CHAPTER IV. THE PROJECT

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A. Objectives and Components of the Project

1. Objectives and Scope of the Project

The Project Area is one of the regions that are left behind in economic development of the country. An average per capita income of about ₱780 00 in this region is much lower than the national average of ₱895.00.

Many reasons could be accounted in this regard; however, the main reason is the lack of water sources available for irrigation under the existing conditions Under the circumstances, in the right bank area of the Bonga river, there exist many diversion dams (so-called brush dams) to divert irrigation water to the existing communal irrigation systems. However, cropping area in the dry season in quite limited due to the low river discharges. The Batac-Paoay area and the Badoc-Pinili-Sinait areas which are proposed as the objective area along seashore have only a few water sources to supply irrigation water to the areas, and hence the rainfed paddy cultigation prevails in the wet season, and in the dry season, The upland crops of tobadcco, garlic and mungbeans, etc., which require little irrigation water, are grow in the area

In addition to shortage in irrigation water, the deteriorated irrigation and drainage systems in the whole Project Area have caused much water losses from insufficiency in water management due to intricated canal networks. Furthermore, the road networks including farm roads are poorly provided. Particularly, the roads to access to Bonga right bank area as well as those within the said area have been damaged by floodings in the wet season with no river improvement works implemented yet, and the said area is isolated from other neighboring areas due to unavailability of the transportation facilities.

Under the conditions, the agricultural productivity in the Area has remained in the low level, which results in poor farm income. These unfavorable matters have been caused mainly from lack or absence of the effective facilities of irrigation and drainage systems, farm roads, etc. to meet the requirements in modernized agriculture.

Since the Project Area is blessed with favorable natural conditions such as soil, climate and topography for paddy and upland crops cultivation, the potentiality of the Project Area for agriculture development could be surely exploited by means of constructing adequate facilities.

The project aims to increase agricultural production, generate hydropower, create the employment opportunities throughout the year, and to improve the living environment through rural development in focusing on stable irrigation water supply backed by improved agricultural supporting services, farm road systems.

In order to achieve the above-mentioned objectives and to get quick benefit in the whole Project Area, followings should be envisaged by phasing manner in accordance with the proposed work schedule.

i) Establishment of irrigated agriculture by paddy double cropping with high yield varieties and introduction of cash crops in the dry season in the parts of the Project Area;

ii) On-farm development for irrigated agriculture as well as for modernized ·agricultural practices;

iii) Institutional arrangement and planning for strengthening the agricultural supporting services for full development of the Project Area; and,

iv) Rural community development posterior to the implementation of on-farm development and electrification programs.

2. Components of the Project

The components of the Project are irrigation and hydropower, which are described as follows:

Irrigation · to plan the irrigated agriculture providing with rationalized irrigation and drainage systems, on-farm development, road networks and agricultural supporting services.

Hydropower · to generate hydropower by the released water which will be diverted through headrace tunnel connected with the proposed Palsiguan storage reservoir in the Abra province.

B · Project Formulation

1. Proposed Scheme of Development

The preliminary studies of the proposed scheme of development for the Ilocos Norte Irrigation Project have been made in the Overall Plan, aiming at year-round irrigation for potential acreage from technical and economic viewpoints, and based upon the various alternative plans which are mainly subjected to utilization of water resources, their associated benefits and costs. As the optimum plan for the project development through the studies, a single reservoir plan with the Palsiguan dam (trans-basin plan) has been proposed. (See Appendix-A)

The development of the proposed area of about 22,600 ha as shown in Table 4-1 are planned in the phasing manner - Phase I and Phase II The Phase I development areas are about 10,200 ha located in the right bank area of the Bonga river, and their water resources for irrigation are river waters diverted by the diversion dams constructed across the rivers such as the Labugaon, the Solsona, the Madongan, the Papa, and the Nueva Era. The detailed descriptions of the Phase I project are given in the report of the Ilocos Norte Irrigation Project (Phase I) prepared in 1979.

The proposed irrigable areas of the Phase II development are estimated at about 12,400 ha and its major water resources for irrigation are stored water in the Palsiguan dam in the Abra province as well as the river waters diverted by diversion dams provided in the Madupayas and the Tibangran rivers. The stored water in the dam will be led through trans-basin tunnel (headrace) to the upstream of the Bonga river in the Ilocos Norte province and diverted by the Nueva Era dam provided for the regulation of hydropower, to the service areas of the Phase I and Phase II through link canals, which will be connected with each provided diversion dam and its main canals. The detailed description of the Phase II project is given in the report of the Ilocos Norte Irrigation Project (Phase II) prepared in 1980.

In the Project Area, irrigation and drainage canals will be newly constructed and/or improved to separate irrigation and drainage systems, and terminal facilities will be rearranged and reinforced.

Furthermore, hydropower generation is planned in the Project by using the effective water head between the Palsiguan reservoir and the Bonga river bed (Bonga power station) and also water head at the Nueva Era dam (Nueva Era power station).

Table 4-1 Potential Irrigation Acreage

Sub-Project Area		Potential Acreage (ha)
Phase I,	Labugaon area	1,560
	Solsona area	2,140
	Madongan area	3,190
	Papa area	2,560
	Nueva Era (R.B.) area	750
	Sub-total	10,200
Phase II,	Cura area	1,410
	Nueva Era (L.B.) area	670
	Madupayas area	160
	Batac-Paoay area	5,190
	Pinili area	1,400
	Badoc-Sinait area	3,570
	Sub-total	12,400
	Total	22,600

2 Irrigation Plan

a) Proposed Irrigation Area

The proposed irrigation area in the Project Area, Phase I and Phase II, has been estimated based on available water resources, and the potential arable land is tabulated as follows:

Proposed Irrigation Area

(Unit: ha)

Sub-Area	Phase I Area	Phase II Area	Total
Labugaon	1,560	–	1,560
Solsona	2,140	–	2,140
Madongan	3,190	–	3,190
Papa	2,560	–	2,560
Nueva Era (R.B.)	750	–	750
Cura	–	1,410	1,410
Nueva Era (L.B.)	–	670	670
Madupayas	–	160	160
Batac-Paoay	–	5,190	5,190
Pinili	–	1,400	1,400
Badoc-Sinait	–	3,570	3,570
Total	10,200	12,400	22,600

b) Irrigation Water Requirement

1) Proposed Cropping Pattern

The irrigation water requirement is computed for the following cropping area which crop diversification, of which detailed descriptions are given in the paragraph of "Proposed Agricultural Development."

Proposed Cropping Pattern

(Unit: ha)

	Phase I Area			Phase II Area		
Season	Paddy	Upland 1/ Crops	Total	Paddy	Upland 2/ Crops	Total
Wet Season	10,200	–	10,200	12,400	–	12,400
Dry Season	9,200	1,000	10,200	4,970	7,430	12,400

1/ Tobacco, garlic and onioin.

2/ Tobacco, garlic and mungbeans

2) Water Requirement

Consumptive Use

The consumptive use of paddy, which is equivalent to actual evapotranspiration, is estimated based on the potential evapotranspiration (ETP) computed by the Penman Method in using the meteorological data observed at Vigan and the ratio of an evaporation observed at Vigan and Laoag The consumptive use of upland crops, furthermore, is estimated by multiplying the estimated ETp values by the relevant crop coefficients for vegetative stage of the crops.

Estimated Consumptive Use

(Unit: mm)

Month	Paddy	Tobacco	Garlic	Mungbeans	Cotton	Onion
May	6.5			2.6		
Jun.	6.5					
Jul.	5.4					
Aug.	5.9					
Sep.	5.7					
Oct.	6.9		2.1		2.7	
Nov.	6.1	4.3	2 1		3 0	4.3
Dec.	6.7	5.4	3.4		6 4	5.0
Jan.	6.4	4.5	1.6		5.8	4.2
Feb.	6.0				3.8	
Mar.	6.6			3.3		
Apr.	6.7			5.0		
Average	6.3	4.7	2.3	3.6	4.2	4.5

Crop Water Requirements

In estimating the crop water requirements, the following values are accounted:

- Percolation rate in the paddy fields is two millimeters per day throughout the growing period.
- Additional water supply for land soaking and preparation is decided at 250 mm for the wet season paddy and 230 mm for the dry season paddy. On the other hand, those waters for land preparation of the upland fields after October (tobacco and mungbeans) is decided at 40 mm, taking into account the dry soil conditions However, no water supply is accounted in the amount for land preparation before October, because sufficient soil moisture is expected immediately after the wet season.

Crop water requirements of paddy and upland crops are estimated as follows based upon the above procedures

Crop Water Requirement

(Unit: mm)

Season	Phase I Area			Phase II Area		
	Paddy	Upland Crops	Average	Paddy	Upland Crops	Average
Wet Season	1,073.2	–	1,073.2	1,183.4	–	1,183.4
Dry Season	1,085.6	483.3	1,025.4 1/	1,114.7	405.6	618.3 1/
Total	2,158 8	483.3	2,098.6	2,298.1	405.6	1,801.7

Note: 1/ estimated on the basis of the following diversification ratio:

Phase I Area
- Paddy 90%
- Upland crops 10%

Phase II Area
- Paddy 30%
- Upland crops 70%

Diversion Water Requirement

The diversion water requirement can be calculated by adding effective rainfall and irrigation efficiency to the average crop water requairements weighted by the planted area The criteria of the effective rainfalls and irrigation efficiency applied for the Project are as follows

- Effective Rainfall

The effective rainfall to the paddy fields during the land soaking period is estimated at 250 mm considering the land soaking capacity. The maximum effective rainfall to the paddy fields during the growing stage is decided at 60 mm considering the minimum flooding depth of 20 mm. Therefore, the maximum allowable flooding depth is 80 mm.

The effective rainfall for upland crops, on the other hand, is decided as follows: The rainfall less than 3.7 millimeter, which is equivalent to the average daily consumptive use during the growing periods of upland crops, is considered to be zero and the rainfall more than the total readily available moisture (TRAM) of 49.8 millimeters, which will be described subsequently, is considered to be waste water. Consequently, the effective rainfall for upland crops is those rainfalls more than 3.7 millimeters and less than 49.8 millimeters.

- Irrigation Efficiency

Overall irrigation efficiency is estimated to be 46.8 percent in the wet season and 54.0 percent in the dry season, based on the following percentage of water losses.

	Percentage of Losses (%)	
Water Losses	Wet Season	Dry Season
Farm wastes	35	25
Conveyance losses	20	20
Operation losses	10	10

The diversion water requirements of crops in the design year corresponding to about 10-year probability is given below:

Diversion Water Requirement

(Unit: mm)

	Phase I Area			Phase II Area		
Season	Paddy	Upland Crops	Average	Paddy	Upland Crop	Average
Wet Season	611.7	–	611.7	983.4	–	983.4
Dry Season	1,923.0	806.5	1,837.6	2,036.8	728 5	1,121.0
Total	2,534.7	806.5	2,449.3	3,020.2	728.5	2,104.4

c) Design Discharge for Planning of Irrigation Facilities

Terminal Irrigation Canals

The maximum design discharge for the supplementary farm ditches, which will occur during the land soaking and preparatoin periods, is decided at 1.78 lit/sec/ha for the Phase I area and 1.64 lit/sec/ha for the Phase II area, including 35 percent of application losses, while that of the main farm ditches will vary from 53.40 lit/sec to 10.68 lit/sec and 65.50 lit/sec to 13.12 lit/sec for the Phase I and Phase II area respectively. These discharges are determined depending upon the following criteria.

	Phase I Area	Phase II Area
One rotation area	30 ha	40 ha
Land preparation period for one rotational area	25 days	35 days
Water requirements for land soaking and preparation -		
Wet season	250 mm	250 mm
Dry season	230 mm	230 mm
Application losses -		
Wet season	35%	35%
Dry season	25%	25%

In the above computation, supply of water from the main farm ditches to the supplementary farm ditches is planned to be carried out in full-scale, while the distribution of water from the supplementary farm ditches to the farm lots is made in rotational system.

Lateral Irrigation Canal

According to the proposed cropping pattern and cultivation schedule, the maximum water requirement of lateral irrigation canal is estimated at 2.33 lit/sec/ha for the Phase I area and 2.16 lit/sec/ha for the Phase II area.

1) Water to be Released from the Palsiguan Dam to Existing Communal Irrigation Systems in the Abra province

There exists an area of 323 ha commanded by three communal irrigation systems located on the downstream of the proposed Palsiguan dam in the Abra province; that is, Lagayan CIS for 255 ha, Calambat CIS for 29 ha and Collago CIS for 39 ha. These areas are irrigated by the river water at present. Under the conditions, the water to be stored in the Palsiguan dam should be released from the dam after the completion of the Project at the rate of 0.814 cu.m/sec estimated for this purpose.

d) Depth and Interval of Irrigation Application for Upland Crops

1) Measurement of Intake Rate

In order to find out an irrigation method suitable for upland irrigation in the Project, measurements of intake rate were undertaken at four sites under dry and wet conditions. The results of the measurements are plotted on a logarithmic paper and the basic intake rate (IBi) which is a constant value of intake rate as time increase.

The following table gives the calculated basic intake rate:

Obtained Basic Intake Rates (Wet Condition)

Observation	Location	IBi (mm/hr)
No. 1	Barrio Aracua, Batac	4.2
No. 2	Barrio Linang, Paoay	12.6
No. 3	Barrio Napo, Badoc	5.8
No. 4	Barrio Pactit, Badoc	20.9
Average		10.9

From the above figures, it could be considered in this stage that the furrow irrigation method would be suitable for water supply to the upland crops during the growing season of the plants although further studies on upland irrigation are needed.

In parallel with such measurements of the intake rate, soil samples in the depth of 50 cm at an interval of 10 cm depth were taken to analyze the physical properties of the soils in the field, such as specific gravity, porosity, field capacity, and wilting point.

The analyzed results of the soils under the wet condition are summarized as follows:

Physical Properties of Soils1/

Depth	Real Specific Gravity (Sr)	Apparent Specific Gravity (Sa)	Porosity2/ (P)	Field Capacity (Fc)	Wilting3/ Point (Wp)
	(g/cm^3)	(g/cm^3)	(%)	(%)	(%)
10	2.61	1.21	53.9	42.7	20.8
20	2.63	1.22	53.8	39 4	19.0
30	2.64	1.18	54.9	38.7	18.7
40	2.62	1.19	54.9	40.4	19.6
50	2.62	1.17	55.4	41.1	19.9

Note: 1/ Average of four samples. 2/ $p = (Sr - Sa) \times 100/Sr$. 3/ $Wp = 0.36\ Fc^{1.08}$

2) Depth and Interval of Irrigation

Depth and interval of irrigation for upland crops is determined in following the procedures mentioned below.

i) Determination of effective root zone

ii) Determination of moisture extraction pattern

iii) Calculation of available moisture of each soil layer within effective root zone

iv) Calculation of total readily available moistrue (TRAM)

v) Determination of depth and interval of irrigation application.

Depth of Effective Root Zone

The depth of effective root zone was determined on the basis of field investigations on root zone as shown below.

Upland Crops	Depth of Effective Root Zone (cm)
Tobacco	50
Garlic	30
Mungbeans	50
Cotton	50

Moisture Extraction Pattern

The consumptive use of soil moisture by crop evapotranspiration will vary depending on the depth of soil. This consumptive rate of soil moisture is so-called "moisture extraction pattern", which will be determined based upon the field investigations.

Due to the lack of such data concerned, the following pattern was applied.

Depth of Effective Root Zone (cm)	Ratio of Moisture Extraction (%)
1 – 10	40
10 – 20	30
20 – 30	20
30 – 40	10

Available Moisture in Each Soil Layer within Effective Root Zone

Available Moisture (A.M.) is obtained from the following equation:

$$A.M. = \frac{1}{100} \cdot \Sigma(Fc - Wp) \, . \, Sa.d \text{ (mm)}$$

Where, Fc: Water holding capacity after 24 hours of soil saturation (%)

Wp: Moisture ratio at wilting point (%)

Sa: Apparent specific gravity (g/cm^3)

d: Depth of soil in each soil layer (mm)

Total Readily Available Moisture (TRAM)

Total readily available moisture (TRAM) is calculated as follows:

In the soil layer concerned,

$$\text{Consumed Moisture} = \frac{\text{Available Moisture}}{\text{Ratio of Moisture Extraction}}$$

The layer presenting minimum value obtained from the above equation is the restricting layer of moisture and its value become total readily available moisture (TRAM). According to the above calculation, the value of TRAM, i.e., net amount of water to be replaced, becomes 49.8 mm for each crop.

Interval of Irrigation Application

The interval of irrigation application is obtained by dividing the TRAM by the maximum crop evapotransmiration.

Upland Crop	TRAM (mm)	Maximum Evapotranspiration (mm/day)	Irrigation Interval (days)
Tobacco	49.8	5.4	9
Garlic	49.8	3.4	15
Mungbeans	49.8	5.0	10
Cotton	49.8	6.4	8

From the viewpoint of water management, the same interval of irrigation application is favorable; therefore, 10-day irrigation interval is adopted for the project.

3 Reservoir Plan

a) Storage Volume

The study on water balance for the selected alternative, Case II, has been made for the period from May 1960 to April, 1970 as the run-off data were available.

As a first step, shortage in water in the supply by the natural flow through diversion dams was computed as listed in Table 4-2

Table 4-2 Summary of Shortage in Water Depending Upon Palsiguan Water

(Unit: MCM)

		Phase I Area		Phase II Area			
Year	River 2/ Run-off	I.W.R 3/	Shortate 1/ Water	River 2/ Run-off	I.W.R.	Shortage Water	Sum of Shortage Water
1960	666.0	293.3	91.8	123.8	287.7	221.6	313.4
1961	1,107.8	235.9	68.3	217.9	211.0	168.3	236.6
1962	1,222.8	248.7	61.3	224.5	234.8	168.1	229.4
1963	994.3	265.6	78.1	179.0	243.9	171.1	249.2
1964	1,629.7	236.0	12.0	280.5	231.3	135.3	147.3
1965	931.3	223.1	88.1	181.4	209.9	154.6	242.7
1966	1,134.6	279.6	17.8	167.0	266.0	165.4	183.2
1967	1,293.4	252.2	36.4	223.3	231.7	144.0	180.4
1968	883.4	282.9	100.4	173.6	267.2	194.2	294.6
1969	781.7	297.3	79.6	127.5	272.2	209.0	288.6

Note: 1/ Sum of shortage in water based on 10-day unit computation.

2/ Phase I: The Labugaon, Solsona, Madongan, Papa and Nueva Era rivers

Phase II: The Madupayas and Tibangran rivers.

3/ I.W.R. Irrigation Water Requirement

The above water shortage occurring mainly in the dry season will be supplemented by water to be stored in the Palsiguan dam.

To determine the required capacity of the dam, the water balance for the Palsiguan dam has been studied for the said period to be given in Table 4-3

Table 4-3 Water Balance on Palsiguan Dam
(Irrigation Water only)

(Unit: MCM)

Water Year	Run-off of the Palsiguan River	Compensation 1/ Water	Available 2/ Run-off	W.R. 3/	Required 4/ Storage Volume
1960	313.6	9.7	303.9	221.6	167.5
1961	394.3	7.8	386.5	168.3	137.5
1962	390.4	8.2	382.2	168.1	142.0
1963	375.7	8.8	366.9	171.1	136.0
1964	415.1	7.8	407.3	135.3	80.9
1965	255.7	7.5	248.2	154.6	171.9 5/
1966	281.6	9.2	272.4	165.4	139.4 5/ (max.)
1967	299.7	8.4	291.3	144.0	120.6
1968	365.7	9.4	356.3	194.2	172.4
1969	408.9	9.8	399.1	209.0	154.5

1/ Compensation Water is considered for communal irrigation area downstream of the Palsiguan Dam, i.e., Calambat - Collago, 68 ha, Lagayan 255 ha, in total 323 ha.

2/ Available Run-off = Run-off - Compensation Water

3/ W.R.: Water requirements equivalent to shortage water

4/ Excluding reservoir losses and minimum water requirements for power generation.

5/ Continuous drought years therefore, 193.4 MCM in 1966 derives for the influence of storage volume in 1965.

The table shows that the maximum volume required for storage appears in 1966 (accumulated requirements occur in July first 10-day, 1966) and the necessary volume will be 193.4 MCM excluding the reservoir losses and the minimum water requirements for power generation.

However, this value has resulted from the influence of previous two drought years. Thus, the second value, 172.4 MCM in 1968 is selected for the storage volume of the Palsiguan dam in order to relieve the proposed irrigation area from shortage in water in the 10-year frequency drought.

In considering the minimum water requirements for peak power generation at the Nueva Era dam, the storage capacity is determined as follows:

o Storage required for irrigation	172.4 MCM
o Minimum requirements for peak generation	13.1
o Reservoir losses	3.5
o Effective capacity	189.0
o Dead water volume	43.0
o Total storage capacity	232.0

Capacity of the reservoir thus determined will be totally used for irrigation and power generation

The water for power generation consists of irrigation water and some surplus water stored in the reservoir, i e., all irrigation water is subject to power generation. For the operation analysis, 10-day period is taken as a unit time and 10-year operation is simulated. The conditions to control the water for power are that i) the reservoir should be filled to the full capacity level at the start of the dry season crop, ii) the stored surplus water is to be used for power generation evenly throughout the year and iii) the inflow into the reservoir is to be used for power generation so as to minimize the uneffective release from the reservoir. (Refer to Phase II F/S Report "Reservoir Plan".)

In taking the careful considerations as mentioned above, a simulation analysis is made for the period of 1960 - 1969 to yield yearly power generation.

4 Drainage Plan

a) Design Modulus for Drainage Canals in the Paddy Fields

Design Rainfall

On the basis of the long-term rainfall data (1951 to 1979) observed at Laoag station, probability analysis was made in order to estimate the return period and corresponding magnitude of rainfall, and the 3-day consecutive rainfall of 493.3 mm in the 5-year return period is decided as the design rainfall. The daily and hourly distribution of the selected rainfall was estimated based upon predominant rainfall characteristics in the Ilocos Norte region, that is, 122.6 mm in 1st-day, 313.5 mm in 2nd-day and 57.2 mm in 3rd day.

Method for Estimation of Drainage Modulus

The Project Area for Phase I is located on the alluvial fan with a gentle slope, and thereby the drainage analysis for the paddy fields was made based on the simplified principale and assumptions of the hydraulic phenomena. However, on the contrary, the Project Area for the Phase II is located on relatively low-lying area in flat topography, and hence, the paddy fields function to store the rainfalls.

The run-off discharge from the paddy fields was estimated based on the convenience method for the Phase I and the Ekdahl's method for the Phase II.

According to the aforementioned methods for the paddy fields, the hourly rainfall obtained for 5-year return period was adopted to estimate the run-off discharge, q (mm/hr) and flooding water depth H (mm), together with the duration of water stagnation in the paddy fields. Even if a paddy field is submerged by excess standing water more than 25 cm in depth. The paddy grown in the fields do not suffer from submergency in case that its duration is less than three days.

The following design drainage modulus has been computed based on the above-mentioned methods and the base flow of 0.02 cu.m/sec/sq.km.

The Design Drainage Modulus for each Phase

Descriptions	Design Drainage Modulus
Phase I	0.872 cu.m/sec/sq.km (8.72 lit/sec/ha)
Phase II	0.866 cu.m/sec/sq.km (8.66 lit/sec/ha)

These modulus could be applied to the areas smaller than 400 ha, but a smaller modulus should be applied to a larger area than the above-mentioned, because the rainfall intensity becomes low in a larger areas than 400 ha.

When such reduction factor (F) is applied to the areas larger than 400 ha, the discharge criteria for drainage are obtained as shown below.

Discharge Criteria for Drainage

	Drainage Modulus (lit/sec/ha)	
Area (ha)	Phase I	Phase II
0 – 400	8.72	8.66
400 – 1,000	8.37	8.33
1,000 – 3,000	7.63	7.60
3,000 – 5,000	7.15	7.10

b) Drainage Discharge from Hilly Land

Many small rivers and creeks of which the catchment areas are less than 100 sq.km are flowing through the Project Area at their upper portions.

Several procedures, in general, have been applied to estimate the storm run-off from hilly land, but the procedures through the Mcmath or Rational methods have been usually used for the purpose in the NIA's projects. Out of these methods, the Mcmath method is applicable to the river basin having the concentration time more than one hour with catchment area more than 100 sq.km, so that the storm discharge from the hilly land related to the Project can be analyzed by applying the Rational method. As a result, the specific discharge of the storm run-off from hilly land is estimated at 3.06 cu m/sec/sq.km

5. On-Farm Plan

Provision of the terminal on-farm facilities such as farm ditches, farm drains farm roads is essential to execute the irrigated agriculture including farm mechanization, and in this work, farmers' eagerness for agriculture will act as the prime mover. With their support which are the prerequisite for upgrading the agriculture, the rationalized land parcelling and land allocation will be materialized. Thus, the modernized irrigation and drainage systems as well as the new organization for farm management will be established at an early stage.

a) Premise in Farm Land Development

Farm Management

The standard irrigation rotation block covers 30 ha for Phase I area and 40 ha for Phase II area. Operation and maintenance of on-farm facilities will be made by the Irrigators' Group to be organized in each block, especially, the distribution of irrigation water will be performed intentionally at each rotation area.

Crops

The proposed crops in the Project are high-yielding paddy and various upland crops. And there are two typies in cropping areas; one is the areas where high-yielding paddy is grown in both seasons, the wet and the dry, and the other is the areas where high-yielding paddy in grown in the wet season and upland crops in the dry season.

Farming Practices

For the farming practices to grow paddy, an integrated farm mechanization system will be established using hand tractor, thresher and drier which will be introduced for land preparation, threshing and drying works respectively, and the other works will mostly be made by a combination of manpower and carabao for the time being.

For the farming practices to grow upland crops, the hand tractor which will be introduced for the paddy growing will be used for land preparation works, and the other works will mostly be made by a combination of manpower and carabao for the time being.

b) Land Parcelling

1) Principle for Land Parcelling

The farm land parcelling plan in the Project should be worked out to meet the aforesaid premises with due consideration on the topographical conditions and the existing communal irrigation systems in the areas. The points to which a careful attention should be paid are as follows.

i) The plan should be closely related with the farm management plan;

ii) The plan should secure easy but adequate water management for irrigation and drainage; and,

iii) The plan should secure easy but proper farm management for paddy cropping.

2) Design of Rotation Area

Location of Farm Ditches

The following two alternative schemes for determining the locations of farm ditches are considered in the general cases.

i) The main farm ditches are aligned across the contour lines, so that the supplementary farm ditches can be located along the contour lines.

ii) The main farm ditches are located along the controur lines.

In taking into consideration the direction and density of existing canals, the latter scheme should be basically adopted. However, the former scheme would still be applicable to some areas depending on their topographic conditions.

Rotation Area and Units

Each rotational area and unit has been planned as mentioned below in consideration of the existing communal irrigation systems, their topographic conditions and so on.

Rotation Area and Rotation Unit

Name of Area	Rotation Area	Rotation Unit
Phase I Area	30 ha	6 ha
Phase II Area	40 ha	8 ha

c) Terminal Water Management Systems

Irrigation System

The terminal irrigation systems consist of a main farm ditch, supplemental farm ditches and their related structures Rotation in irrigation water supply will be made within the rotational unit which is commanded by the supplemental farm ditch; the water supply in the rotation method will not be carried out between the rotation units as a rule. Namely, water supply from the main farm ditch to the supplementary farm ditches is planned to be made simultaneously, while distribution of water from the supplementary farm ditches to each farm lot is planned to be made rotationally. Hence, the required cross-section of the main farm ditch becomes small towards the downstream with its terminal section corresponding to that of the supplementary farm ditch in area. Irrigation water supply during land soaking and land preparation will be carried out for 25 days in the Phase I area and for 35 days in the Phase II

The seasonal design discharge of the terminal canals based on the premise mentioned above was computed as shown in Irrigation Plan, and the design discharge of the terminal canals is summarized as follows:

Design Discharge of the Terminal Canal

Name of Area	Land Soaking & Land Preparation Stage	Crop Maintenance Stage
Phase I Area	1.78 lit/sec/ha	1.40 lit/sec/ha
Phase II Area	1.64 lit/sec/ha	1.41 lit/sec/ha

Drainage System

Excess water in each farm plot is drained through a notch with a width of about 30 cm to a farm drain which is aligned along the supplementary farm ditch. The farm drain is the terminal drainage canal made of earth and constructed in each rotation unit. The design capacity is 8.72 lit/sec/ha for the Phase I area and 8.66 lit/sec/ha for the Phase II.

6. Road Plan

The proposed roads in the Project Area are classified as follows:

a) Service Road

The service roads are to be provided along the link, main and lateral canals in order to carry out the operation and maintenance of irrigation facilities as well as to transport the input and output materials. The proposed roads have two types of width, six meters along the link and main canals and four meters along lateral canals, and these roads will be paved by coarse materials.

The proposed cross-section of the roads in the above two types has a surfacing of 15 cm thick base coarse and selected borrow of 20 cm thick.

b) On-Farm Road

On-farm roads, which are terminal roads to facilitate the farming works in the cultivated area, are planned along the main farm ditch, and no pavement is planned. The width of the roads is two meters.

7. Hydropower Generation Plan

a) General

The Palsiguan dam site has a catchment area of about 153 sq.km. The averaged daily run-off at the dam site is about 13.64 cu.m/sec with the mean annual rainfall of 2,600 mm. The Nueva Era dam site has an averaged daily run-off of 4.37 cu.m/sec from its own catchment area of about 52.4 sq.km. After trans-basin, the total discharge available at Nueva Era dam site inclusive of discharge from the Palsiguan basin will amount to 18.01 cu.m/sec.

It is a peculiar characteristic of the area that 73 percent of the total run-off appears in the wet season. The averaged run-off during this season is 260.5 MCM; however, the run-off is found to widely flactuate from the maximum of 338.6 MCM to the minimum of 160.9 MCM according to the 11 years data from 1960 to 1970.

In principle, the Palsiguan dam water will be utilized not for the wet season irrigation but for the dry season irrigation. The same can be said on hydropower generation. However, the dam water will be available for hydropower generation during the wet season except drought years under the restriction that irrigation water for the dry season should be guaranteed.

The hydropower generation plan has been formulated as follows, based on the above-mentioned principle taking into consideration the recent sharp escalation of oil price.

i) In taking into account economical construction and power generation, the high and low water levels of the Palsiguan dam have been determined at 334.50 m and 275.0 m, respectively. The proposed dam height is 3.16 m higher than the actually required for irrigation; however, this dam height results in saving the construction cost since the headrace can be shortened by 1,250 m in length.

ii) The Palsiguan headrace tunnel has been planned in consideration of geological and topographical conditions of the Bonga river basin. Its economical diamter is 3.6 m with the length of about 6,150 m. A pressure tunnel has been proposed for this headrace.

iii) The underground types Bonga power station will be constructed at 50 m downstream of the surge tank which will be located at the extreme downstream of the headrace tunnel. The depth of this power station from ground surface will be about 70 m, which corresponds to the difference of elevation between the Bonga river bed running near the surge tank and the high water level of Bonga afterbay. The tailrace from the Bonga power station will be 2,950 m long.

iv) The maximum discharge of the Bonga power station has been determined at 28.225 cu.m/sec, which corresponds to the maximum irrigation requirement in the dry season.

v) With the effective water head of 149.30 m, the Bonga power station will have the installed capacity of 36,000 KW, resulting in the annual power generation of about 159.66 GWh.

vi) The afterbay will be given a sufficient regulation capacity to meet the maximum discharge of 28.225 cu.m/sec from the Bonga power station for six hours, which is equivalent to the total volume of about 0 5 MCM In consideration of sediment accumulation during a 50-year period, the total storage capacity of this afterbay will be about 4.99 MCM with the crest elevation of 150.0 m and the effective depth of 1 50 m.

vii) A dam-type power station has been planned at the Nueva Era site taking into consideration the required intake water level for irrigation. Therefore, the power station will be located at the immediately downstream of the dam body. The Nueva Era power station will have the maximum discharge of 29 273 cu.m/sec inclusive of the run-off from its own catchment area.

viii) With the effective water head of 27.92 m, the Nueva Era power station will have the installed capacity of 6,800 KW, resulting in the annual power generation of about 39.54 GWh.

ix) The Bonga afterbay will require a considerably high and long dam body with the height of 45.50 m and the crest length of 220.0 m since the dam site is thickly covered by river deposits. A concrete dam has been proposed for the safety of the dam body and economical construction.

Unit prices as of January 1980 have been employed in construction cost estimate In economic evaluation of an alternative plan, the KW value of 714 ₱/KW/year has been applied on the assumption of a 100,000 KW class thermal power station requiring some countermeasures against air pollution. In consideration of the recent price escalation of oil, the electric power value per KWh has been evaluated at 0.429 ₱/KWh.

b) Preliminary Design

The major dimensions of the Bonga and Nueva Era power stations are shown in the Table 4-4.

c) Operation Plan of Dam

In principle, the operation plan of dam has been formulated to meet the irrigation requirement. Based on hydrological data observed from November 1959 to October 1969, the dam operation study has been made.

In order to meet the irrigation requirement and to generate the hydropower effectively by making use of sharply varying inflow discharge into the reservoir, the following operation rules have been set up through trial computation for the reservoir operation.

i) Two standard reservoir volumes have been determined for each 10-year period, that is, the upper limit reservoir volume (URV) and the lower limit reservoir volume (LRV)

ii) The dam shall be operated to keep the reservoir water level within the URV and the LRV

iii) When the reservoir water volume exceeds the URV due to a small irrigation requirement, the reservoir water is released, within the limit of maximum discharge of 28.225 cu.m/sec for Bonga power station.

iv) When the reservoir water level is lower than the LRV, the water is released to meet the irrigation requirement only within the restriction of minimum discharge of 8.00 cu.m/sec for Nueva Era power station. Otherwise, it would become difficult to raise the reservoir water to the full water surface by the end of Octover, resulting in a shortage in irrigation water to meet the requirement of minimum discharge of 9.50 cu.m/sec for Bonga power station.

Table 4-4 Major Dimensions of Power Station

	Descriptions	Unit	Bonga P/S	Nueva Era P/S
1)	Output			
	Installed Capacity	KW	36,000	6,800
	Firm Capacity	KW	–	1,830
	Firm Peak Capacity	KW	30,510	–
	Annual Generation	GWh	159.66	39.54
	Effective Output	KW	33,776	4,514
2)	Discharge and Head			
	Maximum Discharge	cu.m/sec	28.225	29.273
	Minimum Discharge	cu.m/sec	9.500	8.000
	Average Discharge	cu.m/sec	13.640	18.000
	Maximum Head	m	184.500	29.500
	Average Head	m	163.150	28.750
	Effective Head	m	149.300	27.915
3)	Water Level and Reservoir			
	High Water Level	m	334.50	150.00
	Low Water Level	m	275.00	148.50
	Tail Water Level	m	150.00	120.50
	Drawdown	m	59 50	1.50
	Reservoir Area	sq.km	5.07	0.37
	Total Reservoir Volume	MCM	232.00	4.99
	Effective Reservoir Volume	MCM	189.00	0.50
4)	Water-Way and Powerhouse			
	Headrace (Pressure Tunnel)	m	ϕ3.6 x 6,150	–
	Tailrace Tunnel	m	ϕ3.8 x 2,950	–
	Powerhouse		Underground type	Dam type
5)	Machine, Equipment			
	Turbin	set	1	1
		type	Deriaz	Kaplan
		r.p.m	450	327.5
	Generator	KVA	39,600	7,480
	Transformer	KV	115	115

d) Function of Bonga Afterbay (Nueva Era dam)

The Bonga afterbay has been planned to keep high the firm peak of Bonga power station and concurrently to serve as a diversion dam for irrigation. As already mentioned above, a concrete dam with the height of 45.5 m and the crest length of 220 m has been planned. This dam will be equipped with five units of gate (7m x 6m) to cope with the designed flood discharge of 970 cu.m/sec. If this dam is used only as a diversion dam for irrigation, a smaller one can meet the requirement. However, since the major function of this dam is to secure the firm peak of Bonga power station, the above-mentioned scale of dam has been planned.

This dam has its own catchment area of about 52.4 sq.km, and abundant run-off from the catchment area occures from May to October when discharge from Bonga power station is controlled small. Therefore, a constant discharge is available at Nueva Era power station. The dam is advantageous in this aspect though its effective head is not so high.

The firm peak value of Bonga power station and the power generation value of Nueva Era power station make the economic benefits very high. The Bonga power station with the afterbay is much more economical than that without the afterbay. Furthermore, the Banga power station cannot generate the firm peak without this afterbay, so it cannot meet the local demand, resulting in the fact that the hydropower generation plan its self is already meaningless.

e) Output Study

A computeraized output study has been made based on 10-year period data from November 1959 to October 1969 for each power station.

Bonga power station:

The Bonga power station is a firm peak load power station, and the minimum discharge of 4.70 cu.m/sec/day has been secured for this station. This water quantity is equivalent to the four hours' maximum discharge of 28.225 cu.m/sec. The drawdown of the Palsiguan reservoir water is as large as 59.50 m with the averaged head of 163.15 m. In taking it into account, one unit of the Deriaz type turbine is considered most appropriate. So, the minimum discharge of 9.50 cu.m/sec is selected from the efficiency of this type of turbine. Discharge to be released fluctuates form 9.50 to 28.225 cu.m/sec/day. Through the discharge modeling, these discharges have been allocated on hourly basis to meet the required discharge per day.

