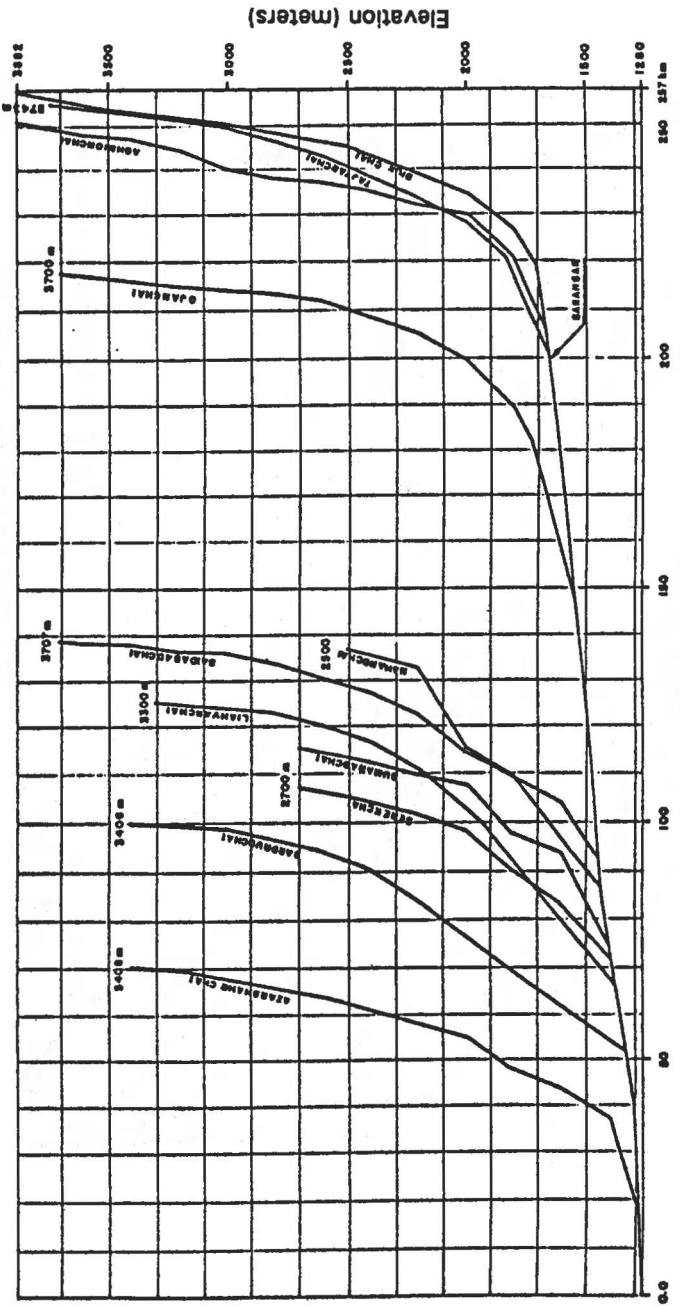

Fig. 2.- Profile along Ajichai, and its tributaries, to Lake Orumiyeh

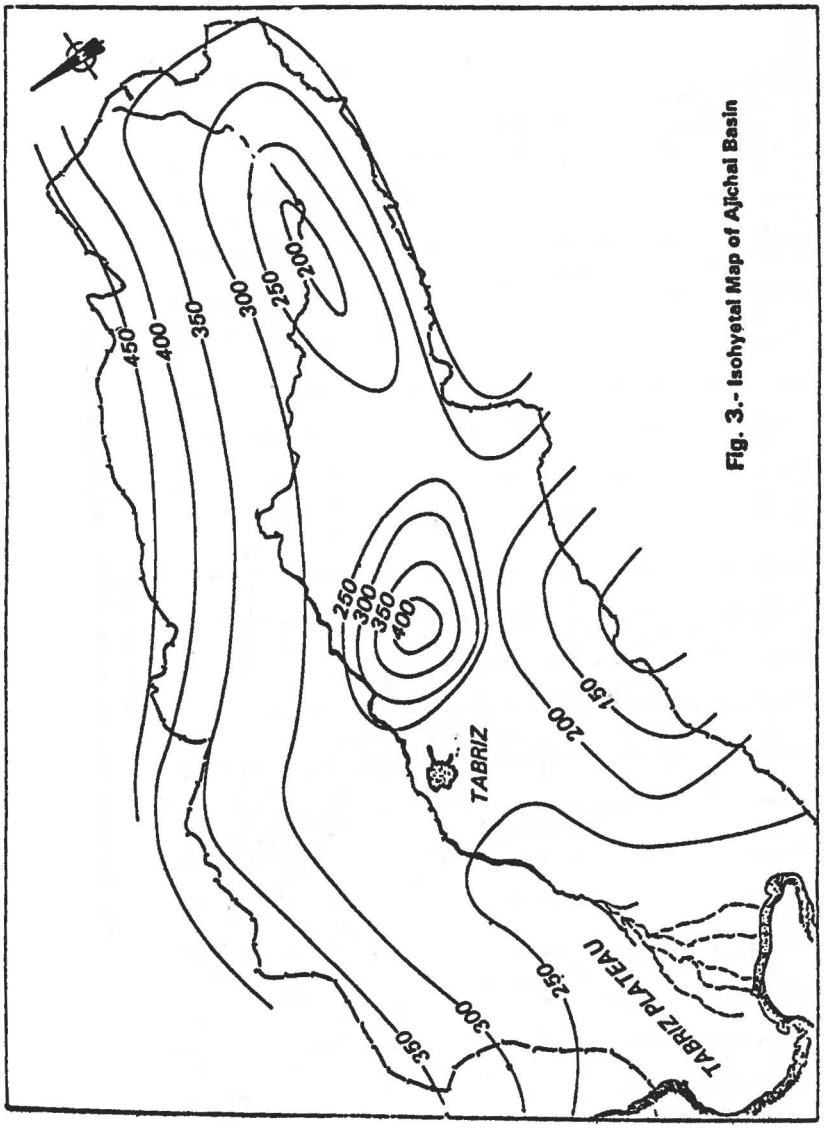

Fig. 3.- Isohyetal Map of Ajichai Basin

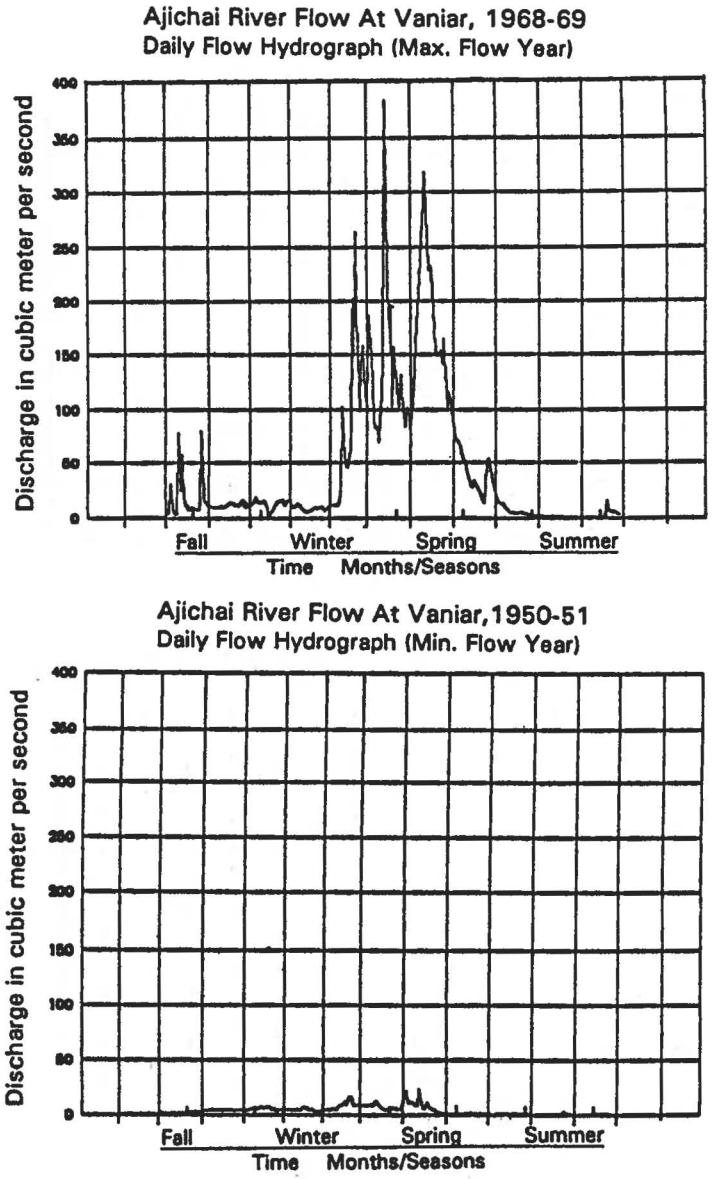

Fig. 4.- Flow Variations in Ajichai River Basin in Wet and Dry Years

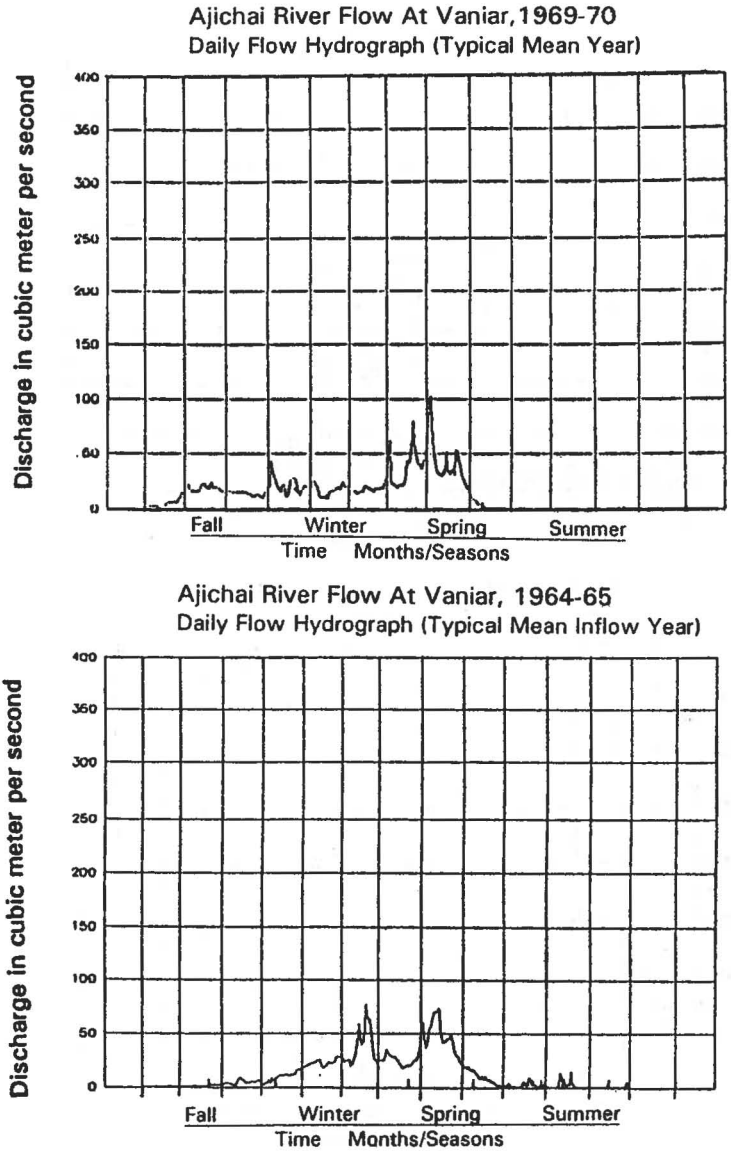

Fig. 5.- Typical Flow Variations in Ajichai Basin

brine, the Electrical Conductivity (EC) of the river for flows above 1,400 cfs (40 cm/s) is about 2000 micromhos per centimeter, and that of flows down to 350 cfs (10 cm/s) is about 5,000 micromhos/cm (Fig. 6). The Sodium Adsorption Ratio (SAR) for flows above 1,800 cfs (50 cm/s) is about 10; and for flows below 175 cfs (5 cm/s) it rises to about 20.

The quality of river flow under the above conditions was not found suitable for irrigation. Therefore, various alternatives were considered to control the effect of saline reaches and brine tributaries on the quality of Ajichai River. These alternatives included:

