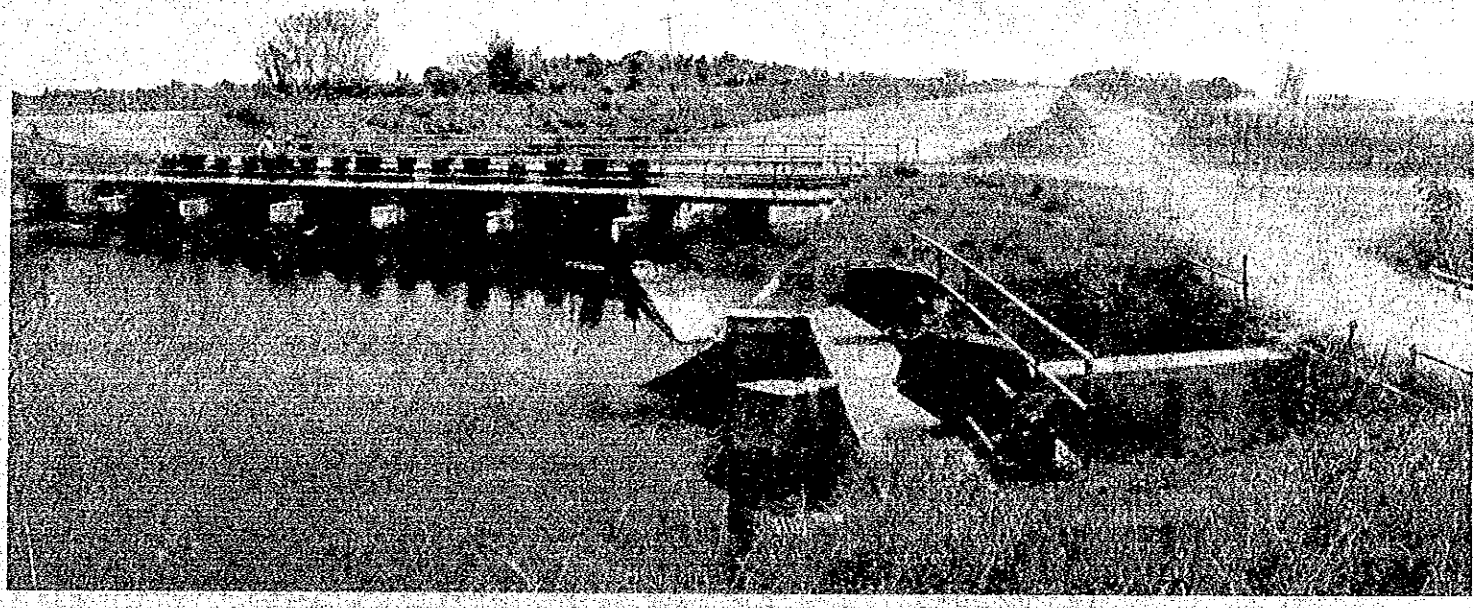
*MASTER PLAN STUDY*
*ON*

# THE IMPROVEMENT PROJECT OF THE O & M
*OF*

# MAGAT RIVER INTEGRATED IRRIGATION SYSTEM
*IN THE*
*REPUBLIC OF THE PHILIPPINES*

## MAIN REPORT



*JULY, 1987*

**JAPAN INTERNATIONAL COOPERATION AGENCY**

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# PREFACE

In response to the request of the Government of the Republic of the Philippines, the Japanese Government has decided to conduct a Master Plan Study on the Improvement Project of the Operation and Maintenance of the Magat River Integrated Irrigation System and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to the Philippines a survey team headed by Mr. Shoichiro HIGUCHI, SANYU CONSULTANTS INC. in 1986 and 1987.

The team exchanged views on the study with the officials concerned of the Government of the Philippines and conducted field surveys in the Cagayan Valley area, Isabela Province. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

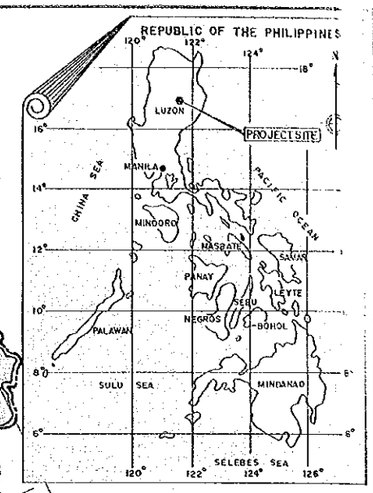
I wish to express my deep appreciation to the officials concerned of the Government of the Republic of the Philippines for their close cooperation extended to the team.

July, 1987

Keisuke Arita

President

Japan International Cooperation Agency




MAGAT DAM

BALIGATAN DIVERSION DAM

MARIS DIVERSION DAM

SIFFURIS DIVERSION DAM

NORTH DIVERSION CANAL

SOUTH HIGH MAIN CANAL

SOUTH LOW MAIN CANAL

OSCARIZ M.C.

SIFFRIS SOUTH M.C.

SIFFRIS NORTH MAIN CANAL

MAGAT RIVER

MARIS RIVER

SIFFU RIVER

CAGAYAN RIVER

LAT A

LAT B

LAT C

LAT D

LATE

LATE F

MACNAO EAST M.C.

LADECO M.C.

CEE M.C.

R. MERCEDES M.C.

JAPAN PHILIPPINE FRIENDSHIP HIGHWAY

CORDON

SANTIAGO

DIFFUN

RAMON

ALICIA

ECHAGUE

SAN MATEO DIS II

DIS III

AURORA

SAN MANUEL

ROXAS

MUNOZ

CALIGUIAN

CABATUAN

CAUAYAN

MRIIS HEAD OFFICE DIS IV

DIS I

NO.2 P.S

NO.3 P.S

NO. P.S

SIFFU E.E #1

SIFFU E.E #2

DISTRICT - I

DISTRICT - II

DISTRICT - III

DISTRICT - IV

16°40'

16°50'

17°00'

17°10'

121° 30'

121° 40'

121° 50'

12° 40'

LEGEND

- BOUNDARY OF SERVICE AREA
- BOUNDARY OF DISTRICT
- MAIN AND LATERAL CANALS
- DRAINAGE CANAL AND CREEK
- TOWN AND ROAD
- DAM AND DIVERSION DAM
- RIVER AND TRIBUTARIES
- IRRIGATION PUMP
- CHECK GATE FOR RETURN FLOW
- NIA HEAD OFFICE AND DISTRICT OFFICES

SCALE

0 4.0 8.0 12.0(KM)

# GENERAL PLAN FOR MAGAT RIVER INTEGRATED IRRIGATION SYSTEM

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IMPROVEMENT OF FACILITIES



AGRICULTURE AND AGRO-ECONOMY

SOCIAL INFRASTRUCTURE

## ABBREVIATIONS AND GLOSSARY

### Abbreviations

| | |
|---|---|
| ADCC | Agricultural Development Coordinating Council |
| AMC | Area Marketing Cooperative |
| ADD | Agricultural Development Division |
| AE | Area Engineer |
| AWMT | Assistant Water Management Technicians |
| BA | Barangay Association |
| BAEx | Bureau of Agricultural Extension |
| BAI | Bureau of Animal Industry |
| BAEcon | Bureau of Agricultural Economics |
| BCOD | Bureau of Cooperative Development |
| BFAR | Bureau of Fisheries and Aquatic Resources |
| BPI | Bureau of Plant Industry |
| BS | Bureau of Soil |
| CIADP | Cagayan Integrated Agricultural Development Project |
| DFIA | District Federation of Irrigators' Association |
| DT | Ditch Tender |
| EOD | Engineering and Operation Division |
| FACOMA | Farm Cooperative Marketing Association |
| FIG | Farmers Irrigators' Group |
| GK | Gate Keeper |
| HEP | Hydroelectric Plant |
| IA | Irrigators' Association |
| IDD | Institutional Development Division |
| IRRI | International Rice Research Institute |
| ISELCO-I | Isabela - I Electric Cooperative, Inc. |
| ISELCO-II | Isabela - II Electric Cooperative, Inc. |
| ISU | Isabela State University |
| JICA | Japan International Cooperation Agency |
| KKK | Kilusang Kabuhayan at Kaunlaran |
| MAF | Ministry of Agriculture and Food |
| MAR | Ministry of Agrarian Reform |
| MARIS | Magat River Irrigation System |
| MFD | Main Farm Ditch |
| MHS | Ministry of Human Settlement |
| MRIIS | Magat River Integrated Irrigation System |
| MRMP | Magat River Multi-purpose Project |
| MPWH | Ministry of Public Works and Highways |
| NAPHIRE | National Post Harvest Institute for Research and Extension |
| NCSO | National Census and Statistics Office |
| NEA | National Electrification Administration |
| NEDA | National Economic and Development Authority |
| NFA | National Food Authority |
| NIA | National Irrigation Administration |

| | |
|---|---|
| NIS | National Irrigation System |
| NPC | National Power Corporation |
| NPGC | Northern Philippines Grains Complex |
| NWRC | National Water Resources Council |
| O/M | Operation and Maintenance |
| PLDT | Philippines Long Distance Telecommunication |
| PNB | Philippines National Bank |
| SIFFURIS | Siffu River Irrigation Section |
| WCCS | Water Control Coordination System |
| USAID | United State Agency for International Development |
| USBR | United State Department of the Interior, Bureau of Reclamation |
| WM | Water Master |

Units of Measurement

| | | |
|---|---|---|
| mm | : | millimeter |
| cm | : | centimeter |
| m | : | meter |
| km | : | kilometer |
| | | |
| sq.cm | : | square centimeter |
| sq.m | : | square meter |
| sq.km | : | square kilometer |
| MSM | : | million square meter |
| | | |
| l, lit. | : | liter |
| cu.m | : | cubic meter |
| MCM | : | million cubic meter |
| lit/sec | : | liter per second |
| m/s | : | meter per second |
| PPM | : | part per million |
| | | |
| g | : | gram |
| kg | : | kilogram |
| ton, m.t. | : | metric ton |
| cavan | : | 50 kg |
| | | |
| EL | : | elevation above mean sea level |
| MSL | : | mean sea level |
| FWL | : | full water level |
| HWL | : | high water level |
| LWL | : | low water level |
| | | |
| sec. | : | second |
| minu. | : | minute |
| hr. | : | hour |
| min. | : | minimum |
| max. | : | maximum |

| | | |
|---|---|---|
| % | : | percent |
| No. | : | number |
| °C | : | degree centigrade |
| °F | : | degree fahrenheit |
| Cl | : | chlorine |
| HP | : | horse power |
| ET | : | evapotranspiration |
| N | : | nitrogen |
| P | : | phosphorous |
| K | : | potassium |
| HYV | : | high yielding variety |
| O & M | : | operation and maintenance |
| KWh | : | Kilowatt hour |
| EIRR | : | economic internal rate of return |
| B/C | : | benefit cost ratio |
| FY | : | fiscal year |
| ₱ | : | Pesos, ₱ = approx. US$ 0.05 |
| $ | : | Dollar, US$ = approx. ₱20.5 |

Conversion Factors

| Unit | | Comparison | English Equivalent |
|---|---|---|---|
| Unit of Length: | | | |
| Millimeter | (mm) | 0.001 meter | 0.0394 inch |
| Centimeter | (cm) | 0.01 meter | 0.3937 inch |
| Meter | (m) | | 3.2800 inch |
| Kilometer | (km) | 1,000 meter | 0.6213 mile |
| Unit of Area: | | | |
| Square centimeter | (sq.cm) | 0.0001 sq.m | 0.155 square inch |
| square meter | (sq.m) | | 10.764 square feet |
| Hectare | (ha) | 10,000 sq.m | 2.471 acres |
| Square kilometer | (sq.km) | 1,000,000 sq.m | 0.386 square mile |
| Unit of Volume: | | | |
| Cubic centimeter | (cu.m) | | 0.061 cubic inch |
| Liter | (1,000 cu.cm) | 0.001 cu.m | 1.0567 quarts (liquid) |
| Cubic meter | (cu.m) | 1,000 liters | 35.3145 cubic feet |
| Unit of Weight: | | | |
| Gram | (g) | | 0.0353 ounce |
| Kilogram | (kg) | 1,000 grams | 2.2046 pounds |
| Metric Ton | (mt) | 1,000 kg | 2,204.6 pounds |

Miscellaneous

| | | |
|---|---|---|
| 1 cu.m per second | = | 1,000 liters per second (l/s) |
| | = | 35.3145 cu.ft per second (cfs) |
| | = | 15,850 gallons per minute (gpm) |
| 1 liter per second for 1 day | = | 8.64 mm depth over one hectare |
| 10 mm depth over 1 hectare | = | 1.157 liters per second for 1 day |
| | = | 3,532 cu.ft |

Terminology

| | | |
|---|---|---|
| Project Area | : | Area of 164,800 ha corresponding to the objective area for Magat River Integrated Irrigation System |
| Service Area | : | Area of 97,400 ha to be benefited by the project |
| service area | : | Indivitual irrigation area in District, Division IA, FIC and etc. |
| Province | : | A political subdivision of a country comprising several towns |
| Barangay | : | A political subdivision of town |
| Poblacion | : | Political center of town |
| Monsoon | : | Periodic wind that blows from the sea to the continent and oppositely in winter |
| Typhoon | : | A storm or system of winds occurring in the Philippines and China Sea regions, known as hurricane in the West India and South Pacific, cyclone in the Indian Ocean |
| Palay | : | The rice plant which bears a staple cereal, or the cereal itself unhulled. Sometimes called rough rice. |
| IR58, IR60, IR62: | | High yielding rice varieties from the IRRI, Los Baños, Laguna, Philippines |
| Ganta | : | A common unit of volume for rice equivalent to 2.24 kilograms of milled rice |
| Bamboo | : | A woody grass with a big hollow in the center of the internodes, growing in groves or clumps reaching a height of 25 meters or more |
| Nipa | : | Heavy-leafed type of reed used in thatching huts |
| Share Tenancy | : | A practice where operators rent the land they work and pay as rent a share of the cash or crops grown |

Terminology

| | | |
|---|---|---|
| Carabao | : | The animal that most farmers used for plowing and other farm work. It is about the size of an ox and is similar to the water buffalo in other Asian countries |
| Fiesta | : | Spanish term for feast, celebrated pompously once a year to honor the patron saint |

# CHAPTER I. INTRODUCTION

# CHAPTER I. INTRODUCTION

## 1.1. Background of the MRIIS

The Magat River Integrated Irrigation System (hereinafter referred to as the MRIIS) is composed of the Magat reservoir, three diversion dams, a large number of irrigation canals and three pumping stations to supply irrigation water for an area of about 97,400 ha. It also includes hydroelectric power plants with 360 MW at Magat reservoir, 6,000 KW at Baligatan and 2,500 KW at Magat mini-hydroelectric power plants in Maris main canal.

