The Role of Private Consulting Firms in Modern Water Resource Development

By

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INTRODUCTION

Over the last 50 years, the role of the private consulting engineer has undergone a dramatic change. The present day projects are of such size and complexity that they can no long be handled by an individual consulting engineer—the consultant today must have an integrated staff of specialists to be in a position to cope with the varied technological problems that are inherent in large projects. With the advances in materials, techniques, and equipment which are being employed in the construction industry today, the large projects now in progress are being completed within the same period of time as the smaller projects of yesterday. The private consultant must have sufficient staff to keep pace with these advances, therefore larger organizations are the order of the day.

This has been the history of the Harza Engineering Company. Our founder, the late Mr. L. F. Harza, started his career as an individual consultant and soon thereafter it became apparent to him that additional staff was required to meet the challenge and provide full consulting services. This pattern of growth continues today.

The period since World War II has seen a tremendous expansion throughout the world in the use of private consulting engineering services in the field of water resource and power development. The expanding population, with its need for increased food supplies and industrial products, coupled with the establishment of independent governments in all areas of the world, has resulted in the development of water resources and power at an unprecedented rate. Much of this development has taken place in areas where there was limited local engineering experience available in this field, with the result that experienced consulting engineers from other countries have been called upon to assist in carrying out this work.

Because of the lack of local investment capital in many of the countries of the free world, international financing agencies have been established to

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provide the necessary investment capital. These agencies have required that the engineering for the projects they finance be carried out by competent engineering groups, as an insurance of the success of the work.

There are several things which the private consulting engineer must offer to a client desirous of developing water resources :

First, the most important, is an impeccable reputation with both the local and international financing agencies. This reputation requires a history of structurally and functionally successful projects. It also requires a background of cost estimates which have not been overrun to the embarrassment of either client or financing agency. Similarly, advance predictions by the consultant of power demands, water uses, irrigation resettlement rates, revenues, and benefits must not have seriously underrun.

Secondly, but also important, the consultant must offer a variety of experience with large and small projects, and the ability to judge what is appropriate to the immediate and to the long-range needs of the country. Many clients desire a TVA, Grand Coulee, or Hoover Dam. These have become an international status symbol—a sort of water resource Cadillac. Unfortunately, local economy and foreign credit are not always commensurate with these aspirations.

Thirdly, the private consultant, operating independently and with no ties with either manufacturers or constructors, can assist his client in achieving reasonable objective in water resource and power development without paying exorbitant prices for unnecessary or oversized projects. Without the protective advice of independent consultants, these clients could mortgage their future credit to an extent which would jeopardize other important developments.

The private engineering consultant's services are employed in all phases of water development projects, from the over-all basin planning work through the planning, design and engineering inspection of construction of individual projects. Some examples of the work our firm has done in these areas may help illustrate the role of the private consulting firm in modern water resource development.

BASIN PLANNING

We may be confronted with a potentially valuable river basin about which almost nothing is known. And there are many of these, even in large, semi-developed countries. Proper investigations and planning for such a basin involves a considerable expenditure of effort, and consequently, money. Funds for this purpose are available from the U. N. Special Fund, the U. S. Agency for International Development, the International Bank for Reconstruc-

tion and Development, the Inter-American Development Bank, and others. The private consultant knows the procedures for preparation of application for such funds, and can assist his client in the definition of scope and budgets for the necessary investigations.

The need for basin-wide planning is becoming increasingly appreciated in the developing countries. With such planning, priorities can be established within groups of potential projects to match available capital, and assurances can be given that initial projects will not block ultimate development.

Lempa River

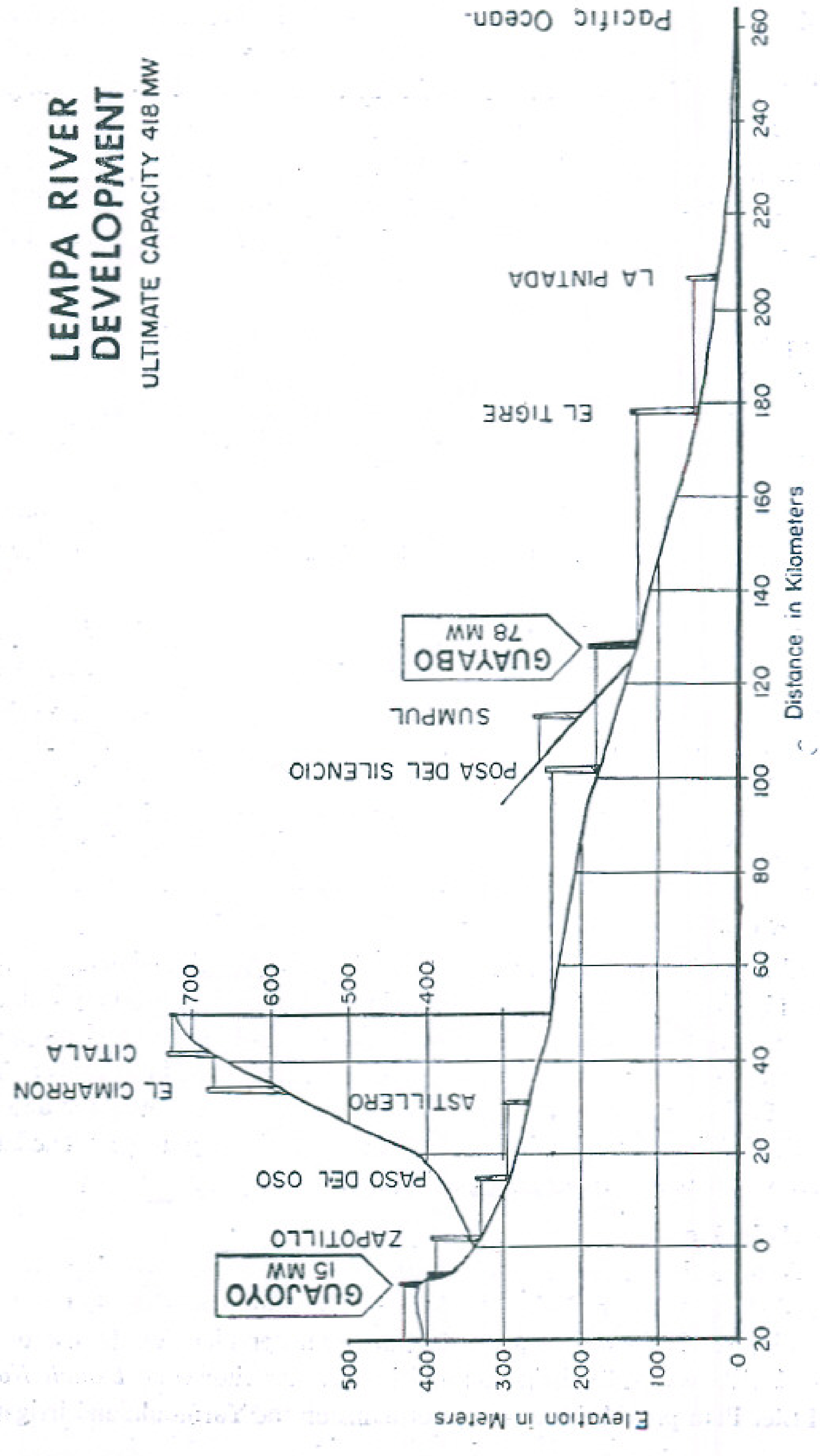
One example of this type of planning is that which we have done for the power development of the Lempa River in El Salvador, Central America. These studies were made for the Comision Ejecutiva Hidroelectrica del Rio Lempa (CEL) which is an autonomous government corporation charged with providing the electric power needs of the country. The Lempa River is one of the largest rivers in Central America, and therefore is an ideal source of electric power.

