MASTER PLAN STUDY
ON
THE IRRIGATION AND DRAINAGE PROJECT
IN
THE ADJACENT AREA TO THE YACYRETA DAM
(SECOND YEAR)

MARCH 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

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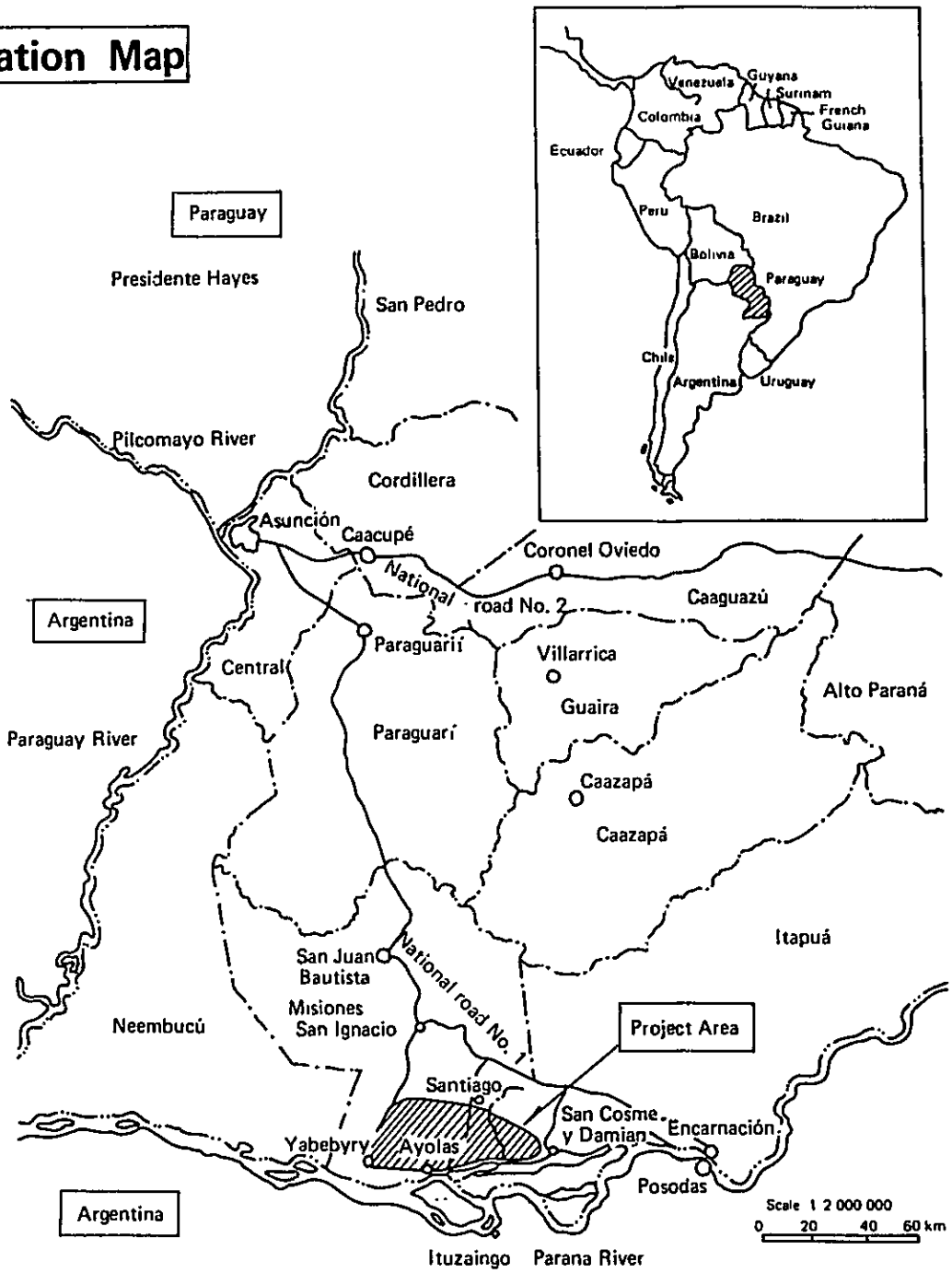
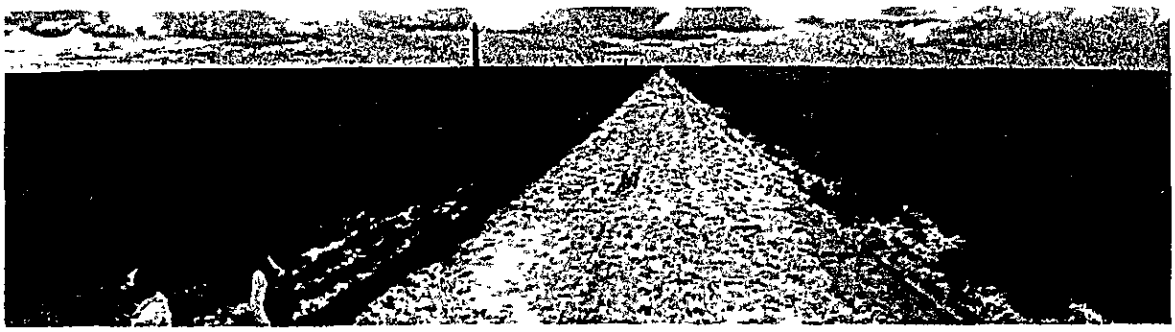
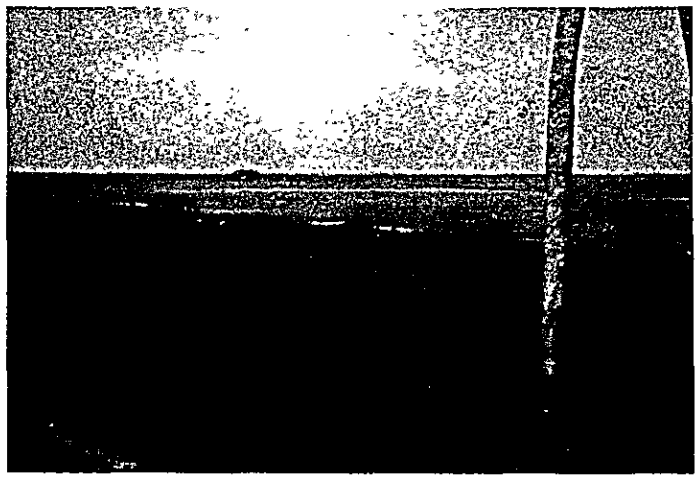
Location Map





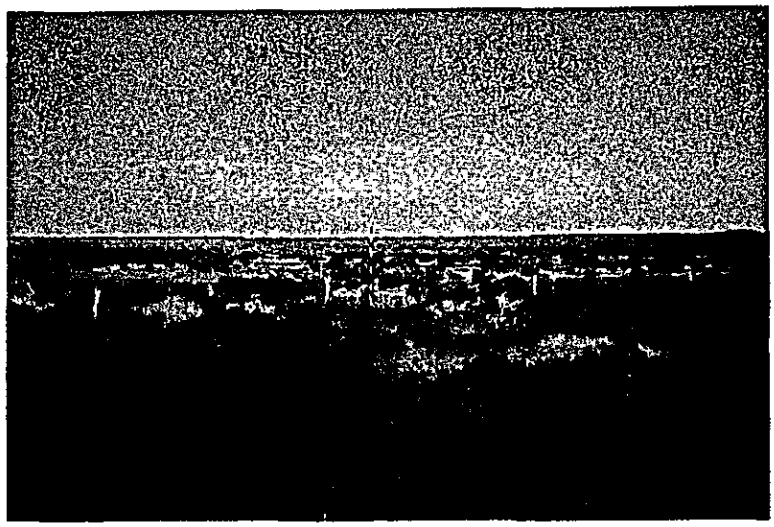
San Ignacio – Yabebyry Road (taken looking north)
The right side (within the project area) is inundated and the previous grazing land is turned into wild land
The left side (outside the project area) is used as grazing land.

Paddy field between Yabebyry – San Ignacio
(area: approx. 10 ha) rice shoots about 15 cm high (the adjacent land to the project area)



Tortoise-shaped cracks occurring in swampy land
Depth: 15 ~ 30 cm
Width: 20 ~ 40 cm
Rainwater accumulates in these cracks after a rainfall.

Road (Ayolas – Santiago)
Control point survey

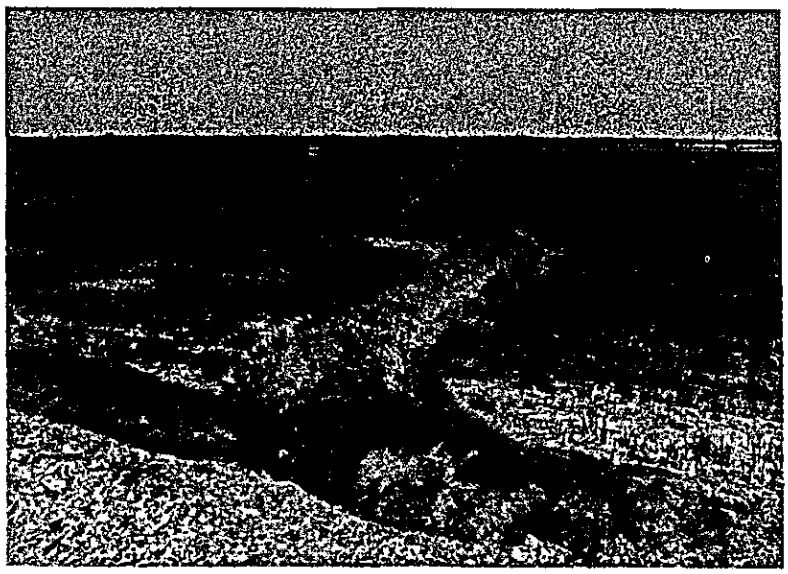


Atinguy River
Estuary River measurement

Caje cué
Autographic water level gage & rain gage
(Tipping bucket type)
(2nd year setting)

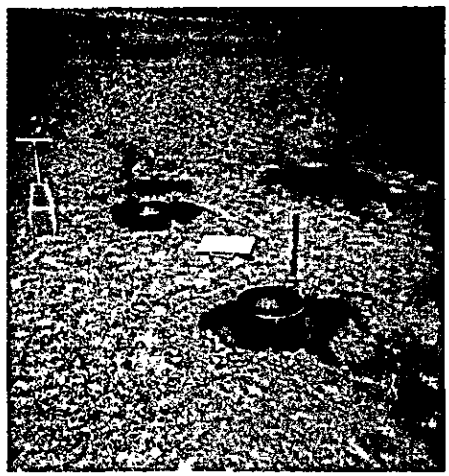
Yabebyry River
Autographic water level gage
(2nd year setting)

Bolf Farm
Conter levee dike
(immediately after construction)



Trying a standard penetration test (at the point of 1.5 km SW from Romero Cué Farm)

Cylinder intake rate Survey at Bolf Farm paddy field (under land preparation)



Abbreviations and Conversion Rates

US$	:	United States Dollars
G.S.	:	Guaranies
1 US$	:	160 GS, (1 GS = ¥1.5 1 US$ = ¥240)
Cr.	:	Cruzeiro
P	:	Peso
MAG	:	Ministerio d Agricultura y Ganaderia
GT	:	Gabinete Tecnico
IAN	:	Instituto Agrónomico Nacional
CRIA	:	Centro Regional de Investigacion Agrícola
CEMA	:	Centro de Mecanización Agrícola
IBR	:	Instituto de Bienesta Rural
DIEAF	:	Direccion de Investigación y Extensión Agropecuaria y Forestal
DIAF	:	Departamento de Investigación Agricola y Forestal
SEAG	:	Departamento del Servicio de Extension Agrícola y Ganadera
SENASE	:	Servicio Nacional de Semilla
AUCA	:	Asociación de Usarios del Credito Agrícola
SFN	:	Servicio Forestal Nacional
CEDEFO	:	Centro de Desarrollo Forestal
F.B.Y.	:	Entidad Binacional Yacyreta
IAGS	:	Inter Americano Geodésico Servicio
IGM	:	Instituto Geogratico Militar
BNF	:	Banco Nacional de Fomento
CAH	:	Credito Agriicola de Habilitación
FG	:	Fondo Gamadero
CORPOSANA	:	Corporacion de Obras Sanitarias
MOPC	:	Ministro de Obras Publicas y Comunicaciones

ANDE : Administración Nacional de Electricidad

ANTELCO : Administración Nacional de Telecomunicaciones

ANNP : Administración Nacional de Navegacion y Puerto

STP : Secretaria Tecnica de Planificación Economica de la Presidencia

PIDAP : Seccion Coordinación Tecnica

Remarks	
	Irrigation Area
	Non Irrigation Area
	Forest Area
	Trunk and Main Road
	Trunk and Main Irrigation Canal
	Main Drainage Canal

Project Name	The irrigation and drainage project in the adjacent area to the Yacyreta Dam
Map Name	General Planning Map
Legend	

1 : 300,000
0 10 km 20 km

CONTENTS

CHAPTER 1

INTRODUCTION

1.1 Progress of the Survey

The Government of Paraguay concluded the Yacyreta Dam Agreement (Tratado de Yacyreta) with Argentine in December of 1973 and planned to construct a huge multi-purpose dam for the main purpose of generating electric power at the Yacyreta Island in Parana river running along the boundary between those two countries, financially supported by the World Bank, Inter-American Development Bank and city banks. Under such circumstances the infrastructures related with dam are now under construction. As the agreement for the construction works of the dam has been concluded, they are about to start the works so as to complete the construction by 1989. Due to the conclusion of Yacyreta Agreement both of the countries have come to obtain the right to take a maximum of 108 m^3/sec of water for agricultural development respectively. The Government of Paraguay planned to develop the agriculture in the areas adjacent to the dam by utilizing the water of 108 m^3/sec. This agricultural development consists mainly of large-scale irrigation agriculture and livestock farming. For Paraguay who basically depends her economic basis upon agriculture and livestock farming, such integrated agricultural development is regarded as a model of integrated agricultural development project in the long-term agricultural policy.

In this relation the Government of Paraguay requested the Government of Japan for a technical cooperation needed to make a master-plan relating to the integrated agricultural development plan in January of 1982. To this request the Government of Japan dispatched a preliminary survey mission to Paraguay in July of 1982 to confirm the intention of the Government of Paraguay, conduct a field survey, and to make the confirmation about the adequacy of cooperation to this integrated agricultural development plan. Based upon the results of the preliminary study, the Government of Japan sent a survey mission covering "the Scope of Works" concerning the integrated agricultural development study, and agreed on "the Scope of Works" with the Government of Paraguay. At the same time the Government of Japan decided to conduct a necessary survey for making the master-plan of integrated agricultural development plan relating to the areas adjacent to the Yacyreta Dam as a part of overseas technical cooperation programs by the Government

of Japan. In accordance with "the Scope of Works" Japan International cooperation Agency, which execute the technical cooperation programs planned by the Government of Japan, determined the enforcement of this master-plan making to be done for three years from 1982 to 1984.

Based upon the results of aforementioned survey and the scope of works, in December of 1982, Japan International Cooperation Agency sent the first year study mission who made such basic studies as the present conditions of the areas to be surveyed, extraction of the problems and the formulation of outline of the project area to be covered by the development plan.

Although the second year study was set to be conducted earlier in 1983, the greater portion of the areas to be surveyed in the second year suffered from a great flood occured out of Parana River and Paraguay River attributable to extraordinary heavy rainfall beginning from the end of 1982. Therefore, prior to the start of the second year survey mission the advance survey mission was dispatched in July of 1983 for the purpose of confirming about the possibility of conducting the second year survey and the problems extracted in the first year. As a result the possibility of conducting a full-scale survey and it's implementation plan were confirmed and, in September of the same year, the second year survey mission was sent for the implementation of the second year survey.

The second year survey mission was given instructions to continue the basic study for the first year in part and to engage in the study for fundamental concept of development and the formulation of outline of the development plan, both of which are regarded as the major content of survey for the second year.

1.2 Purpose of the Survey

By the joint program with Argentine the Government of Paraguay made a general plan to develop the agriculture covering the major contents of large-scale irrigated agriculture and livestock farming in the wide-spread areas on the right-hand side of Parana River by utilizing the water of 108 m^3/sec available from the Yacyreta Dam to be built at the Yacyreta Island situated in the Parana River.

As the basic goals of this integrated agricultural development the achievement of following four items is set.

(1) Production expansion by modern agricultural methods and quality improvement of agricultural and livestock products.

(2) Promotion of settlement for the population increase in the rural areas.

(3) Promotion of resettlement of the farmers living in the areas to be submerged by the Yacyreta Dam.

(4) Production expansion of agricultural and livestock products to be exported.

Thus, the Government of Paraguay regards the integrated agricultural development plan covering the areas adjacent to the Yacyreta Dam as the important part of national economic and social development plan in Paraguay.

In accordance with these basic goals a master plan will be set up so as to implement the integrated agricultural development in the areas adjacent to the Yacyreta Dam. At the same time, in this survey, it should be done to make a proposal for the purpose of promoting the establishment of an implementation methods needed for the realization of integrated agricultural development, transfer of the technology and modern agricultural methods. That is to say, it will be established a integrated agricultural development to realize a high productive agriculture with large-scale irrigation and drainage scheme in the wide-spread areas adjacent to the dam, assuming that the water to be supplied from the dam will be effectively used.