The intake water level is determined by the reservoir water level, whereas the tailrace water level is determined by the afterbay water level to be regulated. However, the trailrace water level of EL 150 has been employed in this study because the fluctuation of water level in the Bonga afterbay cannot be utilized from the viewpoint of the structure of this tailrace.

Nueva Era Power Station.

Run-off from the catchment area of the Bonga river and discharge from the Bonga power station are regulated constantly by Bonga afterbay in order to generate hydropower and to supply irrigation water. Therefore, the intake water level for the Nueva Era power station has a daily fluctuation. However, the averaged daily regulation water level has been determined at 149.25 m at the maximum A large inflow discharge such as floods will cause to raise the water level. When the averaged daily inflow discharge is 29.279 cu.m/sec/day, which is equivalent to the maximum discharge, the water level arrives at the maximum water level of 150 m. The water level in the downstream canl (releasing water level) varies depending on the turbine discharge Since the power station has a low water head, the intake and releasing water levels bring about a great influence on output.

The minimum discharge of 8.00 cu.m/sec/day will be secured by the daily run-off discharge from the catchment area of the Bonga river and discharge from the Bonga power station. However, it will happen in drought years that the above-mentioned minimum discharge cannot be secured for all day long due to the drawdown of the Palsiguan reservoir water Even if such difficulty arises, irrigation requirement discharge can be supplied, for instance, by 12 hours' operation, or such time falls in non-irrigation seasons. Therefore, a discharge of more than 8.00 cu.m/sec can be released for power generation. The turbine efficiency varies from 0.8 to 0.895 in accordance with a discharge volume as shown by the efficiency curve.

C. Proposed Agricultural Development

1. Proposed Land Use

The Project has a total area of 37,787 ha, of which 22,600 ha are arable lands; 10,200 ha in Phase I and 12,400 ha in Phase II area respectively as seen in the following table. The total non-arable land 15,187 ha includes residential area, rights-of-way and others.

Table 4-5 Proposed Land Use

(Unit: ha)

Area	Arable Lands	Right-of-Way	Residential Areas	Others	Total
Phase I	10,200	816	445	4,426	15,887
Phase II	12,400	1,010	930	7,560	21,900
Overall	22,600	1,826	1,375	11,986	37,787

The whole arable land is proposed to be fully irrigated in both the wet and the dry seasons by the Project. The proposed land use pattern has two types; "double cropping of paddy rice in the wet and the dry season" and "paddy rice in the wet season and upland crops in the dry season". The selected upland crops for the latter are cash crops like garlic, tobacco, mungbeans and cotton The area to be cultivated with these upland crops in each sub-project area is determined based mainly on the soil and drainage conditions. As a result, the upland crops cultivation during the dry season is proposed to occupy 10 percent of irrigation area in the Phase I area and 60 percent in the Phase II area.

2. Proposed Cropping Pattern

Based on the proposed land use pattern, five major cropping patterns are proposed as shown in Table 4-6 The cropping patterns for the corresponding crop areas are as follows:

Table 4-6 Proposed Cropping Pattern

Cropping Pattern (Wet Season)	(Dry Season)	Phase I	Phase II	Total
1. Paddy +	Paddy	9,200	4,970	14,170
2. Paddy +	Diversified Crops			
(1) Paddy +	Tobacco	300	2,130	2,430
(2) Paddy +	Garlic1/	700	2,205	2,905
(3) Paddy +	Garlic + Mungbeans	–	2,065	2,065
(4) Paddy +	Cotton	–	1,030	1,030
	Sub-total	1,000	7,430	8,430
Total (Physical area)		10,200	12,400	22,600
(Cropping area)		20,400	26,865	47,265
Cropping Intensity		200%	217%	209%

Note: 1/ including 350 and 70 hectares of onion in Phase I and Phase II, respectively.

As shown in the above table, the cropping intensity in the whole Project Area is estimated at 209 percent which is 59 percent higher than the present one. The cropping calendar of the respective cropping patterns are as shown in the Feasibility Reports on the Ilocos Norte Irrigation Project (Phase I & II). As seen in these cropping patterns, the Project will allow the upland crops to be grown at proper time, especially garlic and cotton. All cropping calendars irrespective of cropping pattern require generally irrigation water from late May to March in the following year in the Phase I area, and May to early April in the Phase II area. This would give at least about 30 days of off-irrigation period to carry out maintenance of the irrigation systems.

3. Crop Production

The yields of the respective major crops in the Project Area have been so far increased at considerably low rate, and these increasing rates will remain as low as at present when the Project is not realized. For paddy rice and the major upland crops, the yield increase rates in the past were assumed to range from 0.8 to 1.4 percent per annum according to the data on crop production in the Project Area. One of the major factors inducing such low rates in crop yield increase is the inadequate provision of crop production infrastructures like, irrigation water supply system.

The target yields and total production of the respective crops in case of "with project" are estimated as shown in Table 4-7.

The target yield for paddy rice in the Project is decided at 3.9 tons/ha and 4.2 tons/ha for the wet and the dry seasons in the Phase I area. On the other hand, there is a possibility to have higher target yield of the both the wet and the dry season crops in Phase II because this area provides the first class lands much more than the Phase I area. But Madongan area, one of the sub-projects in the Phase I will give the less target yield for the wet season paddy because of the poor production conditions by flooding during the wet season.

The increments of crop production of the overall Project are as follows:

Table 4-8 Increment of Crop Production

(Unit: ton)

Crop	Without Project At Present (1978) (1)	With Project Future (1993) (2)	Increment (2) – (1)	Ratio (2)/(1)
Paddy	45,279	152,225	106,946	3.4
Tobacco	2,368	4,011	1,643	1.7
Garlic	5,358	11,865	6,507	2.2
Mungbeans	415	2,272	1,857	5.5
Cotton	–	2,575	2,575	–
Onion	–	5,320	5,320	–

Table 4-7 Crop Production

	Crop	Phase I			Phate II			Overall	
		Cropping Area (ha)	Target Yield (ton/ha)	Production (ton)	Cropping Area (ha)	Target Yield (ton/ha)	Production (ton)	Cropping Area (ha)	Production (ton)
1.	Paddy								
	- Wet Season	10,200	3.9(3.7)1/	39,140	12,400	4.2	52,080	22,600	91,220
	- Dry Season	9,200	4.2	38,640	4,970	4.5	22,365	14,170	61,005
	Total	19,400		77,780	17,370		74,445	36,770	152,225
2.	Tobacco	300	1.3	390	2,130	1.7	3,621	2,430	4,011
3.	Garlic	350	2.7	945	4,200	2.6	10.920	4,550	11,865
4.	Mungbeans	–	–	–	2,065	1.1	2,272	2,065	2,272
5.	Cotton	–	–	–	1,030	2.5	2,575	1,030	2,575
6.	Onion	350	14.0	4,900	70	14.0	980	420	5,320
	Total	20,400			26,865			47,265	

Note: 1/ The target yield for the Madongan sub-project area.

Expected crop production as listed above will be attained within five years after the completion of the Project under the proper on-farm level irrigation water management and sufficient supporting services, particularly in the extension services and agricultural credits, the marketing of agricultural products, etc.

4. Supporting Services

1) Research and Extension

Although it is desirable that the existing research organizations will undertake the required activities by the Project, these organizations are not in a position to concentrate their activities to the very specific tasks Therefore, it is necessary to establish a Pilot Farm to undertake the research activities along with the Project requirements and to demonstrate the production technology.

The sufficient extension services have to be provided in the Project by the authorities concerned in accordance with the implementation schedule of the Project. But it is diffult that the related governmental agencies concentrate their efforts into extension activities to the farmers in the Project Area. On the other hand, it is essential that the farming activities have to be carried out in parallel with water management according to the schedule For this purpose, in the proposed O/M organization of the Project, "agriculture division" is set up for the smooth development of crop production in the Project Area and one Water Management Technician (W.M.T.) is proposed to be assigned for each unit area of about 300 to 500 ha.

2) Farmers' Organizations

Aiming at an effective farming practices after the completion of Project, a functional farmers' organization shall be established in the Project Area.

As mentioned previously, there are some existing organizations in the Project Area such as Communal Irrigation System (CIS) for irrigation, Samahang Nayon for Cooperatives activities and Farmers' Association to cooperate with the extension agents However, these existing organs are not to properly function as promoting bodies for the Project and it will be necessary to rearrange them and to strengthen their functions.

The proposed farmers' organization shall be fully provided with the following functions.

i) to carry out O & M for irrigation/drainage facilities and a rational water distribution at on-farm level together with control of farm machineries and collection of O & M cost to be made by farmers themselves,

ii) to perform positively cooperative activities for such supplies as seeds, fertilizers, insecticides, pesticides, farm machineries and daily commodities, collective selling of products and credit services, and

iii) to introduce extensively new farming techniques learned from guidance by the BPI and the BAEx.

In considering the above specific matters, establishment of farmers' organization is proposed as shown below.

a) Farmers Irrigators' Group (FIG)

For O & M of the irrigation facilities at on-farm level, a Farmers Irrigators' Group (FIG) shall be established in each rotational area.

b) Farmer Irrigators' Association (FIA)

At Barangay level, Farmer Irrigators' Association (FIA) which has the following functions shall be established.

i) Following the NIA's plan for O & M of the irrigation systems, related Farmers Irrigators' Association shall make a necessary arrangement for fair water distribution among members.

ii) Under the guidances/supervision of the BPI and the BAEx, the new farming techniques and farm machineries shall be introduced, and joint use of the machineries and collective works shall be actively promoted by Farmer Irrigators' Association.

iii) O & M and repair of terminal ditches and farm roads downstream of turnout structures shall be made by farmers.

iv) In case there will be any changes in the NIA's water distribution program, which depends on the weather conditions and so on, the FIA has a secure a full coordination among the related FIGs, and the most reasonable water distribution shall be carried out through close cooperation with the NIA's Water Master, Water Management Technician and Ditch Tender.

v) In cooperation with Samahang Nayon and Kilusang Bayan, collective selling of farm products and procurement of various farm inputs shall be promoted.

vi) Cooperating with Samahang Nayon, promotion of savings and rural development shall be made actively.

vii) Cooperating with the NIA, the FIA has to collect irrigation fee, repayment of project cost and O & M fee for the FIA management.

viii) The FIA shall actively participate in the training programs to be organized by the NIA and other governmental agencies and provide farmers training programs for O & M of irrigation facilities

ix) Under a full cooperation by the administrative organizations at Barangay level, irrigated agriculture shall be actively promoted

It is necessary that the establishment of the proposed farmers' organizations are promoted so as to function in accordance with the implementation schedule of the Project construction. For this purpose, in the agriculture development component, the costs for the following items are involved.

i) Preparation of the establishment of the FIA,

ii) Construction of the FIA offices, and

iii) O & M cost for the FIA during three years after its starting.

D. Proposed Facilities

1. Palsiguan Dam

a) Geological Conditions of the Dam Site

The proposed Palsiguan dam site is located in mountainous Ginataran area with steep slopes about seven kilometers upstream of Baybaytin in the Abra province The Palsiguan river flows almost straight through the dam site to the south-west, and joins the Tineg river near Polot village which is situated about 11 km downstream of the dam site.

Topographically, the left bank at the proposed dam site has a slope of about 45 degrees, while the right abutment around 35 degrees The river bed width is about 30 m. The cord-height rate at the proposed dam axis with the elevation of 340 m is 3.5. The valley shows the V-shape of which high portions unfold to a degree.

The bed rock of the proposed dam site is mainly comprised of dacite. Diorite is distributed about three kilometers upstream of the dam site, whereas limestone is widely distributed about three kilometers downstream of the dam site. The access road will be constructed across the limestone area.

According to the field investigation and core-boring conducted at the proposed dam site, dacite and basalt forming the base rock of the site have deeply-developed joints and cracks. However, the rock itself is hard and compact and has a sufficient bearing capacity for rockfill dam.

The permeability test of the bed rock of the dam site conducted at bore-holes shows that the bed rock of the dam site falls in the category of "the semi-permeable rock."

b) Embankment Materials

Since the Palsiguan dam has been planned to have a dam height of 143.5 m, the material mixed with gravel in clay is considered suitable for impervious material. The clay and gravel which are sampled in the Polot area are provided for material test.

The qualities of this mixed material are as follows:

Gradation	:	clay 11%, silt 23%, sand 26%, gravel 40%.
Natural moisture content	:	14%
Dry density	:	1.873 g/cm^3
Permeability coefficient	:	2.2×10^{-7} cm/sec

The spillway site and a part of the mountain connected with this site are considered to be suitable for quarry of embankment materials for the Palsiguan dam. The quarry is mainly composed of dacite with the small-scaled dike of basalt. These rock materials have good qualities as shown below:

Specific gravity	:	2.95
Absorption	:	1.9%
Soundness	:	4.2%
Compressive strength	:	418 kg/cm^2

Therefore, the shearing strength of 45 degrees in internal friction angle and void ratio of 0.4 will be secured, since the compaction with high energy is practicable.

c) Topographic Conditions

Access Road

It is proposed to construct the 7.2 km access road from Baybaytin in the Abra province (more than EL 150 m) to the dam site along the Palsiguan river, and in addition, to widen the existing road with 6.3 km distance from Lagayan to Baybaytin so that the dam site can be directly connected to Polot (Lagayan) where the quarry of impervious materials for the dam embankment is located.

Dam Site

The dam axis has been determined about 500 m upstream of Ginataran (direction: about N 72° W). This is the same dam axis that was previously selected by the NIA. In the topographic aspect, this site is deemed suitable for dam construction, although the low and thin ridge adjoining the right abutment is observed.

Location of Appurtenant Works

The right bank of the Palsiguan river is much more favorable than the left bank in construction of the diversion tunnel. The right bank requires the tunnel length of about 740 m, whereas the left bank about 880 m. Cellophill Resources Corporation has utilized the river flows to transport wood from the Palsiguan upstream reaches to Baybaytin. Therefore, the diversion structure should not hinder this wood transportation.

The location of spillway should also be determined to minimize its excavation volume and to smoothen the diversion of flood discharged from the reservoir to the downsrream reaches through the spillway. In this aspect, the right abutment is advantageous to the left one. If the mountain adjoining the right abutment is found favorable for the quarry site of rock materials for dam embankment, the excavation required for the spillway will be reduced to a great extent.

d) Layout of the Dam and Appurtenant Works

Diversion Works

Layout of the open flow type diversion works has been made in order to release the designed flood discharge of Q = 950 cu.m/sec. The diversion of this type requires a little bigger tunnel in comparison with the pressure flow type, whereas needs a smaller coffer dam than the pressure flow type. Therefore, the total construction cost is, as a whole, not much different in the both types.

The major dimension of diversion works are as follows:

Diversion Tunnel

Location	:	right abutment of the dam
Type	:	standard horse shoes type
Slope	:	7/740 = 1/105.71
Tunnel length	:	740 m
Water depth	:	7.74 m (discharge: 950 cu.m/sec)
Velocity	:	14.3 m/sec (discharge: 950 cu.m/sec)
Elevation of tunnel entrace	:	EL 207.00 m
Water level of approach flow	:	WL 222.60 m

Coffer Dam

River water depth	:	(discharge: 950 cu.m/sec)
Before damming-up	:	more than 4m
After damming-up	:	more than 15.6 m
River velocity		
Before damming-up	:	4.6 m/sec
After damming-up	:	0.7 m/sec
Top elevation of coffer dam	:	EL 225.00 m

Dam

In determining the Palsiguan dam height, careful studies were conducted to select the most appropriate low and high storage water levels for the effective storage requirement of 189 MCM, in taking into consideration of the headrace length, the effect in power generation and the construction cost of dam itself

The major dimentions of dam are as follows:

Catchment area	:	153 sq.km
Dam type	:	earth and rock-fill dam
Effective capacity	:	189 MCM
Capacity at F.W.L. 334.5 m	:	232 MCM
Capacity at D.W.L. 275.0 m	:	43 MCM
Sediment volume at 259.0m	:	23.3 MCM
Freeboard	:	4.0 m
Dam height (bedrock EL 195.0m)	:	143.5 m
Crest width (top of dam, EL 338.5m)	:	10.0 m
Crest length	:	480 m
Slope, upstream	:	1:2.8
Slope, downstream	:	1:1.9

Embankment volume -		
Core material	.	1,724 x 10^3 cu.m
Filter	.	600 x 10^3 cu.m
Rock	:	5,364 x 10^3 cu.m
Coffer dam	:	1,390 x 10^3 cu m
Total	.	9,078 x 10^3 cu m
Excavation (stripping)	.	936 x 10^3 cu.m

Spillway

Layout of the spillway has been made in order to release smoothly from the right abutment the designed flood discharge of Q = 3,070 cu.m/sec. The spillway type will be "the gated chute with flip-bucket", which has been adopted to the spillways of all existing large dams in the Philippines.

A wide and deep approach canal should be constructed to make water streams smoothly approach to the spillway. Furthermore, the gated overflow weir should have a sufficient relative height at the both upstream and downstream sides.

The major dimensions of the spillway are as follows·

Location	.	right abutment of the dam
Type	·	gated chute with flip-bucket
Designed discharge	·	3,070 cu.m/sec
Water head	.	12.0 m (designed discharge)
Gate size		H = 12 5 m, B = 11.5 m
Gate number	:	3 units

Outlet works

A vertical shaft will be erected at the tunnel uppermost which will be located at the elevation of 259 m, the expected sediment elevation of the dam. The capacity of this outlet work will be about 30 cu.m/sec at the full water level, while about 22 cu.m/sec at the low water level.

The outlet capacity is much larger than the water quantity to be required in the downstream irrigated area (less than 1.0 cu.m/sec): however, this capacity is required to drain the reservoir water ti the level lower than the designed low water level for the maintenance of the dam.

2. Palsiguan Headrace Tunnel

a) Geology of Palsiguan Headrace Tunnel

The proposed Palsiguan Headrace Tunnel route is aligned starting from a point at the tributary of the Dogot river running through the proposed reservoir area to reach straight in the Nueva Era in crossing the Cordillera Central of Luzon.

The geological survey for the tunnel route was made by only one core-boring carried out at the inlet of the headrace, and the field investigation revealed that almost of whole route is geologically composed of dacite and basalt with penetration of diorite.

The geology around the tunnel inlet is dominant by dacite, and boring at the weathered zone found the thickness of its layer to reach as deep as about 20 m. The field investigation also found outcropping of fresh dacite on the river bed with about 3.0 m thick terrace deposits distributed.

The proposed tunnel route is laid out to cross the geological formation line developing along the Cordillera Central of Luzon. Therefore, it is essential to take measures for expecting spring water from faults or fructured zones, and loosening of rocks by mineralization.

b) Design of the Headrace Tunnel

The headrace is the facility to serve to driving the water from the Palsiguan reservoir to the Nueva Era river for the dual purposes of irrigation and hydropower generation. The maximum design discharge is 28.225 cu.m/sec. The proposed route has been determined as shortest line between the Palsiguan reservoir and the surge tank of the Bonga power station. The total length of the tunnel is 6,210 m; 6,150 m for pressure tunnel and 60 m for the intake portion. When taking the standard horsehoe shape as typical section, the economic radius available as the pressure tunnel can be estimated at 1.80 m in diameters.

The tunnel lining is designed as reinforced concrete and its thickness by 0.40 m.

3. Nueva Era Dam

a) Geology of Nueva Era Dam Site

This dam has been planned across the Bonga river which comes from the Cordillera central mountains of the Northern Luzon. The dam site is located about 1.5 kilometer south of Nueva Era town where the mountainous zone faces the plain.

Terrace deposits are observed from the immediately downstream of the dam site toward the downstream reaches Specially, the terrace deposits are thickly accumulated on the downstream reaches of Nueva Era town

The reservoir area is located on the plateau-like mountainous zone The left mountain slope at the dam site is about 45°, while the right slope is about 30° The river bed is about 150 meters wide at the dam site. The length-height cord of the dam site at the elevation of 150 meters upon the dam axis is 6 1 The valley shows an adverse trapezoid with a long bottom side.

The seismic prospecting and core-hole drilling were conducted in the geological study of this dam site The study has revealed that the dam site is mainly underlain by agglomerate, the river deposits are distributed to the depth of about 15 meters, and the terrace deposits with about 18 meters thick exist on the right abutment portion

On the other hand, the core-hole drilling indicates that the base rock is weathered to five to ten meters deep on the both abutment portions. On the contrary, no weathered layers are distributed on the river bed. The terrace deposits on the right abutment portion are mainly composed of sandy layers, and soft to a considerable degree

The rock test of agglomerate, has verified that the base rock of this dam site has the unconfined compressive strength of 250 kg/sq m, the specific gravity of 2.84 and the absorption of 5.8 percent. Therefore, the agglomerate falls in the category of medium compact rocks.

The seismic prospecting shows that the maximum velocity layer of fresh rocks has a velocity of 4.0 to 4 4 km/sec.

At this dam site, a gravity type concrete dam with a dam height of about 45 meters has been planned. No crushed zones, which hinder the construction of such concrete dam, have been found in the geological surveys so far conducted.

b) Selection of Dam Type

Nueva Era dam will regulate discharge for hydropower generation. To meet this requirement, the above-mentioned concrete dam has been planned in the following reasons

i) The reservoir will be located on the Bonga river having its own catchment area of about 52.4 sq.km. The draw down of this reservoir is so small as 1.50 meters. The water level shall be controlled near the full water surface almost throughout the year. Under the situations, careful gate operation will be required to control flood discharge, and it can be said that this dam might be sometimes jeopardized by overflow of water. To secure the safety of dam body under such conditions, a concrete dam might be the most appropriate.

ii) In case of a concrete gravity dam, an overflow type spillway can be constructed on the center of dam crest. This way of construction of the spillway saves its construction cost much.

iii) Topographically, no temporary diversion tunnel is required since such facilities can be economically constructed across the dam body.

iv) Topographically and geologically a concrete dam is the most suitable at the dam site.

v) Concrete aggregate of a high quality can be obtained about 3.5 km downstream of the dam site.

vi) Since the power station is constructed immediately downstream of the dam site, its intake and penstock can be installed on the dam body, resulting in very economical construction of these facilities.

c) Major Dimensions of Nueva Era Dam

The major dimensions of Nueva Era dam are shown below:

Table 4-9 Major Dimensions of Nueva Era Dam

<u>Reservoir</u>	
Catchment area	: 52.40 sq.km
Storage capacity	: 4.99 MCM
Effective capacity	: 0.50 MCM
Full reservoir area	: 0.272 sq.km
High water level	: EL 150.00 m
Low water level	: EL 148.50 m
Draw-down	: 1.50 m
Design flood	: 970.00 cu.m/sec
<u>Dam</u>	
Dam type	: Roller compacted concrete gravity dam
Dam height	: 45.50 m
Crest length	: 220.0 m
Dam volume	: 141,000 cu.m

Slope, upstream		Vertical
Slope, downstream	.	1 0 88
Overflow crest		EL 144.30 cu.m
Overflow dimension		Width, 45.0 m; Depth, 5.70 m
Apron dimension	:	Width, 45 0 m; Length, 35.0 m
Gate	·	Five - 6m high x 7m wide
Diversion canal		
Type	:	Diversion facility in dam
Dimension	·	One - 10 m wide x 7 m high
Canal length	:	466.0 m
Design flood	:	320.0 cu.m/sec

d) Dam Type and Construction Method

From the viewpoint of construction method, the roller-compacted dam has been selected for this dam site, taking into consideration the following; The unit price of cement is high in the Philippines. Therefore, the construction will be economically made by employing the roller-compacted dam (RCD).

i) The cement quantity per cubic meter amounting at 120 to 130 kg for the RCD is much smaller than that of 170 to 180 kg for other gravity dams.

ii) The compaction is made by vibrating roller. Therefore, a small water-cement ratio can be secured, resulting in a sufficient strength of the dam body.

iii) Concrete placing height for one lift is low as 0.75 to 0.80 meters In addition to the relatively small cement quantity per cubic meter, the low lift will keep the heating value low Therefore, cooling after concrete placing is not necessary.

iv) One of the advantages of the RCD is that a costly cable way system is not necessary for hauling concrete since it can be transported by truck to the placing point, resulting in easy and economical construction.

v) The dam height is low, and the maximum designed vertical strength in earthwuake is about 91.5 ton/sq.m. Under the situations, no high strength of concrete is necessary.

vi) Concrete hauling is made by truck, so the access road can be routed as may be required. The speed of construction can increase to a considerable extent in this reason.

e) Stability Analysis of Dam

A computerized stability analysis has been made to determine the slopes of this dam. The analysis revealed that the upstream surface of dam can be constructed vertically whereas the downstream surface shall have the slope of 0.88.

f) Concrete Aggregate

Concrete aggregate is available on the Bonga dry bed about 3.5 km downstream of the dam site. The fine aggregate at the quarry have favorable grain sizes, whereas the coarse materials with a large diameter are short. However, such materials are obtainable at the immediately downstream reaches of the dam site. Under the situations, the aggregate materials covering all necessary grain sizes are available as a whole.

g) Temporary Diversion Facilities

The designed flood discharge during the construction period is determined at 320 cu.m/sec. To cope with this flood discharge, the diversion facilities will be installed on the right bank, and a tunnel with 10.0 meters wide and 7.0 meters high will be constructed across the dam body. Therefore, for this portion of the dam concrete placing should be finished early so that the tunnel can play its role in the dry season.

4. Diversion Dam

Totally seven diversion dams have been, planned as listed below:

Phase I	:	Labugaon Diversion Dam
		Solsona Diversion Dam
		Madongan Diversion Dam
		Papa Diversion Dam
		Nueva Era Diversion Dam
Phase II	:	Madupayas Diversion Dam
		Tibangran Diversion Dam

The foundation of these seven proposed diversion dams are composed of andesite rock and diorite which intrudes into the andesite. These are the main constituent of basement of the Project Area, and of Cordillera Central Mountain.

The foundation of Labugaon and Papa diversion dams consists of diorite having granodioritic faces while that of Solsona and Madongan diversion dams consists of andesite. The foundation of the Nueva Era diversion dam consists of agglomerate. The foundation of Madupayas and Tibangran diversion dams consists of the miocene to pliocene sandstone and shale. These rocks have joints and cracks. A part of them have been crushed. However, it has sufficient bearing capacity for diversion dam construction. The river deposit of about three meters thick overlies the above-mentioned basement, and there is no problem in installing diversion dam at the proposed sites from the viewpoint of geology.

Explanation of each dam site is briefly made below:

Labugaon Diversion Dam

The Labugaon river course a little upstream of the starting point of the alluvial fan where the river begins to flow into the alluvial plain has been selected as Labugaon diversion dam site. The intake will be installed on the left bank to divert water to the Labugaon and the Cura areas. The diversion dam will be of fixed type

Solsona Diversion Dam

The starting point of the alluvial fan where the Solsona river begins to flow into the plain has been selected as the Solsona diversion dam site. The service areas extend on both banks. However, no portion of this river course is favorable for the double intake system. Thereby, water required for both service areas will be diverted to the left bank service area will be conveyed to the right bank through a siphon in the dam body. The diversion dam will be of fixed type.

Madongan Diversion Dam

The starting point of the alluvial fan where the Madongan river begins to flow into the plain has been selected as the Madongan diversion dam site. The service area extends on both banks of this river. However, no portion of this course is favorable for the double intake system. Under the situations, a required water quantity for both service areas will be diverted to the right bank and a necessary water volume for the left bank will be conveyed through a siphon in the dam body. The diversion dam will be of floating type.

Papa Diversion Dam

The starting point of the alluvial fan where the Papa river begins to flow into the plain has been selected as the Papa diversion dam site. The service areas extend on both banks. However, no portion of this river course is favorable for the double intake system. Water required for both bank service areas will be diverted to the right bank where the water-route is stabilized. Water for the left bank service area will be diverted to the left bank through a siphon in the dam body. In order to utilize water of the small stream jointing the Papa river near the proposed dam site, an intake will additionally be constructed on the left bank. The diversion dam will be of fixed type.

Nueva Era Diversion Dam

The Bonga river course, about 1.6 km south of the Municipality of Nueva Era, has been selected as the Nueva Era diversion dam site in consideration of the dam foundation and the necessary elevation for water supply to the right bank area The service areas extend on both banks. However, there is no favorable site for the double intake system. The intake will be, therefore, installed on the left bank where the water-route has been stabilized. Water required for both service areas will be diverted by this intake and necessary water for the right bank service area will be conveyed through a siphon, which is located downstream of this diversion dam. The diversion dam will be of floating type. The irrigation water to these service areas will be supplied from the afterbay of the Nueva Era Power Station after completion of the Nueva Era dam. Therefore, this diversion dam will be out of use by that time.

Maduyapas Diversion Dam

The Madupayas river course, about 10 km upstream of its confluence with the Tibangran river, has been selected as the Madupayas diversion dam site. The intake will be installed on the left side of the river. The diversion dam will be of floating type.

Tibangran Diversion Dam

The starting point of the alluvial fan where the Tibangran begins to flow into the plain has been selected as the Tibangran diversion dam site. The service area extends on the left bank. And the intake will be placed on the left bank. The diversion dam will be of floating type.

Table 4-10 indicates the major features of proposed diversion dams.

5. Irrigation Canal

Irrigation canals are classified into three types - link canals, main canals and laterials.

i) Link canals to be connected from Nueva Era dam to main canals;

ii) Main canals to be started from diversion dams or link canals and extended vertically downstream toward contours; and,

iii) Laterals to be extended from main canal to each farming area so as to convey the irrigation water.

Table 4-10 Major Features of Diversion Dams

	Item	Labugaon	Solsona	Madongan	Papa	Nueva Era	Madupayas	Tibangran
1.	Catchment Area (sq km)	100.5	79.0	153.8	51.4	52.4	24.3	72.7
2.	Design Flood Discharge (cu.m/sec)	1,310	1,030	2,000	670	970	320	950
3.	Intake Discharge (cu.m/sec)							
	Left Bank	3 63	3.29	4.64	3.17	--	4.00	7 71
	Right Bank	3.03	1.71	2.80	2.84	1.75	–	7.20
4.	Water Surface (m)	WL 113.20	109 85	120 00	134.50	122.00	86.00	36.50
5.	Dam Crest Elevation (m)	EL 113.35	110.00	120.15	134.64	122.15	86.15	36 65
6.	Dam Height (m)	2.30	2.30	2.50	2.30	2.15	3.00	2 50
7.	Intake Type	Intake on the left bank	Intake on the left bank	Intake on the right bank	Intake on both banks	Intake on the left bank	Intake on the left bank	Intake on the left bank
8.	Dam Type							
	Scouring Sluice	8.00x 1set	7.00x 1set	7.00x 2set	7.00x 1set 3 00x 1set	7.0x 1set	5 00x 1set	7.00x 1set
	Fixed Weir (m)	48.00	42.50	60.00	30 00	73.00	44.00	73.00
	Cut-off Wall (m)	27.50	16.00	104.00	107 00	–	32.00	46 00
	Dam Length (m)	85.00	67.00	181.00	172.00	81.50	82.50	126.00
	Dam Type	Fixed type	Fixed type	Floating type	Fixed type	Floating type	Floating type	Floating type

A careful layout of the canal networks was made in 1:50,000 military map. The canal system is located in such a way that a maximum area could be benefited at a reasonable cost or that would have a full command of the adjoining areaa.

The planned main and lateral irrigation canals are the trapezoidal earth canal which is conformed to the design standard prepared by the NIA The said standard indicates as follows:

Base-depth ratio	:	2.5
Side slope	:	1:1.5 (vertical per horizontal)
Coefficient of roughness	:	0.025
Permissible velocity (min.)	:	0.25 m/sec
(max.)	:	1.0 m/sec
Freeboard,	:	Fb = 0.30 + d/4

Where Fb: Freeboard (m)
d : Depth of water (m)

As a result, the total length of the canals is about 640 km and the canal density is estimated at 28.4 m/ha including link canals as given below:

Table 4-11 Proposed Length of Canals

Item	Proposed Canal Length (km)	Service Area (ha)
Phase I Area		10,200
Link Canal	–	
Main Canal	116.5	
Laterals	92.0	
Sub-total	208.5	(20.5 m/ha)
Phase II Area		12,400
Link Canal	96.0	
Main Canal	96.6	
Laterals	240.2	
Sub-total	432.8	(34.9 m/ha)
Total	641.4 km	22,600 ha (28.4 m/ha)

6. Drainage Canal

The planned drainage canals are the trapezoidal earth canal which is conformed to the design standard prepared by the NIA. The said standard indicates dimensions as follows:

Base-depth ratio	·	0 8
Side slope	.	1 1
Maximum permissible velocity	.	1 0 m/sec

The proposed length of the new drainage canals (main and lateral) are estimated as follows:

Table 4-12 Proposed Length of Drainage Canal

Item	Proposed Canal Length (km)	Service Area (ha)
Phase I Area		10,200
Main Canal	55.0	
Laterals	92.1	
Sub-total	147.1	(14.4 m/ha)
Phase II Area		12,400
Main Canal	75.3	
Laterals	47.8	
Sub-total	123.1	(9.9 m/ha)
Total	270.2	22,600 (12 0 m/ha)

7. On-Farm Facilities

In order to allow the irrigated agriculture practised under well-controlled water management in the Project, improvement of on-farm facilities inclusive at terminal facilities such as main farm ditches, farm drains and farm roads is a prerequisite in the Project.

The service areas extend nearby mountains and the topographic slope of the area is relatively steep as shown below:

Right bank of Bonga river	.	1/75	–	1/200
Nueva Era area	:	1/50	–	1/200
Batac-Paoay area	:	1/100	–	1/500
Badoc-Pinili-Sinait area	:	1/50	–	1/200

The paddy fields in service areas are classified into four categories in topographic conditions as follows·

Gently slope type	-	The paddy fields which extend over relatively gently sloped area.
Ragged type	-	The paddy fields which extend nearby mountains are steep in the topographic slope with ragged or rolling condition.
Flat type	-	The paddy fields which extend over the considerable flat area.
Shifting type	-	The paddy fields which extend the shifting land from sloping land to flat land.

Under the topographic conditions mentioned above, four sample areas have been selected to give the suitable plan for the proposed on-farm facilities, and the model design of irrigation and drainage canals, on-farm roads as well as land parcelling were carried out. Then, the required construction cost for on-farm development were estimated and their results were applied to designing of on-farm development works in the whole Project Area.

Phase I

Sample Area No. 1	:	Solsona Municipality (gently slope area)
Sample Area No. 2	:	Barrio Barikir (ragged area)

Phase II

Sample Area No. 1	:	Paoay Municipality (flat area)
Sample Area No. 2	:	Badoc Municipality (transitional area)

In designing the on-farm development, the followings are emphasized:

Communal Irrigation Canals

In the communal irrigation systems, there are, at present, many communal irrigation canals, which have dual purpose of water supply to paddy fields and drain of surplus water in the fields. In order to reduce the required construction cost of on-farm development, which will be burdened with farmers in the beneficial area, land consolidation is planned to be avoided as much as possible, that is, farm ditches should be planned to utilize the existing communal canals to a possible extent. Therefore, the existing boundary of fields which will coincide with the boundary of land holding, should be kept as it is, if possible.

Land Parcelling and Canal Design

The study on land parcelling has been made on the topographic map of sample areas at the scale of 1:2,000, and finally an average size of rotational area to be served by one turn-out has been decided at 30 ha for Phase I and 40 ha for Phase II, taking into account the topographic conditions, existing farming practices in the area and also NIA's criteria on water management.

To utilize the communal canal effectively, the supplementary farm ditches (SFD) is aligned across the contour lines. These farm ditches are to be designed according to the criteria of on-farm water management, which was proposed by the NIA in September, 1978

The main farm ditches and supplementary farm ditches together with the farm drains and farm roads will be constructed with earth materials.

8. Road Plan

The proposed roads in the project are classified as follows:

Service Roads

The service roads will be provided along the link canals, the main and lateral canals for operation and maintenance of the irrigation and drainage facilities as well as to transport the farm inputs and outputs The proposed roads have two types of width, six meters along the link and the main canals and four meters along the lateral canals, and both types will be paved by coarse materials.

The proposed road cross-sections of the above two types have a surfacing of 15 cm thick of base coarse overlying 20 cm thick of selected materials at the borrow area.

Total length of the proposed service roads is as follows:

		Phase I	Phase II	Total
Type A	(along link and main canal)	93.7 km	190.3 km	284 km
Type B	(along laterals)	83.4	239.6	323
	Total	177.1 km	429.9 km	607 km

Road intensity in the Project Area is estimated at 26.9 m/ha.

On-Farm Roads

The on-farm roads, which are the terminal roads for farming in the cultivated area, are planned to be located along the main farm ditches, and these roads will not be paved. The width of the roads is two meters.

9. Power Plant

a) Bonga Power Station

A differential type surge tank has been adopted in planning the Bonga Power Plant. The said surge tank is designed with 12.0 m in tank diamter, 90 m in tank height and 3.6 m in riser diameter as a result of necessary surging computation. A chamber surge tank, which might be suited to the proposed plant with considerably long tunnel and heavy drawdown expected, should be taken into consideration in the detail design stage.

A penstock, being connected with the underground power plant, will be provided in the ground with average bore diameter of 3.0 m, total length of 208 0 m including 116.8 m of vertical portion. The penstock, having 11.0 mm thickness on an average, should be placed on the reinforced concrete, to transfer internal pipe load on the bed-rocks.

The underground power house is designed with 15.5 m span of arch and 1.2 m crown thickness. The power house will have 33.0 m in full height and 20.0 m in length. The center of the turbine will be set at EL 145.0 m. Geologically, the proposed site is expected to provide good foundation rock with sufficient bearable capacity for power house.