1) Capture of Ajichai flows in a storage dam during the period of high flows and diversion of its flow to downstream during the low flow season,
2) Isolation of saline tributaries and conveyance to downstream of project limit,
3) Considerations were also given, though implicitly, to collection of fresh water in upper catchments and conveyance to a storage reservoir using aqueducts,
4) No project and status quo.

Alternative 2 was selected because the number of reaches and the magnitude of flows were smaller making them more suitable for storage and conveyance to a discharge point in Lake Orumiyeh, with due provisions for protecting the environment. To accomplish this objective various dam sites were identified in the basin as shown in the Figures 7A and 7B. The brine water originating from salt domes will be conveyed to storage dams and eventually to a disposal site at its natural destination, Lake Orumiyeh. This brine water will be diluted before discharging to the lake. At present time, development of criteria for discharges to Lake Orumiyeh is under investigation. One potential source of water under consideration for dilution is the reclaimed water from the wastewater treatment plat of the City of Tabriz (population 1,000,000).

One of the objectives of the reclamation project is to develop water with a salinity level acceptable for irrigation. Therefore, based on economy crops suitable to the area, a goal was set to develop water with EC in the range of 800 to 1800 micromhos/cm and SAR below 10. This level of salinity may result in less than 25% reduction of the yield of the least tolerant plants planned for the area, such as field, vegetable and forage crops. The goal is achievable by isolating saline waters by means of the dams and conveyance facilities mentioned above.

Groundwater also will be used in conjunction with surface water for irrigated agriculture.