To achieve these goals, in this second year, it is necessary to continue the basic studies, to plan the fundamental concept of development

as key principles for master plan and to make a formulation of outline of projects composing the development plan in succession of last year's study (first year) covering such basic studies as those for the present conditions of the areas to be surveyed, extraction of the problems and rough determination of the areas to be covered by the development plan.

1.3 Implementation Policy of the Survey

1.3.1 Yearly program of the survey

In this survey the study for making a master plan will be implemented for a integrated agricultural development plan of the areas adjacent to the Yacyreta Dam based upon the agreement of the "Scope of Works" signed between the Government of Paraguay and the Government of Japan in September of 1982 for three years from 1982 (first year) to 1984 (third years). The works of this survey will be implemented under the program of works mentioned below, confering with the Government of Paraguay and related organizations.

(1) The first year

Centered on the basic study, the survey will place an emphasis upon the grasping of the present situations to be surveyed, treating the extraction of problems and the rough determination of the areas to be covered by the development plan at the same time.

1) Collection and analysis of existing data
2) Installation of observation equipment for collecting data
3) Fact-finding study regarding meteorology, hydrology, soil, farm management, irrigation and drainage facilities, etc.
4) Rough determination of the areas to be covered by the development plan.

(2) The second year

The basic study for the first year will be continued. Based upon the results of the basic study, a fundamental concept of development will be established in conformity with the basic goals of development and the formulation of outline of development plan will be made.

1) Continuation of the basic study for the first year
2) Formulation of outline of development plan

(3) Third year

On the basis of fundamental concept of development roughly determined in the second year, it will be done to set up a irrigation - drainage plan and land reclamation plan, to make a rough estimate of various costs for development plan, to conduct a economic evaluation of the development plan and to complete an integrated agricultural development plan in the third year.

1) Establishment of the individual programs of irrigation-drainage, land reclamation, farm management, etc.

2) Rough estimate of costs for the development plan

3) Economic evaluation (economic analysis, financial analysis)

4) Set-up of an integrated agricultural development plan

5) Confirmation of the priority order for sub-project development

1.3.2 Principles for the implementation of the second year survey

This year as the second year of survey, with the continuation of the basic study for the first year basically, collection of the necessary data, establishment of the fundamental concept of development by the analysis and study of the data and formulation of outline of the projects composing the development plan will be done.

In order to implement this effectively the results of the second year advance survey must be fully utilized which was conducted this July. There will be a need for the survey to make sufficient discussions with the Government of Paraguay in the process of doing the works of survey and work in coordination with the works of preparatory map from Landsat to be done in another way.

The projects composing the development plan are the structutal elements of the plan. They are generally classified as follows:

(1) Land improvement plan

This means the hard-ware factors in the development plan and consists of irrigation, drainage, land reclamation projects, etc.

(2) Agriculture plan

This is deeply concerned with agricultural production in the development plan and composed of the determination of proposed cropping pattern due to farm management plan and cultivation plan and land use plan.

(3) Economic and management plan

This plan is composed of the following factors;
As to individual agricultural management, regional economy, agriculture economics of Paraguay, formulation of outline of farm management plan

concerning the individual agricultural management body, viewing from the stand-point of national and international market of agricultural products, formulation of outline of circulation plan suitable for national scale, formulation of outline of export plan and so on.

(4) Administrative system

This development plan is the first large-scale irrigation and drainage project in Paraguay. Therefore, there has not been any administrative method by which they can implement such a project. There is a need to take effective administrative measures for implementing this project smoothly. In this connection it is necessary to make effective recommendations against administrative measures the Government of Paraguay will take.

For the formulation of outline of these four plans, in this year preliminary study should be done as a part of survey works which will be implemented in the third year. That is to say, it is necessary to study the scheme of execution and rough estimate of costs of the projects and make them contributable to the works of formulation of outline regarding the projects composing the development plan.

On the other hand there will be a need to make confirmation of the development methods and sub-projects concerning the integrated agricultural development in this area after the formulation of outline of the projects composing the development plan will be made this year.

In consideration of the history of irrigated agriculture in Paraguay and experience of projects implementation, what is more, it will be very important factors for smoothly conducting feasibility study, implementation of detail design works and projects execution from now on to transfer the technologies of the methods for both individual projects planning composing the development plans and fundamental concept of the development plan.

For this reason the works will be conducted, divided into domestic survey, field survey and the survey of neighboring countries for this year.

(1) Field survey

In the field survey the collection of necessary data will be continued in succession of the first year basic study and the dimensions of

program and design will be established based upon the results of analysis for collected data. Technology transfer will be made regarding the methods of development plan by conducting the joint study works with the counterpart of the Government of Paraguay.

(2) Domestic survey

In domestic survey the works of the formulation of outline will be conducted with regards to the projects composing individual development plan on the basis of the dimensions roughly made in field survey. As already pointed out, the individual plans which is classified into four catagories are respectively composed of several individual plans structured and there is a mutually important relationship between them. Therefore, after alternatives are made concerning the individual projects, the conformity will be confirmed by mutual adjustment, making a formulation of outline of an integrated development plan.

(3) Survey of neighboring countries

In this agricultural development plan there will be a need to make research upon the present situations of rice cultivation, research and development, agricultural system and market survey in Brazil which is a great rice-producing country deeply concerned with this agricultural development plan and a great rice-consuming country, being considered to be a potential rice-importing country at the same time, on the other hand it is necessary to make research upon the cultivation methods, processing of agricultural products, storage and quality of rice in Argentine, one of rice-exporting countries, for a formulation of outline of this development plan.

In addition, it has decided to make a survey in the land improvement plan judging from the similarity of natural conditions in these neighboring countries.

1-4 Outline of Survey Activities

1-4-1 Member of supervisory committee

Position	Name	Organization
Chairman	Minoru Nakagawa	Deputy Director General Agricultural Structure Improvement Bureau, Ministry of Agriculture, Forestry and Fisheries
Vice chairman	Isamu Sakane	Director the Land Development Division, the Construction Department, Agricultural Structure Improvement Bureau Ministry of Agriculture, Forestry and Fisheries
Member	Yasumi Yamaguchi	Deputy Director the Land Development Division, the Construction Department, Agricultural Structure Improvement Bureau Ministry of Agriculture, Forestry and Fisheries
"	Katsushi Minegishi	Deputy Director the Animal Production Division, Livestock Industry Bureau Ministry of Agriculture, Forestry and Fisheries
"	Masao Muromatsu	Deputy Director, Development Plan Division, Director General's Secretariat Hokkaido Development Bureau
	Teruyuki Ueshima	Deputy Director, Agricultural Survey Division, Department of Agriculture and Fisheries Hokkaido Development Bureau

1-4-2 Members of the survey team on the irrigation and drainage project in the adjacent area to the Yacyreta dam

Position	Name	Assignment	Present Status
Leader	Kiyoshi YAMASHITA	Leader	Executive Director of Overseas Activities, JALDA
Sub-Leader	Fumio KOBAYASHI	Irrigation	Senior Advisor, Dept. of Overseas Activities, JALDA
Sub-Leader	Hitoshi NAKAJIMA	Drainage	Director, Dept. of Overseas Activities, JALDA
Member	Yukio SUGIYAMA	Flood Analysis	Unit Chief, Development Div., Dept. of Construction
"	Toshiyuku KIYONAGA	Meteo-Hydrology	Unit Chief Dept. of Overseas Activities
"	Shigekazu KOMA	Plant Husbandry & Pedology	Head of Resources Planning Div., Dept. of Planning & Investigation
"	Shozo MIYAKI	Land Utilization	Senior Engineer, Dept. of Special Project
"	Takayoshi KATO	Farming Program	Senior Agronomist, Abukuma-Yamizo Regional Office
"	Naoya SHIMIZU	Livestock	Unit Chief, Farming Facility Div., Kyushu Regional Office
"	Akira ITO	Land Development	Unit Chief, Dept. of Technical Services & Monitoring
"	Kazuo KIMURA	Rural Settlement Planning	Chief Engineer, Dept. of Overseas Activities
"	Masayuki OTA	Agro-Economy	Senior Economist, Dept. of Overseas Activities
"	Tetsuo TAKAHASHI	Environmental Conservation	Adviser, Dept. of Construction
"	Kazuhiko YASUDA	Farming Machinery & Postharvesting	Vice Director, Goyosanroku Reclamation Project
"	Ken NISHIDA	Soil Mechanics	Unit Chief, Development Div., Dept. of Construction
"	Choki KAMEYA	Transportation & Marketting	Senior Economist, Dept. of Technical Survices & Monitoring
"	Yoshiaki OTSUBO	Agricultural System	Chief Engineer, Dept. of Overseas Activities
"	Koji HATTORI	Social Infrastructure	Chief Engineer, Dept. of Overseas Activities
"	Mitsutoshi KUSANO	Structure Planning	Senior Engineer, Kyushu Regional Office
"	Osamu SHIMIZU	Survey & Design	Engineer, Dept. of Overseas Activities
"	Akira MIYOSHI	Survey & Design	Engineer, Nemuro Reclamation Project

1-4-3 Counterparts of Paraguay Side

In charge of	Name	Organization
(Ministry of Agriculture and Livestock)		
General/Coordination	Ing. Conrado Pappalardo M.	M.A.G.
Technical Coordination	Ing. Wilfrido A. Zárate G.	"
General Affairs	Dr. Hermes Sanabria	"
Advisor (JICA Expert)	Ing. Shiro Hirata	
(Yacyreta Public Corporation)		
General Coordination	Ing. Fernando Yaluk O.	E.B.Y.
Technical/Coordination	Ing. Roberto M. Cubas C.	"
(Specialized Counterparts)		
Topograpy	Sr. Benito Salinas	"
"	Sr. Claudelino Fernandes	"
Meteorology	Ing. Menando Grisetti	"
Hydrology	Ing. Miguel A. Leguizamon	"
Soil/land classification	Ing. Ramon Ramirez	"
Irrigation	Ing. Roberto M. Cubas C.	"
Drainage	Ing. Marco Martinez	"
Soil mechanics	Ing. Bernardino Caballero	"
Construction planning	Ing. Carlos Martinez	"
Agriculture and livestock	Ing. Aristides Raidan	M.A.G.
"	Ing. Wilfrido A. Zárate G.	"
Agriculture extension	Ing. Nelson Cesar Leiva	"
"	Ing. Carnelio Vazquez	"
Farming	Ing. Rubén Rolón	"
Farming machinery	Ing. Rubén Duarte	"
"	Ing. Toshimasa Okamoto	"
Livestock and grassland improvement	Ing. Nelson Blanco	"
"	Ing. Osvaldo Raidan	"
Social improvement	Ing. Susana Pussineri	"
Environment conservation	Ing. Juan Albert Lopez	Forestry Bureau

1-4-4 List of Contacted Person

Organization	Name	Position
Ministry of Agriculture and Livestock	Ing. Don Hernando Bartori	Minister
	Ing. Oscar Meza	Director, Technical Cabinet
	Ing. Ricard Sanudio	Chief Secretary, Agriculture Livestock Experiment Extension Planning Office
Yacyreta Public Corporation	Ing. Julio Cesar Mongelos	Chief, Planning Coordination Office
National Experimental Station (I.A.N.)	Ing. Roberto Casaccia	Chief
	Ing. Fatecha	Researcher (soil)
	Ing. Rodas	" (rice cropping)
Asuncion University	Dr. Gonzales Erico	Professor (Pedology)
	Dr. Patrocinio Alonso	" (")
	Dr. Ruben Fretes	" (Grassland)
	Dr. Alberto Oka	" (Breeding)
Japanese Embassy in Paraguay	Tatsuo Yamaguchi	Ambassador
	Shinzo Uchimura	Councilor
	Toshiaki Akakuma	Secretary
	Takashi Fuchigami	Expert examiner
Japanese Consulate at Encarnacion	Tadaharu Ohkawa	Consul
	Toshio Satō	Sub chief
JICA (Asuncion Office)	Toshiro Kojima	Director general
	Takeo Yanagihara	Deputy Director general

Organization	Name	Position
JICA (Asuncion Office)	Masaharu Torii	Head, First Operation Division
	Takehiko Maeda	Head, Second Operation Division
	Chihiro Ohishi	Second Operation Division
	Kenji Yamamoto	"
JICA (Encarnacion Office)	Hitoshi Sasaki	Director General
	Tooru Inoue	Head, Operation Division
	Kenichi Kariya	Staff
	Tetsuya Hayakawa	"
JICA (Yguazu Office)	Akira Kayao	Director General
	Yuji Ishihara	Deputy Director General
	Akira Yokoyama	Head, Operation Division
JICA (Paraguay agricultural Experimental Station)	Takao Okumura	Director General
	Shigenari Koga	Reseacher
Dispatched Expert	Shiro Hirata	Ministry of Agriculture and Livestock
	Sadakichi Yoshida	"
	Akira Machida	CRIA
	Hideo Katahira	"
	Yoshijiro Kokubu	"
	Morio Chiba	"
	Takayuki Serizawa	CEMA
	Yoshio Chikita	"
	Katsuo Itō	"

Organization	Name	Position
Dispatched Expert	Rokuro Ebina	Animal Reproduction Improvement Project in Paraguay
	Sakae Matsuoka	"
	Toshio Satō	CEDEFO

Argentine

Organization	Name	Position
Argentine		
National Grain Committee	Eduardo Enrique Navarro	Technical Director General
Ministry of Public Works	Oscar Moretti	Director, Arid-zone project
Mendosa State	Jorge Horacio Sanches	Head, Construction Division, General Department of Irrigation
	Alfonso Thorres	Staff, General Department of Irrigation
	Cesar Hugo Desa	"
INTA Mendosa State Branch Office	Mario Julio Cesar Oriolani	Laboratory of Soil and Irrigation
	Edmundo H. Escobar	Laboratory of Soil
Japanese Embassy in Argentine	Yuko Ozawa	First Secretary
JICA (Buenos Aires Office)	Shoji Saito	Director General
	Koji Ono	Head, General Affairs Division
	Koji Kawai	Second Operation Division

Brazil

Organization	Name	Position
Japanese Consulate at San Paulo	Soichi Ogasawara	Consul
JICA (San Paulo Office)	Kazu Fusumada	Director General
"	Inohiro Kosuge	Head, Agricultural Information Office
JICA (Porto Alegre Office)	Fujio Kamo	Director General
JICA (Ribeira River Agricultural Development Project)	Hajime Takeuchi	Expert
Cotia Agricultural Cooperative	Hideki Amenomori	Sub-Manager
Secretary of Agriculture Institute of Agricultural Economy	Minoru Matsunaga	Agriculture Engineer
Secretary of Agriculture and Supplying Cabinet of Secretary	Takao Namekata	Technical Advisor
Institute for Rice in Rio-Grandense, Experimental Station for Rice	Sidnei Bicca do Rocha	Coordinator of EEA
S. Morita Office, LTDA	Sakyo Morita	President
International Interchange Fund Sao Paulo Resident Office	Kiyoshi Kadono	Director General

1.4.5 Advisory committee

(1) Purpose of establishment

The economy of Paraguay is basically dependent on the agriculture and forestry category, which play a very important role in the National Economic and Social Development Plan. The development of agriculture and forestry division is generally aimed at 1) increasing the productivity and the production per unit and improving the quality, and 2) improving the living conditions of local population, and rationalizing and preserving the use of natural resources. This agricultural development plan was started by the Government of Paraguay who desired to promote for the purpose of

1) expanding the production by modern agricultural methods and improving the quality of agricultural and livestock products,
2) promoting the settlement for population increase in local area,
3) promoting the settlement of the farmers living in the areas to be submerged under water, and
4) expanding the production of agricultural products to be exported.

However, there does not exist any concrete plan regarding the crops to be introduced into this project areas, type of farm management, outlook for the distribution of products, system and organization needed for project implementation, guidance of farmers after completion of the project and organizations for management. Accordingly, it will not be made feasible unless we will make coordination with the Government of Paraguay in establishing the integrated agricultural development plan of this areas. Therefore, the Committee has been set up in order for the Committee members, who can discuss sophisticated policy in the related organizations, to have the discussions on the matters proposed from the study mission and establish a plan covering the policy acceptable to each of the organization.

(2) Committee members

Committee members are to be appointed by the heads of related organizations, based upon the request from the Minister of Agriculture and Livestock. The Committee members are as follows;

	Name of member	Organization
* Ing. M. S.	OSCAR MEZA ROJAS	GT/MAG
Ing. Ph. D.	RAUL TORRES	DIEAF/MAG
Ing. Agr.	HUGO HALLEY MERLO	IBR
Ing. M. S.	PEDRO GIMENEZ	SEAG/MAG
Ing. M. S.	GUZMAN GARCIA R.	GT/MAG
Ing. Agr.	SHIRO HIRATA	GT/MAG
Ing. Agr.	CONRADO PAPPALARDO M.	GT/MAG

* indicates Chairman

(3) Summary of proceedings

1) The first Committee

a) Date Sept. 23, 1983

b) Themes

1. Choice of crops
2. Farming pattern
3. Distribution of agricultural products
4. Issues in implementing the project

2) The second Committee

a) Date Oct. 24, 1983

b) Themes

1. Farming pattern
2. Distribution of agricultural products

3) The third Committee

a) Date Nov. 24, 1983

b) Themes

1. Confirmation of the matters discussed by the time of the second Committee
2. Trial calculation for each type of farm management
3. Basic concept of the development

4) The fourth Committee

a) Date Dec. 2, 1983

b) Themes

1. Expression of discussed matters in the Committee
2. Fundamental concept of development

1.5 Summary of the Formulation of Outline of the Development Plan

1.5.1 Fundamental concept of development

(1) Background of the survey

Paraguay has the land area of approximately 400,000 square kilometers, the population of 3.17 million (1980), the population density of 8 persons/ km^2, per-capita income of US$1,300, employment rate by agriculture and livestock of 45% and share of agriculture, livestock and forestry in the gross national products of 30% thus, agriculture, livestock and forestry play very important role in GNP.