An afterbay chamber with a large section will be provided immediately down-stream of the draft tube for surging control of the downstream tailrace. An air duct will be installed at the afterbay chamber with its outlet open outside through the duct provided for surge tank construction works.

The tailrace of non-pressure type tunnel with 3.80 m diameter is so designed that it can have the maximum discharge of 28.225 cu m/sec with a slope of 1/1,000. The tunnel lining will be made by 0.40 m thickness with reinforcing steel bar against expected flood pressure.

The designed water level at the outlet is EL 150.0 m and the outlet should be installed at the place where the sediment will not develop easily in the Bonga river for facilitating to flush sands from the outlet.

The Deriaz type turbine with variable pitched blades is recommended in this power plant that provides various conditions such as water level drawdown as large as 59.5 m. maximum effective water head of 170.65 m and discharge fluctation from maximum 28.225 cu.m/sec to 9.50 cu.m/sec The diameter of the runner inlet and the number of revolution are economically determined by 2.100 mm and 450 rpm respectively And the rated output is 36.000 KW. One set of the turbine of this type will be installed together with set of generator with capacity of 39.600 KVA.

This power plant will be operated by the remote control system from the Nueva Era Power Station, so that managerial cost can be minimized.

The standard design effective water head was obtained by 149.30 m from computation on the basis of 10-year average water amount in the reservoir

b) Nueva Era Power Station

A penstock, welded steel pipe embeded to the dam body, will link the intake tower attached to dam and the power station located at immediate downstream of dam. The pensotck has 3.00 m in diamter, 11.0 mm in thickness and 30 0 m in length, providing gate at its inlet and expansion joint at its outlet.

The power house is designed in steel-frame reinforced concrete structure with 16.0 m in width, 18.0 m in length, 13.5 m in building height and 12.0 m in foundation height The generator room provided in the house will equip a crane with 9.0 m span for mounting and maintenance works of the main body of the generator. And afterbay with 6 0 m in width and 16.0 m in length will be constructed at immediate downstream of the draft tube, linking with an irrigation canal. And the floor elevation of the generator room is designed as EL 126.0 m in considering the floodings.

The regulation at the Bonga afterbay will range from 29 273 cu.m/sec to 8.00 cu.m/sec in the discharge. The effective water head is as small as 27.92 m only Hence, the vertical Kaplan type turbine is adopted for this power plant. The diameter of the runner inlet and the number of revolution are 2,050 mm and 327 5 rpm, respectively. One set of the turbine with 6.800 KW output capacity in this type will be installed in the power house together with a set of generator with 7,480 KVA capacity.

c) Transmission Lines

The NPC's power transmission program in 1979 defines that the existing 115 KV transmission line between the Narvacan substation and the Laoag substation will be converted in use as 69 KV when the new transmission line of 230 KV is connected to the

Narvacan substation. The transmission plan in this Project should be formulated in accordance with the above-mentioned NPC's program, but since, actually, the NPC's program has not defined yet its time table of implementation, the plan in this Project was made up on the premise that the 115 KV line would be laid down between the both substations in future.

The two lines, one by the NPC's Luzon Grid (115 KV) and the other by this Project, are designed to be connected at Badoc Furthermore, 115 KV line will be installed with wooden poles in single circuit between Badoc and the Nueva Era power station (about 22.0 km) as well as between the Nueva Era power station and the Bonga power station (about 3.8 km). The conductor size, in that case, will be taken by 336.4 MCM, ACSR.

E. Cost Estimate

The total investment cost for overall plan was computed by the sum of estimated construction costs for the Phase I and the Phase II; however, the construction cost for the Phase I was estimated on the prices as of January, 1978. Accordingly, the construction cost for the Phase I is converted from the cost as of January, 1978 by using the price escalation index (25% for foreign currency and 45% for local currency)

The total investment cost exclusive of price escalation factors during the construction period and related interest is, finally, estimated at 2,760.7 million pesos (US$373.1 millions), 1,691.5 million pesos (US$228 6 millions) of foreign currency component and 1,069.2 million pesos (US$144.5 millions) in local currency.

The following table shows the summary of the investment cost (Table 4-13 shows the investment cost of the Project for overall).

Summary of Investment Cost

(Unit: '000 pesos)

Description	Overall	Phase I	Phase II
Irrigation			
Investment cost	1,777,812	310,832	1,466,980
Cost per hectare ($/ha)	9,890 1/		
Hydropower			
Investment cost	982,891	–	982,891

Note: Irrigation Area
Phase I: 10,200 ha   Phase II. 12,400 ha

1/ ₱ 1,653,661 x 10^3/22,600 ha = 73,170 ₱/ha
= 9,890 $/ha

Table 4-1[illegible] Investment Cost of the Project (Overall)

Description	Phase I F.C. (₱'000)	Phase I L.C. (₱'000)	Phase I Total (₱'000)	Phase II F.C. (₱'000)	Phase II L.C. (₱'000)	Phase II Total (₱'000)	Total (Overall) F.C. (₱'000)	Total (Overall) F.C. (US$'000)	Total (Overall) L.C. (₱'000)	Total (Overall) L.C. (US$'000)	Total (₱'000)	Total (US$'000)
1. Civil Works												
1-1 Preparation	56	1,58[illegible]	1,638	[illegible]	3[illegible],62[illegible]	[illegible]	19,567	2,644	34,2[illegible]	4,6[illegible]	53,769	7,2[illegible]
1-2 Palsiguan Dam	-	-		466,337	228,137	694,474	466,337	63,019	228,13[illegible]	3[illegible]	694,474	93,84[illegible]
1-3 Headrace	-	-		49,941	54,57[illegible]	104,516	49,941	6,749	54,57[illegible]	7,4[illegible]	104,516	14,12[illegible]
1-4 Power Plant & Tailrace	-	-		[illegible]	[illegible],777	173,715	123,938	16,748	[illegible]	[illegible]	173,715	[illegible]
1-5 Nueva Era Dam	-	-	-	4[illegible],[illegible]36	41,883	84,619	[illegible]	[illegible]	41,88[illegible]	5,66[illegible]	84,61[illegible]	[illegible]
1-6 Diversion Dam	33,128	37,0[illegible]	70,[illegible]	[illegible],521	[illegible],698	[illegible]	[illegible]	[illegible],[illegible]34	4[illegible],77	[illegible]	[illegible]	[illegible]
1-7 Irrigation & Drainage Canal	24,519	48,5[illegible]	73,0[illegible]	[illegible],435	[illegible],733	[illegible],[illegible]28	[illegible]	[illegible]	2[illegible]	34,897	428,254	[illegible]
1-8 On-farm	6,640	[illegible],089	15,7[illegible]	[illegible]	20,640	[illegible]	[illegible]	[illegible]	[illegible]	4,017	38,836	[illegible]
1-9 Road	4,680	8,686	13,[illegible]	[illegible]	14,[illegible]	[illegible]	[illegible]	[illegible]	[illegible],888	3,093	37,284	[illegible]
1-10 Pre Engineering		[illegible]	[illegible]	-	[illegible]	5,156	-		[illegible],686	768	5,686	[illegible]
Sub-total (by ₱'000)	69,023	105,46[illegible]	174,48[illegible]	[illegible],667	666,421	1,[illegible]38,088	[illegible]		77[illegible]		[illegible],71[illegible],573	
Sub-total (by US$'000)	(9,327)	(14,25[illegible])	(23,574)	(117,793)	(90,057)	([illegible])		1[illegible]		[illegible]04,30[illegible]		231,[illegible]
2. Land Acquisition & Compensation	-	[illegible]	[illegible]	-	[illegible]	[illegible],337			[illegible]	[illegible]	5[illegible],99[illegible]	[illegible]
3. Construction Equipments	38,334	[illegible]	3[illegible]	[illegible],100	[illegible],000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4. Agricultural Development	-	[illegible],900	[illegible]	-	[illegible]	4,3[illegible]		-	[illegible]	[illegible]	7,240	[illegible]
5. Operation & Maintenance Cost	[illegible]	7,034	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14,84[illegible]	[illegible]
6. Project Facilities	878	[illegible]	[illegible]	449	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7. Project Administration (3%)	-	[illegible]	[illegible]	-	[illegible]	[illegible]	-	-	[illegible]	[illegible],288	[illegible]	[illegible],28[illegible]
8. Consulting Services	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3,[illegible]	[illegible]	[illegible]	3,[illegible]
Sub-total (1 to 8 by ₱'000)	116,44[illegible]	[illegible]	270,28[illegible]	[illegible]	[illegible],87[illegible]	[illegible]	[illegible]		[illegible]		[illegible],619	
Sub-total (1 to 8 by US$'000)	(1[illegible],73[illegible])	(2[illegible])	(3[illegible])	([illegible],133)	([illegible],448)	([illegible])		[illegible]		[illegible]		[illegible]
9. Contingency (15%)	17,466	[illegible]	[illegible]	[illegible],167	[illegible]	[illegible]	[illegible],633	[illegible]	[illegible]	18,846	3[illegible],093	48,66[illegible]
Sub-total (1 to 9 by ₱'000)	133,909	171,[illegible]	31[illegible]	[illegible]	[illegible]	2,449,87[illegible]	[illegible],641,518		[illegible]		[illegible],76[illegible],70[illegible]	
Sub-total (1 to 9 by US$'000)	([illegible])	(23,408)	(4[illegible],004)	([illegible],487)	(1[illegible],576)	(331,[illegible])		[illegible]		[illegible]44,484		373,067
10. Price Escalation	26,26[illegible]	[illegible]	[illegible]	[illegible],487	522,84[illegible]	1,1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible],269,243	171,52[illegible]
Total (by ₱'000)	160,178	226,[illegible]	386,7[illegible]	[illegible],228,096	1,415,111	3,643,20[illegible]	[illegible],488,[illegible]		1,641,672		4,029,946	
Total (by US$'000)	(21,646)	(30,[illegible])	(52,262)	(301,094)	(191,231)	(49[illegible],32[illegible])		[illegible],74[illegible]		[illegible]21,847		544,587

CHAPTER V. PROJECT IMPLEMENTATION AND OPERATION

CHAPTER V. PROJECT IMPELEMENTATION AND OPERATION

A. Executing Agency and Coordination

Ilocos Norte Irrigation Project involving the irrigation and the hydropower components is a part of the Ilocos Norte Integrated Rural Development Project (INIDP), so that the executing agency of the project will be organized and operated, prior to the establishment of the executing agency of the said INIDP. Under the situation, the NEDA will make overall coordination of the project, and NIA and NPC will function as the executing agencies for implementation of irrigation and hydropower components respectively. In order to make a good coordination between above agencies, Joint NIA/NPC Technical Committee will be organized.

Figure 5-1 indicates the proposed organization for the Project implementation.

B. Construction Schedule

The Project Area has a total beneficial acreage of about 22,600 ha, and of which construction has been planned to be carried out in two stages, Phase I and Phase II.

The construction period of overall plan is scheduled for nine years from FY1979 to FY1987 including the final design, and the construction will start from FY1980 and last to FY1987. In this time table, the Phase I will start from FY1979 and end in FY1984, while the Phase II will start in FY1980 and end in FY1987.

The construction schedule of the Project is given in Figure 5-2.

C. Executing Agency and Organization for Operation Maintenance

The entire Project works, upon completion of the Project, will be taken over to the NIA Regional Office No.I, and the responsibility of operation and maintenance of all irrigation and drainage facilities will fall under the Ilocos Norte Irrigation System Office (INISO) to be newly organized.

Operation and maintenance of the facilities will be performed by the Irrigator's Association under the jurisdiction of the INISO. On the other hand, the operation and maintenance of the facilities for hydropower will be undertaken by the NPC. The proposed organization chart for operation and maintenance is shown in Figure 5-3.

FIGURE 5-1 ILOCOS NORTE IRRIGATION PROJECT
PROPOSED ORGANIZATION CHART FOR PROJECT IMPLEMENTATION

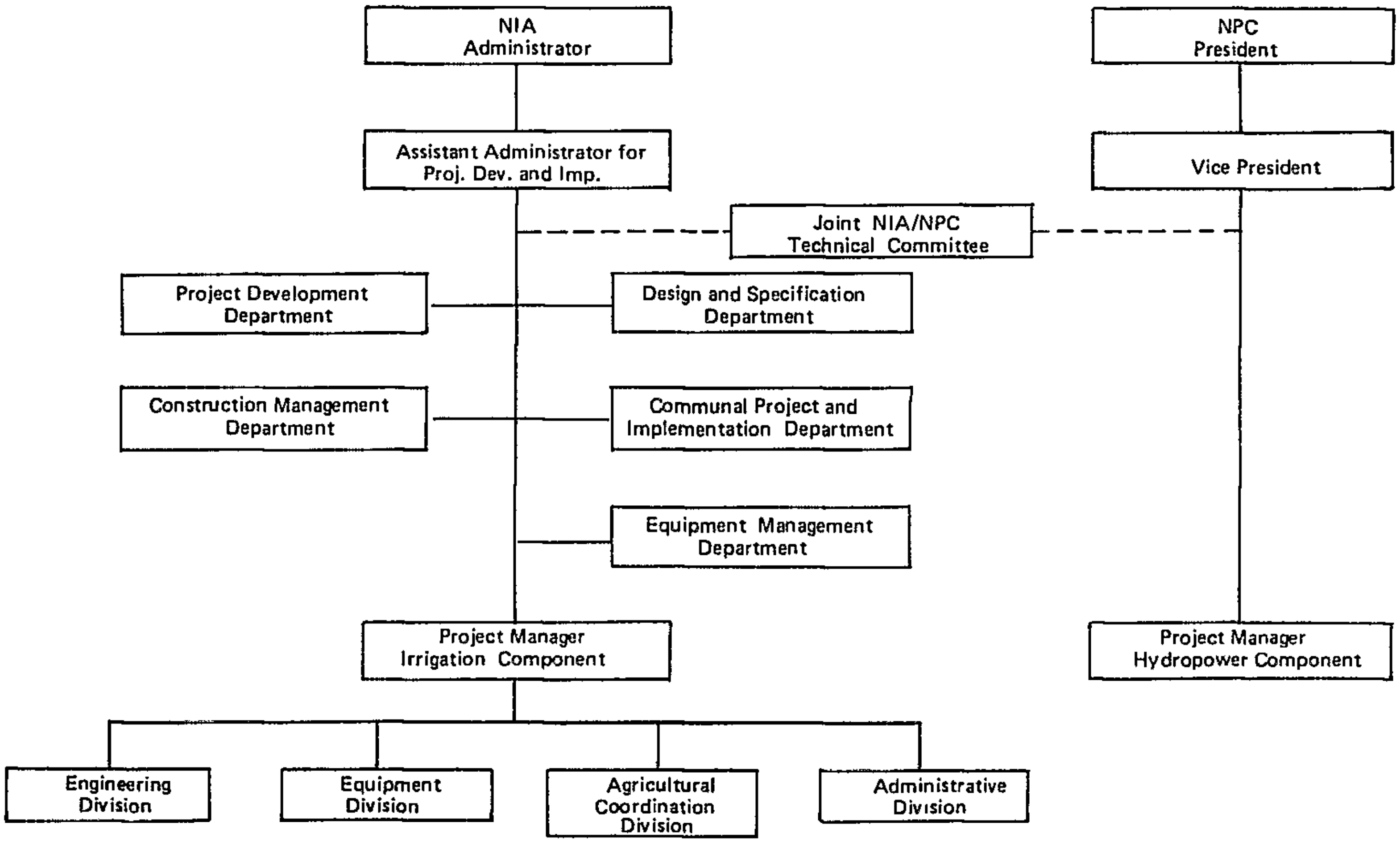


FIGURE 5 2 IMPLEMENTATION SCHEDULE FOR THE PROJECT

Phase I
Phase II

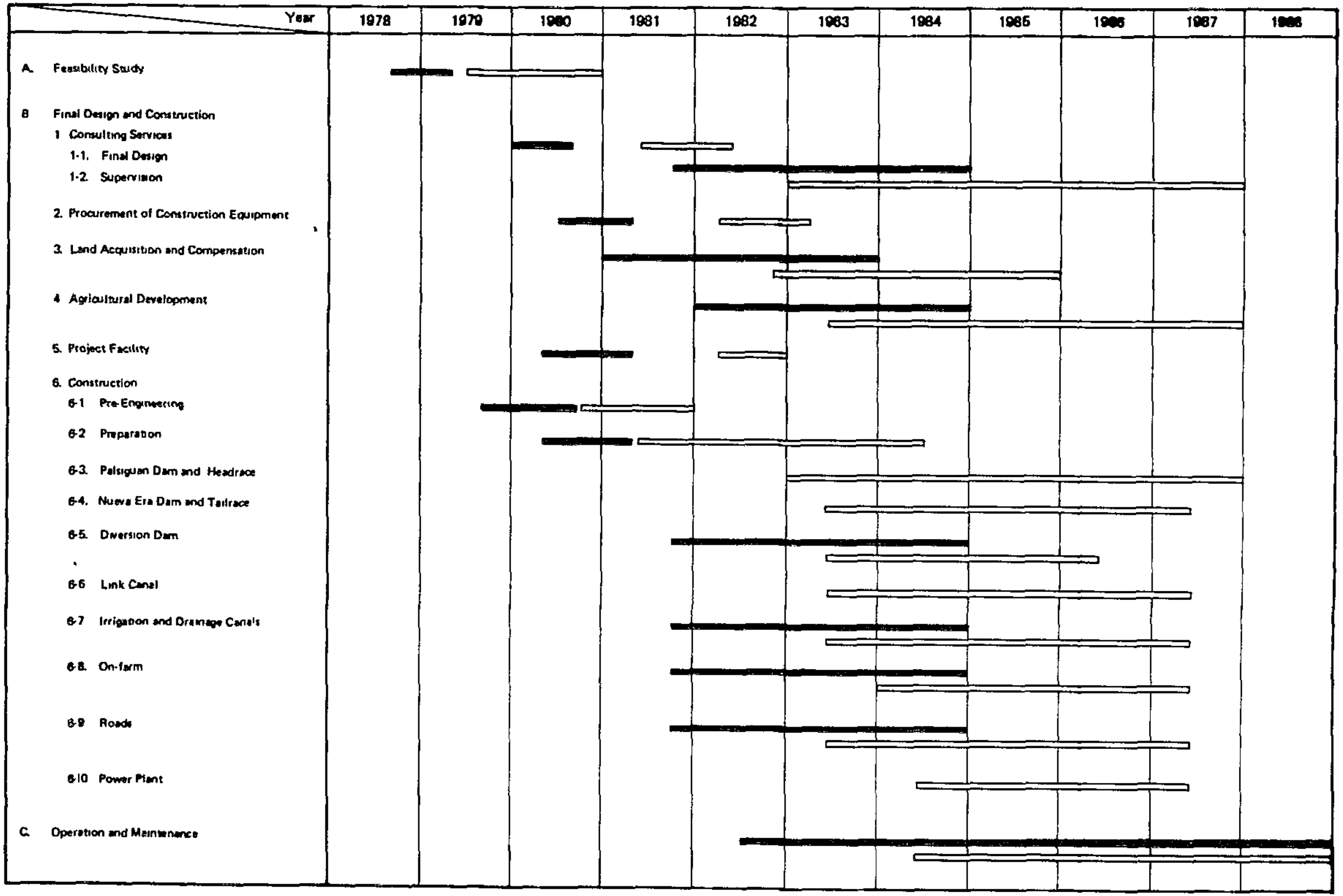
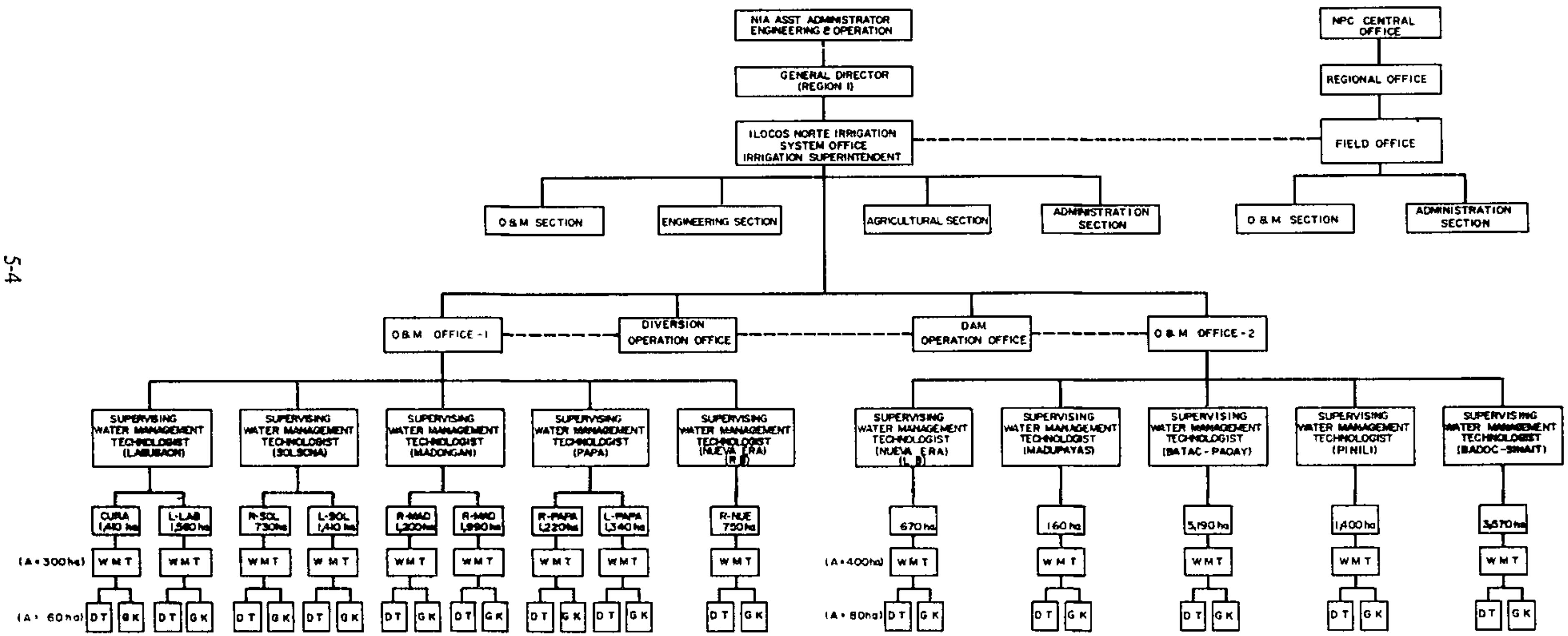


FIGURE 5-3 PROPOSED ORGANIZATION CHART FOR OPERATION AND MAINTENANCE



NOTE
WMT WATER MANAGEMENT TECHNOLOGIST
DT DITCH TENDER
GK GATE KEEPER

CHAPTER VI. PROJECT JUSTIFICATION

CHAPTER VI. PROJECT JUSTIFICATION

A. Economic Evaluation

1. General

The direct purpose of this Project is to increase the farm labor opportunity and the cash income for the small-size farmers and to improve their living status in terms of farm economy. These benefits due to the Project would be realized as the results of increase and stabilization in yield of commercial crops, intensive utilization of fields and organization of irrigation water control.

This Project was also schemed to meet the needs of national economy, such as supply of staple food, increase in exporting crops and substitution crops with the trading commodities, increase in employment opportunity, correction of income inequality and contribution to relief of energy problem.

To meet these purposes, the Project components as mentioned in the previous chapter have been schemed. After completion of the Palsiguan dam, Nueva Era dam, diversion dams, irrigation and drainage canals, the direct benefit is expected from crop growing in 22,600 hectare in the Project Area.

The electricity of 42,800 KW expected from the Bonga and the Nueva Era power stations would grow a great deal of social and economic benefits.

The measurable economic benefits and costs are expressed in monetary terms and the both stream of benefits and costs in annual forms over the evaluation period are converted to the respective present worth values. An economic price presented by border price is applied to an economic evaluation. The internal rate of return (IRR) is used as the main indicator for the economic evaluation of the Project. The Project is evaluated based on the difference between the "development with the Project" and the "development without the Project". Thus, the project evaluation deals with incremental benefits and required costs.

2. Agricultural Benefit

a) Irrigable area with the Project

The formation of annual benefited areas were decided to match with the annual construction schedule. Irrigable areas with the Phase I and the Phase II are shown in the following table.

Table 6-1 Irrigable Area with Project

(Unit: hectare)

Sub Area	Project Area	Irrigable Area			
		Wet Season		Dry Season	
		Phase I	Phase II	Phase I	Phase II
Labugaon	1,560	1,560	–	780	780
Solsona	2,140	2,140	–	610	1,530
Madongan	3,190	2,290	900	720	2,470
Papa	2,560	1,340	1,220	400	2,160
Nueva Era (R.B.)	750	750	–	450	300
Sub-total	10,200	8,080	2,120	2,960	7,240
Cura	1,410	–	1,410	–	1,410
Nueva Era (L.B.)	670	–	670	–	670
Madupayas	160	–	160	–	160
Batac-Paoay	5,190	–	5,190	–	5,190
Pinili	1,400	–	1,400	–	1,400
Badoc-Sinait	3,570	–	3,570	–	3,570
Sub-total	12,400	–	12,400	–	12,400
Total	22,600	8,080	14,520	2,960	19,640

The total construction works of the Phase I project will be completed at the end of 1984. Since part of the Phase I, however, is expected to be completed before 1984, benefit growing will start from the wet season in 1983 in some areas. But even after completion of the Phase I construction works, production of some areas in the Phase I area will not reach the target yield due to shortage in irrigation water untill the Phase II project is completed and linked with Phase I facilities. As a result, the benefit growing areas of the Phase I project are estimated at 8,080 ha in the wet season and 2,960 ha in the dry season after completion of the construction.

The construction of the Phase II project covers five years from 1983 to 1987. Before the Palsiguan dam and the Nueva Era dam are completed in the course of construction works of the Phase II, the objective irrigable area of 12,400 ha will not be fully supplied with water due to insufficiency in water diverted. Finally, the benefit will be generated from the total area of 12,400 ha plus some remaining areas in the Phase I project after 1988, when all major facilities are completed together with their appurtenant structures in the system.

Table 6-2 & Table 6-3 show the expected irrigable areas and cropping areas "with Project" by years.

Table 6-2 Irrigable Area with the Project by Years

Field	Project	Sub Area	1983 Dry	1983 Wet	1984 Dry	1984 Wet	1985 Dry	1985 Wet	1986 Dry	1986 Wet	1987 Dry	1987 Wet	1988 Dry	1988 Wet
	Phase I	Labugaon	–	–	–	1,560	780	1,560	780	1,560	780	1,560	780	1,560
		Solsona	–	2,140	610	2,140	610	2,140	610	2,140	610	2,140	610	2,140
		Madongan	–	–	–	–	720	2,290	720	2,290	720	2,290	720	2,290
		Papa	–	–	–	–	400	1,340	400	1,340	400	1,340	400	1,340
		Nueva Era (R.B.)	–	–	–	–	450	750	450	750	450	750	450	750
		Sub-total	–	2,140	610	3,700	2,960	8,080	2,960	8,080	2,960	8,080	2,960	8,080
	Phase II	Cura	–	–	–	1,410	–	1,410	–	1,410	–	1,410	1,410	1,410
		Nueva Era (L.B.)	–	–	–	–	–	–	–	–	–	670	670	670
		Madupayas	–	–	–	–	–	–	–	160	–	160	160	160
		Batac-Paoay	–	–	–	–	–	–	–	–	–	–	5,190	5,190
		Pinili	–	–	–	–	–	–	–	1,220	–	1,400	1,400	1,400
		Badoc-Sinait	–	–	–	–	–	3,390	–	3,390	–	3,570	3,570	3,570
		Sub-total	–	–	–	1,410	–	4,800	–	6,180	–	7,210	12,400	12,400
		Labugaon	–	–	–	–	–	–	–	–	–	–	780	–
		Solsona	–	–	–	–	–	–	–	–	–	–	1,530	–
		Madongan	–	–	–	–	–	–	–	–	–	–	2,470	900
		Papa	–	–	–	–	–	–	–	–	–	–	2,160	1,220
		Nueva Era (R.B.)	–	–	–	–	–	–	–	–	–	–	300	–
		Sub-total	–	–	–	–	–	–	–	–	–	–	7,240	2,120
		Grand Total	–	2,140	610	5,110	2,960	12,880	2,960	14,260	2,960	15,290	22,600	22,600

Table 6-3 Cropping Area with Project

(Unit. ha)

	Crop	1983	1984	1985	1986	1987	1988
1.	Phase I Project						
	Paddy, Wet	2,140	3,700	8,080	8,080	8,080	8,080
	Paddy, Dry	–	550	2,670	2,670	2,670	2,670
	Tobacco	–	20	90	90	90	90
	Garlic	–	20	100	100	100	100
	Onion	–	20	100	100	100	100
	Total	2,140	4,310	11,040	11,040	11,040	11,040
2.	Phase II Project 1/						
	Paddy, Wet	–	1,410	4,800	6,180	7,210	14,520
	Paddy, Dry	–	–	–	–	–	11,500
	Tobacco	–	–	–	–	–	2,340
	Garlic	–	–	–	–	–	4,520
	Mungbeans	–	–	–	–	–	2,065
	Cotton	–	–	–	–	–	1,030
	Onion	–	–	–	–	–	250
	Total	–	1,410	4,800	6,180	7,210	36,225
	Total	2,140	5,720	15,840	17,220	18,250	47,265

Note: 1/ Including Phase I remaining field.

b) Annual Production

Annually benefited area multiplied by the target yield gives gross production with the Project.

Full benefit would be attained by 1992; then it will take 13 years from starting of detail design for the Phase I Project in 1980 to reach the goal of the Project.

The incremental production is expected to reach about 100,000 tons of palay, 6,000 tons of garlic, 1,200 tons of tobacco, 2,580 tons of cotton and 1,780 tons of mungbeans by 1992.

Table 6-4 shows the annual production of major crops in the Area.

c) Incremental Production Benefits

Incremental net production value in shown on Table 6-5.

3. Power Benefit

Annual power benefits are generally evaluated by using the standard capacity-energy approach. Dependable capacity and average annual energy production were evaluated based on the cost of an alternative oil-thermal plant.

The proposed installed capacity is 42,800 KW in total and an average annual energy is 199.2 GWh. A dependable capacity is 30,510 KW.

A location of alternative oil-thermal plant for estimation of capacity unit value was assumed to be around the San Fernando port where the unloading facilities of petroleum will be available.

A construction unit cost of this alternative plant is estimated at 4,630 pesos/KW.

The capacity cost (KW value) was assumed to be equal to the annual fixed cost of the alternative plant. Items of fixed cost consist of interest, depreciation, personal and repairing expenses in O & M cost, administration charge for main office and tax. The unit capacity value was estimated at 700 pesos/KW.

The energy cost (KWh value) is assumed to be equal to the annual cost of fuel, operation and maintenance cost of the alternative thermal plant. The energy value was estimated at 0.429 pesos/KWh. This value was computed based on the NPC data, that is, the high viscocity fuel oil cost in Batan thermal power plant.

Table 6-4 Main Crop Production

(Unit. 1,000 tons)

Project	Year	Paddy Wo[1/]	W[2/]	Tobacco Wo	W	Garlic Wo	W	Mungbeans Wo	W	Cotton Wo	W
1. Phase I Project											
	1983	19.10	15.29	0.02	0.02	–	–	0.02	0.04	–	–
	1984	19.31	22.79	0.02	0.02	–	0.04	0.02	0.08	–	–
	1985	19.52	30.91	0.02	0.10	–	0.20	0 02	–	–	–
	1986	19.72	35.36	0.02	0.11	–	0 23	0.02	–	–	–
	1987	19.93	39.15	0.02	0.12	–	0.25	0.02	–	–	–
	1988	20.14	41.56	0.02	0.12	–	0.26	0.02	–	–	–
	1989	20.35	42.27	0.02	0.12	–	0.27	0.02	–	–	–
2. Phase II Project[3/]											
	1983	28.72	28.72	2.51	2.51	5.67	5.67	0.45	0.45	–	–
	1984	28.97	30.78	2.54	2.54	5 73	5.73	0.45	0.45	–	–
	1985	29.22	35.09	2.58	2.58	5.78	5.78	0.46	0.46	–	–
	1986	29.47	38.74	2.61	2.61	5.84	5.84	0.46	0.46	–	–
	1987	29.72	42.75	2.64	2.64	5.90	5.90	0.47	0.47	–	–
	1988	29.98	85.32	2.68	3.15	5.95	8.82	0.47	1.45	-	1.55
	1989	30.24	94.27	2.71	3.41	6.01	9.77	0.48	1.71	–	1.89
	1990	30.50	102.60	2.74	3.65	6.07	10.78	0.48	2.00	–	2.24
	1991	30.74	108.79	2.78	3 83	6.12	11.55	0.49	2.21	–	2,49
	1992	31.01	110.95	2,81	3,89	6,18	11.78	0.49	2.27	–	2.58

Note: 1/ Without Project

2/ With Project

3/ Including Phase I remaining area

Table 6-5 Incremental Production Benefits

(Unit: Million Pesos)

Year	Without Project GPV 1/	Without Project PC 2/	Without Project NPV 3/	With Project GPV	With Project PC	With Project NPV	Incremental Production Benefits
1. Phase I Project							
1983	41.67	8.86	32.81	44.38	8.08	36.30	3.49
1984	42.12	8.95	33.17	49.97	9.28	40.69	7.52
1985	42.57	9.05	33.52	70.15	12.19	57.96	24.44
1986	43.03	9.15	33.88	88.30	13.80	66.50	32.62
1987	43.48	9.24	34.24	88 93	15.17	73.76	39.52
1988	43.93	9.35	34.58	94.31	16.16	78 15	43.57
1989	44.38	9.44	34.94	95.93	16.17	79.76	44.85
2. Phase II Project 4/							
1983	147.07	31.34	115.73	147.07	31.63	115.44	- 0.29
1984	148.57	31.38	117.19	152.40	32.05	120.35	3.16
1985	150.25	31.43	118.82	162.67	32.87	129.80	10.98
1986	151.74	31.46	120.28	171.32	33.64	137.68	17.40
1987	153.27	31.51	121.76	180.83	34.28	146.55	24.79
1988	154.92	31.55	123.37	334.98	62.32	272.66	149.29
1989	156.48	31.59	124.89	373.00	66.32	306.68	181.79
1990	158.00	31.64	126.36	409.98	70.33	339.65	213.29
1991	159.65	31.68	127.97	437.41	74.12	363.29	235.32
1992	161.18	31.73	129.45	448.29	74.31	373.98	244.53

Note: 1/ Gross Production Value

2/ Production Cost, input materials and hired labor cost

3/ Net Production Value

4/ Including Phase I remaining area

Generated energy from Bonga and Nueva Era power stations is forecasted to be supplied to Ilocos Norte, Abra and Ilocos Sur province service areas which are covered by NPC's 115 KV transmission line system

Annual energy of 199.2 GWh is expected to be generated from 1988. But a requirement volume is service area will not attain to full supply volume for several years. Then a surplus energy will be transmitted to La Union area through 230 KV line from Narbuacan substation. This unbalance would be forecasted to be resolved by 1996. The benefited energy is estimated at 189.2 GWh using five percent of transmission line loss.

Using the unit value of power and energy, annual benefits in 1996 are estimated as follows·

KW value	28,945,000	Pesos
KWh value	81,183,000	Pesos
Total	110,128,000	Pesos

4. Economic Evaluation of Project Cost

The direct cost to be used in project justification consists of those costs for engineering design, property, construction equipment and facilities, project administration, consulting services and contingency, but does not include interest during construction of the Project

Financial project cost excluding the escalation factor are 2,760.7 million pesos (US$373.0 millions) including purchase cost of construction equipment and 2,564.6 million pesos (US$346.6 millions) including depresiation cost of equipment. This financial costs are estimated using domestic market prices other than the international price for construction equipment. Then this financial cost has to be revised using economic price, that is shadow price.

Both interest and tax are considered as transfer payments, so that they can not be included in the economic cost. The project economic cost in this study includes depreciation cost of construction equipment. Economic cost including purchase cost of equipment will be dealt in sensitivity analysis.

The unskilled labor cost and oil cost were re-estimated using opportunity cost or shadow price. The acquisition cost for arable land in the Project Area was excluded because a decrease in incremental benefit obtained from such land was already computed in the benefit stream.

The re-estimation of project cost was carried out using the conversion factors. The World Bank conducted the social cost-benefit analysis in Dec., 1978. In this analysis the shadow prices and country parameters were estimated. According to these data, a standard conversion factor is 0.820 and the conversion factors for capital goods, consumption, transportation and construction are 0.865, 0.840, 0.777 and 0.827, respectively.

The financial project costs of 2,564.6 million pesos excluding escalation factor was re-estimated at economic costs of 2,120.9 million pesos as shown in the following table.

Evaluation of project economic cost

(Unit: million pesos)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	Total
Financial Cost	2.12	13 33	49 28	172.29	285.61	379.36	546.68	588.21	526.87	0.86	2,564.61
Economic Cost	1 79	11.67	38 40	141.38	234.31	317.80	446.57	485.36	435.74	7.84	2,120.86

B. Internal Rate of Return

The internal rate of return (IRR) was estimated by using a linear interpolation method. The incremental benefits are computed by subtracting the project cost from the benefits by each project year The Project costs consist of initial capital and operation and maintenance cost for irrigation and power plant, and benefits are incremental production benefits and power benefits. The total present worth value of incremental benefits are positive at the discount rate of 13 percent and negative at 14 percent.

