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PROGRAM OF SURFACE-WATER INVESTIGATIONS IN TURKEY

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and
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Ankara, Turkey
October 1962

Administrative Report

Program of Surface-Water Investigations in Turkey

by

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U. S. Geological Survey

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SURFACE-WATER INVESTIGATIONS
IN TURKEY

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Introduction

Elektrik Isleri Etud Idaresi (Electric Power Resources Survey Administration) is responsible for hydroelectric planning, including the basic stream-gaging network and other electric power responsibilities. Except for some geographical and historical information this report reviews the program since assistance was begun under the United States technical aid program and includes some suggestions and recommendations which are believed should improve the future program. Devlet Su Isleri (State Hydraulic Works) began an extensive streamflow investigations program in 1959 that is not included in this project. The assistance project, PIO/T 277-22-267, Hydrological Data Study and Training, covers assistance to the Hydrographic Section of Elektrik Isleri Etud Idaresi (E.I.E.) to improve its basic data collection program.

Acknowledgements

Interest in the improvement of surface-water investigations data shown by certain personnel of E.I.E. and the companionship during the thousands of kilometers of field trips was most appreciated. It is regretted that the language barrier prevented closer associations with all the personnel. Only a few of the many persons whose efforts and kindnesses were most appreciated can be mentioned herein.

Acknowledgement is given to Mr. Ibrahim Deriner, General Director of E.I.E., who has maintained a great interest in the water investigations

program since his career first began as a young engineer with the Hydrographic Section, later as its Chief, and presently as General Director of E.I.E.; to Mr. Turgut Ozal, Assistant Director, for his close contact in the important administrative phases of the program; and, to Mr. Hikmet Kargi, who as chief of the Surveys Division, quietly supervised the program of the Section.

Special mention is made of Mr. Resit Ogan, Chief of the Hydrographic Section until March 1962, who helped so much to make the assignment a pleasant one; to Mr. Vedat Arica, without whose great interest and effort the assignment would have been very difficult; and to Mr. Oguz Bayar, Chief of the Section since March 1962, whose recognition of the need for reliable streamflow data added an impetus to the Section for technical improvement.

Others who have demonstrated greater than ordinary interest and effort toward their work include Sabih Guvenlidal and Musa Elmaci.

The cooperation of Mr. John E. Hall, power advisor of U.S. A.I.D./ Turkey, under whose overall assistance project this program was a part, and of the administrative personnel of the Industry Division and other offices of U.S.A.I.D. is appreciated.

Geography

Turkey, with an area of 767,120 square kilimeters (296,185 sq. mi.), lies between latitudes 36° and 42° North and Longitude 26° and 45° East. About three percent of the area (Thrace) is on the European side of the Dardanelles, Sea of Marmara, and Bosphorus Straits and the bulk of the area is in Anatolia, or Asia Minor. It is bordered by the Black Sea on the north; Bulgaria, Greece and Aegean Sea on the west, the Mediterranean Sea, Syria, and Iraq on the south, and the U.S.S.R. and Iran on the east. Topographically, it is largely a high, rugged plateau between coastal mountain ranges which join in eastern Turkey; low plains are common in the western, Aegean, region and high plains in the central area. Mountain ranges lie primarily in an east-west direction along the north and the south coasts and result in a number of large closed basins, of which the Lake Beysehir-Konya plain-Tuz Gol (Salt Lake) and Lake Van basins are the largest. Elevations range from sea level to the 5,165 meters (16,940 ft.) of Mt. Ararat, with the elevation of the western half of the country mostly from sea level to about 2,000 meters and the eastern half averaging about a thousand meters higher.

Though geographically in the temperate zone the climate varies within a wide range. The southern coastal area is sub-tropical, the eastern mountain areas have severe winters with much snow, the central plateau area has a fairly typical temperate zone, semi-arid climate, and the Aegean and Black Sea coasts enjoy a fairly humid warm-temperate coastal climate. Agricultural products vary with climate and include bananas and citrus fruits along the Mediterranean; tobacco, tea, nuts, and fruits along the Black Sea; olives, peaches and figs in the Aegean and Marmara area; and the principal product, wheat, as well as sheep and cattle, in the central plateau and mountainous eastern region.

Precipitation

Precipitation generally follows the coastal ranges as storm patterns move in from the northwest and west. It occurs generally during the winter and spring months as rain or snow; however, the north coastal area experiences local rains in all seasons. Precipitation ranges from less than 250 mm annually in the central area to more than 4,000 mm along the eastern Black Sea coast. The Black Sea coast has recorded all the maximum daily, monthly, and annual precipitation totals. The maximum precipitation data are:

Max. daily	:	431.5 mm at	Zonguldak,	Aug. 1, 1955
Max. monthly	:	781.5 " "	Rize	, December, 1931
Max. annual	:	4045 " "	Rize	, in 1931.

The second highest daily and monthly maximums are along the Mediterranean coast; 290.7 mm at Antalya, December 18, 1949, and 757.9 mm at Manavgat December 1940.

Runoff

Streamflow is variable depending on the precipitation, geography and topography. The north and south coastal areas with their coastal mountain ranges experience serious local flash flows; the east-and-west oriented mountain ranges confine most of the interior runoff into lengthy streams which flow generally westward until they break through a mountain range to the sea or south into lower elevations. Such streams, which are the largest in Turkey, are the Firat (Euphrates) and Tigris, which flow south into Syria and Iraq; Sakarya, Kizilirmak and Yesilirmak, which flow into the Black Sea; and the Buyuk Menderes and Gediz Rivers, which flow into the Aegean Sea. Those stream systems collect most of the interior drainage and are the streams most susceptible to major development; however, intermediate sized streams such as the Aksu, Goksu, Ceyhan, Seyhan, and others, are also well situated for irrigation and power development. Geologic and topographic conditions have an effect on streamflow, as found especially in the southern coastal region where the predominating limestone formations result in many, and large, sinks and springs so that some streams, such as the Manavgat River, discharge flows about twenty times that of other streams in the general area on a drainage area basis and three or four times the basin precipitation. Snow-melt is the principal source of runoff in the Euphrates and Tigris basins and to a lesser extent in the Kizilirmak and Yesilirmak; most other major streams receive water from winter and spring rains and lower-level snow.

Sediment

Sediment loads have been significant since ancient times. The ancient seaport city of Tarsus is now some 12 km. from the sea; the important ancient seaport of Miletus, at the mouth of the Buyuk Menderes (Meander) River, gave way to Ephesus on the Kucuk Menderes River, which in turn lost its port. Although sediment loads may not be excessive, the effects on advanced civilizations over periods of thousands of years of sediment deposition and delta formation are well illustrated.