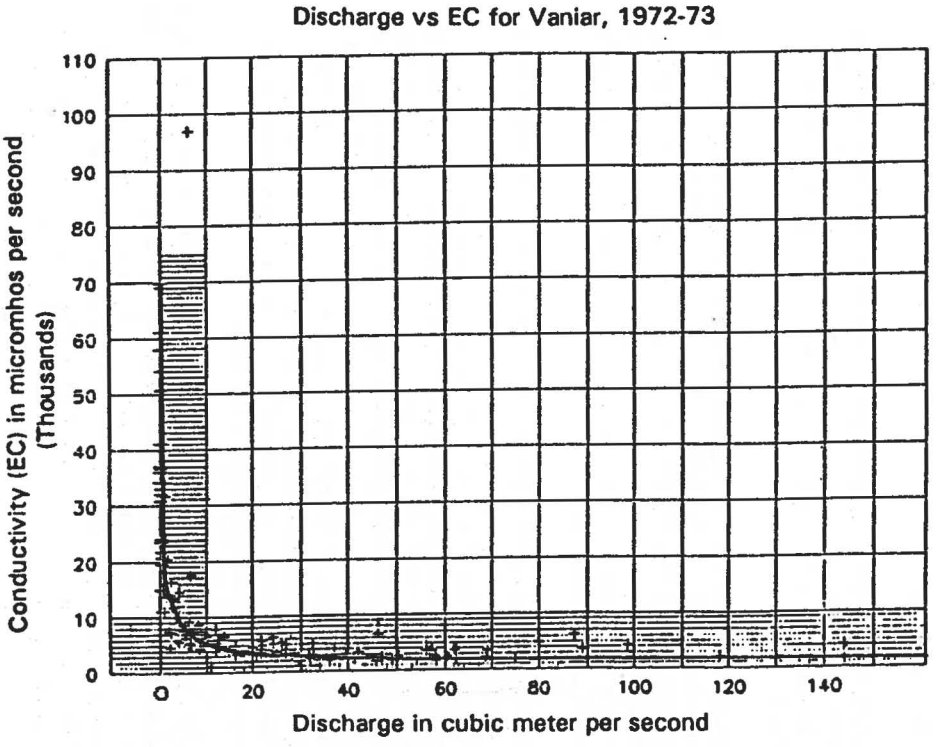

Fig. 6.- Discharge Vs Electrical Conductivity in Ajichal River Basin at Vaniar

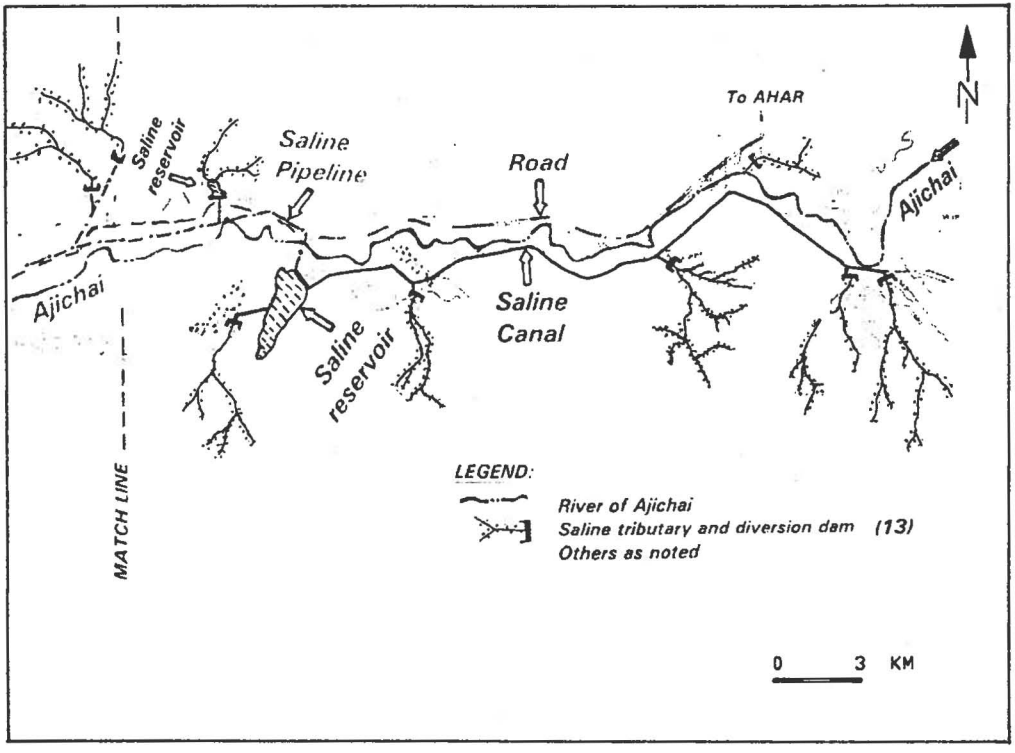

Fig. 7A. – Primary Dam Site at Vaniar, and Various Small Dam Sites for Storage, and/or Diversion, and Conveyance of Saline Waters