Soybean, cassava, cotton and corn, which are regarded as 4 major agricultural products in Paraguay, account for 58% of the total agricultural production in Paraguay. The major items to be exported in Paraguay are agricultural products. Out of the total amount 37,200 million Gs, of exports for 1981, cotton accounted for 44% which is ranked first, followed by soybean (16.1%), woods (12.3%) and oil cake (4.8%). On the other hand imports amounted to 91,400 million Gs, of which mining products accounted for 14.5% being ranked first, followed by mechanical equipments/electric appliances (12.4%) and transportation equipments (9.7%). The mainly agricultural product to be imported is wheat, and the production increase project has come to be an important policy for Paraguay.

Thus, as the Paraguayan economy is basically dependent upon agriculture, livestock farming and forestry, an emphasis is placed upon agriculture, livestock and forestry in the framework of National Economic and Social Development Plan. In the same plan general goals have been set up as mentioned below;

1) Productivity increase and improvement of production per unit and its quality
2) Improvements of living-standards of rural people
3) Rationalization of use of natural resources and it's maintenance

The Government of Paraguay is constructing Itaipu hydro power plant in cooperation with Brazil. Regarding the construction of the power plant, the dam construction is already completed and the construction of a plant is now in progress. In succession of Itaipu hydro power plant the Government of Paraguay launched the project of Yacyreta hydro power plant

as a national project in a joint venture with Argentine. In December of 1973 the Government of Paraguay concluded the Yacyreta Dam agreement with Argentine and, at the present time, the related infrastructures are under construction which are deeply concerned with a dam. The dam construction works are somewhat delayed compared to the time-schedule made beforehand. In October of 1983 the contract of construction works was concluded with a construction firm. On December 3, 1983 the inauguration ceremony was held and, then, they were set to enter into the full-scale works.

As the national project this integrated agricultural development plan was made which mainly contains the large-scale irrigated agriculture and livestock by using the water available from the dam to be constructed. This integrated agricultural development is expected to contribute to the achievement of the goals defined in the national economic and social development plan. The basic goals are shown below;

1) Expansion of productivity with modern agricultural methods and the improvement in the quality of agricultural and livestock products.
2) Settlement programs to increase the rural population.
3) Resettlement of the farm population of the submerged areas owing to dam construction.
4) Expansion of productivity of agricultural and livestock products for export.

In order to achieve these goals, the Government of Paraguay requested the Government of Japan to provide them with the technical cooperations needed for the establishment of a integrated agricultural development plan.

In response to this request the Government of Japan sent a preliminary study mission in August of 1982 and also the scope of works mission in September. As a result Japan decided to set up a master plan of the integrated agricultural development covering the areas adjacent to Yacyreta Dam as a part of overseas technical cooperation programs.

(2) Regional Situation

The project area to be surveyed is located at the Southern part of Paraguay and the area covering approximately 150,000 ha extends to a low and swampy place being 60 to 90 meters above the sea level along the

Parana River, spreading over Itapua and Misiones Department. On both the Eastern and Northern sides there lies a hill with the rise and fall of 100 to 150 meters. running the road from Yabebyry to San Ignacio on the Western side. The Southern side is surrounded by the Parana River and there lies a gradual descent toward the South from the North. In the central part of area lies a shallow depression inundated constantly. Toward the West from the road (Yabebyry-San Ignacio) the wide-spread Neembucu swamp spreads down to the confluence of the Parana River and the Paraguay River.

The basin area including a hinterland amounts to 2,577 km^2 and the drainage rivers are confined to the Atinguy and the Yabebyry Rivers. In addition, those rivers are meandered natural rivers with narrow cross-section and, therefore, the project area get inundated at every time of rainfall.

The soil of the project area is classified as Planosols, Gleysols and Regosols, generally being sandy and weak acid soil.

The annualy rainfall at the Yacyreta observation site is 1,516 mm with dry period being the three months of July, August and September where the monthly rainfall is about 90 to 100 mm. Thus the rainfall is fairly evenly distributed throughout the year.

Taking a look at the situation of land use in the area, the pasture land undeveloped accounts for approximately 70%, lakes and unused land 22% and forests 6% respectively. The land being used as agricultural land amounts to approximately 5,000 ha. In the area of approximately 4,000 ha paddy is cultivated of all the agricultural land.

Over 90% of the land of project area is owned by the large land owners who own more than 1,000 ha. Approximately 100,000 ha accounting for two-third of the area is owned by 20 land owners.

In the Department of Itapua the average area of management per farm is 31 ha. The farmers owning 10 to 50 ha account for 40% and the farmers owning 5 to 10 ha account for 25%. On the other hand, in the Department of Misiones the average area of management per farm is 72 ha. The farmers owning 1 to 5 ha account for 35% and the farmers owning less than 1 ha account for 19%. Thus, a greater portion of lands are owned by large land owners.

(3) Fundamental concept

This region is a large expanse of lowland easily inundated by each rainfall for which the improvement of the drainage is one of the conditions essential for its development and effective utilization. The construction of the Yacyreta Dam will provide inexpensive and stable water for irrigation which will give the area a merit which is not to be found in other projects. The project of providing large-scale irrigation/drainage is the first experience in Paraguay and so careful and adequate consideration of the Paraguayan economy, the technological level of agriculture, financial performance and the marketability of the agricultural products are necessary to plan with a high degree of realizability.

Since the population density of Paraguay is sparse the development of such a large scale as this will require agricultural management through mechanized agriculture for the extensive type.

However, the resettlement of the population engaged in small-scale agriculture in the regions peripheral to the area and in the area submerged by the construction of the Yacyreta Dam will require small-scale farm management plans as well.

One of the methods for the development of lowlying land is to provide facilities such as drainage canals and pumps to reclaim all-purpose fields which can be used either as paddy fields or as upland fields. However, Paraguay is one country where the cost of agricultural land is relatively inexpensive because of having wide area for agricultural use and so the final plan for development must be one requiring a suitable project cost which will give economic benefits to the project. Practically most of the project area is at a height above sea level of over 70 m and it is intended that the drainage condition will be improved through the existing rivers enlargement and by the construction of new drainage canals. However, the plan in which partial inundation is allowed at the expecting rainfall must be mapped out, because the plan with no inundation will bring about enormous increase of project cost.

The crops cultivated under the extensive type in Paraguay which is grown even in the areas where the level of groundwater is high, with temporary inundation include paddy rice, upland rice, maize and sugar cane, etc. However, after considering the profitability, paddy rice is selected as the crop to be cultivated in the lowlands. Over 22,000 ha of paddy rice

is cultivated in Paraguay and in Itapua, Missions it accounts for over a 77% share of paddy rice production and it is considered that the farmers in the surrounding area like the Carmen del Parana region are skilled in the cultivation of paddy rice. In the project area a large-scale mechanized paddy rice cultivation with the area of 600 ha, Bolf Farm, has been managed effectively. As measures taken to maintain soil fertility, to prevent for red rice and also to control weeds, the rotation system between paddy rice and ranching is discussed as well as the system taken in surrounding area. Such a crop rotation system is rather popular even in Brazil and Argentine, however, in case of this area with irrigation facilities it is necessary to examine the introduction of continuous cultivation of paddy rice.

In the higher land improved drainage, soybean of one of Paraguayan most important product arable area of which remarkably increase recently, and wheat of import crop are introduced. The rotation system between soybean and wheat has promoted by national policy and prevailing in the Department of Itapua. Small-scale production of vegetables and cotton will be also planned in the third year study.

Of the increased agricultural production in the project area, wheat is used for domestic consumption to lower the level of imports and the soybeans are channeled to the existing export routes. An increase in the domestic demand for rice is also foreseen but a considerable amount can only be sent to the export market. There is the necessity for management so the production cost and quality are on a par with those of Argentine which is the largest rice exporting country in South America.

A standard farm management model must be set up in order to execute agricultural development and there is also the necessity to create a system for the execution of the large-scale drainage irrigation project. The land and settlement systems are items which require the administrative activities of the government of Paraguay and there is the necessity to closely consult between both parties in order to map out the plan with a very high degree of realization.

On the basis of fundamental investigation done in these two years the outlining of development is currently formulated, however, to which the future work of cost estimation and economic analysis will be feed back. The final development policy shall be established in early third year.

The following explains some of the more important items.

1) Project area

The eastern and northern edges of the project area shall be located in lowland areas following a range of hills, having a height above aea level of less than 90 m. To the west is the Yabebyry - San Ignacio Road and to the south is the road running along with the Parana River. The total area of the region is 152,300 ha.

2) Drainage block

Improvement of drainage is fundamental development as this drainage problem is the major obstruction to the land utilization in the project area. The height for the project area is above 70 m, however, there is partially a area of about 60 m height along the Yabebyry River. Accordingly, for the general drainage of the project area, the present Atinguy and Yabebyry Rivers are planned to enlarge and to make new drainage canals system flowing along existing inclination of the land from the north to the south, which drains water directly into the Parana River.

3) Irrigated block

The water source provided by the Yacyreta Dam will give 108 m^3/s of water to the project at a height of 82 m. The location of the main canal must be selected so as to ensure the most effective utilization of the water and the largest possible irrigable area as well as to reduce the numbers of crossing work for the drainage canals. The north part of the project area was selected after due to consideration of these factors. Pumps will be used in parts where a sufficient water level cannot be gained and gravity irrigation cannot be provided.

4) Crop selection and cultivation plan

With respect to the crop for which cultivation in the project area is thought possible, the selection must be made after an investigation into the temperature, rainfall, sunshine, soil, underground water, resistence for inundation and other natural conditions, as well as into other factors such as mechanized cultivation, large-scale farm management, cultivation technology, cultivation conditions and the marketability.

Paddy rice was chosen as the key crop because of its high profitability and its resistance to the high level of groundwater and to the inundation in the lowland areas.

Crops such as soybeans and wheat which have a high marketability

are to be the main crops in the higher areas which are provided with good drainage.

The respective proposed yields are 5 t/ha for paddy rice and 2.0 t/ha for soybeans and 1.6 t/ha for wheat. The paddy fields shall have rotation system between paddy rice and ranching as a countermeasure against red rice, weed control and in order to maintain the soil fertility.

Upland fields are to produce soybeans and wheat and are to be grown green manure for one year cropping every four years, or have fertilized cultivation so that the soil fertility is maintained.

5) Land utilization

The region is situated in the well drained area of high land to the north of the main canal and is to be developed as Area A for upland farming.

The crops as the extensive type are soybeans and wheat and as intensive type horticulture crops and dairy livestock such as vegetables and cotton.

Area B is the region to be developed as paddy fields. The main crops are paddy rice in a rotation system with ranching.

Existing forests will be kept unchanged as a standard rule, and natural banks running along the Rivers of Atinguy and Yabebyry will not be developed as a conservation zone.

Land use plan

	Zone area	Beneficiary area	Note
Area A	33,525 ha	26,820 ha	The beneficiary area accounts for 80% of a total area.
Area B	99,850 ha	79,880 ha	
Forests	18,925 ha	-	
Total	152,300 ha	132,375 ha	

6) Economic and management plan

The scale of farm management is determined by the conditions like the objective amount of income, the capital investment and the settlement policy but it is to be investigated for the following scales and decided upon discussions with the government of Paraguay.

Furthermore, small-scale farming is to be investigated after the basic direction of the government of Paraguay towards it becomes known.

Upland field zone (soybeans, wheat rotation)
100 ha, 50 ha, 25 ha

Paddy field zone (paddy rice, pasture rotation)
1,000 ha
(rice 500 ha, pasture 500 ha)
200 ha
(rice 100 ha, pasture 100 ha)
100 ha
(rice 50 ha, pasture 50 ha)
50 ha
(rice 25 ha, pasture 25 ha)

In case of paddy a farming scale of more than 150 ha (paddy field) is profitable, and 150 ha of farming scale being profitable in soybean and wheat.

Small-scale farm management will be studied in the third year.

The domestic demand for rice will not meet the amount produced and exports will be investigated. Investigations will be made into the production situation and the possibility of exporting to Brazil which the largest rice importer in South America. The import performance of Europe and Africa will also be investigated, in addition to the exporting situation of Argentine which is the largest rice exporter in South America.

Paraguay imports wheat and so the increased production of wheat can be used to offset the domestic demand.

7) Land improvements

An irrigation plan is set up assuming that gross water requirement for paddy cultivation is decided to be 2.6 ℓ/s/ha. The irrigable area should be 39,940 ha equivalent to 50% of Area B and a peak volume of water should be 103.8 m^3/s. Irrigation canal should be an earth canal. In the area where gravity water level is not available for down stream zone, they must raise up the head by pumping facilities.

As the volume of water available from Yacyreta Dam amounts to 108 m^3/s, approximately. 4 m^3/s is to remain unused. However, the remainder of water will be used either in case that the stock-piling area of Yacyreta Public Corporation may be used for agriculture or in case of the upland irrigation by small-scale farm management. Thus, the methods of water use will be determined in the third year.

With regards to the rainfall of drainage plan, an inundation analysis will be conducted by drainage simulation study against the value of 164.4 mm, a daily rainfall of 10 years probability at Yacyreta Observation Station. Drained volume of water per unit should be determined as 0.5 $m^3/s/km^2$. In this case inundated area of more than 30 cm depth accounts for 9%. The sturcture of drainage canal is of earth canal.

The block of land is based upon 500 × 500 m and, in case of paddy field, borders should be established depending on the geographical slope.

8) Sub-project

The area to be surveyed is as wide-spread as 152,300 ha. As it is not effective to develop the whole area at the same time, it is suggested that the zone should be divided into several parts and implemented step by step. It is considered that the methods of dividing are composed of the division by type of construction and one by district. Since in this area it must be made effective by introducing an irrigation system as well as the improvements of drainage, the project should be forwarded generally by district.

By district this area is divided into 3 zone as follows; Eastern zone from the Yacyreta Dam to the Atinguy River covering the area of 43,850 ha, Central zone between Atinguy River and the 10th trunk drainage canal covering the area of 51,075 ha and Western zone from the 10th trunk drainage canal to the border covering the area of 57,375 ha. Considering the geographical conditions, a priority should be placed upon Eastern zone from where water is taken.

1.5.2 Summary of the development plan

(1) Agriculture plan

On planning the integral agricultural development, what should be

considered first of all is to which direction the agricultural policy and foods conditions proceed in a specific country. Before starting the establishment of a master plan in the area to be surveyed, we conducted the survey of food conditions in Paraguay. The results of the survey reveal that most of major agricultural products except wheat are self-supported or exported, food conditions being excellent and stable. It also reveals that this country is lacking in the industrial basis upon which exports are promoted except agriculture. In this sense agriculture plays an important role in this country.

On the other hand the protection and rearing of farmers are encouraged by agricultural policy. In Paraguay where the share of farmers is very high in the total population, a rise of living level by farmers is equivalent to one by the total population to a considerable degree. In other words, a rise of living level by farmers is contributable to the stability of the nation.

When a master plan is made for this area based upon the above, a production of agricultural products for exports and settlement of local population should be especially taken into consideration. Under such circumstances an agricultural plan was established. An agricultural plan must be determined by studying about the economic rationality suitable for the purpose of project, based upon a production foundation brought about by the project. In accordance with this aim we determined the main crops to introduce to this area this year, calculated the production costs trially and conducted a survey of distribution for products. In this order an explanation is made as follows. The main crops to be introduced to this area must be determined in consideration of the following factors.

1. For the crops to be introduced the natural conditions of this area is suited.
2. Cultivation technologies of those crops exist in Paraguay.
3. Those crops are of land utilization type and, so, a large-scale area can be effectively utilized for the crops.
4. It is possible to export those crops rather than to supply in the domestic market.
5. In case of those crops an irrigation effect is high.

Thus, it is understood that paddy rice, soybean and wheat are most suited as main crops. That is to say, all the crops are of land utilization type having a long history of cultivation in Paraguay. In addition, the possibility of exports is very high as for paddy rice and soybean.

In case of the large-scale cultivation of paddy, crop rotation becomes necessary with pasture because of the maintenance of soil fertility, weed control and countermeasure against red rice. On the basis of survey results a crop rotation system will be adopted with paddy cultivation and pasture respectively for 3 years.

When wheat is introduced as a second crop, soybean become the reasonable crops for double cropping because the same agricultural machine can be used for both crops.

As for the main crops determined, each planning dimension of cultivation was determined. The planning dimensions were determined with reference to hearing survey conducted from farmers in the area and results of experimentation made at the experimental stations.

Planning dimension

Crops / Items		Paddy rice	Soybean	Wheat	pasture
Variety		CICA-8	Parana	Itapua 25	Pulse pasture
Period of cultivation		140~150 days	110~130 days	120~140 days	-
Fertilizing	Basal	170~180kg/ha	-	140~150kg/ha	50kg/ha
	Additional	60~70 kg/ha	-	30~40 kg/ha	-
Yield		5,000 kg/ha	2,000 kg/ha	1,600 kg/ha	7,680kg/ha (converted from DM)

Beef cattle feeding by grazing as a second crop of paddy has the restriction coming from paddy cultivation. The reclamation of improved pastures is to be implemented by seeding and fertilizing. A dairy farming will be introduced to supply raw milk within the area 100 km distant from dairy farming center.