Water-use development

Development of water resources for various uses has been carried on for thousands of years. The accessibility of the coastal areas by sea, coupled with the mild climate, probably made the Aegean, Mediterranean, and Black Sea coasts the centers of ancient culture and civilizations; however, the streams undoubtedly were a reason for the old Hittite, Phrygean, Lydean, and other civilizations of three or four thousand years ago. Numerous ruins of ancient Roman aqueducts remain where water had been carried for great distances from a good source of supply, such as the aqueduct from the dependable Manavgat River to ancient Side. There elapsed a long period of time from the ancient civilizations to the fairly recent past when developments were either non-existant, subject to deterioration, or very small; however, in the 15th century some aqueducts were constructed and in the 18th and 19th centuries the sultans again constructed dams and reservoirs to supply water to Istanbul and other areas. In the past two decades the government of Turkey has launched many great water resource development projects. The investigation of water resources relative to this development shows that the hydroelectric power potential of Turkey is the greatest of any European country except Norway and Russia, and that millions of hectares of land may be beneficially irrigated from surface water sources. It is the duty and the purpose, therefore, of the Hydrographic Section of E.I.E., as well as of Devlet Su Isleri (D.S.I.), and any succeeding agency, to continually strive to improve and to expand the studies of the surface water resources of Turkey so that the greatest benefits may be obtained from the large, though somewhat irregularly distributed, surface water supply. For project planning - whether for power, irrigation, flood control, municipal and industrial supply, recreation, or other use--a reliable inventory of surface water throughout the country is a basic need. Water is the greatest resource, as it is renewable and not subject to serious depletion. When good, reliable streamflow data is available it is possible to properly plan water-use projects and to avoid the costly errors of over-or under-design, which otherwise will occur.

Surface water Investigations

Streamflow investigations have been carried on by E.I.E. since 1935 within its general authority to study streams for hydroelectric power development. The first gaging stations were established on streams with good power possibilities, on international streams, and on some lakes. By 1951 the number of gaging stations operated reached 100 and then increased to 300 in 1960. D.S.I. also began large scale surface water investigations about four years ago in connection with its authority for the planning and construction of irrigation, drainage, flood-control, multi-purpose projects and municipal water supplies. Etibank, a governmental bank authorized to operate hydroelectric power facilities, as well as other activities, operates three streamflow stations above Sariyar dam on the Sakarya River, and one below. Discharge measurements at these three stations are occasionally made by E.I.E. and all of the data are computed, compiled, and published by E.I.E. E.I.E. data has been published and has been available since 1935; D.S.I. issued its first publication in 1962, which includes 1959 data for some streams. Figure 1 indicates the expansion of the gaging station network of E.I.E. from 1935 to the present time, as well as the number of discharge measurements made and the number of station records computed and published during each year.

Technical Assistance

Assistance to the streamflow investigations program of E.I.E. began with the assignment of Mr. Kenneth N. Phillips of the U.S. Geological Survey (U.S.G.S.) under the United States International Cooperation Administration aid program, for the period Apr. 1 to July 2, 1957. Mr. Phillips made a preliminary study of the program and prepared a report entitled "Report and Recommendations on Surface Water Resources Investigations in Turkey", which furnished background information and included recommendations pointed toward the up-grading of the overall program. Mr. C. C. Yonker, also of the U.S.G.S. and under the ICA program, followed Mr. Phillips and completed a 2-year assignment to assist and advise in the implementation and improvement of the program. The writer, also of the U.S.G.S. and assigned to the ICA/AID program, arrived for a one-year assignment June 22, 1961, to continue the assistance to the E.I.E. Hydrographic Section. At the request of E.I.E. the assignment was extended by U.S.A.I.D./Turkey for an additional four months. In addition to the assistance to E.I.E., the Hydrology Section of D.S.I. also received assistance during 1955-57 from Bureau of Reclamation engineers attached to the assistance

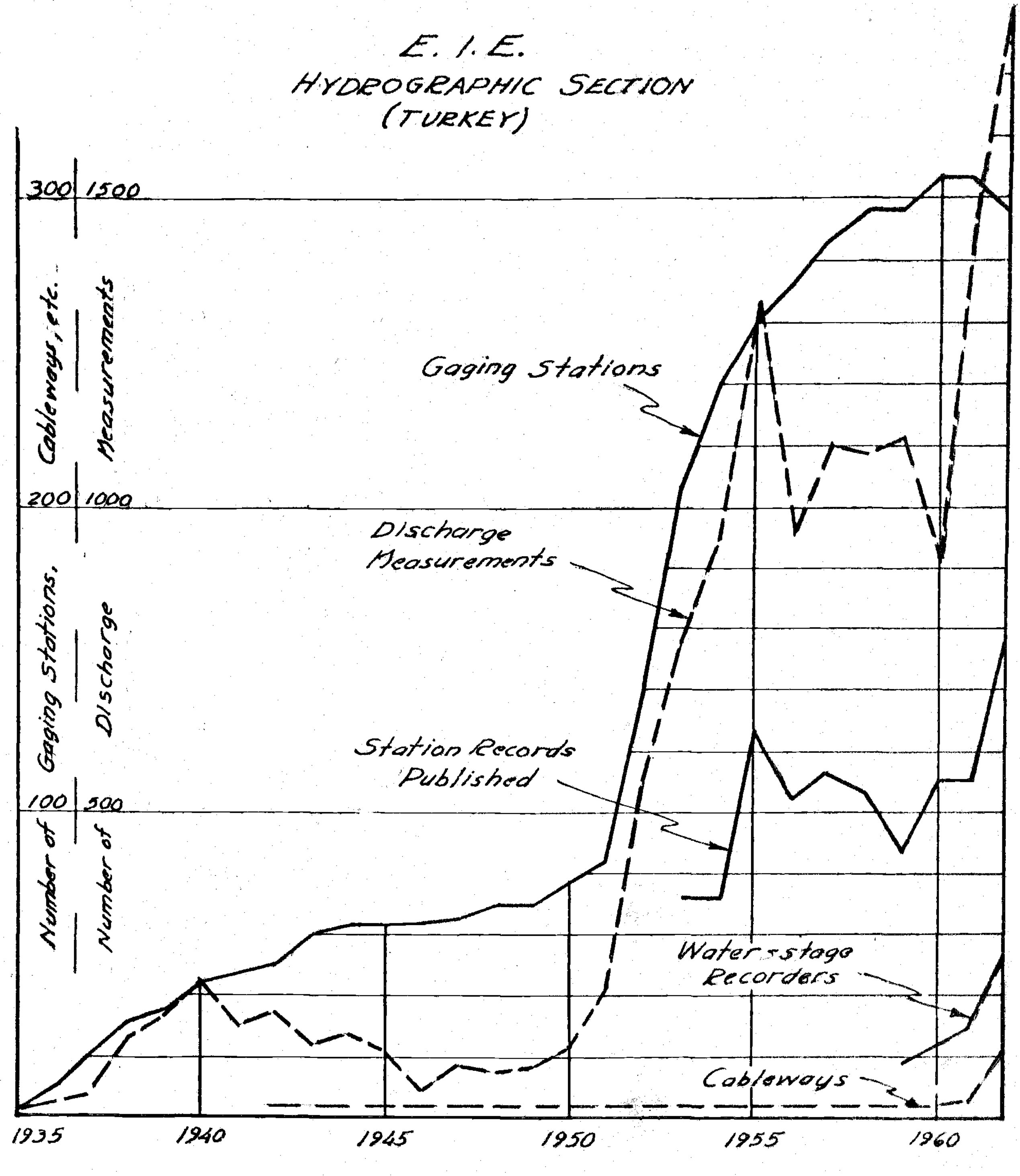

Figure 1.--Number of Gaging Station, Water-Stage Recorders and Cableways installed and Discharge Measurements made and Station Records published by E.I.E., 1935 to present (1962 partly estimated).

program. That assistance appears to have been largely in hydrologic studies for project planning; however, D.S.I. later increased its program of basic data collection, for which the E.I.E. Hydrographic Section had been primarily responsible.