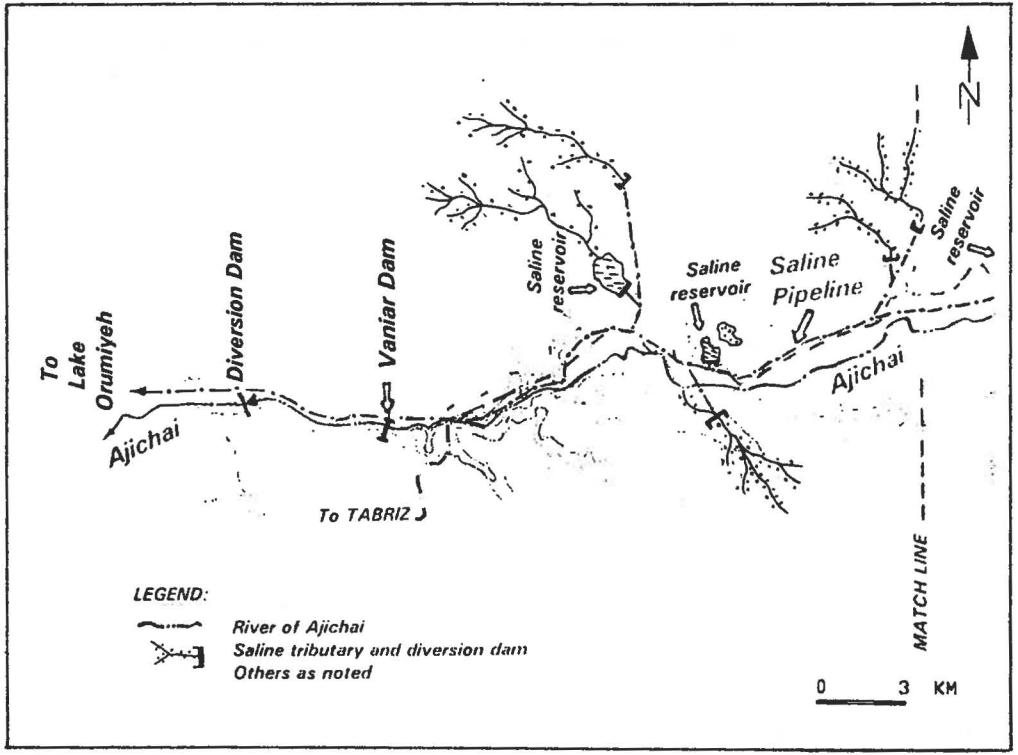

Fig. 7B. – Primary Dam Site at Vaniar, and Various Small Dam Sites for Storage and/or Diversion, and Conveyance of Saline Waters

CONSIDERATION OF QUALITY OF WATER RELEASED FROM VANIAR DAM

It is anticipated that despite isolation of brine water sources from Ajichai, the overall quality of the flow in the river may vary during wet and dry season of the year. This situation may affect the quality of the water at various levels in the main storage dam for irrigation water. A hydrodynamic investigation using computer models is underway to determine the most favorable manner to release water from the reservoir.

WATER CONVEYANCE SYSTEM

A diversion dam was planned downstream of the main storage dam at Vaniar to divert water from Ajichai to the irrigation sites on Tabriz plateau (Fig. 7B). Two main canals, which will be concrete lined, will take the water from this diversion dam and will convey it to the east and west sides of Tabriz plateau (Fig. 1). A series of secondary and tertiary canals will distribute the water to the planned farmlands. The secondary and tertiary canals also will be lined to reduce conveyance loss and avoid affecting the high groundwater table which itself is a problem, as discussed later in this paper. Furthermore, a conveyance system consisting of open channel and pipeline will convey saline waters from storage reservoirs and discharge it to Lake Orumiyeh.

LAND QUALITY AND SOIL CLASSIFIFICAIONS

The topography of the land in the planned irrigated area is excellent for agriculture, provided necessary reclamation measures to remove salt and lower the high water table. In this regard, EARWA initiated detailed soil studies and classified the soils of the irrigation project site. Generally speaking, the land is composed of alluvial sediments. The soil is very deep. The majority of the land consists of soil with medium texture. A relatively small portion of the land has fine texture. Correspondingly, the infiltration rate also ranges from medium to low. Approximately 1/3 of the land has low saline soil, which consists of the land near perimeter of the project area. Another third of the land has saline-alkali soils, comprising the majority of the land for the developed area. The last third of the land is saline-alkali with very high groundwater table. This last portion of the land consists of the area at vicinity of the Lake Orumiyeh. The efforts of reclamation are concentrated only on the 2/3 of the land with saline and saline-alkali soils, as described above. The boundaries of project area are shown in the Fig. 8.

GROUNDWATER AND SOURCE OF SOIL SALINITY

In connection with this project, EARWA conducted a study on groundwater in the project area. The general direction of the groundwater flow is from the foothills toward the lake, as one would expect (Fig. 9). The quality of groundwater is better near the perimeter of the project where the salinity of soil is low as well. However, moving towards the central portion of the plateau and towards Lake Orumiyeh, the quality of groundwater becomes more saline.