This system had been developed as a project in stage-wise way by NIA since 1960's and, as one of the largest irrigation projects with hydroelectric power generation in the nation, was completed in 1983 with total investment of about US$500 million for the production of about 760 thousand tons of paddy (equivalent to 2,700 million pesos) and 1,000 GWH of power, equivalent to 2,000 million pesos per annum.

An integrated organization for operation and maintenance (O/M) of the MRIIS was established in 1984 and has been undertaking a variety of tasks. Currently, however, the related O/M works to the MRIIS have faced a number of difficulties to require for taking the following countermeasures urgently.

(i) Expansion of the present irrigation area of about 71,000 ha to the target of 97,400 ha by accelerating a development of land consolidation and on-farm facilities for paddy field to be irrigated.

(ii) Improvement of water management for the allocation of irrigation water to service areas, reservoir operation of the Magat dam, outflow control at the diversion dams, distribution control in the canal systems and water use at on-farm level.

(iii) Improvement of the system facilities such as diversion dams and canal systems for supplying irrigation water to meet the requirement and schedule in the service area.

(iv) Improvement of the present O/M organization and its functions to carry out the effective operation for irrigation water supply and the proper maintenance of the system facilities.

(v) Improvement of the paddy cultivation techniques to increase the production yield and to retrench the production cost.

(vi) Improvement of the farmer's institution to well manage irrigation water use and the farming practices, and to increase the farmer's income.

In order to improve the present operation and maintenance works of the system as mentioned above, NIA requested the Japanese Government to carry out to formulate the Master Plan for the Improvement Project of the Operation and Maintenance of the Magat River Integrated Irrigation System (MRIIS) under the technical assistance program.

In response to the request, the Japanese Government decided to implement this Master Plan Study by the Japan International Cooperation Agency (JICA). The study was commenced in the middle of March 1986 and completed in July 1987.

## 1.2. Objectives of the Study

The objective of the study is to formulate the Master Plan of the Improvement Project of O/M of the MRIIS.

The study was carried out in three phases in the following manner;

### First Phase

The study in the first phase was made from 17th March to 14th April, 1986 to formulate a detailed plan of approach for the study in the second and third phases based on the preliminary survey in the project area and discussions with NIA personnel.

### Second Phase

The study in the second phase was composed of the field and home office works. The field works was from 26th May to 23rd August, 1986 to collect data and information, carry out an inventory study on the present O/M works and identify improvement requirements for the future O/M.

The home office works was made from 24th August to 25th October, 1986 in Japan to analyze collected data and information and to preliminarily formulate an improvement project based on the results of the field works. An Interim Report was prepared based on the outcomes of the second phase.

### Third Phase

The study in the third phase was composed of the field and home office works. The field work was made from 26th October to 20th December, 1986. In the field work, a review of the improvement project was made in conformity with the outcomes of the discussions

between NIA and the Study Team on the primary formulation provided in the Interim Report. The field survey and discussions between NIA and the Study Team were made to consolidate concepts of O/M Manual.

The home office work was carried out from 5th January to 15th March, 1987 in Japan in order to formulate the definitive improvement project for the O/M and to prepare O/M Manual. Results of the home office work were reflected in the Final Report of the study and the O/M Manual was prepared.

The Final Report was submitted to NIA in July, 1987 after receiving comments of NIA on the Draft Final Report and preliminary O/M Manual,which have been prepared by the Study Team in May,1987.

Members of the Advisory Committee, Study Team and NIA counterparts personnel assigned to the study are attached at the end of this report.

# CHAPTER II. PRESENT STATUS OF THE MRIIS O/M

# CHAPTER II. PRESENT STATUS OF THE MRIIS O/M

## 2.1. Outline of the MRIIS

### 2.1.1. General Features in the MRIIS Area

#### (1) Location and Geography

The MRIIS area is located over parts of the Provinces of Isabela, Quirino and Ifugao in the Region II, expanding along the Magat and Siffu rivers running into the Cagayan Valley.

The Service Area of the MRIIS lies at the elevation of 100 m in the western hilly area and of 50 m in the eastern flat area near the Cagayan Valley. The southern and western areas as well as some parts of eastern area present in undulated topography while the central area is formed to be flat with a very gentle slope.

The MRIIS area has about 164,800 ha in total, of which the irrigation Service Area is estimated at 97,400 ha. The Service Area is divided into two parts by the Magat river; the left bank area of the river named District III and the right bank areas covering the District I, II and IV. The areas in District II, III and IV are formed with rather flat topography except a part of eastern area along the Cagayan Valley, while District I is undulated hilly area.

The Magat river, main water source of the MRIIS area, has a length of about 60 km between the damsite and the Cagayan Valley with a gentle slope of about 1/1,000.

The Siffu river, which is also a water source for District III service area, runs into the Cagayan Valley along the northern boundary of the Service Area. The river length and slope are similar to those of the Magat river.

Many small waterways called "creeks" are developed in the Service Area and run from the western and southern mountains to the Cagayan Valley. These creeks serve as natural drainage canals in the Service Area.

(2) Administrative Division and Population

The MRIIS area belongs administratively to three Provinces of Isabela, Quirino and Ifugao, and Isabela Province occupies large portion in the area. Numbers of Municipality, Barangay and the population in each Province are summarized as follows;

Administration and Population (1986)

| Province | No. of Municipality | No. of Barangay | No. of Population | No. of Household |
|---|---|---|---|---|
| Isabela | 19 | 429 | 529,700 | 94,100 |
| Quirino | 3 | 27 | 35,500 | 6,500 |
| Ifugao | 1 | 6 | 3,400 | 700 |
| Total | 23 | 462 | 568,600 | 101,300 |

Population and number of households in the MRIIS area were 478,000 and 87,000 respectively in 1980 statistics, but have been increased to 569,000 and 101,300 according to the statistic data as of 1986. The population growth rate in the MRIIS area is 3.2 percent, which is rather high as compared with 2.6 percent of the the Cagayan Valley area in the Region II, because of the remarkable progress of agricultural development in the MRIIS.

The farmers' population in the MRIIS area in 1986 is about 387,000 occupying 68 percent of the total. The distribution of farmers' population in the MRIIS area is shown in the O/M Drawings No.5 and summarized as follows;

Farmers' Population in the MRIIS Area (1986)

| Item | Total | Non-Agriculture | Agriculture | | |
|---|---|---|---|---|---|
| | | | Total | Operator's Farmer | Labor's Farmer |
| (1) Population | | | | | |
| Isabela | 529,700 | 169,600 | 360,100 | 292,900 | 67,200 |
| Quirino | 35,500 | 11,800 | 23,700 | 19,100 | 4,600 |
| Ifugao | 3,400 | 200 | 3,200 | 2,900 | 300 |
| Total | 568,600 | 181,600 | 387,000 | 314,900 | 72,100 |
| (2) Household | | | | | |
| Isabela | 94,100 | 31,000 | 63,100 | 51,400 | 11,700 |
| Quirino | 6,500 | 1,900 | 4,600 | 3,700 | 900 |
| Ifugao | 700 | 100 | 600 | 500 | 100 |
| Total | 101,300 | 33,000 | 68,300 | 55,600 | 12,700 |

As shown in the above table, there is labor's farmer in the MRIIS area, occupying about 20 percent of total farmers. The labor's farmer is not farming the paddy cultivation directly, but engaging in the farming works such as transplanting and harvesting works of paddy cultivation as the temporary workers under the operator's farmers.

Municipalities with dense or sparse households are summarized in the following table;

Dense and Sparse Population

| Dense Population Municipalities | | | Sparse Population Municipalities | | |
|---|---|---|---|---|---|
| Municipality | Total Household | Farm Household (%) | Municipality | Total Household | Farm Household (%) |
| 1. Santiago | 14,800 | 43.9 | 1. Naguilian | 300 | 66.7 |
| 2. Cauayan | 10,200 | 56.1 | 2. Potia | 700 | 81.4 |
| 3. San Mateo | 8,200 | 76.3 | 3. Saguday | 1,400 | 86.1 |
| 4. Alicia | 7,900 | 76.5 | 4. Cabarroguis | 1,900 | 65.8 |
| 5. Ramon | 7,600 | 52.5 | 5. Luna | 2,100 | 85.2 |
| 6. Roxas | 6,300 | 75.2 | 6. San Isidro | 2,300 | 86.0 |
| 7. Echague | 6,100 | 62.0 | 7. Angadanan | 2,500 | 84.2 |

(3) Meteorology and Hydrology

General Meteorology

Meteorological conditions in the MRIIS area are tropical in the nature with two seasons; wet season from June to December and dry season from January to May. Annual average temperature varies from 23 to 28°C and the lowest and the highest is from 10 - 15°C in February and 34 - 38°C in May, respectively. Relative humidity varies from 50 to 65 percent in the dry season and 70 to 80 percent in the wet season. Evaporation rate shows 140 to 150 mm/ month.

These meteorological features give no particular constrain to cultivation and ensure the year-round cultivation.

Rainfall

There exist six rain gauge stations in the MRIIS Service Area as shown in O/M Drawings No.7 and the observation has been conducted since 1977. The records, however, are not available straightly for the period from commencement and not accurate due to poor maintenance of rain gauges and shortage in observation staffs; therefore, these data are considered ineffective for the study.

The rainfall records at Ilagan Station in Ilagan City, capital of Isabela Province, adjacent to the MRIIS area are adopted for the study, because of their high reliability and long-term records of 26 years since 1961.

As seen in the monthly rainfall at Ilagan Station in Table A-1 in Annex, the annual average rainfall in the MRIIS area amounts to about 1,800 mm, of which 1,100 to 1,200 mm are concentrated in the wet season, especially in September to November, and average amount for three months is about 800 mm. The average rainfall in the dry season from January to May shows a small amount of 320 mm, which is too insufficient to cultivate the dry season crop without irrigation water.

The rainfall from May to June, which is very important for land soaking and land preparation of the wet season paddy, is about 300 mm on an average and less than 100 mm in dry years; therefore, supplemental irrigation water is required for the wet season paddy cultivation.

The rainfall in the Magat reservoir has been observed at the damsite since 1976, resulting in annual average amount of 1,650 mm, and the monthly rainfall heavily fluctuates by season; wet and dry, and by year; normal and dry years. The related details are shown in Table A-2 in Annex.

The rainfall in the Magat catchment area has been observed at Consuelo station since 1959 and presents a remarkable annual fluctuation in a range from 3,000 to 4,000 mm in wet years and 1,000 to 1,500 mm in dry years.

The annual rainfall in the MRIIS area is generally influenced by frequency and magnitude of typhoon attacking the area from July to November; therefore, it is rather difficult to forecast rainfall amount in the wet season.

(4) River Runoff

The Magat and Siffu rivers are the main water sources for the MRIIS, and the former is used for irrigation and power generation being controlled by the Magat dam, and the latter only for irrigation without control by the Siffuris diversion dam.

Both river flows presently remarkable change by month and years; wet or dry. A big runoff in the rivers occurs often in a period from August to November by typhoon with heavy rainfall. On the contrary, a little runoff appears in the dry season from January to May.

The runoff of both rivers has been observed since 1953 and their monthly records are shown in Table A-12 and A-13 in Annex.

The Magat River Runoff

The Magat river has three big tributaries of the Alimit, Iburao and Matuno, having a catchment area of 4,143 sq.km at the damsite. The annual runoff of the river presents a considerable fluctuation from 3,300 MCM to 4,500 MCM in dry years and 9,000 MCM to 12,500 MCM in wet years, and the average annual amount is about 6,550 MCM.

The characteristics of the monthly runoff are shown in Table A-12 in Annex. The runoff from January to June in several dry years as shown in the following table could not cover the required water demand for the Service Area, because the runoff in these months has a small amount compared with the irrigation requirement of about 1,367 MCM for growing period of the dry season paddy and for the beginning stage of the wet season paddy.

Runoff in Dry Year

| Year | Runoff Amount (Jan. to Jun.) (MCM) | Year | Runoff Amount (Jan. to Jun.) (MCM) |
|---|---|---|---|
| 1954 | 1,114 | 1979 | 1,229 |
| 1958 | 1,038 | 1980 | 993 |
| 1961 | 1,091 | 1983 | 928 |
| 1969 | 924 | 1985 | 1,384 |
| 1978 | 807 | | |

The Siffu River Runoff

The Siffu river at the Siffuris diversion damsite has a catchment area of 627 sq.km and an average annual runoff of 880 MCM, while each of the maximum and minimum runoff is about 2,000 MCM and 290 MCM, respectively.