The IRR should be rounded to the nearest percentage as follows, and then indicated at 14 percent.

$$IRR = 0.13 + \frac{69.23}{69.23 + 16.09} \times 0.01 = 0.1381$$

This integrated project is considered justifiable from the economic viewpoint.

The IRR of each single project of irrigation and power were estimated at 15 percent and 12 percent respectively.

The power project with the lower internal rate of return is considered to attain to the justifiable line.

The IRR of Phase I and the Phase II has been computed based on the project investigation costs, and the results of the computation were summarized as follows;

Internal Rate of Return by the Project

	Overall	Phase I	Phase II
	%	%	%
Irrigation	15	13	15
Power	12	–	12
Total	14	13	14

C. Socio-Economic Impact

Besides the direct benefits mentioned above, the Project will create the indirect benefit and give the socio-economic impact to both farm economy in the vicinity of the Project Area and provincial or national economy.

In view of the farm economy, the following impacts would be given.

i) The farmers can timely make their farm planning for marketing of commercial products after completion of the Project works. This will contribute to a control of market price in associating with promotion of agricultural cooperative activities.

ii) An increase in farm income will improve the farmer's standard of living. This improvement will contribute to an increase in savings in farm economy, tax revenue for province and a rise of standard of education. A part of savings would be converted to formation of capital.

From the viewpoint of national or provincial economy, the following items are enumerated.

iii) Contribution to the self-sufficiency of staple food

The balance of demand and supply of rice at present in the Ilocos Norte Province is still instable. After completion of the Project, the Ilocos Norte province, producing surplus rice, would contribute to the solution of problems in deficitridden provinces in rice supply, such as La Union and Benguet.

The government forecasted that the self-sufficiency of staple food will be attained in the next five years, 1978 - 1982. In fact, the Philippines has just become a rice exporter since 1977. The incremental rice after completion of the Project would contribute to the international trade of the Philippines.

iv) Increase in employment

The raise of cropping intensity will increase employment capacity of family labor and hired labor. According to the labor analysis, the farming labor demand was projected to increase from 2.0 million man-days without Project to 3.4 with Project.

The demand of hired labor will increase from about 25 percent without Project to about 45 percent with Project in total labor demand.

v) Correction of income inequality

According to the 1.1 hectare farm budget analysis, per capita farm income of leaseholder was estimated at 770 pesos at present and 2,820 pesos with Project.

The increase in cropping area due to the Project will be different by sizes of farms. The cropping areas of tobacco and garlic per farm are limited because of imbalance in labor distribution. A smaller farmer will be able to cultivate commercial crops with a comparatively larger percent to farm field area than that of a larger farmer.

vi) Easement of energy

About 90 percent of the country's energy requirements are met with power generated by imported petroleum. Construction of hydroelectric power instead of alternative oil-thermal plant will reduce the import volume of petroleum in country's economic activities.

The oil consumption volume corresponding to annual energy of 199.2 GWh are roughly estimated at 35,000 barrel of petroleum. The annual saving of foreign currency is expected at about US$945,000 (seven million pesos) using US$27 per barrel of crude oil arriving in the Philippines.

vii) Improvement of transportation network

The operation and maintenance roads constructed by the Project will speed up in transport of the input and output materials.

viii) Income increase during construction

Many farmers will be employed in various project-related works during the construction of the Project. The required unskilled labor wages are estimated at 16 3 million pesos at peak in 1986. This income is about 19 percent of total net production value without Project.

ix) Inland Fisheries

The annual production from the fish ponds in the Philippines occupies only eight percent of the total fish production in the nation, whereas the unit price of the fish cultivated in the ponds is higher than that of the fish produced by the method other than fish pond culture. The inland fishery in the Ilocos Norte, the annual production of which occupies about 45 percent of the total provincial fish production, is considered playing a vitally important role in the fishing industry of the Ilocos region. And the largest allotment of the budget has been made to the fish pond development plan in the five-year development plan for fisheries (1981 - 1985).

The both reservoirs at the Palsiguan and the Nueva Era dams will provide the useful water resources for running the inland water fishing, although further specific survey is required for determining the fish species to be liberated and cultivation method as well as fishing method, and studying the optimum scale of the fish culture and its profitability.

The Nueva Era reservoir will be constructed across the Bonga river about 2.5 km upstream of the Nueva Era village. This reservoir will allow to provide a stable environment for fish culture which will generate benefits as long as the stored water is supplied from the Palsiguan dam. Without water supply from the Palsiguan dam, the Nueva Era reservoir will not be able to store the water in its full capacity throughout the year, and hence, the benefit from the fisheries is not expected for the period of the Stage I.[1/]

1/ First stage (stage I) of the Phase II development Project formulated as an alternative plan of the Phase II, in which the construction of the Project was divided into two stages, Stage I and Stage II

APPENDIX A. Alternative Studies on Optimum Scale of Overall Development

APPENDIX A. Alternative Studies on Optimum Scale of Overall Development

A. Concepts of Alternative Plans

The Phase I feasibility study was performed based on the alternative studies which had been made before the said feasibility study by the field survey at August of 1978. Irrigation acreage, power capacities, and some dimensions of the facilities were improved by the Phase II feasibility study. However, since this improvement is based on the recommendable plan of the said alternative studies which was performed on the Phase I study, the said alterantive studies are regarded as the basis and discussed as follows;

The overall development plan aiming at year-round irrigation for the potential acreage of the proposed land use has been formulated depending upon preliminary analysis of alternative plans mainly subjected to utilization of water resources, their associated benefits and costs thus their economic feasibility.

The Project Area is divided into two, the Phase I area and the Phase II are, taking into account the topography and the available data especially on meteology and hydrology to be fit for the feasibility study which will be studied following the overall plan. The Phase I area is located on the right bank of the Bonga river, alluvial fan developed by the Bonga river and its tributaries, and the Phase II area, on the other hand, is the so-called Batac-Badoc area situated on sedimentary plain developed by the Badoc river and other rivers.

The potential irrigation acreage in overall project covers 21,400 ha of which 10,200 ha is categorized into the Phase I area and 11,200 ha into the Phase II area.

Irrigation water requirement for the potential acreage of 21,400 ha, which is estimated based on the proposed cropping pattern for the case of the year-round irrigation available, is estimated at 497.3 MCM per annum, equivalent to about 2,320 mm per hectare, as a mean value during the period of 11 years from 1960 to 1970

Table A-1 Annual Irrigation Water Requirement

Year	Phase I (10,200 ha) (MCM)	Phase II (11,200 ha) (MCM)	Total (21,400 ha) (MCM)	Water Requirements per ha (mm)
1960	293.3	272.5	565.8	2,644
1961	224.9	211.1	447.0	2,089
1962	248.7	226.4	475.1	2,220
1963	265.6	246.1	511.7	2,391
1964	236.0	221.5	457.5	2,138
1965	223.1	202.3	425.4	1,988
1966	279.6	262.3	541.9	2,532
1967	252 2	224.9	477.1	2,229
1968	282.9	266.2	549.1	2,566
1969	297.3	274.1	571.4	2,670
1970	238.2	210.2	448.4	2,095
Mean	259.3	238.0	497.3	2,324

To meet the water demand of the proposed acreage, effective and rational utilization of water resources available in the Project Area is inevitably required.

Taking into account the topographical and geological conditions, seven river basins in the Ilocos Norte province and Palsiguan river basin in the Abra province are planed to develop their water resources by provisions of diversion dams and/or storage dams.

The stream flow amount for each river basin at the site of proposed structures is estimated as shown in Table A-2 on the basis of Solsona and Tineg river run-off for which comparatively long term stream flow records have been observed.

B. Proposed Alternative Plans

The following four alternative plans are proposed from an aspect of water-resources development (See Figure A-1).

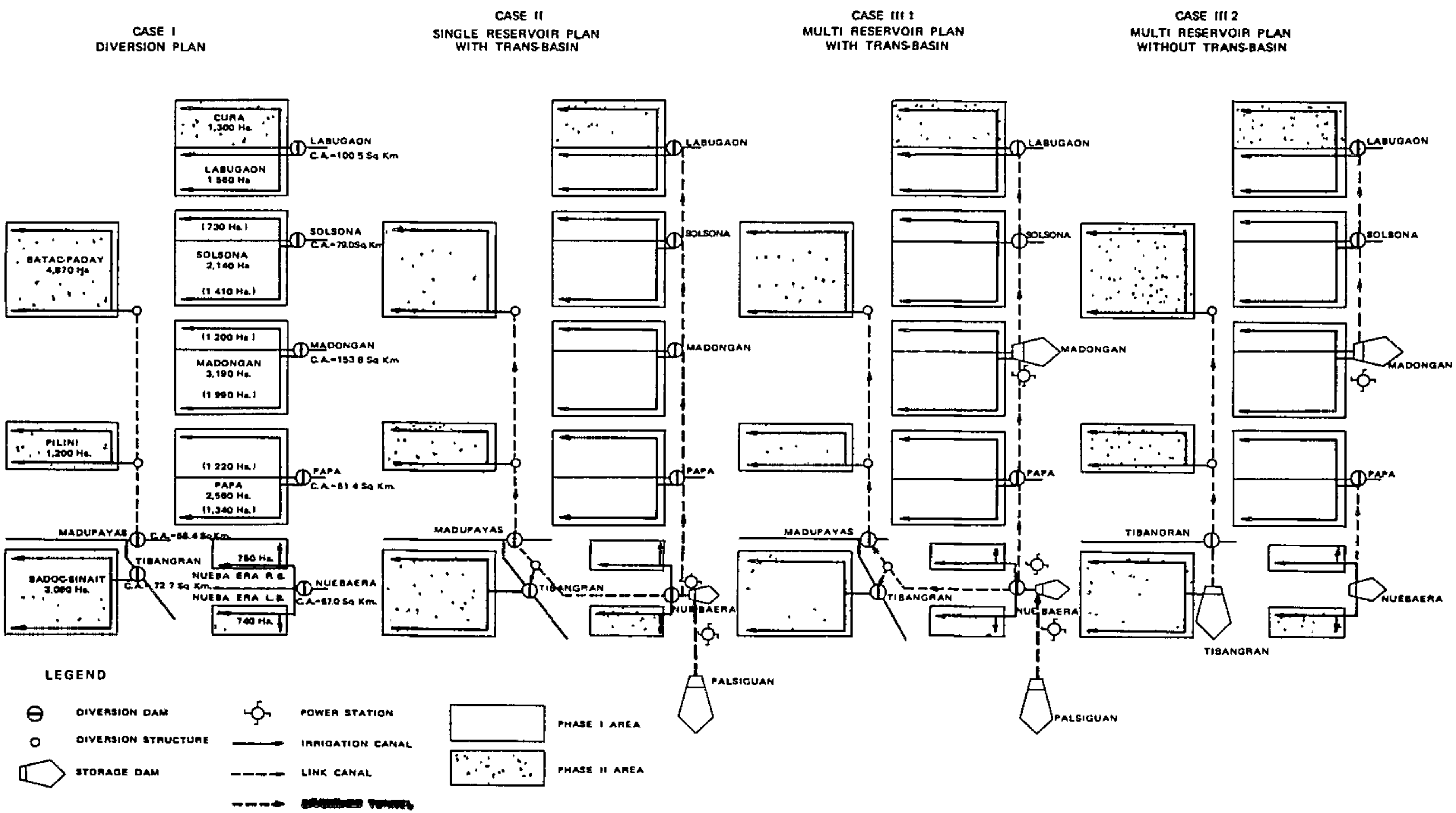
Case I - Diversion Plan

To utilize major natural river flows within the Ilocos Norte province by provision of seven diversion dams of Labugaon, Solsona, Madongan, Papa, Nueva Era, Madupayas and Tibangran.

Table A-2 Stream Flow at Each Basin

Year	Labugaon (C.A.=100.5 sq.km)	Solsona (79.0)	Madongan (153.8)	Papa (51.4)	Nueva Era (57.0)	Madupayas (68.4)	Tibangran (172.7)	Palsiguan (153.0)
1960	188.4	148.1	201.8	96.3	106.8	68.2	136.3	347.3
1961	284.9	224.0	300.9	145.7	161.6	103.3	206.1	403.7
1962	293.0	230.3	394.5	149.8	166.2	106.2	211.9	407.4
1963	237.7	186.8	323.7	121.6	134.8	86.2	171.9	325.3
1964	399.7	314.2	446.5	204.4	226.7	144.9	289.1	438.0
1965	259.3	203.8	285.7	132.6	147.1	94.0	187.6	286.3
1966	246.5	193.8	271.7	126.1	139.8	89.4	178.4	246.3
1967	346.5	272.3	440.0	177.2	196.6	125.6	250.6	383.9
1968	241.3	189.7	251.2	123.4	136.9	87.5	174.6	347.0
1969	179.0	140.7	241.0	91.5	101.5	64.9	129.5	376.7
1970	170.8	134.3	156.8	86.4	96.8	61.9	123.6	378.9
Mean	258.8	203.5	301.3	132.4	146.8	93.8	187.2	358.3

FIGURE A-1 ALTERNATIVE PLANS OF OVERALL DEVELOPMENT FOR ILOCOS NORTE IRRIGATION PROJECT



Available water for irrigation will fluctuate year by year depending upon river discharges and thus irrigable acreage will be limited; however, investment costs will become comparatively lower than those of other plans.

Case II - Single Reservoir Plan

To attain the entire development of the project by delivery of irrigation water through trans-basin i.e. by provision of Palsiguan dam & tunnel in combination with the said seven diversion dams.

Under the trans-basin program, the total difference in elevation between the water surface at a storage dam and the released water at a tunnel is available as necessary head for hydropower energy production

Case III - Multi-Reservoir Plan

III-1. With Trans-Basin

To obtain overall development of the project, provided by Madongan and Palsiguan dams to relieve the irrigation area from shortage in water with the usage of run-off river flow through diversion dams.

Considering an aspect of phasing development, a provision of Madongan Dam will lead the Project to more incremental benefits in Phase I area; in addition, as a by-product of irrigation, hydropower energy will be generated and the dam plays an important role to reduce flood damage to the Project Area.

III-2. Without Trans-Basin

To develop the major water resources available within the Project Area by provision of three dams of Madongan, Nueva Era, and Tibangran. This alternative presents utilization of proper water resources in the area, although potentiality of water resources seems low to meet the entire irrigation water demand.

C. Evaluation of Alternatives

As a first step to evaluate each alternative, estimation of irrigable area by relevant water resources has been made on the basis of water balance study for the period from 1960 to 1970 as listed in Table A-3. The associated benefits and costs including hydropower component have been placed on a comparable basis by appropriate conversions such as their unit cost per hectare and internal rate of return.

Table A-3 shows the comparison of alternatives in the eocnomic aspect.

In case of non-phasing development, IRR for Case II is highest of all alternatives, although the project cost per hectare amount of US$ 7,270.

From the aspect of phasing development, IRR for Case II Overall also attains 12.2 percent of the justifiable line and that for Phase I becomes 12.3 percent, and the project cost per hectare is very low at US$ 2,850.

Therefore, Case II is considered as an optimum for the overall plan.

Table A-3 Summary of Alternative Studies

Item	Non-Phasing Development				Phasing Development			
	Case I	Case II	Case III-1	Case III-2	Case II		Case III-1	
	Overall	Overall	Overall	Overall	Overall	Phase I	Overall	Phase I
1. Project Area (ha)	21,400	21,400	21,400	21,400	21,400	10,200	21,400	10,200
2. Irrigable Area (ha)								
1st Crop (Wet season)	13,150	21,400	21,400	18,600	21,400	8,080	21,400	8,980
2nd Crop (Dry season)	4,630	21,400	21,400	11,270	21,400	2,960	21,400	7,740
3. Power Capacity (MW)	–	42	51	11	42	–	51	–
4. Project Cost (million Pesos)								
Irrigation	475	1,151	1,233	1,080	1,151	215	1,233	452
Power	–	280	330	60	280	–	330	60
Total	475	1,431	1,563	1,140	1,431	215	1,563	512
(1,000 US$)	64,190	193,380	211,220	154,050	193,380	29,050	211,220	69,190
5. Irrigation Project Cost								
Cost per hectare (US$/ha)	3,000	7,270	7,790	6,820	7,270	2,850	7,790	5,990
Allocated Joint Cost (US$/ha)	–	6,580	6,780	6,470	6,580	–	6,780	5,260
6. Annual Full Benefits (million Pesos)								
Irrigation	47	173	176	135	172	32	172	66
Power	–	37	45	11	37	–	45	11
Total	47	210	221	146	209	32	217	77
7. IRR (%)	8.7	13.1	12.7	10.5	12.2	12.3	12.1	12.3
8. Construction Period (year)	7	7	7	7	8	4.5	8	5.5

APPENDIX B. Study on Safty Yield of Groundwater

APPENDIX B. Study on safety Yield of Groundwater

1. Objective

In determining the safety yield in groundwater exploitation, a hydrological circulation in the relevant groundwater basin is first modeled, and then various designed yields are inputted to the hydrological circulation model so prepared, to study the consequences of the groundwater exploitation, that is, effects on groundwater table, water balance and possible damage on existing water supply facilities.

The above-mentioned technical procedure is most reliable in determining the safety yield; however, it requires sufficient data on aquifers, yearly fluctuation of groundwater and relationship between the surface water and groundwater. Since such data are not available, the annual safety yield of groundwater in the Project Area has been roughly estimated from the presumptive groundwater recovery based on the groundwater variation observed in 1979 for studying the groundwater potentiality for supplemental water source for irrigation in dry seasons.

2. Groundwater Basin and Aquifers

The Project Area is surrounded by mountains geologically composed of various pre-Neogene layers which are deemed aquiclude, and situated in a composite alluvial fan formed by the Cura, Labugaon, Solsona, Madongan and Bonga rivers. This composite alluvial fan is regarded to form a groundwater basin. The groundwater basin is geologically composed of the Quaternary alluvial fan, river and littoral deposits mainly consisting of sand and gravel layers. The deposits are more than 150 meters deep in Solsona and its neighborhood. Detail of aquifers here is not clear.

In this groundwater study, the alluvial fan of about 225 sq.km extending in the east of the Bonga river (See Figure B-1) is considered to be the groundwater basin. About 70 percent of the groundwater basin is occupied by cultivated land, mainly paddy fields, and the remaining 30 percent is covered by wasteland along rivers (riverwashed area). River channels in the groundwater basin are quite unstable. It sometimes occurs that the major portion of the groundwater basin is submerged during a high flood period. On the contrary, it has been found out that the river waters underflow low water period.

3. Data Available

a) Groundwater Tables

The groundwater table was observed, on daily basis for one year of 1979, at 42 existing wells as shown in Table B-1 and Figure B-1. The observation data are graphically shown in Figures B-2 Although the observation was not completely made throughout the year and a few observation mistakes are included in the data, the observation points were favorably selected and the observation itself was as a whole accurately made.

b) Precipitation

Rainfalls have been observed at several meteorological stations in the groundwater basin and its surrounding areas. Out of the observation data, those observed at Laoag station have been used in this groundwater study taking into consideration the necessary accuracy and observation duration of data.

c) Evapotranspiration

Based on meteorological data observed at Vigan and Laoag, the mean monthly evapotranspiration from 1951 to 1977, which is also adopted in the Phase I report, is used in the groundwater study.

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep	Oct.	Nov.	Dec.
E.T. (mm/day)	6.4	6.0	6.6	6.7	6.5	6.5	5.4	5.9	5.7	6.9	6.1	6.7

d) River Discharge

The Solsona river discharge has been observed, although there is absence of the data found for 1979 when the groundwater observation was conducted in the Project Area. In general, discharge data of a single river are not sufficient for groundwater analysis. Under the situations, the discharge data have not been used in the groundwater study.

e) Percolation from Paddy Fields

The mean daily percolation from paddy fields has been determined at 2.00 mm/day on an average based on the relevant observation data in the Project Area.

f) Hydraulic Coefficients of Aquifers

The pumping-out test performed at three deep wells in Solsona has revealed that the transmissibility coefficient is as small as 50 to 80 sq.m/day. (See Table B-2)

The transmissibility in deeper layers presumably smaller than the above-mentioned. Neither transmissibility nor specific yield in the other areas than Solsona are avaiable.

g) Geological Column

The geologic columns of the above-mentioned three points have been prepared as shown in Figure B-3. The columns indicate that gravel layers are distributed to the depth of 150 meters or more around Solsona. No stratigraphy in the other areas nor classification of aquifers is clear.

4. Circulation, Variation and Recovery of Groundwater

Figure B-1, Table B-3 and Figures B-2 indicate the equipotential lines of groundwater in both low and high water seasons, the main factors involved in groundwater fluctuation and the hydrograph of groundwater in the Project Area, respectively. In Table B-3 similar-shaped graphs are grouped.

As seen in Figure B-1, groundwater in the Project Area flows, having a similar slope to the topographic slope, toward the Bonga river in each alluvial fan. The groundwater has a slope of about 1/80 in the upper portion of groundwater basins and a gentle slope of 1/300 in the lower portion. The lower portion might have a larger water conveyance capacity than the upper portion, or the groundwater volume circulating in the lower portion is smaller than that in the upper portion since some spring out along the boundary of alluvial fans and mountains. One of the above-mentioned or both might have caused the difference in groundwater slope.

April falls in low water seasons. During this month the groundwater table stands at two to three meters below ground surface in the middle and lower portions of alluvial fans, whereas about 10 meters below ground surface in the upper portion. In general, groundwater table is high in the lower portion and low in the upper portion. As soon as the wet season starts in May, groundwater sharply rises, and goes up nearly to the paddy field surface in both upper and lower portions of alluvial fans from June to September or to October except in the upper most.

During wet seasons groundwater table ranges in 0.2 to 0.3 m below ground surface where groundwater table is nearly to the paddy field surface. The fluctuation of groundwater in the upper portion is not much different from that in the lower portion. The fluctuation of groundwater where groundwater level is lower than the paddy field surface is slightly large in ranging from 0.5 to 2.5 m. The annual fluctuation of groundwater in the middle and lower portions of alluvial fans is one to three meters, whereas that in the upper portion arrives at 6 to 12 meters. 80 to 90 percent of the upward fluctuation of groundwater in most existing wells takes place in the early wet seasons.

The sharp rise of groundwater table in the early wet seasons and a high groundwater table nearly equal to the paddy field surface during the wet season suggest that percolation from paddy fields is the major water source recharging groundwater in the Project Area. Furthermore, the river water underflows in each alluvial fan during dry seasons, therefore, the river water also functions to recharge groundwater in the Project Area.

When careful attentions are paid to the groundwater rising period in early wet season, it is noted that such period falls in the middle of March in most parts of the Project Area when it begins to rain. However, the groundwater in the upper alluvial fans formed by the Papa, Solsona and Labugaon rivers starts rising at the end of April The groundwater in the upper portion of alluvial fan formed by the Nueva Era river begins to rise in the beginning of June. In the Papa and Nueva Era river basins, the groundwater table in the beginning of a year is widely different from that at the end of the year, which suggests that the annual water balance is not equilibrated. The above-mentioned regional difference presumably takes place due to the regional time-lag in the beginning of wet season and due to the difference in paddy cultivation methods.

5. Computation of Groundwater Recovery in Series Storage Models

a) Computation Method

In general, the hydrograph of groundwater (time-serial observation values of groundwater head) indicates a depletion curve of the expotential function type. If the unconfined hydrograph of groundwater clearly corresponds to the rainfall pattern, rainfall data are inputted to the series storage models which are usually applied to the run-off analysis of river flow, and recharging/outflowing structure of groundwater is assumed in considering the groundwater tables as verified values, premising the following;

i) The lower tank is regarded as the aquifer;

ii) The aquifer tank has a size corresponding to the specific yield (effective porocity) of the aquifers;

iii) The upper tank of the aquifer tank corresponds to the structure of surface run-off discharge;

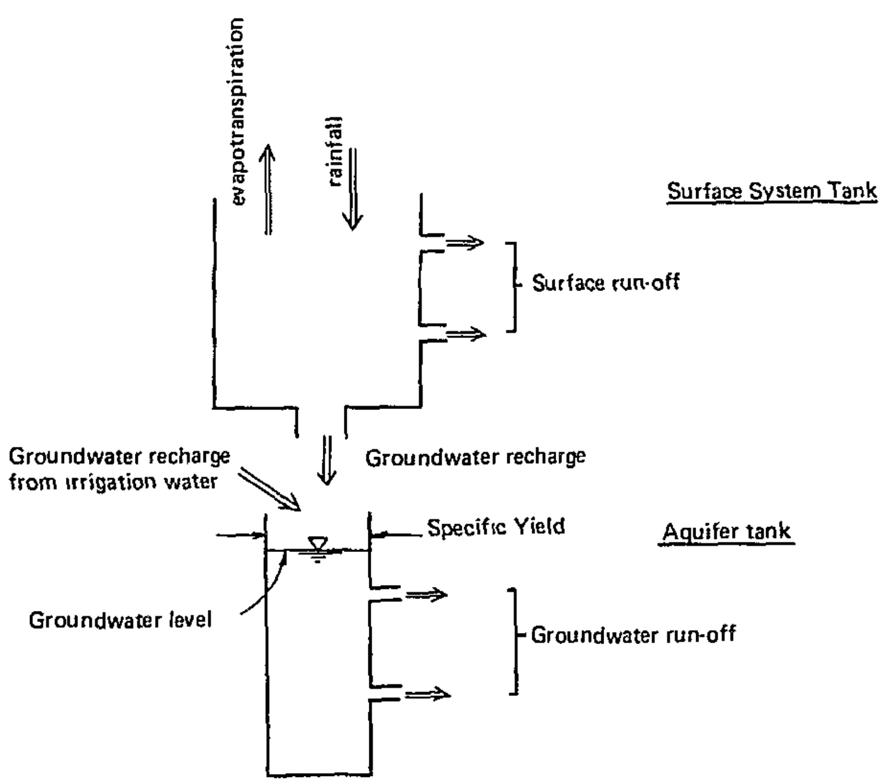
vi) The verification of simulation results is made based on the simulated groundwater level in the aquifer tank;

v) The evapotransmiration loss is deducted from the water level in the upper tank; and,

vi) The vertical percolation of irrigation water from paddy fields is added to the second tank through the outlet at the bottom, if any,

The serial storage tank model is schematically shown as follows;

SCHEMATIC TANK MODEL



The size of percolation holes (outlet at the bottom) from the ground surface system tank to the aquifer tank and the size of aquifer tank are not independent each other; one of the two should have been fixed. However, specific yield of most unconfined aquifers narrowly ranges from a few percent to some ten percent at the utmost. In general, surface run-off analysis show that the size of percolation holes does not exceed 0.3. The simulation is made in consideration of the above-mentioned. In general, two tanks are sufficient in dealing with shallow groundwater.

Even in case of unconfined groundwater, the behavior of groundwater not only in the limited are around an observation well but also in a relatively wide area can be considered to reflect upon the hydrograph of the observation well. If the specific yield of the observation well is appropriate, the groundwater recovery covering the surrounding areas of the well can be roughly estimated from the groundwater recovery computed through the tank model simulation. Furthermore, the variation of groundwater table and groundwater recovery can be roughly predicted by inputting the percolation data of rainy water and irrigation water to the tank model.

b) Groundwater Recovery

By applying the groundwater hydrographs at 12 points the simulation has been made to reappear groundwater in tank models to compute the major factors involved in the water balance The computation results are shown in Figures B-4 and on Table B-4. The main features of each tank model are shown in Figure B-5. If the groundwater table does not appear only with rainfalls, a certain quantity of groundwater recovery was added on the premise that groundwater is recharged by irrigation water. Such groundwater recovery volume is 1.2 to 30 mm/day from May to June when groundwater rises and 0.8 to 3.5 mm/day from June to December. The large volume of groundwater recovery by irrigation has been adopted for the former taking into account that there is a big time-lag between the groundwater rising period and the beginning of wet seasons as seen in the rainfall pattern at Laoag. The latter is regarded as groundwater recovery caused by irrigation water only; however, it is assumed that the presumptive specific yield is a little larger than the actual since the above-mentioned recovery is large in comparison with the average percolation of 20 mm/day from paddy fields, although fluctuating from one to seven millimeter per day.

The evapotranspiration shown in Table B-4 is smaller than that in moderate. The reason is that the water balance near the ground surface cannot be well expressed in the tank models in spite that groundwater table goes up to the paddy field surface. However, since the groundwater recovery is mainly determined by the groundwater hydrograph and specific yield, the above-mentioned fact does not affect much the computation of groundwater recovery.

By determining the commanded area of each hydrograph, based on the Thiessen method as shown in Figure B-1, water quantities involved in the water balance in the whole groundwater basin are computed as shown in Table B-5. The annual groundwater recovery in the whole groundwater basin is about 145 million cubic meters, out of which about 90 percent is concentratedly recharged from May to October. About 50 percent of the annual groundwater recovery is made by rainy water, and the rest by the other sources. However, the water sources other than rainy water are not clear since the horizontal groundwater recharge cannot be expressed in the tank model method and the groundwater recharging by rain water from ground surface is made through paddy fields in submergency as intermedia of submerged paddy field.

The presumptive specific yield is 0.066 on an average in the whole groundwater basin. The groundwater recovery would presumably decrease to a half of the above-mentioned if the specific yield is a half of the presumptive one.

6. Safety Yield of Groundwater

The safety yield (or permissive yield) is defined as groundwater quantity that can be utilized semi-permanently, and it should meet the following two requirements;

i) A groundwater quantity should be lifted semi-permanently in the both aspects of the water balance and technology;

ii) The influence of variation in the relevant groundwater basin upon the others should be in allowable extent.

a) Safety Yield

In general, the groundwater is not exhausted if its quantity to be lifted is smaller than its recovery. If more groundwater lift than its recovery causes groundwater table lowered to result in technical and economic difficulty to continue the groundwater lifting. Therefore, the appropriate quantity of groundwater to be lifted is limited to 20 to 30 percent of the groundwater recovery.

The safety yield of groundwater in the Project Area is 29 to 43.5 million cubic meter per year. Irrigation area during November to December when supplemental irrigation by groundwater is required will increase by 2,370[1/] ha in the Project. Therefore, the groundwater recovery of 5.7 million cubic meters is additionally expected on the assumption that the percolation from paddy fields amounts at 2 mm/day. (2 mm/day

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1/ Proposed dry season cropping area 9,200 ha - (present dry season cropping area 3,411 + one half of present wet season cropping area 3,421) = 2,370 ha x 2,370 ha x 120 day). The safety yield of groundwater in the Project Area is determined at 35 to 49 million cubic meters per year, accordingly.

b) Effects on the Groundwater Basin caused by Pumping-up of Groundwater

The groundwater basin has a big recharging capacity in wet seasons to groundwater sharply rises to the paddy field surface and keeps such condition in the vast Project Area; however, the recovery is hardly made in dry season.

Under the situations, if groundwater is lifted from November to February, the groundwater table lowers to the extend that the groundwater quantity has been lifted.

If the above-mentioned groundwater quantity is lifted, the groundwater table will lower by two to three meters on an average in the whole basin premising that the specific yield is 0.066 As seen on Table B-1, the bottom of existing shallow wells is only by one to two meter deeper than the minimum groundwater table at present. Under the circumstances, if the groundwater rable lowers by this extent, the groundwater through the wells is no more available. Therefore, some countermeasures such as further deepening of existing wells will be required. Since the water of existing shallow wells now operated is seepage water from paddy fields, some measures will be also required in this case for quantity control of water.

7. Conclusion

1) Safety yield of groundwater in the whole Project Area ranges from 35 to 49 million cubic meter per year.

2) If this quantity of groundwater is lifted in dry seasons, it causes to lower the groundwater table by two to three meters on an average, and lifting from existing shallow wells will become impossible for some times in dry seasons, some measures will be required against this problem;

3) In general, deeper wells are recommendable to cope with the variation of groundwater table; however, the pumping-out test conducted at Solsona area suggests that the transmissibility in lower layers is small, and not favorable for groundwater exploitation. If groundwater is lifted from shallow layers through shallow wells, etc., whose transmissibility is large, groundwater table will lower, and make it difficult to lift groundwater. Furthermore, groundwater is required not in the wet season when the groundwater table is high but in the dry seasons when groundwater table is low. Large-scaled water supply facilities are weeded, which makes the groundwater exploitation economically unfeasible

4) Taking into account the above-mentioned, large scaled and systematic groundwater exploitation for supplemental irrigation in the dry season is not recommendable. The other water sources should be considered.

Table B-1 Summary of Observation Wells

Well No.	Location	Elevation at Ground Surface (G.S.) (m.a.s.l)	Measuring Point (M.P.) - G.S. (m.a.g.s)	Well Depth (m.b.g.s)	Groundwater Level in 1979 Max. (m.b.m.p)	Groundwater Level in 1979 Min. (m.b.m.p)	Groundwater Level in 1979 Max. - Min. (m)	Observation Period
PG-1	Lanas Sur	50	0.55	4.68	3 72	0 60	3.12	Jan.13-Dec.31'79
2	San Marcelino, Dingras	98	0.70	10.83	10.72	4.95	5.77	-do-
3	Baggay, Dingras	31	0.50	-	2.98	0.13	2.85	Jan.12-Dec.31
4	Fox, Dingras	22	1.05	4.32	3.69	1.57	7 12	Jan. 9-Dec.31
5	Mandaluque, Dingras	18	0.85	4.08	3.70	0 10	3.60	Jan 15-Dec 31
6	San Esteban, Dingras	23	0.90	2.43	2.44	0.59	1.85	-do-
7	Bagut, Dingras	20	0.60	4.07	2.82	0.80	2.02	-do-
8	Maglayaan, Dingras	41	0.93	5.24	4.67	0.82	3.85	Jan.12-Dec.31
9	Barong, Dingras	41	0.86	2.82	2.39	0.38	2.01	Jan.13-Jan.31, Feb.17-Dec.31
10	Bagbago Sur, Solsona	40	0.85	3.06	2.54	1.20	1 34	Jan.12-Dec 31
11	Bagbago Norte, Solsona	33	0.77	-	2.21	0.94	1.27	-do-
12	Dareadas, Solsona	45	0.52	1.73	1.18	0 31	0.87	-do-
13	Santiago, Solsona	32	1.04	2.54	1.70	0 20	1.50	Jan.10-Dec.31
14	Baltao, Solsona	42	0.70	2.78	1.89	1.10	0.79	Jan.10-May 21, Jun.20-Dec.31
15	Talugtog, Solsona	65	0.95	2.92	3.36	1.57	1 79	Jan.12-Dec 31
16	Mananteng, Solsona	97	0.92	6.74	6.43	0.53	5 90	-do-
17	Pakias, Solsona	65	0.70	-	6.16	0.29	5.87	Jan.11-Dec.31
18	Nagpatpaton, Solsona	50	0.78	3.79	2.58	0.28	2.30	-do-
19	Sta. Ana, Solsona	58	0.94	-	4.70	0.19	4 51	Jan 11-Apr 14, May 1-Dec 31
20	Catanglaran, Solsona	76	0.78	8.26	7 81	0.45	7.36	Jan.11-Jul 31, Sep 1-Dec 31
21	Bagbag, Solsona	25	0.60	2 82	2.62	1.07	1.55	Jan 15-May 31, Jul.12-Dec 31
22	Callusa, Piddig	25	0.76	5.82	3.40	2.07	1.33	Jan.15-Dec.31
23	Boyboy, Piddig	28	0.75	7.23	6.11	3 29	2.82	Jan.15-Mar 6, Mar 12-Dec 31
24	Tonoton, Piddig	20	0.68	4.64	4.40	0 34	4 06	Jan.15-Mar.31, May 1-Dec.31
25	Pob., Nueva Era	121	0.66	13.42	13.25	3 96	9.29	Jan.13-Dec 31
26	Acnam, Nueva Era	96	0.63	10.20	9 64	2 97	6.67	-do-
27	Barikir, Nueva Era	101	0.82	14.79	8 63	0 78	7 85	Jan 12-May 31, Jun 16-Dec 31
28	Catagtaguen, Espiritu	65	0.77	12.48	13.99	0.58	13.41	Jan 13-May 4, May 11-May [illegible], Jun.18-Dec.31
29	Cadaanan, Banna	83	0 66	-	10.77	0 27	10.50	Jan 11-May 10, Jun.11-Dec.31
30	Castebanan, Espiritu	88	0.82	-	5 21	1.36	3.85	Jan 11-May 11, Jun.10-Dec.31
31	Sta. Maria, Espiritu	100	0.80	-	5.10	0 47	4 63	Jan.11-May 4, Jun.18-Dec 31
32	San Jose, Espiritu	74	0.95	-	5.64	0 11	5.53	Jan.12-Jan.31, Feb.16-May 15, Jun 14-Dec.31
33	San Magro, Marcos	92	0.78	-	5.50	0.02	5.48	Jan.11-May 10, Jun.10-Dec.31
34	Crispina, Espiritu	55	0.84	-	2.96	1.37	1.59	Jan 12-Dec.31
35	Coribquib, Espiritu	48	0.43	-	7.59	0.01	7.58	Jan.11-Apr 30, Jun 11-Dec.31
36	Nagpatayan, Espiritu	78	0.92	-	6.78	1.21	5.57	Jan.11-Dec.31
37	Macayepyep, Espiritu	98	0.71	-	17.65	0.47	17.16	Jan.13-Apr 30, Jun. 9-Dec.31
38	Ragas, Espiritu	57	0.83	-	2.37	0.20	2.17	Jan.11-May 15, Jun.10-Dec.31
39	Daguioag, Marcos	57	0.67	-	4.80	2.72	2.08	Jan.11-Dec.31
40	Balbalay Culao, Marcos	48	0.92	-	3 37	1.02	2.35	Feb.15-Apr.30, May 19-Dec.31
41	Capitan, Marcos	47	0.63	-	1.65	0.06	1.59	Jan.13-Mar.31, Jun.16-Dec.31
42	Darasdas, Marcos	38	0.66	-	4.06	2.26	1 80	Jan.13-May 31, Jul. 1-Sep.30, Nov. 1-Dec.31

Note: m.a.s.l: meter above sea level, m.a.g.s: meter above ground surface, m.b.g.s: meter below ground surface, m.b.m.p: meter below the measuring point.