Depth to groundwater around the perimeter of the project area is about 65 feet (20 m) and the EC ranges from 500 to 2000 micromhos/cm (Fig. 10). Again, moving towards center of the project area and towards the lake, the depth to groundwater becomes less and EC increases. In this zone, the EC ranges from 2000 to 7000 micromhos/cm and the depth to groundwater ranges from 10 feet (3 m) to 3 feet (1 m) as shown in Figures 10 and 11, respectively. This situation indicated that the primary source of salinity of the soils is saline groundwater with high water table.

Studies indicated that the salinity of shallow groundwater is higher than that of the water which comes from deep wells in the area. This fact suggests that a hard pan may be present. Further investigations are underway. In the presence of a hard pan, relief wells will be utilized to dissipate artesian pressure.

SOIL RECLAMATION MEASURES

Based on the characteristics of the soil and groundwater described above, three measures were planed for soil reclamation. These are soil leaching, soil amendments and underground drainage. Field experimentation was conducted to determine the effect of soil amendments on soil texture and infiltration rate, and determine leaching fractions. An underground drain system was planned to lower groundwater to minimum of 10 feet (3 m) below ground surface. This requirement is to minimize the migration of salt from groundwater to topsoil by capillary rise. Nowhere in the area the water will reach to 4 feet (1.3 m) from ground surface.

The water from Vaniar dam will be utilized in conjunction with the groundwater in the project area. The saline soil will be leached to remove the salt to a level tolerable by selected crops. The saline-alkali soils will be reclaimed by both soil amendments and leaching. The general slope of land in the project area ranges from 0.005 to 0.0005. This allows removing the drainage water from the area and disposing it to Lake Orumiyeh. As mentioned earlier, the groundwater flow is towards Lake Orumiyeh as well. The typical hydraulic gradient is about 0.0002.