From a study of the entire river, a series of potential damsites were identified, the ultimate regulated flow and electric generating capacities were computed. (*Exhibit No.* 1) Preliminary economic studies were made of each project, and a program of priorities established. In addition to this over-all plan of the Lempa River power development scheme, power market studies were carried out to determine the probable future needs of the country. *Exhibit No.* 2 shows the results of the market studies, and also indicates the probable dates when the various projects on the river will be needed to meet the power demands.

El Salvador is now proceeding with these projects individually as they are needed, with the confidence that the earlier projects will conform to ultimate developments. Power resources for the future are well known, and programs for capital investment can be predicted a decade or more in advance. The Guajoyo Project is under construction, and the steam plant at Acajutla and the installation of the 5th unit at Guayabo are in the final design stage. The latter projects will be placed under construction this year.

Yarmouk-Jordan

Another interesting example of the value of basin planning is the Yarmouk-Jordan River Project in Jordan. A comprehensive study of the Yarmouk river basin was made to develop a Master Plan for the use of the Yarmouk river waters for irrigation and power. As shown on *Exhibit No.* 3, the Master Plan provided for a series of dams on the Yarmouk, and irrigation



LEMPA RIVER PROFILE
Exhibit 1

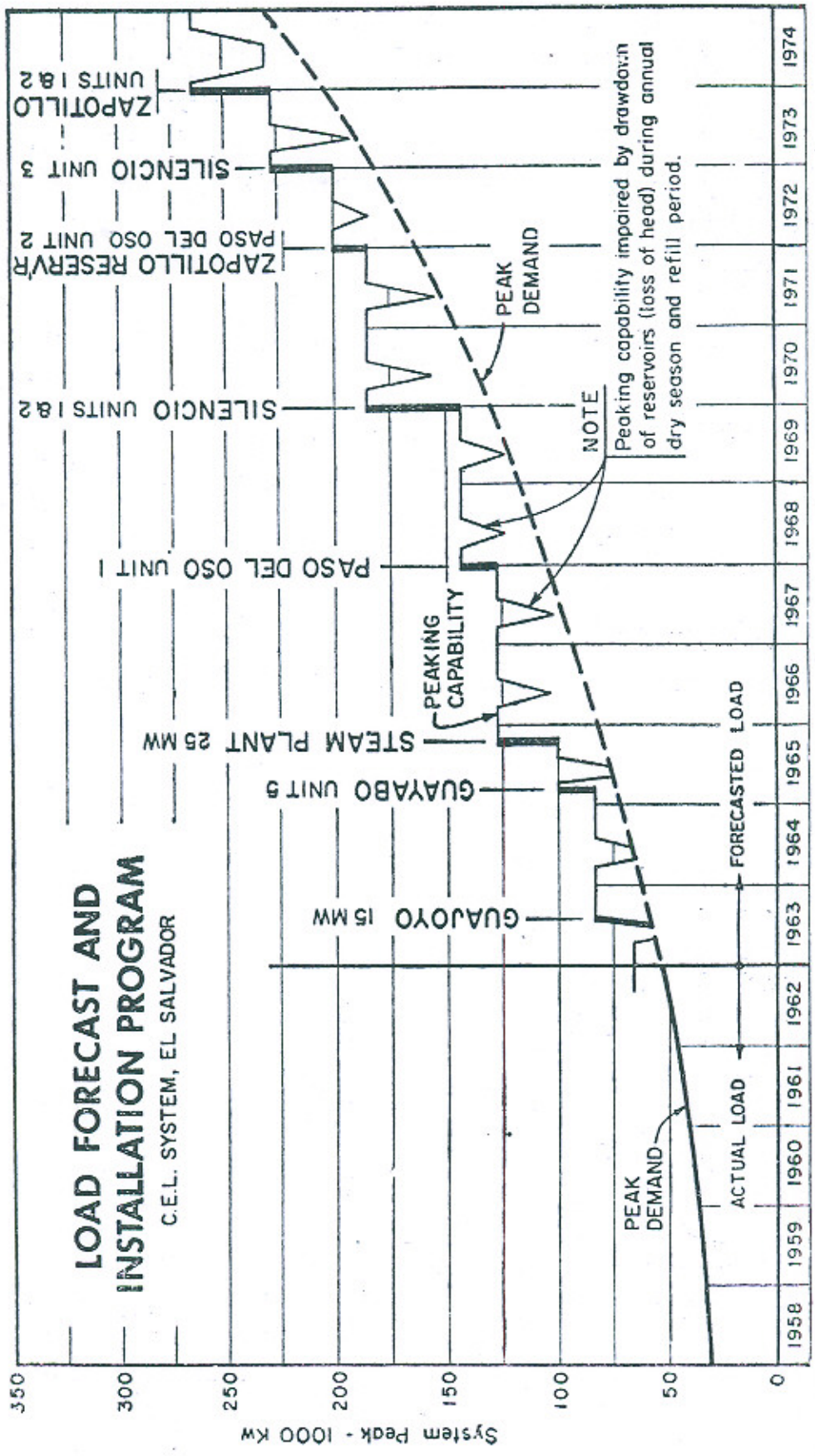
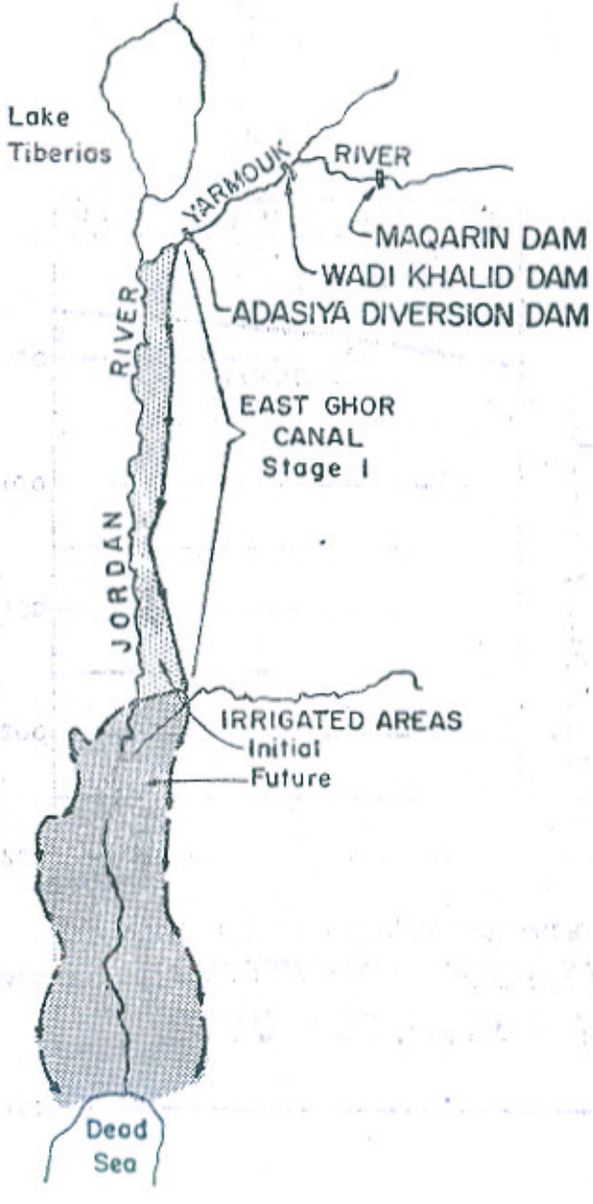
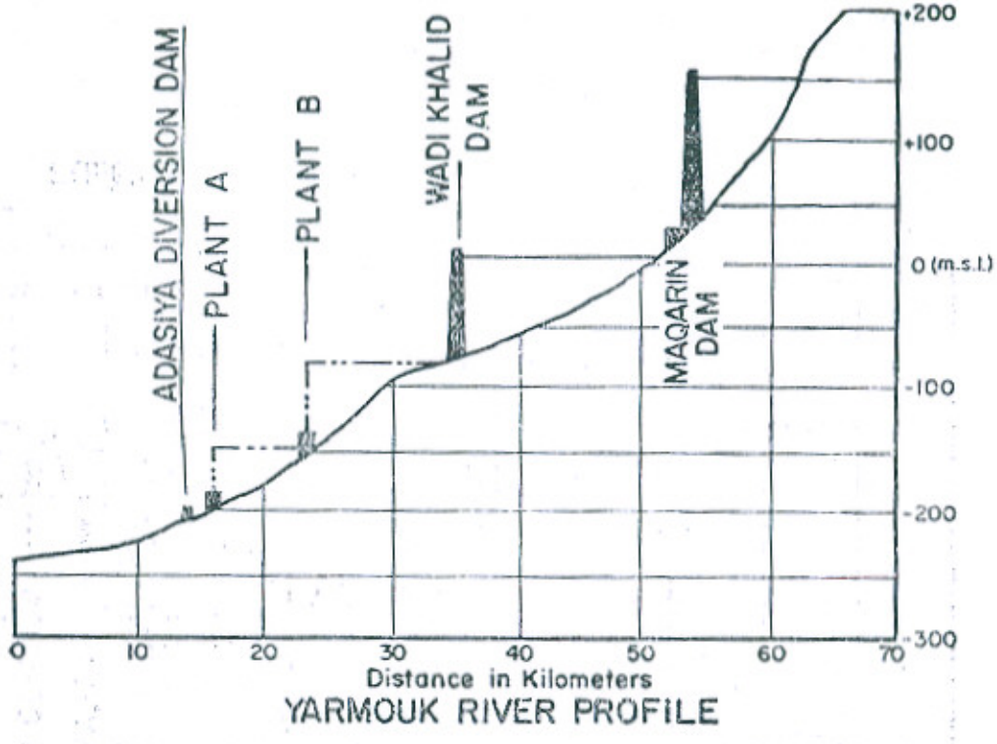

