No. 103

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[illegible] STUDY

[illegible] AND WARNING SYSTEM

[illegible]

[illegible] CO., LTD.

List of Final Report

PREFACE

In response to a request from the Government of the Republic of Turkey, the Government of Japan decided to conduct a feasibility study on Flood Control, Forecasting and Warning system for Seyham River Basin and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Turkey a study team headed by Mr. Eiichi Yoshitake, Nippon Koei Co., Ltd., 3 times between April 1993 and August 1994.

The team held discussions with the officials concerned of the Government of Turkey, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Turkey for their close cooperation extended to the team.

October 1994

Kimio Fujita

President

Japan International Cooperation Agency

October 1994

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

Letter of Transmittal

We are pleased to submit herewith the Final Report of the Feasibility Study on Flood Control, Forecasting and Warning System for Seyham River Basin.

The Report presents the results of the Feasibility Study on Flood Control, Forecasting and Warning System in the Seyham River basin comprising the hydrometeorological observation plan, flood forecasting, optimum reservoir operation and data collection, processing and transmission system. Based on the Study, the optimum flood control, forecasting and warning system is proposed for the Seyham River basin.

The Report consists of four (4) Volumes, the Summary, Main Report, Supporting Report and Data Book. The Summary presents main outputs of the Study. The Main Report covers all the study results including analysis of the respective disciplines. The Supporting Report gives additional and supporting information, and the Data Book provides data obtained from the field surveys and investigations.

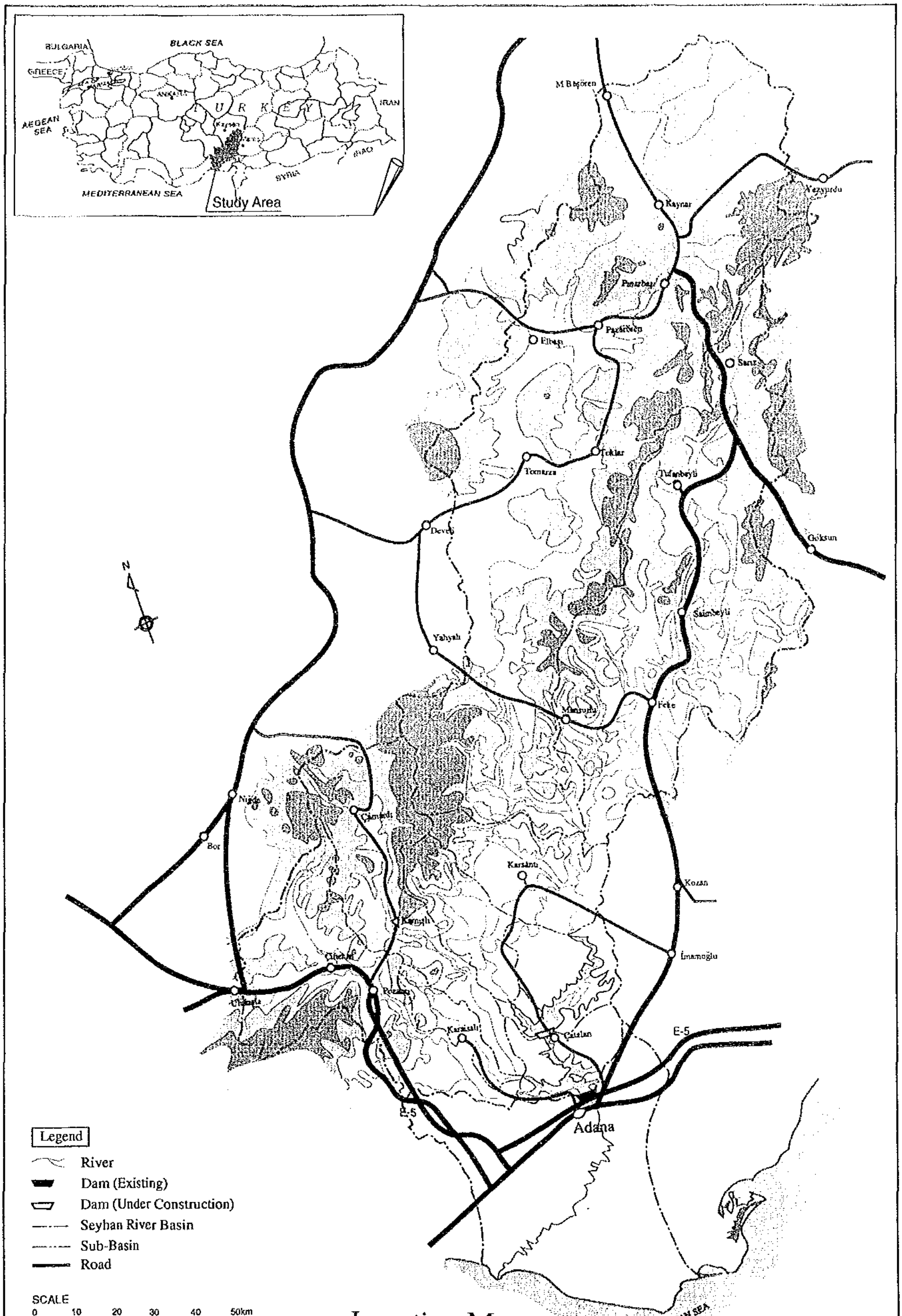
We would like to express our heartfelt thanks to the personnel of your Agency, the Embassy of Japan in Turkey and also to officials and individuals of the Government of Turkey for the assistance and advice extended to the Study Team. We sincerely hope that the results of this Study will contribute to the national and regional development of the country.

Yours sincerely,

E. Yoshitake

Eiichi Yoshitake
Team Leader
Feasibility Study on Flood
Control, Forecasting and Warning
System for Seyhan River Basin

Location Map



Location Map

SUMMARY

1. Introduction

Following the mutual agreement on the Feasibility Study on Flood Control, Forecasting and Warning System for the Seyhan River Basin, the Study Team and DSİ commenced the investigation work in close cooperation with each other in April 1993. Since that time, the investigation work, composed of Site Investigation in Turkey and Planning and Analysis Work in Japan, has progressed smoothly. In particular, the radio wave propagation test carried out for two and a half months in mountainous area was successful in realizing our purpose with the generous support of the DSİ Officials.

Up to now, the Study Team has submitted the following reports and the Minutes of Meeting were signed by both sets of delegates on each occasion:

- Inception Report on 12 April 1993
- Progress Report on 28 June 1993
- Interim Report on 8 November 1993
- Progress Report 2 on 24 March 1994
- Draft Final Report on 29 July 1994

On the basis of the agreed documents the Study Team carried out the formulation of the optimized telemeter system, evaluation of the flood Runoff model, calculation of the project cost and benefits, etc. in Japan. This Final Report presents the results of the Planning and Analysis work up to the middle of September 1994.

2. Background of the Project

(1) Present condition of project area

The study area for the Project is the Seyhan River basin which is located within the bounds of 36°30' to 39°15' North latitude and 34°45' to 37°00' East longitude, and situated at the south part of Turkey. The Seyhan River basin climatologically expands across two regions, namely, the Central Anatolia Region and the Mediterranean Region.

The Seyhan River basin is mainly composed of Zamantı River, Göksu River, Seyhan River after the confluence of the Zamantı and Göksu Rivers, and other tributaries after the confluence of the Zamantı and Göksu Rivers. Total catchment area of the Seyhan River basin at the base point of the Seyhan Dam is estimated to be 19,337 km^2. The maximum river length from the Seyhan Reservoir's HWL is estimated to be 420.5 km.

Mediterranean climate is dominant in the Mediterranean Region and continental climate is dominant in the Central Anatolian Region. In the Mediterranean climate winters are warm and rainy, summers are hot and dry, and in the continental climate winters are cold and generally snowy, summers are hot and dry. The subareas of the Seyhan River basin close to the geographical region are transitional zones from the Mediterranean climate and the continental climate, and the continental climate is more dominant than the Mediterranean climate in these zones.

In the coastal area of the Seyhan River basin precipitation is about 800 mm annually. At higher elevations it increases to 1,000 mm, and in the northern parts of the basin the value diminishes to 400 mm. Most of the precipitation which is 50 % of the annual total, fall between December and March. The mean annual precipitation of the basin is 590 mm. According to the climatic features of Turkey, the precipitation falling over the areas above 1,000 m elevation in winter is generally in the form of snow and it produces the snow cover on the ground. Snow melt starts around the end of winter or at the beginning of spring due to the temperature rises of the air.

The Seyhan River basin spreads over five provinces; the Sivas Province, the Kahramanmaraş Province, the Kayseri Province, the Niğde Province, and the Adana Province. Furthermore, part of the flood plain in the lower reaches belongs to the İçel Province. However, most part of the Seyhan River basin is covered by the Adana Province. Coverage by the Sivas Province and the Kahramanmaraş Province is especially marginal.

Socio-economic activities in the lower area is much more vital compared to the upper area. According to the 1985 census more than 80 percent of total population in the entire area are estimated to reside in the lower area. The City of Adana which is the fourth largest city in Turkey with approximately 1,000,000 inhabitants, is the political, commercial, industrial, and cultural center of the region. Most of economic activities including industrial, commercial, service, and agricultural activities are significantly concentrated in the lower area. In the City of Adana and its vicinity, many educational, cultural, entertainment, health, and social welfare organizations and facilities exist and they are vital.

Most part of the new concrete levees between the intake dam and the regulatory dam may be completed within a few years. The new concrete levees aims to keep flood time river width as same size as the low water channel. Based on this construction plan, new development in the areas between the old levees and the new levees is underway. The development includes a large scale shopping mall, a theater, a large mosque, an amusement park, and other entertainment and cultural facilities.

From the regulatory dam to the south, an area between the existing levee and the low water channel on the right bank is used as residential areas and fruit tree yards. An area with the above mentioned condition on the left bank is used as fruit tree yards and for grazing.

Within the gross project area, total 5,000 ha lands between the low water channel and the levees are cultivated by farmers at their own risk. Wheat is the main crop occupies approximately 50% of the land mostly with corn or soy beans as the second crop. Corn and citrus follow it both with approximately 20% land.

According to the Adana PTT regional directorate, three types of PTT communications lines are present below:

- The communications lines in Adana City consist of optical fiber cables.
- Local cities are connected via micro wave radio communications links.
- The communications lines between a majority of the cities, towns and villages along the Seyhan River basin areas, are made up of open wires.

The telecommunications network of the DSİ consists of HF-SSB radio communications equipment, VHF radio communications equipment and VHF walkie-talkies. The EİE possesses HF-SSB radio communications equipment, VHF radio communications equipment and VHF walkie-talkies. The DMİ telecommunications network consists of METEOSAT receiving equipment and HF and UHF radio telex communications equipment.

The electrical energy in the Seyhan River basin areas is supplied by Çukurova Elektrik A.S., the TEK Adana regional directorate and Kayseri ve Civarı T.A.Ş.
The following surveys were obtained as to the current electrical power supply conditions in the Seyhan River basin areas:

Adana Region		Kayseri Region	
AC power source, 1¢ :	220 V ± 10%	AC power source, 1¢ :	220 V ± 5%
	50 Hz ± 2%		50 Hz ± 1%
AC power source, 3 ¢ :	380 V ± 10%	AC power source, 3 ¢ :	380 V ± 5%
	50 Hz ± 2%		50 Hz ± 1%

(2) Present flood control

Flood season is from November to April. Rainfall increases in this season and melting snow boosts up the river discharge. Some annual peak runoffs in summer season are recorded at the tributaries of the Seyhan River basin. The flood in 1980 was the biggest flood and gave the biggest damage. Flood damage took place not only at the Çukurova plain but also at the upstream area and tributaries of the Seyhan River. Around Feke district, floods hit in 1979 and 1980. The flood in 1980 destroyed 21 buildings and damaged 76 buildings. After the flood, the river bed was widened from 16-17 m to 30 m. The flood is equivalent to 100-year probable flood.

The Seyhan River meanders largely from the downstream of Adana city. The river length of the high water channel between the right and left levees is 51 km, while that of the low water channel of the original river bed is 86 km. The groyne structures were constructed at many curved locations in the low water channel. Through experience, the low water channel may have a bankfull flow capacity of 500 m^3/s.

A feasibility study for the Seyhan Dam was carried out in 1949 to 1951,and was constructed in 1953 to 1956. The gated spillway is located between the emergency spillway and the dam body. Radial gates of 6 nos. with 7.0 m width x 6.1 m height are installed on the spillway weir. The spillway has the capacity of 2,500 m^3/s discharge. The power plant is located at the left bank, of which design discharge is 231 m^3/s (3 unit x 77 m^3/s). Irrigation outlet is equipped on the penstock of the power plant, which is connected to the irrigation channel YS1 with 11 m^3/s capacity. On the right bank of the dam, pump station for irrigation intake is located, which is connected to the irrigation channel TS1 with 21 m3/s capacity. No other outlet facility is equipped with the Seyhan Dam.