The runoff from January to June in dry years, playing a very important role for irrigation for the dry season paddy and the early stage of the wet season paddy, is about 100 to 150 MCM, which can

cover sufficiently the irrigation requirement for the Siffu North main canal service area of about 3,000 ha. But in the Siffu South main canal service area of about 8,200 ha requires some supplemental water from the Maris diversion dam.

Monthly Runoff in Siffu River

| Month | Runoff (MCM) | Month | Runoff (MCM) |
|---|---|---|---|
| Jan. | 42.6 | July | 94.2 |
| Feb. | 28.8 | Aug. | 111.8 |
| Mar. | 24.7 | Sep. | 128.8 |
| Apr. | 26.1 | Oct. | 120.4 |
| May | 52.5 | Nov. | 111.6 |
| Jun. | 71.0 | Dec. | 72.5 |

Return Flow at Gaddanan Creek

The return flow brought by excess irrigation water in the service area along the Gaddanan creek is estimated at 5.0 to 10.0 cu.m/sec and is utilized for the irrigation for the downstream area of about 6,000 ha covered by the Macanao and Ladeco weirs.

(5) Present Land Use

The objective area for the MRIIS (so called as the Project Area) is estimated at about 164,800 ha based on the topographic map of 1:25,000 in scale. Out of this Project Area of 164,800 ha, about 114,300 ha (Paddy fields 92,700 ha and upland field 21,600 ha) equivalent to about 70 percent of the Project Area, is utilized for cultivation land.

Paddy field occupies a large portion of the MRIIS area extending not only in the flat area but in the hilly area with a gentle slope. The area covered with paddy fields mostly consists of heavy clay soils, which are not suitable for crop diversification due to impermeable character.

The upland fields are found in the Dual class land extending along the Magat river and consisting of sandy loam soils with high permeability. The Dual class land is formed by transported deposits of the Magat river and is most suitable for upland crop cultivation. Corn, peanut, tobacco, beans and vegetable, etc. are presently planted in the left bank area and some parts in the right bank area of the Magat river, while paddy cultivation prevails in the right bank area of the river.

### 2.1.2. Development History of the MRIIS

Irrigation facilities in the MRIIS were constructed by the stage of development consisting of the stages Ia, Ib, II and III from 1957 to 1986 and the total investment costs reached about 10,600 million pesos at the present value in 1986.

Total Investment Cost for the MRIIS

(unit: Million Pesos)

| Stage | Implementing Year | Investment Cost | Present Value in 1986 |
|---|---|---|---|
| Initial Stage | 1957 - '68 | 24 | 380 |
| Stage Ia | 1974 - '76 | 228 | 480 |
| Stage Ib | 1975 - '83 | 1,207 | 1,750 |
| Stage II | 1977 - '86 | 4,870 | 6,740 |
| Stage III | 1979 - '86 | 996 | 1,200 |
| Total | | 7,325 | 10,550 |

(1) Implementation of Initial Stage Project

In 1957, the Maris diversion dam on the Magat river and some canals in the upstream service area were constructed by the Ministry of Public Works in order to develop the irrigation area of about 23,000 ha. This was the first project in the MRIIS area but its actual irrigation area was about 20,000 ha in the wet season and 14,000 ha in the dry season.

In 1960, the Siffuris diversion dam on the Siffu river and its canal system covering the area of about 10,000 ha were also constructed by the Ministry of Public Works in order to develop the land along the Siffu river. The actual irrigation area, however, was about 8,400 ha in wet season.

In 1968, NIA which was established in 1964 to promote the national irrigation projects, implemented the extension works with irrigation area of about 10,000 ha in the middle stream area of the Maris canal. With these expansion works, the total irrigation area in the MRIIS reached about 40,000 ha in 1968.

(2) Implementation of Stage Ia Project

In 1973, NIA commenced the implementation of the integrated agricultural development in both Angat and Magat project areas by the fund of the Asian Development Bank. The development works for the Magat project were the rehabilitation of irrigation canal systems already provided since 1957 and the on-farm development works in the irrigation area of about 40,000 ha.

This Stage Ia project was completed in 1976, and the facilities have been operated up to now for the irrigation of about 40,000 ha.

(3) Implementation of Stage Ib Project

In 1975, the implementation of Stage Ib project composed of the following sub-projects was commenced by NIA by the fund of the World Bank.

- Improvement of 890 ha along the Maris canal.
- Integration of communal irrigation area of about 1,300 ha.
- Improvement of about 10,000 ha in the Siffu area.
- Expansion of about 10,400 ha along the North Diversion canal and the Siffu South main canal.

The major works conducted in the Stage Ib project are as follows;

- Improvement of the Maris and Siffuris diversion dams to raise up their dam height to introduce much river water to canals.
- Improvement of the canal system in the Maris and Siffu service areas to increase its discharge capacity for extension area.
- New construction of the South Low main canal and the North Diversion canal as well as the extension of the North and South main canals in the Siffu area.
- Improvement of maintenance road of 830 km in the Maris and Siffu areas.
- New construction of bridge crossing the Magat river and accessing to the North Diversion main canal.

These project facilities were constructed stage by stage and completed totally in 1983.

(4) Implementation of Stage II Project

In 1977, the construction of the Magat dam with a reservoir capacity of 1,250 MCM and hydroelectric power plant of 360 MW was commenced by the fund of the World Bank in order to supply the irrigation water for whole area of about 100,000 ha in the MRIIS and to generate the power of about 1,000 GWH/annum.

This Stage II project was completed in 1983 except miscellaneous works and the operation was commenced in the middle of 1983.

(5) Implementation of Stage III Project

In 1979, the Stage III project was commenced for the development of new extension area of about 27,000 ha to be irrigated by the reservoir water of the Magat dam.

The project facilities were composed of the Baligatan diversion dam, South High main canal, three pumping stations and lateral canals in the extension area, most of which were completed up to 1983 except some lateral canals which were completed by 1986.

(6) Establishment of the MRIIS O/M Office

The operation and maintenance (O/M) works for the completed irrigation facilities at each stage have been made by the construction office of the Magat project in parallel with the construction of the remained project facilities.

In 1984, however, the integrated MRIIS O/M Office was established and the related its O/M works have been conducted thereafter.

2.1.3. Irrigation Service Area

The irrigation area in the MRIIS was defined to be 97,400 ha in 1983 by a detailed survey made by the MRIIS O/M Office based on the existing cadastral maps.

The area of 97,400 ha was divided into four Districts from the viewpoint of the O/M works and the area in each District is as follows;

| | | |
|---|---|---|
| District I | : | 24,054 ha |
| District II | : | 24,468 |
| District III | : | 24,793 |
| District IV | : | 24,087 |
| Total | | 97,402 ha |

Each District is also divided into several Divisions consisting of 20 to 25 units covering the service area of 1,200 to 700 ha per Division.

Location and boundary of each District and Division are shown in O/M Drawings No.8.

The irrigation area has been expanded year by year as shown below, in accordance with the development progress of the MRIIS.

Especially after completion of the Magat dam in 1983, the irrigation area was rapidly expanded to the area of about 60,000 ha in 1984. Such expansion of irrigation area, however, has not been progressed so much in 1985, although the whole irrigation facilities in the MRIIS were mostly completed and fully operated.

Expansion of the MRIIS Irrigation Area

(unit: ha)

| Year | Dry Season | Wet Season | Third Crop | Total |
|---|---|---|---|---|
| 1975 | 16,100 | 26,400 | - | 42,500 |
| 1976 | 5,300 | 31,000 | - | 36,300 |
| 1977 | 15,400 | 35,600 | - | 51,000 |
| 1978 | 25,600 | 45,000 | - | 70,600 |
| 1979 | 34,500 | 40,300 | - | 74,800 |
| 1980 | 39,700 | 42,400 | 5,100 | 87,200 |
| 1981 | 34,400 | 40,300 | 200 | 74,900 |
| 1982 | 44,900 | 42,900 | 40 | 87,840 |
| 1983 | 44,600 | 40,800 | 200 | 85,600 |
| 1984 | 56,100 | 60,400 | 400 | 116,900 |
| 1985 | 67,200 | 69,100 | - | 136,300 |

About 26,300 ha of lands still remains as unirrigated area in 1986 due to limitation of farmers' capacity to reclaim the land into paddy fields, some defects in completed irrigation facilities and other reasons.

The unirrigated areas in 1986 classified by reason are shown in O/M Drawings No.5 and summarized as follows;

Unirrigated Area in 1986

(unit: ha)

| Area Conditions | District I | II | III | IV | Total |
|---|---|---|---|---|---|
| Total Area | 24,054 | 24,468 | 24,793 | 24,087 | 97,402 |
| Irrigated Area in 1986 | 17,874 | 20,708 | 17,403 | 15,077 | 71,062 |
| Ratio of Irrigated Area (%) | 74 | 85 | 70 | 63 | 73 |
| Unirrigated Area in 1986 | | | | | |
| - Undeveloped | 4,330 | 1,080 | 2,940 | 4,870 | 13,220 |
| - Lack of On-Farm Facility | 310 | 1,270 | 2,660 | 2,460 | 6,700 |
| - High Elevation | - | 370 | 860 | - | 1,230 |
| - Drainage Problem | 130 | 300 | 540 | 830 | 1,800 |
| - Financial Problem | 970 | 470 | - | 610 | 2,050 |
| - Others | 440 | 270 | 390 | 240 | 1,340 |
| Total | 6,180 | 3,760 | 7,390 | 9,010 | 26,340 |

(1) Undeveloped Area

An undeveloped area means that the area is not prepared for paddy land and remains as grass land or fallow land. The development of such land is, in principle, to be made by farmers themselves, but actually has not been implemented due to lack of farmers' technology and fund, difficult conditions of land such as undulated topography, absence of investment by absentee land owners etc.

The total undeveloped area in the MRIIS is reduced from 15,090 ha in 1985 to 13,220 ha in 1986, but the land development works to paddy field have not been progressed yet in District II, III and IV except District I as shown below;

Progress of Undeveloped Area

(unit: ha)

| Year | District I | II | III | IV | Total |
|---|---|---|---|---|---|
| 1985 | 5,760 | 970 | 2,950 | 5,410 | 15,090 |
| 1986 | 4,330 | 1,080 | 2,940 | 4,870 | 13,220 |
| Decreased Area | 1,430 | -110 1/ | 10 | 540 | 1,870 |

1/: Reason to increase the undeveloped area of 110 ha from 1985 to 1986 is that the area along the Magat river is damaged by the river flood and not rehabilitated yet.

(2) Area Lacking On-Farm Facility

On-farm facilities of the farm ditches, farm drains, turn-outs and farm roads in the terminal areas of 20 ha to 30 ha are to be constructed by farmer's institution.

However, the area without on-farm facilities is increased from 4,930 ha in 1985 to 6,700 ha in 1986 as shown in the following table.

Progress of Lack of On-Farm Facilities Area

(unit: ha)

| Year | District I | II | III | IV | Total |
|---|---|---|---|---|---|
| 1985 | 670 | 1,070 | 1,460 | 1,730 | 4,930 |
| 1986 | 310 | 1,270 | 2,660 | 2,460 | 6,700 |
| Increased Area | -360 | 200 | 1,200 | 730 | 1,770 |

The reasons of the irrigation area decreasing caused by the lack of on-farm facilities are considered as follows;

- The on-farm facilities have not been provided along with the progress of the land development, because farmers' institution, which carry out the works has not a sufficient fund and proper technology to conduct the works. In addition, farmers' institution is not fully organized yet.
- The construction of the on-farm facilities in the service area with undulated topography would be rather difficult without proper assistance by NIA for design and construction. The present farmers' institution has no sufficient ability to prepare plan and to carry out the construction of the on-farm facilities at the undulated areas.
- Some existing on-farm facilities constructed by the farmers' institution have been deteriorated and out of function due to inadequate construction and poor maintenance.

- In some service areas, alignment of the lateral or sub-lateral canals and location of turn-outs in the canals are selected improperly and then the farmers' institution can not provide the on-farm facilities.

(3) Other Unirrigated Areas

Besides the above reasons, the area of about 8,260 ha remained unirrigated in 1985 due to those problems of high elevation, drainage and financing, although they were reduced to 6,420 ha in 1986.

High Elevation Area

The high elevation areas can not get irrigation water due to higher elevation of the areas than the water level in the lateral canals constructed by NIA. These areas were about 1,400 ha in 1985 and reduced to 1,230 ha in 1986. The service areas with high elevation are mainly found in the downstream hilly areas in District II and the areas served by pumping stations of No.2 and No.3.

In order to solve such problems of high elevation area, new lateral and sub-lateral canals should be implemented by District O/M Office.

Drainage Problem Area

The unirrigated areas due to drainage problem were 1,490 ha in 1985 but increased to 1,800 ha in 1986. These areas are mainly located in District III and IV and require new drainage systems to be constructed by NIA.

Financial Problem Area

The unirrigated areas due to financial problem were 2,130 ha in 1985 and 2,050 ha in 1986. Since low income farmers do not have

enough fund for obtaining seeds, fertilizers, equipment, etc., they are forced to abandon the irrigated cultivation for paddy.

2.1.4. System Facilities

(1) Magat Dam

The water of the Magat dam, the biggest dam in the Philippines, is main water source for the MRIIS area. The dam has the total capacity of 1,250 MCM and effective capacity of 820 MCM, and functions as a multipurpose dam which controls the rich run-off of the Magat river during wet season and supplies the water for irrigation and hydroelectric power generation. It is an inclined core type rock fill dam having the height of 114 m and the crest length of 4,160 m.