LOAD FORECAST AND INSTALLATION PROGRAM
C.E.L. SYSTEM, EL SALVADOR
System Peak - 1000 KW
350
300
250
200
150
100
50
0
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
GUAJOYO 15 MW
GUAYABO UNIT 5
STEAM PLANT 25 MW
PASO DEL OSO UNIT 1
SILENCIO UNITS 1 & 2
ZAPOTILLO RESERVR
PASO DEL OSO UNIT 2
SILENCIO UNIT 3
ZAPOTILLO UNITS 1 & 2
PEAK DEMAND
ACTUAL LOAD
FORECASTED LOAD
PEAKING CAPABILITY
NOTE
Peaking capability impaired by drawdown of reservoirs (loss of head) during annual dry season and refill period.

Exhibit 2





YARMOUK RIVER PROFILE

	PLANT A	PLANT B	WADI-KHALID	MAQARIN	TOTAL
Useable Storage			250 MCM	300 MCM	550 MCM
Kilowatts Installed	7,400	9,700	11,500	17,100	45,700
Kilowatt hrs. per year	28,000,000	32,000,000	45,000,000	60,000,000	165,000,000

Ultimate irrigated area 117,000 acres

YARMOUK-JORDAN VALLEY DEVELOPMENT

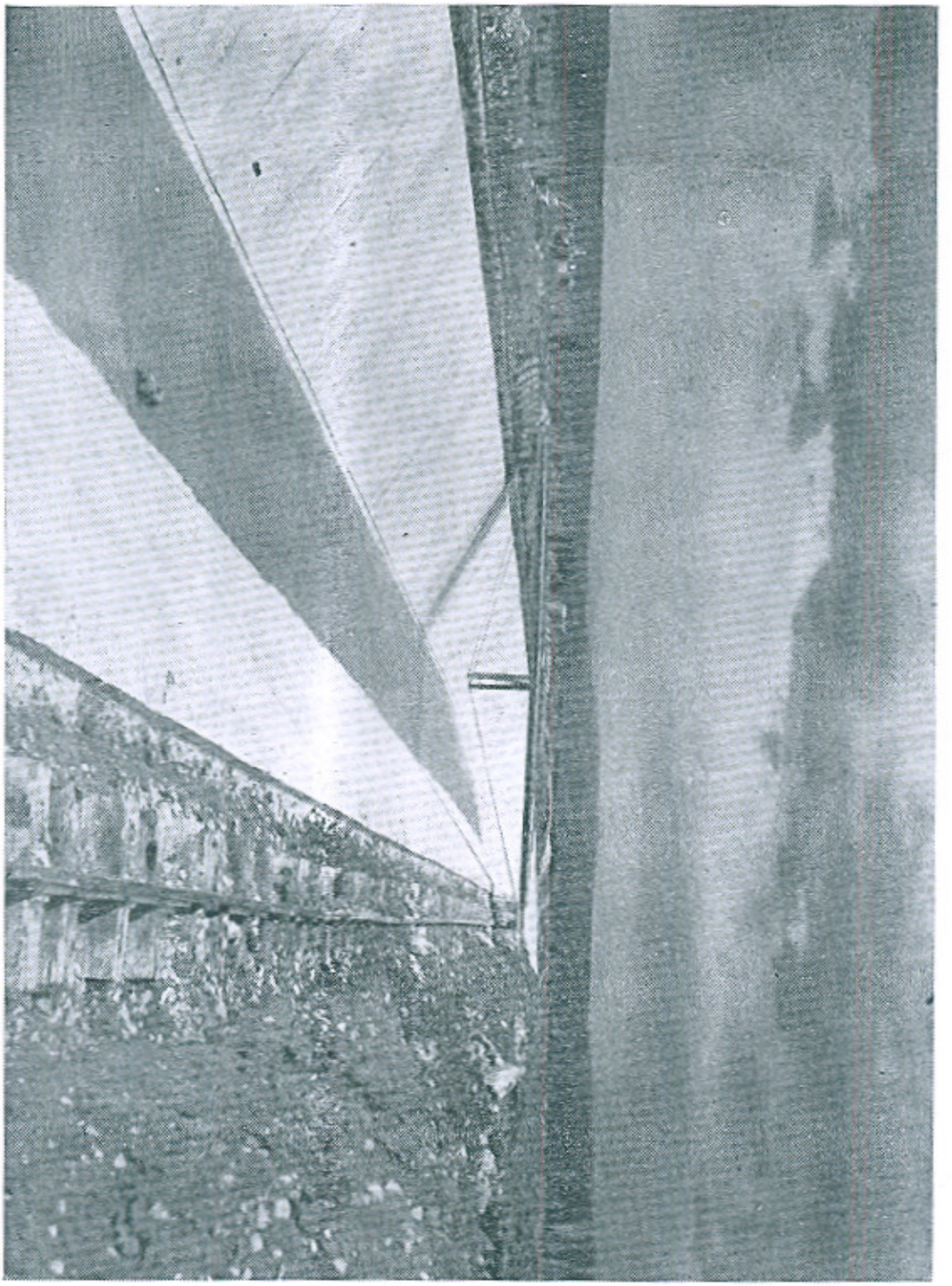


Exhibit 5

canals to utilize the stored waters. This Master Plan, completed in 1955, provided the basis for initiation of an extensive irrigation program, keyed to the needs of the country, and its financial capabilities.