The first investigation of the Çatalan Dam was made in 1966. The Çatalan Dam was studied in the Lower Seyhan Master Plan Report in 1980. The flood damage in 1980 harnessed an urgent implementation of the Çatalan Dam construction. The dam construction was started.on 12 February 1982. After the dam completion, the Çatalan/Seyhan Dams will be able to protect the downstream area against 500-year probable flood. The Çatalan Dam will firm up power generation at the Seyhan Dam.

The Çukurova plain irrigation project was initiated by construction of the main canal at the right and left bank of the Seyhan River from 1937 to 1947. In order to protect the irrigation farm from flood, the Seyhan River levee was constructed at the right and left bank from 1949 to 1953. The total length of the levee was about 100 km along the right/left levee. The levee was designed to have flood capacity of 1,200 m^3/s with 1 m free-board. After the flood in 1975, a part of levee stretch was heightened or reinforced. After the flood in 1980, the levee on the left bank was extended at a few kilometers distance toward the Mediterranean sea to protect two villages.

(3) Present condition of flood forecasting and warning

The current data transmission system during floods in the Seyhan River basin can be broadly divided into two sub-systems: a data collection sub-system and a data transmission sub-system. Data and information on flood control activities can be broadly classified into meteorological information, hydrometeorological data and dam data. About eight (8) IBM personal computers and about thirty (30) ARC personal computers are provided in the DSİ 6th regional directorate. The IBM personal computers form a local area network (LAN), and the ARC personal computers are now used by individuals. The inflow volume from dams are estimated using these personal computers, and data is manually entered. In the event of flooding, a flood control committee, is organized in the DSİ 6th regional directorate to undertake flood control activities for the rivers currently under the management of this directorate. Also, the ASO is specially organized to undertake flood control activities for the downstream Seyhan area. Information on these flood control activities is transmitted through VHF radio communications network. Currently, the occurrence of any signs of flooding is reported from the flood control committee of the DSİ 6th regional directorate to the Adana provincial governor. The Adana provincial governor gives directions to each head of official district to undertake evacuation activities for the residents. The provincial governor, after having been informed from the flood control committee to the effect that there are signs of a large-scale flood, convokes the Emergency Assistance and Rescue Committee takes the command of the committee during evacuation activities.

In Turkey, the flood forecasting and warning system is not established for the river management, using real time and on-line data transmitting and processing systems. Inflow can be forecast by the correlation between downstream water level or discharge and upstream water level or discharge, with the estimated travel time of the flood wave between the two locations. Information on upstream water level can be reported by local observers, by telephone line. The mean snow melt runoff calculation is carried out for the snow melt duration, estimated by degree-day method.

3. Basic Concepts of Flood Forecasting and Warning

The objective of the Flood Forecasting and Warning is to establish the Flood Protection System in the Seyhan River basin and main items are described as follows;

- Flood protection of levees in the lower reaches
- Flood control of Seyhan and Çatalan Dams
- Dam operation for hydroelectric power generation

The river structures which are treated for the Flood Forecasting and Warning System are Seyhan Dam and Çatalan Dam. Çatalan Dam is also the multipurpose dam which shall be regulated for flood control. Based on the forecasting of the inflow into the reservoir, the outflow shall be input in the forecasting system.

The flood runoff forecasting can be made by estimating the rainfall - runoff process or/and snowmelt runoff process. The future's inflows in a few hours into the Seyhan and Çatalan Dams can be forecast by the measured rainfall and forecast rainfall.

To take into consideration the runoff from the subbasins and the routing effects of the river channels, the following non-linear hydrological models are applied.

- Storage function basin model for rainfall-runoff process in the subbasins
- Storage function river model for river channel routing effects

The simple snowmelt runoff model is also constructed and combined with the above models. The method of flood forecasting is summarized below:

- To compute the flood runoffs based on the flood runoff models
- To evaluate the past forecasting errors by the updated telemetered information
- To forecast the future flood runoff with the presently measured and telemetered information

The following lists basic ideas for flood forecasting and warning system in Seyhan River basin.

- Hydrometeorological data is collected from hydrologic standpoint for flood control in Seyhan River basin and flood forecast is executed. DSI 6th regional directorate is agency which administer river control on the basis of processed data.

- Seyhan Dam and Çatalan Dam (under construction) are most important flood protective facility for flood control in Seyhan River basin, and therefore, it requires fast and high quality system to transmit data and information regarding operation and management of these facilities.

- It requires the system to collect Hydrometeorological data fast and certainly, to process fast flood forecast and transmit certainly flood warning.

Flood forecasting and warning system is composed of system to collect data, to process data and to transmit data. It requires system design to combine these organically.

4. Formulation of Optimum Flood Forecasting and Warning System

(1) Formulation of hydrometeorological observation plan

Based on the comparative studies to formulate the representative water level and rainfall gauging stations to be telemetered, three alternative plans are conceived as summarized below:

Alternative Plans of Hydrometeorological Observation Network

Alternative	No. of water level gauging station		No. of rainfall gauging station	No. of temperature gauging station	Note
	Base station	Forecasting station*			
1	8	2	16	7	Zamantı and Göksu Rivers are divided into two subbasin at 1822 and 1801
2	6	2	13	7	Zamantı and Göksu Rivers are treated as one basin
3	7	2	10	7	Zamantı River is divided into two subbasins at 1822, but no rainfall stations are installed for sub-basin above 1822

Note *: Forecasting station is installed at Seyhan and Çatalan Dams.

Among three conceivable alternative plans studied by the statistical methods and hydraulic consideration, Alternative 1 is the most suitable plan for the Seyhan River basin taken into consideration the unpredictable natural phenomenon.

Optimum Plan of Hydrometeorological Observation Network

Base Water Level Gauging Station	Forecasting Water Level Gauging Station	Rainfall Gauging Station	Temperature Gauging Station
1822 (Zamantı upstream)	Seyhan Dam	Çatalan Dam	Karsantı
1806 (Zamantı downstream)	Çatalan Dam	Karsantı	Pozantı
1801 (Göksu upstream)		Çiftehan	Kamışlı
1805 (Göksu downstream)		Pozantı	Mansurlu
1818 (Seyhan River)		Karaisalı	Tufanbeyli
1825 (Eğlence River)		Kamışlı	Şıhlı (Şeyhli)
1820 (Körkün River)		Çamardı	Tomarza
1828 (Çakıt River)		Feke	
		Mansurlu	
		Saimbeyli	
		Tufanbeyli	
		Kazancık	
		Pınarbaşı	
		Şıhlı (Şeyhli)	
		Toklar	
		Tomarza	

(2) Formulation of optimum plan

The flood forecasting and warning system consists of three subsystems: the data collection system, the data processing system, and the data transmission system:
During setup of alternative plans, combinations that allow these sub-systems to exist as alternative plans in terms of the relationship between the functions and processing capabilities of each sub-system, the scale of facilities, and costs, are studied.

Two alternative plans can be derived from the studies described in up to Section 5.3. These two alternative plans, namely Alternative A and B, are studied in comparison below;

Alternative plan A is combinations of alternative plan 1 for the data collection system, alternative plan 2 for the data processing system and alternative plan 1 for the data transmission system.

Alternative plan B is combination of alternative plan 4 for the data collection system, alternative plan 2 for the data processing system and alternative plan 1 for the data transmission system.

Alternative plans A and B are derived from the results of evaluation of the basin rainfall calculation accuracy of collected rainfall gauging stations and the support functions of calculation accuracy by radar rain gauges. These two factors are studied in Section 5.3.2 (2). It is considered that alternative plans A and B differ in the functions of the corresponding facilities. The degree of application to various needs for system functions also is considered. If the information obtained from the flood forecasting and warning system is to be divided into direct information and indirect information, then although the former would usually become higher in the degree of needs, the latter would also be required. Overall judgments therefore are performed, including the comparison of facilities construction costs.

It is judged to be appropriate from the above studies that alternative plan A should be formulated for the intended system for the moment. As studied previously in the section on radar rain gauges, it can be said that for the flood forecasting and warning system, radar rain gauges also become powerful equipment that complements the functions of ground rain gauges. It is desirable, therefore, that use of radar rain gauges will be included in future plans and that the facilities costs for these rain gauges will be improved in steps. Alternative plan A should be formulated as the optimum plan for the reasons listed below.

(1) The studies discussed previously in Section 5.4.4 indicate that the difference in facilities costs between the two Alternative plans becomes about $6,661,320 under the cost estimation conditions, and compared with alternative plan A, alternative plan B brings about significant total system cost burdens.

(2) In actual forms of system operation, a majority of existing flood forecasting and warning systems use ground rain gauge data, not radar rain gauge data, as the basis for judgment. Since, however, radar rain gauges have the feature that they can analyze the areal and dynamic characteristics of rainy regions, many systems actually use them as one powerful component that complements such function of the systems.

(3) Although improvement of the accuracy of radar rain gauges is likely to become possible by carrying out analytical studies based on after-installation data storage, it is judged to be appropriate that for the moment, ground rain gauges should be used to perform flood forecasts and warnings, because the ground type surpasses the radar type very significantly in terms of the history of actual data storage.

5. Hydrometeorological Analyses

(1) Mean basin rainfall model

The Thiessen method was applied for calculating areal rainfall averages in sub-basins in the Seyhan River basin. For the purpose of estimating the basin mean rainfall, the representative rainfall gauging station is selected among the existing rainfall gauging stations by the statistical method, namely, the multiple linear regression analysis on the observed storm rainfall records.

(2) Subbasin rainfall-runoff model

Non-linear rainfall-runoff model, so called, Storage Function Model is applied for the rainfall-runoff model. Storage function between basin storage S and basin runoff Q, namely, constants K and p can be determined by the past rainfall and runoff records.

The main characteristics of Storage Function Model are summarized as follows.

(a) The basin storage process is additionally introduced between rainfall-runoff process.
(b) The basin storage is expressed as a catalytic function. The relationship between rainfall and runoff is expressed as an equation.
(c) By this equation, water budget of storage volume can be calculated. Finally, runoff hydrographs can be obtained.

(3) River routing model

Applications of hydrologic routing techniques to problems of flood prediction are numerous. Most flood forecasting and warning systems instituted by Ministry of Construction in Japan or other organizations overseas incorporate some form of this technique to predict flood stages in advance of a severe storm. Additionally, the synthesis of runoff hydrographs from gauged and ungauged watersheds is possible by the use of basic assumption inherent in this approach.

Non-linear hydrologic river routing model was also introduced by Dr. Kimura with an assumption of the river channel storage. The main characteristics of Storage Function River Model are basically the same with Storage Function Basin Model.

(4) Rainfall-runoff event simulation model

The rainfall-runoff event simulation model by storage function method is constructed for the Seyhan River basin as a main flood forecasting computer program. The parameter setting of the models is undertaken based on the comparison of observed and simulated values at the base points for the calibration of the models. For the purpose of creating an easy-to-use model, the interactive computer software for simulation, namely, Extend, version 2.0 is used.

(5) Snowmelt runoff model

The several factors, such as, snow line, relationship between temperature and elevation, snowmelting zone and snowmelt rate in a basin are discussed regarding the snowmelt runoff process and the prediction equations to estimate the snowmelt due to the temperature increase in a basin are presented. Reflected upon the availability of data required for the snowmelt runoff estimate, the simple snowmelt runoff model by regression analysis is adopted for the Seyhan River flood forecasting system. The temperature indexes are selected to estimate the snowmelt runoff because of the easiness of data availability. The flow chart of snowmelt runoff determination by the temperature indexes is described in Figure 6.3.5. Based on the flow chart and data hypothetically estimated in a subbasin and measured at the meteorological gauging stations, the estimate of snowmelt runoff in 1980 flood is made as a typical example of the snowmelt runoff in the Seyhan River basin.

(6) Simulation of flood flow and forecasting

The calibration of the event simulation model presented in 6.2 is carried out by the following basic consideration.

- The calibration of the event simulation combined with basin and river models in the entire Seyhan River basin is mainly carried out at the gauged base points.
- The calibration of the event simulation is mainly carried out at the Seyhan Dam taken into consideration the consistency of the parameters in terms of the basin and river characteristics.

The proposed flood runoff model in the Seyhan River basin is selected by the evaluation of the results of the comparative study on the calibration methods. The selection is made for non-snowmelt season and snowmelt season.

Based on the above evaluation, the calibration method by the integrated storage function is considered to be much more reliable and safer than the calibration method by the gauged base points.

The proposed flood runoff model for snowmelt season is composed of the following models.

(a) Storage function basin and river model for snowmelt season
(b) Snowmelt runoff model

Two models (a) and (b) can be combined by the event simulation of Extend. Results of computation for flood in 1980 are shown in Figure 6.4.2.

6. Optimum Comprehensive River Control

(1) Flood innundation and damage

Non-uniform flow analysis method is applied to routine the river water surface to the irregular river cross section at the downstream stretch.

In accordance with DSİ's experience, low water channel capacity is estimated at about 500 m^3/s. That of high water channel is experienced at 1,200 m^3/s with 1.0 m free-board and at 1,800 m^3/s without free-board. The discharges of 200, 300, 400 and 500 m^3/s are examined for the low water channel. Those of 1,200, 1,600 and 2,000 m^3/s are examined for the high water channel.