Based upon the planning dimension of cultivation determined herewith, trial calculations were made of production costs. When a farm management plan is usually set up, the management scale and estimated earnings of farmers are to have been determined. The crops to be introduced and crop rotation system are often determined based upon such factors. Otherwise, the other factor is sometimes determined after one has already been determined beforehand. In this plan it is considered that there will be few cases in which existing land-owners continue to be farm-owners even after the implementation of the project. It is also considered that the farms will be managed by newly-settled farmers in most cases.

Under such circumstances the types of farm management are presented as a menu herewith. That is to say, trial calculations are made with production costs and profits in several types of farm management (with the difference of cultivated crops and management scale).

Crop \ Managing scale / Item		25 ha	50 ha	100 ha	150 ha	200 ha	250 ha	400 ha	500 ha
Paddy rice	Production cost per ha (GS)	125,744	118,214	118,302	112,989	-	113,001	113,009	113,001
	Profit per ha (GS)	15,256	22,786	22,698	28,011	-	27,999	27,991	27,999
	Profit rate (%)	10.8	16.2	16.1	19.9	19.9	19.9	19.9	19.9
Soybean	Production cost per ha (GS)	59,582	56,105	52,924	49,312	53,409	-	-	-
	Profit per ha (GS)	3,582	105	3,076	6,688	2,591	-	-	-
	Profit rate (%)	-	-	5.5	11.9	4.6	-	-	-
Wheat	Production cost per ha (GS)	63,735	6,0194	58,076	54,631	58,608	-	-	-
	Profit per ha (GS)	265	3,806	5,924	9,369	5,392	-	-	-
	Profit rate (%)	0.4	5.9	9.3	14.6	8.4	-	-	-

Judging from the results, the production cost of paddy rice is higher than that of double cropping with soybean and wheat. As for each of soybean and wheat the production cost is almost equal to half of paddy rice. When studied about the profit by management scale, it is made clear that the management scale of 150 ha bring about the maximum profit for paddy rice as well as soybean and wheat. The decrease of profit is seen as for the scale of 200 ha of soybean and wheat. This is attributable to a slow-down of operating ratio as two more combine were introduced in addition to one due to a lack of capacity.

Viewing from the economy, the management scale of 150 ha is desirous for each of paddy rice, soybean and wheat. In case of scale expansion it is reasonable to expand it by unit of 150 ha.

On the other hand the management scale of 25 ha makes a loss with soybean and wheat. As even 50 ha makes a loss with soybean, the management by less than 50 ha is not desirous. As for paddy rice, however, the management scale of 25 ha makes the profit of more than 15,000 Gs/ha. If extra-income is obtainable from the effective use of surplus of labour and agricultural machines, farm management will be sustained.

As the result of a trial calculation for labour-force plan covering the project area to be surveyed, it is made clear that labour demand and supply are not well balanced in neighboring 5 towns and villages. In Itapua and Missiones Departments Labour force must be obtained firmly. By studying about the possibility of management in the scale of 25 ha for paddy rice, it is made clear that the income of a farmer will amount to approximately 1.2 million Gs including the extra-income and a farm management will be sustained with the total income.

Next, we conducted the survey upon the distribution of products. Out of key crops such as paddry rice, soybean and wheat, more than 50% of wheat consumption (approx. 70,000 ton) are imported. Therefore, the production of wheat is encouraged by the Government's program.

The volume produced in this area is smaller than that of imports. Price does not matter so much because there is the sufficient demand of domestic products due to the production possibility at a domestic distribution price in Paraguy.

Regarding the paddy rice, production a year amounted to approximately 70,000 t/year for the past five years and the paddy rice demand and supply are well balanced in the domestic market. When paddy rice production is started in the project area, exports of paddy rice must be taken into consideration because a production of about 200,000 t/year will probably break the balance of demand and supply in the domestic market. If population increase is considered in Paraguay, an increase of consumption can be expected. In Paraguay paddy rice accounts for most of rice production and, so, irrigation facilities will be needed to cultivate paddy rice. In considering the present situations under which any large-scale irrigation project does not exist except this one, it is foreseeable that an increase of domestic consumption can be supplied by this project.

Taking a look at the balance of domestic demand and supply in Brazil, Brazil transfered to a importing country of rice from the latter part of 1970s. Such a transfer was partly caused by irregular climate conditions because most of rice produced in Brazil was upland rice at that time. Ten years after rice will fall short of approximately 2.7 million ton due to a great population increase. In order to produce rice for the shortage in Brazil, paddy rice cultivation is desired with irrigation facilities rather than instable upland rice.

Judging from the present financial conditions of Brazil, it is difficult to construct the irrigation facilities with which rice will be stably supplied ten years after. The volume of rice produced in the project area to be surveyed will amount to approximately 150,000 ton excluding the domestic domestic demand of 50,000 ton. Brazil has turned out to be a big client as export market.

By studying about production cost and market price, it was made clear that the present production cost is fully competitive in Brazilian market.

Talking about soybean, Brazil owns oil-extraction plant whose scale exceeds her productive power. In spite of the fact that Brazil is the largest producing country of soybean in the world, soybean is imported to operate this oil-extraction plant.

Thus, soybean production turned out to be possible for exports in Paraguay. As the results of calculation including transportation and storage costs, it was made clear that soybean production in Paraguay is feasible in terms of marketability and price.

(2) Land improvement plan

1) Irrigation plan

This irrigation plan is set for the purpose of insuring the stable production of paddy rice as the key crop in the Area B, which dominates a substantial part of the project area.

Evapotranspiration is using the Modified Penman Method, of all the method for the same purpose, for reputed high accuracy of computation. Meteorological data for use in the computation of evapotranspiration will be obtained from the Yacyreta Observatory, which is under the control of the Ministry of National Defence, or, if not available from this Observatory, from the Encarnacion Observatory.

Determination of the crop coefficient for paddy rice which relates duty of water with computed evapotranspiration is based on FAO's Irrigation and Drainage Paper No. 24 Crop Water Requirement. Furthermore, it is assumed for the purpose of computations that the paddy rice to be cultivated is of CICA variety, the sowing is done directly on farm without flooding, initiated on October 20 of the year, and the planted period runs from 140 to 150 days.

The facts of low soil seepage, availability of flat topography for efficient use, and the status of existing paddy fields have led selection the flood irrigation method by means of contour levee.

Water management is carried out in three stages; the initial stage which starts immediately after sowing to just before the tillering of the paddy, the second stage which runs immediately after the tillering to the completion of flooding, and the final stage which is from the end of flooding to drainage of residual water. The initial stage of water management is in fact done at non-flooding condition.

As for effective rainfall, it is decided, as a result of comparison of the various computation methods, to base the determination of effective rainfall on total readily available moisture (TRAM) for the peiod of the initial stage, just as in the case of upland field irrigation, since the paddy rice fields are not yet filled with water. Consequently, a daily rainfall of less than 5 mm represents nil for effective rainfall while of 5 mm or above entails effective rainfall in equivalent to 80% of this precipitaiton. On the other

hands, for the rest of water management period following the initial stage, a daily rainfall of less than 5 mm likewise represents nil while of 5 mm to less than 80 mm and of 80 mm or above mean effective rainfall in the among equivalent to 80% and 64 mm, respectively, of the precipitation.

Water balance calculation for the peak net duty of water and the seasonal total duty of water was made on the basis of rainfall data starting with October 20, 1977 to April 20, 1978. The crop season when the paddy rice planted period has the second smallest effective rainfall in past 10 years. The results are given below.

Peak net duty of water	:	13.4 mm/day or 1.5 ℓ/sec/ha
Seasonal total duty of water	:	1,095 mm/ha

Computation of the designed amount of diversion is based on net duty of water and estimated water loss. Determination of the water loss factor is based on irrigation efficiency. The irrigation efficiency is determined according to various factors of irrigation such as the size and shape of the paddy field concerned, the status of the irrigation system, and the system of water management employed, which are respectively represented by field efficiency, conveyance efficiency, and water application efficiency. As a result of study of the plans for terminal paddy fields in the irrigation system, canal structure, and water management, the field efficiency, conveyance efficiency and water application efficiency of the planned system are respectively rated 80%, 80% and 90%, which determines integrated irrigation efficiency by multiplication, that is:

integrated irrigation efficiency = 57.6% (= 80% × 80% × 90%).

As a consequence, the unit designed amount of diversion is determined at 2.6 ℓ/sec/ha = 1.5 ℓ/sec/ha/57.6%, the amount of peak diversion at 103.8 m^3/sec/ha = 39.940 ha (total area of irrigation) × 2.6 ℓ/sec/ha , and the seasonal total amount of diversion at 437,000,000 m^3 (= 39,940 ha × 1,095.1 mm).

According to the Irrigation Plan, the irrigation facilities is planned to consist of irrigation canals, aqueducts, diversion works,

drops, water level adjustment facilities, and pump stations. The intake work for this irrigation system is to be built under a separate plan which constitutes part of the Yacyreta Dam Project. The determined design of the main irrigation facilities is as follows.

Trunk irrigation canal	:	length 92.0 km, capacity 103.8 ∿ 12.4 m^3/sec
Main irrigation canals	:	eight main canals measure in total length 135.4 km, capacity 0.39 ∿ 21.4 m^3/sec
Pump stations	:	five units, capacity 2.16 ∿ 12.4 m^3/sec, H = 1.5 ∿ 4.0 m
Diversion works	:	eight installations
Aqueducts	:	eight installations (built across the drainage canals)

2) Drainage plan

The development area is subject to permanent inundation. Study of meteorology as well as topographical conditions and proposed cropping patterns indicates that stable agricultural production in the area is dependent on the execution of an comprehensive drainage system.

Accordingly, this year will be devoted to outlining a drainage plan with view to production stability. In this planning, selection is made of the most suitable of plural proposed designs which are expressed in mathematical models for analysis by the simulation technique.

There are a variety of analytical methods for computing the amount of runoff arising as a result of rainfall that can cause inundation in a given topographical area. The Characteristic Curve Method is finally selected as most effective for application to the present case chiefly because that the development area offers no records of actual measurements necessary for calculations by the other methods and that the area is largely topographically flat.

Analysis by the Thiessen Method has led to selection of the meteorological data of the Yacyreta Observatory, which is under the control

of the Ministry of National Defense, as the data on which the determination of rainfall probability and contineous rainfall occurrence characteristics are based. This determination is based on those meteorological data from 18 years ago to date. As a result, simulation is conducted on the assumption that 1/10 probability daily rainfall of 164.4 mm occurs evenly over the period of 12 hours. Moreover, in the second year study, automatic water level recorders and rain gauges were installed and meteohydrological data are being collected now. Then analysis is made on the assumption of rainfall losses being 0 mm, 50 mm, and 80 mm, respectively.

The hinterland is divided into 30 blocks, depending on the topographical features, on a runoff model in which topographical map on the scale of 1 : 50,000 is used.

Discharge analysis in the project area is made by using the method developed by the Agricultural Engineering Research Institute of the Ministry of Agriculture, Forestry and Fisheries, in which the nonuniform flow of drainage in a canal is determined by solving the simultaneous equations for motion and continuation.

Moreover, the project area is hydraulically analyzed on a hydraulic model designed with the bottom height, slope, and berm of canals and the surface elevation of fields, devised on the basis of surveying data and topographical map on the scale of 1 : 50,000.

The optimum cross-section of the planned drainage canal is selected by means of simulation techniques from five cases of canal cross-section designed for different unit amounts of drainage as follows.

Case 1 : the cross-section for a unit drainage of 0.25 $m^3/sec/km^2$ (corresponding to the existing cross-section of the Atinguy and the Yabebyry River)

Case 2 : the cross-section for a unit drainage of 0.5 $m^3/sec/km^2$ (corresponding to the cross-section of draining out in two days the amount equivalent to 1/10 probability daily rainfall)

Case 3 : the cross-section for a unit drainage of 1.0 $m^3/sec/km^2$

Case 4 : the cross-section for a unit drainage of 2.0 $m^3/sec/km^2$

Case 5 : the cross-section for a unit drainage of 3.0 $m^3/sec/km^2$

The planned drainage system is designed to orient north-south the flow of discharge originating in the project area and the hinterland in alternate two systems. The first system allows discharge into two separate main drainage canals as well as into the Atinguy and the Yabebyry River (system I). In the system II all discharge from the project area is guided into the Atinguy and the Yabebyry River mainly. Selection of the better system is made by the simulation techniques.

The design water level of the Parana River is assumed equivalent to the 1/10 probability water level of the design water level for Ita Ibate Dam.

The water level, velocity, discharge, and lateral flow of the canal and the inundation area and the depth of inundation were computed for each of the proposed cases by the simulation techniques.

Analyses of the results of these computations have led to selection of the system I as the suitable drainage system in view of the effect of drainage facilities and the convenience of the staged construction method employed in which the project area is divided.

Studies with respect to conditions of inundation and drainage efficiency have led to determination of the cross-section of the planned drainage canal to be 0.5 $m^3/sec/km^2$ which is expected to result in the project area having about 9% of inundation area with depths greater than 30 cm.

The main drainage canals are designed to be some 350 km in total length, with the total catchment area of 2,577 km^2.

3) Agricultural land development plan

The agricultural land development plan includes outlining a on-farm plan of farm block, terminal irrigation and drainage canals, farm roads, and pasture fences and a road plan.

Studies of the current status of existing farms in the project area like the Bolf Farm and the plan of irrigation, cultivation, farming and settlement formulated in the master plan, have led to selection of a s standard farm block of 500 × 500 meters in the both Areas A and B. These farm block will be divided into field block and lot by levee which will be conducted every year in the process of farming according to the type of crop cultivated.

It is planned to build branch irrigation canal and farm ditch in the paddy fields of the Area B which form the terminal irrigation canal system. In the design of this canal system, these farm ditches are laid upstream of each of the farm block. On the other hand, the branch canals are situated, connecting the farm ditches to the trunk and main irrigation canals, parallelly with one another on either side of a secondary road and one kilometer spaced apart with two rows of farm blocks interposed between each neighboring pair thereof. The farm ditch canals are designed to be constructed in the structure of earth canals, measuring 1.5 meters in bottom width and 0.3 meters in depth. The branch irrigation canals, on the other hand are designed in the structure of earth canals to measure 6.0 meters in bottom width and 0.5 meter in depth.

In addition, it was planned to construct branch drainage canals in the upland fields of the Area A which form the terminal drainage canal system and branch drainage canals and farm drainage ditches in the paddy rice fields of the Area B which also make up the terminal drainage canal system. In the paddy rice fields, each of the farm blocks has an farm drainage ditch at downstream. In the upland fields of the Area A, a catch drain canal is constructed in the course of farming for discharge of the fields drain into the branch drainage canals. These branch drainage canals are situated one kilometer spaced apart with two rows of farm block interposed between each neighboring pair of themselves on either side of a farm road. The farm drainage ditches are of earth canal construction measuring 1.0 meter in bottom width and 0.4 meter in depth. The branch drainage canals, also earth canals, measure 6.0 meters in bottom width and 0.9 meter in depth.

The design of the planned farm road network is such that each farm block is flanked by farm roads on all three sides and by secondary roads on one side. These farm roads will be build to permit the temporary installation of large farm machinery on them and changing of direction for operation. These farm roads are designed to measure 6.0 meters in width, with a banking of earth 0.4 meter thick in the paddy rice fields and with surface leveling without banking in the upland fields.

It is also planned to fence in each of the farm blocks to protect crop against grazing cattle and prevent cattle from escaping.

The density of the designed facilities on farm was computed on model blocks established in the project area. The results are as follows.

Branch irrigation canals	:	21.1 m/ha
Farm ditch	:	20.8 m/ha
Branch drainage canals	:	9.5 m/ha
Farm drainage ditch	:	21.3 m/ha
Farm roads	:	36.0 m/ha
Pasture fences	:	68.8 m/ha

The road plan includes determination of the layout and structure of trunk roads, main roads, secondary roads, and operation/maintenance roads according to their intended purposes.

The trunk roads are designed to extend north-south in the project area and installed along the trunk or main irrigation canals, and some of them may be improved existing roads. They are planned to measure 15.0 meters in overall width, 10.0 meters in effective width, constructed in a pavement of asphalt, gravels or crushed stones, with a banking of 1.0 meter high.

The main roads are to be situated parallel with the trunk or the main irrigation and drainage canals partly for the purposes of facilitate management of these canals. They are designed to measure 10.0 meters in overall width, 7.0 meters in effective width and constructed in a payment of gravels or crushed stones with a banking of 1.0 meter high.

The secondary roads are designed to extend parallel with the branch irrigation canals and one kilometer spaced apart with two rows of farm blocks interposed there between. The overall width; 8.0 meters, the effective width; 6.0 meters, the structure is a gravel pavement with a banking of 0.6 meter high.

The operation/maintenance roads are intended to run parallel with those trunk and main irrigation and drainage canals which are not designed to extend parallel with the trunk or main roads, and are to be constructed in the same manner as a secondary road is.