The spillway located at the left abutment of the dam was constructed in concrete Ogee type with the designed flood capacity of 30,600 cu.m/sec and has seven radial gates with the width of 16.5 m and the height of 19.05 m.

There are two outlets to release the stored water; one for the hydroelectric power plant of 360 MW releasing the maximum discharge flood capacity of 480 cu.m/sec to the Maris diversion dam and the other for the Baligatan outlet releasing the maximum irrigation discharge capacity of 33.7 cu.m/sec to the Baligatan diversion dam for the South High and Oscariz main canal. The outline of Magat dam is shown in Table F-1 in Annex.

(2) Maris Diversion Dam

The Maris diversion dam with the capacity of 7.3 MCM is located at Barangay Oscariz, six kilometers downstream from the Magat dam, and has function as a re-regulating reservoir of the Magat hydroelectric power generation. The intakes with inclined sluice

gates are installed at both sides of the dam. The right intake is for the Maris main canal with the maximum capacity of 121.5 cu.m/sec and the left one is for the North Diversion main canal with the capacity of 59 cu.m/sec.

The Ogee type spillway with 16 steel stop log is constructed across the river, and they are operated by a gantry crane installed on the operation bridge.

(3) Baligatan Diversion Dam

The Baligatan diversion dam is constructed on the North Baligatan creek about three kilometers downstream from the Magat dam, and has a function to catch the released water from the Baligatan outlet. Two intakes are installed at both sides of the dam; one at the right bank for the South High main canal with the maximum capacity of 26 cu.m/sec and the other at the left bank for the Oscariz main canal with the maximum capacity of 7.7 cu.m/sec.

(4) Siffuris Diversion Dam

The Siffuris diversion dam is constructed on the upstream of the Siffu river in order to take the run-off flow from the Siffu river and to introduce the water into the Siffu North and South main canals in the Siffu service area. The maximum intake capacity is 13.6 and 5.23 cu.m/sec for the Siffu South and North main canals, respectively.

The Ogee type spillway without gates is provided across the full section of the river. The intake amount at the Siffuris diversion dam has a considerable fluctuation due to the uncontrolled river water, so that insufficient water amount for irrigation requirement for the South canal service area is covered by the supply from the North Diversion main canal. The dimension of diversion dams is shown in Table F-2 in Annex.

(5) Main Irrigation Canal

The fifteen main irrigation canals with a total length of 321 km are constructed to serve the area of 97,400 ha. All canals are designed as earth canal with the average slope of 1/5,000, so that the canal discharge velocity varies from 1.0 m/sec for larger section to 0.3 m/sec for smaller one.

The canals have a number of gate structures such as head, check and turn-out gates and other related structures of siphons, road crossings, drops, bridges, etc. Major features of each main canal are shown in Table F-3 in Annex.

(6) Lateral Canals

The lateral canals branching off from the main canals are designed as the earth canal with a number of related structures. The capacity of these laterals varies from 35 cu.m/sec for the larger ones to more or less 1.0 cu.m/sec for smaller ones.

The lateral canals have the total length of 1,150 km. The density of canals in the Service Area is about 15 m/ha which is a little smaller than that specified in NIA's criteria by 20 m/ha. The outline of the lateral canals is shown in Table F-4 in Annex.

(7) Macanao and Ladeco Weir

The Macanao or Ladeco weirs are constructed for the use of return flow from the irrigation canal. The gates installed at those weirs are too small and time-worn to operate timely, so that upstream area along the creek is suffered from inundation during the wet season.

(8) Pumping Station

There are three pumping stations provided and operated in the Service Area. Station No.1 is provided to irrigate the hilly areas

in the Cauayan East Extension Area of District IV by introducing the water from the Cauayan East Extension main canal. The service area of 1,700 ha is expected to be irrigated by pumps with discharge capacity of 3.45 cu.m/sec.

Those of No.2 and No.3 are installed to irrigate the hilly areas in the east end of District III. The irrigation water for both stations is introduced from the lateral canals F-2 and conveyed through the Bugnay creek. The water lifted up at first at the pump station No.2 is conveyed to pump station No.3 through the Siffu East Extension canal and distributed to the service area along the irrigation canal. At the end of the canal, the conveyed water is lifted up again at pump station No.3 to irrigate an area with higher elevation.

The service area irrigated by No.2 and No.3 stations are 6,600[1/] ha and 3,000 ha, and the pumping discharge capacities are 16.6 cu.m/sec and 7.4 cu.m/sec respectively. The outline of the pumping stations is shown in Table F-5 in Annex.

2.1.5. Operation and Maintenance

(1) Organization

The organization for the MRIIS O/M consists of a Head Office to manage all District Offices, a Dam and Reservoir District carrying out the O/M works in the Magat dam as well as Maris and Baligatan diversion dams, and four Districts engaging in the O/M works of the irrigation service area. About 910 O/M staffs are assigned under this organization.

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1/: Pump station No.2 its own service area is 3,600 ha, but this pump station covers both areas irrigated by pump station No.2 and No.3.

The operation and maintenance works of the MRIIS O/M Office are summarized as follows; water management and irrigation service fee collection, maintenance of system facilities, assistance to farmers for on-farm facilities development, and establishment and strengthening of Irrigators' Association (IA).

(2) Water Management

The water management works is the most important subject and it is conducted by District Offices under the direction of the MRIIS O/M Head Office based on the diversion water requirement proposed by each District Office on the weekly basis after summarizing the farming progress in the area commanded by each terminal turnout area.

Actual water management works have not been made well due to two major reasons; one is inaccurate estimation of diversion water requirement corresponding with farming progress monitored on weekly basis, and the other is inadequate water distribution control among canal networks which is caused by worn water control facilities as well as inadequate water management.

(3) Irrigation Service Fee Collection

The irrigation service fee is essential and the most important source of income for NIA O/M. The amount of annual collection has increased annually depending upon the irrigation development by the MRMP, however the collection efficiency is relatively low with 60 to 70 percent against the collectible amount.

The collected irrigation service fee in 1985 amounts to 29.5 million pesos against the collectible amount of 49.6 million pesos and the collection efficiency is 61 percent.

(4) Maintenance of Facilities

The maintenance works of facilities are conducted by two organizations in Districts, one is WM Division which takes charge of routine clearing works of canal section and minor structures, and the other is Operation and Maintenance Section which conducts major maintenance and rehabilitation works of system facilities.

The responsibility for routine maintenance works in canal section is gradually transferred to Irrigators' Association (IA) since the MRMP construction stage under the lateral turnover scheme which has been promoted by NIA in the national level.

The major maintenance of facilities has not been made well since its initial development due to insufficient budget for the system O/M. As the result, the function of facilities on water conveyance has deteriorating year by year so that it needs rehabilitation works in the whole system.

(5) Institutional Development

About 240 IAs have been organized in the service area, most of which was established during the MRMP implementation period.

At present, about 140 IAs has undertaken O/M works in the canal section by contract, and about 540 km or 37 percent of canal section has been maintained under the responsibilities of IAs.

(6) Income and Expenditure

Income

The total income for the MRIIS O/M in 1985 amounts to 35.4 million pesos which is itemized as 29.5 million pesos of irrigation

service fee, 3.0 million pesos of the cost allocation from NPC for the Magat dam O/M, 0.1 million pesos of water service charge for Magat mini-hydroelectric power plant, and 2.8 million pesos of other sources.

Expenditure

The total expenditure for the MRIIS O/M in 1985 amounts to 45.1 million pesos which is itemized as 5.5 million pesos for the MRIIS O/M Head Office, 25.0 million pesos for the District Offices and 14.6 million pesos for the Dam and Reservoir District.

The total O/M expenditure in 1985 is resulted in the deficit of 9.1 million pesos against the O/M income for the same year.

2.1.6. Hydroelectric Power

(1) Hydroelectric Plant

Three hydroelectric plants exist in the project area at Magat, Baligatan and Maris canal, and they are described below;

(a) Magat Hydroelectric Plant

The Magat hydroelectric power plant started in its operation with three units, No.1, No.2 and No.3 from August 1983 and the output has come to 360 MW of the maximum installed capacity with No.4 generator installed in December, 1983. There is further plan to provide additional two units (90 MW x 2).

The Magat hydroelectric power generation is considered to play an important role in Luzon Power Supply System. The maximum installed capacity of 360 MW corresponds to 8.8 percent in gross installed capacity of 4,101 MW, and 29.6 percent of a gross installed capacity of hydroelectric power of 1,215 MW in Luzon Island in 1985.

The plant functions as a peak load power plant in the dry season and a base load power plant in the wet season. The major features of power generation are summarized as follows;

| | | |
|---|---|---|
| ° | Maximum Plant Discharge | : 480 cu.m/sec (120 cu.m/sec x 4 units) |
| ° | Rated Design Head | : 81.0 m |
| ° | Installed Capacity | : 360 MW (90 MW x 4 units) |
| ° | Annual Energy | : 1,200 GWH |

(b) Baligatan Hydroelectric Plant

The Baligatan hydroelectric plant located on the right saddle of the Baligatan dam is under construction by NIA and will be operated and maintained by NIA as well. The produced energy is transmitted to the Luzon Grid and the Cagayan Valley Power Supply System through Santiago Substation.

The major features of the power generation are summarized as follows;

| | | |
|---|---|---|
| ° | Maximum Plant Discharge | : 23.8 cu.m/sec x 1 unit |
| ° | Rated Design Head | : 30.0 m |
| ° | Installed Capacity | : 6.0 MW x 1 unit |
| ° | Annual Energy to be Generated | : 18.5 GWH |

The maximum installed capacity of the plant is about 6,000 KW which is required for the operation of three pumping stations in the service area, and consequently NIA will be able to save high operation costs of pumping by swapping supply of energy with NPC.

However, the produced energy by the plant is considered to be unqualified electricity, because it is subjected by the irrigation water demand. In other words, the produced energy is very unstable both in time and in quantity to be generated.

(c) Mini-Hydroelectric Plants

The mini-hydroelectric plants, Magat (A) and Magat (B) have been constructed by NEA along the Maris main canal and their operation and maintenance were taken over to ISELCO-I in 1984 and 1985.

The major features of power generation are summarized as follows;

| | Magat (A) | Magat (B) |
|---|---|---|
| ° Maximum Plant Discharge : | 54.0 cu.m/sec (13.5 cu.m/sec x 4 units) | 41.0 cu.m/sec (13.5 cu.m/sec x 3 units) |
| ° Rated Design Head: | 3.5 m | 3.5 m |
| ° Installed Capacity: | 1,440 KW (360 KW x 4 units) | 1,040 KW (360 KW x 3 units) |
| ° Annual Energy (1985): | 4.9 GWH | 3.2 GWH |

According to the operation records of the plants in 1984 and 1985, the plant factor was small value of 36 percent (50 percent in the planning stage), and the maximum installed capacity has not been generated. Furthermore, inoperation period is found by more or less 100 days in a year. The reasons of a low plant factor are as follows:

- Small irrigation water requirement in April and May.
- Suspension of power plant operation by frequent shutdown of electric current served by NPC.
- Low plant efficiency caused by invading trash in the canal.
- Line fault by the broken insulator from poles.

In addition to these problems, the sequence of starting and shutdown of the plants causes the rapid fluctuation of water level in the Maris main canal, which brings the problems for water management in Maris main canal.

(2) Transmission and Distribution Lines

(a) Transmission Line

The transmission line networks and substations which connected with the Luzon Grid at the existing Ambukulao power plant, were constructed by NPC in 1981, so as to intensify the electric power supply system in the Cagayan Valley.

Mutual power exchange between the Luzon Grid and the Cagayan Valley Power Supply System has been carried out through the Santiago Substation in the MRIIS.

The Magat hydroelectric power plant was connected with the Santiago Substation by a transmission line of 230 KV in August 1983, and the Baligatan hydroelectric power plant was connected also with it by a transmission line of 69 KV in November 1986.

The outline of major transmission line networks is shown in following table.

Transmission Networks of NPC

| Transmission Line | Voltage (KV) | Circuit | Type of Supporting | Line Length (KM) |
|---|---|---|---|---|
| Ambukulao - Santiago | 230 | DC | ST 1/ | 106.0 |
| Santiago - Magat | 230 | DC | ST | 14.5 |
| Santiago - Baligatan | 69 | SC | WP 2/ | 14.0 |
| Santiago - Tugegarao | 230 | SC | ST | 116.3 |
| Santiago - Cauayan | 69 | SC | WP | 41.5 |
| Cauayan - Ilagan | 69 | SC | WP | 30.9 |
| Roxas - Gum Service Point | 69 | SC | WP | 31.8 |

Note: 1/ ... Steel tower 2/ ... Wooden pole

(b) Distribution Line

Hydroelectric power in the Project area has been supplied by ISELCO-I in the southern parts of the Magat river, by ISELCO-II in the northern parts of the Magat river, and by QUIRELECO in the southern extremity zone, respectively.

The outline of distribution lines is shown in the following table.