In 1959, construction of the first stage of the plan was started. This stage will provide for irrigation of about 30,000 acres of land along the East Ghor of the Jordan River. Previously a dry-farmed area, irrigated land holdings are being established at a norm of $7^1/_2$ acres. This requires the purchase of original lands and resale to new tenants. Credit facilities, farm development assistance and extension programs have been necessary to aid farmers in the purchase of land and equipment, in preparation of individual farms, and in the training of irrigation techniques.

First water deliveries were made in 1961, and completion of this stage is expected this year. Construction has not been rapid, but resettlement rates are hard pressed to keep up. Thus, in this instance, a program of 8,000 acres per year seems to be a practical limitation. Future extensions of this irrigation system have been planned in successive stages to cover about 125,000 acres of the Jordan Valley.

Exhibits Nos. 4 *and* 5 show the main canal and water distribution ditches.

Our work on the design of the canal and irrigation structures was done in Jordan, by Jordanian engineers working under the direction of engineers from our firm. In this way, the local engineers were able to become familiar with sound irrigation engineering practice. It is expected that they will now be able to undertake small irrigation projects themselves, although they will still need outside help on the larger storage and power projects of the scheme.

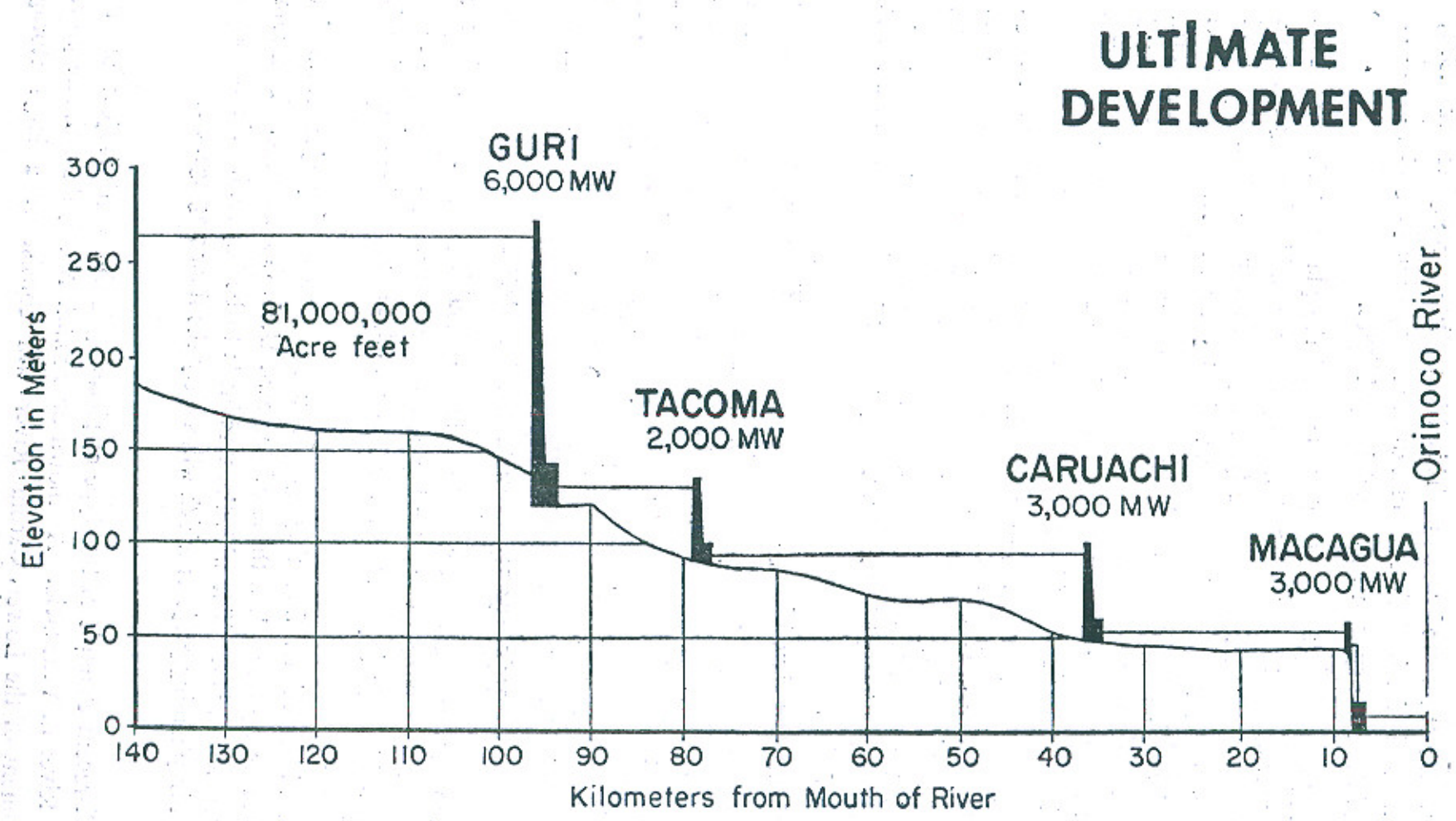
INDIVIDUAL PROJECT PLANNING

Another important aspect of the private consulting engineers' services in connection with water resource development is the preparation of definite plans for an individual project and the economic analyses to be used in financing negotiations.

The international financing agencies use standards for project evaluation that are more rigorous than those of our own U. S. Government. The competent consultant is familiar with the standards to be imposed. He can assist his client in planning projects which will satisfy the financing agencies.