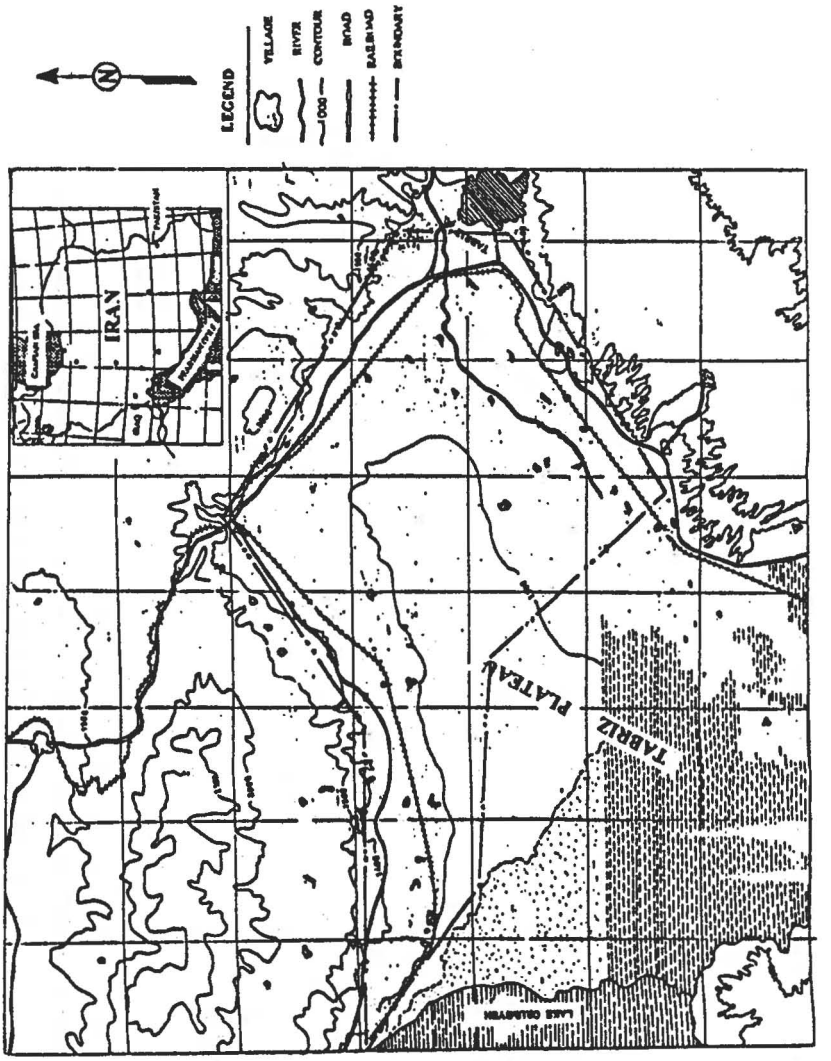

Fig. 8. – Boundaries of Project Area in Tabriz Plateau

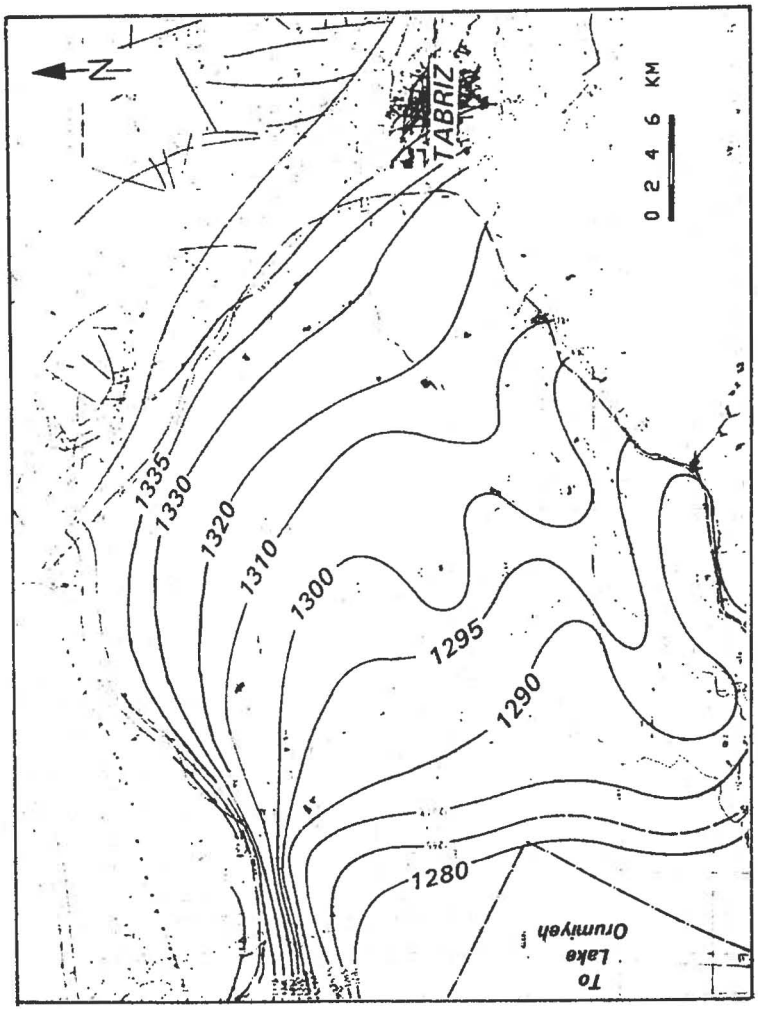

Fig. 9. – Groundwater Equipotential Lines (meters) in Tabriz Plateau

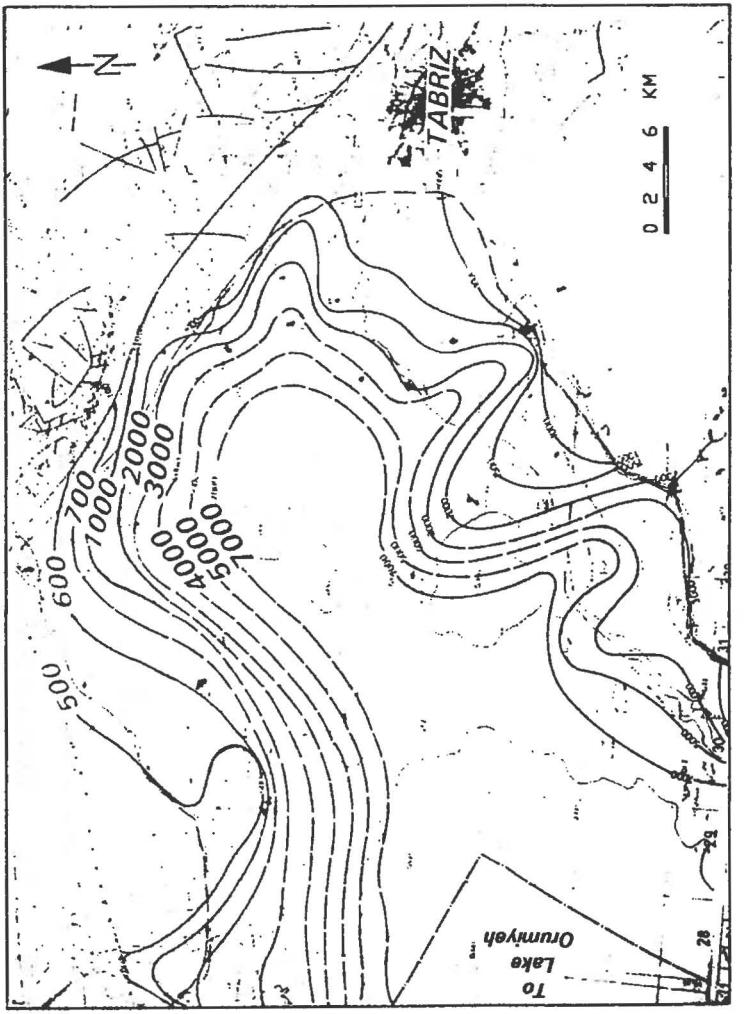

Fig. 10. – Contours of Equal EC (micromhos/cm) points in Groundwater in Tabriz Plateau