Distribution Line

| Electric Co-operative Inc. | Line Length (km) | Note |
|---|---|---|
| ISELCO-I | 218 | 3 phase class |
| ISELCO-II | 86 | less than 13.8 KV |
| Total | 304 | |

## 2.2. Management of Irrigation Water

### 2.2.1. Irrigation Requirement

According to the obtained data, outflow discharge for irrigation and power generation from 1984 to 1986 is summarized as follows;

Present Outflow Discharge

(unit: MCM)

| Year | Magat Power Plant (Power+Irrigation) | Diversion Dam | | | |
|---|---|---|---|---|---|
| | | Baligatan | Maris | North Div., Siffu | Total |
| 1984 | | | | | |
| Wet (May - Oct.) | 3,949.6 | 90.5 | 1,045.4 | 305.3 | 1,441.2 |
| Dry (Nov.- Apr.) | 1,680.6 | 99.1 | 1,051.2 | 341.9 | 1,492.2 |
| Sub-total | 5,630.2 | 189.6 | 2,096.6 | 647.2 | 2,933.4 |
| 1985 | | | | | |
| Wet (May - Oct.) | 3,166.7 | 141.7 | 1,223.1 | 400.3 | 1,765.1 |
| Dry (Nov.- Apr.) | 2,159.0 | 171.7 | 1,146.6 | 386.0 | 1,704.3 |
| Sub-total | 5,325.7 | 313.4 | 2,369.7 | 786.3 | 3,469.4 |

Since the outflow discharge from the diversion dam is considered to be used for irrigation purposes, such outflow discharge from three diversion dams of Baligatan, Maris and Siffuris, are tabulated in Table C-3 in Annex. Annually supplied water per hectare, which was estimated at about 4,320 mm in 1984 and 5,080 mm in 1985 for two season crops respectively is considerably higher than that indicated in the present O/M Manual by 2,960 mm, 1,700 mm for wet season and 1,260 mm for dry season paddy, respectively.

These big amounts of water can be explained such that the water released from the diversion dam and delivered to the irrigation canals is not used actually for irrigation in the paddy fields but wasted to drainage canals or creeks through paddy fields.

Every creek, therefore, releases a considerable amount of discharge to the downstream areas during the irrigation season. With the introduction of much irrigation water to paddy fields with uneffective use and waste of excess water to creeks, the downstream area of the MRIIS has always suffered from shortage of water in the dry season as well as inundation problems in the wet season. The present poor water management for irrigation has been caused by the following reasons and shall be improved urgently; otherwise water shortage and inundation problems will become critical year by year depending on expansion of irrigation area from present irrigation area of about 71,000 ha to the target one of 97,400 ha, although the used water currently has much allowance for irrigation of about 71,000 ha, because the Magat reservoir is planned for the irrigation area of 97,400.

- The upstream service area by the Maris and Siffu canal systems implemented in Stage Ia project had introduced the run-off flow from diversion dam since 1976. In this connection, the upstream area used to introduce water in the fields as much as possible in the case that water is available, because of big fluctuation of river flow and no provision of storage facilities. Such practices still remain customarily in the way of water utilization.

- Water management rule for distribution in the canal system has not been established yet, and therefore, water distribution control at head and turn-out gates cannot be properly made by Water Masters (WM) and Gate Keepers (GK) assigned to the system.

- The present cropping calendar for paddy has the staggered way of works, so that irrigation schedule to supply water cannot be planned to meet paddy growing condition.

- The water more than the irrigation demand is naturally released through turn-out due to no function of gates to control water.

### 2.2.2. Irrigation Schedule

The standard irrigation schedule in accordance with present cropping calendar is prepared in the present O/M Manual. The existing irrigation schedules for 1984 and 1985, however, do not

cope with that mentioned in the Manual and are staggered as shown in the O/M Drawings No.11. Land soaking and land preparation periods have taken about four months from May to August for the wet season paddy and from November to February for the dry season paddy. As a result, the paddy growing period has also taken a longer period, so that an adequate irrigation schedule can not be applied at present.

### 2.2.3. Allocation of Irrigation Water

#### (1) Classification of Projected Service Area

The projected Service Area of 97,400 ha is divided into four Districts for the purpose of effective operation and maintenance of the whole irrigation systems. Furthermore, the Service Areas can be subdivided into seven areas from a viewpoint of the canal networks as shown below;

| | | | |
|---|---|---|---|
| i) | Maris Main Canal System | : | 46,000 ha |
| ii) | South High and Oscariz Main Canal System | : | 12,700 |
| iii) | South Low Main Canal System | : | 7,900 |
| iv) | North Diversion Main Canal System | : | 13,600 |
| v) | Siffu South Main Canal System | : | 8,200 |
| vi) | Siffu North Main Canal System | : | 3,000 |
| vii) | Macanao and Ladeco Return Flow System | : | 6,000 |
| | Total | | 97,400 ha |

#### (2) Request and Allocation Rule of Irrigation Water

The rule of request and allocation of irrigation water has been decided as follows;

- Water Master (WM) shall grasp, at first, the acreage of paddy fields for irrigation services requested by IA, and irrigation schedules specified into four stages of land soaking, land preparation, vegetation and reproduction, on the basis of each Division and week.

- The WM shall estimate the necessary irrigation water based on the requested areas and the unit irrigation requirement indicated in the O/M Manual after approval of District Manager on the weekly basis.

- The Water Control Coordination Section (WCCS) in the MRIIS O/M Head Office shall review the requested irrigation water taking into account effective rainfall, irrigation water depth at paddy fields and remaining reservoir water in the Magat dam, and then determine the final allocation of irrigation water for each District and the outflow from reservoir and diversion dams.

- The amount of the irrigation water to be allocated to the Division and the outflow from reservoir and diversion dams are instructed to each District Office by the MRIIS O/M Head Office manager, and the water management and control are to be made according to the instructions.

(3) Present Procedures for Request and Allocation of Irrigation Water

The present procedures for request and allocation of irrigation water are inefficient due to the reason as shown below.

- Irrigation area and schedule for services to be requested by farmers can not be estimated accurately by WM due to such reasons as absence of exact cadastral map and exact acreage on the turn-out basis by staggered cropping calendar, etc. Therefore, estimation of the required amount of irrigation water for each Division is very rough and does not correspond to the actual amount to be used.

- Even if the irrigation area and schedule to be requested could be estimated properly by the WM in some Division, the estimation of irrigation water on Division basis could not be made quickly and accurately, because a lot of calculation depending on a number of classified area by staggered cropping calendar at each turn-out (at FIG) will be required.

- Exact allocation of irrigation water on weekly basis at each check and head gate points is very hard, because the accumulated discharge along each canal system could not be estimated due to no accurate flow diagram in irrigation canal system.

- Allocation of irrigation water in each Division shall be made taking into account effective rainfall against the estimated irrigation water by area and unit irrigation requirement. However, this water allocation method is not properly made due to no available rainfall data in the Service Area.

### 2.2.4. Water Management in Magat Dam

#### (1) Present Water Management

The Water Management in the Magat reservoir consists of the outflow control works at the hydroelectric power plant, Baligatan outlet and spillway and the monitoring works for hydrological observation to forecast the flood entering into the reservoir. Such water management works are made by the Dam and Reservoir District of the MRIIS except the outflow control for the hydroelectric power plant which is carried out by NPC.

##### (a) Outflow Control at Power Plant

The outflow control at the Magat hydroelectric power plant with the maximum output of 360 MW is presently made by NPC as follows;

- The daily outflow amount is determined at first by the MRIIS O/M Office in accordance with the outflow estimated for the irrigation of the service area covered with the Maris diversion dam and additional outflow for power estimated based on the rule curve in the reservoir. Additional outflow for power is allowed in case the water level in the reservoir is expected to be higher than the rule curve after releasing irrigation outflow.
- Water Control Coordination Section (WCCS) in the MRIIS Head Office estimates the daily average outflow amount and instructs to NPC on weekly basis. NPC converts this instructed outflow to the peak outflow in accordance with required peak power in Luzon Power Grid and release the peak outflow through power plant. The MRIIS O/M Office does not touch the outflow operation at power plant, which is directly made by NPC.

- The result of outflow control in the reservoir from 1984 to 1986 is summarized in the O/M Drawings No.15. As clear in the O/M Drawings, the reservoir water level reaches the full water level of 193.0 m in October to November in the wet season and decrease gradually to the low water level of 160.0 m releasing the irrigation water in the dry season from December to June. The fluctuation of water level in the reservoir based on the actual outflow in 1984 to 1985 does not always follow with the rule curve, especially the water level from March to September in 1984 and from June to September 1985 is very high, and from January to April in 1985 is very low compared with the water level defined in the rule curve. This means the actual outflow of water in the reservoir is not made in accordance with the rule curve, and its reason may be considered as follows;

  - The water operation in the reservoir is at the initial and preliminary stage commenced at the beginning of 1984.

  - The river run-off in the dry season from December 1984 to April in 1985 presents rather small amount due to drought year and the reservoir water level is not recovered to the expected water level shown in the rule curve.

  - The present rule curve may be unsuitable for controlling the annual and monthly runoff with a big fluctuation.

  - The outflow demand for irrigation could not be made properly due to irrigation schedule depend on staggered cropping calendar in the service area.

(b) Baligatan Outflow

The outflow for irrigation water to the South High and Oscariz main canals is made at the Baligatan outflow in the Magat dam. The monthly outflow amount from 1984 to 1986 is shown in the O/M Drawings No.15. This outflow is controlled directly by Dam and Reservoir District because of irrigation purpose only. The Baligatan outflow is properly controlled at present to meet the irrigation requirement in the service area of the South High and Oscariz main canals.

(c) Monitoring Works for Hydrology and Flood Forecast

The monitoring systems for rainfall and runoff observation to forecast the flood are installed in the reservoir catchment area as shown in the O/M Drawings No.7. The system, however, is not functioning at present due to defect of some equipment in the system. This system is also an old type and could not fulfill the role of flood forecast, because the system has no data filing processing and logging equipment and no program to analyze the hydrology and flood forecast.

In this connection, this system is scheduled to be completely improved by the new system under the Cagayan Valley Flood Forecasting System Project, Phase II which is presently undertaken by the PAGASA and NIA, and financed by the fund of OECF in Japan, so that Study Team does not study for the improvement of the system.

(2) Reservoir Operation Rule

At present, the Magat reservoir has been operated according to the instructions given in the O/M Manual as follows;

- The reservoir has the highest water level of EL.193.0 m and the lowest water level of 160.0 m and the effective storage is estimated at 820 MCM.
- The reservoir operation rule curve has been decided as illustrated in the O/M Drawings No.15, and the water level for each month has been controlled so as not to stand lower than the rule curve.
- In principle, the water level comes to the highest level at the end of December, and gradually decreases according to the releasing schedule for irrigation from January to May. From May through June, the reservoir is operated to make the water level lower to reach the lowest of 160.0 m.
- From May/June throughout December, the reservoir inflow much more than the releasing water allows the water level to recover. And in such case, the excessive inflow to the releasing water can be used as discharge for power

generation. The water release for power generation, however, shall be carried out with the restriction that the storage water level must not decrease below the monthly rule curve.

- The reservoir water shall be released by operating the power station as much as possible so as to minimize the ineffective discharge from the spillway.

- The water release from the spillway has been practiced according to the instructions given in the gate operation rule.

The present rule curve, however, shall be improved, and the Study Team has been looking thoroughly into the revision.

2.2.5. Water Management in Diversion Dam

(1) Maris Diversion Dam

(a) Operation Rule

The water management at the Maris diversion dam has been carried out under the supervision of the Dam and Reservoir District Office, including re-regulation of the daily maximum discharge from the Magat hydroelectric power station and water release to the Maris main canal and North Diversion canal. The operation rule of the facilities for the aforesaid works is shown as follows;

Operation and Regulation of Reservoir

The re-regulation control shall be made with the reservoir capacity of 7.3 MCM available from water level 99.50 m (LWL) to 105.00 m (FSL). The re-regulation storage is accomplished by installing stop logs on the crest of dam. The storage of Maris diversion dam is needed to re-regulate the unsteady release of water through power plant during irrigation season. Re-regulation would be damed up by stop-logs to be installed on the crest.

Operation of Intake Facilities

The design intake amount has been decided by instruction of the MRIIS O/M Head Office. The intake through the Maris diversion dam has been made by steady discharge control with the gates appropriately operated according to the fluctuation of the water level at the diversion dam. The gate operation has been conducted empirically according to the fluctuation of the water level at the starting point of the main canal and such empirical works have resulted in difficulty in grasping the accurate intake amount of water.

Intake gates are controlled frequently in accordance with fluctuation of water level in the Maris diversion dam. But, the control gates are not operated well due to the defects of motor system for the gate operation.

(b) Outflow Control

The outflow for the irrigation to the Maris main and North Diversion canals is to be controlled by the intake gate operation at the right and left bank in the Maris diversion dam in accordance with the irrigation demand in the service area on weekly basis.

However, this outflow control is not always made properly at present and the discharge releasing to the canal is fluctuated hourly and daily for the following reasons;

- Re-regulation of the peak discharge for power generation at the Maris diversion dam shall be made based on its amount and releasing hours as well as the daily irrigation demand. However, no previous information for the amount, time and operating hours of peak discharge is given to the MRIIS O/M Office from the NPC, so that the plan for the regulation of the irrigation water is not properly made.
- Since the water level in the Maris diversion dam considerably fluctuates depend on the amount of peak discharge to be released from the power plant, the present gate operation could not follow with its fluctuation and

the releasing water to the canal is also fluctuated.

- The different water head between diversion dam and canal, which is the basis of discharge control is not accurately measured due to no proper measurement devices, so that proper gate operation corresponding to the water head and irrigation demand is rather difficult.

Under the conditions, automatic control system operated depend on the fluctuating water level and irrigation demand shall be introduced in the Maris intake gate.

(2) Baligatan Diversion Dam

(a) Operation Rule

The water management by the Baligatan diversion dam has been carried out by Dam and Reservoir District Office for water release control to the South High and Oscariz main canals. The operation has been made according to the following rule.