Trunk roads (8 routes)	:	256 km in total length
Main roads (18 routes)	:	257 km in total length
Secondary and operation/ maintenance roads	:	2,310 km

(3) Other plans

The present land classifications were conducted in order to make a land utilization plan for the project area. These classifications, made on the basis of studies of aero-photos and Landsat data, include soil classifications, topographical features, flooding damage, and forest. These four classification factors were divided into two groups, those which will have varied as a result of development, i.e., flood damage and forest, and those which will not be affected by the execution of development, e.i., soil and topographical features, and separately studied. Fig. 1-5-1 illustrates the results of integrated classification with respect to the development area by soil and topographical features. As shown soil suitable for an upland field is centered in the northern hilly lands while one or a paddy field being found in the central and northern sections of the development area. Since damage of flooding can be eliminated by the proper execution of drainage work, the formulation of outline of a land utilization plan was determined from studies of drainage using the simulation technique for post-development adaptation for those sections which are now subjected to damage by flooding.

The study of social infrastructure was made with respect to the following and the formulation of outline of a socially related plan was determined.

1) Educational facilities
2) Transportation and communication facilities
3) Medical facilities
4) Power service
5) Water supply system
6) Broadcasting system
7) Other related facilities

It is expected according to the rural development plans made in 1979 in Itapua and Missiones Departments that the construction of the Yacyreta Dam will result in an increase of population up to about 20,000 between Ayolas and San Cosme. With this expectation taken into consideration, the social improvement plans from a view point of the infrastructure of society, are demanding the new construction of two primary schools and a junior high school or agricultural college so far as educational facilities are concerned.

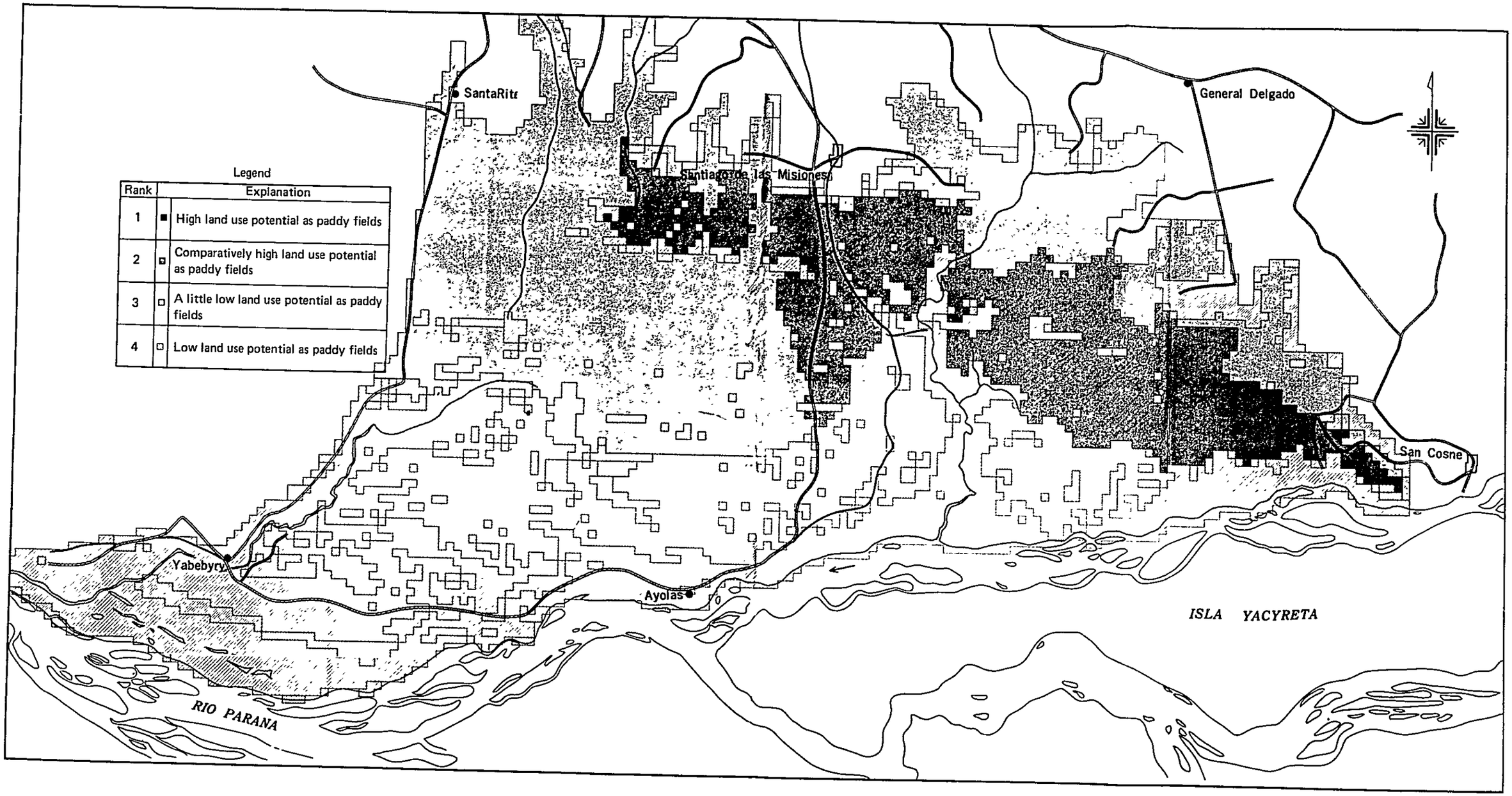
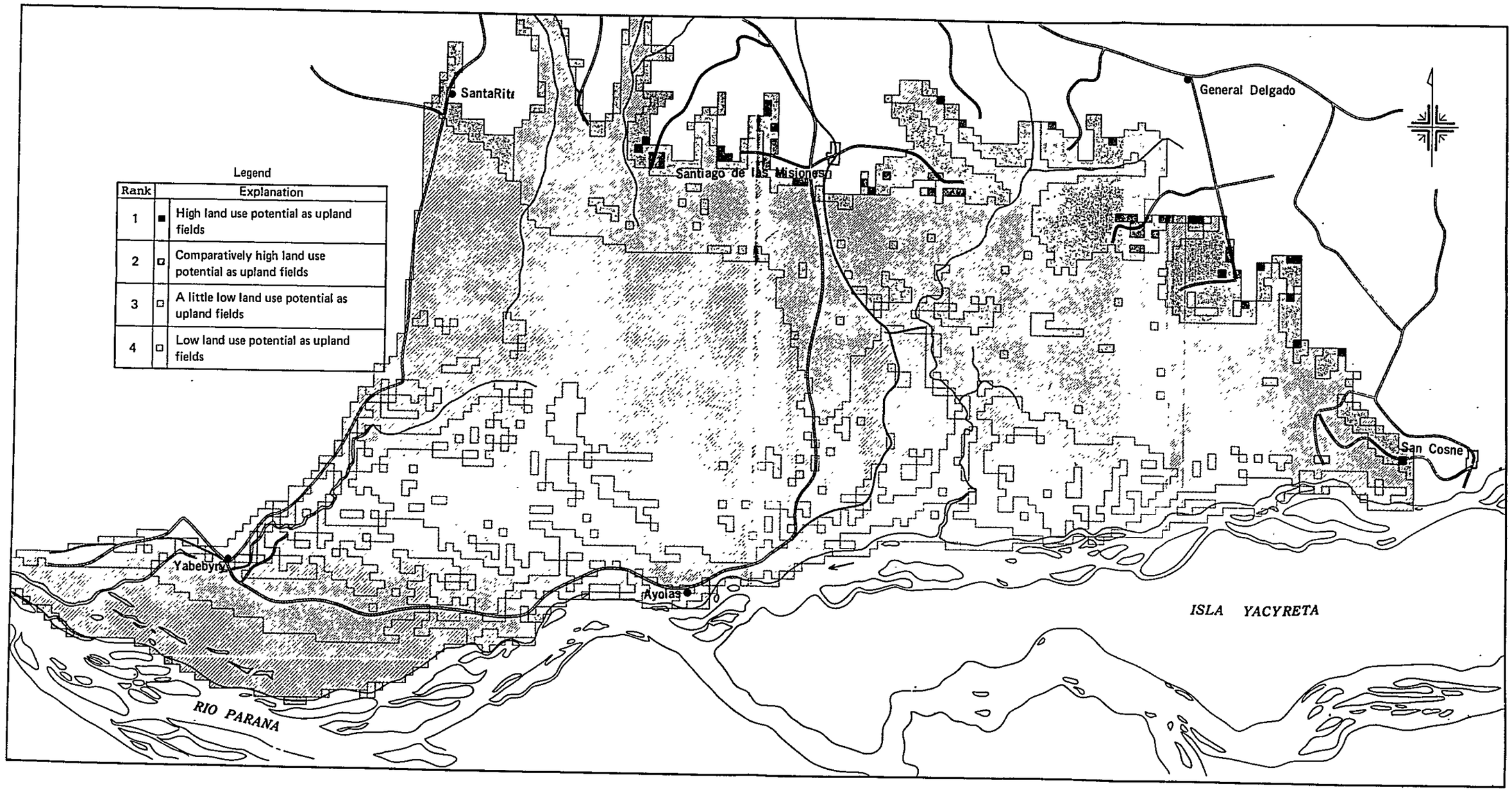


Fig. 1-5-1 (1) Map for the Classification of Land Productivity (paddy fields)

Legend

Rank	Explanation
1	High land use potential as upland fields
2	Comparatively high land use potential as upland fields
3	A little low land use potential as upland fields
4	Low land use potential as upland fields



0 5 10 15Km

1 : 250,000

Fig. 1-5-1 (2) Map for the Classification of Land Productivity (upland fields)

It is also planned that the medical center of the Yacyreta Public Corporation will establish branch medical institutions in Ayolas, Yabebyry, and San Chiago.

The electricity plans which are developed for effective use of the power which will be generated by the Yacyreta Dam now under construction include the laying of power transmission networks which, in rural electrification of, supply power to the irrigation pumps and water supply pumps.

In the water supply plans the water requirements are to be met by the capacity of existing water plant in conjunction with a small water supply system, if necessary, which will be constructed. The projects also include the construction of desired facilities such as an agricultural experimental station, a seed center, a repair center of agricultural machines, and a storage system for rice, wheat, soybeans, etc.

The environmental conservation plans concentrate restoration of forests, growth of forests for agricultural use, and evaluation of the role of forests in the conservation of agricultural facilities, while avoiding lumbering with view to compliance with Forest Law.

In addition, the preservation of animals inhabiting the Yacyreta Island was discussed with the Yacyreta Public Corporation and it was decided to establish a reserve for wild animals outside the project area.

1.6 The Scope of Future Study

The master plan placed in the first year emphasis, while centering on the results of basic studies, on grasping the current status in those survey areas in order to determine the scope of problems to be considered and the formulation of outline of a development area. In the second year, the basic studies were maintained to collect additional data and make analyses on these data. On the basis of these data, also, the fundamental concept of each planning for development projects was determined. In the third year, the formulation of a land utilization plan, agricultural plan, irrigation and drainage plan, and agricultural land development plan are made in accordance with the fundamental concept of development projects. These projects are evaluated with respect to projects cost incurred and benefits they will bring about and from an economic point of view. Then, a integrated agricultural development project is established. Moreover, as a result of classification of the development area into divided sections, the project will come with sub projects for application to the individual divided section and the order of priority of execution will be determined.

As stated above, the studies will be specialized in the third year. The projects cost and benefits which will be calculated next year should be feeded back to the outline of projects formulated this year and the final development project will be determined as one effective and adapted to the regions. We will now describe important points which demand particular attention from the view point of the results of previous surveys.

(1) Cultivation and farm management plan

This year, the scope of study is to be confined to key crops products. Consequently, the production costs and farmer's income from proposed production of paddy rice, soybean and wheat, raised on different farming pattern or management scales, were estimated. In the low-elevation part of the development area (called Area B with a total area of about 80,000 ha) where irrigation is possible, the designed farming pattern is a basic rotation of paddy rice and pasture. In the high-elevation part (called Area A with a total area of about 27,000 ha) it is a basic crop rotation of soybean and wheat.

Apart from the above mentioned crops, there are other products which are effectively raised on large scale farming such as sugarcane

and corn. These crops are not regarded to claim the position of stables from the standpoints of natural and economic conditions. Projects for producing them as secondary crops are a consideration.

For the third year consideration is made of a cultivation plan and farming plan for main crops raised by the intensive method on small management scales.

(2) Farm product market

In this year the demand and supply of key crops, i.e., paddy rice, soybean, and wheat was studied. Wheat poses no market problems since it has a regular domestic market. Since there is in these years a progressively increasing demand for soybean in the overseas markets, increase in supply from the future production of soybean in the development area will without difficulty find outlet through the existing trade routes. As for paddy rice, Brazil has in these years been an importer of large amounts of paddy rice and is highly expected to be so for years which follow. However, Brazil is basically an agricultural country and may come to meet the national demands with increased production of paddy rice. A permanent export policy is to find a market in European and African countries which are perpetual importers of paddy rice. To this aim, it is necessary to study the conditions of importation, the taste and the trade restrictions of prospective importers among these countries.

(3) Operation and maintenance of trunk irrigation canals

The trunk irrigation canals will be such in design that water diverted from the Yacyreta Dam flows from east to west on the north side of the project area. The canals are designed to allow water to flow from an upstream point where the peak flow is at 108 m^3/sec through the entire course of some 10 kilometers with a gentle gradient, in fact, a very much grand-scale canal system with no precedence. Consequently, their design requires a wide range of studies including hydraulics. Moreover, in the design of the irrigation system under the project, the method of diversion of irrigation water, flow adjustment by means of the check gate and flow control upon rainfall require careful consideration including other method of water management.

(4) Simulation of drainage

The plan for drainage in the development area has been established

in a formulation of outline of design in this year, which was based on study of the designed amount of drainage, the cross-section of the drainage canal, and the condition of inundation by means of simulation of drainage. It should be noted, however, that this simulation was for the most part based on data obtained by measurements in Japan but not on site in the development area of Paraguay on account of limitations on available time. It is expected therefore to repeat the simulation using the data from actual measurements on site for the third year, with further study of inundation conditions for the purpose of reflecting more detailed facts in land utilization plan.

(5) Settlement plan and projects system

Paraguay has ever made no national project for so large-scale irrigation before. The present project is the first large-scale agricultural development plan to Paraguay. Consequently, the execution of this project requires considerations not only at the technical level but also communications and relations at the administrative level.

The Paraguay government itself locates this project as a national project. Opinions are exchanged between the Government and the Mission to further the progress of affairs through the established Advisory Committee whenever problems arise which require administrative solution. Following the second year, it would be necessary in 3rd year to make a practical project for settlement in the development area and establishing an institution for enterprises in cooperation with the Paraguay government.

CHAPTER 2

GENERAL PROJECT RESEARCH

2.1 Meteorology and Hydrology

2.1.1 Meteorological observation facility

As meteorological observation facilities in the neighborhood of the Yacyreta area, the Meteorological Department, Ministry of National Defence has three observatories and the Yacyreta Public Corporation has five such stations. Of those run by the department bureau, the Encarnation Observatory started oepration in 1940 and its 43 years history is longer than other government-operated observatories. The stations in San Juan Bantista and Yacyreta were established in 1963 and 1975 respectively.

Existing meteorological observation facilities are located in a way to surround the survey area. In Yabebyry located in the southwestern part of the area, no meteorological facilities or equipment except for a rainfall gage existed, and so our survey mission was to install a water level gage. Because of this, a meteorological observatory was created at a time when the first-year survey was launched.

At the same time, during the second-year survey, an automatic water level gage was installed at two sites in an attempt to increase the accuracy of area inundation analysis in drainage simulation tests. (at the junction of access road 1-B and the Ingua River and the junction of the Yabebyry-San Igunacio road and the Caje Cue River)

The installation of these new equipment enabled networking of meteorological data obtained in the survey areas. Refer to Fig. 2-1-1 and Table 2-1-1 for the location of these meteorological observation facilities and observation equipment, respectively.

The meteorological observation facilities installed during the latest survey are supervised and controlled by the Yacyreta Public Corporation.

2.1.2 Water level observation facility

As water level observation facilities in the vicinity of the survey areas, the Yacyreta Public Corporation has four automatic water level gages, but only such gage, installed near the estuary of the Atinguy River (at the pier of a bridge at the intersection with a road linking Ayolas to San Cosme y Damian), served the areas we surveyed this time.