The clearance between the river water surface and low water channel shoulder is bigger where the low water channel width is wider and the channel depth is deeper. The river flow discharge less than 300 m^3/s does not inundate the high water channel. The discharge of 500 m^3/s inundates the high water channel until 20 km from Sec-26A. The river flow discharge above 700 m^3/s inundates the high water channel at the full stretch. The bankfull discharge is estimated at 2,000 m^3/s or river flow may over-flow at some stretch. If the above Japanese criteria is applied, the designed discharge is attained at 1,200 m^3/s, though free board is less than 1.0 m at some stretch.

The present capacity of high water channel of the downstream river is carefully checked by the past flood records and the operation records of flood routing activity at the Seyhan Dam.

(2) *Flood flow operation*

Spill-out discharge is to be minimized so as to decrease flood damages at the downstream, or flood water is to be stored in the reservoirs as much as possible. There are two methods on dam gate operation rule to regulate flood flow. One is called as "constant outflow operation" and the other is as "constant ratio operation". Operation rule is explained below.

Flood routing at Çatalan Dam is carried out by "constant ratio operation" to examine the optimum spill-out discharge. Flood hydrograph at 500-year probability is adopted in the analysis. Target spill-out discharge (Q_t) is changed at 600 m^3/s, 800 m^3/s, 1,000 m^3/s and 1,200 m^3/s.

(1) Flood control volume = 628 x 10^6 (m^3)
(2) Safety factor = 1.2
(3) Flood control volume with safety factor = 628 x 10^6 /1.2 = 523.3 x 10^6 (m^3)

Spillout discharge of 800m^3/sec.is selected for Çatalan Dam.

Comparison at the Seyhan Dam between "constant outflow operation" and "constant ratio operation" operated at the Çatalan Dam is made in Figure 7.2.4 to 7.2.7. The results are summarized as follows.

Constant ratio operation at Çatalan Dam

	Spill-out from Çatalan	Inflow from subbasin	Inflow peak	Stored vol.	Max. RWL	Outflow
1/2	582 m^3/s	280 m^3/s	861 m^3/s	132.2x10^6 m^3	63.73 m	591 m^3/s
1/5	622 m^3/s	435 m^3/s	1,054 m^3/s	148.6x10^6 m^3	64.03 m	659 m^3/s
1/10	647 m^3/s	550 m^3/s	1,195 m^3/s	162.9x10^6 m^3	64.29 m	720 m^3/s
1/50	715 m^3/s	825 m^3/s	1,534 m^3/s	194.0x10^6 m^3	64.84 m	856 m^3/s
1/100	738 m^3/s	955 m^3/s	1,691 m^3/s	206.6x10^6 m^3	65.06 m	913 m^3/s

Constant outflow operation at Çatalan Dam

	Spill-out from Çatalan	Inflow from subbasin	Inflow peak	Stored vol.	Max. RWL	Outflow
1/2	1,175 m^3/s	280 m^3/s	1,455 m^3/s	158.1x10^6 m^3	64.20 m	699 m^3/s
1/5	1,200 m^3/s	435 m^3/s	1,635 m^3/s	210.6x10^6 m^3	65.13 m	931 m^3/s
1/10	1,200 m^3/s	550 m^3/s	1,750 m^3/s	247.7x10^6 m^3	65.76 m	1,102 m^3/s
1/50	1,200 m^3/s	825 m^3/s	2,025 m^3/s	287.3x10^6 m^3	66.40 m	1,288 m^3/s
1/100	1,200 m^3/s	955 m^3/s	2,155 m^3/s	288.7x10^6 m^3	66.42 m	1,293 m^3/s

(3) Water use operation

Daily power generation is simulated in case of "without system" and "with system". Daily inflow (Q_i) in 1970, 1975 and 1988 are adopted. Daily inflow (Q_i) on the operation day is assumed as same as the Q_i on the previous day, in case of "without system" operation. It is assumed that Q_i on the operation day can be forecasted in advance, in case of "with system" operation.

(Unit : MWh)

Year	Probability	"Without system"	"With system"
1970	1/2	715,962	717,567
1975	1/5	790,301	791,919
1988	1/10	992,199	996,315

It can be found that power operation "with system" can generate energy more stably than power operation "without system".

Additional energy production obtained by the difference of operation is calculated and tabulated below.

(1) Çatalan Dam (T.W.L = 64.0m, he = 3.0m)

	2-year	5-year	10-year	50-year	100-year
Difference of Storage Volume (x 10^6 m^3)*	44.1	86.9	124.3	178.5	198.4
Ave. Water Level	118.9	119.3	119.7	120.5	120.9
Ave. Head (m)	51.9	52.3	52.7	53.5	53.9
Energy output (MWh)	5,296	10,516	15,157	22,097	24,744

(2) Seyhan Dam (T.W.L = 30.3m, he = 3.5m)

	2-year	5-year	10-year	50-year	100-year
Difference of Storage Volume (x 10^6 m^3)*	25.9	62.0	84.4	93.3	82.1
Ave. Water Level	62.6	63.1	63.4	63.7	63.7
Ave. Head (m)	28.8	29.3	29.6	29.9	29.9
Energy output (MWh)	1,726	4,203	5,780	6,455	5,680

* : Storage volume by constant outflow operation - Storage volume by constant ratio operation

7. Feasibility Grade Design for the Optimum System

(1) System configurations

The overall configuration and functional block diagram of the flood forecasting and warning system should be shown in Figure 8.1.1. The flow chart of data should be shown in Figure 8.1.2.

The overall circuit configuration of the flood forecasting and warning system should be shown in Figure 8.1.3.

The station configuration of the flood forecasting and warning system facility should be shown in the table below.

Type of station	Number of stations
Control center (DSİ 6th regional directorate flood control committee)	1
Data monitoring stations (DSİ general directorate, Adana EİE and DMİ)	3
Seyhan Dam office facility	1
Çatalan Dam office facility	1
Multiplex radio repeater stations	3
Multiplex radio repeater stations (Telemetering repeater station also provided)	4
Telemetering repeater stations (V-V and Cross type)	7
Water level gauging stations (Seyhan Dam and Çatalan Dam water level included)	10
Rainfall gauging stations (Çatalan Dam rainfall included)	9
Rainfall/temperature gauging stations	7
Adana Provincial Governor	1
UHF repeater station	1
ASO UHF radio liaison stations(Doğankent and Yenice)	2
Town/villages' head UHF radio liaison stations (downstream areas of Seyhan Dam)	5
Mobile station	1

(2) System scheme and function outline

In principle, the intervals of data collection should be based on the following table:

Gauging item	Collection conditions	Remarks
Rainfall	Every hour on the hour	Calculations of hourly rainfall, every hour on the hour, become the minimum unit.
Water level	Every hour on the hour	It is preferable that whenever neces-sary, collection of any data should be possible.
Air temperature	Every hour on the hour	It is preferable that whenever neces-sray, collection of any data should be possible.

Data should be transmitted in image service from the control center. The service area and the types of services should be listed below.

(a) Image service destination stations and service types

The following lists stations to which image services should be provided:

Image data distribution source	Image data distribution destination	Service image type
• Control center (Flood control committee of DSİ 6th regional directorate)	• DSİ general directorate • Seyhan Dam office • Çatalan Dam office • Adana EİE regional directorate • Adana DMİ regional directorate	• River basin status chart • Rainfall data table • Water level data table • Discharge data table • Air temperature data table • Rainfall chronological graph • Water level chronological graph • Discharge chronological graph •Air temperature chronological graph

8. Implementation Plan and Cost Estimation

(1) Implementation schedule

The implementation schedule for the structuring of the flood forecasting and warning system is shown in Table 9.1.1.

The entire work, which ranges from detailed designing to civil construction work, equipment procurement, transportation, installation, adjustment, acceptance test and site OJT (On -the-Job

Training) will be completed within twenty two (22) months; this period considering the scale of the system and the number of places which require work.

(2) Construction cost estimation

Direct construction work costs are estimated on the basis of the work quantities and work unit costs during the feasibility study. The major assumptions and conditions for construction cost estimation are listed below.

(a) All prices will be the market prices existing as of February 1994. Commercial power leading-in work expenses and inland transport expenses, however, are estimated by multiplying the market prices existing as of February, 1994, by 1.6.

(b) Construction costs are estimated in both foreign currency (the US. dollar) and domestic currency (the Turkish lira). The exchange rate as of February 1, 1994, is used as that of the dollar and the yen. This exchange rate is shown below.
$1 = ¥109.20

(c) Construction costs consist of the following items:

- Direct construction expenses
- Governmental overhead expenses
- Engineering expenses
- Educational and training expenses
- Provisional expenses

(d) Land compensation expenses are estimated in domestic currency and included in construction costs.

Outline of the construction costs is given below.

Item	Foreign currency (Unit: $)	Domestic currency (Unit: 1000 TL)
Direct construction expense	10,096,490	19,745,400
Land acquisition expense	0	6,600
Governmental overhead expense	0	197,454
Engineering expense	1,170,200	0
Educational/training expense	148,580	0
Provisional expenses	554,870	2,630,010
Total construction expenses	11,970,140	22,579,464

9. Evaluation of the Project

The evaluation consists of the following three component: a) identification of the project impacts, b) financial and economic analyses, c) social and technological evaluations. The expected project impacts are identified from the typical or theoretically possible impacts by the flood forecasting and warning system considering the present and expected future conditions and activities, and past experiences. Among the identified impacts, quantifiable ones in monetary term are utilized for financial and economic analysis and others are elements of the social and technological evaluation. The economic benefits of the project are the following items: (1) substitution effect of the personnel related to the flood forecasting and warning by the system, (2) Decrease in flood areas/damages by proper dam operations, and (3) Maximization of reservoir water use by more flexible and appropriate dam operations.

The EIRR of this project is 4.75% with 2 years construction period and 17 years of project life cycle. The figure is slightly lower than the agricultural development project's 5% opportunity cost. Although the economic figures are not favorable for the project implementation, technological and socio-economic factors including (1) increase in social safety feelings by reliable information, decision making, and proper public sector's action, and decision making for the implementation, (2) decrease in possibility of potential risk realization and increase in social safety feelings by reduced discharge water volume from the Seyhan Dam during the flood time (3) the valuable experience of DSİ in regard to the introduction of new technology concerning flood forecasting and the telemeter system for the Seyhan River Basin will help to secure the spread Seyhan River of the up-to-date river administration throughout the country, support the positive decision making.

Furthermore the amount of the investment made for the flood protection of the Lower Seyhan Reaches consists of the Seyhan Dam, the existing and new levees, and the Çatalan Dam, and the new on going capital investment on the former HWC in the Adana City, the investment of the system may acceptable for the society to have its contribution to more accurate and faster flood forecasting aiming the reliable dam operation and the reliable information provision to the society.

Such function become the eye and the ear of the general public and attract public attention. Therefore this project is appreciated not only as a result of the immediate economic effect, but because it greatly contributes to society. The benefit of the project cannot be estimated in monetary terms but in terms of the saving of human life, stabilization of living conditions, and advancement of flood forecasting techniques.

10. Recommendation

(1) Proposed organization and administration

The existing legal, organizational and administrative functioning system detailed in the previous section seems to be compatible with the envisaged aims. The organization chart and administrative structure implemented by DSİ in flood control and fighting measures (see Figure 2.3.3) have a scope that can best serve the system to be proposed.

The existing organization chart (Figure 2.3.2) which is used by General Directorate of DSİ and Regional Directorates for flood protection and fighting measures will be adequate if it is equipped by additional staff and equipment.

(2) Hydrometeorological observation

In view of the above, the following works and studies are to be carried out by both DSİ and EİE:

- Continuation of flood observation
- Continuation of periodical discharge measurement
- Updating of rating curves
- Continuation of snow depth and related observations

(3) Maintenance management system

To efficiently operate the flood forecasting and warning system in the Seyhan River basin and make this system develop its maximum performance, it becomes important to establish a maintenance and management system that matches to the particular configuration of the facility. Figure 11.3.1 shows an example of a maintenance personnel system that is recommended for the maintenance and management of flood forecasting and warning system. It is necessary that seeing Figure 11.3.1, the DSİ 6 th regional directorate should secure personnel, then educate/train them, and establish a maintenance and management system.

THE FEASIBILITY STUDY
ON
FLOOD CONTROL, FORECASTING AND WARNING SYSTEM
FOR
SEYHAN RIVER BASIN

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1. INTRODUCTION

1.1 Background

The government of Turkey (GOT) requested the Government of Japan (GOJ) in January 1991 to conduct the Feasibility Study (the Study) on Flood Control, Forecasting and Warning System for the Seyhan River Basin in the Republic of Turkey.

In response to this request GOJ decided to implement the Study and concretely the Japan International Cooperation Agency (JICA) was decided to carry out this Study.

Thereupon JICA dispatched the Preparatory Study Team (SW Mission) to the Republic of Turkey for 2 weeks, from 22 July to 4 August 1992.

The SW Mission confirmed the Terms of Reference, collected relevant data and carried out site investigation.

The Scope of Work (SW) in which the real plan of the Study, proper measures of both countries, and so on were included, was discussed by the two countries concurrently.

Consequently SW of the Study was agreed upon in July 1992 between the General Directorate of State Hydraulic Works (DSİ) and JICA.