Commodity Aid

During the fiscal years 1959-61, $49,000 of commodity assistance was furnished under the aid program to E.I.E. Major commodity items were:

8 Current meters, Price	10 Wire-weight gages
8 " " , pygmy	8 Rowboats, Aluminum
7 " " , Ott	8 Outboard motors
32 Sounding weights	8 Handline sets
18 Water-stage recorders	8 Bridge measuremet cranes
12 Rubber rafts	8 Wading rod assemblies
1 Automobile, sta. wagon	8 Boat measuring assemblies
18 Office calculators	16 Tag-lines, steel, 100 and 300 m.
1 Multilith Duplicator	16 Stop Watches
12 Sounding reels	10 Waders, shoulder-high
4 Recorder clocks, extra	7 Sediment samplers
1 Clock test stand	1 Set 600 ft. cableway equip.

Accessories and spare parts, rubber boots, tapes, gages, floats, oars, paddles, and other miscellaneous equipment were also furnished. In addition, the U.S.G.S. supplied more than three thousand dollars worth of demonstration equipment under its backstopping responsibilities, including a complete set of standard measuring equipment, standard forms, and heavy measuring equipment for use on the Euphrates and Tigris Rivers. The expensive multilith duplicator obtained under a commodity order was, however, not only for the use of the Hydrographic Section but also for other E.I.E. departments.

Program and deficiencies

Mr. Phillips' review of the surface water investigations program in Turkey described the methods then in use and recommendations for improvement. During the two years in which Mr. Yonker was the advisor, and during the 16 months of the writer, advice, recommendations, and training were offered to improve practices.

Field Work

Although field work has improved considerably, a few items are mentioned below as a reminder of points still to be corrected:

1. The locations of streamflow stations have not always been satisfactory and some poorly located stations have been continued in use although hydrographers visited them very seldom or conditions prevented satisfactory records. More care is now taken to install gages at locations where satisfactory records are possible and where the gage is accessible. Some existing gage installations have been relocated or improved and others still should be relocated. A good record at a point <u>near</u> a proposed project site is preferable to poor, or no, records for a station at the site.

2. Type of gage or construction was such that gages were difficult to read or to maintain, recording gages were often affected by silt, or

otherwise not satisfactory. The one-meter long enameled iron gage sections manufactured in Istanbul are an improvement; also, the wire-weight gages installed on some bridges assure better gage readings. Although the agency still uses 30 or 40 cm diameter recording gage wells, the wells are now usually equipped with clean-out doors or with cone-type sediment cleaning devices. Larger diameter wells equipped with intake pipes and flushing systems have not been accepted, although loss of record could be prevented by use of about one-meter diameter wells at some recording gage installations. However, gage readers are employed at most gaging stations so that the loss of the recorded low water record is not too serious.

3. Referencing and checking of the datum of gages have always been done, and sometimes overdone; however, level notes are not kept in the files so that datum corrections as a result of settlement of gages, or other movement, are somewhat doubtful and not always considered in the computations. The recommendation that level notes be checked and filed, and that gages be checked at least once a year, is therefore repeated.

4. Care and maintenance of staff and recording gages have been fairly good; however, clock stoppages are frequent and differences in gage readings by observers and hydrographers are too common. The latter casts doubt upon the hydrographer's reliability because his readings are often disregarded in favor of the gage readers' observations.

5. Discharge measurements have improved although there are still some items which should be corrected. Practically all hydrographers still indicate that both the depth of water and the velocity are zero

at each bank and thereby introduce probable errors into the measurement when the depths and velocities at the edges may be far from zero. Measurements that differ appreciably from the rating curve or other recent measurements should be repeated or the probable reason for the change in rating given in the notes. Hydrographers do not give sufficient information in the notes to permit office computers to understand the reason for probable changes in the stage-discharge relation with the result that many measurements must be disregarded as unreliable.

6. The gage height of zero flow is as important, or more so, as a discharge measurement and should be obtained once or twice a year at low water; however, after more than a year of emphasis on that point the hydrographers fail to provide that easily available figure with the result that computed low flows may be appreciably in error.

7. Discharge measurements had been made on the average of about two or three per station per year and those usually made by "flood-waiting" crews, which resulted in a series of measurements during a flood, or rise, at a few stations and one, two, or no measurements during a year at others. The great recent improvement is that most stations are now measured approximately on a monthly basis with additional measurements, if necessary, during flood or high stages.

8. Some hydrographers often make "wading" measurements from a rubber raft instead of by use of boat-measurement equipment, or measuring from a cableway or bridge, if available. As that practice is, probably, largely from lack of training with better equipment,the method should improve with time.

9. High discharge should be computed by indirect methods if high stages are not defined by current meter measurements.

Discharge measurements are subject to personal errors, and slight variations are expected in the measurement of distance, depth, and time, which cause variations in the results. However, with a good, fairly permanent control the measurements should fall within $2\frac{1}{2}$ or 3 percent of a mean curve. Larger variations indicate a change in the stage-discharge relation or that the measurement is faulty.

Office Computations

Much of the unreliability of old records was due to the use of average "rating" curves for a streamflow station year after year regardless of changes from year to year, or season to season, caused by scour or fill in channel or riffles forming the control, or other reasons. Other errors were caused by simple extension of rating curves above the highest or below the lowest measurement with little if any basis for such extension. Also, records at some stations were computed for many years although no discharge measurements were made.

Computed records are now much more reliable. Some records may now be classed as excellent (within 5 percent) and the majority of them as good or better as compared to the records prior to 1960, which are mostly fair to poor in accuracy. The so-called "shifting-control" adjustments were used in the 1961 computations for the first time and all published records for that year are considered reliable.

With better and heavier equipment available, the streamflow stations are better rated at high stages. Extensions to "rating" curves are not now as long and are now made by logarithmic extension in most cases and are checked, or sometimes extended, from area-velocity curves.

A few minor improvements in the computation procedures could be made, which should improve and simplify the work as well as to reduce cost. The suggested changes in procedures are:

1. To discontinue the use of the formula $h = \frac{a + 13b + c}{18}$ and $h = \frac{a + 5(b+c)+d}{12}$ for the mean daily gage height for a gage read once daily, and twice daily, respectively (where "a" is the gage reading of the previous day, "b" the daily reading, "c" the reading of the following day, for once daily readings; and "a" is the 4 p.m. reading of the previous day, "b" is the 8 a.m. reading, "c" is the 4 p.m. reading, and "d" is the 8 a.m. reading of the following day, for twice daily readings). For most of the 1961 records the gage heights for rapidly changing stages were plotted and the mean daily gage height determined from the graph. For other than the periods of rapidly changing stage the use of the once daily reading , or the mean of twice-daily readings, will save considerable labor and not be appreciably less reliable than the formula.

2. The computations could be standardized somewhat more even though all the central office personnel now make computations in essentially the same manner. Daily discharge, and most other figures, should not be carried beyond three significant figures below 1,000, and not beyond 4 significant figures above.