- The inflow to the Baligatan diversion dam is almost equivalent to the released water from the Magat dam. The catchment area at the diversion dam is so small in its acreage that the runoff discharge decreases rapidly and in short time when rainfall takes place.

- The water level is controlled in principle at EL.128.3 m by steady flow regulation. The normal water level at the diversion dam is maintained by elevation of overflow portion of the weir plus overflow depth (EL.128.40 m + ) at maximum.

- The diversion dam provides actually no capacity of water storage and all of the discharged water from the Magat dam is diverted to the both main canals of South High and Oscariz main canals.

(b) Intake Control

The intake control has been carried out by appropriate gate operation in corresponding to the water level at the diversion dam. In the both main canals, however, the gate operation should be

appropriately practiced to meet the water level in the canals where there will be back water caused by damming-up by check gate operation. Check gates at upper reach of main canal should be operated carefully and exactly.

(3) Siffuris Diversion Dam

(a) Operation Rule

The water management at the Siffuris diversion dam has been executed by the District III Office, including water intake from the Siffu river and water distribution to the main canals of the Siffu North and South areas. The operation rule of the diversion dam is as follows.

- In principle, the intake to the Siffu North main canal shall be practiced preferentially to the South main canal.
- If the Siffu river discharge is insufficient to meet the diversion requirements for both main canals, such insufficiency in diversion water shall be supplemented depending upon the Magat dam. The supplemental water shall be diverted to the Siffu South main canal through the North Diversion main canal.

(b) Water Control at Intake

The water control at intake will be comparatively easy when the river has abundant discharges in the wet season. In case of the dry season, however, when the river discharge can not meet the diversion requirements, the prudent gate operation will be essentially required for preferential diversion to the Siffu North main canal. The Siffu South main canal is connected with the North Diversion main canal which can supply supplemented water from the Magat dam.

The gate operation of the Siffuris division dam, however, has not been able to correspond to the fluctuations of the river discharge and water level. It is observed that some of the

discharge overflows uselessly even in dry season. After taking water into the Siffu North main canal, the river water is diverted to the Siffu South main canal, although not accurately grasped in its amount. Ambiguity in the information has resulted from insufficiency in records and data on water intake and diversion at the Siffu diversion dam. In other respect, the flushing gates at the both banks are not poorly maintained with heavy piles of sand sediment around the immediate upstream of the gates. A series of these matters have caused hindrance of the gates from appropriate operation.

In this connection, improvement should be made on the intake gate control and operation system, so that the intake can be practiced effectively according to the water level fluctuation. The flushing gates on the both banks should be repaired for the purpose as well.

### 2.2.6. Water Management in Canal System

The water management in canal system consists of the following works in principal.

- To estimate the accurate discharge to be allocated in the canal.
- To carry out the proper discharge control at check, head and turn-out gate points in accordance with the allocated discharge.
- To check the discharge flowing down in the canal at the major control points by the discharge measurement.
- To make data management for water management.

The present water management relevant to the above works, however, is hardly made in the MRIIS O/M Office due to many reasons and difficulties. As a result of poor water management in canal system, much irrigation water has been introduced in the upstream service area but less water in the downstream area. Therefore, the

downstream area is suffered from the inundation problem by the surplus irrigation water released from the upstream area in the wet season and brings the water shortage problem in the dry season.

(1) Distribution Control of Canal System

The irrigation water is delivered to the whole Service Area through 347 canals with 1,470 km in length. Out of these canals, the distribution control at the upstream section of the Maris main canal with 13 km in length from the beginning point to the branch point of the lateral D, is being carried out directly by the MRIIS O/M Head Office, because the upstream section of the Maris main canal has branched off the important and large canals.

The other main and lateral canals are controlled by each District Office I to IV. The classification of assignment by each canal is shown in Table E-1 in Annex.

Distributed water through head gates and turn-out gates is allocated by four District areas and their activities for water management are as follows:

- Allocated discharge reviewed by the MRIIS O/M Head Office is indicated to Water Master (WM) through District Manager on every Monday.
- 99 Water Masters indicate the operation of check, head and turn-out gates to the MRIIS O/M staff; 34 Gate Keepers, 225 Ditch Tenders and 162 committed Operators.
- The operation of the allocated water at each gate position is held on every Tuesday.

(2) Present Discharge Control in Canal System

The present discharge control is not properly made due to the following reasons;

- Discharge control has been carried out by utilizing 231 staff gauges, as shown in O/M Drawings No.17, but the staff gauges without relation between water level and discharge - rating table account to 40 percent of total number, and therefore proper discharge control cannot be made.

- Moreover, existing rating tables were prepared on the assumption that canal flow is uniform. However, canal flow is affected by back water by the check gate in downstream. Consequently, the accuracy of discharge control by gates is considered to be relatively low.

- Allocated discharge at the check, head and turn-out gates in canal is not calculated accurately and on schedule, so that the Water Master and Gate Keeper do not know the discharge to be released.

- The water level at canal is fluctuated hourly and daily, since the gate operation cannot follow with its fluctuation, and the allocated discharge through the gate is also fluctuated. Especially Maris main canal presents considerable fluctuation of water level, because the water diverted from the Maris diversion dam is not controlled properly as mentioned in paragraph 2.2.5. In addition, the Magat mini-hydroelectric Power Plants "A" and "B" installed in the Maris main canal are often operated by its power demand which is not corresponding to the allocated discharge for the irrigation. The upstream water level at the mini-hydroelectric Power Plants is rapidly decreased or increased by the power outflow fluctuation.

- The staff gauges are not sufficiently and properly installed at the check and head gate points, so that the Gate Keeper cannot read the water level clearly and operate the gates keeping the constant water level in canal section.

- Gate Keeper controlling the check and head gate is not well trained yet to operate the gate properly in accordance with the different discharge and water level.

- There are many canal sections smaller than designed discharge due to siltation and many defective gates which cannot control discharge.

(3) Present Discharge Management in Canal System

The discharge measurement shall be made in order to check the result of discharge control carried out by the Gate Keeper. Though these activities have been made by five hydrographer's group in the MRIIS O/M Head Office and four District Offices, systematic discharge measurement has not been made up to now due to lack of measuring equipment and no determination of measuring points.

Taking consideration of these situations, the Study Team has carried out the discharge measurement together with the hydrographers in the MRIIS O/M Head and District Offices at the major points of canals which seem to release much or less discharge compared with the allocated one. The result of discharge measurement is shown in the O/M Drawings No.18.

According to the result of discharge measurement, the actual discharge is not corresponding to the requested discharge which is instructed to each District by the Head Office. Differences in discharge are estimated at 20 to 40 percent in the main canal and 30 to 60 percent in the lateral canal.

This fact shows that the discharge in canal is not controlled properly, especially in the following canals;

Result of Discharge Measurement

| Name of Canal | Requested Discharge(1) (cu.m/sec) | Measured Discharge(2) (cu.m/sec) | (2)/(1)x100 (%) |
|---|---|---|---|
| Downstream of Maris Canal | 6.8 | 4.06 | 59 |
| North Diversion Main Canal | 23.0 | 15.92 | 69 |
| Siffu South Main Canal | 9.7 | 5.75 | 59 |
| Macanao East Main Canal | 6.5 | 4.98 | 76 |
| Lateral B | 3.5 | 1.64 | 77 |
| Lateral E | 2.8 | 2.01 | 72 |

(4) Present Data Management in Canal System

Following data should be managed for water management, but few data have been managed up to now.

- Planned discharge
- Allocated discharge
- Water level at major point of canals
- Gate operation
- Record of discharge measurement
- O/M of staff gates, automatic water level recorders and current meters

2.2.7. Water Management at On-Farm Level

(1) Size of Terminal On-Farm Area

The sampling survey has revealed that the acreages of terminal on-farm area range from 0.5 to 2.5 ha. In most cases, these fields have a rectangular shape with long side by 500 to 600 m.

Farming practices, particularly the water management at on-farm level has been carried out for farm plots as operation unit which is segmented from the farm field. One unit plot has about 0.1 to 0.15 ha on an average, although having a variety of acreage by conditions of topography, slope, etc. Every plot has one to three notches of its own to deliver irrigation water, through which the plot-to-plot irrigation has been carried out.

The farmland connects with a farm ditch at a corner of the farm, and the water is taken into the field through the ditch. When the supplemental farm ditches along the long side of the farmland are arranged, the time required for irrigation can be reduced to a half of time. The irrigation conditions for the fields of the sampling survey are summarized in Annex E.

(2) Irrigation at On-Farm Level

Irrigation water is supplied to the fields through the farm ditches by Farmers Irrigators' Group (FIG). Some of the FIG, however, have not carried out the water distribution management adequately. The turn-out gates at on-farm have always kept opened for taking water into the fields as much as possible.

The water taken into the field from the farm ditches is distributed to the terminal plots by plot-to-plot irrigation method. And the surplus water is also drained to the farm drain by plot-to-plot flow. In this connection, present water management at the field requires much more water than the designed discharge.

Approximately 2,900 turn-outs are provided along the lateral canals to irrigate the area of 97,400 ha. These turn-outs are the unit for irrigation water supply to the field to command the areas ranging from 20 ha to 30 ha. The turn-outs have a capacity of about 100 lit/sec, which exceeds the amount of the designed discharge, and this sufficient capacity has resulted in much water losses due to no effective control of the turn-out gates. Under the situation, Water Master (WM) and the Gate Keepers (GK) should strictly check the operation of the turn-outs by FIG.

The existing farm ditches are considerably low density as about 25 m/ha and bring the problems that it takes a long irrigation period more than one day at the field. The length of the farm ditch, therefore, is desirable as long as by 60 m per hectare in density with the improvement of supplemental farm ditch having the length of 100 to 200 m at on-farm level.

(3) Water Distribution and Related Problems at On-Farm Level

The plot-to-plot irrigation method has been applied to the on-farm irrigation in the Service Area. However, the irrigation in the area has not been practiced under a well-planned rotational

method but carried out individually and disorderly on the daily basis or at interval of three or five days by each turn-out as the unit. For the practical irrigation for land soaking, it takes two to seven days, although it will be fully depending upon plot sizes, intake capacity, aridity of field soils, etc.

The rotational irrigation is essentially required for the irrigation at the early stage of paddy cropping in view of the irrigation water requirement and the lateral canal capacity. Actually, however, the continuous distribution of irrigation water has prevailed therein on the daily basis due to the following various problems.

- Farming works like puddling, transplanting, etc. in the fields commanded by one head gate are practiced within a period from one to three months tediously. In a word, there is no peak time for the cropping and farming works which are distributed evenly throughout the long season.
- The water intake, even to the farm ditches, has been carried out with the upstream fields preferentially to downstream fields. The fields in the downstream can not be irrigated until the upstream field irrigation would be completed.
- There are many ill-drained fields, which are considerably moistened even in the early stage of irrigation.

In any cases, promotion of the scheduled irrigation will inevitably require appropriate intake at a turn-out, rotational water distribution, farmers/FIG leaders' training/campaign for water management, and so forth. The training items are shown below;

- Effective operation of a turn-out at the lateral canals, of which operation and maintenance have been transferred to FIG.
- Methodology of the rotation irrigation necessary for peak irrigation period and operation of the farm ditches.
- Provision and consolidation of farm ditches and farm roads, and
- Water supply of adequate water depth in fields.

## 2.3. Maintenance of System Facilities

### 2.3.1. Maintenance of Dam and Diversion Dams

(1) Magat Dam

Magat dam was constructed in 1982 and four years passed after its completion, however no particular problems are found in the dam on the functional and structural viewpoint, and no repairing works are necessary at present.

(2) Maris Diversion Dam

There are 12 sluice gates on the right bank for the Maris main canal and two sluice gates on the left bank for the North Diversion main canal.

Ten gates out of 12 gates on the right bank were installed in 1957 and are too old to function well. Another two gates and the left intake gates constructed in 1979 are well functioning. Double spindle type is applied for the lifting device and one motor operates two or five gates by using a conversion gear. The lifting devices are connected with a motor by gears and chain, and operated by a manual clutch. The motor operation is made by a button installed beside the machine and the lifting device is a simple one without opening meter or automatic stopper.

There are no particular problems on the structure and function of the dam body, however, a part of the apron of the Maris diversion dam has been scoured with the spilled discharge energy due to enheightening and reconstruction as bucket type spillway. Its scoured volume reaches about 12,000 cu.m extending over an area of about 3,000 sq.m and a depth of about 4.0 m. This scoured depression will be wider and deeper year by year due to a flood energy. The concrete blocks placed on the apron to dissipate the flood energy are only of small unit with a weight of one ton, and presently scoured out already to the downstream by the flood.

(3) Baligatan Diversion Dam

The Baligatan diversion dam was constructed in 1982 and is operated in good condition.

The Ogee type spillway without gates with the maximum design flood capacity of 230 cu.m/sec is installed across the river and the sand sluice way with an electrically operated radial gate with a size of 5.25 m width and 3.80 m height is located beside the spillway. Six sluice gates for the right intake and two sluice gates for the left intake are installed and manually operated. The facilities are in good condition and no rehabilitation is necessary at present.

(4) Siffuris Diversion Dam

The existing dam has been enheightened on the old dam with 1.2 m in 1979 under the fund of the World Bank. The intake discharge is controlled by three sluice gates for right bank and one sluice gate for the left bank. These gate operation are hardly adjusted, due to manual operation.

There is no operation bridge, therefore a small boat must be used to cross the river for operation of the gate on the left bank.

Furthermore, the redesign of sand sluice gates located at both sides of the spillway had not been made when heightening of the dam was undertaken, therefore the gate operation became harder and harder. Finally the gates became completely unoperationable.