Table B-2 Summary of Pumping Tests in Solsona

Well No.	Location	Depth (m)	Diameter	Strainer (m)	Discharge (cu.m/day)	Drawdown (m)	Specific Capacity (cu.m/day/m)	Transmissivity 1/ (sq.m/day)
INS-1	Juan, Solsona	125.5	10", 8"	24-43, 64-68 96-114	–	–	–	–
INS-2	Juan, Solsona	120.0	8"	24-43, 96-114	849 (Aug. 10, '79)	33	26	80
INS-3	Talugtog, Solsona	110.5	6"	22-38, 57-62 79-85	512 (Aug. 9, '79)	21	17	70

1/ Calculated by the recovery method.

Table B-3 Summary of Fluctuation of Groundwater Table

Well No.	Location	Ground Level (m)	Location in a Fan	Annual Fluctuation (m)	Min. Monthly Average Depth (m.b.g.s)	Max. Monthly Average Depth (m.b.g.s)	Fluctuation in Higher Level (m)	Increase of Water Level in Early Wet Season (m)	Assumed Specific Yield
PG-25	Nueva Era	121	U	9.29	4.29 (AUG)	12.33 (APR)	1.0 - 2.5	5.5	0.04
27	-do-	101	U	7.85	0.24 (AUG)	7.64 (MAY)	1.0 - 2.5	6.7	0.04
28	Espiritu	65	M	13.41	0.46 (AUG)	12.31 (MAY)	1.0 - 1.3	12.3	0.05
29	Banna	83	M	10.50	0.36 (AUG)	9.86 (MAY)	1.0 - 1.3	8.5	0.05
34	Espiritu	55	L	1.59	1.40 (AUG)	2.02 (APR)	1.2	0.5	0.05
31	-do-	100	U	4.63	-0.06 (JUL)	3.96 (APR)	0.1 - 0.3	4.2	0.08
33	Marcos	92	U	5.48	-0.65 (SEP)	4.12 (MAR)	0.1 - 0.3	4.8	0.08
38	Espiritu	57	M	2.17	-0.49 (SEP)	1.49 (APR)	0.2	1.5	0.08
40	Marcos	48	M	2.35	0.30 (JUL)	2.29 (APR)	0.2	2.0	0.08
41	-do-	47	L	1.59	-0.49 (SEP)	0.92 (MAY)	0.2	-	0.08
1	-do-	50	M	3.12	0.69 (AUG)	2.95 (MAY)	0.5 - 0.75	2.3	0.06
42	-do-	38	M	1.80	1.97 (JUL)	2.96 (MAY)	0.5 - 0.75	1.2	0.06
3	Dingras	31	L	2.85	-0.09 (AUG)	2.10 (APR)	0.2	2.3	0.08
8	-do-	41	L	3.85	0.05 (JUL)	3.33 (APR)	0.2	3.5	0.08
9	-do-	41	M	2.01	-0.39 (JUL)	1.37 (APR)	0.2	1.8	0.08
2	-do-	98	U	5.77	5.33 (JUL)	9.44 (MAR)	1.75	3.3	0.04
16	Solsona	97	U	5.90	-0.08 (JUN)	5.19 (APR)	0.2 - 0.3	5.4	0.08
17	-do-	65	U	5.87	-0.23 (JUN)	5.23 (APR)	0.2 - 0.3	5.5	0.08
20	-do-	76	U	7.36	-0.06 (JUL)	6.76 (APR)	0.2 - 0.3	6.8	0.08
10	-do-	40	M	1.34	0.44 (NOV)	1.92 (APR)	0.2 - 0.3	1.1	0.08
15	-do-	65	M	1.79	0.80 (JUN)	1.82 (APR)	0.2 - 0.3	1.6	0.08
12	Solsona	45	M	0.87	0.06 (JUL)	0.45 (APR)	0.2	0.4	0.08
14	-do-	42	M	0.79	0.73 (JUL)	1.13 (APR)	0.2	0.4	0.08
11	-do-	33	M	1.27	0.28 (OCT)	1.38 (AUG)	0.3	0.7	0.08
13	-do-	32	M	1.50	-0.60 (AUG)	0.60 (APR)	0.3	1.2	0.08
21	-do-	25	M	1.55	0.97 (AUG)	1.96 (APR)	0.3	1.0	0.08
22	Piddig	25	L	1.33	1.62 (AUG)	1.54 (APR)	0.3	0.9	0.08
4	Dingras	22	L	2.12	1.21 (AUG)	2.60 (APR)	1.0 - 1.5	2.0	0.05
5	-do-	18	L	3.60	0.29 (AUG)	2.13 (MAY)	1.0 - 1.5	1.8	0.05
6	-do-	23	L	1.85	0.26 (JUL)	1.51 (APR)	0.5 - 0.6	1.1	0.06
7	-do-	20	L	2.02	0.78 (AUG)	2.03 (MAR)	0.5 - 0.6	0.8	0.06

U: UPPER, M: MIDDLE, L: LOWER, m.b.g.s: meter below ground surface.

Table B-4 Water Balance Calculated From 12 Well Hydrographs In 1979

Well No.	Specific Yield	Area (km^2)	Rainfall (mm)	Evapo-transpiration (mm)	Surface Run-off (mm)	Groundwater Recharge From Rainfall (mm)	Groundwater Recharge Another Origins (mm)	Groundwater Recharge Total (mm)	Groundwater Run-off (mm)	Balance (mm)
27	0.04	9.72	1818.8	582.3	1032.5	204.1	403.0	607.1	491.6	+ 115.5
29	0.05	17.50	-do-	593.7	700.7	524.4	863.0	1387.4	1232.5	+ 154.9
34	0.05	14.64	-do-	581.4	826.8	410.6	-	410.6	476.1	- 65.5
33	0.08	15.52	-do-	450.1	1230.0	138.7	956.0	1094.7	908.0	+ 186.7
40	0.08	18.18	-do-	600.4	842.3	376.1	-	376.1	357.7	+ 18.4
2	0.04	18.46	-do-	593.7	700.7	524.4	-	524.4	468.0	+ 56.4
1	0.06	21.03	-do-	571.9	896.8	350.1	396.8	746.9	767.9	- 21.0
10	0.08	28.46	-do-	580.5	1029.3	209.1	285.6	494.7	505.4	- 10.7
4	0.05	15.73	-do-	588.9	761.6	468.3	-	468.3	496.1	- 27.8
16	0.08	21.52	-do-	528.2	1041.0	249.6	1105.0	1354.6	1199.2	+ 155.4
12	0.08	30.76	-do-	543.5	1140.3	135.0	-	135.0	180.0	- 45.0
6	0.06	13.71	-do-	619.3	846.3	353.2	-	353.2	375.7	- 22.5

Table B-5 Approximate Water Balance In The Groundwater Basin In 1979

Average Specific Yield	Area (km^2)	Rainfall (MCM)	Evapo-transpiration (MCM)	Surface Run-off (MCM)	Groundwater Recharge From Rainfall (MCM)	Groundwater Recharge Another Origins (MCM)	Groundwater Recharge Total (MCM)	Groundwater Run-off (MCM)	Balance (MCM)
0.066	225.2	409.6	127.8	211.0	70.9	74.1	145.0	137.4	+ 7.6

FIGURE B-1 EQUIPOTENTIAL MAP AND THIESSEN POLYGONS FOR CALCULATION OF WATER BALANCE

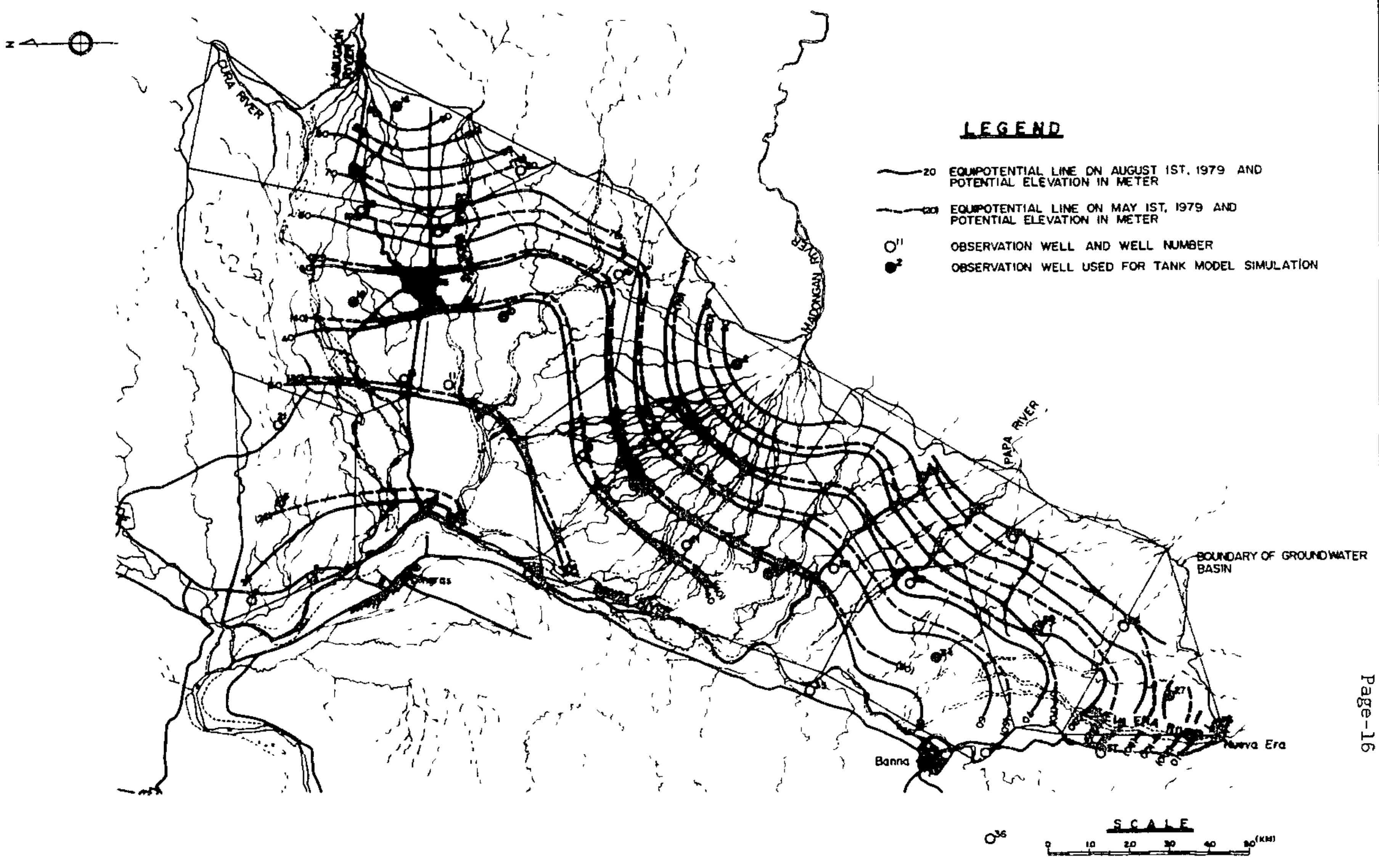


FIGURE B-2. OBSERVED GROUNDWATER TABLE (1)

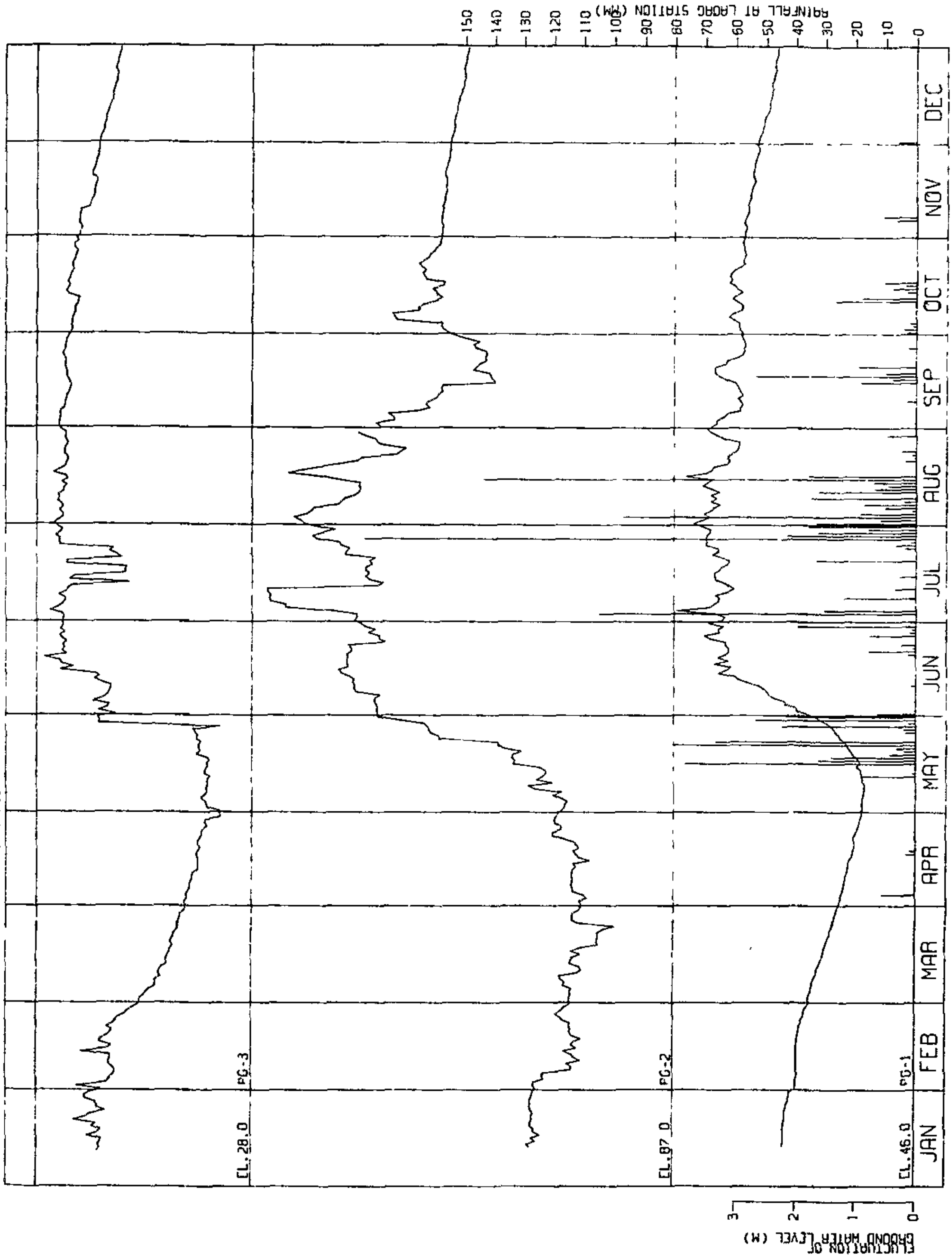


FIGURE B-2. OBSERVED GROUNDWATER TABLE (2)

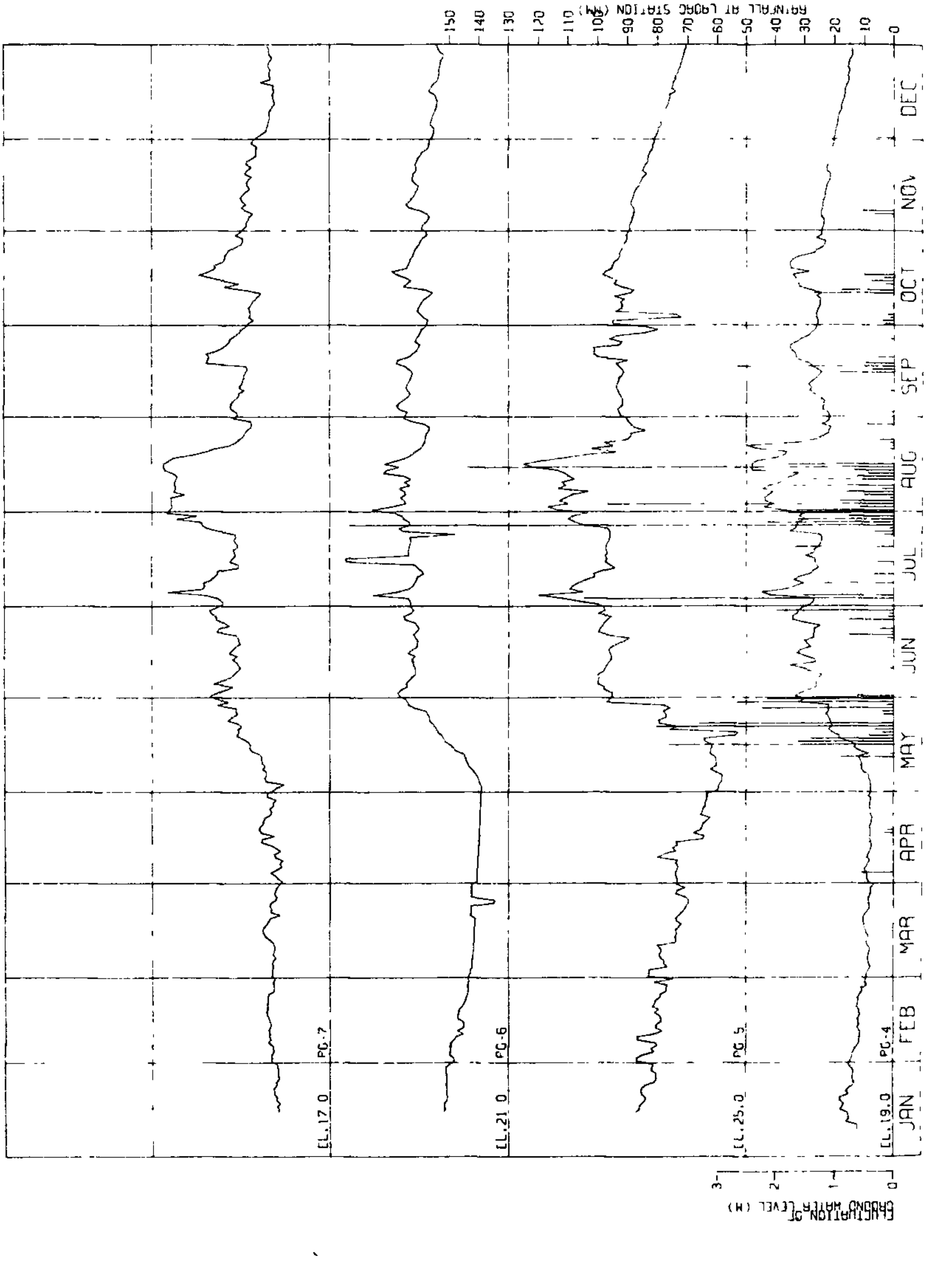


FIGURE B-2. OBSERVED GROUNDWATER TABLE (3)

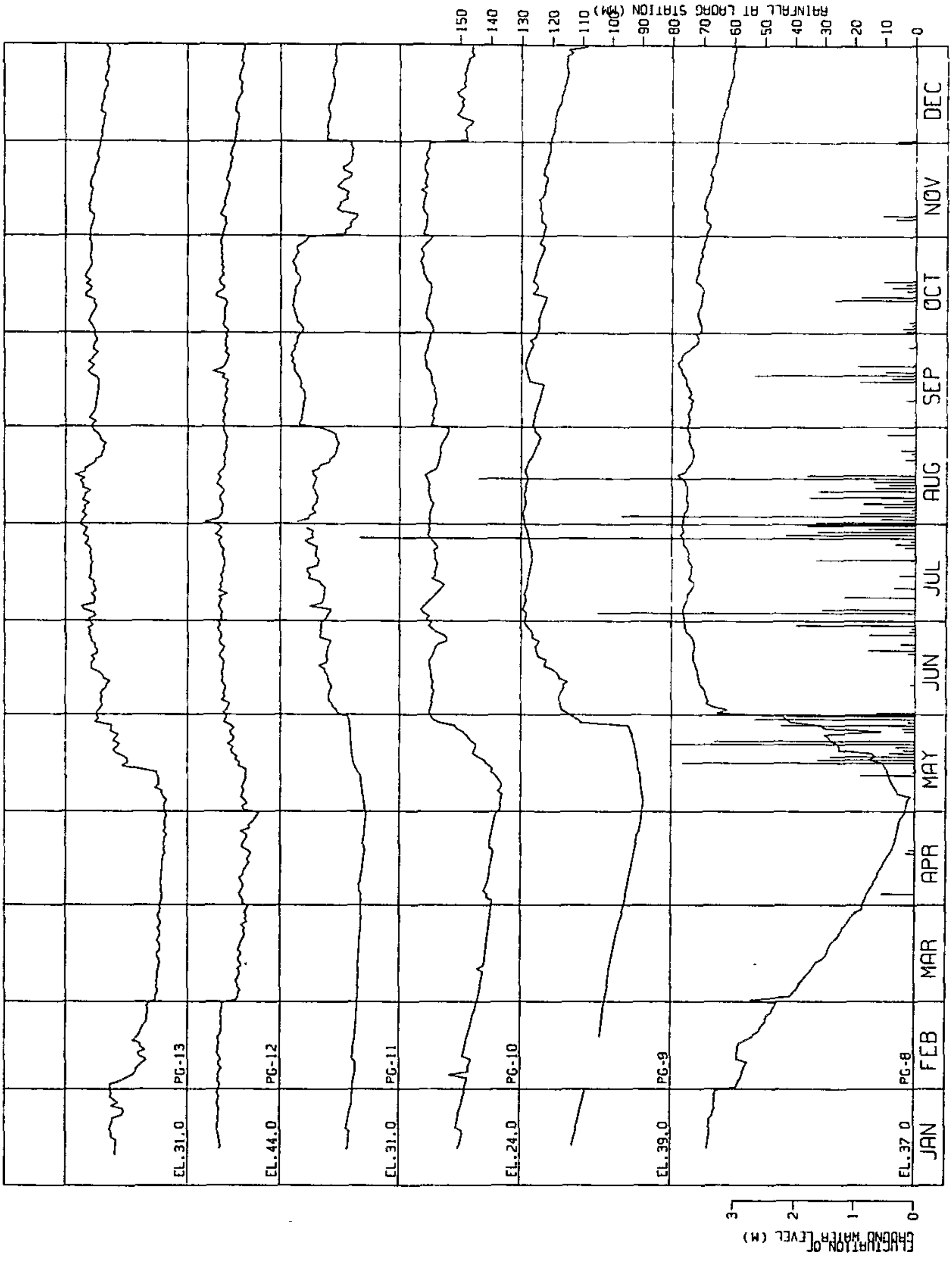


FIGURE B-2. OBSERVED GROUNDWATER TABLE (4)

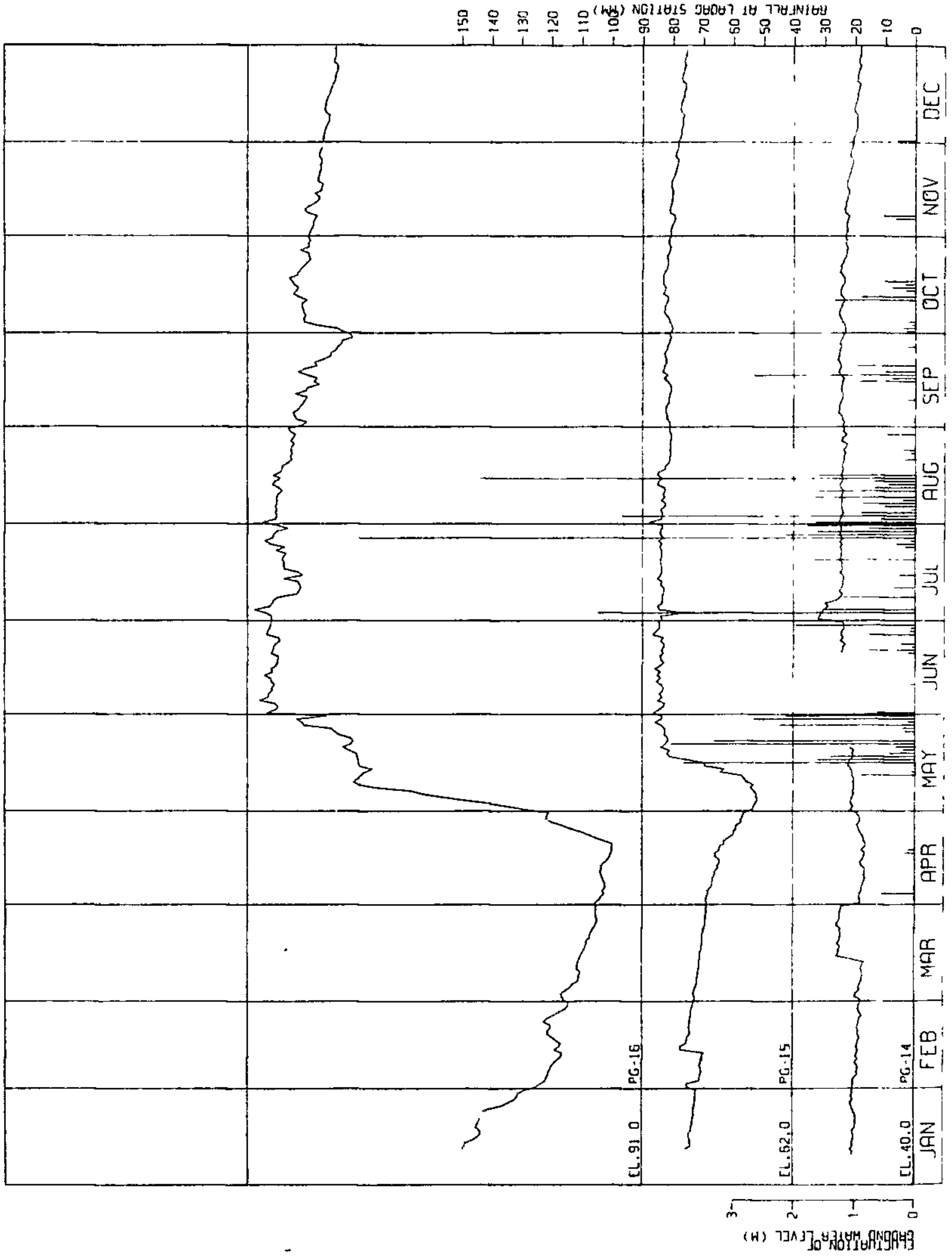
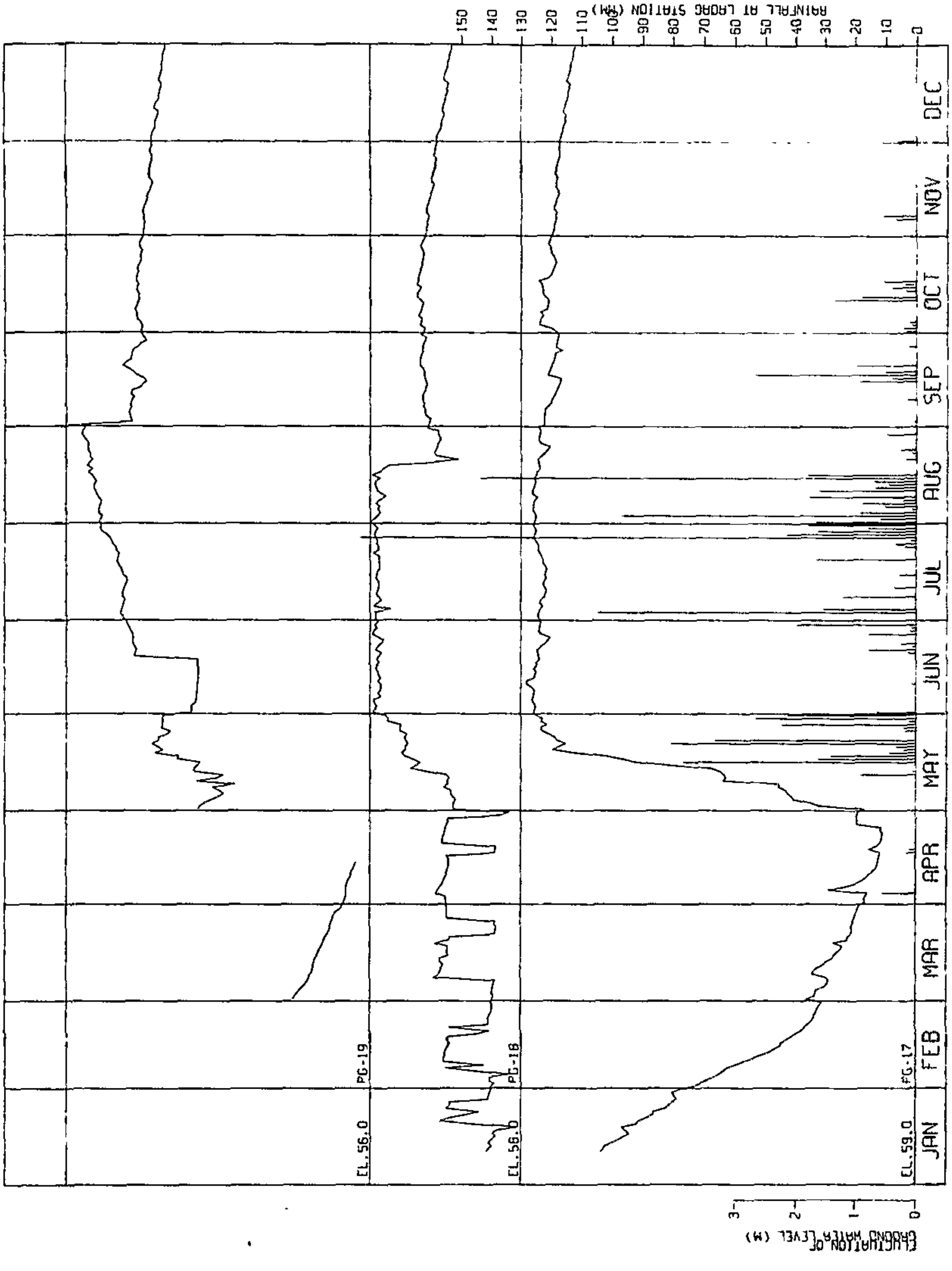


FIGURE B-2. OBSERVED GROUNDWATER TABLE (5)



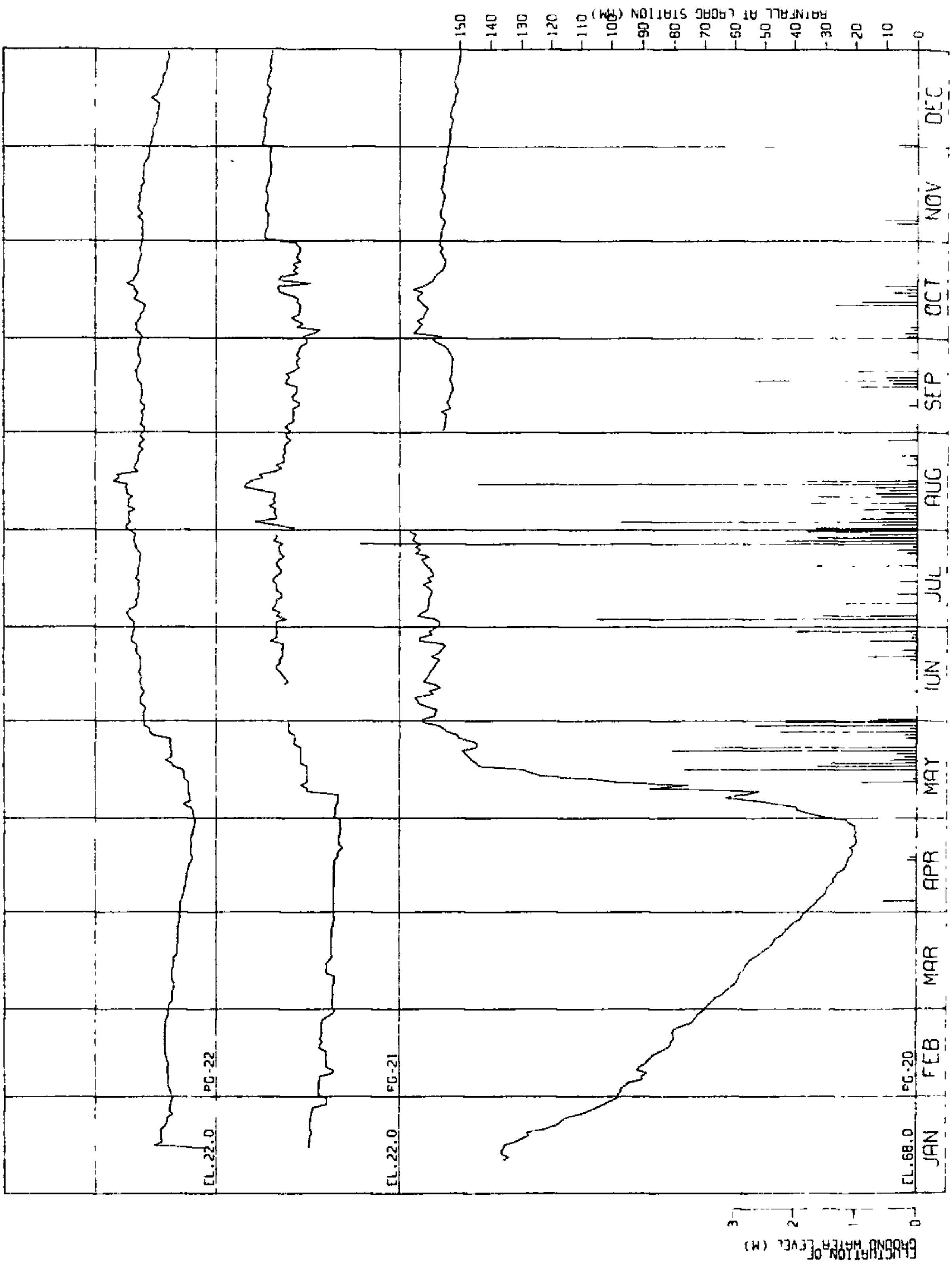


FIGURE B-2. OBSERVED GROUNDWATER TABLE (6)

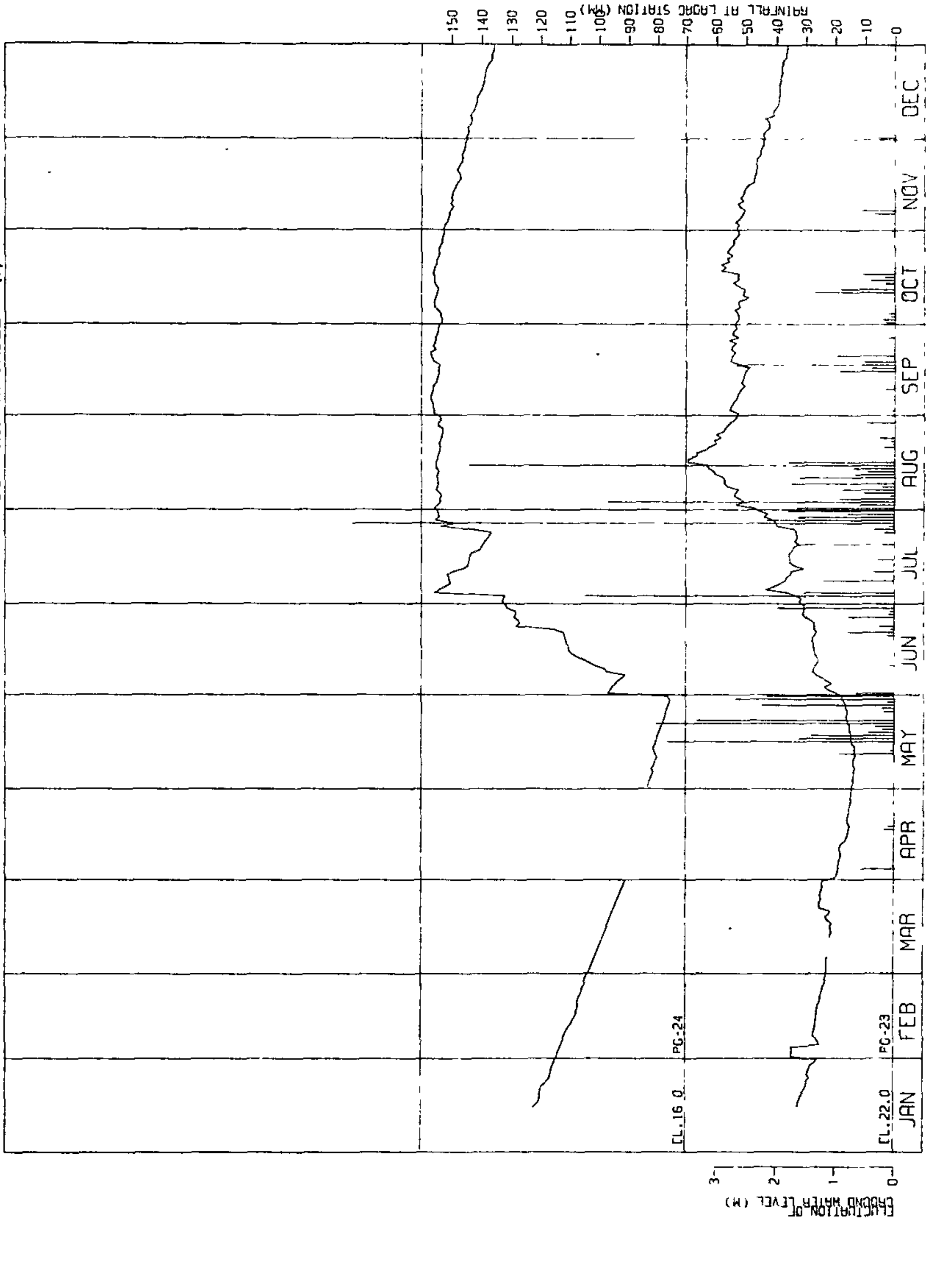


FIGURE B-2. OBSERVED GROUNDWATER TABLE (7)