About 60∿90 meters above the sea, the survey areas are a swampy flat area, with a gradual north-to-south slope. Since the central parts of a

Table 2-1-1 List of Observation Instruments in Meteorological Observatory

Observatory	Rainfall	Temperature • Humidity		Wind	Atmospheric pressure	Evaporation	Sunshine hours	Remarks
		Max. and min. temperature	Hygrometer					
Encarnacion	Automatic Pluviometer (float type) / Cylindrical pluviometer } Both equipped	Fuess type thermometer / Thermograph } Both equipped	Ventilated hygrometer / Thermograph } Both equipped	Vane anemometer / Robinson type anemometer } Both equipped	Automatic barograph / Mercury barometer } Both equipped	Large type evaporimeter / Balance type evaporimeter } Both equipped	Cambell stockes sunshine recorder	8 times a day, observed
San Juan Bautista	"	"	"	Anemometer	"	Balance type evaporimeter	"	8 times a day, observed
Yacyreta	"	"	"	Anemometer	"	—	—	6 times a day, observed (anemometer will be equipped in second year)
Santa Rosa	"	Fuess type thermometer	Ventilated hygrometer	—	—	—	—	3 times a day, observed
Gral Delgado	Cylindrical pluviometer	"	"	—	—	—	—	"
Carmen del Parana	"	"	"	—	—	—	—	"
San Cosmé y Damián	Automatic pluviometer / Cylindrical pluviometer } Both equipped	"	"	—	—	—	—	"
Ayolas	"	"	"	—	—	—	—	"

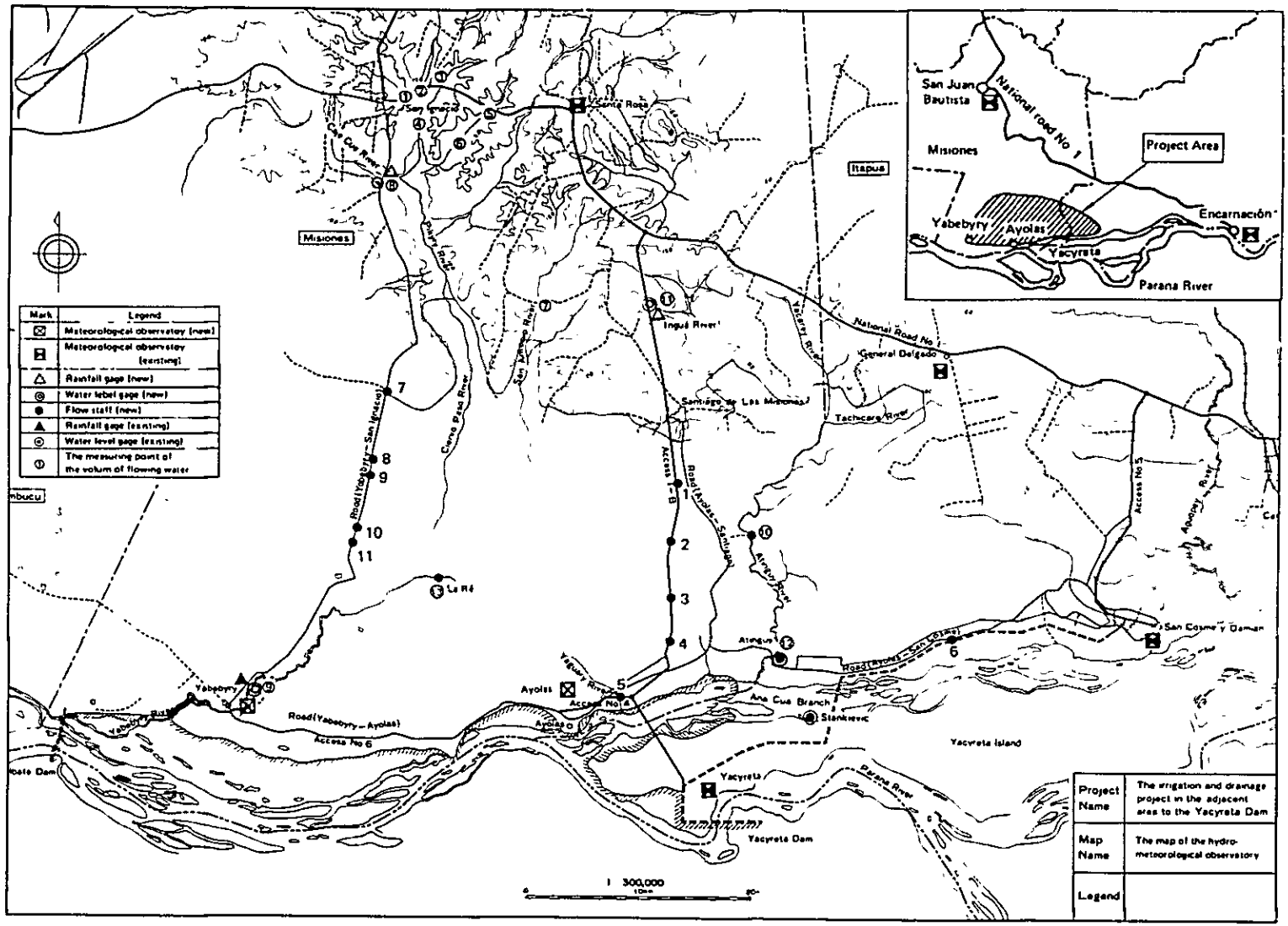


Fig. 2-1-1 Location of Meteorological Observation Stations

Table 2-1-2 List of Observation Instruments (newly equipped) in Meteorological Observatory and Hydrologic Observatory

Observatory	Rainfall	Wind	Evaporation	Duration of sunshine	Temperature	Water level	Remarks
Yabebyry (Public Work Army, Ministry of National Defence)	Pluviograph (three months recording) Cylindrical Pluviometer	—	Evaporimeter (7 days recording)	—	Thermometer (bar type)	—	Equipped in first year (Observation starts at Mar. 1983)
Caje Cué river	"	—	—	—	—	Automatic water gage	Equipped in second year (observation atarts at Dec. 1983)
Ingúa river	"	—	—	—	—	"	" " (")
Yacyreta island (Meteorological Department, Ministry of National Defence)	—	Vane anemometer	—	—	—	—	" " (")
Yabebyry river	—	—	—	—	—	Automatic water gage	" " (")
Ayolas á (Yacyreta Agency)	—	—	—	Sunshine recorder (7 days recording)	—	—	Equipped in first year (Observation starts at Mar. 1983)
Access road 1-B	—	—	—	—	—	Water gage (5 points)	" (Observation starts at Apr. 1983
Sun Ignacio ∿ Yabebyry road	—	—	—	—	—	" (5 points)	" (Observation starts at Mar. 1983)
Ayolas ∿ Sun Cosmé road	—	—	—	—	—	Water gage (1 point)	" (Observation starts at Apr. 1983)
La ré	—	—	—	—	—	Water gage (1 point)	Equipped in second year (Observation starts at Dec. 1983)
Listoro	—	—	—	—	—	Water gage (1 point)	" " (Observation starts at Nov. 1983)

dish-shaped area are constantly inundated, water balance analysis was necessary to the extent it would cover surrounding the area in order to formulate a development program.

Therefore, we installed a total of three automatic water level gages during the survey this year -- on the Caje Cue River running through the survey areas (combined with a rainfall gage), on the Ingua River (combined with a rainfall gage) and on the Yabebyry River flowing out of the survey areas into the Parana River.

Also, in order to elevate accuracy in drainage simulation tests, staff gage were installed during this year's survey in the constantly inundated Listoro on the midstream of the Atinguy River running through the center of the eastern part and in La Re located on the Yabebyry River, the river flowing through the center of the western part.

The data from the newly installed observation sites are presently being collected, so cannot be used in analytical works during this year's survey. However, with observation operations due to be launched continuously, they, coupled with subsequent data, will prove effective for the third-year's survey and feasibility studies in later years.

The location of these hydrological observation facilities are shown in Fig. 2-1-1, while observation equipment are given in Tables 2-1-1 and 2-1-2. The Yacyreta Public Corporation's office in Ayolas supervises and controls the hydrological observation facilities installed during the latest survey.

2.1.3 Analysis of meteorological and hydrological data

(1) Collection of meteorological data

In Paraguay, Meteorological Department, Ministry of National Defence has direct responsibility for meteorological observation. The data collected by all local observatories are sent to the Department, and manually organized and reviewed, the fact that costs much time in putting them together.

The data obtained at the observatories in Santa Rosa, Gńal Delgado, Carmen del Parana, San Cosme y Damian and Ayolas are being organized at the Yacyreta Public Corporation. Yet even these meteorological data are once sent to the Meteorological Department, Ministry of National Defence,

Table 2-1-3 List of Meteorological Data Collected and Station

Observatory	Location		Organization	Collected data	Observation period	Remarks
Yacyreta	South latitude West longitude Elevation	27°24'00" 56°27'00" 86 m	Meteorological Department, Ministry of National Defence	Temperature, Humidity, Rainfall	Jan. 1981 ∿ Sep. 1983	
Sunta Rosa	South latitude West longitude	26°53'15" 56°50'55"	Yacyreta Agency	Temperature, Rainfall	Jan. 1983 ∿ Aug. 1983	
Gŕal Delgado	South latitude West longitude	27°07'05" 56°23'52"	"	"	Aug. 1982 ∿ Aug. 1982	
San Cosmé y Damián	South latitude West longitude	27°18'59" 56°19'44"	"	"	Aug. 1982 ∿ Aug. 1983	
Ayolas	South latitude West longitude	27°23'27" 56°48'22"	"	"	Aug. 1982 ∿ June 1963	

which relays them back to the Corporation, wherein to review and systematize for feed-back to the Department. The Department putting an end of th this complicated procedure, keeps them in custody.

Table 2-1-3 shows contents of the meteorological data collected by individual local observatories during the latest survey.

(2) Collection of hydrological data

1) Water level recording

Local residents are asked by the Meteorological Department, Ministry of National Defence to observe the water levels of the Atinguy River, while those of the Parana River are being checked and surveyed by the Department staff assigned to Yacyreta Island. Material and data on the water levels of the Atinguy River was collected during the January-August period of 1983, with data from February to September of the same year on the Parana River, being obtained from the Yacyreta Public Corporation.

Data on the observatory data at the 11 staff gage installed during the first-year survey, was collected in the March-December period of 1983.

2) Observation records on discharge

During the latest survey, 39 rounds of discharge observation were conducted for 13 points. As a result of interviewing of the water levels of individual rivers, it was found that the average rate of flow was lower for each river than in ordinary years, unabling us to establish an H-Q curve from the results of that survey.

However, as the Yacyreta Agency is currently continuing discharge observation of its own, its outcome will be able to be used for analyses in the third-year survey.

(3) Analysis of meteorological data

1) Meteorological features

Though Paraguay is subtropical, it is far from coast lines. As such, its weathers are continental. Broadly speaking, the country has only two seasons, summer (November to March) and winter (June to August). In between, there are short seasons of spring and the fall, which span September and October, and April and May, respectively.

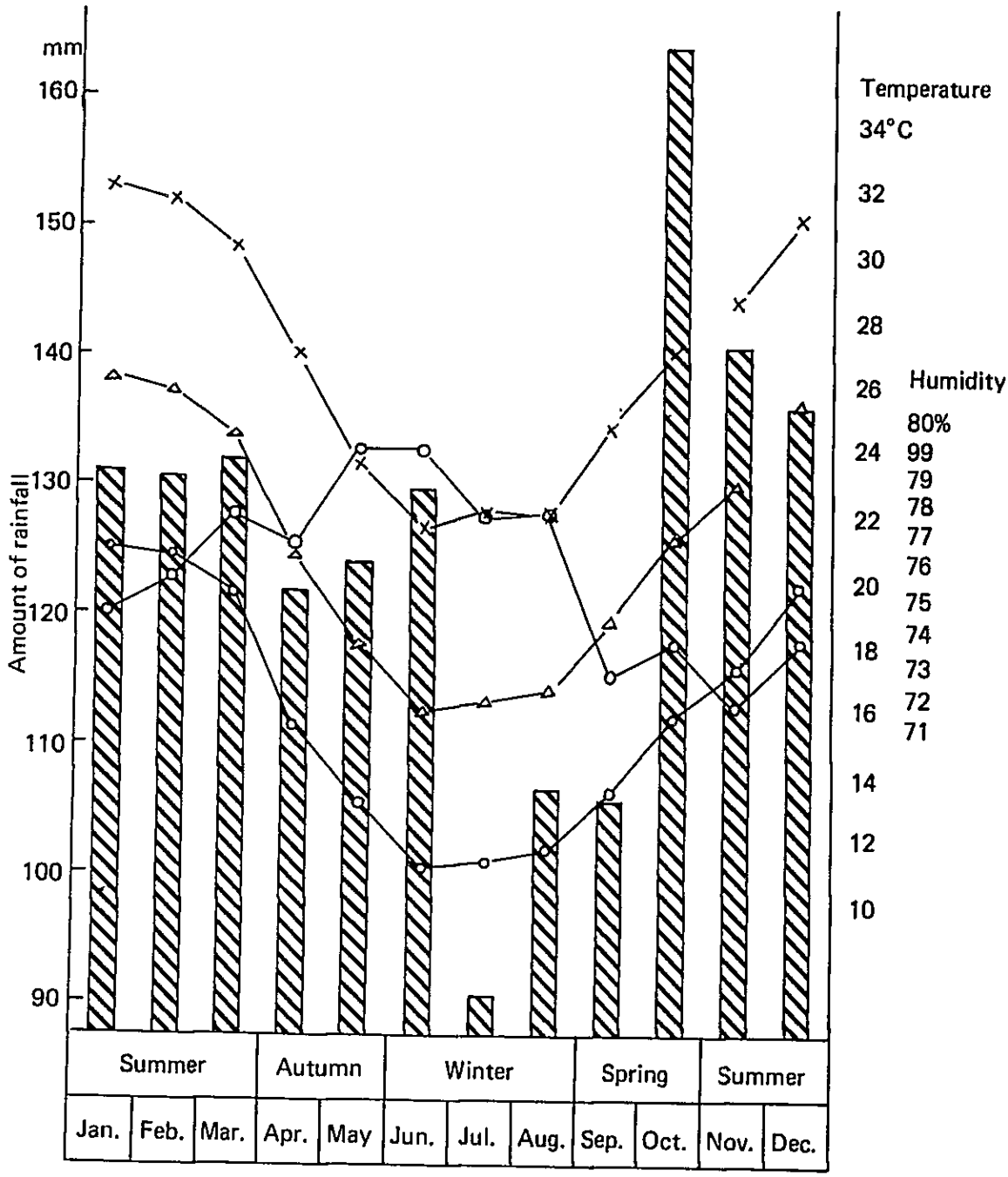


Fig. 2-1-2 Meteorological Characterstics of Yacyreta

Source: Data of Meteorological Department, Ministry of National Defence
Period: 1971 ~ 1980 (10 years)

Table 2-1-4 Distribution of Classification of Seasons Rainfall

Observatory	Rainfall/ year (mm)	Spring rainfall and ratio Sep.∿Oct. (mm)	Summer rainfall and ratio Nov.∿Mar. (mm)	Autumn rainfall and ratio Apr.∿May (mm)	Winter rainfall and ratio Jun.∿Aug. (mm)
Encarnacion	1,695.6	320.3 (19%)	754.7 (45%)	263.4 (15%)	357.2 (21%)
Sun Juan Bautista	1,644.4	290.8 (18%)	812.7 (49%)	243.8 (15%)	297.1 (18%)
Yacyreta	1,515.6	271.9 (18%)	668.9 (44%)	246.0 (16%)	328.8 (22%)

The survey areas belong to the most rainy parts of Paraguay with an average annual rainfall of 1,500 mm. As is shown in Fig. 2-1-2, the rainfall is relatively much in the spring month of October and is extremely little in the winter month of July.

According to the classification of seasons (see Table 2-1-4), about 44 percent of the total rain are concentrated in the summer period with the remainder being divided equally among other months.

2) Rainfall

Yacyreta had an average annual rainfall of about 1,500 mm from 1971 to 1980, which made the area to be the most rainy in Paraguay with a difference of as much as 1,000 mm with other parts of the area.

In terms of monthly rainfall, summer months are the most rainy and the winter is generally dry. The rainfall days averages at seven a month in this district with equal rainfall throughout the year. From these facts, Yacyreta can be said as a meteorological zone of unclear division of dry and rainy seasons.

The largest ever monthly rainfall in and around the survey areas were 581.9 mm. recorded in Encarnacion in October, 1954. In that month, the number of rainy days was 15.

Encarnacion also recorded a monthly rainfall of 556.8 mm in November, 1982, the month when abnormal rain began to hit the southern parts of South America, including Paraguay, Brazil and Argentina. In May of the subsequent year, the rainfall reached 581.6 mm. The largest rainfall ever in Yacyreta was 494.4 mm recorded in November, 1982.

In these twin years of abnormally heavy rain, Yacyreta had 2,164.9 mm from August, 1982 through May, 1983, and the comparable rate was 2,496.0 mm in Encarnacion, 1.4 times and 1.5 times larger than the eight-month average in the 1971 ∿ 1980 period, respectively. (see Table 2-1-5)

3) Days of dry weather

Table 2-1-6 indicates the longest monthly spell of dry-weather days observed by the Yacyreta Observatory from 1970 to 1980.

In Yacyreta's case, the average monthly spell of dry-weather days was minimal in February at 12 and the longest in April and June at 15 each. Also, it recorded a spell of 33 dry-weather days from August to September, 1978.