Guri

A recent example of this type of planning is the Guri Project on the Caroni River in Venezuela. As shown on *Exhibit No.* 6, the ultimate power development of the Lower Caroni River will consist of a large storage



CARONI RIVER PROFILE

Exhibit 6

reservoir upstream, and a series of run-of-river power plants downstream. Total potential is about 14 million kilowatts.

Maximum use of the natural unregulated flow of the river has already been made at a waterfall near the mouth of the river, by the 300,000 kilowatt Macagua plant. Further power development requires storage and flow regulation.

The ultimate storage dam will involve a very large investment, and it will have an on-site potential of about 6 million kilowatts, at a very low cost per kilowatt. Unfortunately, such a large amount of power could not be absorbed in Venezuela for 25 years or more. The same ultimate dam with a small initial power plant would be costly.

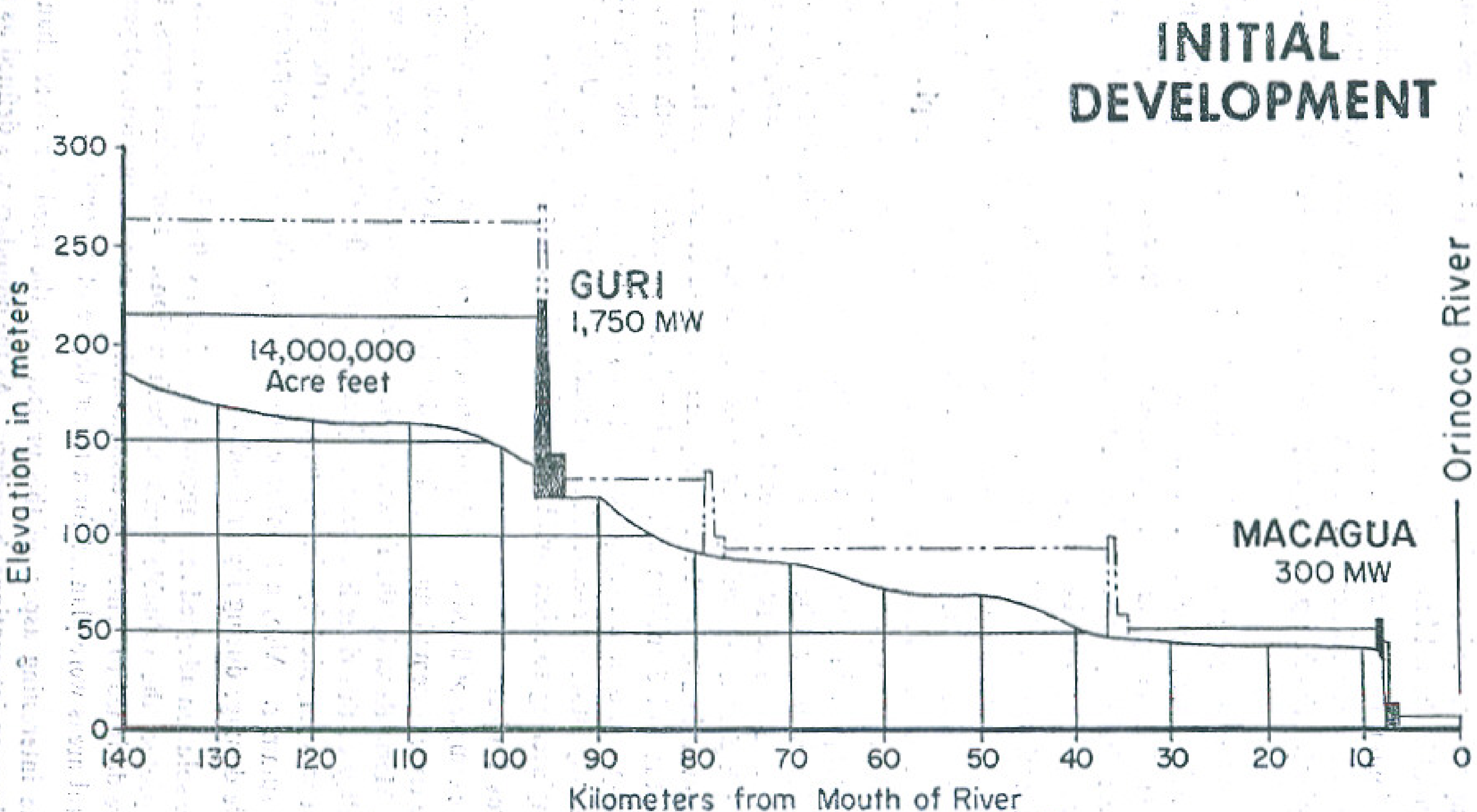
Venezuela has available large deposits of natural gas and the possibility of constructing low-cost, gas-fired, steam-electric plants. An overbuilt hydroelectric plant could not be economically competitive, and would not receive the support of the international financing agencies. Therefore, the plan shown on *Exhibit No. 7* was evolved for the Guri site. A lower initial dam is planned, having a power plant installation commensurate with realistic estimates of power markets. Provisions will be made for expansion of generating capacity at the initial dam to meet 8 to 10 years of load growth. The dam is designed for raising to a higher level, with power plant expansion for another decade of increased power demands. Then, finally the dam can be raised to its ultimate height and the full 6 million kilowatts installed as needed. With the total investment spread over a long period of years, the hydroelectric development is economically more attractive than alternative thermal power. Only with such an engineering solution could international financing be obtained.

Meric-Evros Project

An example of flood control protection for both urban and agricultural areas is the levee system planned for the border river between Greece and Turkey. Called the Meric River by the Turks, and Evros River by the Greeks, the wide alluvial valley of this river had been subject to annual flooding. Agricultural production was impeded by the slow recession of waterlogging in late spring and early summer. Also, a number of towns along the valley experienced appreciable damage during higher floods.