3. Data received from the field offices should be closely reviewed by the most experienced man before recording and filing. Serious or repeated errors of discrepancies should be called to the attention of hydrographers or district chiefs. Such checking will relieve the computers of the study of questionable data months later when it is difficult to determine the reasons for doubtful data.

It is realized that sufficiently experienced and capable personnel are not available to perform all the checking and supervision that are necessary and desirable. That may, however, be possible in a matter of time and the office procedures should then become more standardized and streamlined.

Mr. Phillips listed in his 1957 report the following items of office practice which could stand correction:

"1. Rating curves are commonly extended on Cartesian coordiantes, or area and mean-velocity curves are similarly extended.

2. Differences are not shown on rating tables; as a result some tables have slight reversals.

3. Lists of discharge measurements do not show shift adjustment required, or percentage departure from applicable rating tables. Some discharge measurements differ by large percentages from published values of discharge.

4. Method of shifting control has not been used to compensate for continual small changes in rating, as shown by results of discharge measurements at some stations.

5. Tables of daily discharge are computed and published to show too many significant figures."

The five items have been corrected.

E.I.E. Hydrographic Section Organization

Prior to 1959 all field work was carried on from the central office in Ankara. Installation of gages and other equipment, as well as discharge measurements, were made by crews sent to the field for such specific purposes. The crews would remain at a station, or locality, until the assignment was completed, which usually resulted in a series of discharge measurements during a flood or rise at a station. That system was very inefficient as the crews could only cover a few of the total number of streamflow stations during the high water season and left many stations without measurements. Most stations were covered at least once a year during low flow, however, the one or two low measurements were quite meaningless.

The need for sub-offices was recognized by Mr. Phillips and recommended by him. A total of nine sub-offices was later determined as practicable and two offices, at Bursa and Aydin, were established in late 1959, and an office at Adana in 1960. The boundaries of the areas were drawn so as to eliminate excessively long distances of travel, travel over possibly snow-bound mountain passes, and by considering the number of gaging stations to be covered by the assigned number of men. An office covering a smaller area was established October 1961 at Antalya, which would also be in close contact with the United Nations Food and Agriculture team which is making a study of water-use developments in that area. During the first half of 1962 the remaining sub-offices were established in Elazig, Kayseri, Ordu, Erzerum, and Ankara. The Ankara sub-office is located in different quarters from the central office so that it may operate somewhat independently as do the other sub-offices.

Each sub-office is headed by a "district chief", who is one of the older employees, and who supervises, usually, two crews, each consisting of an experienced hydrographer and an assistant. Each crew has its own four-wheel-drive pickup truck and ordinary measuring equipment; however, only one set of boat measurement and bridge measurement equipment (except hand-lines) are in each district. Additional equipment will be purchased or will be fabricated locally to further equip all hydrographers.

The organization chart, Figure 2, illustrates the overall E. I. E. organization pattern and that of the Hydrographic Section. The latter organizational pattern is not definite as of this date and, although discussed often during the past year, the establishment of a supervisory position under the Chief of the Section, with some delegated authority and responsibility over field offices, has not been implemented. All authority and responsibility rest, therefore, on the Chief of the Section. Supervision, training, and control of field personnel are not as effective as they should be considering the size of the program and the variation in the capabilities of field men.

In positions superior to the Chief of the Hydrographic Section are:

ORGANIZATION CHART

Elektrik Isleri Etud Idareşi
(Electric Power Resources Survey Administration)

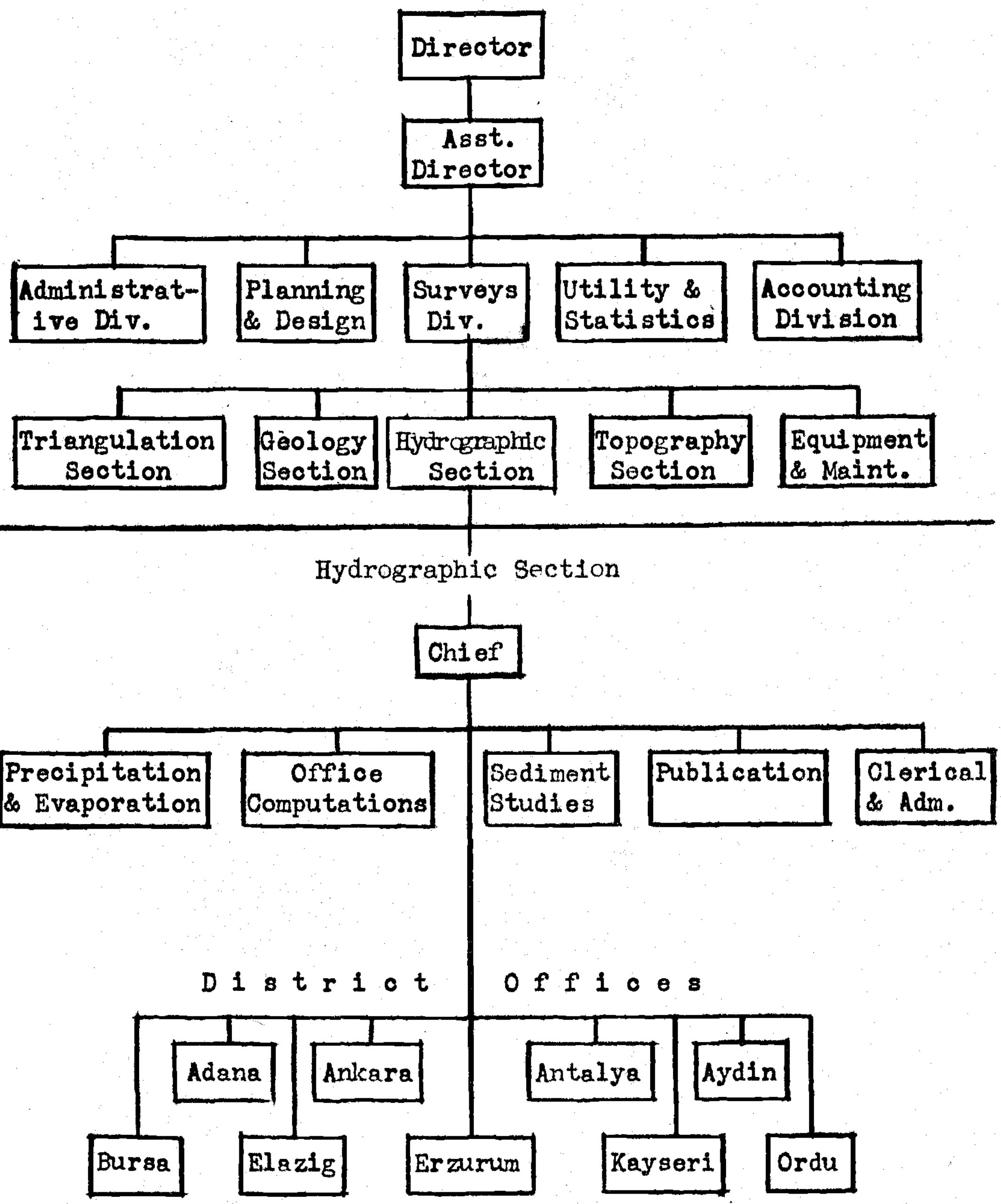

Figure 2

Ibrahim Deriner	General Director
O. Behcet Karamanoglu	Assistant General Director
Turgut Ozal	Assistant General Director
Hikmet Kargi	Chief of Surveys Division