FIGURE B-2. OBSERVED GROUNDWATER TABLE (8)

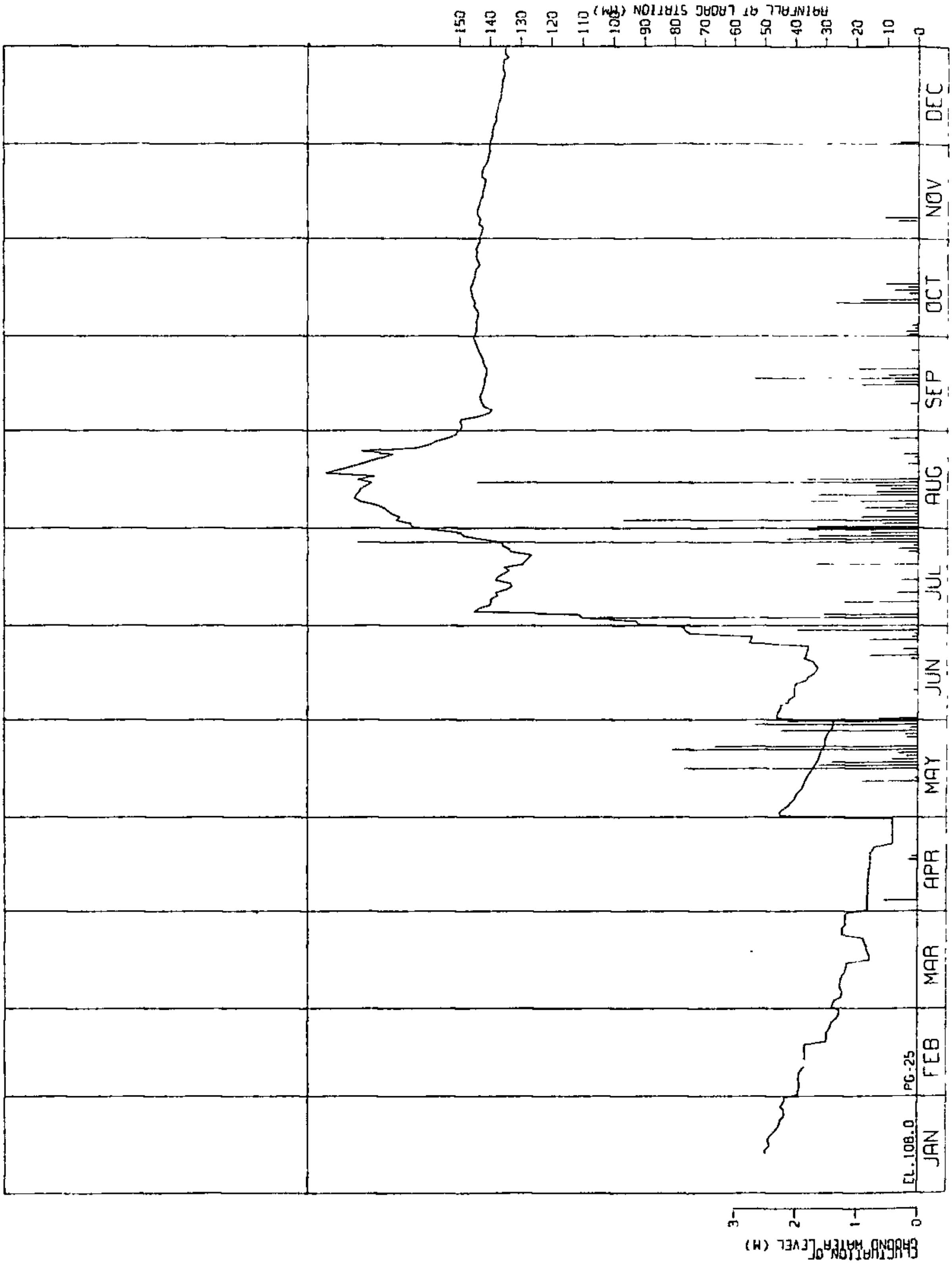


FIGURE B-2. OBSERVED GROUNDWATER TABLE (9)

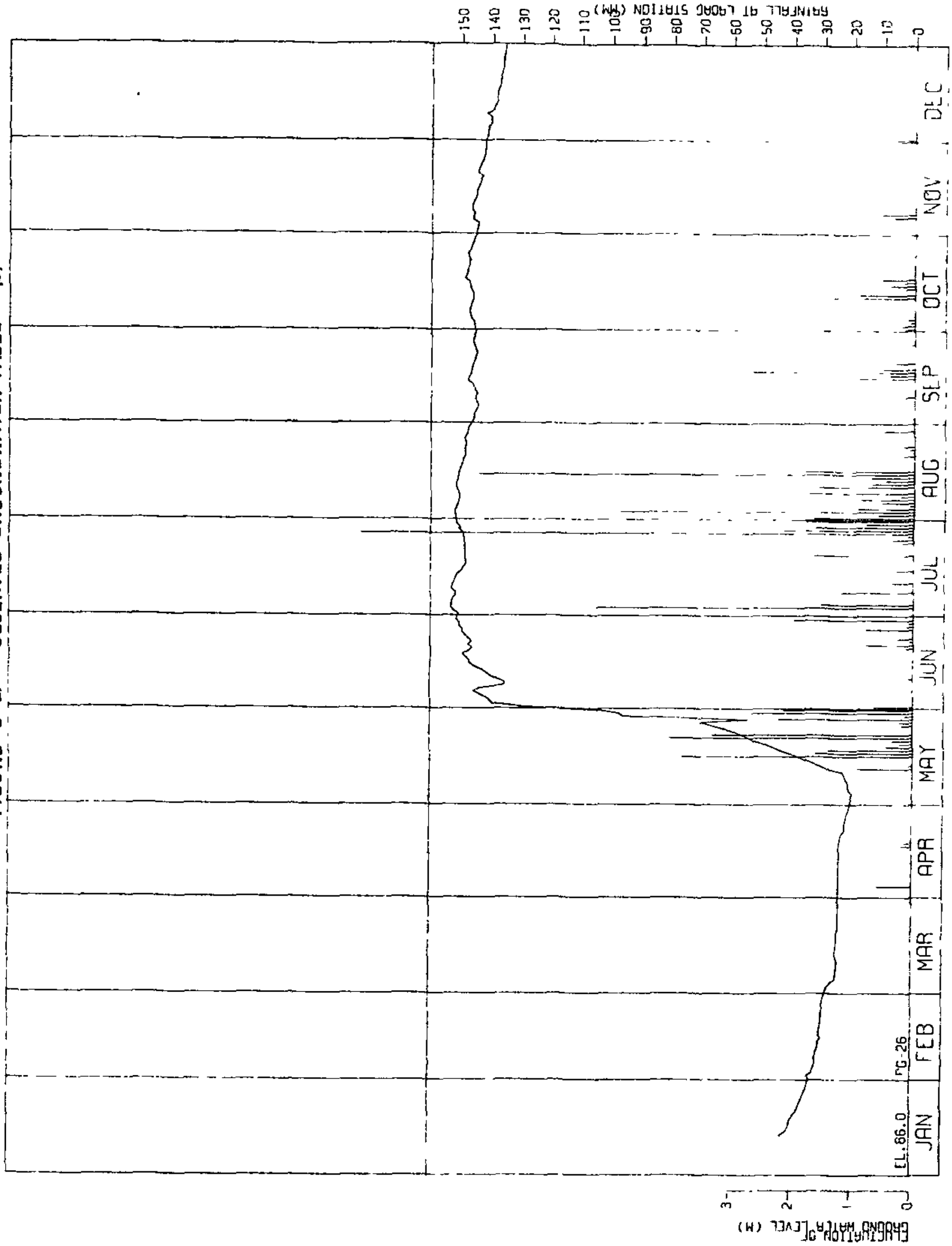


FIGURE B-2. OBSERVED GROUNDWATER TABLE (10)

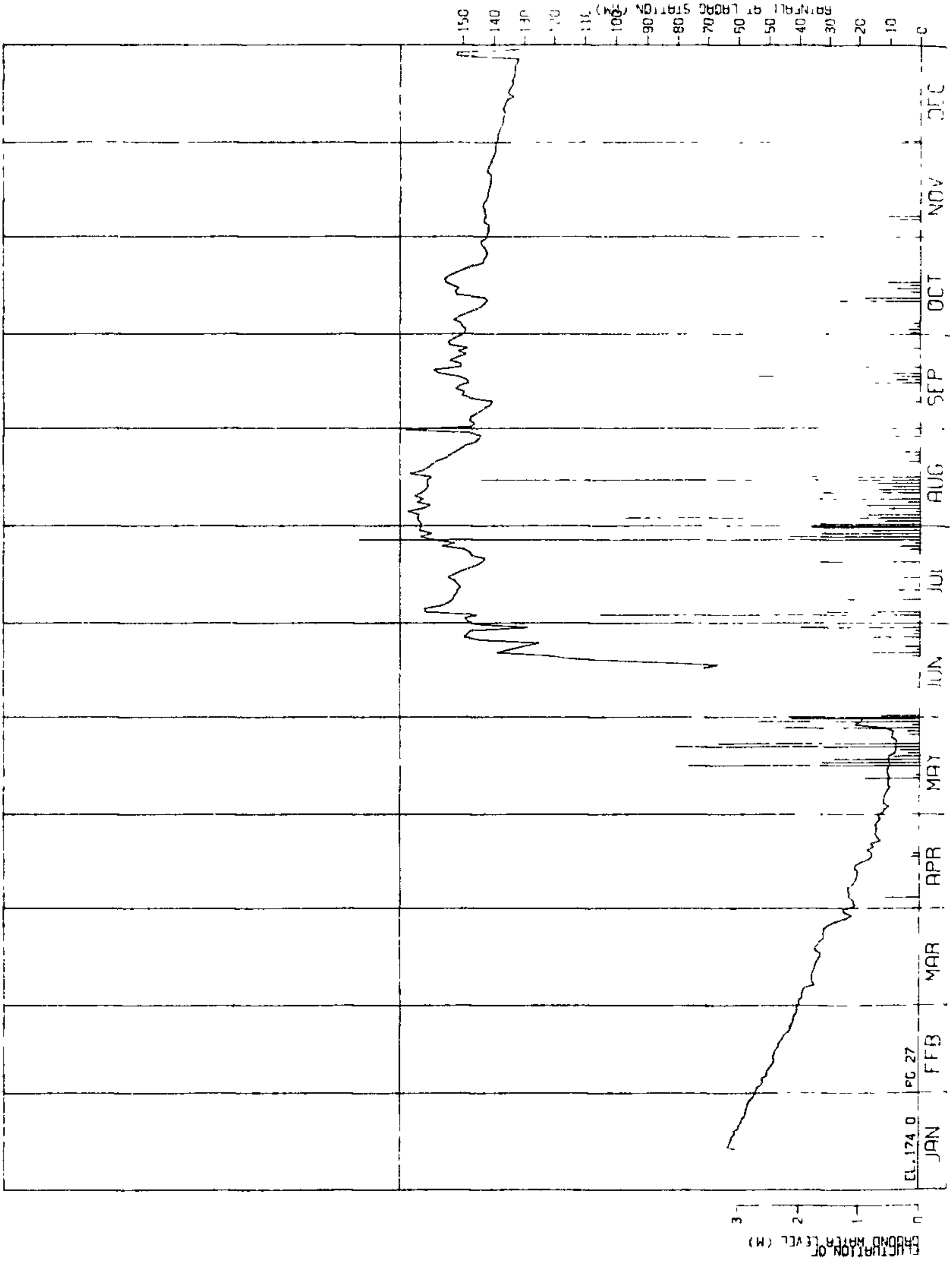
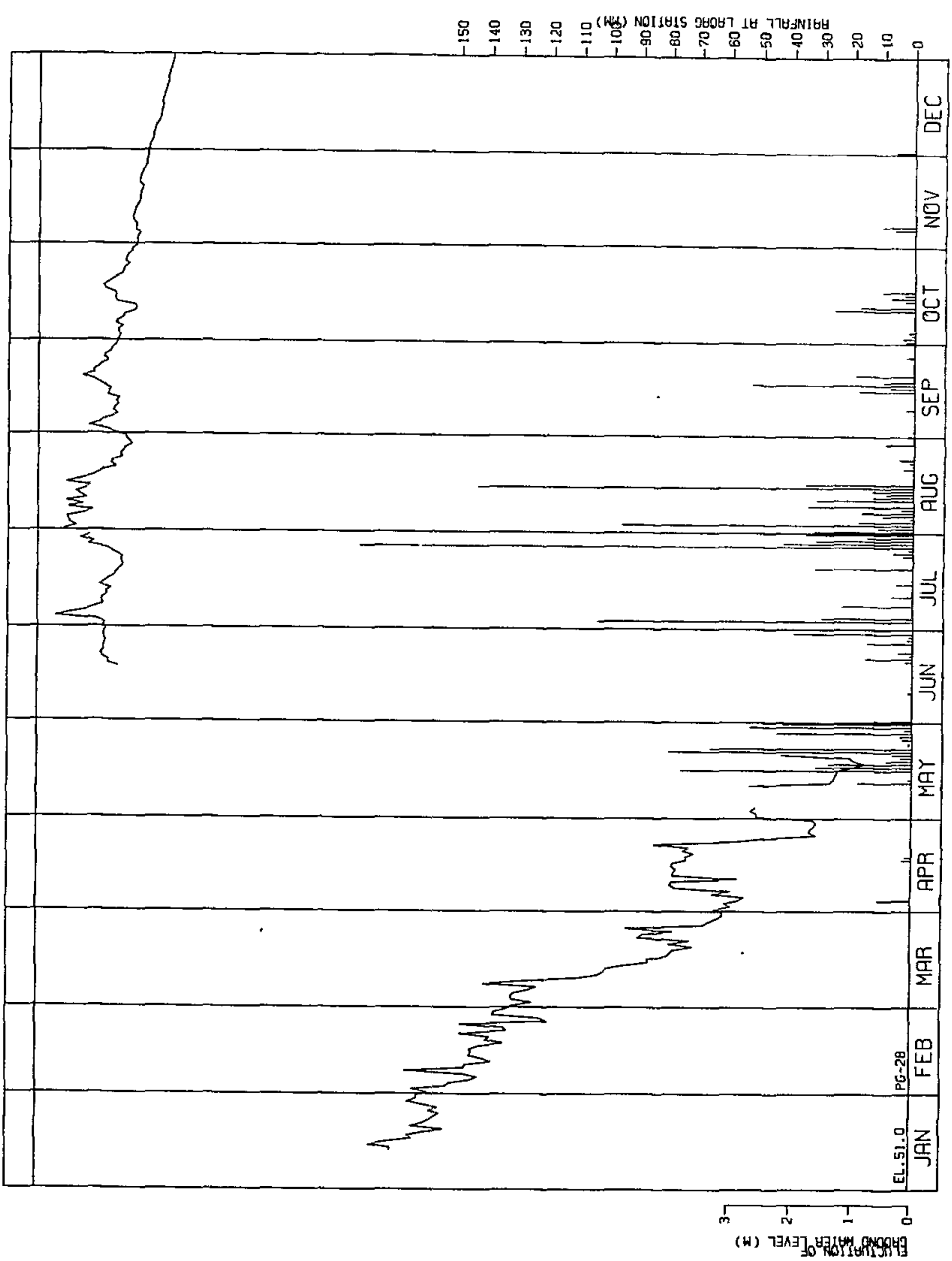


FIGURE B-2. OBSERVED GROUNDWATER TABLE (11)



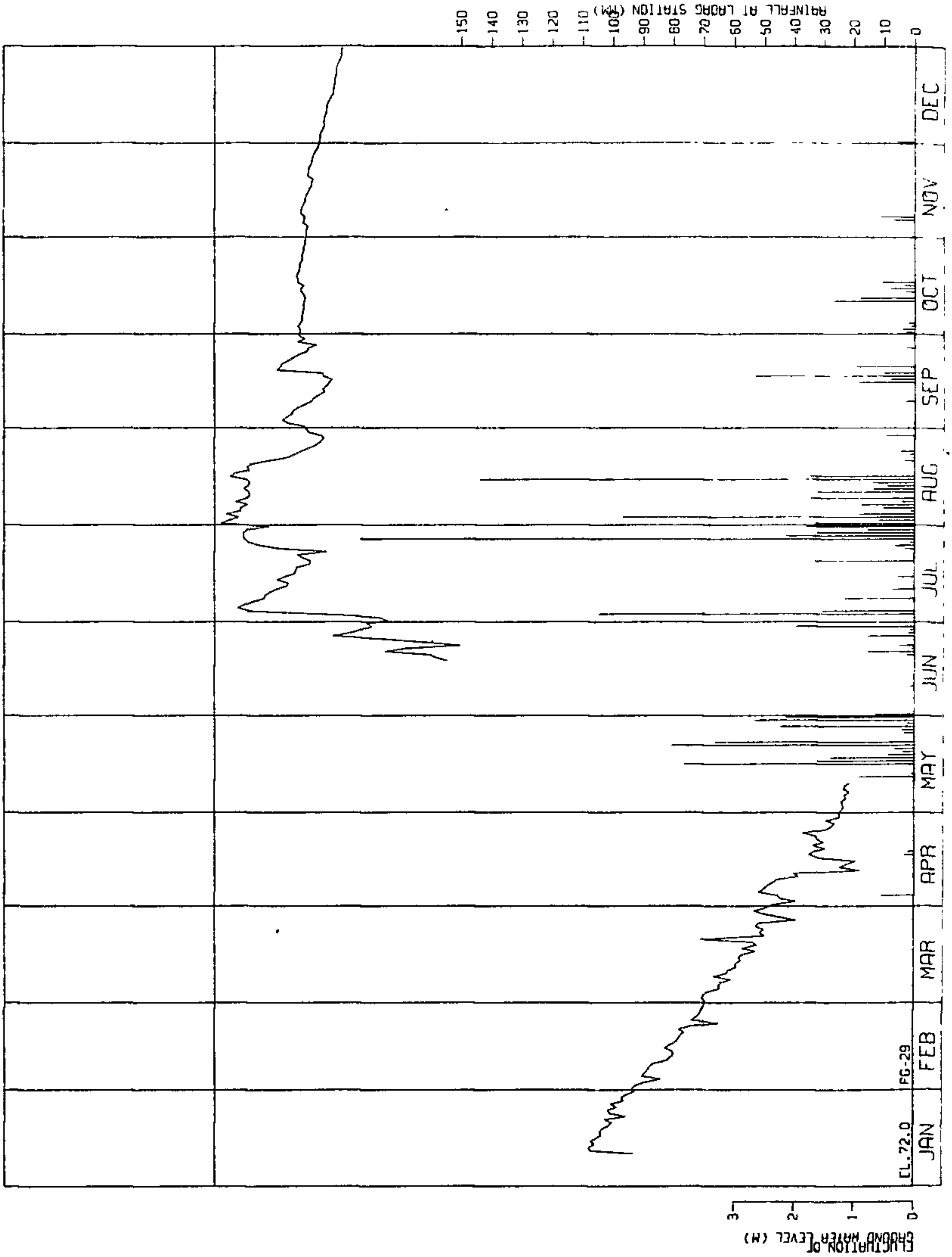


FIGURE B-2. OBSERVED GROUNDWATER TABLE (12)

FIGURE B-2. OBSERVED GROUNDWATER TABLE (13)

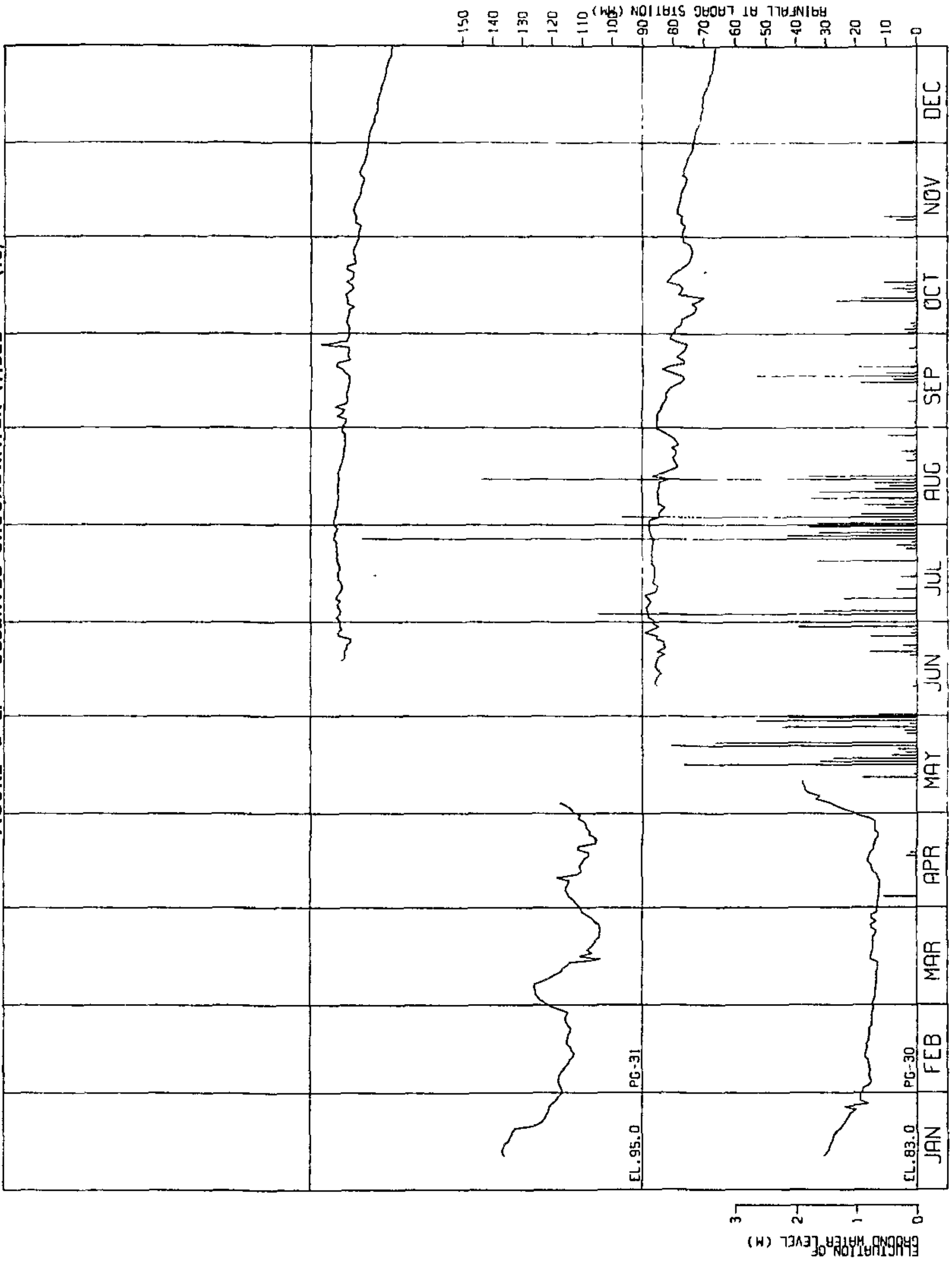
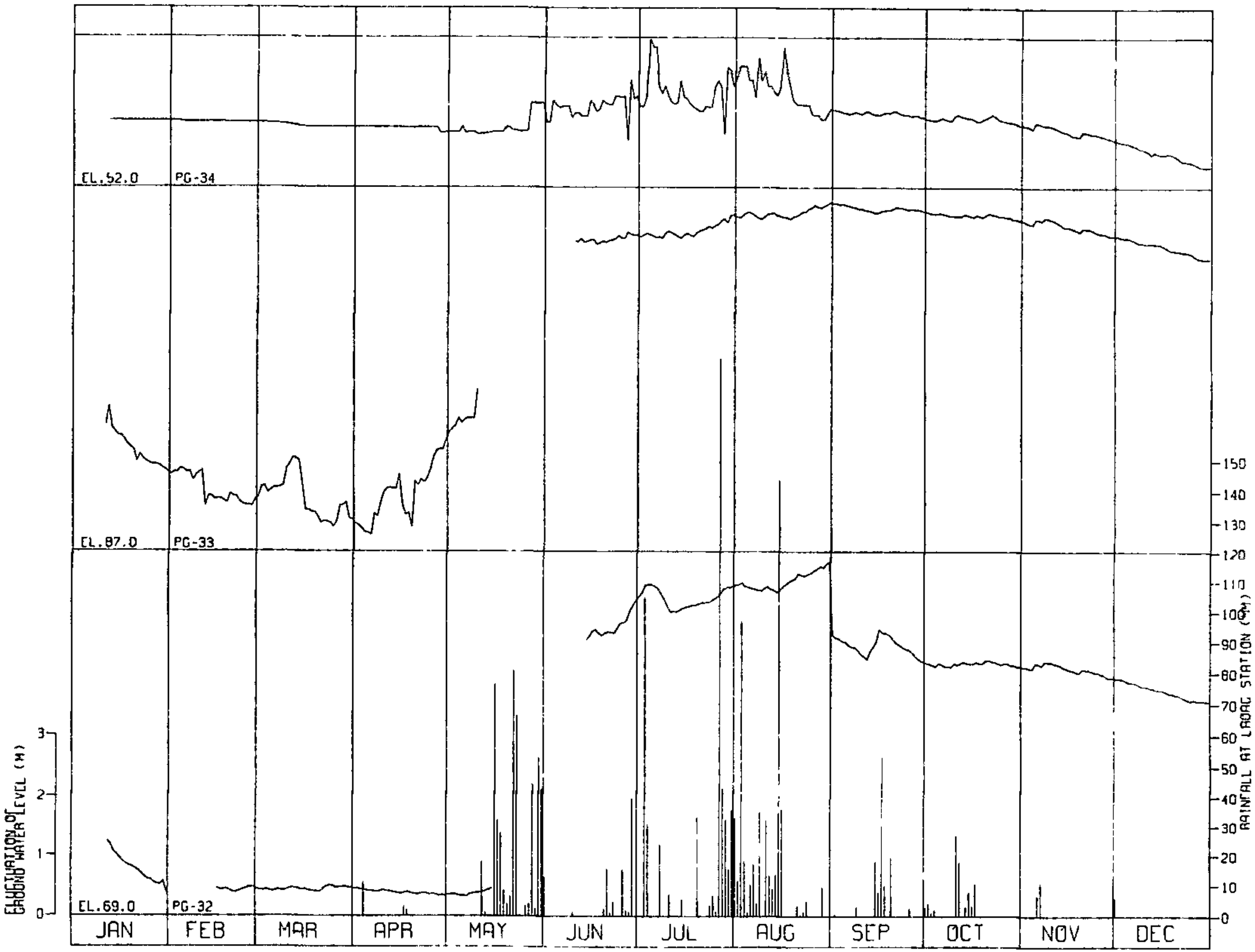


FIGURE B-2. OBSERVED GROUNDWATER TABLE (14)



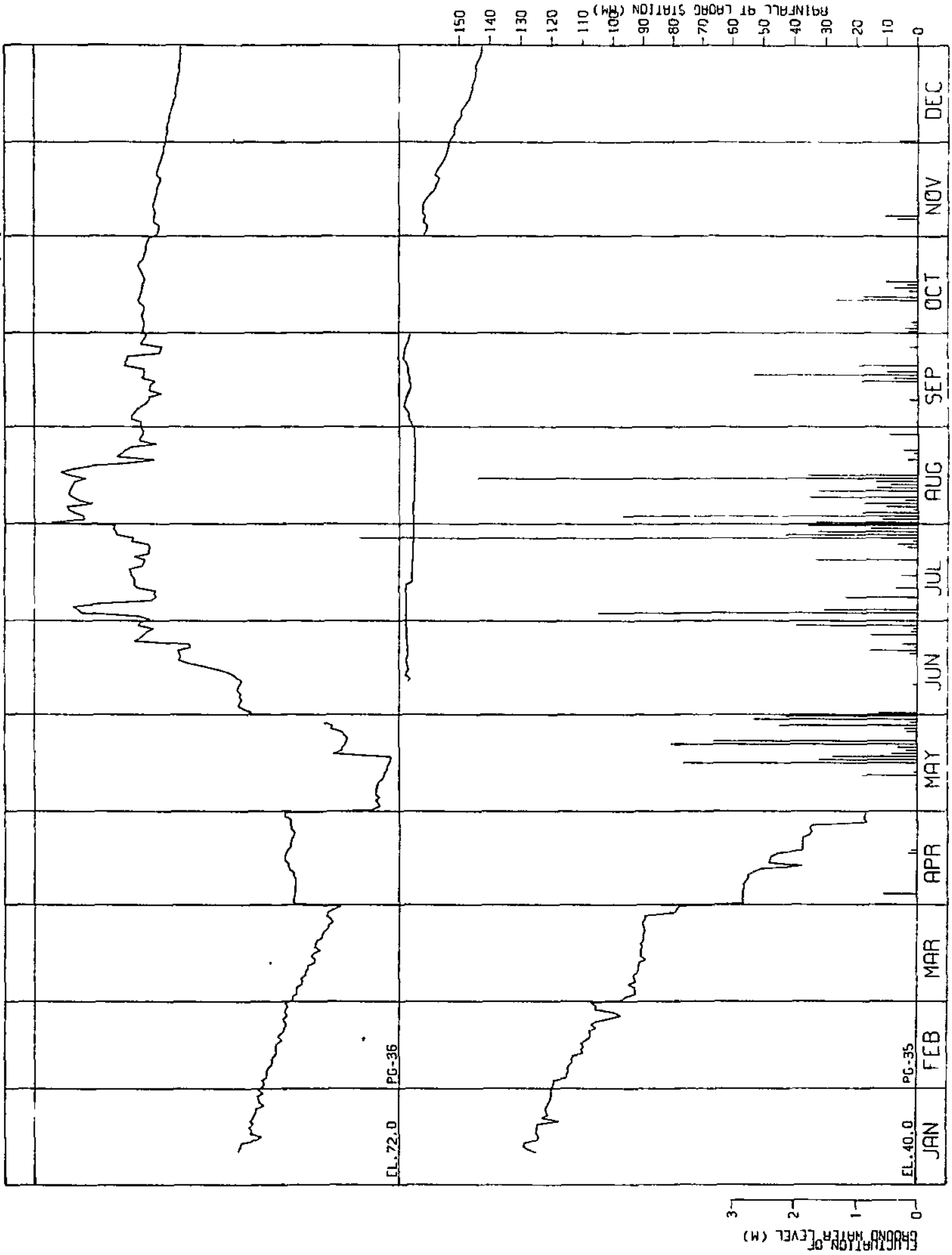


FIGURE B-2. OBSERVED GROUNDWATER TABLE (15)

FIGURE B-2. OBSERVED GROUNDWATER TABLE (16)

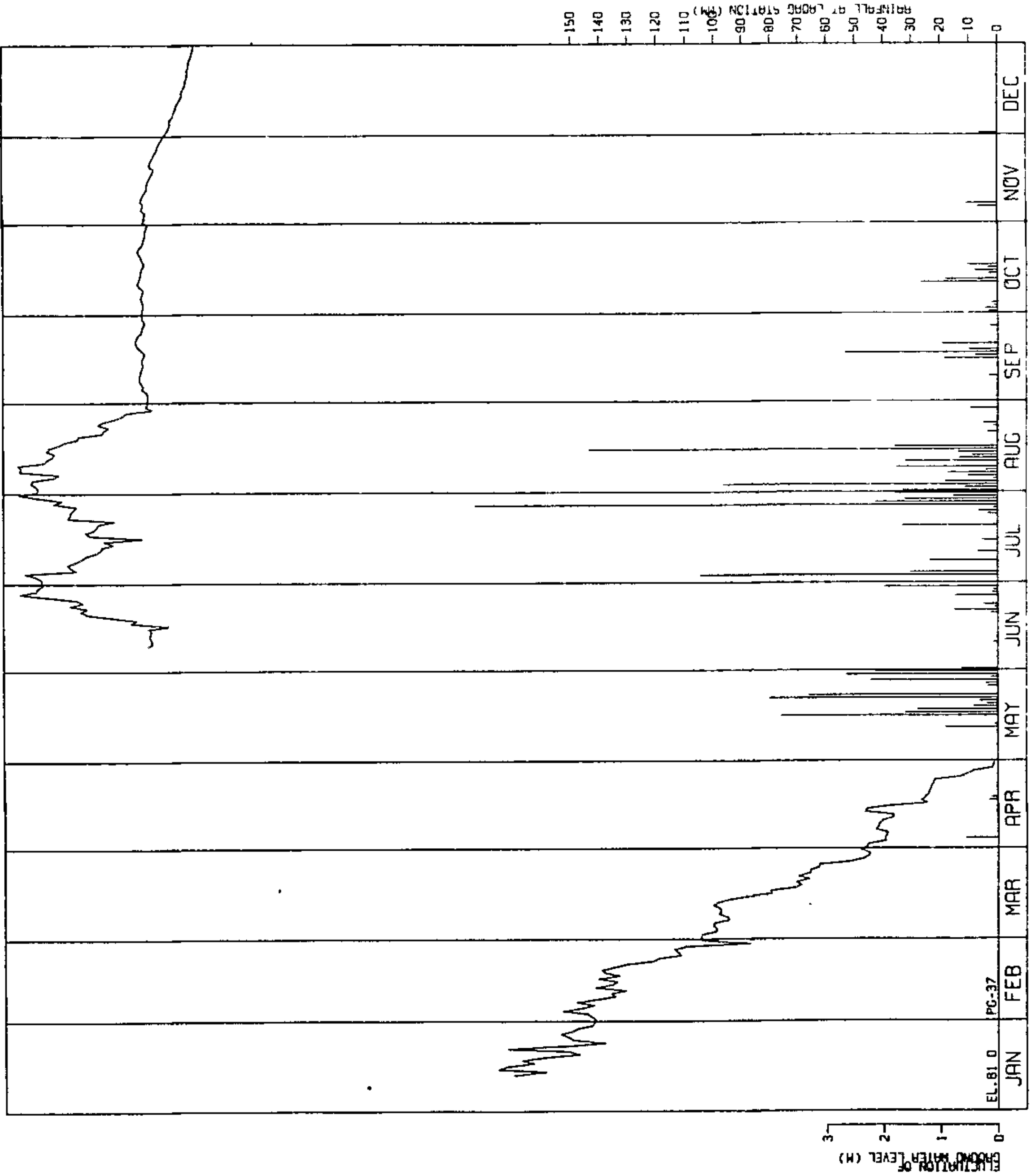


FIGURE B-2. OBSERVED GROUNDWATER TABLE (17)