The objectives of the Study are as follows:

(1) to formulate an integrated flood control, forecasting and warning system based on developing the data collection and evaluation system for the Seyhan River Basin

(2) to effect technology transfer to the Turkish counterpart personnel in the course of the Study

In accordance with this mutual agreement JICA organized the Study Team, composed of 9 experts, and commenced the Study from 4 April 1993 in collaboration with the officials of DSİ.

Besides, JICA has established an Advisory Committee to occasionally provide the Study Team with technical support throughout the Study period.

The members of the Committee are senior Japanese Government officials and are listed in Table 1.1.1.

The Turkish counterparts for the Project were organized from among the parties concerned as listed in Table 1.1.2.

1.2 Work Progress

Following the mutual agreement of both sides, mentioned above the Study Team and DSİ commenced the investigation work in close cooperation with each other in April 1993.

Since that time, the investigation work, composed of Site Investigation in Turkey and Planning and Analysis Work in Japan, has progressed smoothly.

In particular, the radio wave propagation test carried out for two and a half months in mountainous area was successful in realizing our purpose with the generous support of the DSİ Officials.

Up to now, the Study Team has submitted the following reports and the Minutes of Meeting were signed by both sets of delegates on each occasion:

- Inception Report on 12 April 1993
- Progress Report 1 on 28 June 1993
- Interim Report on 8 November 1993
- Progress Report 2 on 24 March 1994
- Draft Final Report on 29 July 1994

On the basis of the agreed documents the Study Team carried out the formulation of the optimized telemeter system, evaluation of the flood Runoff model, calculation of the project cost and benefits, etc. in Japan.

This Final Report presents the results of the Planning and Analysis work up to the middle of September 1994.

1.3 Objectives of Final Report

The Final Report is submitted after obtaining final authorization of both countries on the subject matter of the Final Report.

The aim objectives of this Report are summarized below:

(1) execution of the radio wave propagation test
(2) formulation of the optimized telemeter system
(3) hydrological study of flood
(4) formulation of the optimum dam operation rules
(5) synthetic evaluation of the flood forecasting and warning system
(6) recommendation related to flood control

2. BACKGROUND OF THE PROJECT

2.1 Present Conditions of the Project Area

2.1.1 Location, area and topography

The study area for the Project is the Seyhan River basin which is located within the bounds of 36°30' to 39°15' North latitude and 34°45' to 37°00' East longitude, and situated at the south part of Turkey. The Seyhan River basin climatologically expands across two regions, namely, the Central Anatolia Region and the Mediterranean Region. The Seyhan River basin straddles administratively the provinces of Sivas, Kayseri, K.Maras, Niğde and Adana province. The catchment area of the Seyhan River basin within Kayseri province consists of the middle and upstream reaches of the Zamantı River. The Seyhan River basin in Adana Province consists of the downstream reach of the Zamantı River, the Göksu River basin and the mainstream basin of the Seyhan River and its tributaries. The location map of the Seyhan River basin and its sub-basins with the provincial boundaries are shown in Figure 2.1.1.

The Seyhan River basin is topographically composed of the following three areas;

- Steep mountainous area which formulates upstream and middlestream reaches of the Seyhan River basin, with elevations ranging 1,000 - 3,000 m ASL (above sea level).
- Hilly plateau area which formulates the lower part of the middle reach of the Seyhan River, with the elevations ranging 250 - 500 m ASL, and
- Delta plain area which expands at the lowest part of the Seyhan River after the City of Adana, with elevation of about 10 m ASL.

The Zamantı River rises from Mt. Karaca (El.2,079m) of the Kulmaç Mountain Range and the Göksu River from Mt. Sandikdere (El.2,601m) of the Tahtalı Mountain Range. Two rivers flow approximately in parallel in the south-southwest direction and merge at a point approximately 70 km north-northeast of the City of Adana to form the Seyhan River. The Seyhan River goes down, passing the urban area of Adana, and feeds into the Mediterranean Sea 50 km south of the Seyhan Dam.

2.1.2 Hydrometeorology

The Seyhan River basin is mainly composed of the following tributaries;

- Zamantı River,

- Göksu River,
- Seyhan River after the confluence of the Zamantı and Göksu Rivers, and
- Other tributaries after the confluence of the Zamantı and Göksu Rivers.

Other tributaries after the confluence of the Zamantı and Göksu Rivers are furthermore divided into the following rivers;

- Eğlence River which merges into the Seyhan River at the Çatalan Dam,
- Körkün River which drains into the existing Seyhan Reservoir,
- Üçürge River which drains into the existing Seyhan Reservoir,
- Çakıt River which drains into the existing Seyhan Reservoir, and
- Other small tributaries which drains into the Seyhan River after the confluence.

Based on the division of the tributaries in the Seyhan River basin, the catchment area calculation is performed for each tributary defined above. The catchment area calculation is made for two conceivable cases below;

- Without the Çatalan Reservoir and
- With the Çatalan Reservoir.

The Eğlence River and some small tributaries upstream of the Çatalan Dam are to be affected and inundated after the impounding water in the Çatalan Reservoir.
The results of the catchment area calculation are summarized below.

Catchment Area of Sub-Basins

Sub-basin	Catchment Area (km^2) Without Çatalan Dam	With Çatalan Dam
(1) Zamantı R.	8,822	8,822
(2) Göksu R.	4,397	4,397
(3) Zamantı - Göksu Join to Çatalan Dam (Seyhan R.)	1,430	858 (up to Çatalan Reservoir HWL) 572 (After Çatalan Reservoir HWL)
(4) Eğlence R.	672	590 (up to Çatalan Reservoir HWL) 82 (After Çatalan Reservoir HWL)
(5) Körkün R.	1,547	1,547
(6) Üçürge R.	263	263
(7) Çakıt R.	1,771	1,771
(8) Çatalan B. - Seyhan B. Sub-Basin	435	435
Total	19,377 km^2	

Total catchment area of the Seyhan River basin at the base point of the Seyhan Dam is estimated to be 19,337 km^2. The catchment area of the Seyhan River basin is furthermore divided into two areas depending on the flood control facilities such as Çatalan and Seyhan Dams, and the results are shown below.

Catchment Area of Çatalan & Seyhan Dams

Name of Dam	Sub-basin	Catchment Area of Sub-basin (km^2)	% of Total Catchment Area
Çatalan B.	• Zamantı R.	8,822	46
	• Göksu R.	4,397	23
	• Zamantı-Göksu Joint to Çatalan B.	1,430	7
	• Eğlence R.	672	4
	Sub-total	15,321	80
Seyhan B.	• Körkün R.	1,547	8
	• Üçürge R.	263	1
	• Çakıt R.	1,771	9
	• Çatalan B. - Seyhan B. Sub-basin	435	2
	Sub-total	4,016	20
	Total	19,337	100

The maximum travel distance along the main stream of each major tributaries in the Seyhan River basin is calculated from the base point to the upstream limits of drainage area. The results of the calculation are summarized below.

River Length of Tributaries

Sub-basin	River Length (km)	Base Point
Zamantı R.	331.0	Zamantı - Göksu Confluence to Seyhan River
Göksu R.	182.0	Zamantı - Göksu Confluence to Seyhan River
Seyhan R.	89.5	Seyhan Reservoir's HWL (El. 67.5 m)
Sub-basin (from Çatalan D. site to the confluence of Zamantı - Göksu R.)	35.0	Çatalan Reservoir's HWL (El. 125.0 m)
Eğlence R.	69.7	Seyhan Reservoir's HWL
	57.0	Çatalan Reservoir's HWL (El. 125.0 m)
Körkün R.	126.0	Seyhan Reservoir's HWL
Üçürge R.	53.2	Seyhan Reservoir's HWL
Çakıt R.	114.0	Seyhan Reservoir's HWL

Resultantly, the maximum river lengths from the base points such as Çatalan and Seyhan Reservoir's HWL are estimated below.

- from Çatalan Reservoir's HWL (El. 125.0 m)
  - Max. river length = 331 + 35.0
  - = 366 km
- from Seyhan Reservoir's HWL (El. 67.5 m)
  - Before Çatalan Dam imponding
    - Max. river length = 331 + 89.5
    - = 420.5 km
  - After Çatalan Dam imponding
    - Max. river length = 126 km

To study the general basin geomorphology in the Seyhan River, sub-basin's features of hydrological importance are quantified in terms of stream length and elevation. The slope of the river channels is very much instrumental in creating the velocity of flow, and hence has a very profound effect on the surface runoff process. The river length and its elevation are plotted for each sub-basin and shown in Figure 2.1.2. The mean slope of river is also calculated below.

Mean Slope of River Channel

Sub-basin	Ave. Slope	Note
Zamantı R.	1/74	from the confluence to the Toros Mountain
	1/489	after the Toros Mountain
Göksu R.	1/126	
Seyhan R.	1/384	from Seyhan Reservoir's HWL to the confluence
	1/200	from Çatalan Reservoir's HWL to the confluence
Eğlence R.	1/31	from Seyhan Reservoir's HWL
	1/26	from Çatalan Reservoir's HWL
Körkün R.	1/64	from Seyhan Reservoir's HWL
Üçürge R.	1/33	from Seyhan Reservoir's HWL
Çakıt R.	1/60	from Seyhan Reservoir's HWL

The drainage basin of the Seyhan River takes place within the Mediterranean and the Central Anatolian geographical regions as explained in 2.1.1. Mediterranean climate is dominant in the Mediterranean Region and continental climate is dominant in the Central Anatolian Region. In the Mediterranean climate winters are warm and rainy, summers are hot and dry, and in the continental climate winters are cold and generally snowy, summers are hot and dry. The subareas of the Seyhan River basin close to the geographical region are transitional zones from the Mediterranean climate and the continental climate, and the continental climate is more dominant than the Mediterranean climate in these zones. Furthermore, the isohyets shown in Figure 2.1.3 are in good agreement with the climatic features of the catchment area explained above. Forty percent of the catchment area of the Seyhan River basin is forest covered area and the remaining part is barren. The forest cover is composed of the pin leaf trees such as pines and it takes place in the southern part of the basin. The Toros Mountains lying in the direction of South-Northeast divide the catchment area into two approximately equal subareas.

The mean annual isohyetal map in and around the Seyhan River basin is shown in Figure 2.1.3. It is in agreement with the topographical features and the vegetation cover of the Seyhan River basin and with the general inflow direction of the moist air masses to the basin. The frontal systems entering the basin from south and southeast direction bring the moist air masses over the catchment area and these air masses leave the most amount of their moistures in the form of the precipitation over the Toros Mountains while the air masses are moving over the Toros Mountains that take place in the middle section of the catchment area. Therefore the precipitation over the southern part of the catchment area is much higher than the other parts. The moist air flow continues in the northern direction after it has passed the Toros Mountains, and it carries less moisture. Because of the decrease in the moisture it precipitates in a less scale on the northern parts of the basin. As a result of this physical fact, the mean annual precipitation over the northern part of the catchment area is more less than that of the southern part.

In the coastal area of the Seyhan River basin precipitation is about 800 mm annually. At higher elevations it increases to 1,000 mm, and in the northern parts of the basin the value diminishes to 400 mm. Most of the precipitation which is 50 % of the annual total, fall between December and March. The mean annual precipitation of the basin is 590 mm. According to the climatic features of Turkey, the precipitation falling over the areas above 1,000 m elevation in winter is generally in the form of snow and it produces the snow cover on the ground. Snow melt starts around the end of winter or at the beginning of spring due to the temperature rises of the air.

Temperature decreases from south to north depending on higher elevations. The mean annual temperature in the lower basin is 18°C, while it decreases down to 8°C in the upper regions. The moisture is high in winters in the whole basin and high in summers at the coastal plains. In the northern regions where Central Anatolian climate dominates, moisture content is significantly reduced. The dominant wind direction is from southwest and the strongest winds exist in summertime. The maximum wind velocity recorded is 33.6 m/sec.

2.1.3 Land use

(1) The City of Adana

Lower right bank of the Seyhan Reservoir is developed as residential area of the City of Adana. In lower reach from the Seyhan Dam, surface of the old levee on the right bank of the Seyhan River is used as a highway or a road within the city area. The adjacent area of the right bank levee is developed as office, residential, and commercial use. The area from the Seyhan Dam to the E-5 highway is mainly residential area with some offices and a school. Vicinity of the section south from the E-5 highway to the Stone Bridge is the old city center. This area is still vital with many shops, restaurants, and service and entertainment facilities. From the Stone Bridge to the south, a residential area spreads until the city limit. The housing buildings in the southern end of the residential area, however, are without building permission.

Near the intake dam, elevation of adjacent area of the left bank is rather high and the area consists of housings. From the area, elevation level gradually lowers to the Girne Bridge. The left bank levee originates from this area and its surface is used for the highway. Upland is used for the municipal bus yard and the municipality's land extends to the area between the low water channel and the levee until the Girne Bridge. Neighboring area to the municipality's land is residential area. From the Girne Bridge to the Stone Bridge elevation of the left bank of the river is almost same as the levee's. An industrial area stretches here. From the Stone Bridge the left bank levee is situated just beside the low water channel. A large hospital is adjacent to the lower side of the bridge and is followed by a residential area to the south.