The roster of personnel of the Hydrographic Section as of this date, in positions or grades of district chief, and above are:

Resit Ogan	Chief of Section, counterpart, until March 1962
Oguz A. Bayar	Chief of Section, counterpart, since March 1962
Rahmi Kahyaoglu	Office computations chief
Vedat Arica	Assistant to chief; interpreter-counterpart
Maat Tansu	Antalya; advisor to sub-office
Abdulkadir Yurukur	Adana; advisor to sub-office
Feyzi Yildizbaz	Elazig; district chief
Erol Algan	Bursa; district chief
Burhan Topcugil	Antalya; district chief
Musa Elmaci	Aydin; district chief
Sabih Guvenlidal	Kayseri; district chief
Zekai Gucluturk	Adana; district chief
Talat Kutukoglu	Ordu, district chief
Bulent Azsoz	Ankara; district chief
Bekir Terzioglu	Erzerum; district chief
Kemal Ozkan	Assistant in Kayseri office
Hasan Guclu	Publication of records

The last man is also an experienced hydrographer and has been rotated from a field position to present assignemt. The two men who are assigned to the Antalya and Adana districts in advisory positions could be better utilized by transfer to the central office for overall supervisory duties or be rotated to different districts in order to improve work in all districts.

In addition to the above personnel there are about 18 hydrographers and assistant hydrographers who are assigned to the district offices. The central office also has on its staff one woman for drafting and one who compiles climatological data obtained at evaporation stations maintained by the Section; and, about 12 women who perform the routine gage height and discharge computations under the supervision of the chief of office computations and his one or two assistants, who prepare the stage-discharge relation curves and tables, compute adjustments for shifting control, and other necessary specialized computations. It would be preferable that hydrographers did more of the office computations; however, owing to the shortage of trained men the office work is carried on as above. Three engineering students were hired for summer work in 1962 and may join the Section after receiving degrees.

The field, or district, offices should assume more of the office computations as they become qualified and able to do so, and the women now in the computation section could then check computations made in the field offices and perform computations for other studies. It is preferable that field and office personnel be experienced in both field work and office computations so that they can recognize unreliable field data and the need for good, complete field data.

The organization of the Section has been considerably changed during the past two years, nevertheless the operation of field offices will require strong control and supervision from the central office, although some districts now operate quite effectively. The central office should review data received from the field more closely and within a few days after receipt, and, should furnish advice and training to the district personnel as necessary so as to improve their work. The decentralized offices have, however, greatly increased the field work, as indicated by the increase in the number of discharge measurements made annually, at but a small increase in cost. The effect of only partial decentralization is shown by the increase in the number of discharge measurements made, with approximately the same total number of gaging stations. In water-year 1960 the total number of discharge measurements was 904, in 1961 it was 1,492, and in 1962 it will be more than 1,800. The resulting final streamflow data should be considerably improved and the increased number of measurements should make possible the computation of discharge records for most of the 290 stations operated in 1962 instead of only about one hundred as in each year previously.

Equipment

With the receipt of equipment listed above under commodity aid, the Section has been comparatively well equipped since 1959. All 18 hydrographer crews are equipped with Ott and Price-type current meters, and each district has a price pygmy meter for measurement of low flows. Each district is also equipped with one set of boat measurement equipment, rubber raft, bridge crane, a type-A sounding reel, and sounding weights up to 75 pounds, all of which has been furnished by the assistance project. In addition, the districts have Ott-type current meters and wading equipment that had been used prior to the current assistance program, including some equipment furnished by the Department of Highways at a time that it entered into an agreement for flood studies, which did not materialize.

Although each district is equipped with the essential equipment for measurement of stream discharge, additional equipment is desirable in order that each hydrographer may have a full set of necessary equipment. Such additional items needed in the districts include about ten each of: type-A sounding reels, bridge cranes, hand-lines, and sets of sounding weights. Some districts also require larger and heavier equipment for the measurement of large streams such as the Euphrates and Tigris Rivers. As commodity assistance was not included in the 1962 fiscal year budgets the only equipment received was demonstration equipment furnished by the U. S. Geological Survey under its backstopping responsibilities. That equipment included a heavy duty (Type-B50) sounding reel and a heavier bridge crane base; also, drawings were supplied of various equipment so that cranes, and other equipment, could be fabricated locally.

Local manufacture of a bridge crane and a sounding reel has been attempted but none yet completed satisfactorily because the aluminum sections were not of sufficient strength, or for other reasons. Aluminum, iron, and bronze castings, however, have been quite satisfactory and have been made locally in such items as cable-car pullers, cable-car sheaves, and other items. Also, a thousand enameled iron staff gage sections, one-meter long, were supplied by an appliance manufacturere in Instanbul. Except for precision equipment, such as current meters, automatic water-stage recorders, and steel cable and accessories, much equipment may be procured or fabricated locally in a few years.

Vehicles, as well as the other locally-procured items, are obtained through the regular procurement channels of E.I.E. At the present time transportation equipment is barely sufficient and no spare vehicles are available for use during break-downs. A schedule of procurement of four new vehicles annually during 1963 and 1964, and three thereafter, should be set up to relieve the present shortage and to provide replacement vehicles.

Automatic water-stage recorders were rare prior to 1959. Nineteen old Ott continuous or monthly recorders were in use in 1957. The installation of Stevens A35 continuous recorders, obtained through commodity assistance, and Ott continuous recorders borrowed from D.S.I., raised the total of recording gages installed to 31 in 1961 and to over 50 in 1962. Although it is desirable that all important stations be equipped with automatic recorders, the cost should be spread over a number of years. The installation of about 15 or 20 new recorders per year can probably be maintained for the next few years until about half of the stations are so equipped. Peak stages and flood hydrographs, which are important in project planning, can be best obtained from recording gages. Crest-stage gages have not been used to date, although discussed frequently, but should be used at some of the non-recording gage stations to obtain records of peak stages between visits of the gage reader. The cost of a crest-stage gage is a small fraction of the cost of an automatic recording station. Also, when developments on the Euphrates River, now in the planning stage, near completion, the installation of remote reading instruments should be considered for the Euphrates and Murat Rivers for flood warnings and for operation of that huge hydroelectric development.

Cableways, from which discharge measurements may be made, are even more important than recorders at present. Only five cableways constructed more than 20 years ago were in use prior to 1961. They are of the endless travelling cable type, supported by a 30 mm diameter main cable on steel posts set in concrete and anchored to concrete. During measurements the meter and sounding equipment are manipulated from the bank, or, the hydrographer makes a "wading"-type measurement from the cable-car, which is moved both horizontally and vertically by the permanent dual-drum equipment at one support, operated by another man.