The solution adopted for improvement of this valley included a series of levees to protect the valuable lands of both nations. For urban areas, the levees were designed to contain the maximum flood over the previous 50 years. Agricultural areas were planned for a lesser degree of protection.

One interesting aspect of this project was the need for river channel cut-offs along an international boundary. As the boundary was defined as the



CARONI RIVER PROFILE

Exhibit 7

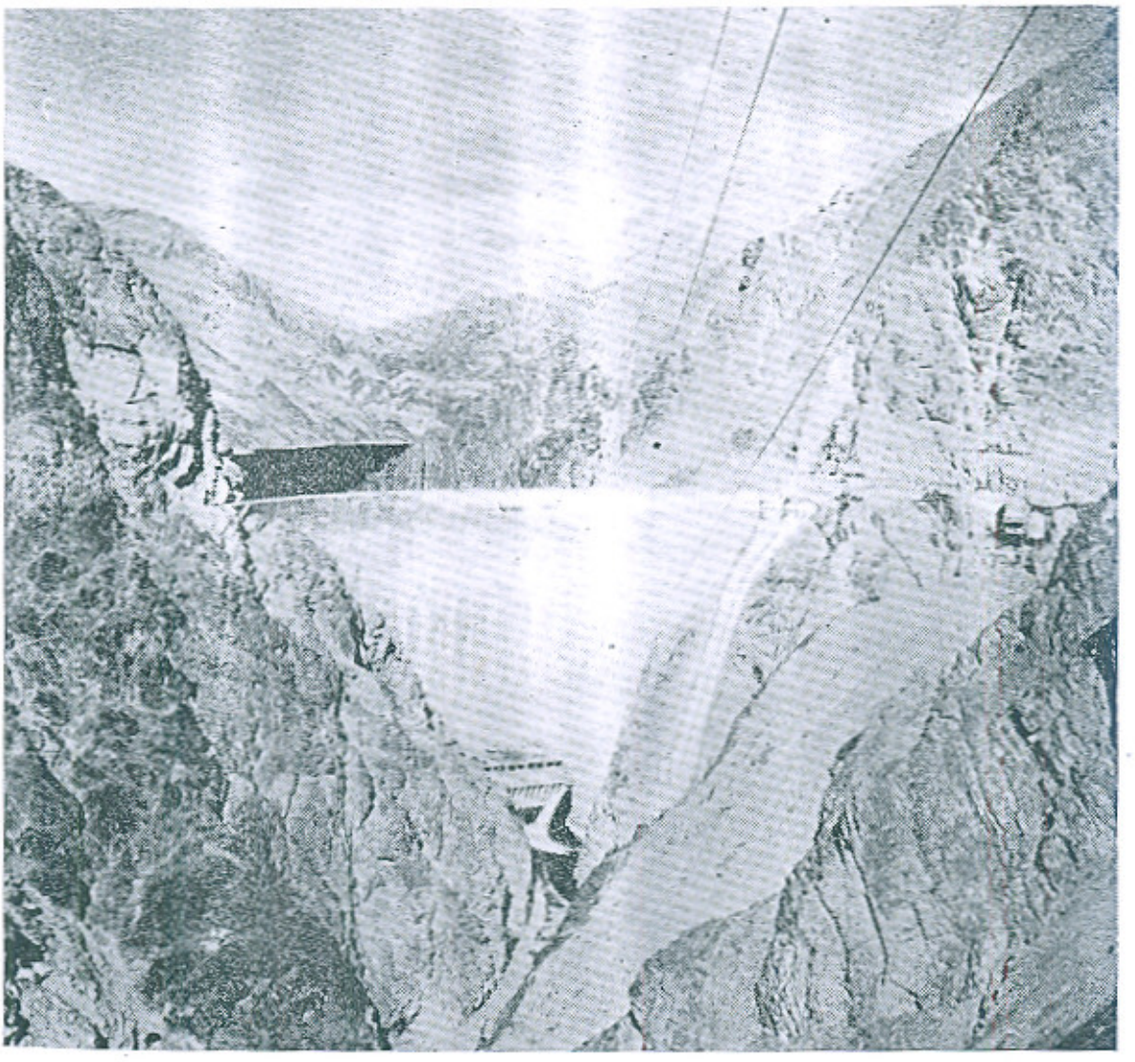


Exhibit 8

"thalweg" or thread of the river, it was necessary, in equity, to compromise the engineering design of the river cut-offs (which changed the thread of the river), to insure that a shift of land to one country was exactly offset by an equal shift to the other.

These levees have now been built and are serving their function.

Karadj

Exhibit No. 8 shows the Karadj Dam which was completed in 1962. This 600 foot high, double curvature arch makes a storage reservoir which provides the first dependable water supply for the Capital City of Iran, Tehran. The power installation of 75,000 kw is a secondary benefit of the project. The City of Tehran is one of the few national capitals in the world which is not located on a large river, and therefore it has been continuously plagued with a poor water supply. The storage at Karadj should give Tehran an adequate water supply for many, many years.

SERVICES DURING THE CONSTRUCTION PERIOD

Specifications

The principal control of a constructing agency over the costs and quality of a water resource project rests in the specifications under which the civil works are contracted and the major equipment is purchased. Two major objectives must be realized by these specifications. A maximum number of competitive bids must be received from competent contractors and manufacturers, and the quality and cost of the work performed must be guaranteed by protection stipulated in the specifications.

The specifications must be so written as to offer the minimum possible loopholes for substandard quality or claims for extra costs. Protection to the owner is provided by requirements for pre-qualification of bidders, surety bond, insurance, performance guarantees, and retentions withheld from progress payments. And the specifications are written for the widest possible competitive participation by qualified bidders from all countries.