Most part of the new concrete levees between the intake dam and the regulatory dam may complete within a few years. The new concrete levees aims to keep flood time river width as same size as the low water channel. Based on this construction plan, new development in the areas between the old levees and the new levees is underway. The development includes a large scale shopping mall, a theater, a large mosque, an amusement park, and other entertainment and cultural facilities.

From the regulatory dam to the south, an area between the existing levee and the low water channel on the right bank is used as residential areas and fruit tree yards. Housing buildings within this area, however, were constructed without permission from the city. Farmers are planting fruit trees at their own risk since they know the area is outside the flood protection area. An area with the above mentioned condition on the left bank is used as fruit tree yards and for grazing.

(2) The Çukurova Plain

From the city limit to the river mouth, the river flows through the Çukurova Plain consists of the Tarsus Plain on the right bank of the river and the Yüreğir Plain on the left. Most of adjacent areas to the river are covered by the Lower Seyhan Irrigation project. The west end of the Tarsus Plain is delineated by the Berdan River. The east boundary of the Yüreğir Plain is Ceyhan River. The Çukurova Plain is flood plain of the three rivers i.e. the Seyhan River in the middle, the Berdan River on the west side, and the Ceyhan River on the east side.

In the Çukurova Plain the Lower Seyhan Irrigation Project, which utilizes water from the Seyhan River, has been implemented. A gross coverage area of the Lower Seyhan Irrigation project, which covers almost the entire Çukurova Plain, is 210,000 ha. Among them 80,000 ha land is located in the Tarsus Plain and 130,000 ha land is in the Yüreğir Plain. A half of the land in the Tarsus Plain, 40,000 ha land, is in the Tarsus District of the İçel Province. The rest of the land falls within the three districts of the Adana Province i.e. the Seyhan District, the Yüreğir District, and the Karataş District.

The Lower Seyhan Irrigation project is still underway. Among the net irrigation and drainage coverage area of 174,100 ha, 65,000 ha was completed as the first stage implementation in 1968. Then the second stage with 48,600 ha and the third stage's 19,800 ha irrigation area were actualized in 1975 and in 1986 respectively. Remaining area of 40,100 ha is yet to be constructed.

The main crop in the project area is cotton which cultivation area occupies 41.3 percent of the total area in 1985. Maize cropping is the second largest in terms of land occupancy with 16.9 percent of the total. Soybean and wheat follow with land occupancy ratio of 12.8 percent and 11.5 percent respectively.

Within the gross project area, total 5,000 ha lands between the low water channel and the levees are cultivated by farmers at their own risk. Cropping pattern in these lands is similar to the Lower Seyhan Irrigation project area.

Areas near the sea shore are dunes. Cultivation in this areas is marginal.

(3) Middle to Upper Reaches

Most of the river basin areas of the upper reaches from the Seyhan Reservoir are mountainous and hilly lands. Marginal flood plains are used for grazing and cultivation. Except some points, land uses of adjacent areas to the river are generally inactive from the socio-economic point of view.

Important exceptional points are the canyon of the Çakıt River and its mouth from Pozantı in the Adana Province up to Ulukışla in the Niğde Province and the Municipality of Feke in which town center the branch river of the Göksu River flows. In both areas flash water from nearby mountainous areas flow into the rivers, and massive and fierce water flows cause serious damages on infrastructure facilities and buildings.

In the canyon and its mouth between Pozantı to Ulukışla important trunk highway, E90/D750, and railroad run parallel with the Çakıt River. Residential areas of the Pozantı municipality has not affected by the flood, since they are located in enough high places which are free from flood influence. Some other residential damages were reported during flood time. However, these damages were caused by failures of slopes due to heavy rain.

The city center of the Feke spreads along the river. There are restaurants, shops, a mosque, a school, and housings. Most of them stand where serious flood struck in 1980. Not so long way from Feke to Adana, part of the high water channel of the Göksu River has been used as log stock yard although logs stocked there were one of the main causes of bridge destructions.

2.1.4 Socio-Economy

(1) Administrative boundary concerning the Seyhan River basin

The Seyhan River basin spreads over five provinces; the Sivas Province, the Kahramanmaraş Province, the Kayseri Province, the Niğde Province, and the Adana Province. Furthermore, part of the flood plain in the lower reaches belongs to the İçel Province. However, most part of the Seyhan River basin is covered by the Adana Province. Coverage by the Sivas Province and the Kahramanmaraş Province is especially marginal.

The origin of the Zamantı River is in the Sivas Province. The river flows into the northeastern district of the Kayseri Province, the Pınarbaşı District, and out from the province's southern most district named Yahyalı to the Adana Province. In the Adana Province, the river flows through the Karaısalı District and joins with the Göksu River at the border of the Karaısalı District and the Kozan District. After the joint the Seyhan River passes along with the border and down to the south.

The other main tributary river, the Göksu River, goes down to the south from the Sarız District occupying southern west part of the Kayseri Province. It flows down through the districts of Tufanbeyli, Saimbeylı, Feke, and Kozan in the Adana Province to the western border of the

Kozan District.

Other medium size branch rivers come down from the Niğde Province through the Pozantı and the Karaısalı Districts in the Adana Province. Then they flow into the Seyhan Reservoir at the border between the Karaısalı District and the Seyhan District.

After the Seyhan Dam, the river flow exhibits distinctive border between the Seyhan and Yüreğir Districts in the upper reach, and the Karataş District in the Adana Province and the Tarsus District in the İçel Province in the lower reach.

The City of Adana, which consists of two municipalities of the Seyhan and the Yüreğir, extends its border to the lower coastal line of the Seyhan Reservoir. These municipalities are both district capitals of the Seyhan and the Yüreğir Districts and are delineated by the Seyhan River too. The right bank side is the Seyhan and left bank side is the Yüreğir. The city center is located just beside the Seyhan River in the Seyhan Municipality. New planned housing development is also significant in the Seyhan side.

Provincial and district boundaries are shown in Figure 2.1.4.

(2) *Socio-Economic activities of the project related area*

Since most part of the river basin and significant flood damage areas belong to the Adana Province, focus of the socio-economic conditions is put on the river basin covered by the Adana Province. This is the most possible influenced area by the project.

This area is divided into roughly two areas. One is the City of Adana and the Çukurova Plain which are located in the lower reach from the Seyhan Reservoir. The other is rest of the area which is upper reach basin from the Seyhan Reservoir.

Socio-economic activities in the lower area is much more vital compared to the upper area. According to the 1985 census more than 80 percent of total population in the entire area are estimated to reside in the lower area. The City of Adana which is the fourth largest city in Turkey with approximately 1,000,000 inhabitants, is the political, commercial, industrial, and cultural center of the region. Most of economic activities including industrial, commercial, service, and agricultural activities are significantly concentrated in the lower area. The upper area's representative economic activities are small scale farming, grazing, and logging. This characteristics are similar in further upper basins. As commonly observed, vigorousness of social activities parallels with the level of economic activities. In the City of Adana and its vicinity, many educational, cultural, entertainment, health, and social welfare organizations and facilities exist and they are vital.

The City of Adana and the Çukurova Plain are well connected not only by a well conditioned highway network but also by the air lines and a railroad. The highway network and the railroad link this area to Ankara and İstanbul for the northwest, and GAP (South-east Anatolia Region) area and foreign countries including Syria and Iraq for the east. The highway linking Ankara and the eastern countries is a trunk road in Turkey. Daily flights to and from Ankara and İstanbul enhance the city's accessibility. These transportation means substantially support commercial and service activities, and industrial and agricultural productions.

Positive agglomeration effects are significant in this area and shown in vital population increase. Forecasted population of Adana in 2010 by the SPO report based on 1985 population of 762,000 is 1,878,000 (3.7% annual growth ratio).

The leading industry in this area is the weaves and clothing industry followed by the petroleum and chemical industry. From employment point view, the weaves and clothing industry is the top. The food, beverage and tobacco industry is the second. Then the petroleum and chemical industry appears. This area's main agricultural products are wheat and cotton. Vegetable and fruits productions are also flourishing. Adana is counted as one of the Turkey's primary production centers of cotton and textile which are nation's principal export items.

2.1.5 Telecommunications

Telecommunications networks should be highly reliable since they will be used to collect and transmit data both rapidly and accurately for this flood forecasting and warning system. In such terms, surveys were performed to study the applicability of the current communications facilities in the Seyhan River basin areas to the flood forecasting and warning system planning.

(1) PTT telecommunications network in the Seyhan River basin

The surveys that were obtained as to current situation of the PTT telecommunications facility for the data collection and transmission of the flood forecasting and warning system planning, are described below.

According to the Adana PTT regional directorate, three types of PTT communications lines are present:

(a) Optical fiber cable

The communications lines in Adana City consist of optical fiber cables. Data transmission through these lines is likely to be highly reliable since they comply with CCITT Recommendation G.821.

(b) Micro wave radio communications link

Local cities are connected via micro wave radio communications links. These links are likely to be highly reliable since they comply with CCITT Recommendation M.1020. For the Seyhan River basin, not all cities are connected via micro wave radio communications links; only several cities, such as Adana, Pozantı, Kozan, etc., are connected using these links, and all other cities, towns and villages are connected using the open wire scheme.

(c) Open wire

The communications lines between a majority of the cities, towns and villages along the Seyhan River basin areas, are made up of open wires. These lines are not almost reliable in terms of data collection and transmission.

(2) DSİ telecommunications network

The telecommunications network of the DSİ consists of HF-SSB radio communications equipment, VHF radio communications equipment and VHF walkie-talkies.
The HF radio communications network based on telephone patch is now used for general business communication and flood information exchange between the DSİ general directorate and regional directorates. The VHF radio communications network is now used for general business communication and flood information exchange between the DSİ regional directorates.

(3) EİE telecommunications network

The EİE possesses HF-SSB radio communications equipment, VHF radio communications equipment and VHF walkie-talkies.
The HF-SSB radio communications network is used to perform general business communications between the EİE general directorate and drilling camps, whereas the VHF radio communications network is used to perform general business communications between drilling camps and drilling sites.

(4) DMİ telecommunications network

The DMİ telecommunications network consists of METEOSAT receiving equipment and HF and UHF radio telex communications equipment.
The nationwide meteorological data telex network further consists of PTT telephone lines, and it uses HF radio communications network as its backup network. The UHF radio telex communications network is used to transmit meteorological data between regional directorates and synoptic stations.

(5) Satellite communications

Although Turkish Satellite 1A, the first communications satellite of the Republic of Turkey, was launched Monday night, January 24, 1994, it burnt out because of the Aryan Rocket failure. It is understood that Turkish Satellite 2, the second communications satellite of the country, will be launched in or after July 1994.
According to the PTT satellite communications project team, the satellite communications network based on the new Turkish satellite is going to use a VSAT (Very Small Aperture Terminal) system. They say that the VSAT system, which is currently under planning, will be put into operation at the beginning of 1995.

2.1.6 Electricity

According to the surveys, the current electricity situation in the Seyhan River basin areas is as follows:

(1) Electricity facilities

The electrical energy in the Seyhan River basin areas is supplied by Çukurova Elektrik A.S., the TEK Adana regional directorate and Kayseri ve Civarı T.A.Ş.

(a) Çukurova Elektrik A.S.

Çukurova Elektrik A.S. is a private company and supplies electrical energy to the paper mills, steel iron company, municipalities and other large-lot consumers in Adana, Hatay, and İçel areas.
The total outage time of the power transmission lines due to interruptions in 1992 was 1,389.35 hours, and the power interruptions were mainly caused by system failures, lightning, or electrical insulation trouble. Since a bypass route was provided for the transmission lines, line failures due to interruptions did

not almost occur.

(b) TEK Adana regional directorate

The TEK Adana regional directorate supplies electrical power to the general homes in Adana area.

According to TEK, 1992 was the worst year in the past decade in terms of both the outage time due to power interruptions and the number of times of interruption. In 1992, the total outage time of the power distribution lines and the transformer stations due to interruptions amounted to 19,576 hours, and the total number of times of interruption was 8,839. The interruptions were mainly caused by the disconnection in distribution lines due to the weight of the snow that had become iced.

(c) Kayseri ve Civarı T.A.Ş.

Kayseri ve Civarı T.A.Ş. is a private company and supplies electrical power to the general homes in Kayseri area.

In 1992, the total outage time due to power interruptions and the total number of times of power interruption were 1,198 hours and 135, respectively. The interruptions were mainly caused by the disconnection in distribution lines, or the collapses of the towers of the distribution lines, due to strong winds or the weight of the snow that had become iced.

(2) Current electrical power supply conditions

The following surveys were obtained as to the current electrical power supply conditions in the Seyhan River basin areas:

Adana Region		Kayseri Region	
AC power source, 1¢ :	220 V ± 10%	AC power source, 1¢ :	220 V ± 5%
	50 Hz ± 2%		50 Hz ± 1%
AC power source, 3 ¢ :	380 V ± 10%	AC power source, 3 ¢ :	380 V ± 5%
	50 Hz ± 2%		50 Hz ± 1%

2.2 Present Flood Control

2.2.1 Flood damages

(a) Flood records

Annual peak runoff at major stream gauging stations is listed in Table 2.2.1. The recorded fifth biggest runoffs at Sta. No. 1818 are summarized below.