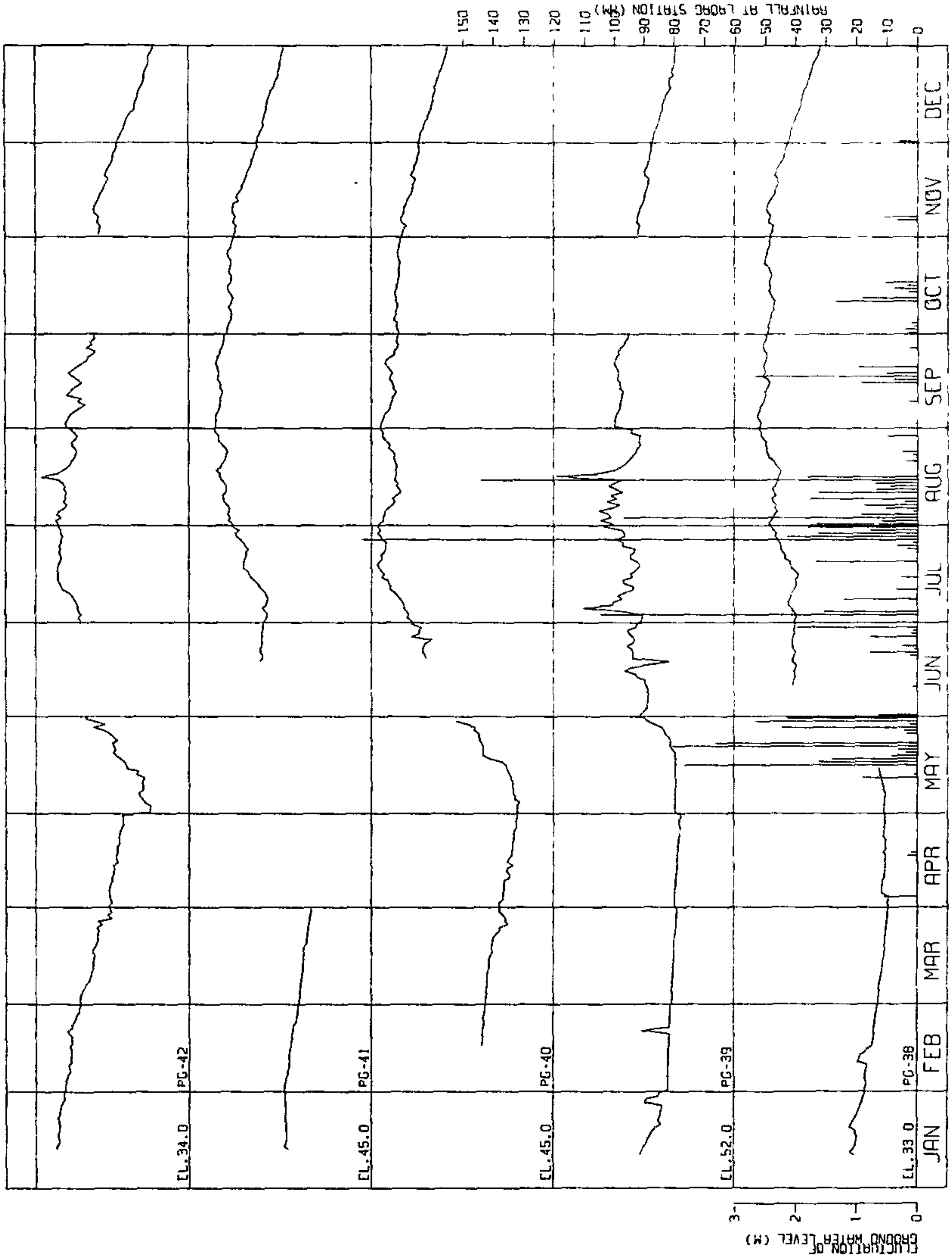


FIGURE B-3. WELL LOG OF INS-1, JUAN, SOLSONA

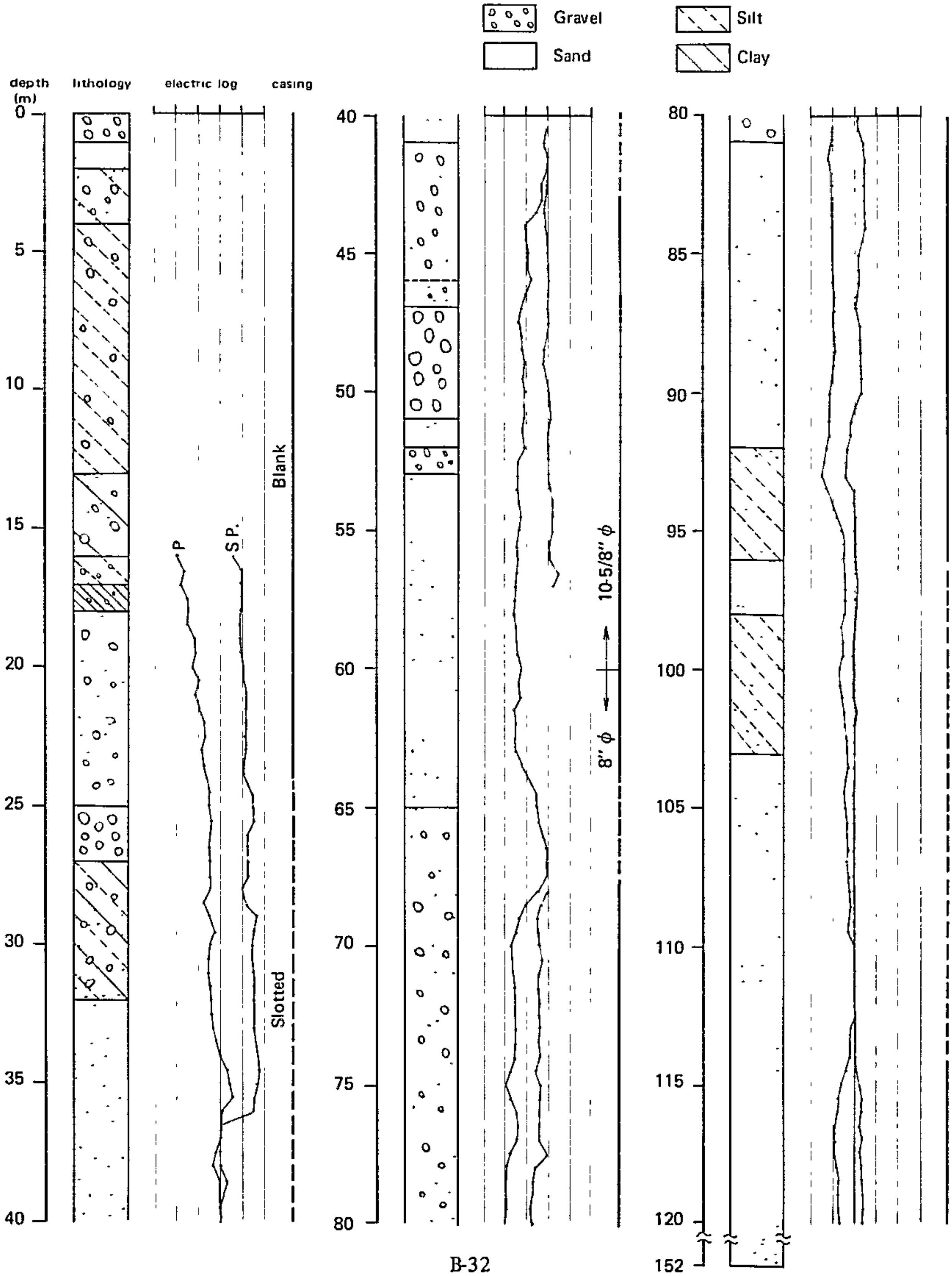


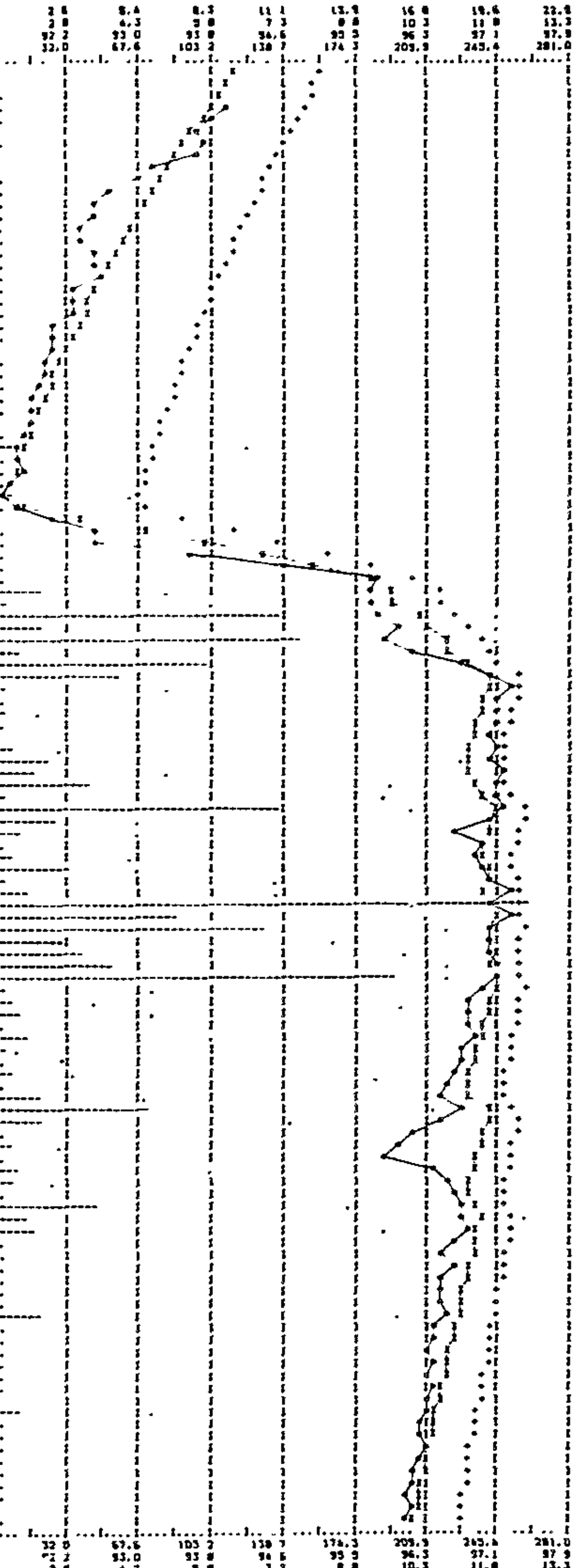
FIGURE B-4. RESULT OF GROUNDWATER SIMULATION (1)

************************* B A N Y U B D C *************************
********* TIME-SERIES PLOT FOR TANK MODEL SIMULAN OF GROUNDWATER RUNOFF *********

**************************PD-16(MANANTINO.BALSAMA) *************************

3-DAY RAIN FALL (AA) ---------- (-)
GW TABLE(OBSERVED) (BB) -- - - - (+) 999.0 = ABSENT DATA
GW TABLE(SIMULATED) (CC) -- -- ---- (I)
GROUNDWATER RUNOFF (DD) - -- - (*)
EVAPOTRANSPIRATION (EE) .... (.)

NO.	DATE	AA	BB	CC	DD	EE
3	79 1 3	0.00	+999.00	94.10	8.10	0.00
6	79 1 6	0.00	+999.00	94.00	7.96	0.00
9	79 1 9	0.00	+999.00	93.90	7.81	0.00
12	79 112	0.00	93.99	93.81	7.67	0.00
15	79 115	0.00	93.81	93.71	7.54	0.00
18	79 118	0.00	93.70	93.62	7.40	0.00
21	79 121	0.00	93.71	93.53	7.27	0.00
24	79 124	0.00	93.65	93.44	7.14	0.00
27	79 127	0.00	93.22	93.35	7.01	0.00
30	79 130	0.00	93.05	93.26	6.89	0.00
33	79 2 2	0.00	92.68	93.18	6.76	0.00
36	79 2 5	0.00	92.99	93.10	6.64	0.00
39	79 2 8	0.00	92.49	93.01	6.52	0.00
42	79 211	0.00	92.34	92.93	6.41	0.00
45	79 214	0.00	92.38	92.86	6.29	0.00
48	79 217	0.00	92.49	92.78	6.18	0.00
51	79 220	0.00	92.52	92.70	6.07	0.00
54	79 223	0.00	92.58	92.63	5.96	0.00
57	79 226	0.00	92.28	92.55	5.85	0.00
60	79 3 1	0.00	92.30	92.48	5.75	0.00
63	79 3 4	0.00	92.27	92.41	5.64	0.00
66	79 3 7	0.00	92.06	92.34	5.54	0.00
69	79 310	0.00	92.02	92.27	5.44	0.00
72	79 313	0.00	92.06	92.21	5.35	0.00
75	79 316	0.00	91.99	92.14	5.25	0.00
78	79 319	0.00	91.92	92.08	5.16	0.00
81	79 322	0.00	91.86	92.01	5.06	0.00
84	79 325	0.00	91.78	91.95	4.97	0.00
87	79 328	0.00	91.77	91.89	4.88	0.00
90	79 331	0.00	91.77	91.83	4.80	0.00
93	79 4 3	0.00	91.69	91.77	4.71	0.00
96	79 4 6	10.90	91.62	91.73	4.63	9.64
99	79 4 9	0.00	91.66	91.67	4.57	0.00
102	79 412	0.00	91.60	91.62	4.48	0.00
105	79 415	0.00	91.57	91.56	4.40	0.00
108	79 418	5.00	91.50	91.51	4.32	5.00
111	79 421	0.00	91.63	91.70	4.37	0.00
114	79 424	0.00	92.03	92.39	5.24	0.00
117	79 427	0.00	92.49	93.06	6.22	0.00
120	79 430	0.00	92.54	93.72	7.18	0.00
123	79 5 3	0.00	93.55	94.37	8.13	0.00
126	79 5 6	0.00	94.65	95.00	9.06	0.00
129	79 5 9	0.00	95.67	95.63	9.97	0.00
132	79 512	18.00	95.64	95.86	10.58	6.50
135	79 515	1.00	95.66	95.85	10.61	8.29
138	79 518	136.50	95.70	96.17	10.90	19.50
141	79 521	18.30	95.93	96.31	11.21	19.50
144	79 524	146.80	95.82	96.56	11.32	19.50
147	79 527	7.30	96.13	96.34	11.60	16.35
150	79 530	99.90	96.68	96.79	11.83	19.50
153	79 6 2	55.40	97.03	97.01	12.20	19.50
156	79 6 5	0.00	97.29	96.97	12.23	6.50
159	79 6 8	0.00	97.09	96.93	12.18	0.00
162	79 611	1.30	97.10	96.89	12.12	1.30
165	79 614	0.00	97.08	96.85	12.06	0.00
168	79 617	0.00	97.01	96.82	12.01	0.00
171	79 620	2.30	97.11	96.78	11.99	2.30
174	79 623	21.00	97.04	96.78	11.95	18.11
177	79 626	15.20	97.18	96.77	11.92	6.50
180	79 629	42.50	97.12	96.86	11.96	15.27
183	79 7 2	0.00	97.11	96.89	12.11	15.23
186	79 7 5	135.20	97.14	97.07	12.33	16.20
189	79 7 8	23.70	96.99	97.03	12.32	5.40
192	79 711	6.80	96.62	96.99	12.26	[illegible]
195	79 714	0.00	96.89	96.95	12.20	0.00
198	79 717	5.20	96.88	96.91	12.14	5.20
201	79 720	33.00	96.92	96.97	12.14	5.40
204	79 723	0.00	97.02	96.99	12.25	10.80
207	79 726	11.20	97.21	96.95	12.20	10.90
210	79 729	238.70	97.02	97.02	12.31	16.20
213	79 8 1	84.40	97.24	97.08	12.29	16.70
216	79 8 4	126.70	97.04	97.04	12.33	17.70
219	79 8 7	28.80	97.02	97.00	12.27	13.10
222	79 810	39.20	96.99	97.07	12.32	15.90
225	79 813	54.40	97.08	97.02	12.31	17.70
228	79 816	193.40	97.07	97.10	12.31	17.70
231	79 819	0.00	96.92	97.05	12.35	5.90
234	79 822	3.70	96.79	97.01	12.29	3.70
237	79 825	6.10	96.77	96.97	12.23	6.10
240	79 828	0.00	96.74	96.93	12.18	0.00
243	79 831	9.40	96.82	96.91	12.14	8.35
246	79 9 3	0.50	96.69	96.87	12.08	0.50
249	79 9 6	0.00	96.66	96.83	12.03	0.00
252	79 9 9	2.80	96.56	96.79	11.97	2.80
255	79 912	0.00	96.54	96.76	11.92	0.00
258	79 915	18.30	96.41	96.77	11.89	9.70
261	79 918	71.10	96.66	96.98	12.09	17.10
264	79 921	19.30	96.40	96.98	12.25	11.40
267	79 924	0.00	96.13	96.94	12.19	0.00
270	79 927	2.40	95.96	96.90	12.13	2.40
273	79 930	0.00	95.81	96.86	12.08	0.00
276	7910 3	8.20	96.37	96.82	12.02	8.20
279	7910 6	2.00	96.54	96.79	11.97	2.00
282	7910 9	0.00	96.60	96.75	11.91	0.00
285	791012	44.80	96.64	96.88	11.98	13.80
288	791015	10.70	96.66	96.91	12.12	20.70
291	791018	13.90	96.80	96.88	12.10	15.11
294	791021	0.00	96.62	96.84	12.05	0.00
297	791024	0.00	96.47	96.81	11.99	0.00
300	791027	0.00	96.63	96.77	11.94	0.00
303	791030	0.00	96.47	96.73	11.89	0.00
306	7911 2	0.00	96.47	96.70	11.84	0.00
309	7911 5	0.00	96.42	96.66	11.79	0.00
312	7911 8	17.30	96.52	96.65	11.76	15.66
315	791111	0.00	96.39	96.62	11.72	0.00
318	791114	0.00	96.39	96.58	11.67	0.00
321	791117	0.00	96.26	96.55	11.62	0.00
324	791120	0.00	96.32	96.52	11.57	0.00
327	791123	0.00	96.30	96.49	11.53	0.00
330	791126	0.00	96.32	96.45	11.48	0.00
333	791129	0.00	96.28	96.42	11.44	0.00
336	7912 2	6.00	96.26	96.39	11.39	6.00
339	7912 5	0.00	96.22	96.36	11.35	0.00
342	7912 8	0.00	96.17	96.34	11.31	0.00
345	791211	0.00	96.26	96.31	11.27	0.00
348	791214	0.00	96.20	96.28	11.22	0.00
351	791217	0.00	96.14	96.25	11.18	0.00
354	791220	0.00	96.07	96.22	11.15	0.00
357	791223	0.00	96.03	96.20	11.11	0.00
360	791226	0.00	96.08	96.17	11.07	0.00
363	791229	0.00	96.05	96.15	11.03	0.00
NO.	DATE	AA	BB	CC	DD	EE



FINAL WATER DEPTH IN TANK NO. 1 0.000 MM

FINAL WATER DEPTH IN TANK NO. 2 96530.000 MM

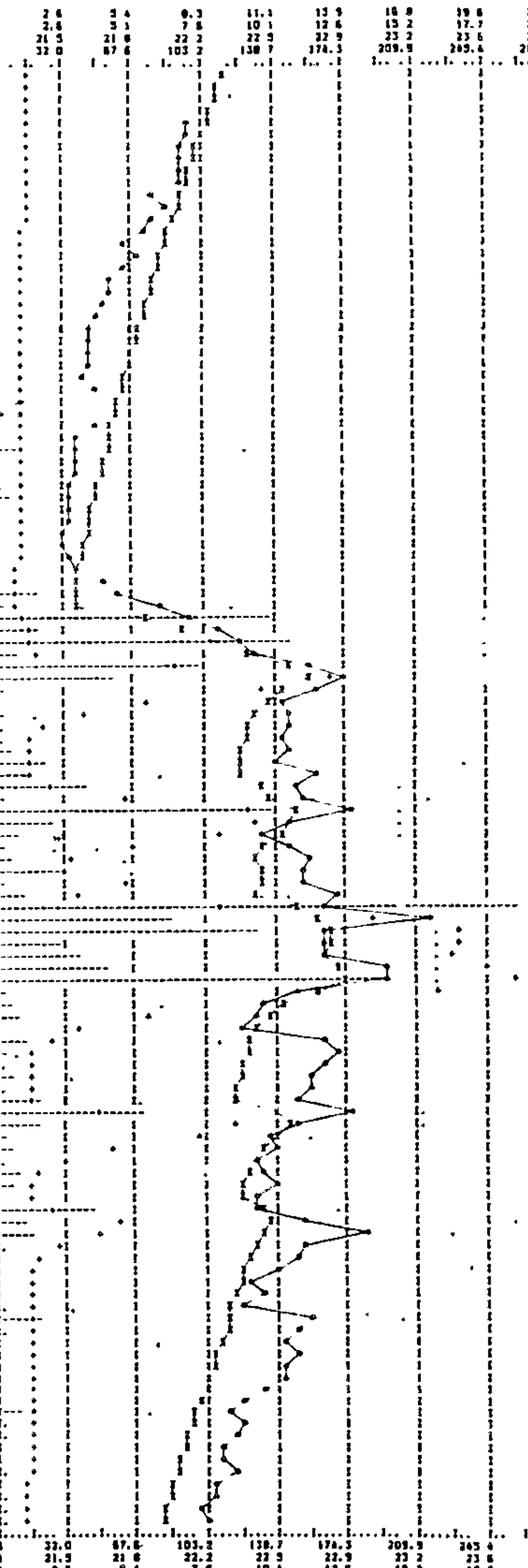
FIGURE B-4. RESULT OF GROUNDWATER SIMULATION (2)

************************* S A N Y U   S D C   ***************************
********* TIME-SERIES PLOT FOR TANK MODEL SIMULAN OF GROUNDWATER RUNOFF *********

*************************PD-SISAN ESTEBAN,BINOHAS) ************************

3-DAY RAIN FALL (AA) .... .. (+)
GW TABLE(OBSERVED) (BB) ... . - (*) 999.9 = ABSENT DATA
GW TABLE(SIMULATED) (CC) - . (I)
GROUNDWATER RUNOFF (DD) (+)
EVAPOTRANSPIRATION (EE) .... (.)

NO	DATE	AA	BB	CC	DD	EE
3	79 1 3	0.00	+999.00	22.28	1.33	0.001
6	79 1 6	0.00	+999.00	22.26	1.3[illegible]	0.001
9	79 1 9	0.00	+999.00	22.23	1.31	0.001
12	79 112	0.00	+999.00	22.21	1.29	0.001
15	79 115	0.00	22.11	22.19	1.28	0.001
18	79 118	0.00	22.09	22.17	1.27	0.001
21	79 121	0.00	22.05	22.15	1.26	0.001
24	79 124	0.00	22.06	22.13	1.25	0.001
27	79 127	0.00	22.05	22.11	1.24	0.001
30	79 130	0.00	22.06	22.09	1.23	0.001
33	79 2 2	0.00	21.93	22.07	1.22	0.001
36	79 2 5	0.00	21.99	22.05	1.20	0.001
39	79 2 8	0.00	21.93	22.03	1.19	0.001
42	79 211	0.00	21.87	22.01	1.18	0.001
45	79 214	0.00	21.77	21.99	1.17	0.001
48	79 217	0.00	21.85	21.97	1.16	0.001
51	79 220	0.00	21.76	21.95	1.15	0.001
54	79 223	0.00	21.70	21.93	1.14	0.001
57	79 226	0.00	21.69	21.91	1.13	0.001
60	79 3 1	0.00	21.68	21.89	1.12	0.001
63	79 3 4	0.00	21.62	21.87	1.11	0.001
66	79 3 7	0.00	21.61	21.86	1.10	0.001
69	79 310	0.00	21.59	21.84	1.09	0.001
72	79 313	0.00	21.58	21.82	1.08	0.001
75	79 316	0.00	21.38	21.80	1.07	0.001
78	79 319	0.00	21.56	21.78	1.06	0.001
81	79 322	0.00	21.64	21.77	1.05	0.001
84	79 325	0.00	21.24	21.75	1.04	0.001
87	79 328	0.00	21.13	21.73	1.03	0.001
90	79 331	0.00	21.63	21.71	1.02	0.001
93	79 4 3	0.00	21.53	21.70	1.01	0.001
96	79 4 6	10.90	21.57	21.69	1.01	10.061
99	79 4 9	0.00	21.5[illegible]	21.68	1.00	0.001
102	79 412	0.00	21.51	21.66	0.99	0.001
105	79 415	0.00	21.50	21.65	0.99	0.001
108	79 418	5.00	21.49	21.63	0.98	5.001
111	79 421	0.00	21.48	21.61	0.97	0.001
114	79 424	0.00	21.48	21.60	0.96	0.001
117	79 427	0.00	21.47	21.58	0.95	0.001
120	79 430	0.00	21.46	21.57	0.94	0.001
123	79 5 3	0.00	21.48	21.55	0.93	0.001
126	79 5 6	0.00	21.54	21.53	0.93	0.001
129	79 5 9	0.00	21.68	21.52	0.92	0.001
132	79 512	18.00	21.74	21.54	0.92	6.501
135	79 515	1.00	21.95	21.54	0.93	3.461
138	79 518	136.50	22.11	21.87	1.05	19.501
141	79 521	18.50	22.23	22.08	1.19	19.501
144	79 524	146.80	22.35	22.36	1.33	19.501
147	79 527	7.30	22.41	22.40	1.49	19.501
150	79 530	99.90	22.72	22.60	6.70	19.501
153	79 6 2	55.40	22.88	22.70	12.02	19.501
156	79 6 5	0.00	22.74	22.57	9.73	14.321
159	79 6 8	0.00	22.58	22.48	5.61	0.001
162	79 611	1.30	22.61	22.43	3.21	1.301
165	79 614	0.00	22.60	22.40	1.84	0.001
168	79 617	0.00	22.57	22.37	1.38	0.001
171	79 620	2.30	22.39	22.35	1.37	2.301
174	79 623	21.00	22.53	22.36	1.37	18.901
177	79 626	15.20	22.76	22.37	1.37	6.501
180	79 629	42.50	22.62	22.45	2.09	16.111
183	79 7 2	0.00	22.68	22.48	4.90	17.301
186	79 7 5	135.20	22.91	22.64	9.14	16.201
189	79 7 8	23.70	22.60	22.61	9.34	16.201
192	79 711	6.80	22.45	22.55	8.09	16.201
195	79 714	0.00	22.60	22.47	4.99	3.951
198	79 717	3.20	22.70	22.42	2.86	3.201
201	79 720	33.00	22.69	22.47	2.57	5.401
204	79 723	0.00	22.68	22.47	4.85	16.201
207	79 726	11.20	22.87	22.42	3.07	11.761
210	79 729	298.70	22.79	22.64	8.14	16.201
213	79 8 1	84.40	23.31	22.76	13.64	16.701
216	79 8 4	126.70	22.78	22.83	16.67	17.701
219	79 8 7	28.80	22.78	22.81	16.61	17.701
222	79 810	39.20	22.77	22.80	16.39	17.701
225	79 813	54.40	23.12	22.84	17.56	17.701
228	79 816	193.40	23.10	22.87	18.62	17.701
231	79 819	0.00	22.65	22.73	16.02	17.701
234	79 822	3.70	22.46	22.57	9.63	6.521
237	79 825	6.10	22.41	22.48	5.51	6.101
240	79 828	0.00	22.35	22.42	3.16	0.001
243	79 831	9.40	22.78	22.40	2.11	8.701
246	79 9 3	0.50	22.87	22.38	1.60	0.501
249	79 9 6	0.00	22.79	22.36	1.37	0.001
252	79 9 9	2.80	22.72	22.33	1.36	2.801
255	79 912	0.00	22.70	22.31	1.35	0.001
258	79 915	18.30	22.64	22.33	1.34	5.701
261	79 918	71.10	22.91	22.53	3.88	17.101
264	79 921	19.30	22.64	22.61	8.68	17.101
267	79 924	0.00	22.51	22.52	7.43	12.441
270	79 927	2.40	22.53	22.45	4.28	2.401
273	79 930	0.00	22.41	22.41	2.45	0.001
276	7910 3	8.20	22.45	22.38	1.48	8.201
279	7910 6	2.00	22.53	22.36	1.38	2.001
282	7910 9	0.00	22.42	22.34	1.36	0.001
285	791012	44.80	22.41	22.46	2.19	13.801
288	791015	10.70	22.66	22.48	4.66	20.701
291	791018	13.90	22.98	22.44	3.74	18.071
294	791021	0.00	22.69	22.41	2.26	0.001
297	791024	0.00	22.62	22.38	1.44	0.001
300	791027	0.00	22.52	22.36	1.37	0.001
303	791030	0.00	22.39	22.34	1.36	0.001
306	7911 2	0.00	22.47	22.31	1.35	0.001
309	7911 5	0.00	22.35	22.29	1.34	0.001
312	7911 8	17.30	22.70	22.29	1.33	16.201
315	791111	0.00	22.65	22.26	1.32	0.001
318	791114	0.00	22.55	22.24	1.31	0.001
321	791117	0.00	22.64	22.22	1.30	0.001
324	791120	0.00	22.57	22.20	1.29	0.001
327	791123	0.00	22.56	22.18	1.28	0.001
330	791126	0.00	22.47	22.16	1.26	0.001
333	791129	0.00	22.36	22.14	1.25	0.001
336	7912 2	6.00	22.29	22.12	1.24	6.001
339	7912 5	0.00	22.34	22.10	1.23	0.001
342	7912 8	0.00	22.30	22.08	1.22	0.001
345	791211	0.00	22.23	22.05	1.21	0.001
348	791214	0.00	22.24	22.03	1.20	0.001
351	791217	0.00	22.33	22.02	1.19	0.001
354	791220	0.00	22.20	22.00	1.18	0.001
357	791223	0.00	22.19	21.98	1.17	0.001
360	791226	0.00	22.15	21.96	1.16	0.001
363	791229	0.00	22.17	21.94	1.15	0.001



FINAL WATER DEPTH IN TANK NO. 1 0.000 MM

FINAL WATER DEPTH IN TANK NO. 2 21325.103 MM

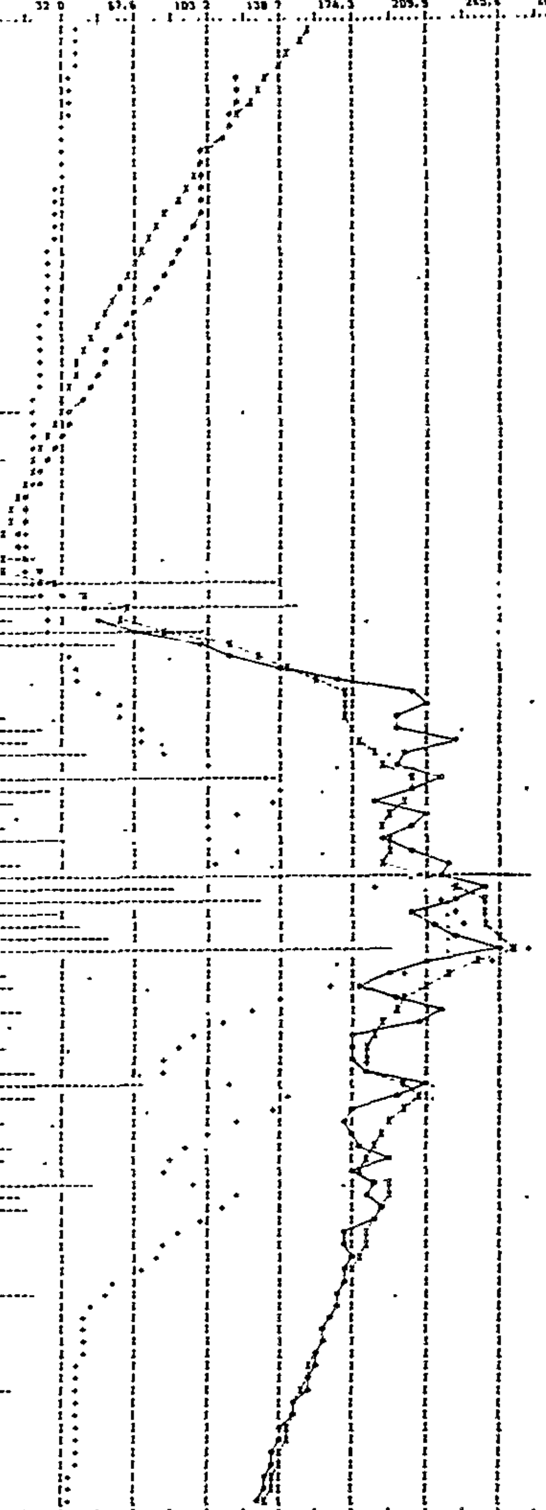
FIGURE B-4. RESULT OF GROUNDWATER SIMULATION (3)

**************************** S A N Y U C O C ****************************
********* TIME-SERIES PLOT FOR TANK MODEL SIMULAN OF GROUNDWATER RUNOFF *********

***************************PO-(ILANAS SUR) **************************

3-DAY RAIN FALL (AA) .... (-)
GW TABLE(OBSERVED) (BB) .. . (+) 999.9 = ABSENT DATA
GW TABLE(SIMULATED) (CC) . ... (I)
GROUNDWATER RUNOFF (DD) .... (+)
EVAPOTRANSPIRATION (EE) .... (.)

Scale									
EE	-0.3	2.6	5.4	8.3	11.1	13.9	16.8	19.6	22.5
DD	0.3	3.3	6.4	9.5	12.5	15.6	18.7	21.7	24.8
BB (CC)	46.7	47.1	47.6	48.0	48.4	48.9	49.3	49.8	50.2
AA	-3.6	32.0	67.6	103.2	138.7	174.3	209.9	245.4	281.0



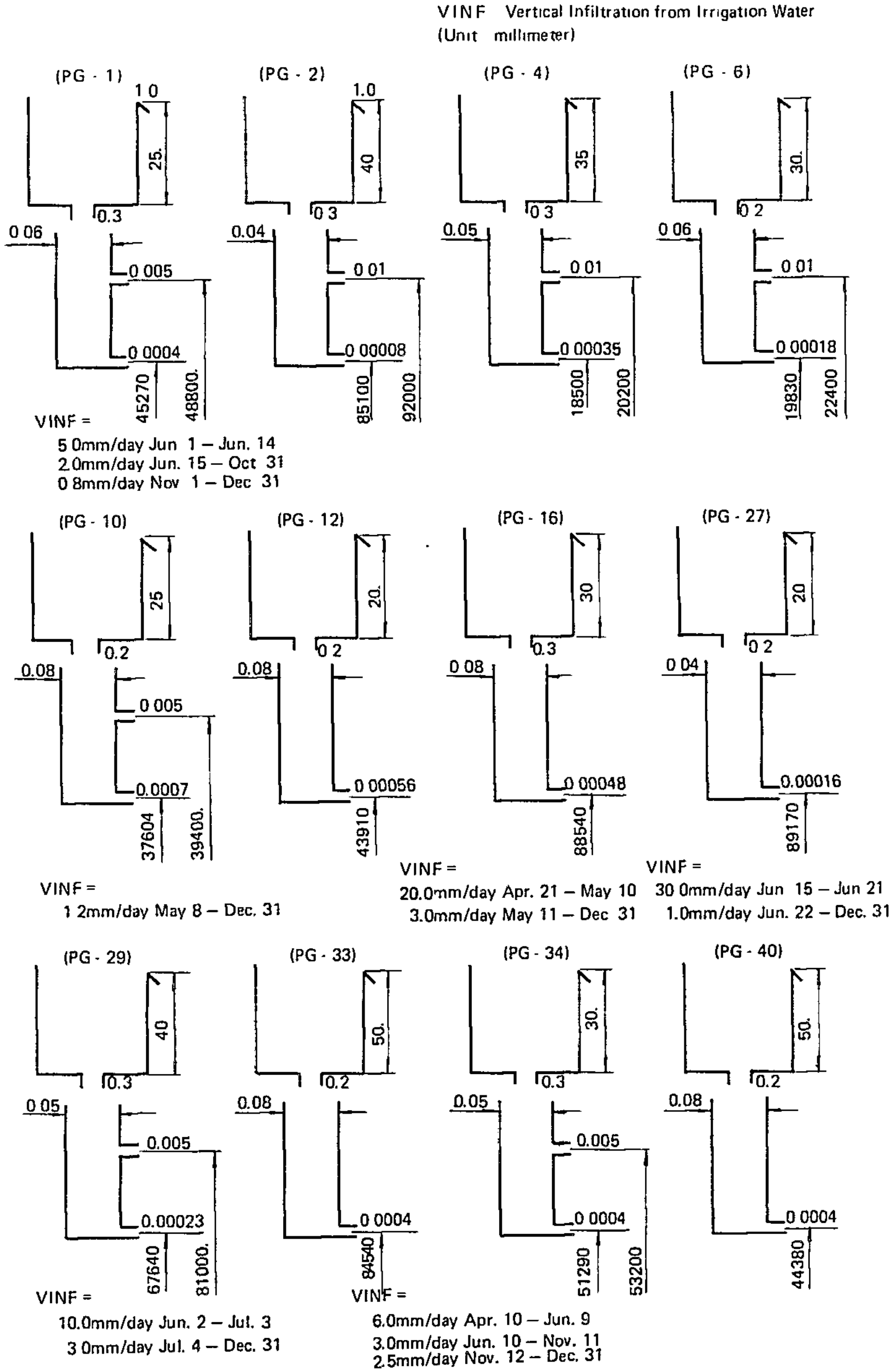
NO	DATE	AA	BB	CC	DD	EE
3	79 1 3	0.00	*999.00	48.63	4.09	0.00
6	79 1 6	0.00	*999.00	48.57	4.01	0.00
9	79 1 9	0.00	*999.00	48.50	3.92	0.00
12	79 112	0.00	*999.00	48.44	3.85	0.00
15	79 115	0.00	48.18	48.37	3.77	0.00
18	79 118	0.00	48.18	48.31	3.70	0.00
21	79 121	0.00	48.17	48.25	3.62	0.00
24	79 124	0.00	48.15	48.19	3.55	0.00
27	79 127	0.00	48.13	48.13	3.48	0.00
30	79 130	0.00	48.08	48.08	3.41	0.00
33	79 2 2	0.00	47.98	48.02	3.35	0.00
36	79 2 5	0.00	47.96	47.97	3.28	0.00
39	79 2 8	0.00	47.96	47.91	3.21	0.00
42	79 211	0.00	47.96	47.86	3.15	0.00
45	79 214	0.00	47.96	47.81	3.09	0.00
48	79 217	0.00	47.95	47.76	3.03	0.00
51	79 220	0.00	47.92	47.71	2.97	0.00
54	79 223	0.00	47.89	47.66	2.91	0.00
57	79 226	0.00	47.83	47.61	2.85	0.00
60	79 3 1	0.00	47.76	47.57	2.79	0.00
63	79 3 4	0.00	47.72	47.52	2.74	0.00
66	79 3 7	0.00	47.70	47.48	2.68	0.00
69	79 310	0.00	47.63	47.43	2.63	0.00
72	79 313	0.00	47.58	47.39	2.58	0.00
75	79 316	0.00	47.51	47.35	2.53	0.00
78	79 319	0.00	47.47	47.31	2.48	0.00
81	79 322	0.00	47.40	47.27	2.43	0.00
84	79 325	0.00	47.36	47.23	2.38	0.00
87	79 328	0.00	47.33	47.19	2.33	0.00
90	79 331	0.00	47.28	47.15	2.28	0.00
93	79 4 3	0.00	47.23	47.11	2.24	0.00
96	79 4 6	10.90	47.18	47.10	2.22	9.64
99	79 4 9	0.00	47.15	47.06	2.18	0.00
102	79 412	0.00	47.11	47.02	2.13	0.00
105	79 415	0.00	47.05	46.99	2.09	0.00
108	79 418	5.00	47.02	46.95	2.05	5.00
111	79 421	0.00	47.00	46.92	2.01	0.00
114	79 424	0.00	46.96	46.89	1.97	0.00
117	79 427	0.00	46.91	46.86	1.93	0.00
120	79 430	0.00	46.87	46.82	1.89	0.00
123	79 5 3	0.00	46.87	46.79	1.85	0.00
126	79 5 6	0.00	46.85	46.76	1.82	0.00
129	79 5 9	0.00	46.83	46.73	1.78	0.00
132	79 512	18.00	46.87	46.76	1.77	6.50
135	79 515	1.00	46.96	46.74	1.79	8.29
138	79 518	136.50	46.97	47.09	2.06	19.50
141	79 521	18.50	47.10	47.23	2.34	19.50
144	79 524	146.80	47.24	47.50	2.61	19.50
147	79 527	7.30	47.35	47.46	2.66	14.64
150	79 530	99.90	47.57	47.73	2.86	19.50
153	79 6 2	55.40	47.97	48.13	3.29	19.50
156	79 6 5	0.00	48.16	48.32	3.61	6.89
159	79 6 8	0.00	48.47	48.51	3.84	0.00
162	79 611	1.30	48.79	48.69	4.06	1.30
165	79 614	0.00	49.27	48.86	4.93	0.00
168	79 617	0.00	49.32	48.86	5.79	0.00
171	79 620	2.30	49.15	48.87	5.86	2.30
174	79 623	21.00	49.15	48.91	6.57	18.11
177	79 626	15.20	49.30	48.94	6.68	6.50
180	79 629	45.50	49.35	49.04	7.70	15.27
183	79 7 2	0.00	49.17	49.05	9.39	13.51
186	79 7 5	135.20	49.42	49.26	12.07	16.20
189	79 7 8	23.70	49.25	49.26	12.42	12.95
192	79 711	6.80	49.01	49.20	12.28	15.99
195	79 714	0.00	49.32	49.12	10.80	0.58
198	79 717	5.20	49.26	49.06	9.62	5.20
201	79 720	33.00	49.09	49.13	9.40	3.40
204	79 723	0.00	49.27	49.12	10.79	12.95
207	79 726	11.20	49.46	49.07	9.73	10.90
210	79 729	298.70	49.41	49.33	12.64	16.20
213	79 8 1	84.40	49.58	49.53	16.55	16.70
216	79 8 4	126.70	49.51	49.67	19.36	17.70
219	79 8 7	78.80	49.29	49.68	20.00	17.70
222	79 810	39.70	49.40	49.68	20.36	17.70
225	79 813	34.40	49.52	49.77	21.62	17.70
228	79 816	193.40	49.80	49.85	22.89	17.70
231	79 819	0.00	49.35	49.67	21.43	13.33
234	79 822	3.70	49.33	49.47	17.68	3.70
237	79 825	6.10	48.95	49.32	14.80	6.10
240	79 828	0.00	49.17	49.21	12.63	0.00
243	79 831	9.40	49.45	49.14	11.26	8.35
246	79 9 3	0.90	49.30	49.08	9.96	0.90
249	79 9 6	0.00	48.91	49.03	8.98	0.00
252	79 9 9	2.80	48.91	48.99	8.29	2.80
255	79 912	0.00	48.91	48.96	7.69	0.00
258	79 915	18.30	49.00	49.00	7.62	5.70
261	79 918	71.10	49.32	49.31	10.45	17.10
264	79 921	13.30	49.13	49.29	12.93	17.10
267	79 924	0.00	48.88	49.19	12.11	5.88
270	79 927	2.40	48.83	49.11	10.60	2.40
273	79 930	0.00	48.30	49.03	9.47	0.00
276	7910 3	8.20	48.56	49.01	8.61	8.20
279	7910 6	2.00	49.10	48.98	7.37	2.00
282	7910 9	0.00	48.88	48.95	7.48	0.00
285	791012	44.90	49.05	49.13	8.82	13.80
288	791015	10.70	48.97	49.14	10.80	20.70
291	791018	13.90	49.06	49.09	10.03	15.10
294	791021	0.00	49.02	49.03	9.12	0.00
297	791024	0.00	48.87	49.00	8.35	0.00
300	791027	0.00	48.95	48.97	7.77	0.00
303	791030	0.00	48.88	48.94	7.33	0.00
306	7911 2	0.00	48.85	48.89	6.69	0.00
309	7911 5	0.00	48.86	48.84	5.63	0.00
312	7911 8	17.30	48.80	48.82	5.13	15.66
315	791111	0.00	48.79	48.78	4.37	0.00
318	791114	0.00	48.75	48.75	4.22	0.00
321	791117	0.00	48.71	48.72	4.18	0.00
324	791120	0.00	48.71	48.69	4.35	0.00
327	791123	0.00	48.69	48.67	4.11	0.00
330	791126	0.00	48.66	48.64	4.08	0.00
333	791129	0.00	48.62	48.61	4.05	0.00
336	7912 2	6.00	48.61	48.58	4.01	6.00
339	7912 5	0.00	48.56	48.56	3.98	0.00
342	7912 8	0.00	48.53	48.53	3.95	0.00
345	791211	0.00	48.45	48.51	3.92	0.00
348	791214	0.00	48.44	48.48	3.89	0.00
351	791217	0.00	48.41	48.46	3.85	0.00
354	791220	0.00	48.39	48.43	3.85	0.00
357	791223	0.00	48.33	48.41	3.80	0.00
360	791226	0.00	48.34	48.39	3.77	0.00
363	791229	0.00	48.31	48.36	3.75	0.00

Scale									
AA	-3.6	32.0	67.6	103.2	138.7	174.3	209.9	245.4	281.0
BB (CC)	46.7	47.1	47.6	48.0	48.4	48.9	49.3	49.8	50.2
DD	0.3	3.3	6.4	9.5	12.5	15.6	18.7	21.7	24.8
EE	-0.3	2.6	5.4	8.3	11.1	13.9	16.8	19.6	22.5

FINAL WATER DEPTH IN TANK NO. 1 0.000 MM

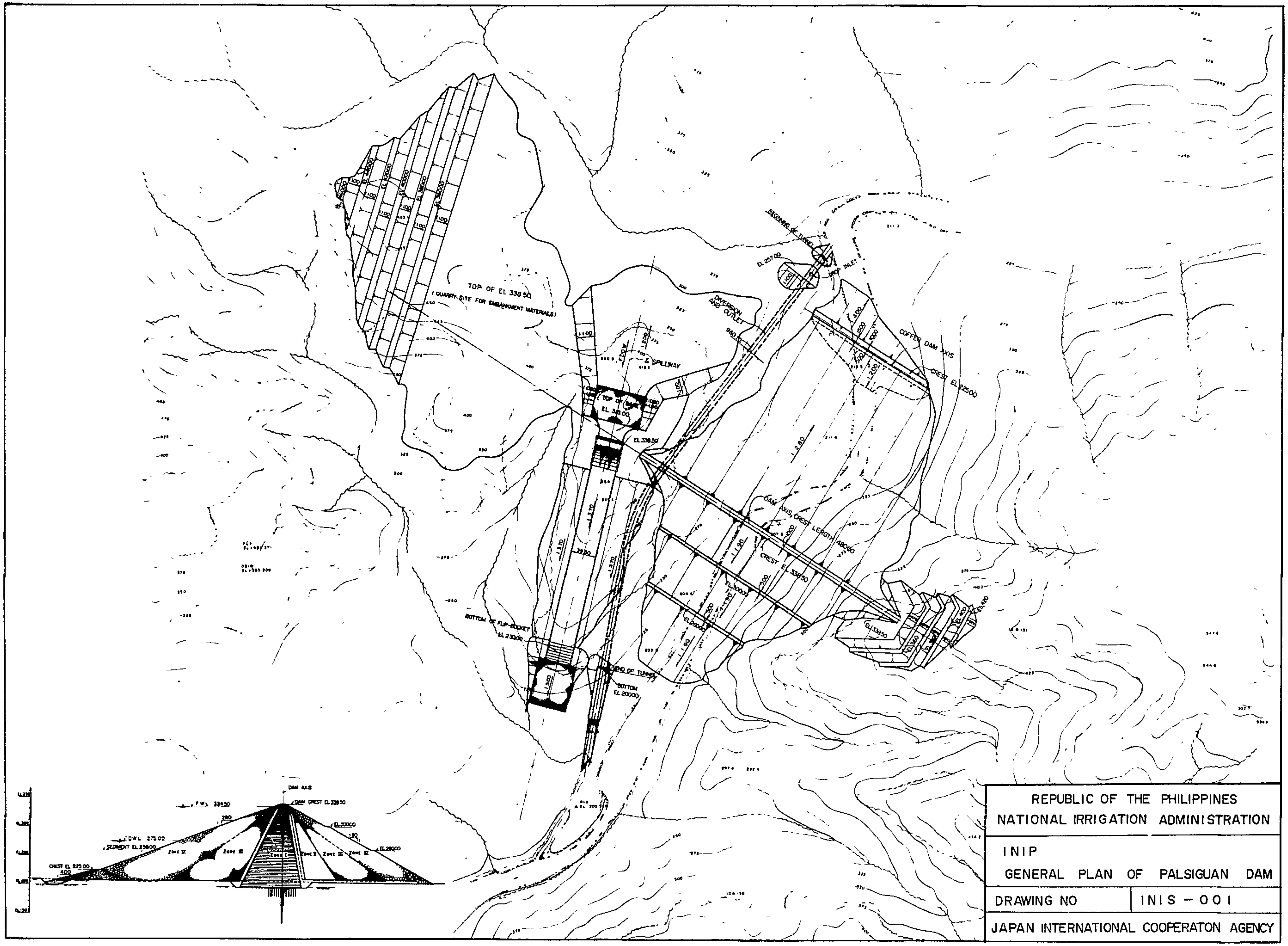
FINAL WATER DEPTH IN TANK NO 2 48349.927 MM

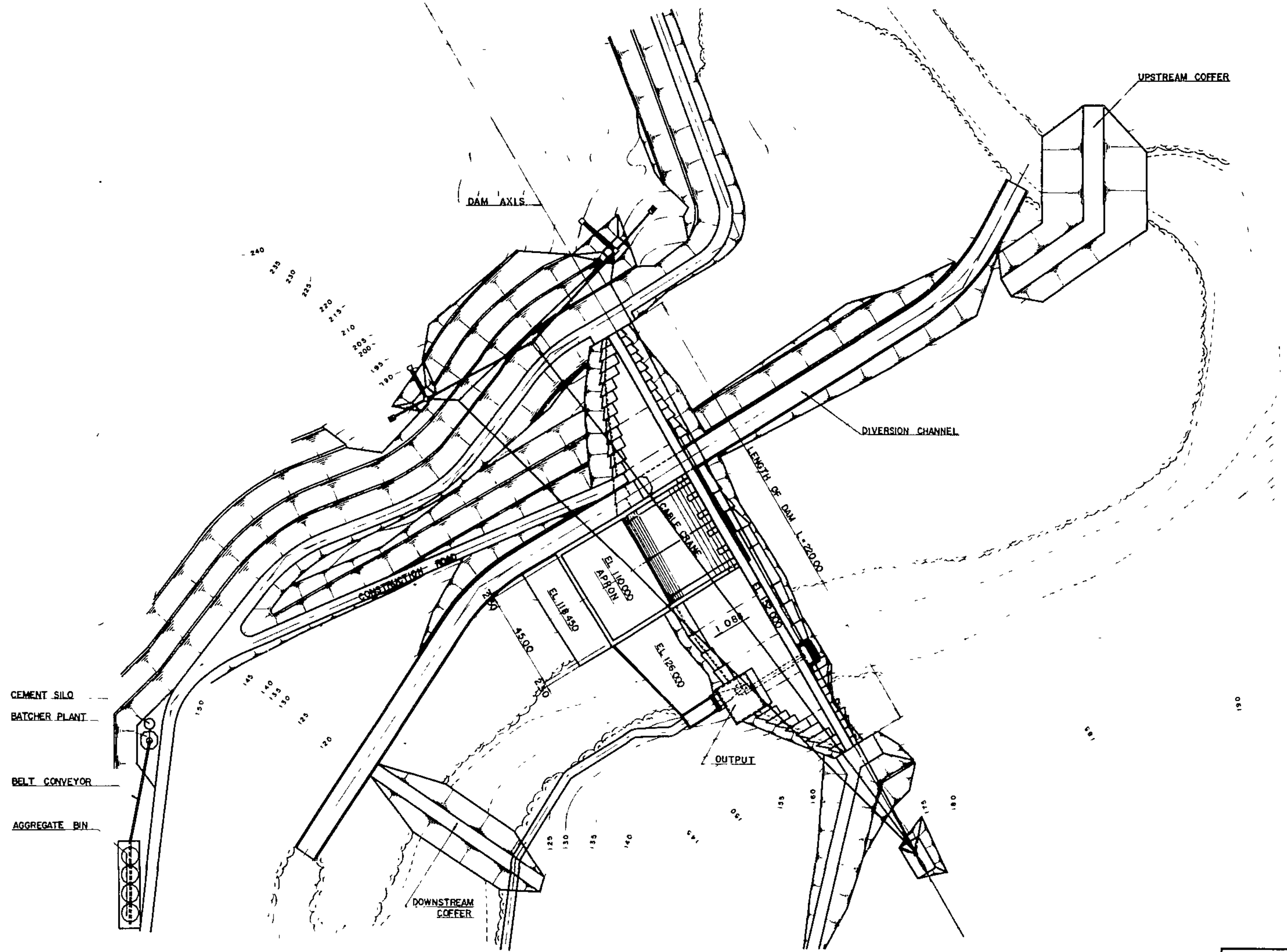
FIGURE B-5. TANK MODELS FOR 12 WELLS



LIST OF DRAWING

DWG NO	TITLE
INIS - 001	GENERAL PLAN OF PALSIGUAN DAM
INIS - 002	GENERAL PLAN OF NUEVA ERA DAM
INIS - 003	NUEVA ERA POWER STATION
INIS - 004	GENERAL PLAN OF MADUPAYAS DIVERSION DAM
INIS - 005	TYPICAL SECTION OF IRRIGATION CANAL
INIS - 006	LAYOUT OF ON-FARM FACILITY (PAOAY AREA)


TOP OF EL 338.50
(QUARRY SITE FOR EMBANKMENT MATERIALS)
DIVERSION AND OUTLET
SPILLWAY
BEGINNING OF TUNNEL
EL 257.00
COFFER DAM AXIS
CREST EL 225.00
DAM AXIS, CREST LENGTH 480.00
CREST EL 338.50
BOTTOM OF FLIP BUCKET EL 233.00
END OF TUNNEL
BOTTOM EL 200.00
DAM AXIS
DAM CREST EL 338.50
F.W.L 334.50
TDWL 275.00
SEDIMENT EL 258.00
CREST EL 223.00
EL 300.00
EL 280.00
REPUBLIC OF THE PHILIPPINES
NATIONAL IRRIGATION ADMINISTRATION
INIP
GENERAL PLAN OF PALSIGUAN DAM
DRAWING NO
INIS — 001
JAPAN INTERNATIONAL COOPERATON AGENCY

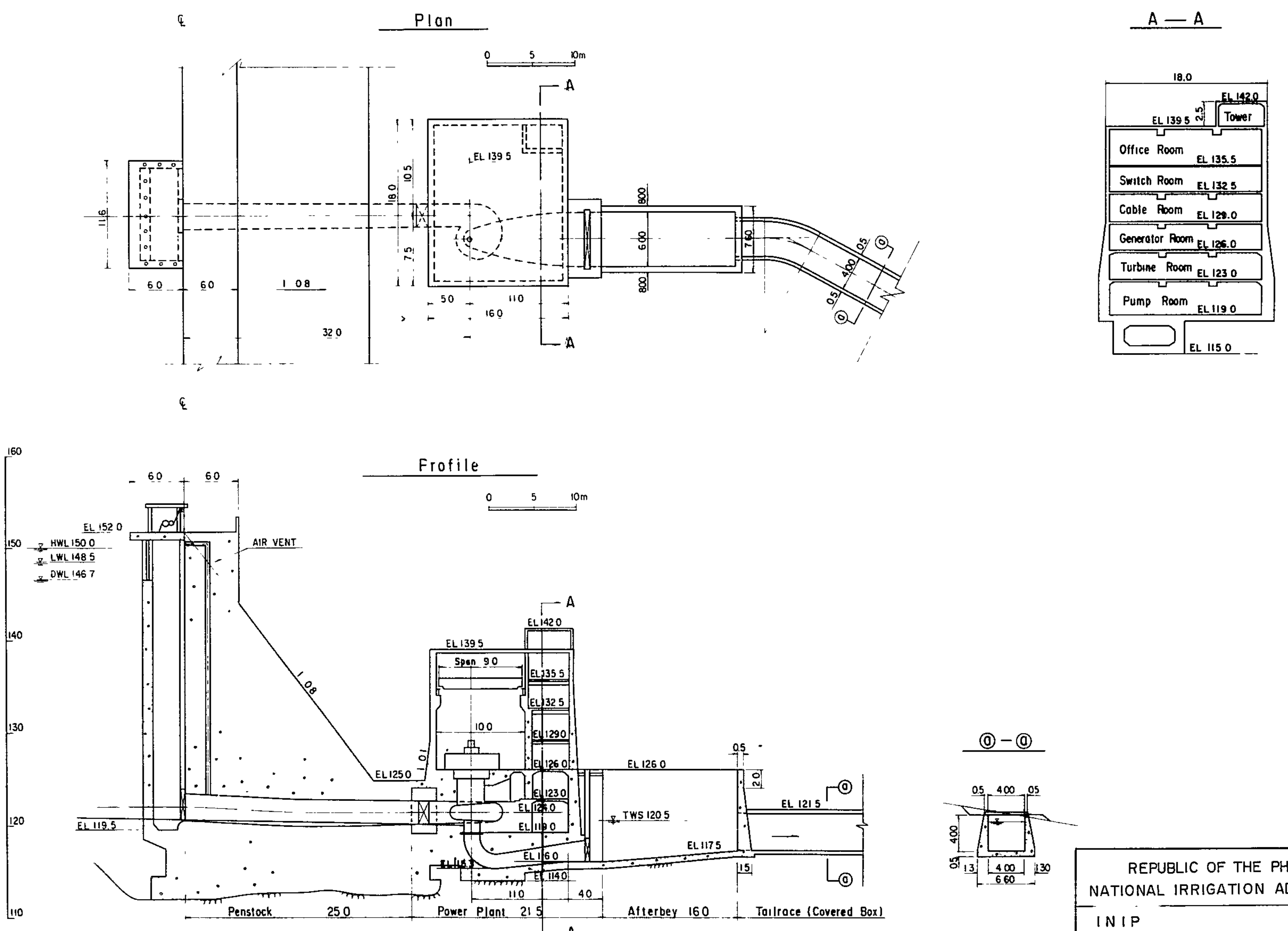


DAM PLAN

SCALE 1 : 100

REPUBLIC OF THE PHILIPPINES NATIONAL IRRIGATION ADMINISTRATION	
INIP GENERAL PLAN OF NUEVA ERA DAM	
DRAWING NO.	INIS — 0 0 2
JAPAN INTERNATIONAL COOPERATION AGENCY	

Nueva Era Power Station

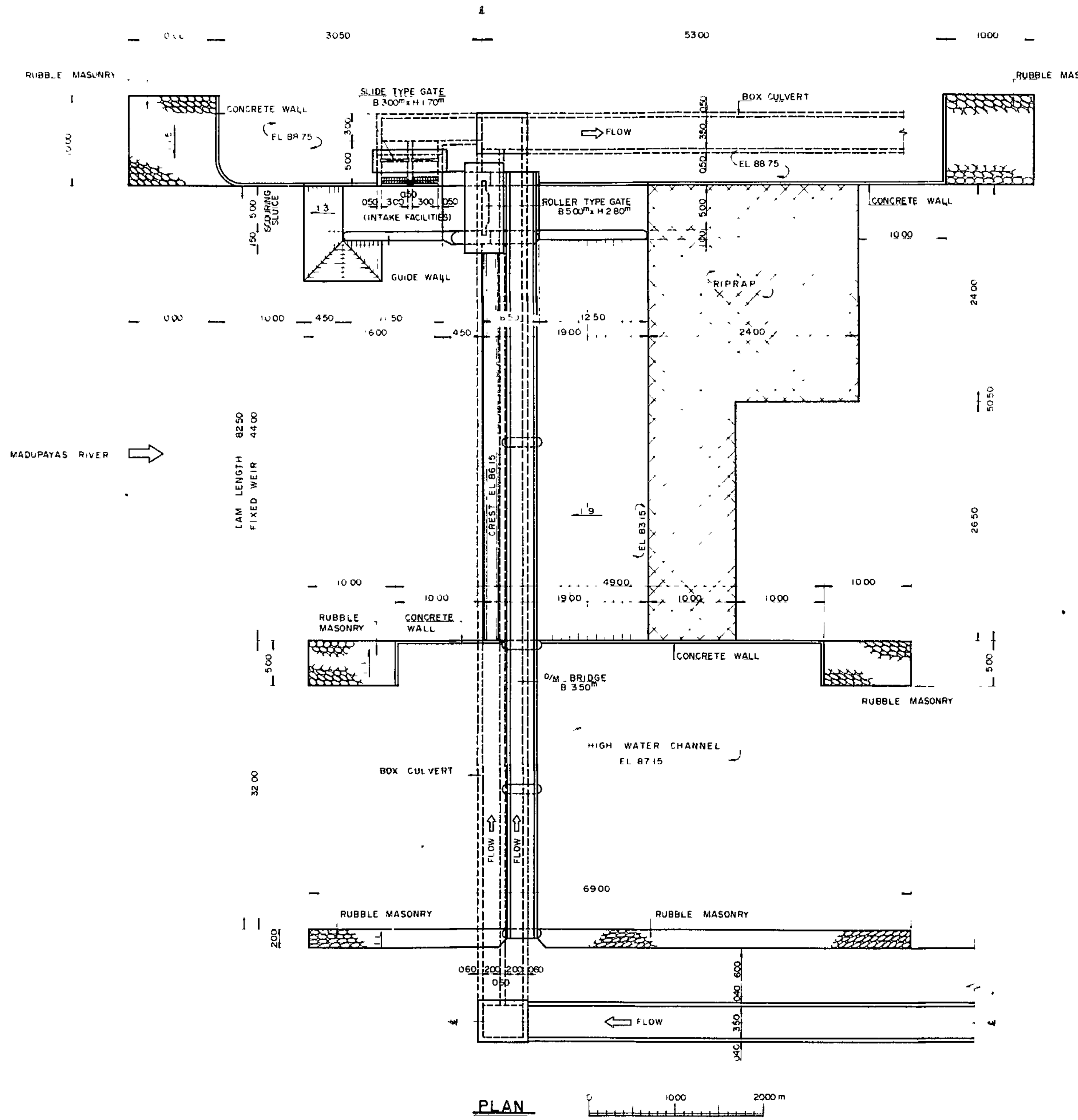


REPUBLIC OF THE PHILIPPINES
NATIONAL IRRIGATION ADMINISTRATION

INIP
NUEVA ERA POWER STATION

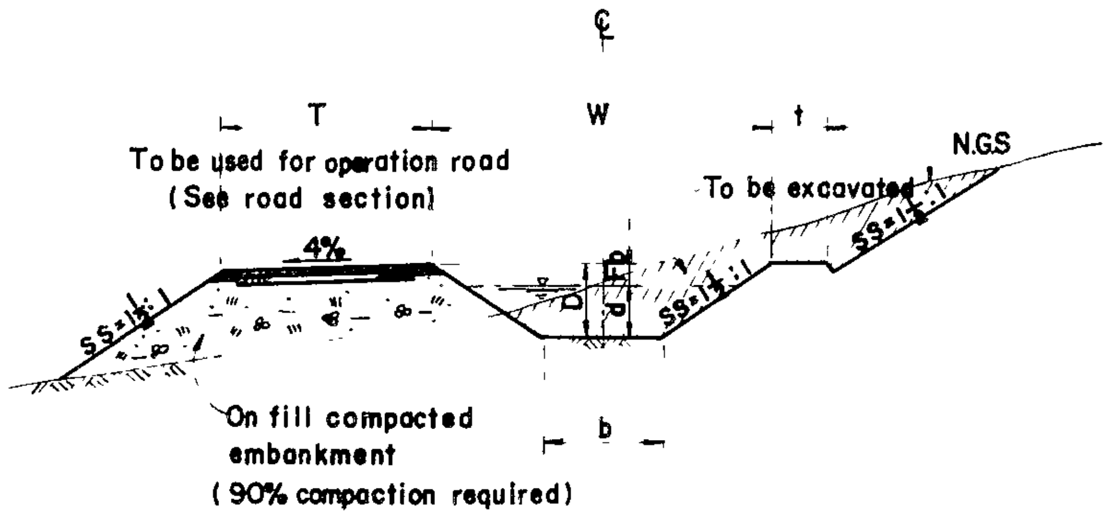
DRAWING NO.	INIS – 0 0 3

JAPAN INTERNATIONAL COOPERATION AGENCY

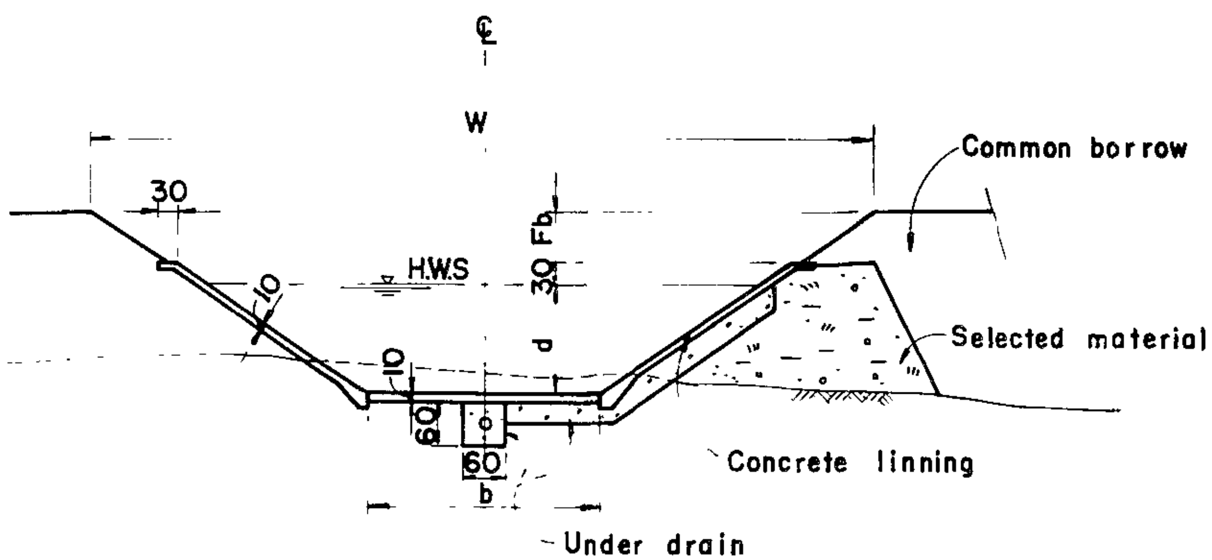


PLAN

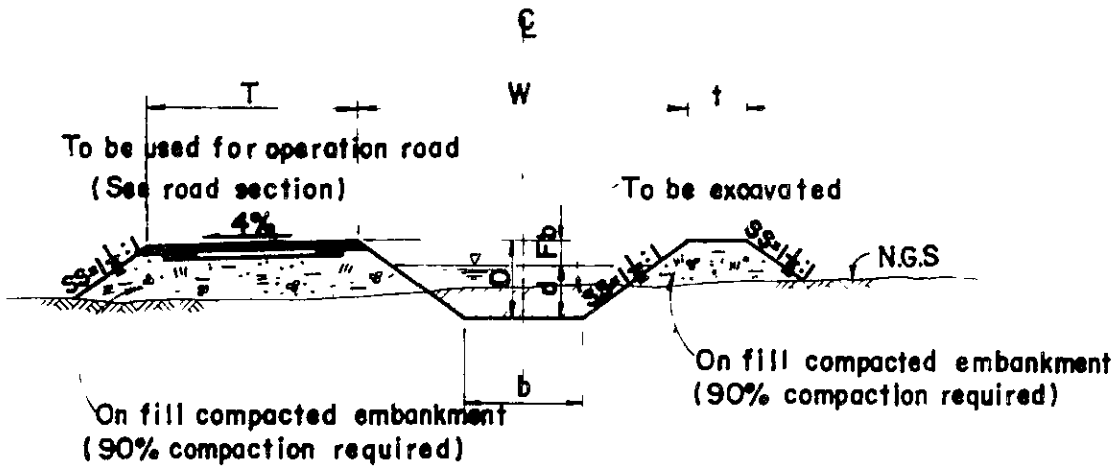
REPUBLIC OF THE PHILIPPINES NATIONAL IRRIGATION ADMINISTRATION
INIP GENERAL PLAN OF MAPUPAYAS DIVERSION DAM
DRAWING NO. INIS −004
JAPAN INTERNATIONAL COOPERATION AGENCY



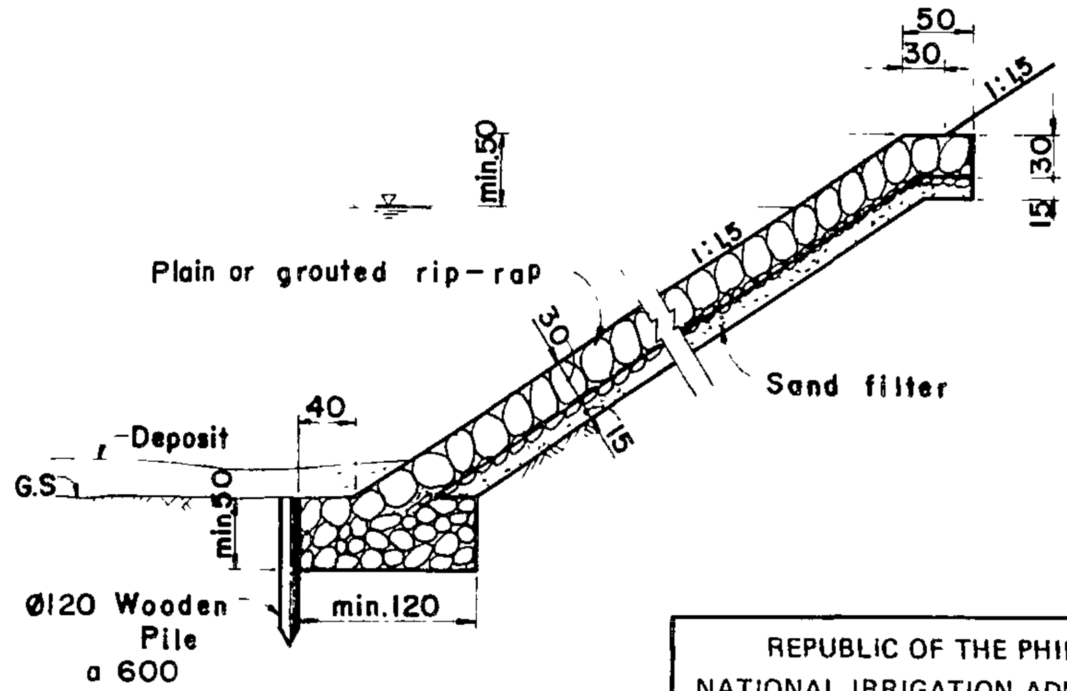
TYPICAL SECTION FOR INCLINED GROUND SURFACE



CONCRET LINNING

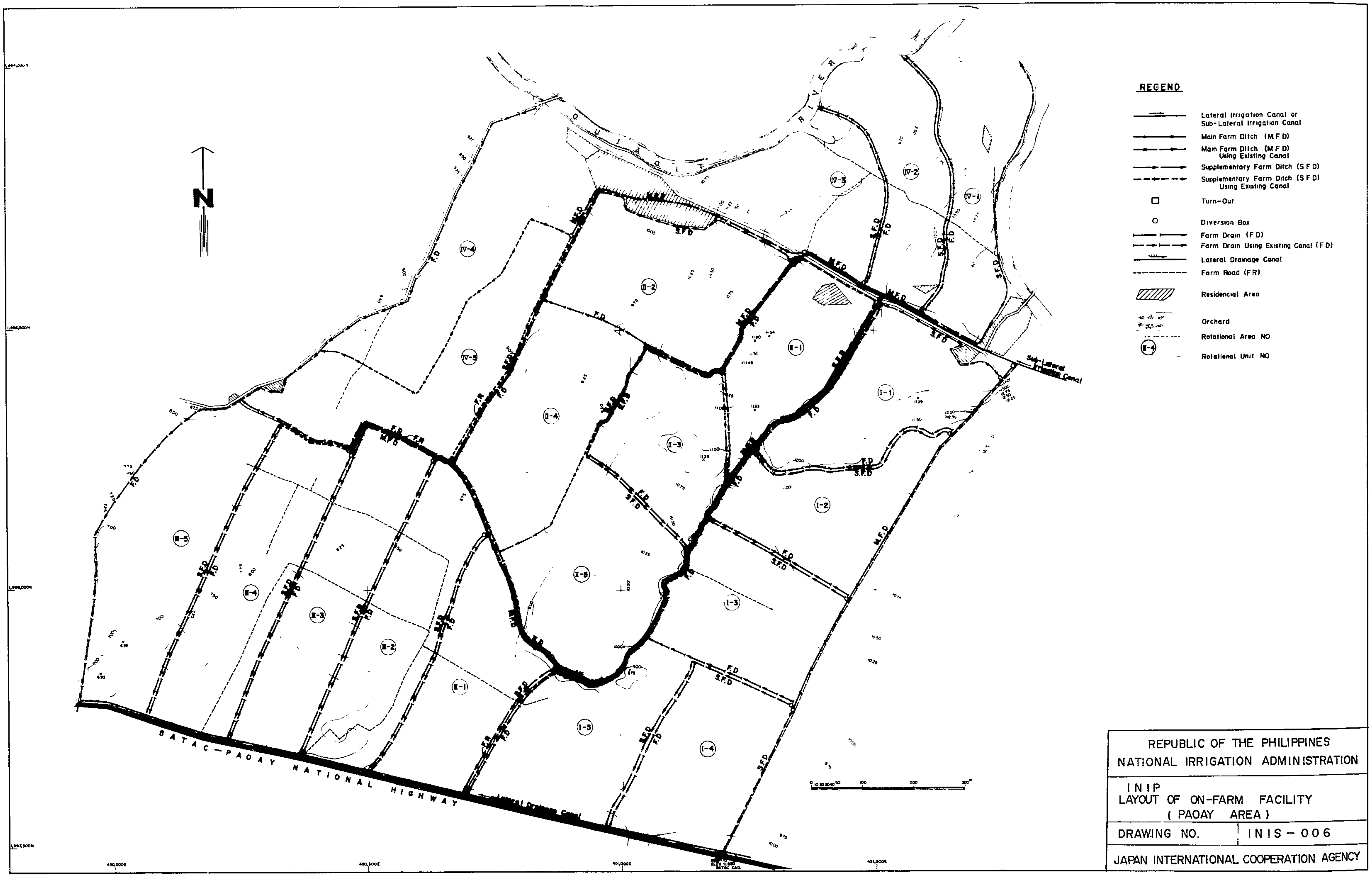


TYPICAL SECTION FOR FLAT GROUND SURFACE



GRAVEL PAVEMENT

REPUBLIC OF THE PHILIPPINES NATIONAL IRRIGATION ADMINISTRATION	
INIP TYPICAL SECTION OF IRRIGATION CANAL	
DRAWING NO.	INIS – 005
JAPAN INTERNATIONAL COOPERATION AGENCY	


REGEND
Lateral Irrigation Canal or Sub-Lateral Irrigation Canal
Main Farm Ditch (M.F.D)
Main Farm Ditch (M.F.D) Using Existing Canal
Supplementary Farm Ditch (S.F.D)
Supplementary Farm Ditch (S.F.D) Using Existing Canal
Turn-Out
Diversion Box
Farm Drain (F.D)
Farm Drain Using Existing Canal (F.D)
Lateral Drainage Canal
Farm Road (F.R)
Residencial Area
Orchard
Rotational Area NO
Rotational Unit NO
N
QUIAOIT RIVER
Sub-Lateral Irrigation Canal
BATAC-PAOAY NATIONAL HIGHWAY
Lateral Drainage Canal
M.F.D
S.F.D
F.D
F.R
IV-1
IV-2
IV-3
IV-4
IV-5
III-1
III-2
III-3
III-4
III-5
II-1
II-2
II-3
II-4
II-5
I-1
I-2
I-3
I-4
I-5
REPUBLIC OF THE PHILIPPINES
NATIONAL IRRIGATION ADMINISTRATION
INIP
LAYOUT OF ON-FARM FACILITY
(PAOAY AREA)
DRAWING NO. INIS-006
JAPAN INTERNATIONAL COOPERATION AGENCY