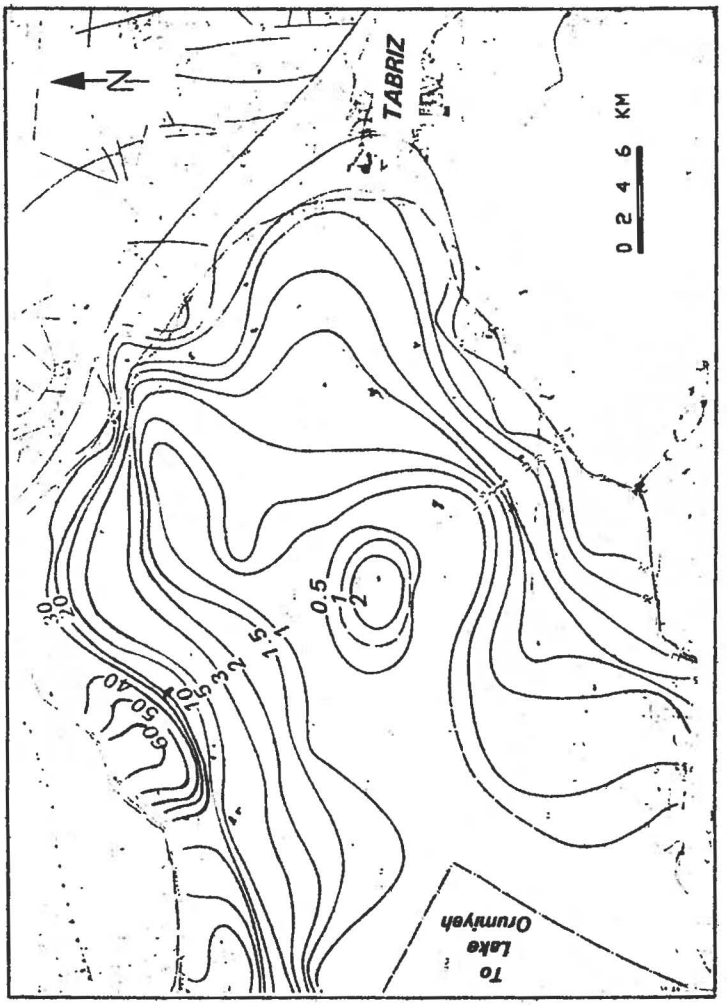

Fig. 11 – Contours of Depth to Groundwater (meters) in Tabriz Plateau

ENVIRONMENTAL ISSUES/LAKE ORUMIYEH

The primary issue of the project pertaining to environment is its impact on the Lake Orumiyeh. This lake contains a very saline body of water. Despite this fact, the discharge of brine water collected from Ajichai basin will be diluted to a level of the lake's water before disposal into the lake. Another major issue related to the subject is maintaining a fixed amount of water to Lake Orumiyeh to prevent its recession. This latter topic is being considered in a regional water plan. Various watersheds from two provinces; i.e., East Azerbaijan and West Azerbaijan are draining to this lake. The total amount of annual runoff will be maintained to offset the annual evaporation from the lake.

SOCIAL ECONOMIC CONSIDERATIONS

Approximately 25% of the land in project area are private farms with some degree of salinity problems and the water shortage. These estates will benefit from the project. Revenues from sale of water to these farmers will contribute to recovery of capital investment. The majority of the land is public land, which will be divided and transferred to private farmers; revenues from transfer of land and sale of water will be used for capital recovery.

MANAGEMENT OF IRRIGATION AND DRAINAGE SYSTEMS

The primary system of water development and delivery, such as dams and main canals, will be operated and maintained by the EARWA. Management of on-farm irrigation and drainage systems, including secondary and tertiary canals and wells, will be under the jurisdiction of a local entity. For this reason, creation of a water district is under consideration to execute a contract with EARWA to be responsible for operation and maintenance of the system and collection of revenue from sale of water. The water district will operate based on general guidelines of EARWA but will be managed by a board of directors elected by the local farmers. The governing body of the Water District will hire a general manager for the water district, and he or she will staff the office, using the district fund. This method of management is considered a major step in the direction of improved efficiency at farm level and encouragement of competence and competitiveness in rural agribusiness operations.

CONCLUSIONS

The project is unique in its ability to differentiate a major source of water from contamination by vast sources of brine water. It also reclaims a vast amount of

land degraded by saline groundwater. Moreover, it introduces an improved method of water management for rural agribusiness regions.

Continued increase in population and excessive use of natural resources have caused a decline in the quality of available resources, despite tremendous technological achievements of the 20th century. Irrigation waters continue transporting salt to agricultural lands, and in numerous cases continue causing drainage problems by rising water table. Implementing careful reclamation measures, described in this paper, is a good example of supporting a sustainable agriculture, while dealing with complex challenges facing irrigation and drainage in the new millennium.

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