Two new cableways were erected during 1961 and about twenty in 1962, including 231- and 253-meter spans across the Euphrates River at Keban and above Halfeti respectively. The new cableways are mainly of the simple A-frame and concrete anchor type with discharge measurements made from a cable car. The five old, elaborate, and expensive cableways may also be changed and equipped with cable cars to permit one-man operation for better control of equipment during the measurement. The construction of cableways will greatly improve streamflow data as the necessary high water measurements may be made easier, faster, and safer than by "wading" rods operated from rubber rafts; also, they will dispense with transportation of boats and rafts.

A flume for the re-rating of current meters would be a desirable addition as the 80, or more, current meters in Turkey require occasional re-rating owing to damage, wear, or replacement of parts. E.I.E. cannot justify the cost of the installation alone or, perhaps, even in cooperation with D.S.I.; however, if the flume was made a part of the hydraulics laboratory of a technical university a large part might be financed by the using agencies and the flume could be used most of the time for laboratory studies at the university.

Gaging station network

Figure 1 indicates the increase in the number of gaging stations since the start of streamflow investigation by E.I.E. in 1935. The total number operated in 1961 was 307. D.S.I. operated less than 10 stations prior to 1957; however, that agency expanded its network since that time to the present approximately 300 stations. Figure 3 gives the locations of the E.I.E. gaging stations operated during the 1962 water year; figure 4 indicates the locations of both E.I.E. and D.S.I. stations.

The Hydrographic Section of E.I.E. has operated the general streamflow station network, as well as the stations for the planning of

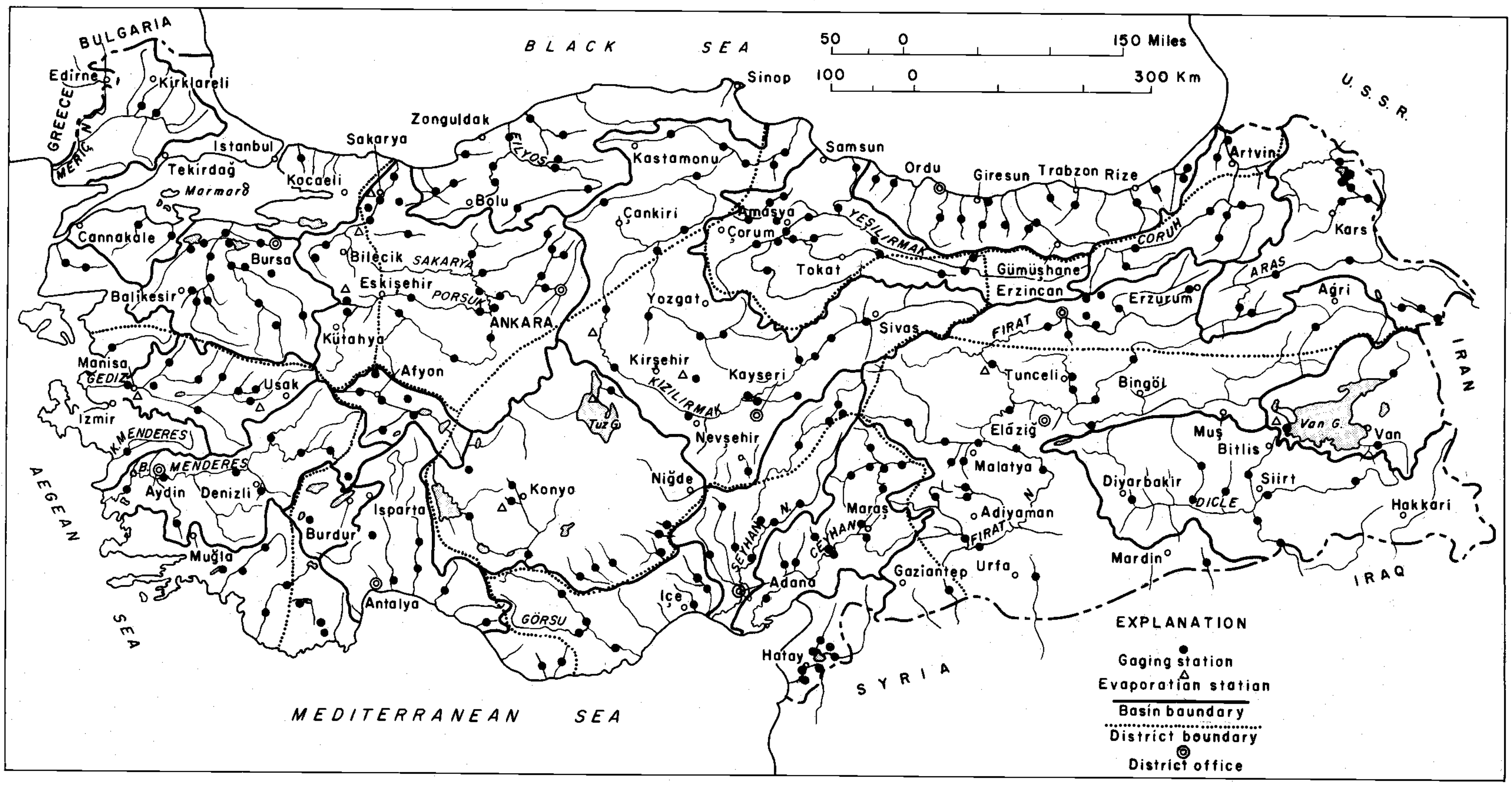

Figure 3. E.I.E. gaging station network, 1962 water year.