2.3.2. Maintenance of Irrigation Canals

(1) Main Canal

Scouring at the immediate downstream of structures, silting at the downstream canal with a gentle slope and settlement of canal

embankment at the flat area are the problems. Followings are details of each main canal;

Maris Main Canal

This canal is the biggest one with a discharge capacity of 121.5 cu.m/sec in the Service Area and covers the service area of about 53,900 ha in the central part of the Service Area by 10 large laterals and the South Low main canal. The canal has the length of 27.4 km and several drops are provided to dissipate excess energy caused by the difference between natural ground slope of 1/1,000 and designed canal slope of 1/5,000. After construction of the upstream section of the canal, three mini-hydroelectric power plants to generate the power are planned by using the excess energy of these drops. However, two of them (Magat mini-hydroelectric Power Plants "A" and "B") have been constructed and are presently operated.

The water control for irrigation at the mini-hydroelectric power plant sites brings a problem due to sudden increase of water level at the occasion of electrical currency failure. This is caused by manual operation of the check gates provided near the power plant, so that the gates should be replaced to automatic operation to release excess discharge diverted from the power plant to the downstream canal.

In order to maintain the distribution water level in the canal at the head and turn-out gates, the check structures of 14 units are installed in the Maris main canal. The canal at the downstream portion of these structures is almost scoured by the flow energy, especially in the canal immediate downstream of the mini-hydroelectric power plants.

As for the operation of check gates, the discharge is not accurately released to the downstream canal due to overtaking water at the head and turn-out gate points in the upstream canal.

Although the discharge should be released to the downstream canal by controlling the opening of check gate, the operation rule is not always kept and the discharge is sometimes overflowing on the top of the gate. This overflowing discharge accelerates scouring phenomenon at the downstream canal.

Since the flow velocity at the downstream canal between branched off points of lateral "G" and "J" is very low as 0.1 to 0.2 m/sec due to a very gentle slope, many siltations take place making the canal cross section area small.

South Low Main Canal

This canal is branched off from the Maris main canal and runs through the areas located at the southern part of the MRIIS Service Area. The canal covers the service area of 7,900 ha with the length of 49 km and the discharge capacity of 17.6 cu.m/sec. The canal cross sections become smaller and smaller at the downstream section because of acceleration of silting due to numbers of checks which disturb water flow, therefore the canal flow does not reach the downstream area on schedule and the area is always suffered from a shortage of water.

South High and Oscariz Main Canals

Both canals start from the Baligatan diversion dam and run through the higher elevation area located at the southern and western boundaries of the Service Area. The South High main canal serves the area of 9,580 ha in the south end of the Service Area with the length of 60 km and the discharge capacity of 26 cu.m/sec. The Oscariz main canal covers the area of 3,100 ha in the south-western hilly areas with the length of 12 km and the capacity of 7.7 cu.m/sec. Both canals including their laterals were constructed recently, so their service area is not fully developed yet and requires the on-farm development. The South High main canal

has many related structures such as drops, siphons, culverts, etc. and requires careful maintenance.

North Diversion Main Canal

This canal starts at the left bank intake of the Maris diversion dam and passes through the west end mountain foot in the Service Area to the Siffuris diversion dam. The canal serves not only the direct service area of 7,300 ha, but also the Siffu South area of 8,200 ha and the Siffu East Extension area of 6,300 ha. Scourings at the check gates are so severe due to sandy soil along this canal that the urgent repair works are required.

Furthermore, siltation is accumulated at the downstream section of canal, and discharge capacity has become smaller.

Siffuris South Main Canal

This canal starts at the right intake of the Siffuris diversion dam and covers the area of 8,200 ha located at the southern area of the Siffu river. The canal length and discharge capacity are 27 km and 14.0 cu.m/sec respectively. This canal cannot take sufficient water in the dry season from the Siffuris diversion dam due to no storage function in the diversion dam, therefore the shortage of water in the dry season is covered with the water supplied by the lateral NDC-7 branched off the North Diversion main canal.

Siffuris North Main Canal

This canal starts at the left intake of the Siffuris diversion dam and flows down along the Siffu river. The canal covers the area of 3,000 ha located at the northern part of the Siffu river with the length of 25 km and the capacity of 5.2 cu.m/sec. This canal takes also the run-off flow from the Siffu river with first priority.

(2) Lateral Canals

The lateral "D" of the Maris area has the discharge capacity of 35 cu.m/sec and is the third biggest canal in the Service Area after the Maris main canal and the North Diversion main canal. The lateral "D" has 39 sub-laterals and covers the service area of 22,000 ha with total canal length of about 175 km. Besides, the lateral "A" of Maris is also a big canal with covering area of 7,400 ha and canal capacity of 22 cu.m/sec. It has 30 sub-laterals and a total length of those canals reaches about 150 km. Canal slopes vary from 1/5,000 to 1/3,000 in the flat area and from 1/2,000 to 1/1,000 in the hilly area. The immediate downstream of the structures is also scoured and siltation is another problem in the downstream section of laterals due to accumulation of sediment materials transported from the upstream.

On the other hand, since the development of the area had been undertaken by extension, some laterals do not have enough discharge capacity to cover their service areas and they must be enlarged.

(3) Check and Head Gate

There are 15 irrigation systems classified by main and lateral canals in the Service Area and they are composed of several main, lateral and sub-lateral canals. Numbers of check gates are provided at an interval of 2.3 km for the main canals or 8.2 km for laterals. And there are also so many check structures without gate installed along the small laterals. Finally, these check structures are at an interval of one to two kilometers.

For the check gate, radial gates are used in the upstream section of main canals due to easy operation, and sluice gates are used in the downstream section of main canals or laterals due to its cheaper cost.

The immediate downstream of the structures are scoured by the discharge energy released from the gates in the condition of critical flow because no dissipator is applied.

There are more than 330 laterals or sub-laterals in the benefited area and head gates are provided at every diversion point of those canals. These gates are sluice type manually operated, however, some of gates, about 25 percent of head gates and about 40 percent of check gates, are not functioning properly at present, and it would be necessary to repair/replace these gates.

The check and head gates are classified depending on the present conditions as shown in Table F-6 and Table F-7 in Annex.

(4) Canal Relative Structure

About 3,300 canal related structures such as parshall flumes, siphons, culverts, thresher crossings, drops, bridges, etc. are provided on the main and lateral canals of 1,470 km in the Service Area. No damages are found yet on those structures because they are constructed with concrete or concrete pipes.

(5) Turnout

There are many turnouts on the main and lateral canals to distribute the water to the Service Area. The number of turnouts in the Service Area is estimated at about 2,900 places with a density of one turnout per 20 - 30 ha on an average. They are principally constant-head orifice type with an orifice gate and a discharge control gate, but some of them are single-gated type without orifice gate.

The turnouts are classified into three status such as N; No gate available, S; Single-gated, and D; Double gated, and they are also classified into three grade according to the present conditions, namely F; Functional, R; Need repair, C; Need replacement or newly installation as shown in Table F-8 in Annex.

### 2.3.3. Maintenance of Drainage Canals

There are no projected drainage canals but so many natural creeks are used for drain in the Service Area. However the capacity of those creeks became smaller year by year due to the growth of aquatic plants or man-made fish traps. Then the surrounding area at the creeks are inundated in the wet season. The length of the creeks to be maintained is about 870 km and its details are shown in Table F-9 in Annex.

### 2.3.4. Maintenance of Pumping Stations

The three pumping stations in the Service Area has been under operation since 1984 but not operated fully. The reasons are i) high electric cost, ii) area without fully developed, and iii) some mechanical faults of pump.

The reason of i) will be solved by the supply of power of Baligatan hydroelectric power plant newly constructed, and the reason of ii) may be solved under the O/M works. There are several mechanical problems on the said pumping stations as follows:

- Leakage from Expansion Joint of Outlet Pipe

  Leakage is found at the expansion joint of an outlet pipe of pumps No.2 station and the floor of pumps is inundated by leakage water. So the expansion joint shall be repaired by changing the packing to a new one.

- Leakage from Air Valve of Outlet Pipe

  Leakage is also found at the air valve of No.3 pump in pump No.2 station. It should be closed by plate cover or an attached sluice valve should be in closed condition because the valve is not so useful on pump operation.

- Problem on Siphon Breaker and Reverse Rotation Preventer

  All pumps of No.1, No.2 and No.3 stations are the same type and no flap valves, nor check valves are applied. The outlet pipe is designed as siphon type and a siphon breaker is installed at the highest point of the pipe to

prevent a reverse flow. And a reverse rotation preventer is applied on the top of a motor to prevent reverse rotation due to the water in the pipe.

An accident that the connecting bolts of reverse rotation preventer were damaged due to the reverse flow, happened No.2 station and it caused damages on the siphon breaker. So the siphon breaker shall be carefully maintained to prevent such a big accident.

- Problem on Water Leakage into Lubricant

After completion of the installation, the pumps were overhauled several times to solve the problem on water leakage. Judging from the operation condition of pumps, structure and mechanism of oil-seal and material of sleeve seem to be unsuitable.

Water pressure is higher than oil pressure in the oil-seal of pumps and the maximum difference of pressure is inspected as 1.5 kg/sq.cm for No.1 station, 2.0 kg/sq.cm for No.2 station and 1.3 kg/sq.cm for No.3 station. The leakage is causing that a lip of oil-seal and shaft sleeve can not resist the difference of pressure or rotation speed of shaft sleeve for a long duration. In case oil-seal is applied for sealing mechanism, it is considered that a hard material must be used for the shaft-sleeve and oil pressure must be made higher than water pressure to prevent water leakage to oil.

For this purpose, the oil seal should be improved as the structure having a room for pressure of oil and water to be released in, and should be attached to drain facilities for leakage of water or oil.

### 2.3.5. Maintenance of Roads

Service roads are provided along all main and lateral canals for operation and maintenance. The width of the service roads is 5.0 m for main canal and 3.5 m for lateral in principal. On the other hand, the existing Barangay roads and provincial roads connecting service roads are improved. These service and access roads are all-weather road paved by gravel and need maintenance every three to five years.

The length of service and access roads to be maintained are shown in Table F-10 in Annex.

## 2.4. Operation and Maintenance Activities of the MRIIS

### 2.4.1. O/M Organization and Function

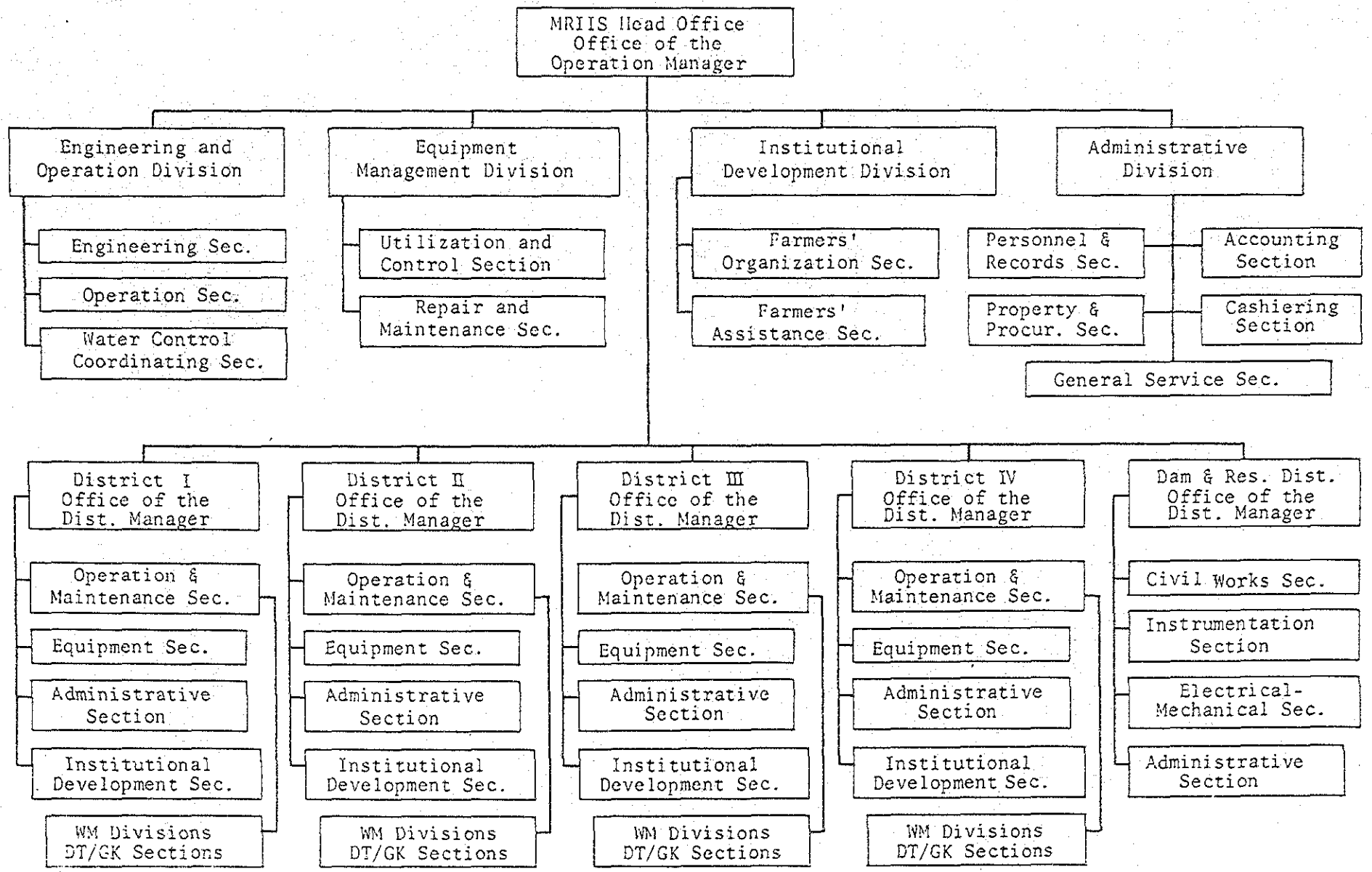
#### (1) Organization and Function

The organization for the MRIIS O/M was established in 1984 after completion of the major implementation works of the MRMP, and it was revised a little by NIA in October 1986. The organization for the MRIIS O/M which consists of a Head Office, a Dam and Reservoir District and four District Offices is shown in Figure 2-1, and the detailed staffing is shown in O/M Drawings No.2.