Table 2-1-5 Monthly Rainfall (Oct. 1982 ∿ May 1983)

Unit: mm

Observatory \ Date	1982			1983					
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Oct.∿May Total
Encarnacion	116.0	556.8	186.5	91.1	480.0	150.2	333.8	581.6	2,496.0
Yacyreta	82.6	494.4	135.7	106.4	412.4	201.4	298.4	433.6	2,164.9
Stroesner	228.8	537.6	439.0	186.4	218.2	192.5	288.0	338.6	2,429.1
Asuncion	77.0	419.1	218.0	134.3	248.3	110.9	261.5	270.6	1,739.7

Source: Meteorological Department, Ministry of National Defence

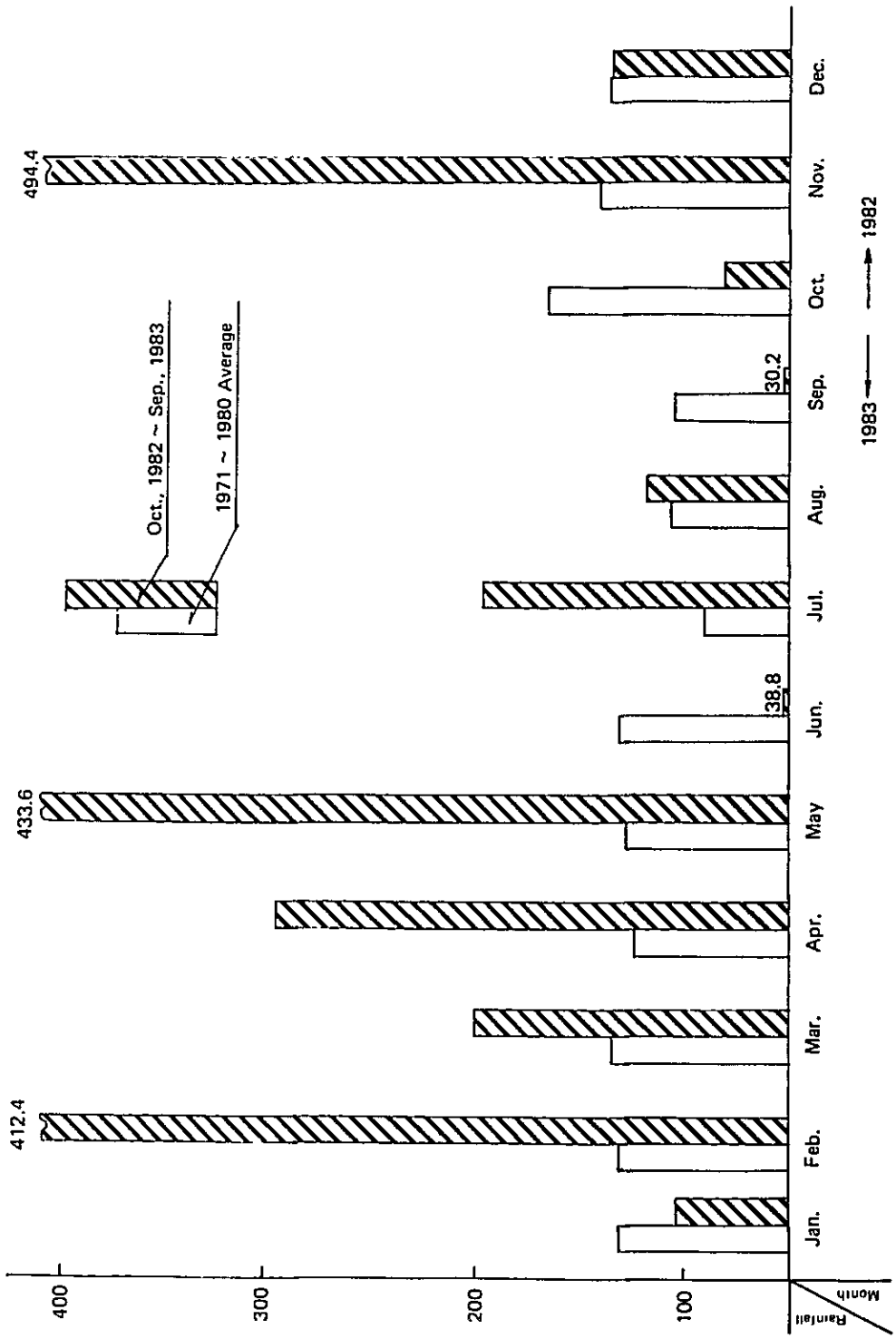


Fig. 2-1-3 Yacyreta by Month Rainfall

Table 2-1-6 Days of Continuous Drought in Yacyreta (Monthly maximum days) 1970 ∿ 1980

Daily rainfall less than 5 mm is unavailable. Unit: days

Year \ Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Maximum days
1970	20	22	8	30	11	8	15	14	7	9	25	10	32
		29	32	32									
1971	17	11	11	14	16	13	15	11	10	9	25	13	25
			25					19					
1972	12	18	7	16	10	9	7	7	15	12	10	15	25
		25		21				18					
1973	6	12	13	7	21	21	10	8	10	12	8	10	21
1974	7	8	8	17	10	11	14	19	16	18	7	9	20
						20							
1975	10	17	5	10	15	15	20	9	8	23	10	16	27
							27						
1976	8	9	12	14	18	21	19	22	25	13	19	11	25
				17									
1977	7	9	23	16	9	17	11	11	14	13	9	23	26
		26			23			22					
1978	7	11	16	17	16	14	10	21	12	14	14	10	33
			20		30			33					
1979	23	6	25	12	10	22	10	7	15	8	9	14	26
			26										
1980	22	7	12	17	10	11	24	10	12	15	8	-	27
	23					17	27						
Average	13	12	13	15	13	15	14	13	13	13	13	13	(33) 13

Upper row: Days of monthly continuous drought
Lower row: Days of drought continuing into the following month

Table 2-1-7 Days of Continuous Drought in Yacyreta
(Maximum days in a year and cultivating period etc.)

Unit: days

Period	Whole year (Jan. ∿ Dec.)		Wet paddy growing period (Oct. ∿ Apr.)		Seeding time (Oct. ∿ Nov.)		Harvesting time (Mar. ∿ Apr.)	
	Maximum days	Order	Maximum days	Order	Maximum days	Order	Maximum days	Order
1970 ∿ 1971	25	6	25	3	26	1	25	2
1971 ∿ 1972	25	7	25	4	12	8	16	7
1972 ∿ 1973	21	9	15	10	12	9	12	9
1973 ∿ 1974	20	10	17	8	18	4	17	6
1974 ∿ 1975	27	3	18	7	23	2	10	10
1975 ∿ 1976	25	8	24	5	19	3	14	8
1976 ∿ 1977	26	4	26	2	13	7	23	3
1977 ∿ 1978	33	1	23	6	14	6	20	4
1978 ∿ 1979	26	5	26	1	9	10	26	1
1979 ∿ 1980	27	2	15	9	15	5	17	5
Probability of first occurrence	1/35 1978 (8/11 ∿ 9/12)		1/15 1979 (3/7 ∿ 4/1)		1/20 1970 (10/31 ∿ 11/25)		1/15 1979 (3/7 ∿ 4/1)	

Table 2-1-8 Probability of Continuous Drought Days in Yacyreta

Unit: days

Probability year \ Period	Whole year (Jan. ∿ Dec.)	Wet paddy growing period (Oct. ∿ Apr.)	Seeding time (Oct. ∿ Nov.)	Harvesting time (Mar. ∿ Apr.)
Year				
2	25.1	20.3	15.3	17.6
5	28.3	23.5	20.1	22.4
10	30.3	25.2	23.2	25.1
15	31.3	26.0	24.9	26.6
20	32.0	26.6	26.1	27.5
35	33.0	27.7	28.4	29.2

Tables 2-1-7 and 2-1-8 show Yacyreta's the maximum number of dry-weather days in a year or a cultivation period and the probability of occurrence of dry-weather days spell, respectively. According to Table 2-1-8, the aforementioned record spell of 33 days occurs once every 35 years. Twenty-six days of continuous drought in the cultivation period (October ∿ April) and in the harvesting period (March ∿ April), meanwhile, takes place once every 15 years. The corresponding spell of 26 days for the seeding period (October ∿ November) hits once every 20 years.

The 1/5-year probability of drought spell for the paddy cultivation period is identical to the 1977 ∿ 1978 term.

(4) Analysis of hydrological data

1) External water level

With the survey areas located on the Parana River, all the river and drainage water from them run into that river. Therefore, it is necessary to analyze the Parana River's water level carefully in formulating drainage plans.

a. Recording of the Parana River's water level

Two water level observatories are located in the survey areas along the Parana River, both controlled by the Ministry of Defense. One of them is installed in Stankievic on the Yacyreta Island about 5 km upstream from the mouth of Atinguy, while the other being in Ayolas. Water level data was collected at these two sites, and also those for the Atinguy River's water level as a source inside water level of the survey area.

b. Relationship in water level between the Parana and Atinguy Rivers

Based on the Ita Ibate Dam's Influence Water Level Map in the Yacyreta Dam Construction Project Procedures (Materials No. 1), the Parana River water level at the water level gage installation point in Yacyreta Island's Stankievic was translated into the Parana River's level at a point near the estuary of the Atinguy River, and then Fig. 2-1-4 was prepared in an effort to analyze the influences of the Parana River to the Atinguy.

The rainfall in the Yacyreta areas, meanwhile,stood at 412.4 mm in February, 1983, 201.4 mm in March and 433.6 mm in May.

To observe the changes in the Atinguy River's water level, we find that the level never fails to go up 2 to 3 days after a rainfall. But, as is the case with the Parana River in water level changes in April, the Atinguy, in some periods, has no relationship in water level with the rainfall in Yacyreta.

The Parana River has a basin of about 975,000 km^2, about 2.6 times as large as Japan's territorial space, most of which being parts of Brazil. For this reason, it seems likely that there exists no clear relationship between the rainfall data collected at the observatories in the survey areas and the water levels of the Parana River.

In comparison of water levels for early February, the level is elevated much higher in the Parana River than in the Atinguy. This is due to an abnormal spell of rainfalls that started to hit the middle and southern parts of South America, including Paraguay, Brazil and Argentina in November, 1982, boosting the Parana River's water level and causing fluctuations in level with an interval of 10 days to one month.

When compared to that of the Parana River, the water level of the Atinguy River seems to show fluctuations more remarkably.

The Parana's water level is higher in April and July than the counterpart of the Atinguy, which, as was mentioned before, has nothing to do with the rainfall in the survey areas, but was caused by other factors leading to the elevated water level of the Parana River. It appears that the relatively slight gradient of the Atinguy's riverbed triggers a back flow from the Parana River.

Also, the water level of the Atinguy River rises in June and July in tandem with that of the Parana River.

From all this, we can speculate that the elevation in the Parana River's water level may touch off a back flow of the Atinguy, a major drainage river within the survey areas, and in the opposite case, it may take much time for flowing downstream because of the Atinguy's limited drainage capacity.

At the same time, if the Parana River is hightened in water level

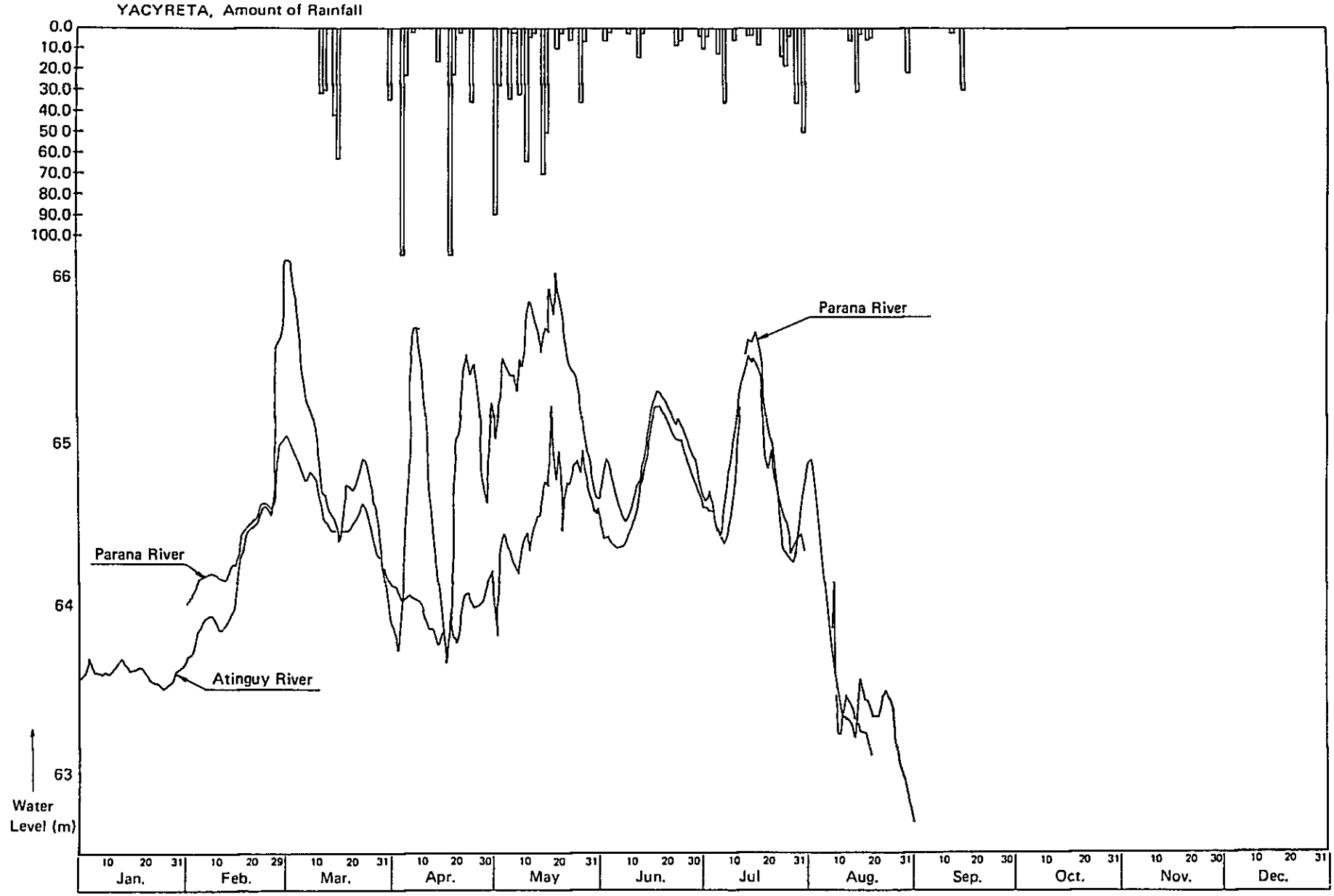


Fig. 2-1-4 Comparison of Water Level of Parana River and Atinguy River (1983)

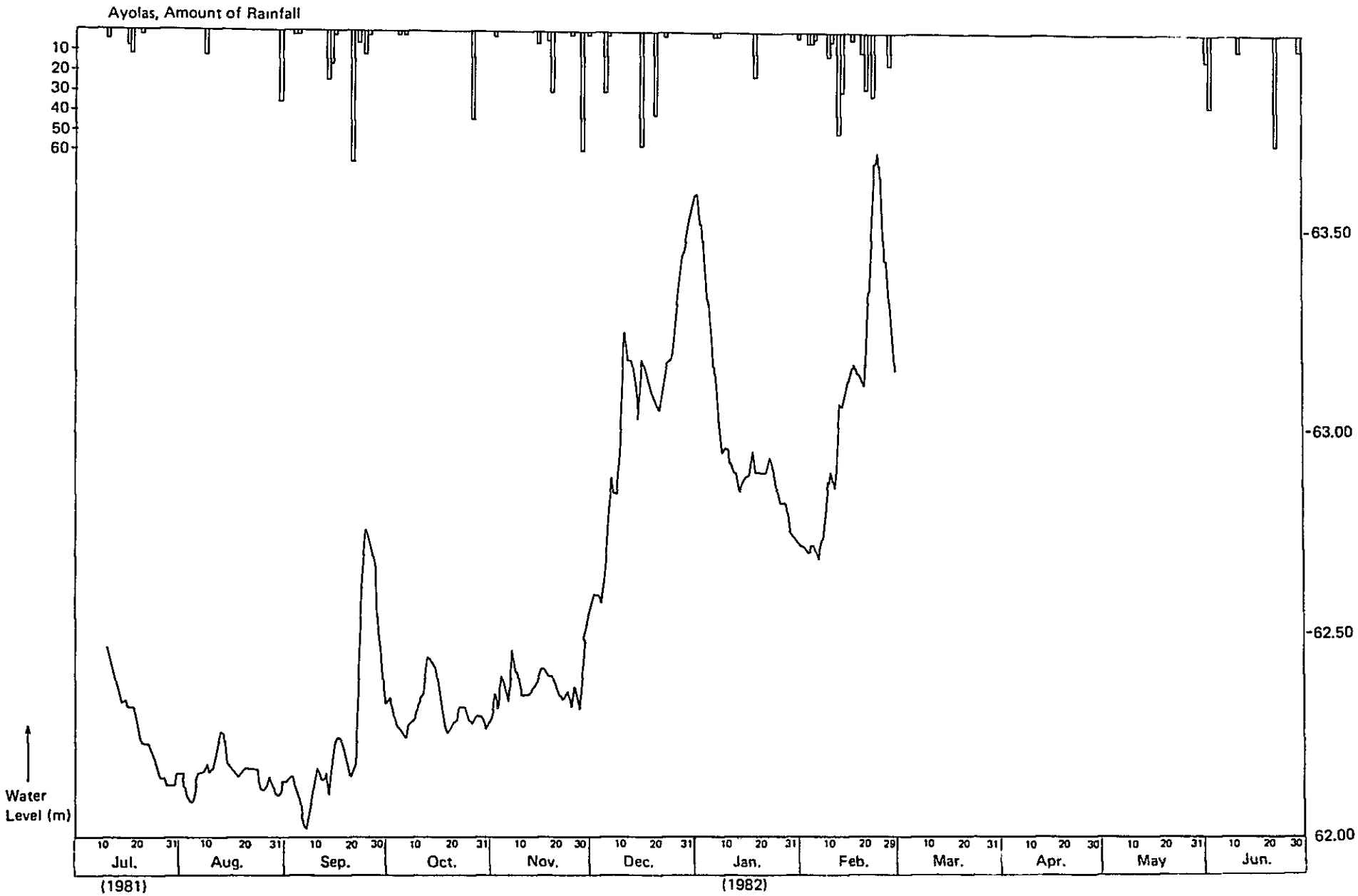


Fig. 2-1-5 Record of Water Level of Atinguy River (Jul., 1981 ~ Feb., 1982)