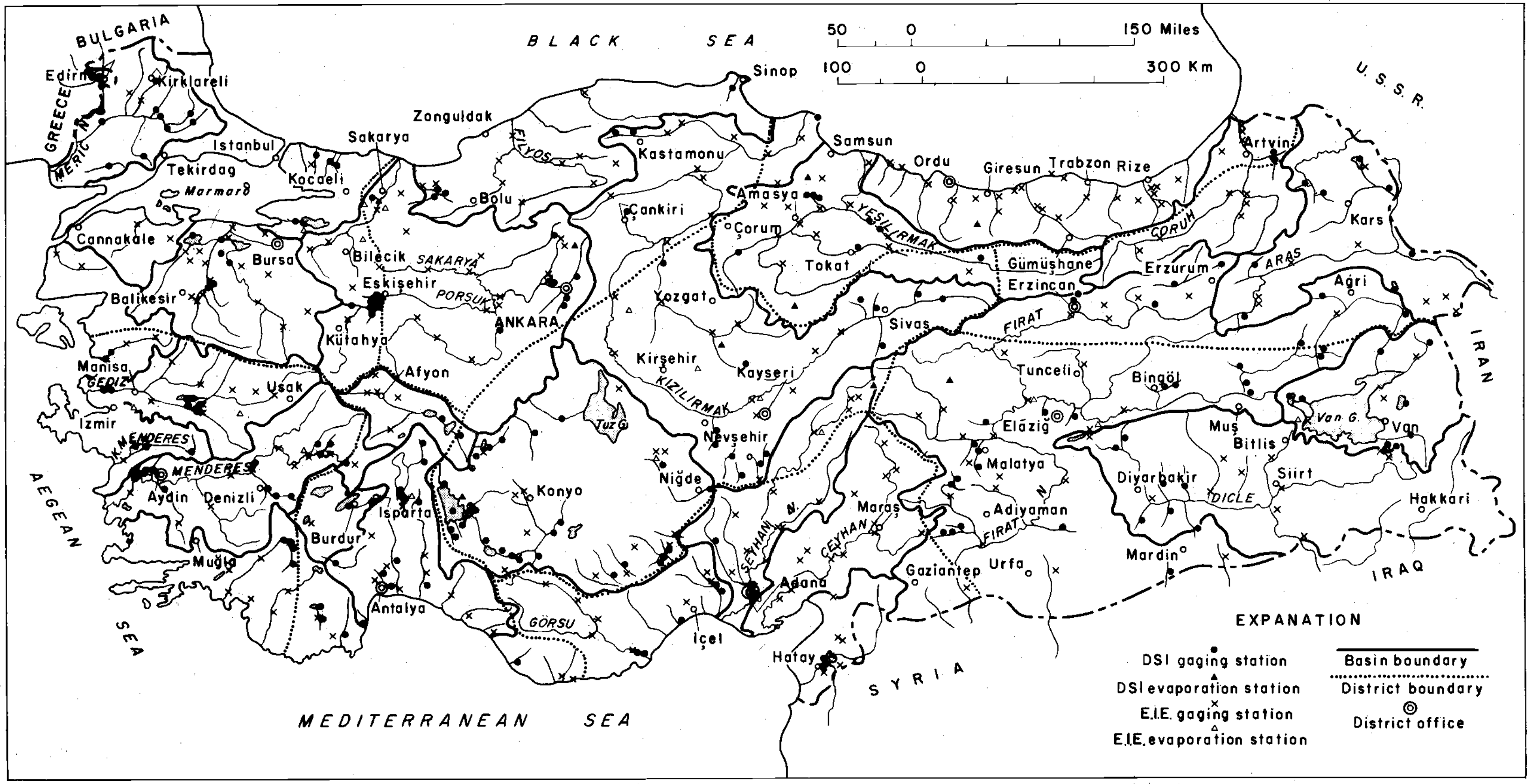

Figure 4. E. I. E. and D. S. I. gaging station network, 1960 water year

hydroelectric developments; the D.S.I. Hydrology Section has operated stations principally for irrigation, drainage, flood control, and municipal water planning and for irrigation operation. The rapid expansion of the D.S.I. network resulted in some duplication of gaging stations (both on the same bridge in some instances); however, during 1962 some of the duplicated stations were eliminated. Also, some exchange of gaging stations was accomplished so that E.I.E. assumed the operation of desirable primary main stream stations and D.S.I. assumed the operation of station primarily for specific planning or operation of water-use projects. Although duplication of effort still exists, the two agencies are endeavoring to cooperate so that necessary streamflow information is obtained with a minimum of duplication. The D.S.I. hydrographers are attached to numerous regional and district offices and are a part of such staffs, where project investigations, construction, or operations are the principal purpose, as compared to the better system of the E.I.E. Hydrographic Section's nine district offices, which are concerned only with water investigations.

The gaging station network study was begun in 1959 and, although most stations had been established for project studies, many were for the long-term water inventory of main rivers and international streams. Also, lake-stage stations had been established on some of the larger, or important lakes. The far-sightedness of E.I.E. officials is to be commended. About 150 stations have been tentatively classified as long-term areal primary, long-term main-stream inventory, or long-term lake-stage stations following a study of station locations relative to artificial regulation, reliability of data, and other criteria. Some stations are also classified as long-term water management stations in addition to their classification as index stations.

The combined E.I.E. and D.S.I. station networks should be studied with the view of inclusion of some D.S.I. station in the primary network. It would then be preferable that such records be published by E.I.E. and, if agreeable, that they be operated by E.I.E. as part of the primary network. Although the combined E.I.E. and D.S.I. gaging stations average one per 1300 sq. km. (1 per 500 sq. mi.), the many closely grouped D.S.I. operation and project stations result in an unrealistic ratio. A total of about 600 gaging stations should be ample for some years, including main canals and diversions as well as long-term water-management stations, but omitting those for irrigation operations, short-term project investigations or special studies without permanent interest. Increased use of water and water-use developments will continually require the establishment of new stations; however, as costs of maintenance and operation increase, it may become necessary to discontinue stations which have served their purpose unless required as primary index stations. Short-term stations operated from five to ten years should be considered and their records extend by correlation with primary long-term stations. With the primary long-term network stations as index stations from which to extend the short-term records, it is possible to obtain quite reliable data for, say, 100 streams in a 20-year period by relocating 25 gaging station installations on an average of each 5 years. Correlation studies will indicate which stations may be discontinued and established elsewhere; although definite variance from adjacent stations indicates the need for a long-term record.

Areal or regional relationships may be computed from which discharge data for ungaged streams may be estimated. Sufficiently capable men for such studies are not now in the Section.

The Department of Highways is very much interested in flood magnitude and frequency studies for culvert and bridges opening design, and cooperated by supplying some necessary equipment to E.I.E. in 1957. The possibility of entering into flood studies with the Department of Highways in 1962 was discussed; however, E.I.E. was not capable of expanding its program for that valuable study because of inadequate personnel.

Sediment Discharge Investigations

The recent emphasis on the construction of dams for storage of water for power, irrigation, industrial, and municipal use necessitated the investigation of the silt, or sediment, discharge of streams. Four integrating suspended sediment samplers (US D49) and three hand samplers (US DH48) were received in 1961. Because of the lack of trained personnel and administrative delays, the sediment program was not firmly established until early 1962. Since January 1961, however, sediment sampling by use of a one-liter bucket had been carried on at the Kizilirmak River station at Gulsehir on a daily basis, with the sediment filtered by the observer and sent to Ankara for analysis. That information is to determine the sediment inflow into Hirfanli Reservoir. Although the samples obtained cannot be considered accurate, the computed sediment discharge for the period January-September 1961 indicated that approximately 3,600,000 metric tons of sediment passed that station. (The Hirfanli Reservoir capacity of 6 billion cubic meters indicates that the 1961 sediment discharge, though not very reliable, is not a serious problem.)

Various men have been assigned to head the sediment program; however, owing to lack of knowledge they were not effective so that the program was not definitely started until April 1962. Transportation and organizational problems also delayed the program. Since early 1962, however, sediment sampling on a regular basis has been done at the following stations:

Kizilirmak River at Gulsehir	daily sampling
Guluc River near Eregli	" "
Firat (Euphrates) River at Kemaliye	periodic sampling
Murat River near Palu	" "
Munsur River near Mazgirt	" "
Peri River near Mazgirt	" "

The Firat, Murat, Munsur and Peri River stations will provide sediment data for the proposed reservoir on the Euphrates River at Keban. The Guluc River investigations are for the proposed water supply for the huge steel mill complex at Eregli. Additional sediment discharge investigations are needed and will be started on the Sakarya River above and below Sariyar Dam and Reservoir, the Ceyhan and Seyhan Rivers, and at other future development sites.