The main function of the MRIIS O/M Office is categorized as follows;

- To operate system facilities in order to provide a year round irrigation to about 97,400 ha of farmland under the developed facilities, as well as to provide water to the Magat hydroelectric plant for power generation by NPC,
- To operate Baligatan hydroelectric power plant by means of flow through Baligatan outlet in order to make use of available energy for pump operation under the system,
- To organize and strengthen farmers' organization in order to achieve better cooperation between the MRIIS and farmers with regards to operation and maintenance of the system,
- To assist farmers in the works of on-farm facilities development in the area,
- To maintain the function of system facilities with appropriate maintenance works, and
- To collect irrigation service fee from beneficiaries in return to irrigation services, which is principal source of income of NIA,

**FIGURE 2–1. ORGANIZATION CHART FOR THE MRIIS**



(2) Function and Staffing of Head Office and Four Districts

The organization of the MRIIS O/M Office consists of four supporting Divisions under the Office of Operation Manager, and the four districts, which have organized by common structures under each Office of District Manager, have four sections correspond with these divisions. The functions for the corresponding organizations are summarized as follows:

- The Engineering and Operation Division in the Head Office and the corresponding Sections take charge of O/M works.
- The Equipment Management Division in the Head Office and the Equipment Section in the District Offices are in charge of management on vehicles and heavy equipments.
- The Institutional Development Division and the corresponding Section in the Districts take charge of IA organizing work.
- The Administrative Division and the corresponding Section are in charge of administrative works for each offices.

The service area in the Districts are divided into 22 to 29 Divisions headed by each Water Master (WM). The WM Division which have an average service area of about 1,000 ha is the terminal organization to execute routine O/M works under the O/M Section.

The WM Division is divided into Sections in which each Ditch Tender (DT) and Gate Keeper (GK) are assigned, who undertake routine O/M works in their Divisions under the direction of WM concerned.

- The Gate Keeper has responsibility for diversion flow control through the specified gate under the direction of Area Engineer.
- The responsibility for O/M works in the section is to transfer the organized IA in accordance with lateral turnover scheme promoted by NIA in the national level.

Actual number of O/M staff in the MRIIS O/M Head Office and four District Offices is shown in the following table.

Number of Staff for Head Office and District Offices

| Name of Division/Section | Head Office | District Offices I | II | III | IV | Total |
|---|---|---|---|---|---|---|
| Office of Manager | 8 | 8 | 9 | 8 | 8 | 41 |
| Operation & Maintenance | 24 | 89 | 124 | 107 | 87 | 431 |
| - In the Office | (16) | ( 7) | ( 8) | ( 8) | ( 8) | ( 47) |
| - In the WM Division | ( 8) | (82) | (116) | (99) | (79) | (384) |
| Equipment Management | 26 | 22 | 23 | 23 | 19 | 113 |
| Institutional Development | 9 | 4 | 4 | 4 | 4 | 25 |
| Administratives | 33 | 28 | 25 | 23 | 10 | 119 |
| Totol | 100 | 151 | 185 | 165 | 128 | 729 |
| No. of IA, BA, & Individual by Contract | | | | | | |
| Under the WM Division | | 77 | 30 | 31 | 24 | 162 |

(3) Dam and Reservoir District

Dam and Reservoir District takes charge of O/M works for the Magat dam and Maris and Baligatan diversion dams as well as Baligatan hydroelectric power plant which will be operated in the near future.

The District is organized by four Sections which take charge of O/M works for specific facilities, as civil works, instrumentations, mechanical electricals as well as administratives under the Office of District Manager.

- The Mechanical Electrical Section undertakes outflow control from the reservoir and diversion control at two diversion dams as well as operation of Baligatan hydroelectric power plant.
- The Instrumentation Section takes charge of hydro-meteorological management in the dam drainage area.

Actual number of staff assigned to the said Sections in the District is shown in the following table.

Number of Staff for Dam and Reservoir District

| Name of Section | NIA Staff | By Contract | Total |
|---|---|---|---|
| Office of Manager | 3 | - | 3 |
| Civil Works | 65 | - | 65 |
| Instrumentation | 45 | 23 | 68 |
| Electrical Mechanics | 45 | - | 45 |
| Administrative | 25 | 27 | 52 |
| Total | 183 | 50 | 233 |

2.4.2. Water Management

(1) Organization of Water Management

Two Sections under the Engineering and Operation Division in the MRIIS O/M Head Office take charge of water management in system level; one is Water Control Coordinating Section (WCCS) in charge of general water allocation to each canal as well as reservoir operation, and the other is Operation Section in charge of monitoring and evaluation of irrigation efficiency.

The water management in District level is conducted by Operation and Maintenance Section dividing the District area into two areas headed by Area Engineer. The water control works in the canal system have been carried out by O/M staff assigned to each WM Division dividing the area into Sections.

The water control of Maris main canal from the head gate to Lateral-D head gate is undertaken by the Gate Keepers assigned to the WCCS in the MRIIS O/M Head Office.

(2) Status of Water Management

Actual water management in the canal system is not made well as presented in Paragraph 2.2.6, and it is considered that at part of present status of inadequate water management is resulted from present organization and staffing of WM Division under the District, which is described as follows:

- The water management rule which is to control water by O/M personnel independently dividing the area into sections is unsuitable for the big canal system, because adequate flow control in the canal network will be possible only through the adequate diversion control for each farm turnout.

- The water management work in the section by contract is not made well as a whole, because the amount of contractual payment is not sufficient for full time service and IAs have no budget to provide such employee for the water management work.

- The total number of DT in the system has decreased by the lateral turnover scheme and the performance of WM Division on water management has declined in accordance with the decrease in number of DT.

Under the organization structure and water management system described in the above, it is quite difficult to achieve adequate water management over the canal networks, and it is required to establish synthetic water management structure mainly for the WM Division level.

### 2.4.3. Maintenance of Facilities

#### (1) Organization of Maintenance Works

The Engineering and Operation Division in the MRIIS O/M Head Office takes charge of repair and rehabilitation works in system level as well as monitoring and evaluation of the works in District level conducted by each District.

The Operation and Maintenance Section in District Offices is in charge of major maintenance and repair works, and the section has kept technical staffs for the works undertaken by force account.

The Equipment Section in District has kept heavy equipments and operators for the use of force account works, and these heavy equipments are managed by each District which provides each motor pool and mechanical shop for the use of equipment management.

The O/M works in the Dam and Reservoir District has executed independently by each Section which is divided into units corresponding with facilities and instruments to be managed, and sufficient number of technical and manual staffs have been assigned under each unit for the specific O/M works.

(2) Maintenance of Magat Dam and Two Diversion Dams

The maintenance works for Magat dam and two diversion dams, Maris and Baligatan, have been undertaken by the Dam and Reservoir District and it is executed by the staff in accordance with the operation manual prepared by the MRMP.

At present, the Magat dam and two diversion dams have been maintained properly by the financial support from the NIA Central Office. However, the NIA Central Office slashed the O/M budget for 1986 operation by 9.1 million pesos from 14.6 million pesos of actual expenditure for 1985, due to destitution of NIA corporation fund, despite it is not enough to maintain the facilities in fair conditions at present.

Since the Magat dam is one of the most valuable infrastructure not only for NIA and NPC but also the Country, it must be maintained properly as long as possible by the responsibility of the MRIIS with adequate staff and sufficient budget correspond with the value of these facilities.

(3) Maintenance of Irrigation System

The maintenance works of irrigation system which are in charge of the MRIIS O/M Head Office and four Districts has not been made properly due to insufficient budget and lack of assessmental rule on the function of facilities. As the result, the deteriorated canal facilities should be rehabilitated and upgraded, in order to restore its original function.

(4) Heavy Equipment

The existing O/M equipments kept in the MRIIS are transferred from the MRMP after completion of the implementation works and distributed among Districts equally for the use of system maintenance. Kind and number of major equipments kept by the system are shown in the following table.

Kind and Number of Heavy Equipment and Vehicles

| Kind of Equipment | Head Office | Dam Dist. | District I | II | III | IV | Total Number |
|---|---|---|---|---|---|---|---|
| Back Hoe | | 0 | 5 | 5 | 4 | 5 | 19 |
| Bull Dozer | | 3 | 3 | 2 | 2 | 1 | 11 |
| Loader | | 1 | 2 | 2 | 2 | 1 | 8 |
| Crawler Crane | | 0 | 1 | 1 | 1 | 2 | 5 |
| Trailer | | 0 | 1 | 1 | 1 | 1 | 4 |
| Dump Track | | 3 | 6 | 6 | 5 | 5 | 25 |
| Stake Track | | 1 | 2 | 2 | 2 | 2 | 9 |
| Vehicles | 12 | 9 | 7 | 7 | 8 | 6 | 49 |

These heavy equipments are considered to be sufficient in number for O/M works, however most of equipments are too old to make use for future O/M works for irrigation facilities during the expected working periods with one month for regular maintenance. Furthermore, using of these old equipment brings about the increase of cost for maintenance and repair.

The MRIIS has kept a number of operator and mechanical staff correspond with existing vehicles and heavy equipment as said in the above, and it will be sufficient for future facility maintenance as well as for equipment management.

These heavy equipments and staff, however, have not been utilized effectively since the new organization was established due to lack of O/M budget allocated to the system.

### 2.4.4. Institutional Development

Agriculture Development Division (ADD) was established in MRMP during the implementation stage for the purpose of organizing farmers into Farmers' Association (FA) to cooperate with NIA with regard to O/M activities, as well as assisting farmers in the field of irrigated agricultural development.

By the operation of ADD, the number of organized IAs and farming productivity under irrigation in the area had developed in successful and in 1984 these accomplishment reached up to the present level.

The number of staff under the ADD were reduced at the late stage of MRMP, and only limited number of staff are engaging for the farmer institution development works under the Institutional Development Division (IDD) which was formally approved as the MRIIS organization in October 1986 by the conterminous with five year agricultural development program.

The farmer institutional development works under the MRIIS organization has not been deployed actively due to the insufficient number of staff, lack of operation budget and equipment, poor farmer supporting activity as well as inadequate water management services.

### 2.4.5. Irrigation Service Fee Collection

#### (1) Rate of Irrigation Service Fee

The MRIIS O/M Office provides two different rates of irrigation service fee for two kinds of irrigation systems, gravity and pump, as well as for wet and dry season crops respectively as shown in the following table. The rate of pump irrigation service fee after one year service was regulated specially by the MRIIS.

| Irrigation System | Wet Season (cavan/ha) | Dry Season (cavan/ha) |
|---|---|---|
| Gravity System | 2 | 3 |
| Pump System (1st one year) | 3 | 5 |
| Pump System | 5 | 7 |

The irrigation service fee is essential and the most important source of income for NIA, which is collected in kind or cash depending on the farmers' option. The collected paddy by the Districts is usually stored in the compound and sold to NFA or private dealers time to time at the current price.

(2) Collection Efficiency of Irrigation Service Fee

The historical rate of irrigation service fee collection in the MRIIS area since 1975 is relatively low with 60 to 70 percent of the collectible amount, and especially it is considerably low in the wet season.

There are two major reasons for the low rate of collection in the Service Area; one is low income of farmers due to high production cost, and the other is low farming productivity due to incomplete irrigation service by the system which has caused by worn facilities and improper water management.

(3) Collection in Kind

The payment of irrigation service fee in kind has increased in 1986, because the selling price of paddy to private dealer is lower than NFA supporting price during the harvest period. As of October 1986, about 75 percent of the irrigation service fee has been paid in kind by farmers.

As the volume of collected paddy increase, the District Offices have been faced with problems how to process the collected paddy efficiently during the harvest season, because District Offices have provided only conventional drying pavement and shades with insufficient capacity for the volume of collectible paddy.

In the latest collection record from November 1985 to October 1986, the volume of paddy stored in the compounds of District Offices varied between 1,880 tons to 4 tons. The insufficient capacity of post harvest facilities has resulted in poor paddy quality with much loss and brought the reduction of selling price of paddy.

(4) Billing for Irrigation Fee Collection

The MRIIS has introduced a computerized billings since 1984 expanding the area of coverage in every cropping, and in 1986 the operation was able to cover the full irrigated area.

However, systematic data management on collection works has not been realized yet, because the complete data management system on cadaster as well as ownership and cultivator, which are essential for the data management, has not been prepared.

(5) Data Management on Collection Activity

The monthly collection accomplishment are reported to the MRIIS C/M Head Office from Districts in accordance with NIA regulation

regarding to collection report, and the Operation Section summarizes the amount of collection in order to make use of monitorings.

However, it is rather difficult to grasp the real collection status from only that of summarized data which is classified simply into the collection in cash and kind, and the data management has been carried out by conventional manual works.