	No. 1	No. 2	No. 3	No. 4	No. 5
Disch. (m^3/s)	3,800	3,348	2,700	2,200	1,957
Date	28 Mar. '80	3 Jan. '79	19 Dec. '63	9 Jan. '58	29 Apr. '75

Monthly occurrence of peak discharge is tabulated below.

Month	St. 1818	St. 1829	St. 1821	St. 1817
Oct.				
Nov.	1 time		3 times	1 time
Dec.	6 times		1 time	
Jan.	7 times		2 times	1 time
Feb.	4 times	1 time	1 time	
Mar.	9 times	1 time	1 time	1 time
Apr.	14 times	3 times	3 times	3 times
May				2 times
Jun.		1 time		1 time
Jul.		1 time		1 time
Aug.		1 time		
Sep.				1 time

From the above table, it is obvious that flood season is from November to April. Rainfall increases in this season and melting snow boosts up the river discharge. Some annual peak runoffs in summer season are recorded at the tributaries of the Seyhan River basin.

The major flood records are listed in Table 2.2.2. Only the flood in 1980 over-flowed the levee. Other floods damaged the area in the high water channel. The flood in 1980 was the biggest flood and gave the biggest damage.

Flood damage took place not only at the Çukurova plain but also at the upstream area and tributaries of the Seyhan River. Around Feke district, floods hit in 1979 and 1980. The flood in 1980 destroyed 21 buildings and damaged 76 buildings. After the flood, the river bed was widened from 16-17 m to 30 m.

Revetment with stone pitching was constructed at some stretch.

Traffic line of highway road and railway was damaged as listed in Tables 2.2.3 and 2.2.4. Total repairing costs for the damaged structure are 65,400 million T.L for the highway road and 118 million T.L for railway.

(2) Flood in 1980

(a) Flood Description

The seasonal lower limit water level of the Seyhan Reservoir at El. 61.0 m was ended at the middle of March 1980 in accordance with the reservoir operation rule curve. The reservoir was scheduled to impound up to the high water level at El. 67.5 m by the beginning of May 1980. The spillway gates of the Seyhan Dam were opened from 7 March 1980 so that the reservoir water level could be maintained to meet the rule curve. The spillway gate opening clearance was at 0.8 m from 7 to 13 March, at 1.5 m from 14 to 16 March and at 3.0 m from 17 March. Under this gate operation, reservoir water was accordingly spilled out with free-flow status. In spite of the gate operation, the reservoir water level could not be lowered to the scheduled water level because of small capacity of the spillway, as listed below.

Date	14	15	16	17	18	19	20
Scheduled RWL.	61.00	61.00	61.14	61.29	61.43	61.58	61.72
Actual RWL.	62.08	62.09	62.12	62.15	62.16	62.20	62.20

Date	21	22	23	24	25	26
Scheduled RWL.	61.87	62.01	62.16	62.30	62.44	62.59
Actual RWL.	62.20	62.18	62.28	62.45	63.04	63.80

On 24 March 1980, it rained with 15 to 30 mm daily density in most of the basin. On 25 and 26 March 1980, precipitation decreased very much, but atmosphere temperature rose on 26 March 1980. This weather condition accelerated snow-melting. On 27 March 1980, precipitation increased again to above 100 mm daily density in some rainfall stations. Thus, the recorded flood hit the Seyhan Dam on 28 March 1980.

Reservoir water level of the Seyhan Dam and the spillway gate opening clearance were recorded at 1-hour interval during the flood. Spill-out discharge and reservoir inflow were estimated by use of the recorded data, as computed in Table 2.2.5. The computation results are shown in Figure 2.2.1. It is estimated that peak inflow at 6,040 m^3/s took place at around 5 a.m. on 28 March 1980. The reservoir water level reached to El. 67.5 m at 10:45 a.m. on 28 March 1980. The reservoir water started to spill out over the emergency spillway automatically.

Maximum bank-full discharge of river channel was at 2,000 m^3/s for the downstream river stretch of the Seyhan Dam. It is estimated that spill-out flow from the dam exceeded the discharge of 2,000 m^3/s at around 21:00 p.m. on 28 March 1980. The flood water might over-flow above the levee since then. The spill-out discharge continued to increase and reached to the maximum outflow of 2,671 m^3/s at 21:00 p.m. on 29 March 1980. The maximum reservoir water level at 69.72 m was recorded at 16:00 p.m. on 29 March 1980.

Flood inflow volume is estimated at 1,808 million m^3 from 26 to 31 March 1980. Stored water volume in the reservoir is estimated at 390 million m3. The flood is equivalent to 100-year probable flood.

In order to protect Adana city, left-bank levee was destroyed intentionally and artificially at around Sta. 13 km on 30 March 1980, which aimed to discharge flood water into the drainage canal YD5. Flood water over-flowed above the levee at 5 locations of the left- bank levee and at 6 locations of the right-bank levee, on 30 March 1980. Some locations where the flood water over-flowed the levee were collapsed, as listed below.

No.	St.	Location	Status
(Right bank levee)			
1		Near K. Yalmanlı village	Over-flow
2		New Koyuncu village	Over-flow
3	24+000	Between Salmanbey and Dervişler village	Broken
4	40+000	Around Yaramıs	Broken
5	43+000		Broken
6	45+000		Over-flow
(Left bank levee)			
7	13+000	Near Kılavuz village	Artifi. breaking
8	16+000	Downstream of Kılavuz village	Broken
9	21+000	Near Yerdelen village	Over-flow
10	34+000	Near Kılavuz village	Over-flow
11	40+000	Between Ziyamet and Ganime village	Broken
12	47+000	Near Ganime village	Broken

On 2 April 1980, it rained in the basin again. Another small flood hit the Seyhan Dam on 3 April 1980, of which inflow peak discharge was estimated at 2,738 m^3/s. The Seyhan Dam spilled out the flood water at 1,870 m^3/s to the downstream river. Çukurova plain was inundated additionally. The inundated area is shown in Figure 2.2.2 and listed below.

Date	Left bank	Right bank	Total (ha)
30 Mar. '80	8,390	9,280	17,670
31 Mar. '80	5,670	8,600	14,270
1 Apr. '80	0	1,300	1,300
3 Apr. '80	600	8,250	8,850
Between levees			5,000
Total	14,660	27,430	47,090

After the flood, repairing levee and irrigation canals was started. The repairing work is listed below.

Levee	St.	Repairing Date	Emb. Vol. (m^3)
Left-bank levee	16+600	10 Apr. to 17 Apr. '80	6,290
Left-bank Levee	40+000	18 Apr. to 26 May '80	13,170
Left-bank Levee	47+000	25 Apr. '80	125
Right-bank Levee	24+600	16 Apr. to 25 Apr. '80	8,585
Right-bank Levee	40+000	12 May to 20 May '80	8,350
Total			36,520

Irrigation canals, left main conveyance channel, YS6 and YS7 are repaired, either.

2.2.2 Flood control structures

(1) Seyhan River

Depending on land use and population density, flood protection stretch of the Seyhan River is limited to Adana city and the downstream area from there. The upstream river remains as a natural river. Exceptionally, river bank protection at a short distance was made at a tributary of the Göksu River in the town of Feke, and along the Çakıt River near Pozantı city, which flows into the Seyhan reservoir.

The Seyhan River meanders largely from the downstream of Adana city. The river length of the high water channel between the right and left levees is 51 km, while that of the low water channel of the original river bed is 86 km. The groyne structures were constructed at many curved locations in the low water channel. Through experience, the low water channel may have a bankfull flow capacity of 500 m^3/s.

The river levee at the downstream of Adana city was constructed from 1949 to 1953. The total length of the right and left levees was about 100 km. The average levee height was at about 2.0 m. The levee has 3.5 m crest width and 1:3 slope at the river side and 1:2 slope at the land side. The average distance between right and left levees is about 2 km. Originally, the levee was designed to have a flood capacity of 1,200 m^3/s with 1 m free-board. The expropriated land boundary of the levee is at 9 m to the river side and land side, or 18 m in total.

Sluice-ways were constructed at 48+810 km and at 31+882 km at the left bank levee for irrigation intake. Those sluice-ways were not used at present because irrigation channels were developed intensively in farm land. The right bank levee was opened at about 10 km downstream of the Seyhan Dam to function as spillway. The discontinued levee at the distance of 400 m is connected to the drainage canal TD0, that is an old river bed channel, to increase high water channel flood capacity. The capacity is estimated at 400 m^3/s through the flood experience in 1980.

The upstream regulatory structure for irrigation intake was constructed at the location of 2-km downstream of the Seyhan Dam in 1943. The downstream regulatory structure was constructed at the location of 4.5-km downstream of the upstream regulatory structure in 1989, which aims to generate hydropower and to raise river water level in Adana city during summer time. The gates are opened twice a month during summer time to change the stored water and to prevent malaria disease. Those structures crosses the Seyhan River and flood capacity has at 2,500 m^3/s.

The distance between right and left levees in Adana city varies from 300 m to 800 m at present. River improvement project was planned by DSİ to narrow the river width so as to develop the present high water channel as shopping center or recreation center. The river width is designed at 120 m with 1,800 m^3/s flood capacity. The river bank will be retained by concrete wall, and earth fill levee will be embanked above the ground between the Girne bridge and the upstream regulatory structure. River bed will be also dredged to increase flood flow capacity. Adana municipal authority will carry out the construction.

A few buildings have been constructed at the present high water channel. Retaining walls have been constructed between the downstream regulatory structure and the Stone bridge by the Çukurova Electric Company at the time of the construction of the downstream regulatory structure. The existing wall between the Stone bridge and Girne bridge will be renewed or heightened.

The Sarıçam River enters into the Seyhan River from the left bank at the immediate upstream of the Köprü bridge.

(2) Dams

(a) Seyhan Dam

The Seyhan Dam at the immediate upstream of Adana city was constructed from 1953 to 1956, as a multipurpose dam for flood control, irrigation and hydropower.

Major physical characteristics of the dam is listed in Table 2.2.5. The dam is characterized by the design of the emergency spillway. The emergency spillway is located at the right bank. The original right-bank mountain was excavated with 260-m width and crest elevation of the spillway was set up at 67.5 m, while the dam crest is elevated at 72.7 m. The emergency spillway functions to spill-out flood water above El. 67.5 m automatically when the gated spillway can not spill-out a flood. The approach road to the spillway crest was made gentler in 1987 so that a big bus could pass on the crest. The spillway crest was paved at that time also.

The gated spillway is located between the emergency spillway and the dam body. Radial gates of 6 nos. with 7.0 m width x 6.1 m height are installed on the spillway weir. The spillway has the capacity of 2,500 m^3/s discharge.

The power plant is located at the left bank, of which design discharge is 231 m^3/s (3 unit x 77 m^3/s). Irrigation outlet is equipped on the penstock of the power plant, which is connected to the irrigation channel YS1 with 11 m^3/s capacity. On the right bank of the dam, pump station for irrigation intake is located, which is connected to the irrigation channel TS1 with 21 m3/s capacity. No other outlet facility is equipped with the Seyhan Dam.

The reservoir mapping is being carried out at every 5-year intervals by means of echo sounding to estimate the reservoir volume. The results are listed in Table 2.2.6 and shown in Figure 2.2.3. The reservoir storage volume are summarized below, in comparison with the original volume in 1956 and the latest volume in 1986.

Item	El. (m)	Volume ($\times 10^6$ m³) in 1956	Volume ($\times 10^6$ m³) in 1986	Decrease ($\times 10^6$ m³)
Dead Storage	30.0 to 49.0	269	159	110
Active Storage	49.0 to 67.5	948	720	228
Flood Control Storage	61.0 to 67.5	421	366	55
Total Storage	30.0 to 67.5	1,217	879	338

Catchment area of the Seyhan Dam is 19,337 km2. Average specific sediment quantity is estimated at 593 m^3/year/km^2(=338x10^6/30/19,337). In accordance with DSİ investigation, the specific sediment quantity is estimated at 250 m^3/year/km^2 at upper catchment area and at 1,000 m^3/year/km^2 at lower catchment area. It is measured at 380 m^3/year/km^2 at 1818-measurement station.

The sediment volume in the reservoir decreased remarkably from 1980. The Çakıt River, which flows into the Seyhan reservoir, is one of the biggest sediment source. Land reservation in the Çakıt River basin was started with reforestation or constructing check dams from around 1980. Construction activity was so prevailed from 1980 in Adana and Mersin cities that a lot of sand and gravel as concrete material were taken at the reservoir entrance of the Çakıt River. The Çatalan Dam construction was started from 1982 by coffering the Seyhan River. Then, sediment from the upper catchment was trapped at the Çatalan Dam. A big flood did not hit the Seyhan Dam after 1980. They are mainly why the reservoir sediment decreased in the recent decade.