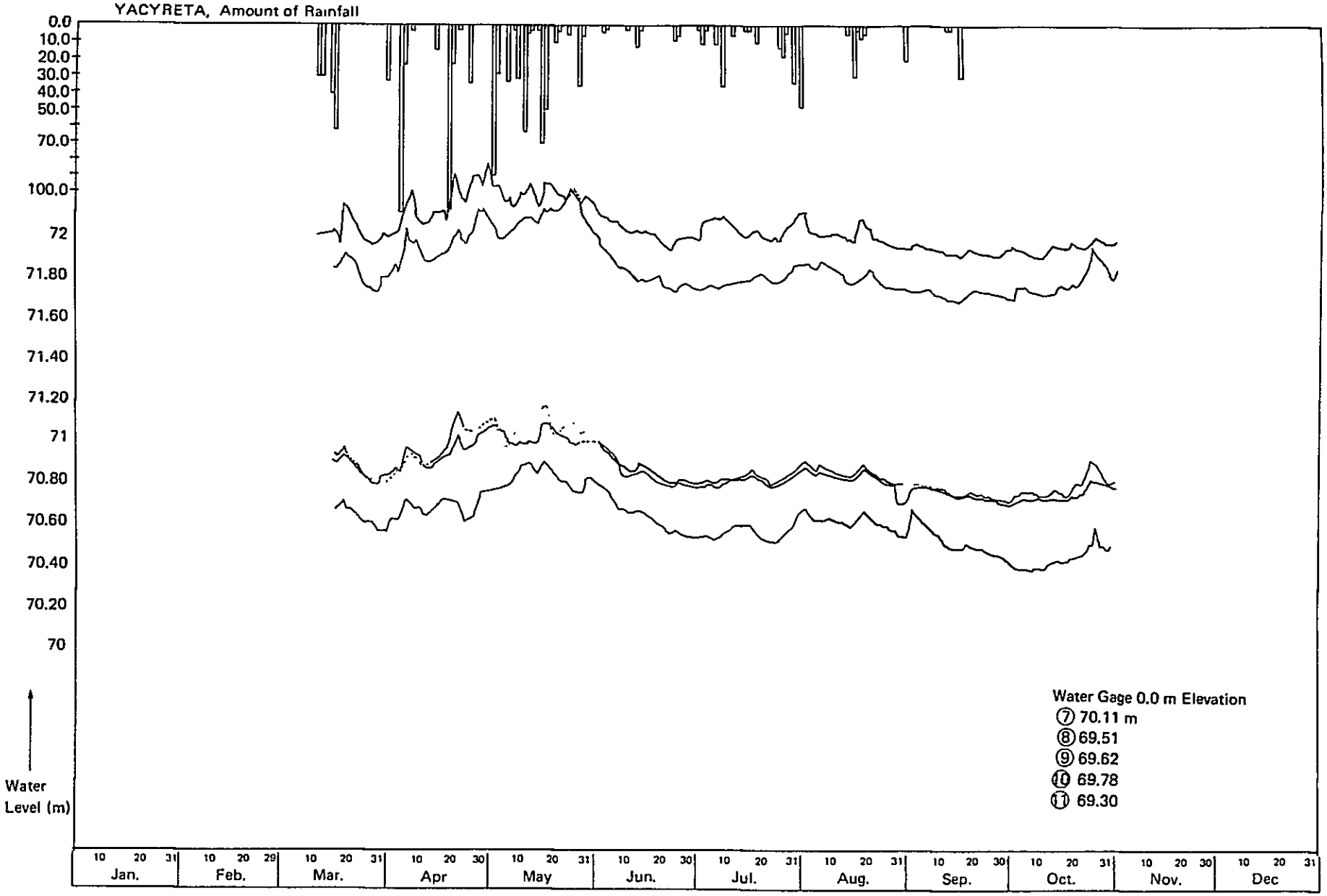
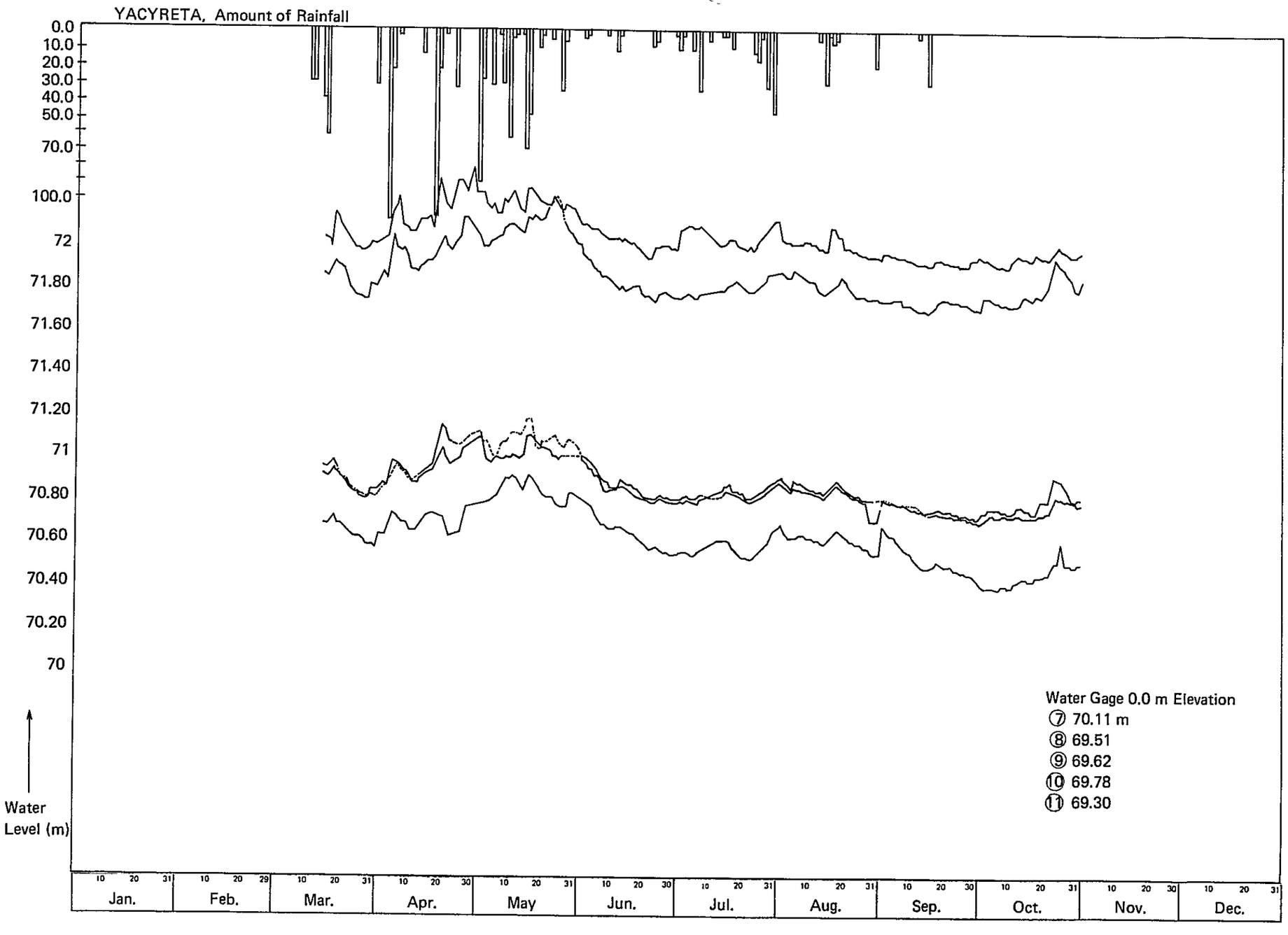


Fig. 2-1-6 Transition of Water Level in Survey Area (1983)
(Access 1-B Road)

Fig. 2-1-7 Transition of Water Level in Survey Area (1983
(Yabebyry – San Ignacio Road)



simultaneously with the Atinguy River, inundation may be brought in to the areas.

Fig. 2-1-5 indicates the changes in the Atinguy's water level from July, 1981 to February, 1982, from which we notice that while the water level remained relatively stable from early August of 1981 to late September of the same year and from early October to late November, the average height showed signs of increase, despite there being little rainfall, as it is influenced by the Parana River in terms of water level.

2) Changes in water level within the areas

Fig.'s 2-1-6 and 2-1-7 show the observation data of the staff gage installed during the first-year survey. These staff gate are installed at inundated points within the survey areas, near the gutters of a road under construction to run through the inundated area and at smaller drainage channels.

As can be read from the two figures, the water levels at these points fluctuate sharply as rainfall changes. Though the data are not definite because they were collected for a period with relating little rainfall, no major drops in water level could not be confirmed at anypoint surveyed.

We view that the inundated areas of the survey areas will not expect any natural drop in water level, since natural channels nearby are all limited in drainage capacity and are located in the geographically dish-shaped area.

We conclude from all this that in formulating a drainage project, the water levels at various points within the survey areas and water flow from the hinterland should be put together into a numerical model and organized as basic data for drainage simulation tests. It is necessary that the collection of this data be continued.

2.1.4 Geographical selection of meteorological observatory

Since the selection of points where to construct meteorological observatories or install observation equipment constitutes the foundation in efforts to formulate masterplans for irrigation and drainage projects. As such, much prudence should be used to determine those positions.

Table 2-1-9 Data of Yacyreta Meteorological Observatory

(Unit: °C, %, mm, days)

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Maximum average temperarure	32.2	31.8	30.3	27.0	23.6	21.6	22.1	22.0	24.7	27.0	28.6	31.1	26.8
Minimum average temperature	21.0	20.8	19.7	15.5	13.1	11.1	11.3	11.7	13.4	15.7	17.2	19.8	15.9
Average temperature	26.3	25.9	24.5	20.8	18.0	15.9	16.2	16.6	18.7	21.2	22.9	25.4	21.0
Average humidity	74	75	77	76	80	80	77	77	72	73	71	72	75
Evaporation	-	-	-	-	-	-	-	-	-	-	-	-	-
Maximum temperature	38.9	39.2	38.2	36.8	33.4	31.2	32.0	33.2	36.4	38.4	37.2	40.5	40.5
Minimum temperature	13.8	12.2	6.8	5.2	-1.0	-1.0	-1.4	1.4	3.0	6.6	9.2	10.7	-1.4
Rainfall	130.8	130.5	131.7	121.7	124.3	129.4	90.5	108.9	107.9	164.0	140.2	135.7	1,515.6
Rainfall days	8	6	7	6	6	7	7	7	5	8	8	7	82

Monthly Means Wind Velocity (Unit: knot)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
6	6	5	5	6	6	7	7	7	7	7	6	6

Resource: Data of Meteorological Department, Ministry of National Defence

Period in statistics: 1971 ∿ 1980

Note: 1 knot = 0.51 m/sec.

Table 2-1-10 Duration of Sunshine and Frosting Days (Average)

Unit: (Hours, days)

Observatory	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Yacyreta	Sunshine hours	-	-	-	-	-	-	-	-	-	-	-	-	-
	Frosting days	0	0	0	0	0.1	0.1	1.1	0.1	0	0	0	0	1.4
Encarnacion	Sunshine hours [1]	244.2	241.3	183.1	211.8	169.8	166.6	171.5	179.1	172.8	217.4	219.4	266.4	2,443.4
	Frosting days	0	0	0	0	0.9	2.7	1.6	0.9	0.2	0	0	0	6.3

Source: Data of Meteorological Department, Ministry of Defence

Period in statistics: 1971 ∿ 1980 (10 years)

Note: 1) Period in statistics: 1975 ∿ 1980 (except 1978 and 1979 because no observed)

Table 2-1-11 Comparison between Evaporations Measured by Balance Type Evaporimeter and Large Type Evaporimeter

Encarnacion

(Unit: mm)

Date	Aug. /81	Sep.	Oct.	Nov.	Dec.	Jan. /82	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Remarks
Large type evaporimeter	115.5	106.5	184.6	170.1	209.5	240.1	150.5	158.3	106.3	91.5	75.1	96.0	108.6	115.7	168.8	153.2	170.8	Total '82 1,634.9 mm
Balance type evaporimeter	62.2	45.2	66.8	49.2	62.3	96.5	58.2	57.0	61.2	49.9	29.6	47.0	49.5	51.8	71.0	52.1	71.9	695.7 mm
Large type/Balance type	1.86	2.36	2.76	3.46	3.36	2.49	2.59	2.78	1.74	1.83	2.54	2.04	2.19	2.23	2.38	2.94	2.38	Average 2.47

Source: Data of Meteorological Department, Ministry of Defence

Table 2-1-12 Rainfall Data

Year	Daily rainfall	Order	2 days continuous rainfall	Order	3 days continuous rainfall	Order
	mm		mm		mm	
1965	120.0	8	130.0	8	156.0	7
66	160.2	2	160.2	5	223.7	1
67	78.5	15	84.0	15	84.0	15
68	73.0	16	73.0	16	81.0	16
69	140.6	5	140.6	7	140.6	9
70	93.0	10	123.0	9	123.0	12
71	189.5	1	191.5	2	196.5	4
72	120.8	7	196.7	1	202.1	2
73	156.2	3	178.1	3	181.1	5
74	92.0	11	98.6	13	114.8	13
75	135.0	6	174.0	4	197.4	3
76	88.0	13	92.2	14	106.6	14
77	94.6	9	117.8	10	141.4	8
78	88.4	12	114.6	11	124.4	11
79	152.2	4	160.2	6	174.6	6
80	81.8	14	108.8	12	131.0	10

Table 2-1-13 Rainfall Probability

Probability	Daily rainfall	2 days continuous rainfall	3 days continuous rainfall	Remarks
	mm	mm	mm	
2	110.6	130.8	148.0	
5	143.1	165.9	185.0	
10	164.4	186.4	204.6	
15	176.4	197.2	214.5	
20	184.8	204.4	221.0	

In and around of the survey areas are a total nine meteorological observation facilities; three controlled and managed by the Meteorological Department, Ministry of National Defence, five run by the Yacyreta Public Corporation and one created by our survey mission during the first-year field study. In addition to them, rainfall gages were installed at two sites during our second-year survey for use in analyzing the discharge from the hinterland covered by this project.

For the reasons mentioned below, we decided to use data from the Yacyreta Meteorological Observatory in formulating this master plan.

(1) Because observation works were to span long periods

While the five observation facilities governed by the Yacyreta Agency only started operations in June, 1981, the three facilities of the Meteorological Department, Ministry of National Defence, including the Yacyreta Observatory, had long been involved in similar works.

(2) Because observation points neighbored with the survey areas

We concluded in the separation of the three aforementioned sites under the Thissen method that data at the Yacyreta Observatory would be adopted for the largest possible gains. For data needed but not available from this observatory, such as those on sunshine hours, we were to rely on the Encarnacion Observatory.

The observation materials and data used under this project are given in Tables 2-1-9 through 2-1-11.

In the subsequent stage, e.g., a feasibility study, data and materials from all the eight observation facilities under the management of the Yacyreta Agency and our survey mission will have to be closely examined and discussed. Also, it will be necessary to study the possibility of using data of certain facilities for each subordinate project, since of the vast size of the project area.

2.1.5 Design rainfall

(1) Rainfall probability

As data collected at the Yacyreta Observatory on rainfall, we collected and resorted to those filed for 18 years from 1963 to 1980. Table 2-1-12 gives daily rainfall and two-day and three-day continuous rainfall in each year from 1965 to 1980. (Similar data in 1963 and 1964 are nonexistent in the table, because observation was not likely made in those years.)

In drainage simulation tests to be studied this time, we were to conduct inundation analysis with a base placed on the 1/10 probability rainfall. (Refer to table 2-1-13)

(2) Days of continuous rainfall

To establish a drainage program, it will be necessary to discuss carefully which one of daily, two-day continuous and three-day continuous rainfall should be chosen as the design rainfall. In this process, the purpose, size and economic efficiency of each project have to be taken into account.

For this purpose, we surveyed the occurrence characteristics of continuous rainfall in accordance with data obtained at the Yacyreta Observatory during an 18-year period, and came up with the results, as are shown in Table 2-1-14. In this survey, we regarded a day of 5 mm or more in rainfall as a rainy day.

As a result, we found that of the total rainy days, single-day rainfalls accounted for an outstanding 78 percent, while two-day continuous rainfalls took up about 16 percent. At the same time, we studied ways it rained to discover that a rainfall of 150 mm or so, a target level for this project, was mostly registered on a single-day basis. Consequently, we decided to take daily rainfall as a reference in formulating the project.

Table 2-1-14 Rate of Continuous Rainfall

Continuous rainfall / Days / Month	1 day	2 days	3 days	More than 4 days	Total	Remarks
1	55	5	7	1	68	
2	56	8	1	1	66	
3	59	12	1		72	
4	50	14			64	
5	38	10	4		52	
6	33	8	4	1	46	
7	38	10	1		49	
8	38	12	1	1	52	
9	41	11	4		56	
10	55	8	8	1	72	
11	46	8	3	2	59	
12	50	8	5	1	64	
Total	559	114	39	8	720	
Rate %	77.7	15.8	5.4	1.1	100	