Suspended sediment samples are obtained in one-pint milk bottles, and concentration and size analyses determined by the soil and water laboratory of D.S.I. Sediment discharge computations have been made only on a provisional basis for stations other than the Kizilirmak River station; however, as high water samples become available during the winter and spring of 1963, the sediment loads may be approximated for the other stations for project planning purposes. Equipment is sufficient at present for the investigations mentioned; however, more wide-spread sampling will necessitate additional sampling equipment. The laboratory analyses performed by D.S.I. are not as standardized as U.S.G.S. practice; however, the concentration analyses should be quite satisfactory. Water temperature is obtained daily at approximately 40 streamflow stations.

Training

Training of personnel is a continuing need which should be given greater emphasis. For many years prior to December 1961 only two partially college-trained engineers were a part of the Hydrographic Section; others were high-school graduates. During December 1961 two graduate engineers were added to the Section, one of whom, with considerable experience in hydrologic planning and design, and an ICA participant to the U. S. Bureau of Reclamation in 1959, is now the Chief of the Section.

Training has been done by the writer on a routine personal basis for the most part and occasionally on an organized class lecture basis, as well as organized field training in discharge measurements. A three-month period of organized class instruction for approximately 20 E.I.E., 25 D.S.I., and 5 Jordanian hydrographers was conducted October-December 1961 and covered all phases of field and office practices and procedures, including three weeks of discharge measurement practice from cableways, bridges, and boats. Training should be continued, especially for the district chiefs as they did not attend the above class. The district chiefs are most in need of training as they are accustomed to old methods and should be trained in better field and office practices so that they may pass the knowledge on to their crews. A one or two week seminar and training course especially for district chiefs should be held annually in Ankara, or one of the district offices, to acquaint personnel with new methods, procedures, techniques, and equipment.

Routine training has consisted of assistance to office personnel in procedures in the computation of streamflow data; preparation of numerous instructions pertaining to procedures, which were then translated into Turkish; advice and assistance in field work when accompanying hydrographers to streamflow stations; and the computation of records as examples for certain streamflow stations. The latter consisted of the computation of routine, uncomplicated records to demonstrate use of shift adjustments as well as other routine practices and the computation of discharge based on slope-stage data. All the procedures and steps in the computations have been explained and shown to most of the personnel, especially in the Ankara office and those responsible for computations. Training was not given the emphasis it requires after mid-May 1962 owing to the assignment of Vedat Arica, the man who had been the principal counterpart and interpreter to the U.S. advisors, to field work in the construction and installation of gaging station facilities and other routine work.

Training and cooperation could be valuable to both the Hydrographic Section and the engineering department of a local technical university. Courses are offered in hydraulics and hydrology at universities in Ankara. Close cooperation through joint investigations or through graduate study might be possible as research is a field not yet entered by the Hydrographic Section.

The partial financing of a flume for the rating of current meters in a university laboratory should be considered.

Participants

No participants from the Hydrographic Section were sent to the United States under the project during the four years of assistance. A number of engineers from the planning and design sections, however, were participants under the overall Hydrological Data Study and Training project for training with the U.S. Bureau of Reclamation in hydrologic studies relative to project planning and design. One of those participants, Mr. Oguz A. Bayar, is the present Chief of the Hydrographic Section, and is well trained and experienced in that field and appreciates the need for reliable basic streamflow data. It is important that two or three participants receive training in basic data collection, computations, compilation and evaluation, as well as sediment discharge studies.

Conclusion and Recommendations

The program of surface water investigations as carried on by E.I.E. has improved very appreciably since 1958. The principal factors which caused the improvement and will continue to increase the reliability of streamflow data are: the establishment of district offices which resulted in the increase in number of discharge measurements made; the new equipment and training in its use; the acceptance of improved office practices and procedures; and the recognition that streamflow data must be available and must be reliable in order to properly plan and design water-use developments. The program and records may still not be as good as might be desired; however, the basic procedures and requirements are known and needs should continually tend to bring about improvements. The progress since 1958 is promising and by continued application of better practices and procedures the surface water data should continue to increase in reliability.

A number of suggestions and recommendations are repeated, which, it is believed, will improve the data and provide better means of control. These are listed under headings somewhat in the order of ease of application and benefits derived.

Field Work

1. Require more complete data and notes on discharge measurements; depths and velocities at edges should be reliable; point of zero flow obtained at least once a year.

2. Level notes for checking of datum of gages should be filed so that checking and review are possible; loose-leaf level note sheets suggested.

3. Automatic water-stage recorder wells should always be provided with means of removal of silt.

4. Gage readings by hydrographers should always be reliable; they should check on observer's readings and records on visits to stations.

5. Slope-area, or other indirect methods, should be used to define high end of rating curve when not defined by current meter measurements.

6. Discharge measurements should be computed before leaving station or area so that a check measurement may be made if necessary.

Office work

1. Discharge measurements, levels, and other field data should be reviewed by a well experienced man for correct methods and be checked before listing and filing.

2. Fairly standard step-by-step procedures should be followed in the computation of streamflow data and the computations checked after important steps, such as plotting of measurements, drawing of rating curve, and computation of shifts, before further computation in order to avoid later time-consuming delays caused by errors.

3. The district offices should assume responsibility for the computations as soon as possible and training carried on in order to accomplish that end.

4. Hydrographs of daily discharge should be plotted on logarithmic paper for check of records and comparison with other stations.

Organization

1. The present number of district offices appears to be satisfactory, however, changes may be necessary as the work load increases in some areas. Too many small districts would result in loss of control and they would

not operate effectively because of loss of supervision.

2. Delegation by the Chief of the Section of some responsibility and authority to an assistant chief or to a chief, or supervising, field engineer is suggested so that the much needed supervision and training may be better accomplished at the district office level.

3. Graduate engineers should be added to the Section at the rate of at least two per year; eventually it would be desirable that each district be headed by an engineer and that an experienced technician be a principal assistant in each office.

4. As surface water investigations are also made by D.S.I., it is essential that duplication of effort be avoided. For the present, until investigations are consolidated, it is suggested that E.I.E. continue to operate the general primary network stations and that D.S.I. operate only its necessary project stations.

5. It is preferable that streamflow investigations be independent of action agencies to avoid too great an influence by such agencies. Although E.I.E. has been quite unbiased in its operation of the stream-gaging network in Turkey, the great expansion in the D.S.I. investigations program for its purposes could very well result in much duplication. It is suggested that studies be made to consider the establishment of a single agency to operate the overall surface water investigations program which would include all of the present E.I.E. gaging station network and such D.S.I stations that are not strictly for local project operation or study. D.S.I. should retain only those stations for irrigation distribution, canal-loss studies, river control, and other investigations made for its immediate needs and not of general interest.

6. The establishment of a high-level water resources committee composed of one of the top members of each agency interested in water investigations and water-use development may be very worth while. The chairman might be a member of the State Planning Office and recommendations of the committee be issued under the authority of that office. Problems of coordination and duplication, as well as necessary research studies, could be discussed and necessary decisions made at the monthly meetings, although the long-range water resources program would be the major problem of the committee.

The work of the E.I.E. Hydrographic Section has improved considerably and should continue to improve, however, it will be limited unless engineers and other more capable employees are added to the Section, training is given greater emphasis, and supervision of both field and office work by qualified personnel is greatly increased. The assignment of two or three of the more promising technicians to the United States Geological Survey for a six to nine month period of intensive in-service training would be of great benefit. These trained technicians would then be in a position to train other Turkish technicians.