REPUBLIC OF TURKEY

MINISTRY OF ENERGY AND NATURAL RESOURCES

GENERAL DIRECTORATE OF STATE HYDRAULIC WORKS

REPORT

ON

RECONNAISSANCE STUDY

OF

BERKE HYDROELECTRIC POWER PROJECT

IN

CEYHAN RIVER BASIN COMPREHENSIVE DEVELOPMENT PLAN

OCTOBER, 1969

GOVERNMENT OF JAPAN

PREFACE

The Government of Japan, at the request from the Government of Republic of Turkey, entrusted the Overseas Technical Cooperation Agency (OTCA) with the task of conducting a reconnaissance survey for the Berke Hydroelectric Power Project on the Cyhan River in Turkey.

OTCA, fully realizing the significance of the mission assigned to it, organized a survey team consisting of six expert members headed by Mr. Akihiro Irie of the Electric Power Development Company, Ltd. (EPDC), and sent out the team to the Republic of Turkey to undertake the reconnaissance study for a period of one month from March 1, 1969.

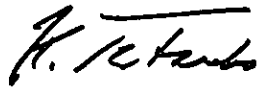
The team performed the survey, and studied and discussed the project with the engineers of the State Hydraulic Works (DSI), the Ministry of Energy and Natural Resources of the Republic of Turkey.

The team, after the return from Turkey, made a preliminary analysis of the technical feasibility of of the Berke Project as well as a general study covering items and work schedule of further investigations, the results of which have been compiled in a report and hereby submitted " Report on Reconnaissance Study of Berke Hydroelectric Power Project in Ceyhan River Basin Comprehensive Development Plan".

It is sincerely desired that this report would serve and assist in the enhancement of the electric power development of the Republic of Turkey and would also contribute to the further promotion of friendship and economic between the two countries.

On behalf of OTCA, I would like to take this opportunity to express, my sincere appreciation to the Government of Republic of Turkey, the Embassy of Japan and other competent Authorities concerned for their assistance and cooperation extended to the team during its stay in Turkey.

September, 1969



Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency
Tokyo, Japan

September, 1969

Dear Sir:

The report hereby presented is a compilation of the results of the reconnaissance study on the Berke Hydroelectric Power Project for Ceyhan River Basin Comprehensive Development of the Republic of Turkey.

The survey team performed a reconnaissance survey, mainly on and around the Berke Damsite, based on the information made available by the State Hydraulic Works (DSI) relating to the topography, geology, hydrology, etc. of the project area, and concurrently collected other data deemed necessary for the planning of the project.

After the return of the team to Japan, a preliminary analysis of the technical feasibility of this Project as well as a general study covering items and work schedule of future investigations and its action schedule were made based on the results of the reconnaissance survey, and thus the report was prepared.

The Berke Project is purported to build an arch dam with a height of 310 m on a rock foundation on the dounstream of the Ceyhan River, to make a reservoir with the storage capacity of 5,000 M. CU. M. to install generators with the maximum output of 800 MW, and to generate an annual energy production of 2,400 x 10^6kWh, which will provide the country with rich, low cost power to meet the power demand which is rapidly increasing in the entire land, particularly in the southern Turkey.

As conceivable benefits of the project, in addition to the above mentioned power production, flood control and securing the supply of required irrigation water would be attained. Therefore, it is highly advisable that a further investigation centering around a geological survey be conducted at the earliest possible opportunity in order to justify the technical feasibility of constructing an arch dam with the height of 310 m. The investigation would take some 20 months including the period necessary for the feasibility study of the project.

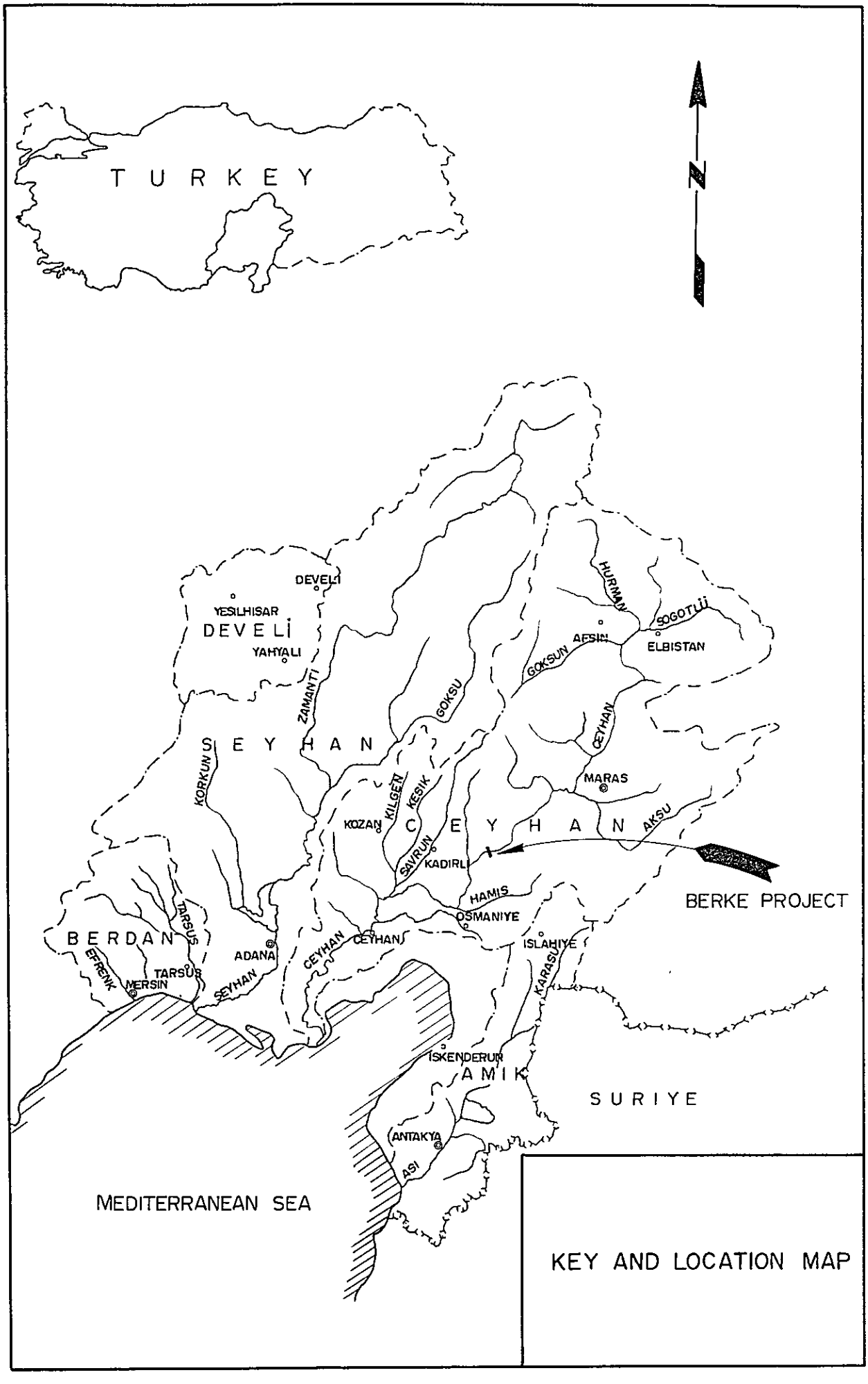
On behalf of the team members, I would like take this opportunity to express our sincere appreciation for the courtesies, assistance and cooperation rendered to the team members by Mr. Hazim Tütüncüoğlu, the General Director of DSI, engineers of DSI and Eti Bank as well as by the Embassy of Japan during our stay in Turkey.

Sincerely Yours,

A. Irie

Akihiro Irie
Leader
The Japanese Government Survey Team
for the Berke Project

(Berke Damsite Looking Upstream)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CHAPTER 1. INTRODUCTION

1-1. Authorization

On February 10, 1969, Mr. Hazim Tütüncüoglu, General Director of the State Hydraulic Works (DSI), the Government of the Republic of Turkey, visited the Japanese Embassy in Turkey and made an official request to the Government of Japan for conducting a reconnaissance survey and making the plan of future investigations and its schedule for the Berke Project on the Ceyhan River.

In response to this request, the Japanese Government assigned the study to the Overseas Technical Cooperation Agency (OTCA). The proposed project is primarily purported to utilize the discharge of the Ceyhan River for power generation, flood control and irrigation. OTCA, on its part, entrusted the execution of the work to the Electric Power Development company, Ltd. (EPDC). The studies including reconnaissance survey, preliminary analysis and preparation of the report were carried out by EPDC in accordance with the above assignment.

1-2. Purpose of Report

The scale and scope of the Berke Project, as envisioned in the Feasibility Report prepared by the International Engineering Company, Inc. (IECO) in 1966, would involve the construction of a 208m dam, a reservoir with the capacity of 600MCM and a power plant with the installed capacity of 236 MW. Also as an alternative, the report recommends the construction of two water way type power plants instead of one plant. At the same time, this report strongly recommends a further geological survey on and around the damsite.

As the results of the investigation conducted by EIE and DSI pursuant to the above recommendation, the construction of a high dam, higher than the pro-

posed 208m, is thought promissing

If construction of such high dams as 280m - 300m heigh is feasible on the proposed Berke Damsite, the storage capacity of a reservior could be enormously enlarged, assumably up to 5,000M.CU.M. By this, the power-house discharge to be utilized for power generation can be expected to increase by 36% as compared with that of IECO plan.

In view of remarkable increment in the power demand in the Southern Turkey, a necessity may arise in a foreseeable near future to boost the power production for satisfying the power demand in such industrial areas as Mersin, Adana, Tarsus, Ceyhan, Iskcuderm, Antakya, Maras, Gaziantep, etc. whereas, it is called for to carry out the feasibility study of the Berke Project as early as possible.

Based on the reconnaissance survey conducted by the Team and on preliminary studies of High Berke Dam using data obtained in Turkey, necessary investigation items and their schedule are described in this report for future feasibility studies of this project.

1-3. Surveys and studies

1-3-1 Field Investigation

The Survey Team stayed in Turkey for about one month from March 2 to 29, 1969, during which it gathered in Ankara and Adana the necessary information and data relating to hydrology, topography and geology with the assistance and cooperation of the Investigation and Planning Department of DSI and the Sixth Regional Construction Office. Also, the Team conducted the reconnaissance survey of the Berke damsite from March 7 to 10 under the guidance of engineers of DSI and EIE.

The names, specialties and organizations of the six members of the Sur-

vey Team dispatched from the Ministry of International Trade and Industry (MITI) and EPDC, for the above investigation are as given below;

Team leader:	Akihiro Irie, Civil Engineer	EPDC
Member:	Yoshito Naito, Economist	MITI
" :	Toshio Hayashi, Civil Engineer	EPDC
" :	Hideharu Kashiwagi, Geologist	"
" :	Kazuo Ozaki, Electrical Engineer	"
" :	Hitoshi Murayama, Civil Engineer	"

1-3-2. Studies in Japan

Upon return of the Team to Japan, studies of topography and geology of the damsite for the construction of a 300m high dam and of investigation schedule were carried out at EPDC under the direction of the chief Engineer.

1-4 Basic Data.

The basic data furnished by DSI are as follows:

(1). Topographical map

Berke damsite: 1/1000

(2). Hydrological Data

Location Map of Guaging stations

Monthly average Discharge of Guaging Stations

Monthly Maximum and Minimum Discharge of Gauging Stations

Climate and Hydrology by IECO.

(3). Geological Data

Damsite Geologic Log of Drill Holes

Geological Report on the Damsite

General Geological Plan of Reservoir areas

Results of Fluorescent-soda tests in Drill Holes

CHAPTER II. SUMMARY OF REPORT

1. The power demand in Turkey in recent years has been remarkably increased and the average growth rate in the past several years maintained 12%. To cope with such an increasing demand, DSI has planned the construction of a large scale reservior type power plant on the Berke site of the Ceyhan River to generate and supply abundant power at low cost, and has mainly performed geological investigations on and around the proposed damsite.

2. The Berke Project is located in the lower basin of the Ceyhan River, and is projected as a part of the Ceyhan River comprehensive development plan.

Annual inflow of the proposed site is estimated at 4,600 M.CU.M., and the topographical features of damsite indicate that the construction of a large reservior is economically possible.

3. As the results of studies of data obtained in the course of the field survey and of the preliminary analysis made in Japan after the return of the Team, it has been revealed that the construction of a 310m high dam on the Berke site will be very hopeful, therefor, subsequent field investigations involving mainly a geological survey are deemed desirous in order to develop a large scale reservoir.

4. Along with the said field investigations, an effect of this project upon the Ceyhan river basin and other basins concerned should be studied, and the master plan covering the whole river basin should also be examined in order to decide the optimum scale of the Berke Project.

5. Investigations and studies to be conducted in future will be composed of principally geological surveys, then hydrological surveys, investigations on

construction materials, power demand and on agriculture, as well as the preliminary designing of dam, hydrological analysis and the reservoir operation rule, etc. The required period for these studies will be about 12 months.

6. After the main investigation items described above are surveyed and studied, the feasibility study of the Berke Project will be carried out, and it will take some eight months including field investigations.

CHAPTER III. GENERAL DESCRIPTION OF PROJECT

3-1. General Description of Projected Area.

The Ceyhan River runs through the areas in the Southern Turkey located between latitude 36^{o} $30^{'}$ - 38^{o} $45^{'}$ North and longitude 35^{o} $20^{'}$ - 37^{o} $30^{'}$ East. The sources of the river trace back to the Eastern upper part of the Toros Mountains and blows down to the south-western direction pouring into the East Mediterranean Sea. It is a large river having a total length of 540km with its catchment area of some 20, 700km^{2}.

The river basin will be divided into three regions an upper region from Kandil with the drainage area of some 6, 365km^{2} is called "The Upper Ceyhan Basin", an area located on the upperstream of the Kiziltas damsite which is under planning called "the Middle Ceyhan Basin" with an area of about 6, 675km^{2}, and the lower reaches of Kiziltas damsite having an area of 7, 660km^{2} is called "the Lower Ceyhan Basin".

Each basin has its own climatic pattern and hydrological features which are shown as follows:

The Upper Ceyhan Basin is situated at 3, 000m - 1, 000m above sea level and has a typical continental climate, warm in summer and cold in winter. An annual average temperature is about $10^{o}C$ and an annual rainfall in the basin area is from 400mm to 800mm while in a certain mountain area has 1, 000mm - 1, 400 mm rainfall. An annual runoff of the river is 1440x106 M. CU. M.

The Middle Ceyhan Basin is located at the elevation of 1, 000m - 350m , and has the continental climate almost the same as that of the Upper Ceyhan Basin. An annual average temperature is about $15^{o}C$. An annual rainfall of this basin is 700mm - 800mm, while an annual runoff of the river is 4, 200 M. CU. M.

The Lower Ceyhan Basin Stretches in between the elevation of 350m and the

sea level, and its climatic condition is of the Mediterranean type having an annual average temperature of 17°C. An annual rainfall in this basin is 500mm - 800mm, and an annual runoff of the river is 7,030 M.CU.M.

The Berke Project belongs to the Lower Ceyhan Basin, and the damsite is located at a place some 250km upstream from the river mouth. The discharge at the damsite is estimated at approximately 4,600 M.CU.M.

This Berke Project constitutes a part of the Water Resources Development Plan which involves the electric power development, irrigation and flood control of the two main rivers such as the Ceyhan and Seyhan and others, Tarsus; Efrenk and Asi.

The definite study of the Aslantas Project located immediately downstream of the Berke Project is currently undertaken aiming at an earlier realization of the project.

3-2 Former Studies

Investigations with respect to the water resources development in this area have been conducted by DSI and other organizations for many years, and among the reports of such investigations, the Berke Project is studied in the following reports:

The Ceyhan Basin Reconnaissance Report 1959

Land Classification Report on Plain
Belonging to Lower Ceyhan Area 1962

Agricultural Economy Report on Several Project
Belonging to Lower Ceyhan Basin 1962-1963

Eastern Mediterranean Basin; Planning Report
on Energy, Ceyhan Basin (Power) 1963

Geologic Report for Berke Damsite 1963

Ceyhan Basin Flood Data, Published Records 1946-1960

" Unpublished Records 1961-1965

Report on Technical and Economic Feasibility
of Berke Project by IECO 1966

Report on Technical and Economic Feasibility
of Kiziltas Project by IECO 1966

Climate and Hydrology Report by IECO 1966

Master Plan of Ceyhan Basin by IECO 1966

3-3. Topographical and Geological Outline on and around Damsite

1. Topography

The proposed damsite is located at the entry of a gorge. In the upper reaches, where the contour lines are gentle, but the lower reaches including the damsite form a steep gorge. That is, the width of the river bed is about 25m, and the slope of the right bank from the river bed to the elevation of 550m is approximately 60°, while the left bank from the river bed to the elevation of 450m is 65° in dip. The width of this valley, however, gradually becomes wider as going toward the downstream. Particularly, in the upper part of the left bank, this tendency becomes remarkably eminent as going up to the altitude around 330m. The upper part of the left bank becomes convex forming a ridge running at right angle to the river. As for the upper part of the left bank at the altitude of about 400m, the ridge becomes thiner, and especially at the altitude above 450m, the ridge forms a line of watershed running in the south-western direction.

The width of the gorge at the proposed damsite at the high water surface of 440m is about 320m, and the configuration coefficient of the gorge as shown by width/height is about 1.1, therefor, from graphical view point, this damsite is favored with satisfactory conditions for an arch dam.

The slopes around the damsite are so steep that there is neither talus nor topsoil on the surface, and is consequently very few plants.

2. Kinds and Properties of Rocks and Their Distribution.

Rocks around the damsite are composed of dolomite, crystalline limestone and serpentine. The serpentine is not found at the damsite , but is distributed in areas about 500m lower stream. The lower part of the dam site is formed with dolomite and crystalline limestone is seen above. The joining surfaces of the two different rocks is hardly distinguished, because they are found so close together and so resembled in applarance. The joining surfaces start from the river bed about 200m downstream of the dam site to the elevation of around 260 m on the damsite left bank, and some 220m on the right bank. But in the upper stream of the damsite, it reaches far higher level, around 450m on both banks. Limestone is of crystalline formation with a mass of calcites in 1-2mm size. A part of the limestone presents a charcoal gray color and is very hard and solid, but in weathered limestone, the crystalline formation is inuisible and looks similar to dolomite. Therefore, it is hard to tell the difference. The only simple way to find the difference is that the limestone is easily foamed against the diluted acid, while dolomite is not. The dolomite is generally comprised of a mass of small dolomitic particles, which have a dark gray color and are hard and solid.

These limestone and dolomite are found having developed strata of 5-20cm spaces running in the direction of mostly $N20^{\circ}$- $40^{\circ}E$ at the dip of $N40^{\circ}$-$50^{\circ}W$. The strata are more clear on the weathered surfaces, and in certain places, the surfaces of strata are occasionally separated like cracks.

3. Geological Formation

As described above, the strata strike toward the direction of $N20^{\circ}$-$40^{\circ}E$, and the dip $N40^{\circ}$-$50^{\circ}W$, and both banks at the dam site are of the equivalent mono-slant formation. The right bank, however, at the point some 100-150m upstream from the dam axis, where a gentle fold are seen, and it is noticed from the left

bank that the strikes of the right bank gradually change from N 20^{o} - 40^{o} E to the direction toward NW. The left bank at some 100m upstream from the dam axis rises to a higher altitude forming a range of precipices, and the foot of the precipices is covered with the talus which makes it difficult to determine the geological formation, however, it can be assumed that there may probably be some faults.

There have been noticed no traces of faults on the ground surface rising from the dam site up to the altitude of 500m on the right bank and up to 400m on the left bank.

3-4. High Berke Project Studied by DSI.

As the results of the investigations conducted by DSI and EIE following the recommendation of IECO Report, there rises possibility for the construction of a high dam of 300m at the proposed Berke dam site from the topographical and geological view points.

The High Berke Project planned by DSI is to build an arch dam of 310m taking advantage of the head of 320m between the Menzelet Dam on the upstream of this damsite and the Aslantas Dam to be built in the lower reaches. Since the proposed arch dam will make a reservoir with the storage capacity of 5,000 M.CU.M., a power plant with the maximum output of 800MW will produce an annual energy of 2,400 x 10^{6}kWh.

This plan, as compared with the IECO plan, is as shown in Table I:

Table I. Characteristics of Proposed Dam in the Ceyhan Basin

Characteristics	Unit	Kiziltas	Kiziltas Low Berke	Kiziltas and Low Berke	Kiziltas High Berke
Average Annual Inflow					
a) At present	$10^6 m^3$	3,278	4,210	4,210	4,210
b) After upstream development	"	2,296	2,428	2,428	2,428
Total storage capacity	$10^6 m^3$	1,900	600	2,500	5,000
Installed capacity	mw	84	237	321	800
Annual Power Production					
a) At present	10^6kWh	458	1,320	1,770	2,400
b) After upstream development	"	331	832	1,162	1,480
Annual Flow in Turbines					
a) At present	$10^6 m^3$	2,873	3,004	3,004	3,690
b) After upstream development	"	1,748	1,975	1,975	2,270
Estimate cost of dam and power plant (1968)	10^6T.L.	630	770	1,400	1,400
Production Cost Power					
a) At present	kW/kWh			5.53	4.08
b) After upstream development	"			8.82	6.62

CHAPTER IV. PRELIMINARY ANALYSIS FOR TECHNICAL FEASIBILITY OF HIGH BERKE DAM.

4-1. Purpose of Preliminary Analysis

The construction of an arch dam reaching 310m height from foundation rock contemplated at present by DSI is an unprecedented attempt in the world with the exception of the Inguri Dam reported to have been built in the Soviet Union. Whereas, a great number of unsolved technical problems is awaiting to be challenged. Particularly, a part of rock formations which constitutes the foundation of the damsite and the reservoir area is being of limestone, problems of undependability in terms of water permeability will give a great deal of technical challenging. However, as the result of the investigations so far conducted by the Team, no indications of such problems were found. Therefore, for this matter, we may have to depend on the future information to be derived from the further investigation. In this report, based on the results derived from the reconnaissance survey centering around the four test adits on the damsite, the treatment method of the thin ridge on the damsite left bank, when an arch dam is adopted, is mainly studied, and the preliminary studies of the feasibility for the construction of a High Berke Dam is carried out. The outcomes of the said studies are compiled as data for future investigations.

4-2. Preliminary Analysis

The topographical patterns and the geological features on and around the proposed Berke damsite are as described in Section 3 of Chapter III and Section 3 of Chapter V. The outline of the topographical and geological information obtained through the reconnaissance are as follows:

(1) The shape of the gorge at the proposed damsite is suitable for construction of a large scaled arch dam. The foundation is formed with hard and solid dolomite and limestone, and although some small cavities are seen, there have been found no large caves enough to present any appreciable danger of water permeability. Also, the water table observations by the boring have proved no indication of seepage from either banks of the river.

(2) The ridge above the left bank is thin in both directions upstream and downstream, besides, strata in the lower part of the left bank slope run parallel with the ground surface, therefore, the stability of the thin ridge has to be carefully analized when an arch dam with H. W. S. of 400m is adopted.

a) The location of the dam as currently contemplated by DSI should be moved to a little upstream in order that the shoulder part of the downstream abutment at the upper part of the left bank can be made large enough to sustain the external forces of an arch dam.

b) Except for the thin ridge on the left bank, the formation of the gorge is uniquely ideal for the construction of an arch dam. Also, the correlation between the arch thrust and the geological formation can be said favorably conditioned and comparatively satisfactory, and in view from the results of the investigations so far, it will be considered that there will be no problem in particular for designing an arch dam, even if H. W. S. of 460m is selected.

c) The total volume of the body of the arch dam with the height of 310m above foundation rock is estimated at approximately 3, 300, 000 C.U.M.

(2) Artificial Abutment on Left Bank

a) If the high water surface reaches 400m, a thrust block would be required for transferring the arch thrust to the foundation rock of the upper part of the left bank. In this case, if the water pressure of the reservior works directly upon the upper stream of the thrust block, then the underground

water level within the ridges will be greatly risen, which will endanger the stability of the downstream slopes of the ridge and subsequently of the entire thrust block after all.

b) One of the ways to solve this problem is to build a wing dam in front of the ridge, then, the pressure of the reservoir will be sustained by the wing dam, and also water tightness would be kept by way of curtain grouting from this dam. Thus, the prevention of the ascending underground water level in the left bank thin ridge where the thrust block will be built can be done.

c) Consequently, the possibility whether or not a wing dam can be made on a place, from where the underground water level in the left bank thin ridge can be efficiently controlled after the filling of the reservior, will be the matter of precondition for the construction of a 310m arch dam on this site.

CHAPTER V. ITEMS FOR FUTURE INVESTIGATIONS AND STUDIES, AND INVESTIGATION SCHEDULE

5-1. Survey and Mapping.

A topographical map of 1/25,000 based on aerial photographs of 1/35,000 covering the entire basin are made available. Also, a topographical map of 1/5,000 covering the reservoir area will be completed in the near future.

As to the upper and lower reaches of the damsite, 1/1,000 scale map by means of Tachmetry is made by EIE after having carried out the vertical and horizontal ground control through the areas.

The items for future investigations are as follows:

1) Surveying of river profile and cross sections on the upstream and downstream around the damsite.

2) With the progress of the investigation plan, additional aerial map of 1/5,000 should be made to facilitate the erection of the temporary equipment and facilities required for the construction such as access roads, quarry and borrow areas, power supply lines, etc.

5-2. Hydrology

In the basin area, there are 32 guaging stations operated by DSI and EIE, of which 22 stations are actually in service (Refer to Fig. 2 and Table 2). Of these guaging stations, the Kilavuzlu (Station No. 2001 which covers an area of 8,686 km^2, and is in service for 29 years since 1940) has the longest records and the one nearest to the Berke damsite is the Cercioglu (Station No. 2013 covering an area of 13, 840 km^2). It has the record of eight years, but currently not in service. There are also six meteorological stations in the basin area.

The items of further investigation are as follows:

1) Establishment of guaging stations around the damsite and discharge observation.

2) Establishment of meteorological stations including evaporation around the damsite and its observation.

3) Sampling of sedimentations on and around the damsite.

5-3. Geology

5-3.1. Past Geological Investigation

The geological prospecting so far made is as follows:

1) Ground Surface Survey. A geological plan and section drawing were prepared based on the topographical map of 1/1,000 around the damsite. Also, as for the reservior, a geological plan and section drawing based on the topographical map of 1/25,000 were made.

2) Test Adits. There are four test adits totaling 226m in length in the damsite, two in the left bank (G-1: 60m, G-2: 61m), and two in the right bank (G-3: 43m, G-4: 62m) as shown in Fig. 5.

The comments on the results of the exploration at each adits are as follows:

G-1: Mainly crystalline limestone formation, but sandwiched with thin layers of dolomite in a complicated pattern. Rocks are generally solid and hard. At the point about 50m from the portal, a stratum with the width of 7-8 cm runs in the strike of N 40°W, N 80°W, and cracks with small cavities were observed. A Also, at around 50 m point, a crack filled with clayey sedimentation which is 10-15 cm wide was observed running in paralled with the above mentioned stratum.

G-2: Mainly dolomite formation with sandwiches of thin layers of crystallins limestone. Rocks are hard and solid. At the point around 10m, 30m and 44m from the portal, some small strikes of thin and secondary calcareous spar were seen.

G-3: At the portal of the adit, there is found mostly dolomite, and deeper parts are mainly composed of limestone. But further inside, both are mixed in a complicated formation.

Around the place at 10m inside, some small openings of 3 - 5 cm and a fractured zone of 40-50 cm were discovered, rocks are hard and solid except for the above fractured zone, and strata are not visible.

G-4: Mainly of crystalline limestone, many thin layers of dolomite were seen in the limestone. At the point about 11m inside, a crack with losen layers of about 5-10 cm width which strikes toward N 60°E was noticed, and at around 18m, a vertical fault with a fractured zone about 40 cm width running at N 65°E was observed. However, in general, rocks are good and hard, and strata are not clearly seen.

At the dam site, seven borings were made in the left bank with a total length of 600m, and four borings in the right bank totaling 366m. The combined length of the boring in both banks is 966m.

The results of the test borings are given as follows:

SK-8: At the depth around 44m, 47m and 59m, cavities of 75 cm, 25 cm and 88 cm in diameters were discovered, but except for these cavities, rocks are formed with solid crystalline limestone and dolomite. The cavities are considered to be formed along the strata and their actual thickness may be assumed much less than they appear. The total length is 80m.

SK-9: At the points around 43m, 62m and 66m, there are fractured zones with clayey materials which are 10 cm, 20 cm and 25 cm wide respectively, and these are thought to be a small fault. Rocks composed of mainly dolomite are good and hard. The total length is 70m.

SK-10: At the points around 6m and 10m, there are fractured zones filled with clay which are 20 cm and 90 cm wide. They appear like small

faults. As for the rock formation, which is of dolomite rock, is good and id solid shape. The total length is 50 cm.

SK-11: Up to 12.7m, brownish weathered clay were seen in rocks. At the points around 50.75-52.25m, rocks appear less solid. But, the dolomite is in general, hard and solid. The total length is 60m.

SK-12: At the point around 25m, a clayey, soft fractured zone of 60 cm width was discovered. Otherwise, the dolomite appear hard and solid. The total length is 70m.

SK-13: At the point around 11m, fractured zones with clay which is about one meter thick were found, except the above, the dolomite with crystalline limestone layers is hard. The total length is 70m.

SK-14: Except for a fractured zone of 50 cm at the point around 30m from the portal, the rock is composed of crystalline limestone which is hard and solid. At the depth of 48.7m, dolomite and crystalline limestone are seen alternately. The total length is 70m.

Boring in G-1 Adit: Except for a cavity of about 10 cm at the depth of about 52m, the rock is of dolomite, but sporadically, slates were observed. The total length is 190m. The underground water table is 109.52m.

Boring in G-2 Adit: Mainly composed of hard and good dolomite and sporadically thin layers of crystalline limestone are sandwiched. The total length is 90m. The underground water table is 58.60m.

Boring in G-3 Adit: Except for the soft, losen layers of about 45 cm and 114 cm width at the depth of about 63m and 65m, the rock is of dolomite which is good and hard, but sporadically the layers of crystalline limestone are sandwiched. The total length is 116m, and the underground water table is 47.5m.

Boring in G-4 Adit: Formed with good and hard crystalline limestone

and dolomite. The total length is 100m.

5.3.2. Future Necessary Investigations Regarding the Dam Foundation and the reservoir.

(1) Geophysical Prospecting

There were observed several cavities of 20-30 cm width in the damsite, but no larger ones were found.

Samll cavities are found in the limestone formation, and small lens-type holes made by the melting of limestone within the dolomite were noticed.

In general, it is extremely rare to find large caves in limestone formation in such area of mature stage topography as in the case of this damsite. Therefore, it is assumed that the proposed damsite probably has no large caves. However, in view of this large scaled project, it is desirable to carry out a geophysical prospecting at the damsite.

Of geophysical prospecting, such two methods as electric and seismic prospecting can be considered. However, the electric method will not be efficient unless the cave is filled with water. In this case, the seismic method will be more desirable. It is considered that the size of the cave that the present prospecting technology can discover will be more than 1,000CU.M., and such caves smaller than this size may possibly be treated by civil works.

The outline of the scope of prospecting is as shown in Fig.2.

(2) Additional Boring

By the reconnaissance survey made this time, it was cleared that the underground water table of the drilling hole in the mountain is not lower than the river water level, and that the gradient of the underground water table is comparatively gentle. That is, the topographic patterns of the ground surface and the elevation of underground water table are separated too far. This is because of the poor underground water storage capacity of the mountain, which

indicates that there may exist some caves in the underground.

For such reasons, it is necessary to make additional test adits and to carry out additional boring in the existing adits, and to measure the elevation of underground water table, and at the same time, inject fluorescence soda to these boring holes to see whether or not such injected fluorescence soda comes out into the river. Thus, the movement of the underground water can be detected. For such tests, a dry season should be selected to distinguish the fluorescence soda from the river water.

(3) Additional Test Adits

It is necessary to make four additional test adits along the dam axis, two adits on both banks of the river. The one in the left bank will be better to have a turn at right angle toward upstream at the point 50m deep. The treatment of the said thin ridge is very important in designing of the dam. For this reason, the construction of a wing dam is recommended, therefore, in order to obtain a necessary information about the foundation of the wing dam, additional three test adits are required to be made on the upstream of the dam axis. Since strata in the downstream on the left bank slope run parallel with a direction of water pressure from the reservoir, it will be desirable to make three test adits on the downstream of the dam axis in order to study the foundation stability of a proposed spillway.

The location and elevation of these test adits are indicated in Fig. 4.

At the point 400-500m downstream of the dam axis, layers of serpentine were discovered. According to the geological map of 1/25,000 prepared by DSI, this serpentine distribution continues to further upstream and reaches reservoir area. Generally, the serpentine is believed to have been formed as the results of changes brought about by penetrated ultra basic igneous rocks. However, when dolomite is silicified, it turns into olivine, and further added

with H_2O, it may change into serpentine.

If the serpentine at the downstream of the dam axis were formed through such process in the past, the serpentine may possibly exist in the proposed damsite. In order to find the existence of serpentine, and at the same time, for the purpose of other geological surveys, it is considered appropriate to make test adits as long as posssible on both banks, and to make some borings in such adits. It is desirable to layout such adits on a certain place, from where grouting of both banks will easily be carried out. These additional adits are not included in the figures, but it is desired that the works will be performed after the dam design is finally completed.

(4) Rock Shear Tests

This project involves as the key element the construction of a large scale arch dam unprecedented in the whole world, and particularly, the strata of the foundation rock of a thrust block on the left bank are unfavourable, it is desired to make rock shear tests in the test adits. The tests should be conducted on the four test-pieces cut out from the adits.

As for shear load, three oil jacks with the capacity of 300 tons each and as for the vertical load, one 100 tons oil jack and an oil pump will be required.

(5) Leakage Survey in the proposed reservior Area

The geological map of 1/25,000 indicates the distribution of limestone on the right bank of both upper and lower reaches of the damsite. The following investigations are recommended to check leakage from the reservoir through possible caves in the limestone.

a) To determine the exact location of the limestone distributions running continuously from the proposed reservoir to outside of the area, which are located in lower elevation than the highest water surface (H.W.S.) of the reservoir.

b) To determine by the reconnaissance survey the existence of caves in exposed limestone formation within the reservoir area at lower elevation than H. W. S. as well as the exposed limestone formation in outside areas.

c) Should caves be found, and no water springs out within the cave, then, inject by a large pump 3 kg of fluorescence soda in 500 liters of water, which will be followed by continuous injection of plain water for about 48 hours. During these hours and about one week therrafter, to measure and find at points located each 500m distance, the fluorescence soda solution in the Ceyhan River to see the continuation of such caves. When there are found more than two caves, then, it is desirous to use Rohdamin as a tracer.

d) When a cave with spring water is discovered, to measure the water pressure, and examine the water quality. If the water pressure is above the highest water level of the reservoir, there will be no problem. By the analysis of water quality, the correlation with the Ceyhan River can be deduced. As to the water in the limestone formation which runs from the reservoir into outside area, a careful investigation is recommended as essential.

(6) Surveys of Land-slide in the Reservoir Area

As certain traces of serpentine land-slides are noticed at the location of 400-500m on the right bank in the downstream of the damsite, it is desired to make an investigation to determine whether there is possible danger of larger scale land-slides in and around the reservoir area, particularly, in such zones as dolomite and quartz schist.

(7) Installation of a Seismometer

It is desired to install at the damsite a seismometer in consideration of the scale and scope of the project.

5-4. Construction Materials

(1) Concrete Aggregate

So far the laboratory tests of the core materials for fill type dam gathered at 5 km downstream from the damsite and of the embankment materials taken from the damsite were made, but no survey as to the borrow area of concrete aggregate was not yet made.

As the supply source of the concrete aggregate, the following can be counted as the possible resources:

Excavated materials from the diversion tunnel, spillway, dam and power plant as well as from the river deposit at 6.5 km downstream of the damsite and from the Horu Creek located 30 km south of the damsite. It is necessary to check and test to see the available volume and quality of the materials, and the quality of the concrete as well.

(2) Cement, Reinforcement Bar, etc.

The nearest cement plants to the project area are in Adana, Gaziantep, and Nigde. The Adana Public Cement, which has an annual production capacity of 300,000 tons, is located at a 110 km distance from the Berke damsite, and a railway transportation service will be available to Yarbasi, 30 km from the damsite.

The steel bars up to the size of 36mm are available from a Steel Mill located in Karabuk. Also the materials for steel structure are manufactured in Karabuk.

Valves of smaller sizes can be locally obtainable, while larger ones are imported. Lumbers and dynamites can be locally available. However, it is recommended that, of the damsite made materials to be used for the Berke Project, a check should be made as to their availability, quality and specifications.

5-5. Power Market Survey, Agricultural and Other Investigations

The total installed capacity of electric power industry in Turkey in 1966 was 2,030MW, and the annual growth rate of the power demand in recent years was estimated at 12%.

This project has been planned in consideration of the rapidly growing power demand in this country. The designed output capacity of this project is estimated at 800MW. But, if this power plant is planned as a peak station and the area of supply is limited to only a certain area in the Southern Turkey, there would be a possibility for this project of which commencement may largely be delayed. Therefore, in order to expedite the development of this project at an earlier date as possible, it is necessary to consider it on the whole nationwide scale.

It is also necessary to make estimations of load forecast, supply potentiality, possible competitive project and nationwide supply systems under the cooperation of the Eti-Bank.

On the other hand, this project is mainly planned as an electric power development project, but since this dam is of a 310m high dam, a reservior will have a storage capacity of 5,000M.CU.M.,and consequently, the Kiziltos project of the upper reaches will be absorbed in this project, therefore, related irrigation projects should be taken into consideration.

Furthermore, it can be expected that the benefit of flood control will considerably be increased. In order to estimate such benefit as acurately as possible, it is recommended to carry out investigations in connection with the amount of water requirement for this water resources development as well as to collect the records of damage caused by the past floods. Also, it is advisable to study the cost of land compensation covering the areas of damsite, reservoir and other necessities for this project.

5-6. Analysis of Hydrological Data

The inflow and the flood-flow discharge of the Berke site were studied by IECO. According to IECO, based on the runoff records at the Kılavuzlu Guaging Station, which has the longest observation records on the Ceyhan River, and the runoff records at the Himmetli Gauging Station located on the nearby Goksu River, both records were correlated, and the runoff during the period from October 1935 to the end of 1963 was developed, and used as runoff records of the Kılavuzlu Station. Therefore, also the runoff records of the Cerioglu Station during the period from 1935 to 1963 were developed based on the correlation between the Cerioglu Station on the downstream of the damsite and the Kilavuzlu Station.

The inflow of the Berke damsite was computed in terms of the propotion of drainage area between the Cerioglu Station and the Berke damsite.

It is advised that, in future, it would be better to review the actual discharge and the natural discharge of the damsite using the data of a proposed guaging station and the data of the said existing stations after 1963. Moreover, it will be necessary to conduct investigations of evaporation and sedimentation as described in Section 2 of Chapter V, and study these conditions.

According to IECO report, the probable maximum flood discharge at the damsite (catchment area of 13,495 km^2) is calculated at 15,500 CU.M. According to the Enveloped Curve of Maximum Flood in Turkey, the flood discharge at this site is estimated at 4,000 CU.M. Referring to the designed flood of other existing and proposed dams, the flood discharge of this damsite is assumed at 5,000-6,000 CU.M.

Since a design flood plays an important role in designing of a dam, it is necessary to select the optimum K in the calculation of the probable maximum flood discharge by means of physical studies instead of merely

relying on the statistical K=15 formula. Also, it is necessary to survey the traces of the past flood at the downstream of the damsite for the analysis of the probable maximum flood.

5-7. Reservoir Operation Rule

The appropriate distribution of the water of the Ceyhan River including the adjacent rivers will be determined based on the data obtained by the power market and agricultural surveys. According to such studies, the operation rule of the Berke Reservoir will be formulated taking into consideration the amount of the flood-cut.

As the Berke Project involves the construction of the largest scaled reservoir in the Ceyhan basin, it is recommended that the master plan of the entire Ceyhan basin would be reviewed so as to determine the optimum scale of the Berke Project producing the maximum benefit of the project. Then, the reservoir operation rule based on the results of such studies will be scrutinized.

5-8. Preliminary Design of Dam

As the results of the engineering studies of the critical height of an arch dam based on the data so far obtained, it was determined that the construction of the arch dam of 310m on the foundation rock is turned out hopeful, therefore, in parallel with the suggestions described in the aforementioned paragraphs, or awaiting the results of such investigations, it is desired to carry out the following works in order to confirm and determine the technical feasibility of the high Berke dam.

(1) Collection and Studies of Basic Data

With the progress of the geological survey, data regarding geological features will be gathered, and the estimation of the modulus of elasticity, shear strength and the friction coefficient of the rocks will be made. Also

the measurement and tests of the strength, elasticity modulus and Poisson's ratio of the concrete will be made together with the studies of the design flood, sedimentation, etc. Based on the information thus derived, the design criteria required for preparation of the preliminary design of the dam will be made. Thereon, the preliminary designing of the dam will be proceeded.

(2) Preliminary Analysis of Dam

The preliminary analysis will be made as to several conceivable alternatives of layout, height and type of the dam. The purpose of this analytic study is to make clear and solve the problems raised with the various alternatives relating to the quantities of works and technicality. In this case, the calculation of the stress of the arch body will be made by means of the Trial Road Method with respect to the typical arch types and as to other alternatives, the analogical study will be applied based on the above calculation. A careful study of each plan will be made as to the foundation stability.

(3) Preliminary Design of Dam

The optimum scale of the Berke Project will be determined based on the above preliminary studies as well as on the master plan which will be separately studied. After this, referring to such results, the preliminary design work of a dam including a power plant and a spillway will be carried out.

5-9. Investigation Schedule

Items to be investigated for the feasibility study of the Berke Project are as indicated in Section 5-1 and 5-8 respectively.

The investigation schedule for the whole items will take approximately 12 months as shown in Fig. 5.

After the abovementioned surveys are completed and the necessary data for studies are made, a survey team should be organized and the team

should conduct field surveys of the damsite and other areas concerned, then the analysis of hydrological data and the master plan of this project are subsequently undertaken. The feasibility studies of the Berke Project including access roads, power supply for construction works and power transmission lines, etc. should be carried out.

The feasibility study will require two or three months for the field investigation, and about five months for the subsequent study and the preparation of the feasibility report.

Table-2 List of Gaging Stations in the Ceyhan Basin

Owners	Names of gaging station	Catchment area (km^2)	Period of observation
			1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966
D S.I	Kerevın (20- 9)		
E.I.E	Tanır (2015)	915.2	
D.S I	Kuskayası (20- 7)	2,084 0	
D.S.I	Güverein (20-12)	356 0	
E I.E	Türkveren (2016)	678 0	
E.I.E	Kabaağac (2005)	4,219 6	
D S.I	Gamkõorũ (20-15)	189.7	
D S.I	Alıglı Bucak (20-16)	291 01	
E.I.E	Karaahmet (2006)	739.2	
E.I.E	Poskofıu (2009)	1,387.2	
E.I.E	Kandll (2019)	6,256.4	
D.S I	Basplnar (20- 2)	215 0	
D.S.I	Kanak Kõp (20- 3)	305 0	
D S.I	Kilıli (20-20)	732 0	
E I.E	Kũrter Avsarı (2010)	3,498 8	
E.I E	Kılaruzlu (2001)	8,484 0	
E.I.E	Cercıoğlu (2013)	13,840.0	
E I E	Aslantas (2020)	14,708.4	
E I E	Yenı Karayolu Kõp (2012)	19,727.2	
D S.I	Tokmaklı (20-13)	105.1	
E.I E	Yıldızkõy (2018)	226 8	
D.S.I	Gebeslı (20-14)	310.5	
E.I E	Darılik (2017)	564.8	
D.S I	Haruniya (20- 6)	177.0	
D.S.I	Sarıkız (20-10)	227 1	
D.S.I	Kanlıgefil (20- 4)	176.0	
D S I	Fana (20- 5)	96.0	
D.S.I	Kadirli (20-18)	414.0	
D.S.I	Memetli (20- 1)	234.3	
D S I	Hazrettin Bah (20-19)	274.1	
E.I.E	Cukur Kõ (2007)	620.0	
D S.I	Osmaniye (20- 8)	131.1	

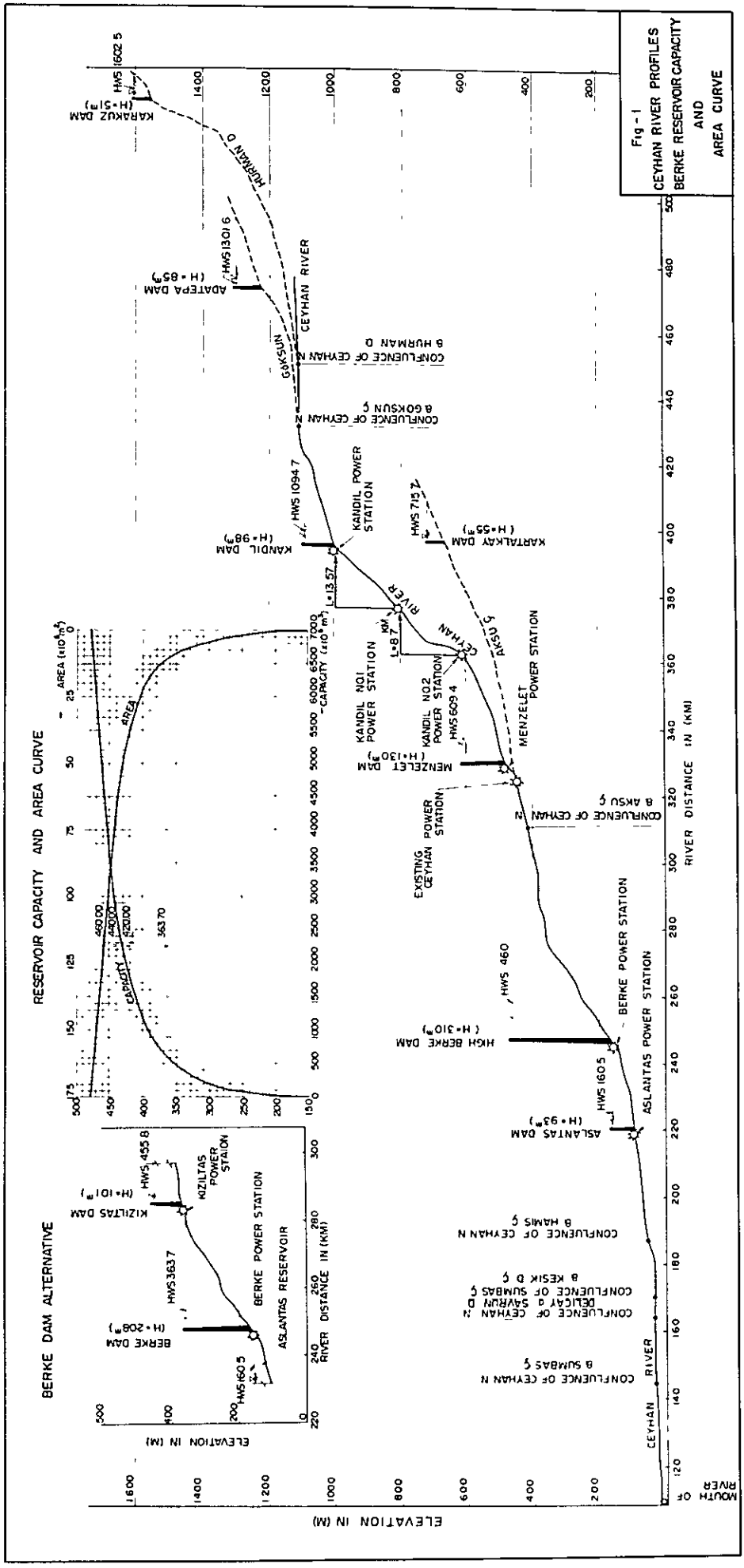
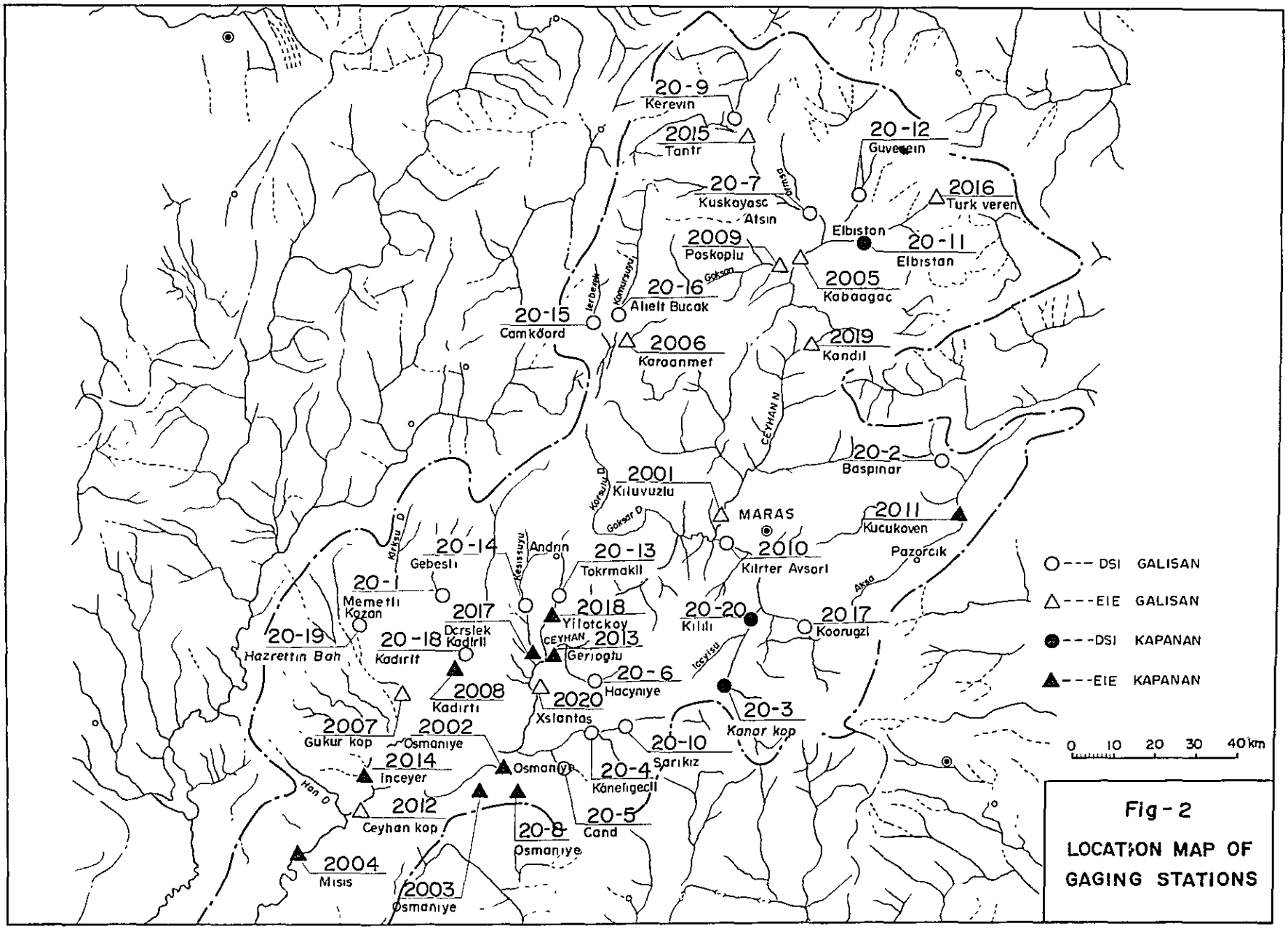


Fig - 1
CEYHAN RIVER PROFILES
BERKE RESERVOIR CAPACITY
AND
AREA CURVE
RESERVOIR CAPACITY AND AREA CURVE
BERKE DAM ALTERNATIVE
ELEVATION IN (M)
RIVER DISTANCE IN (KM)
MOUTH OF RIVER
CEYHAN RIVER
KARAKUZ DAM (H=51m)
ADATEPA DAM (H=85m)
KANDIL DAM (H=98m)
KARTALKAY DAM (H=55m)
MENZELET DAM (H=130m)
HASAN UGURLU DAM (H=310m)
ASLANTAS DAM (H=93m)
BERKE DAM (H=208m)
KIZILTAS DAM (H=101m)
HURMAN D
GAKSUN
CEYHAN RIVER
KANDIL POWER STATION
KANDIL NO1 POWER STATION
KANDIL NO2 POWER STATION
MENZELET POWER STATION
EXISTING CEYHAN POWER STATION
BERKE POWER STATION
ASLANTAS POWER STATION
KIZILTAS POWER STATION
ASLANTAS RESERVOIR
CONFLUENCE OF CEYHAN N & HURMAN D
CONFLUENCE OF CEYHAN N & GOKSUN Ç
CONFLUENCE OF CEYHAN N & AKSU Ç
CONFLUENCE OF CEYHAN N & HAMS Ç
CONFLUENCE OF CEYHAN N & SUMBAS Ç
CONFLUENCE OF SUMBAS Ç & KESIK D Ç
CONFLUENCE OF CEYHAN N & DELICAY & SAYRUN D
AREA
CAPACITY
HWS 1602.5
HWS 1301.6
HWS 1094.7
HWS 715.2
HWS 609.4
HWS 460
HWS 1605
HWS 455.8
HWS 363.7


20-9
Kerevin
2015
Tantr
20-12
Guvercin
20-7
Kuskayasc
Atsin
2016
Turk veren
Elbistan
2009
Poskoplu
20-11
Elbistan
2005
Kabaagac
20-16
Alielt Bucak
20-15
Camkoord
2006
Karaanmet
2019
Kandil
20-2
Baspinar
2001
Kiluvuzlu
MARAS
2011
Kucukoven
20-14
Gebesli
20-13
Tokrmakll
2010
Kilrter Avsorl
Pazorcık
20-1
Memetli
Kozan
2017
Dcrslek
2018
Yilotckoy
20-20
Kilili
2017
Koorugzi
20-19
Hazrettin Bah
20-18
Kadirit
2013
Geriogiu
20-6
Hacyniye
2008
Kadirti
2020
Xslantas
20-3
Kanar kop
2007
Gukur kop
2002
Osmaniye
20-10
Sarıkız
2014
Inceyer
Osmaniye
20-4
Kaneligecli
2012
Ceyhan kop
20-5
Cand
20-8
Osmaniye
2004
Misis
2003
Osmaniye
DSI GALISAN
EIE GALISAN
DSI KAPANAN
EIE KAPANAN
0 10 20 30 40km
Fig - 2
LOCATION MAP OF
GAGING STATIONS

Not Butun kotlardan 2m duşulecektir
Kayalık yerlerde kotlar olmadığı için mümkünse yaklaşık olarak geçirilmiştir

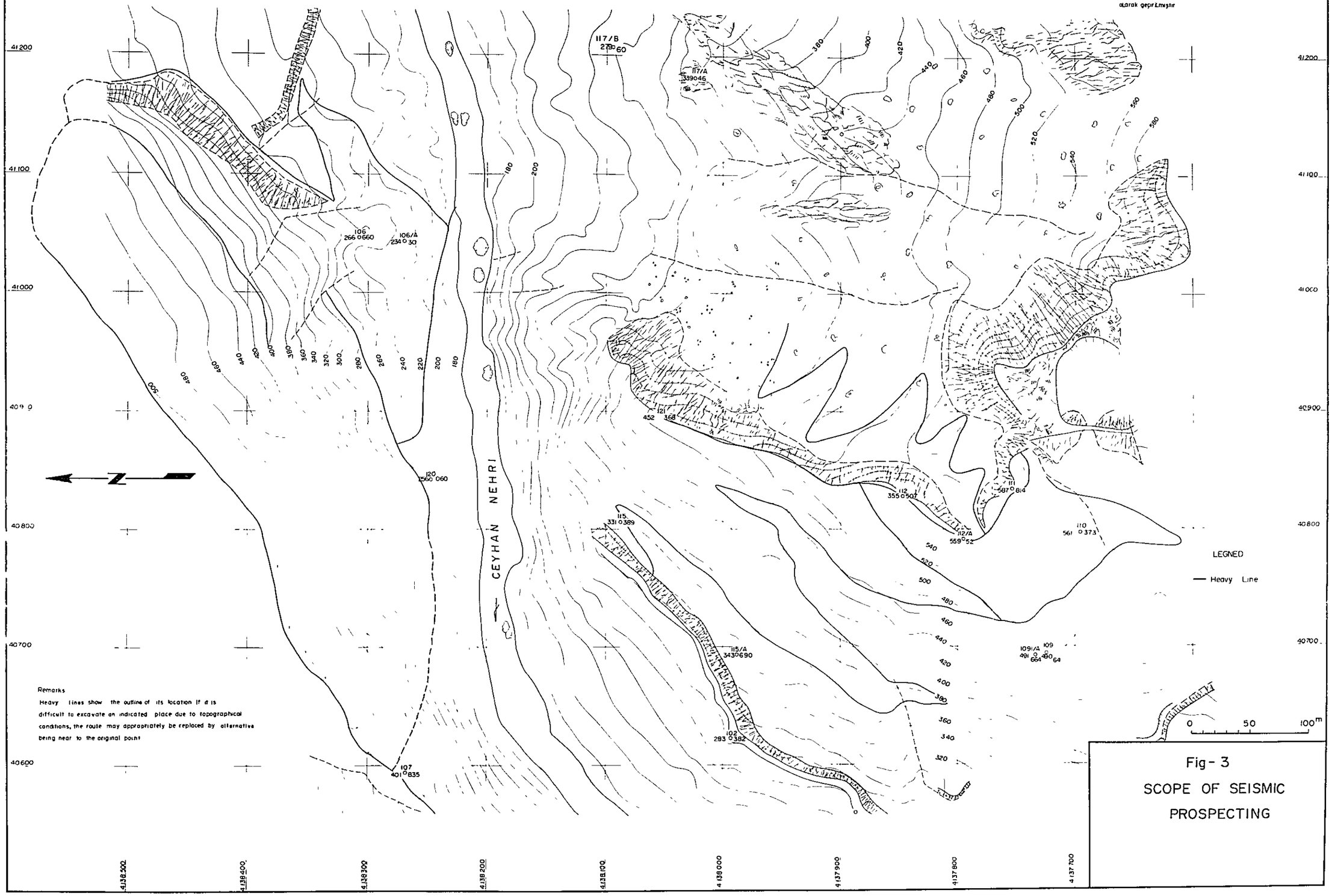


Fig - 3
SCOPE OF SEISMIC PROSPECTING

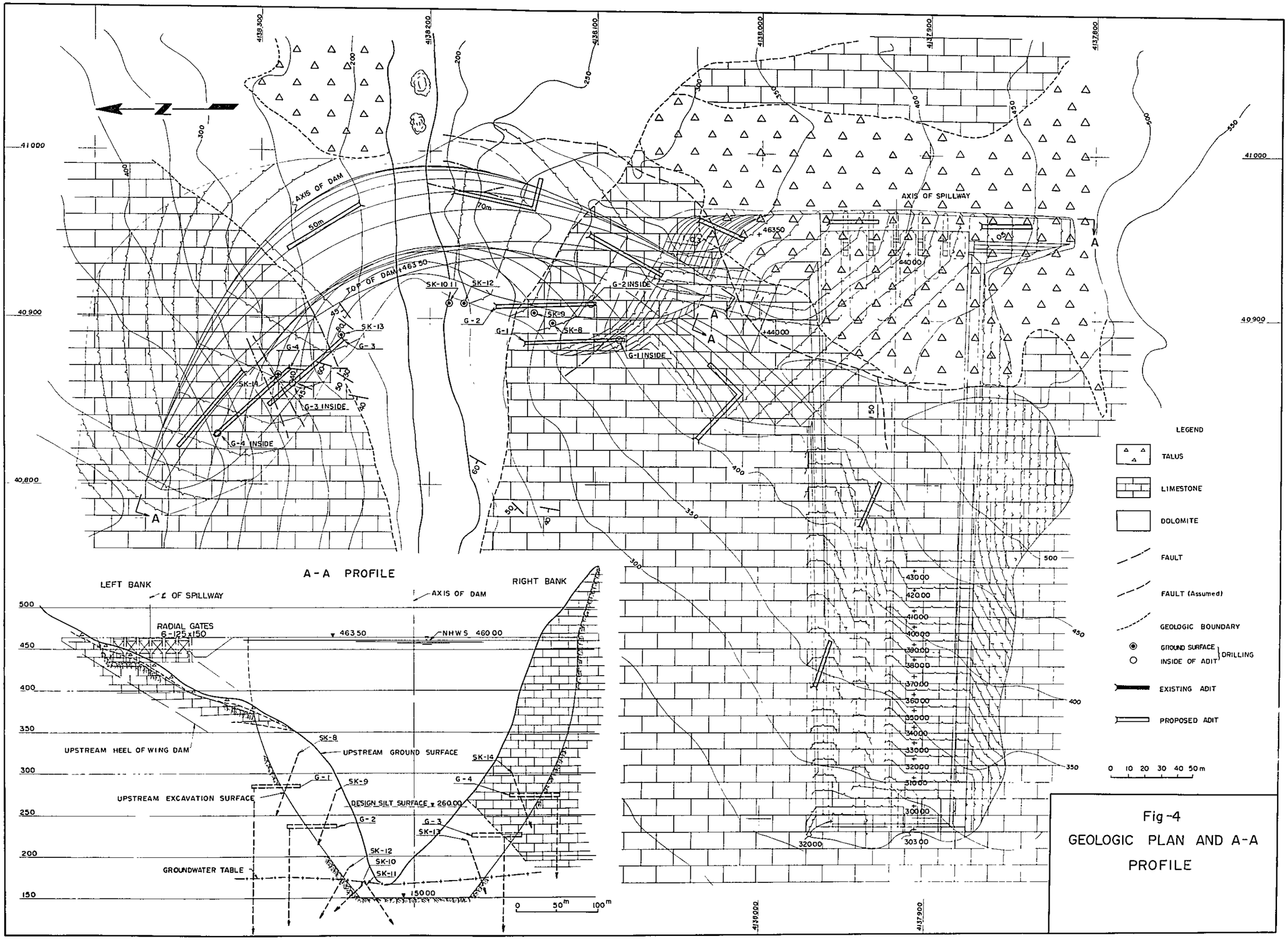


Fig-4
GEOLOGIC PLAN AND A-A PROFILE

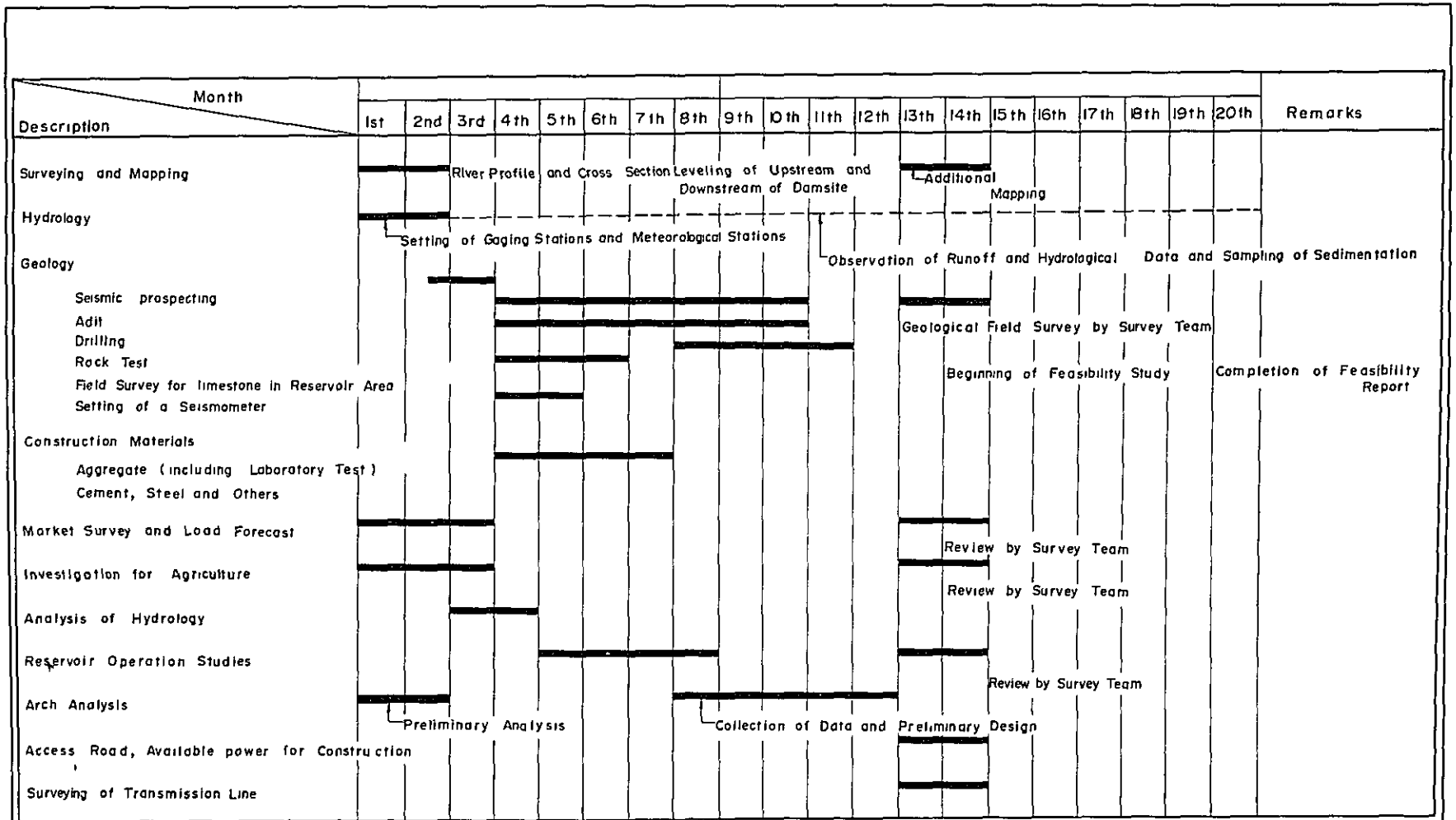


Fig - 5
INVESTIGATION SCHEDULE
FOR
BERKE PROJECT