(b) Çatalan Dam

The first investigation of the Çatalan Dam was made in 1966. The 6th regional DSİ office shifted the dam axis toward 8-km downstream from the original dam axis location because of geology. The Çatalan Dam was studied in the Lower Seyhan Master Plan Report in 1980. The flood damage in 1980 harnessed an urgent implementation of the Çatalan dam construction.
The dam construction was started.on 12 February 1982. The construction cost of civil work is estimated at 31 billion T.L including escalation cost and additional work. The contract price for hydro-mechanical and hydro-electrical equipment is 29 million D.M and 1,155 million T.L, equivalent to 9.5 billion T.L. It is scheduled to impound the reservoir and start power generation of the Unit 1 turbine/generator in 1995.

Major physical characteristics of the dam is listed in Table 2.2.5. The reservoir volume is shown in Figure 2.2.4. After the dam completion, the Çatalan/Seyhan Dams will be able to protect the downstream area against 500-year probable flood. The Çatalan Dam will firm up power generation at the Seyhan Dam.

2.2.3 River improvements

The Çukurova plain irrigation project was initiated by construction of the main canal at the right and left bank of the Seyhan River from 1937 to 1947. After the flood in 1975, a part of levee stretch was heightened or reinforced. After the flood in 1980, the levee on the left bank was extended at a few kilometers distance toward the Mediterranean sea to protect two villages.

Tables 2.2.7 and 2.2.8 show the low and high channel profiles for the downsteam river stretch of the Seyhan Dam.

A lot of sediment were deposited in the Seyhan Dam reservoir at about 300 x 10^6 m^3 up to the present, which corresponds to 1.1 times to the designed sediment quantity. While the Seyhan Dam degraded the flood control function, the huge flood attacked the Seyhan Dam at March and April 1980. The peak inflow into the reservoir and the maximum spill-out discharge from the dam was respectively estimated at 6,040 m^3/s and 2,671 m^3/s. The flood invited the destructive damage at the Çukurova plain.

To control floods and utilize water resource more effectively, construction of another multipurpose dam, the Çatalan Dam, was started from 1982. The dam is located at the immediate upstream of the Seyhan Dam. The dam is scheduled to be completed in 1995. The dam is designed to protect the downstream area against the 500-year probable flood by joint operation with Seyhan Dam.

2.3 Present Condition of Flood Forecasting and Warning

2.3.1 Data collection and transmission

The following surveys have been obtained as to the current situation of data collection and information transmission during floods in the Seyhan River basin:

(1) Current overall data collection and transmission

The current data transmission system during floods in the Seyhan River basin can be broadly divided into two sub-systems: a data collection sub-system and a data transmission sub-system. Figure 2.3.1 shows the results of survey of the corresponding situation.

(2) Current kinds and methods of data collection

Data and information on flood control activities can be broadly classified into meteorological information, hydrometeorological data and dam data. Table 2.3.1 gives an outline of the transmission sources, collection intervals and collection methods of each kind of data, based on the obtained surveys.

(3) Current data processing facilities

About eight IBM personal computers and about thirty ARC personal computers are provided in the DSİ 6th regional directorate. The IBM personal computers form a local area network (LAN), and the ARC personal computers are now used by individuals. The inflow volume from dams are estimated using these personal computers, and data is manually entered.

(4) Current flood control activities and organizations

In the event of flooding, a flood control committee, such as that shown in Figure 2.3.2, is organized in the DSİ 6th regional directorate to undertake flood control activities for the rivers currently under the management of this directorate. Also, the ASO shown in Figure 2.3.3 is specially organized to undertake flood control activities for the downstream Seyhan area. Information on these flood control activities is transmitted through VHF radio communications network.

(5) Transmission of evacuation information

Currently, the occurrence of any signs of flooding is reported from the flood control committee of the DSİ 6th regional directorate to the Adana provincial governor. Figure 2.3.4 shows the evacuation message form used in that case. The Adana provincial governor gives directions to each head of official district to undertake evacuation activities for the residents. The provincial governor, after having been informed from the flood control committee to the effect that there are signs of a large-scale flood, convokes the Emergency Assistance and Rescue Committee shown in Figure 2.3.5, and takes the command of the committee during evacuation activities.
If 500 m^3/sec. of water are to be discharged from the Seyhan Dam, then this is informed from the flood control committee to the provincial governor and, at the same time, the same is informed to the Çukurova Radio Broadcasting Station, from which evacuation information is then radio-broadcast to the people living in the downstream area of the dam. Also, the heads of these towns and villages in the downstream area of the Seyhan Dam, after receiving an evacuation order from the provincial governor, use the broadcasting facilities of mosques, patrol cars and military facilities to undertake evacuation activities for the residents.
The current types of information transmitted are listed in Table 2.3.2, and the information transmission system is shown in Figure 2.3.6.

2.3.2 Flood forecasting and warning

In Turkey, the flood forecasting and warning system is not established for the river management, using real time and on-line data transmitting and processing systems.
The methods of flood forecasting in the Seyhan River basin are described as follows;

(1) Reservoir inflow forecasting

Inflow can be forecast by the correlation between downstream water level or discharge and upstream water level or discharge, with the estimated travel time of the flood wave between the two locations. Information on upstream water level can be reported by local observers, by telephone line.

(2) Snow melt runoff estimate

The mean snow melt runoff calculation is carried out for the snow melt duration, estimated by degree-day method.

The methods of flood warning in the Seyhan River basin are summarized below;

(a) No flood warning facilities are installed such as warning station and warning indicator in advance of floods.

(b) Flood information to the public or community is mainly made by public broadcasting such as radio and television.

2.4 Present Condition of Organization and Administration

2.4.1 Introduction

The organizations related with flood control, forecasting and warning are summarized below:

Only the State Hydraulic Works (DSİ) is directly related with floods. Electrical Power Resources Survey and Development Administration (EİE) and State Meteorological Works (DMİ) collect hydrometric and meteorological data, Turkish Electricity Authority (TEK) and Çukurova Elektrik A.Ş. (ÇEAŞ) help the operation of dams and hydroelectric power plants during the flood. General Directorates of Post, Telegraph and Telephone (PTT) and Radiocommunications (TGM) provide communication. In addition to these, other agencies help DSİ during the flood by supplying main power and machinery. In Turkey, DSİ is authorized and responsible for the flood control, forecasting and warning.

2.4.2 Laws relating to flood

(1) The Law No. 6200

Duties and authorities of the General Directorate of State Hydraulic Works are inclusive of "establishing facilities for protection against floods and inundations" as per Article 2, paragraph (a) of the Law No. 6200, and "providing operation of such facilities (including maintenance and repairs)"as per the same article hereinabove, paragraph (g).

(2) The Law No. 7269

The Law No. 7269 comprises the rules relating to the precautions and assistance to be rendered at locations where there are occurrences or possibilities of damages, which are of a degree to affect the public life, in residential areas, on private, private juridical, or public juridical structures or other public facilities (such as channels, bridges, water supply and sewerage facilities), due to earthquakes, fire, landslides, falling rocks, avalanches and floods.

The most prominent characteristics of the flood areas within the scope of this Law is that structures and public facilities will be subject to flood damages of a degree to affect the public life. Inclusion of a flood area in the scope of this Law is subject to compliance with the principles of "The Regulations for the General Rules Relating to the Effectiveness of Catastrophes to Public Life" and to acceptance of such compliance by the Ministry of Public Works and Settlement.

Areas encountering flood catastrophe which possess such characteristics are determined by the General Directorate of DSİ, as per the Article 2 of the Law No. 7269, revised by the Law No. 1051, upon request of the Ministry of Public Works and Settlement, boundaries are determined and reported to the said Ministry, and the Ministry of Public Works and Settlement undertakes to obtain a decree of the Cabinet of Ministers for acceptance and proclamation of such an area as a region subject to catastrophe.

(3) The Law No. 4373

The Law No. 4373 comprises the rules for determination and proclamation of the boundaries of the areas which encounter or may be subject to overflow of lakes and streams which demonstrate high water levels, activities for removal of obstructions such as structures, facilities, trees and similar barriers which obstruct water flow or increase water level and result in overflows within such boundaries, and prevention of re-establishment of such obstructions, works to be executed before and during flood and obligations in this respect.

The boundaries of areas to be included in the scope of the Law No. 4373 are determined by the General Directorate of DSİ and necessary undertakings are made by the Ministry of Energy and Natural Resources to obtain decree of the Cabinet of Ministers.

2.4.3 Works to be performed and responsible organizations

The Department of Study and Planning is responsible for programming and monitoring of the works for establishment and determination of the boundaries of the areas subject to occurrences or possibilities of floods, which are implemented by DSİ Regional Directorates.

In determination of the areas subject to occurrences or possibilities of floods, priorities shall be given to areas which will be included in the definitions and scope of Laws No. 7269 and 4373 and to areas which are subject to high rate of fatalities and property losses. For determination of such areas;

(a) The boundaries of areas to be determined and announced (by proclamation) as regions subject to catastrophe in cities, towns and villages, as per the Law No. 7269 are plotted on reconstruction plans, and if reconstruction plans are not available, on maps or sketches to appropriate scales, and are proposed with a detailed report to the General Directorate.

(b) For areas to be included in the scope of the Law No. 4373 along streams, the boundaries determined by accepting the thalweg of the bed as the axis and with proper distances on the right and left from the axis for a capacity to carry the discharge for a "recurrence interval" as deemed appropriate by the Department of Study and Planning, are plotted on a map to appropriate scale and is proposed with the reasons to the General Directorate.

In areas which shall be included in the scope of the Law No. 4373, when expropriation of structures, facilities and similar obstructions which prevent water flow or raising the water level and eventually resulting in floods, or restrictions of utilization possibilities of the public from the land is taken into consideration, the boundaries of such areas which extend as strips must be kept neither so wide as to disturb the people nor so narrow as to cause difficulties for water flow.

(c) The boundaries in cities, towns, villages and smaller residential areas, important facilities and irrigation areas subject to occurrences or possibilities of fatalities and property losses due to floods, but outside the definitions and scopes of the Laws No. 7269 and 4373 relating to floods are determined in the order of priorities, taking fatalities as the first priority condition.

The boundaries of such flood areas and areas to be deemed necessary to be evacuated in case of flood, are determined in stages according to various discharges. Such boundaries are plotted on reconstruction plans or scaled maps and sent to the General Directorate for approval in a report together with the maps.

(d) Since the areas submerged under water in closed basins vary according to arid and rainy periods, and submerging periods may also be short or long, the area remaining under water, referencing to a level which shall be determined considering the elevation differences in areas submerged during arid and rainy periods and the status of settlement, transport and communication in areas between such two elevations, is determined as a flood area and presented to the General Directorate for approval.

2.4.4 Announcement (proclamation) of flood areas

Procedures relating to announcement (proclamation) of flood areas are implemented by the Department of Study and Planning of DSİ in accordance with the following principles:

(a) After the proposals relating to the Law No. 7269 transferred to the Ministry of Public Works and Settlement become final and decisive, one copy of the decree of the Cabinet of Ministers shall be sent to the relevant Region, and if there are any facilities constructed or to be constructed in that area, another copy is sent to Operation and Maintenance Department.

In addition, the Ministry of Public Works and Settlement, if deemed necessary, communicates to the relevant Governorships for the purpose of announcing the matter to the people living at the flood zone.

(b) After the proposals relating to the Law No. 4373 transferred to the Ministry of Public Works and Settlement become final and decisive, one copy of the decree of the Cabinet of Ministers shall be sent to the relevant Region, Operation and Maintenance Department and relevant Governorship.

(c) One copy of the documents relating to the areas with boundaries determined in stages which are outside the definitions and scopes of the Laws No. 7269 and 4373 shall be sent to the relevant Region, Operation and Maintenance Department and relevant Governorship, after the approval of the General Directorate of DSİ.

(d) One copy of the documents relating to flood areas in closed basins determined in stages shall be sent to the relevant Region, Operation and Maintenance Department and the relevant Governorship.

2.4.5 Establishment of observation stations

Observation stations are included in annual programs through suggestions by the Regional Directorates, proposals by the Department of Study and Planning, and as approved by the General Directorate, and the following principles are taken into consideration in the establishment of them meeting the requirements:

(a) If no observation stations for precipitation, flow and levels (elevations) established by DSİ or other institutions exist at locations encountering fatalities and property losses which were announced as flood areas, the stations to be established at such locations,

(b) In basins where floods in spring due to snow melting are important, snow observation stations,

(c) Especially at dams which also serve for the purpose of flood protection, observation stations for reservoir inflow and outflow necessitated for reservoir operation studies and other observation stations which may be necessary,

(d) In addition, for the purpose of obtaining hydrological data for the planning studies of facilities which may be constructed in the future on streams in the basins which were announced as flood regions but without any facilities of DSİ, observation stations shall be established.

2.4.6 Establishment of warning (alarm) systems

In cases where it is necessary to estimate or forecast flood beforehand, in stream basins or on streams, automatic or semi-automatic warning systems may be established considering the importance of the flood and the characteristics of the basin, upon suggestions by the Regional Directorates, reviews by the Department of Study and Planning and approval by the General Directorate, to be included in annual programs.

2.4.7 Communication systems

(1) Establishment of communication systems

An effective communication system is established between the precipitation, flow and warning stations established in the basins and beds of the streams causing fatalities and property losses, and the division or operation centers to which such stations report.