As an example of international participation, I cite our experience with hydraulic turbines. Over the past 15 years we have written specifications for the purchase of 69 turbines outside the U.S.A. Actually purchased under those specifications were 12 Japanese turbines, 9 Swiss, 2 Austrian, 6 French, 12 British, 1 Swedish, 23 Canadian, and 4 American.

Construction Drawings

The specification phase of the consultant's service is followed by the preparation of detailed construction drawings.

In this phase, a considerable difference exists between European and American practice. In Europe it is customary for the construction contractor to prepare the detailed drawings of the Project, with only general review by the consultant. Under American practice, the consulting engineer makes these drawings.

The result, however, is an apparent increase in engineering costs. Under European practice, the costs of detailed design are buried in the construction bids. Although the total cost to the owner is at least equal, the engineering costs appear greater under American practice.

Engineering Inspection of Construction

It is preferable that engineering inspection of construction be the responsibility of the consulting engineer, or designer of the Project. In this way, the engineer can maintain close control over the execution of his designs. Unforeseen conditions discovered during construction can be met by measures which are compatible with the original design conception.

Usually, the consulting engineer furnishes the senior resident engineer of the inspection staff. The resident engineer has complete authority over the inspection of construction, and is the only person authorized to give instructions to the contractor. He also is responsible for the certification of work completed and of progress payments.

We have found that in most countries it is possible to recruit the field engineers and inspectors for the construction work from local engineers. They often require training, but we believe this to be a worthwhile effort inasmuch as these field engineers can gain so much experience by actually taking part in the construction of a large engineering project. Also, many of the engineers who work on the construction remain in the maintenance or operating forces, and in some cases we have watched them rise to positions of responsibility in the organization owning and operating the project.

Miscellaneous Services

The private consulting engineer can also provide a variety of other services related to water resource developments, including advice on operation, management, tariffs, etc.

On one recent assignment we were called upon to analyse the tariff structure of the national power system of the Philippines. In Afghanistan we are giving advice on the operations and management of a power system. In Pakistan you are already familiar with the services which American and other consultants are providing the government in almost every aspect of reclamation, water and power development.

THE ROLE OF THE PRIVATE CONSULTANT IN PAKISTAN

The above discussion has covered the services of consulting engineers on a global basis. Those services and the principles and standards under which they are carried out are basic to all private consulting firms. Inasmuch as the major purpose of this symposium is to discuss the "Consulting and Contracting Practices in Pakistan." The concluding portion of our paper will be directed to the role of the private consultant in Pakistan.

Pakistan is presently undergoing a program of large scale development of projects involving a wide range of engineering services. This program will continue and the challenge of such a program should be met by private consulting engineers of Pakistan. For the engineers of Pakistan to meet this challenge requires first that the engineers themselves become skilled enough to carry out the engineering work, and secondly that they assemble themselves into engineering firms that are large enough to undertake the engineering of projects of the magnitude required to meet Pakistan's needs. In addition, the private engineers of Pakistan must persuade the Government that they can do the work adequately, and that it is economically feasible for them to be given the work, rather than to have all engineering for water resource projects done by the Government itself.

An unexcelled opportunity exists at this time for the engineers of Pakistan to gain the experience necessary to permit them to meet the future needs for engineering talent. The Settlement Plan program, involving as it does more than 7.7 billion rupees of major water resources projects, provides a limitless possibility for obtaining experience.

Every Pakistani engineer who is connected with these projects should do his best to learn everything he can concerning the design concepts, details of the engineering work done to develop the basic concepts into working drawings, and the field engineering work required to insure that the construction is carried out in accordance with the plans and specifications. I should insert the cautionary note here that every engineer will not, of course, be able to become familiar with every aspect of the project on which he is working. Rather, each engineer should concentrate on learning as much as he can about the immediate task on which he is placed, be it design, detailing or field engineering. In this way, there will be developed a group of engineers, each of whom is capable of doing well a certain segment of the engineering for a water resource project. By combining the talents of a number of engineers with such experience, a consulting firm could be established which would be competent to undertake the design of a water resource project.

The formation of a consulting engineering firm is a task requiring

business sense as well as engineering ability. Most firms with which I am familiar have started as small firms, and then have expanded as they became able to attract larger and larger assignments. This course seems to me to be a suitable one for Pakistan also. However, it is possible that, because of the magnitude of the projects in Pakistan, and the relative scarcity of Pakistani engineers of long experience on large projects, it might be possible for a group of Pakistani engineers to associate themselves with a foreign firm. Such a procedure would permit the firm so formed to offer more experience (in the form of the experienced engineers from the foreign firm who would be resident in Pakistan) than would otherwise be possible. It would also give the Pakistani members of the firm guidance in the operation of a consulting office, and such guidance would be very helpful in avoiding mistakes often made when a firm is first established.

The financial problems of starting up a firm also must be satisfactorily worked out. Sufficient money must be available to permit the firm to meet its payroll for several months, at least, to provide time for the collection of bills from clients. Also, funds are needed for rent, and other operating expenses.

Before opening an office, the engineers who are involved in the new venture should have a reasonably firm idea as to where they can obtain other initial engineering contracts. These contracts are usually the outgrowth of connections developed by the engineers in the course of their previous engineering work. After the first assignment is received, the future success of the new firm will depend largely upon the excellence of the work they do.

In summary, it appears to me that a great opportunity exists for the development of private consulting engineering firms in Pakistan. The large program of water resources development now in hand is providing a training ground of unparalelled scope for Pakistani engineers. By availing themselves of this experience, the engineers of Pakistan are obtaining the experience and judgment necessary to carry out such works on their own. I am sure that they will be able to put this experience to good use in the future by doing more and more of the engineering of water resource projects in Pakistan.