Taking the importance and characteristics of the expected floods and the status of observation stations into consideration, either wired or wireless communication system is selected and proposed by the Region to the General Directorate. Such proposals by the Regional Directorate are realized upon reviews by the Departments of Study and Planning and Operation and Maintenance, approvals by the General Directorate and included in annual programs.

In addition, considering the conditions of observation stations and flood areas, remote alarm, detection and control systems may also be utilized.

It is not necessary to establish an additional communication system if PTT centers or railway stations are available at the place where observation stations are located. As per the Article 12 of the Law No. 4373 it is obligatory for post, telegrams and telephone centers and railway stations to accept the telegrams and telephone calls for floods as toll-free and urgent, and for officers in charge to send the received text immediately to the designated address.

2.4.8 Preparation of regional flood plan

The plan demonstrates the works to be executed in beds of important streams and creeks within the region before, during and after the flood. This plan is prepared by the Regions and Divisions and executed by the "Flood Council".

(1) Flood Council

Flood Council comprises:

(a) Regional Director as the Head,
(b) Assistant Regional Directors,
(c) Operation and Maintenance Technical Group Manager,
(d) Machinery and Supply Technical Group Manager,
(e) Study and Planning Technical Group Manager,
(f) Relevant Technical Division Managers and Technical Staff.

Flood Council is assembled before November-May period during which flood occurrences are experienced, and the latest in October, and reviews the "Regional Flood Plan". In addition, the Council is assembled as per the instruction of the Regional Director within the flood season, reviews the measures relating to floods and implements into force.

(2) Regional Flood Plan

Regional Flood Plan includes three main parts:

(a) Works to be executed before flood,
(b) Works to be executed during flood,
(c) Works to be executed after flood.

2.4.9 Flood forecasting and organization of early warning system

The most obvious characteristics of the flood areas within the scope of Law No. 7269 is that buildings and public facilities there must have been damaged by flood to such extent as to affect public life. For a flood area to be included within the scope of the said law, it must meet the criteria set out in the "Regulation Concerning Guidelines Regarding the Effect of Disasters on Public Life", as recognized by the Ministry of Public Works and Settlement.

In accordance with article 2 of Law No. 7269, as amended by Law No. 1051, those areas where such a flood disaster takes place will be identified by DSİ upon the demand of the Ministry of Public Works and Settlement and will be notified to that Ministry. Then the Ministry of Public Works and Settlement will take steps to secure that the Cabinet of Ministers passes a decree recognizing and announcing that area as a disaster area.

The proposal to announce an area as a disaster area, due to a major flood affecting public life, may also be submitted by DSİ to the Ministry of Public Works and Settlement. The organization chart of "Emergency Aid and Rescue Committee", concerning the distribution of authorities and duties in Turkey in case of such a flood, earthquake, landslide-etc., is given in Figure: 2.3.5. As shown on the figure, this organization will be headed by the Governor. In such an event, all governmental and municipal institutions and units will be responsible for providing services to the Governor's Office, and all information will be collected in Disaster Bureau. The Disaster Bureau will evaluate the information received from various agencies, will decide the measures to be taken and will issue directives to the Province Rescue and Aid committee for implementation. The Province and Aid Committee will mobilize the relevant units. This organization will be set up in accordance with Law No. 7269. The duties and responsibilities within the organization are governed by Law No. 4373. This law makes it obligatory for every one in the flood area to be engaged in protection activities against flood and to carry out the orders of the highest civil offices of the locality in this regard. The Law also defines the duties and responsibilities of the Governors, District Governors, Mayors, aldermen, directors of relevant institutions and ordinary citizens.

2.4.10 Organization of DSİ and the relevant regional directorates in case of a flood

DSİ is responsible by Law No. 4373 from all flood control and protection activities throughout Turkey, regardless of the extent of flood. DSİ has issued "DSİ Flood Control Instructions-1982" in order to secure that its Headquarters and Field Offices are organized in line with this objective. DSİ's Regional Directorates are organized in accordance with the chart given in Figure 2.3.2 in order to carry out their flood control and protection activities most effectively.

The organization chart given in Figure 2.3.2 is prepared by the General Directorate of DSİ and its Regional Directorates considering the experiences gained in flood protection and fighting measures. All the regional directorates are organized according to this chart for the floods whatever the extent of it is.

The Regional Flood Control Center given in Figure 2.3.3 shows the organization of Adana Regional Directorate applied only for Lower Seyhan Plain floods. Adana Regional Directorate has wide experience in flood protection and fighting and the chart given is prepared as a result of this experience. In our opinion, this organization chart which is still valid for flood protection and fighting in Lower Seyhan Plain is also suitable for future. However, it may be supported by additional staff and equipment depending on the latest technology.

Law No. 4373 provides for the establishment of Flood Control Commissions, which will participate, under the Province Emergency Aid and Rescue Committee, in technical protection and rescue activities in the event of major floods affecting public life. In such an event all governmental and municipal units, including the military as well, will be obliged to act under the Governor (Natural Disasters Law No. 7269).

3. RADIO WAVE PROPAGATION TEST

3.1 *Objective of the Study*

A radio wave propagation test is one of the foremost study to obtain actual propagation losses in a path, environment noise , and etc. The values of theoretical circuit design are corrected by the values all of that are measured by the test. The radio wave propagation is highly dependent on the geographical condition and radio frequency used. If the site land selected proves to be unsuitable as a result of the test, alternative one should be selected to make a reliable radio link.

The objective of radio wave propagation test and site investigation was to gather necessary information about radio path conditions and site conditions and to design tentative radio circuits so that several alternative plans of telecommunication network can be proposed for the flood control, forecasting and waning system for Seyhan River basin.

The test was placed as a part of OJT program for staff of DSİ. In the program, the significance of test and method of test were discussed through the radio wave propagation test.

3.2 Study Area, Routes and Spans

The study area was the whole catchment area of Seyhan River basin. The test was conducted in accordance with a tentative plan of telecommunication network which was drafted by based on the three alternative plans of hydrometeorological network.

3.2.1 Multiplex radio link

Several locations of repeater station were selected by considering proper repeater spacing. Then a study route was drafted. The theoretical circuit design and field survey were conducted at several conceivable locations. The foremost consideration in setting up a multiplex radio link is that line-of -sight transmission is required. In this field survey, the line-of-sight in a path was examined by means of flashing a path by reflecting sunlight off a mirror to the opposite end of the path, or mirror test. The radio paths were studied and evaluated by checking obstructions. The height of obstruction (ridge) in a path was checked with terrain contour maps.

The circuit design was made on assuming that the 2GHz band to be used for the multiplex radio link .

The main study items of multiplex radio link are listed below.

- Survey of site aspects at the conceivable location
- Examination of site location
- Terrain profile
- Examination of line-of-sight condition with a mirror
- Examination of topography condition
- Examination of topography around the reflecting point

3.2.2 Simplex radio link

Several locations of repeater station were selected to connect each gauging station planned. Then a transmission route was drafted. The theoretical circuit design and radio wave propagation test for telemetry system was conducted based on the three alternative plan of hydrometeorological network, and for UHF radio link system was conducted based on the brief design of the system. The test of simplex radio is made by means of measuring the strength of a signal by transmitting radio waves. Radio frequencies used were: (1) 70.26MHz for the test of telemetry system, and (2) 411.7MHz for the test of data transmission system.

The main study items of simplex radio link are listed below.

- Survey of site aspects (radio wave propagation conditions)
- Measuring of receiving power (receiving input voltage)
- Measuring of polarization plane pattern of antenna (horizontal pattern)
- Measuring of height pattern of antenna (height pattern)
- Measuring of signal to noise ratio
- Recording of external noise
- Survey of radio interference from existing radio station

3.3 Test Results and Evaluation

(1) Multiplex radio link

Conditions of line-of-sight were confirmed by mirror test at each test location. The results of field survey for multiplex radio link are summarized in Table 3.3.1.
In some spans the mirror test was unable to carry out due to a limited survey period; theoretical path calculation was made based on terrain profiles. A mirror test including a field survey for the rest of station is required in the future.

Required field survey items in the future are listed below.

- Detailed field survey at each planed repeater station
- Path survey at each station at which the mirror test was not able to carry out during the field survey

The criteria of multiplex radio link are followed in accordance with CCIR (Consultative Committee International Radio) Recommendation 594 and Report 930.

Hypothetical reference circuit for radio relay system: length of reference circuit: 2,500km

Bit error rate(BER) should not exceed the following values.

- Short term: BER 1×10^{-3} during more than 0.054% x D (km) / 2,500 of any month (integration time 1 second)

- Long term: BER 1×10^{-6} during more than 0.4% x D (km) / 2,500 of any month (integration time 1 minute)

(2) Simplex radio link

The test result shows that some stations require countermeasures such as a placement of repeater station or a selection of alternative location. These problems are mainly caused by obstructions existed in the radio path. The problems and their countermeasures are summarized in Table 3.3.2 and Table 3.3.3.

External noise was measured at several stations. The result suggests that the external noise will not significantly affect the radio circuits because the gauging stations and repeater stations are located in remote area where there are less noise sources such as high voltage transmission lines, factories, and vehicles with ignition system.

As for radio interference from existing radio stations, no interference was observed at each station tested on the frequency and the frequency nearby.

The evaluation was made by considering the receiving voltage(calculated and measured value), fading, terrain profile, antenna patterns(horizontal and height pattern), and external noise power in all their aspects. The results of radio wave propagation test for simplex radio link are shown in Table 3.3.4, Table 3.3.5 and Table 3.3.6.

The criteria of simplex radio link are followed in accordance with a standard which is usually applied for telemetry radio link in VHF/UHF band as described below.

(a) Required signal to noise ratio (S/N)

The required signal to noise ratio for telemetry radio link is 30dB which is equivalent to the bit error rate 1 x 10^{-5} for obtaining the required C/N by applying following factors.

- Characteristics of modulation at VHF/UHF radio equipment
- Equivalent of peak noise power
- Distortion margin

(b) The standard signal to noise ratio of simplex radio link (S/Nsd)

The standard signal to noise is set by applying following factors.

- Fading margin
  70MHz band: 0.1dB/km + 3dB
  400MHz band: 0.2dB/km + 3dB

- Compensative value for 2 span connection
  Simplex radio link: 3dB (per span)
  Multiplex radio link: 0.3dB (Telemetry system)

- Other margin (deterioration margin)
  2.5dB

The standard S/N of simplex radio link is shown below.

(b) The standard signal to noise ratio of simplex radio link (S/Nsd)

Telemetry Radio Link 70MHz Band

Number of radio span:	S/Nsd (dB)	Standard distance (km)
Single span	40.5	50
Two span	43.5	50
Connection with multiplex radio link	40.8	50

Telemetry Radio Link 400MHz Band

Number of radio span:	S/Nsd (dB)	Standard distance (km)
Single span	41.5	30
Two span	44.5	30
Connection with multiplex radio link	41.8	30

(c) Required receiving power

The required receiving power at standard S/Nsd (40.5dB) is set by applying noise figure and deterioration by external noise.

Required receiving power is shown below.

Item	Standard S/N(S/Nsd)	Remarks
EN(Ambient conditions in mountain area)	14.7 (NC: equivalent to 5dB)	The measured value can be applied as EN when the data is available.
Standard S/N	40.5dB	
Single span	-88.8dBm	required receiving power

(d) External noise

The noise deterioration (NC) by external noise to the radio circuit design is adopted from the following values listed below.

Frequency Band	Noise Deterioration (NC)	Condition of Location
70MHz Band	5dB	remote area, mountain area, river side(no residential area or road)
	10dB	suburb, near the high voltage transmission line
	15dB	vicinity of national road, cites
	Measured value	urban area(big city), heavy traffic road, industrial area
400MHz Band	2dB	all area except the area described bellow
	Measured value	urban area(big city), heavy traffic road, industrial area

5dB was adopted as a noise deterioration in design of 70MHz band radio circuit.
2dB was adopted as a noise deterioration in design of 400MHz band radio circuit.

(3) Outline of Telecommunication Network

A telecommunication network is drafted based on the test results and technical considerations. The telecommunication network is made up of the combination of simplex radio, multiplex radio and PTT line. The outline of telecommunication network is shown in Figure 3.3.1.

4. BASIC CONCEPTS OF FLOOD FORECASTING AND WARNING

4.1 Objective of Flood Forecasting and Warning

The objective of the Flood Forecasting and Warning is to establish the Flood Protection System in the Seyhan River basin and main items are described as follows.

(1) Flood protection of levees in the lower reaches

Since the levees in the lower reaches are of importance to protect the life of the residents and their properties and agricultural products, it is needed to transmit the accurate information on flood protection to people concerned for the purpose of obtaining the safety of the levees.

(2) Flood control of Seyhan and Çatalan Dams

The optimum comprehensive flood control of the Seyhan and Çatalan Dams have to be established on the basis of the flood forecasting system.

(3) Dam operation for hydroelectric power generation

Dam operations for the hydropower generation can be improved by the introduction of the telemetering system for hydrometeorological observation network.

4.2 Forecasting Items at Base Points

There exist ten conceivable water level gauging stations which can be utilized for the flood forecasting. The forecasting items and treatment of flood forecasting system at base points are summarized below: