No. 33

MALAYSIA

FEASIBILITY STUDY
ON
SMALL SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT
AT UPPER LIWAGU RIVER BASIN
IN SABAH

FINAL REPORT

SUMMARY

OCTOBER, 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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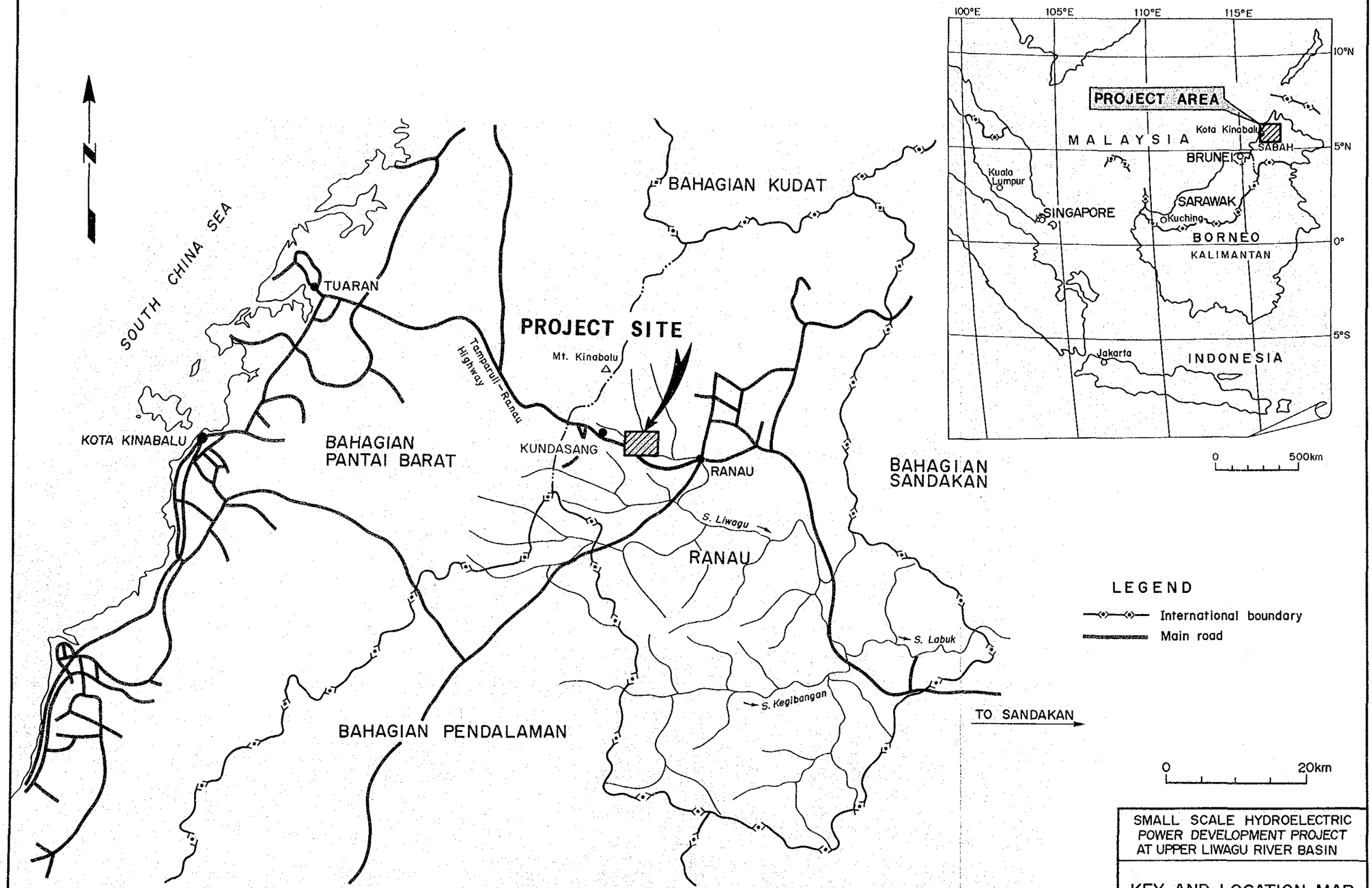
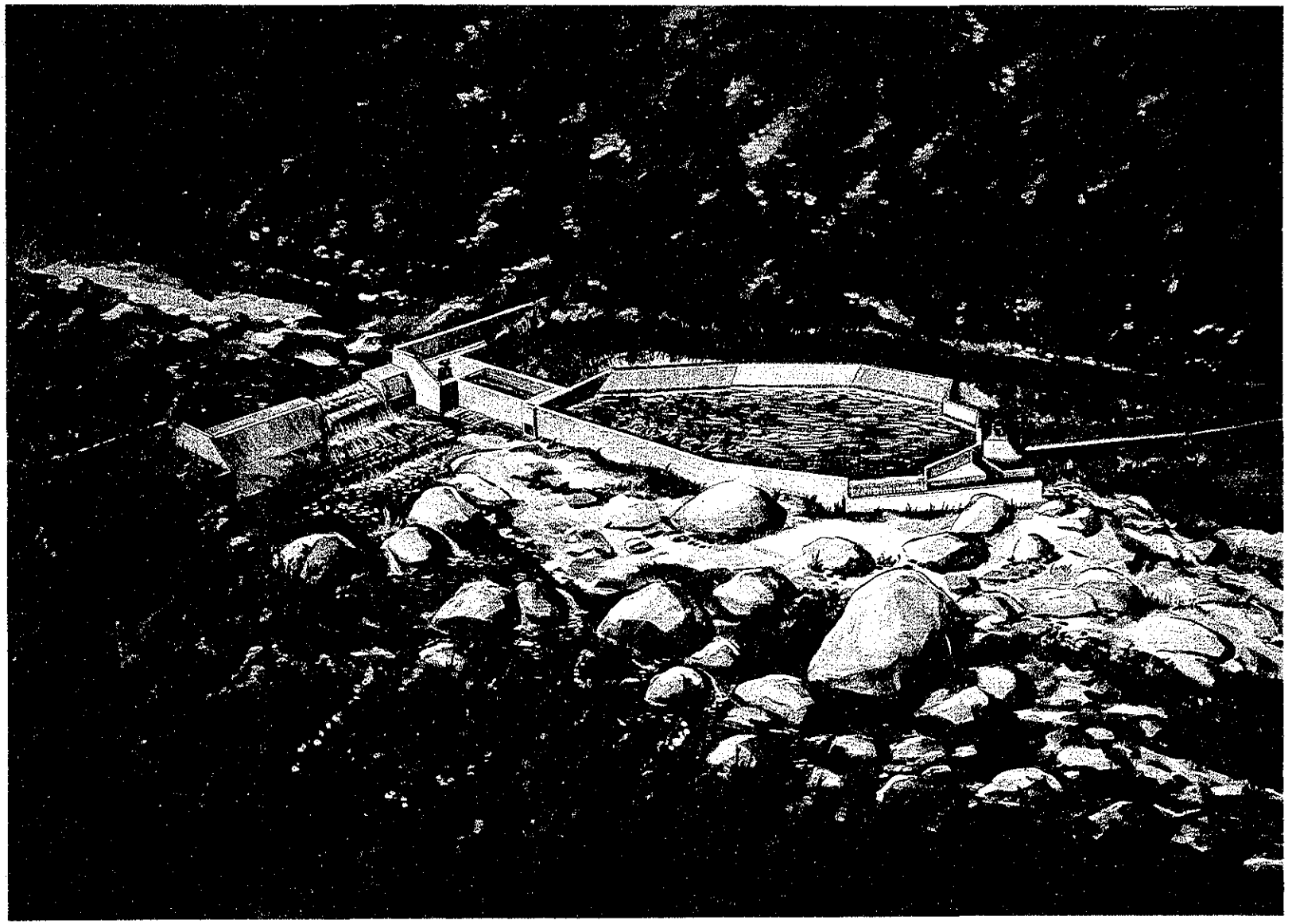


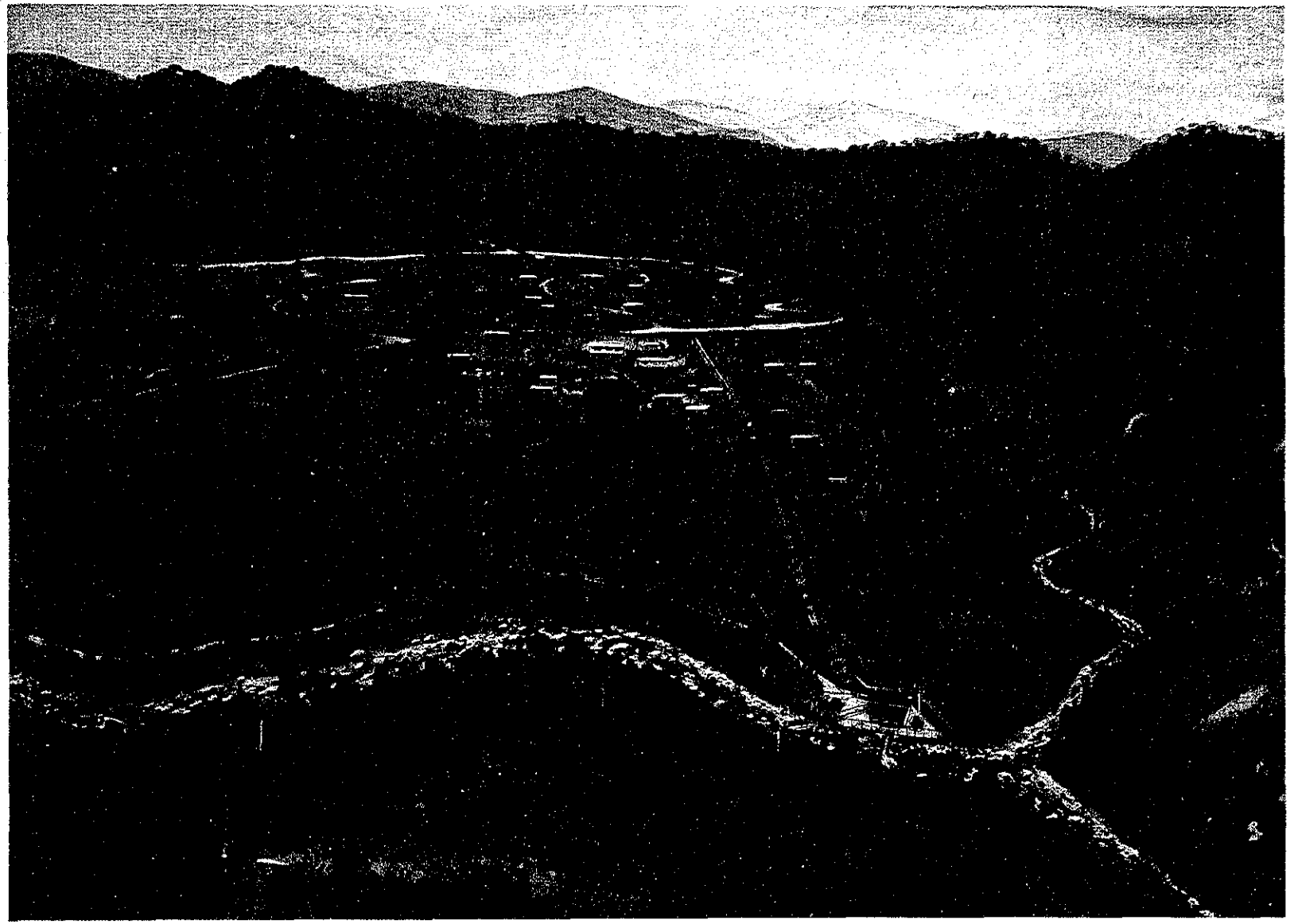
SMALL SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN

KEY AND LOCATION MAP

Fig. 1 – 1



Liwagu Intake Facility



Penstock and Powerhouse

Photo-1 Liwagu Intake Dam
(View from upstream)

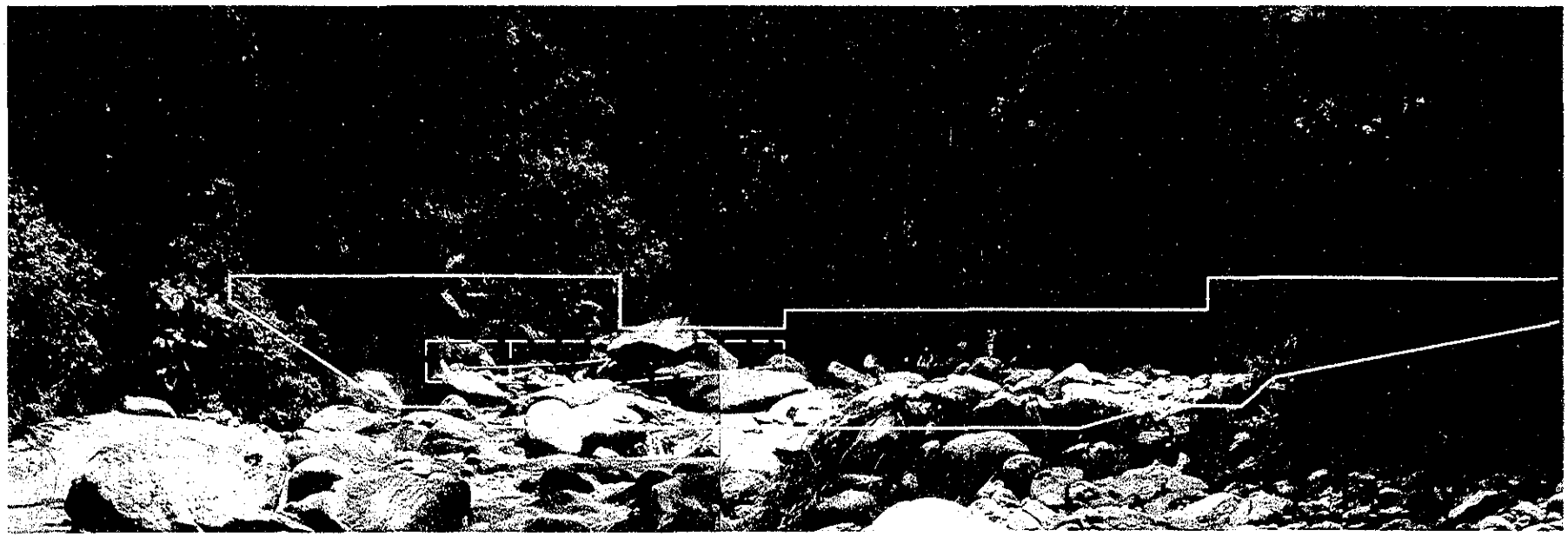


Photo-2 Mesilau Intake Dam
(View from dounstream)

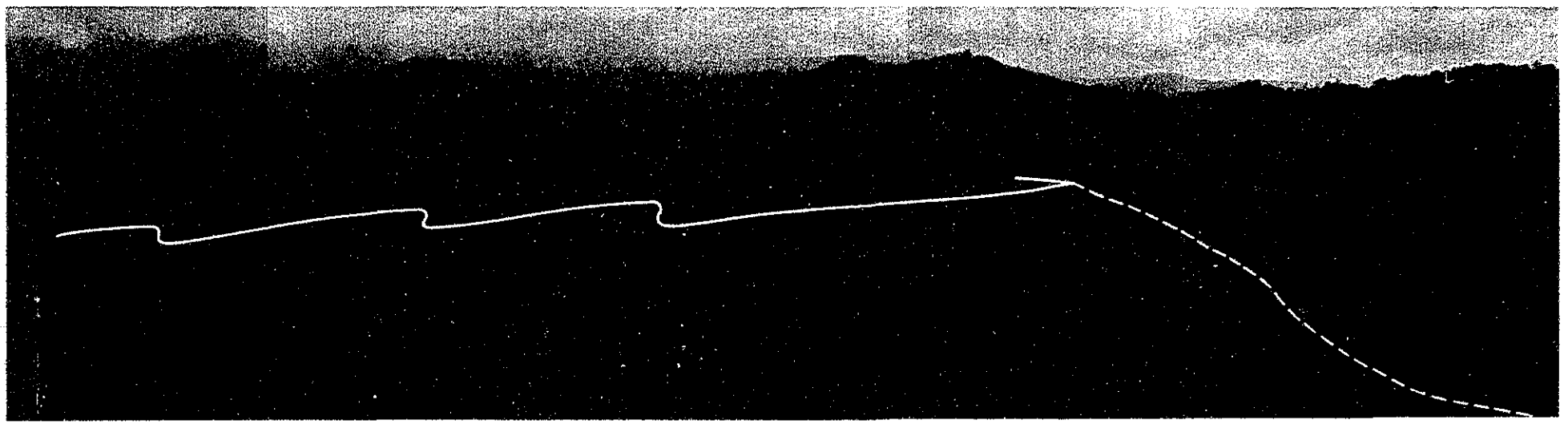


Photo-3 Liwagu Pipeline and Penstock

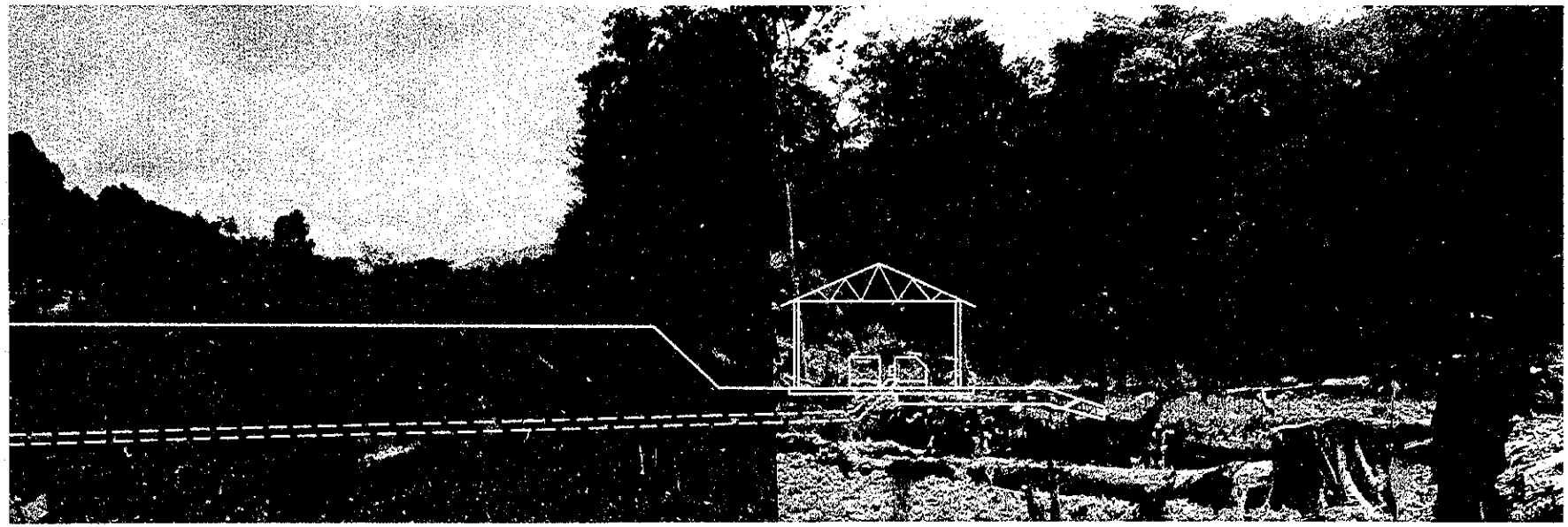


Photo-4 Powerhouse

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1. INTRODUCTION

This Report summarizes the results of the Feasibility Study on Small Scale Hydroelectric Power Development at Upper Liwagu River Basin in Sabah, Malaysia.

The Feasibility study was carried out in response to the request of the Government of Malaysia to the Japan Government. The Scope of Works for the Study was agreed upon between the Economic Planning Unit (EPU) on behalf of the Government of Malaysia and the Japan International Cooperation Agency (JICA) on March 13, 1991.

JICA entrusted the Electric Power Development Co., Ltd. (EPDC), Japan, to perform the study on the basis of the Scope of Works.

The JICA Study Team, headed by Mr. T. Tezuka, Team Leader, started the preparatory works for the study in July 1991. First, the Inception Report was prepared. The Report contained the policy of the study, method of the study, division of the technical undertakings between the EPU and the JICA. In the Report, the Study Team divided the study period into three stages on the basis of the Scope of Works, namely, Identification Stage, Field Investigation Stage and Preliminary Design Stage. Second, the site reconnaissances were carried out to select the optimum site for the project and prepared the Interim Report in September 1991. Third, the field investigation works were carried out at the selected site and the Progress Report prepared in March 1992. Finally, development plan and preliminary design were carried out. All study works were completed in July 1992.

The study was mainly performed at the Sabah Electricity Board (SEB) together with counterparts in SEB. During the study, technical transfer including seminars (by JICA and the Study Team) was given to SEB's engineers.

2. STUDY RESULTS

2.1 Present State of Electric Facility in Ranau Area

Ranau area, to become the object area of the Small Scale Hydropower Development Project, is an isolated area in the power grid, and is approximately 170 km^2 spread out on the southeast side of Mt. Kinabalu (EL. 4,101 m), centered at Kundasang Town located at El. 1,500 m and Ranau Town located at EL. 500 m. The population of this area is estimated to have been approximately 32,600 as of the end of 1990, of which those receiving supply of electric power was 15,100 (2,960 customers x 5.1 capital/customer), from which, if the electrification rate were to be calculated, would correspond to an electrification rate of 46.3%.

The power demand of the installed Ranau-Kundasang Grid was 1,330 kW and the number of customers 2,960 as of the end of 1990. Electric power is being supplied to those customers by 11 kV HV transmission lines and 415 V/240 V distribution lines.

The electric power supply facilities are mainly the diesel power generation facility at Ranau (effective capacity: 1,120 kW) and the diesel power generation facility at Kundasang (effective capacity: 660 kW), while there is also Carabau Mini-hydro power station (installed capacity: 2,000 kW) which started operation in January 1991. Hence the total effective capacity of power generating facilities is 3,780 kW. Furthermore, three Mesilau Mini-hydro power stations (100 kW x 3) were completed at Kundasang from 1983 to 1984, but all three are presently stopped due to landsliding which occurred in 1985. SEB put out repairs of the three Mini-hydro power stations and the repair works are scheduled to be completed around the end of 1992.

2.2 Power Demand Forecast

Ranau-Kundasang Grid had 2,960 customers (an electrification rate of 46.3% at the end of 1990. It was thought the number of potential

customers would be as many as 3,430. The Grid also has been 6,025 MWh of annual energy and 1,330 kW of annual maximum demand.

The power demand forecast for the Ranau-Kundasang Grid was made based on the two parameters of unit requirement (electric energy consumption per customer) and electrification rate taking into account the present state of electrification of the object district.

As the result of power demand forecast, the followings were obtained (Table 1).

Year	Number of Customers Electrified	Annual Energy Requirement (kWh)	Annual Maximum Demand (kW)
1995	4,260	11,583	2,520
2000	5,620	18,958	3,930
2005	6,920	27,064	5,620
2010	8,480	36,585	7,590
2015	9,630	43,617	9,050

The optimum timing of commissioning the Naradaw project (1,600 kW) was determined in 1997 taking into consideration the power demand balance of kWh and kW as shown in **Fig. 1**.

By commissioning Naradaw project, the following fuel oil cost saving of the diesel power stations will be expected.

	1997	2000	after 2009
Oil saving (M$)	842,000	1,338,000	1,764,000
Naradaw P/S Generation (MWh)	4,600	7,300	9,500

2.3 Site Selection

An optimum site for the small scale hydropower development was selected by two basic concepts. First, the site does not prevent the construction of the major hydro project (165 MW) which is located at the middle

stream of the Liwagu River. Second, the optimum site and alternative scheme were studied in consideration of the power demand forecast, the role of hydropower and diesel power.

The Team reviewed 20 sites taking into account requirements for small scale hydro plants to meet future demand in Ranau area; then chose 5 sites and 6 development plans to be studied in detail. They are Kualuan, Naradaw, Gantong A, Gantong B, Pakai and Lamas 2.

As the result of comprehensive study. Naradaw site was selected for the optimum site (hereinafter referred to as Naradaw project).

2.4 Topographic Maps

Existing topographic maps available for use in study of the project are of scale 1/50,000, 1/12,500 and 1/2,500.

For preliminary designing to be carried out on the selected project site, topographic maps of 1/500 scale around the main structures were made through topographic survey in the Field Investigation Stage. JICA Team prepared Technical Specifications for the topographic survey works and advised the survey works. The following areas were surveyed for the topographic maps of the scale 1/500.

- Intake dam site at Liwagu River 0.014 km^2
- Intake dam site at Mesilau River 0.015 km^2
- Penstock and Powerhouse sites 0.115 km^2

2.5 Geology

Regional geology and geology of project sites were studied using the existing geological information. Geological investigation works such as drilling, geological mapping were carried out at the selected sites in the Field Investigation Stage to get geological information for the preliminary design of main structures. JICA Team prepared the

Technical Specifications for the geological investigation works and advised the works.

The following geological investigations were carried out.

Site	Description	Quantity
Liwagu intake	Drilling	2 holes, 30 m
Mesilau intake	Drilling	2 holes, 30 m
Headpond (Alternative)	Drilling	2 holes, 40 m
Penstock	Drilling	2 holes, 40 m
Powerhouse	Drilling	2 holes, 40 m
Project area	Geological mapping	10 km^2
Liwagu intake	Geological mapping	0.012 km^2
Mesilau intake	Geological mapping	0.017 km^2
Penstock-powerhouse	Geological mapping	0.069 km^2

2.6 Meteorology and Hydrology

For hydrological analysis, the regional meteorological data and hydrological data were collected. River flow data of Bedukan gauging station (closed in 1981) was applied for the analysis.

The following discharges were obtained from the hydrological analysis.

95% flow	Liwagu intake	0.24 m^3/s
	Mesilau intake	0.21 m^3/s
	Total	0.45 m^3/s
Return period 50 years (Design flood discharge)	Liwagu intake	200 m^3/s
	Mesilau intake	180 m^3/s
	Powerhouse	220 m^3/s

2.7 Selection of Optimum Development Plan

Naradaw project, the fifth run of river type small scale hydropower plant in Ranau area, has a major objective to save diesel oil and contribute electric power to Ranau-Kundasang Grid, economically.

Selection of optimum plan means to select a net head, a design maximum discharge and an installed capacity by comparing benefit and cost for alternative plans at Naradaw site.

AS the result, installed capacity 1,600 kW and design maximum discharge 1.20 m^3/s were selected as the optimum plan.

The commissioning year of Naradaw project depends on kW and kWh balance caused by supply capability of generating facilities and peak demand predicted in the Ranau-Kundasang Grid and especially on operation condition of Carabau hydropower station. The Carabau has a capability to generate much energy generated from two units, which were occasionally repaired. In the case that both two units work stably in future, the year 2000 is considered to be the commissioning year for Naradaw. In the case that one unit works, the year 1997 will be the commissioning year for Naradaw.

2.8 Transmission Line Route

The powerhouse site of Naradaw Small Scale Power Station is located several tens of meters upstream from the confluence of the Liwagu River and Mesilau River. An 11 kV HV line of 1 km is to be constructed from the 11,000/3,000 V step-up transformer located outdoors of the power station for a connection to be made with the existing 11 kV HV lines constructed along the road between Kundasang and Ranau.

2.9 Preliminary Design

Preliminary design for Naradaw project was carried out on the basis of the optimum development plan. Civil structures such as intake facility, headpond, waterway, powerhouse, access roads and electro-mechanical equipment such as turbine, generator were comparatively studied.

As the result, the stream bed type intake facility including desilting basin was selected at Liwagu and Mesilau Rivers. Concrete facing type

headponds (regulating capacity 800 m^3 for Liwagu, 600 m^3 for Mesilau, respectively) were selected at the downstream of the desilting basin. Low head steel pipelines (horizontal routes) have been designed along the Liwagu River (0.70 m in diameter, 2,680 m in length) and Mesilau River (0.60 m in diameter, 990 m in length). The buried steel penstock (0.80 m in diameter, 780 m in length) was adopted due to the geological condition. Two units of Turgo Impulse type turbine were adopted.

The selected preliminary design of the structures are shown in **DWG. 1~5.**

Salient futures of the Naradaw project are shown below.

Development Plan

(1)	Catchment area	Liwagu	31 km^2
		Mesilau	28 km^2
		Total	59 km^2
(2)	Design maximum discharge	Liwagu	0.70 m^3/s
		Mesilau	0.50 m^3/s
		Total	1.20 m^3/s
(3)	Elevation of intake crest	Liwagu	EL. 1,049.50 m
		Mesilau	El. 1,038.00 m
(4)	Headpond water level	Liwagu	EL. 1,048.30 m
		Mesilau	EL, 1,036.50 m
(5)	Tailrace water level		El. 852.00 m
(6)	Effective head		170 m
(7)	Installed capacity		1,600 kW
(8)	Firm peak power		460 kW

(9) Supply capable energy 9.5 GWh

Facilities

(1) Liwagu Intake Facility

Intake dam

Type	:	overflow type concrete dam
Dimension	:	height 3.50 m, overflow crest length 24.00 m

Intake

Type	:	stream bed type (Tyolean type)

Desilting basin

Dimension	:	width 4.00 m, length 14.00 m

Headpond

Type	:	concrete facing type
Regulating Capacity	:	800 m^3

(2) Mesilau Intake Facility

Intake dam

Type	:	overflow type concrete dam
Dimension	:	height 4.00 m, overflow crest length 22.00 m

Intake

Type	:	stream bed type (Tyrolean type)

Desilting basin

Dimension	:	width 2.50 m, length 11.00 m

Connecting pipe (steel pipe)

Internal diameter	:	0.60 m
Length	:	90 m

Headpond

Type	:	concrete facing type
Regulating capacity	:	600 m^3

(3) Liwagu Pipeline

Type	:	surface type steel pipe
Dimension	:	internal diameter 0.70 m, length 2,680 m

(4) Mesilau Pipeline

Type	:	surface type steel pipe
Dimension	:	internal diameter 0.60 m, length 990 m

(5) Penstock

Type	:	buried steel pipe
Dimension	:	internal diameter 0.80 m, length 780 m

(6) Powerhouse

Type	:	surface type
Dimension	:	width 11.00 m, length 19.00 m

(7) Turbine

Type	:	Turgo Impulse Turbine
Number	:	2 units
Effective head	:	170 m
Max. discharge	:	0.60 m^3/s

(8) Generator

Type	:	3-phase Synchronous Generator
Number	:	2 units
Capacity	:	890 kVA

(9) Transformer

Type	:	outdoor 3 phase oil immersed, self-cooled
Number	:	2 units
Capacity	:	890 kVA

(10) Transmission Line

Voltage	:	11 kV HV
Length	:	1 km

(11) Access Road

New construction

Length	:	5,460 m

Improvement

Length	:	1,450 m

2.10 Construction Plan

Construction works of Naradaw project consist of access roads, intake facilities, pipelines, penstock, powerhouse and electro-mechanical equipment.

Construction period has been planned 2.5 years in total. Access roads to reach intake dams and powerhouse should be started at first. The pipelines will be installed at the same time at several sections of the both the Liwagu and Mesilau pipelines.

Construction schedule of Naradaw project is shown in **Fig. 2.**

2.11 Cost Estimate

The construction cost of Naradaw project is comprised of all costs; civil works, electro-mechanical equipment, transmission line, project land cost/compensation and engineering management.

The construction costs were estimated at the time of June 1992. The unit prices were applied at market prices in Sabah referring to the actual results of the similar mini-hydro power projects of SEB and unit prices of the Public Works Department. The some particular works were estimated based on foreign country prices.

The locally made construction materials were adopted as much as possible to reduce the costs, because the Naradaw project is a small scale hydropower development project.

The total construction cost of the Naradaw project was estimated as follows.

Total construction cost M$ 11,500,000

Summary of construction costs is shown in **Table 2.** The construction costs are estimated in local currency and in foreign currency.

2.12 Environmental Impact Study

Environmental impact study (EIA) for the project was conducted by Universiti Kebangsaan Malaysia. JICA Team prepared the Technical Specifications for the study and advised the assessment.

As the result, potential impacts of the project on the environment are not expected to be significant if the recommendations in the EIA report are followed and appropriate mitigation and abatement measures are taken.

2.13 Economic and Financial Evaluation

The economic evaluation was made comparing the present value of the total construction cost and OM costs of Naradaw project, shown as "Cost", and of the total construction cost, OM cost, fuel cost of its alternative diesel power plant shown as "Benefit".

The financial analysis was performed by comparing the present value of the total construction cost and OM costs of Naradaw project, "Cost", and the gross revenue to be earned by energy sales, "Benefit".

The period of calculation is twenty-five (25) years which are the composite service life of Naradaw project.

As the result, the following EEDR, FEDR and generating costs were obtained.

EEDR : 10.71%

FEDR : 10.86%

Generating cost: (average cost during 25 years)

	Case 1 (all government loan)	Case 2 (all government grant)
Cost	M$ 0.122/kW	M$ 0.068/kWh

3. Conclusion

(1) Annual energy requirement and annual maximum demand in the Ranau-Kundasang Grid in 1990 were 6,025 MWh and 1,330 kW respectively. According to the power demand forecast, the above figures will be increased to 18,958 MWh and 3,930 kW in 2000.

To meet the power demand forecast, an electric power development plan is required in the Grid.

In the Grid, two diesel power stations (Ranau 1,120 kW, Kundasang 660 kW derated capacity, respectively) and Carabau mini-hydro power station (installed capacity 2,000 kW) are operating at the pent. Mesilau mini-hydro (installed capacity 300 kW) is under repair work.

Naradaw project is proposed as a Small Scale Hydropower Development Project at Upper Liwagu River Basin, having the major objective to save fuel oil of existing diesel engine power stations and contribute electric power to Ranau-Kundasang Grid.

(2) The optimum timing of commissioning of Naradaw project (1,600 kW) was determined in 1997 taking into consideration the power demand balance of kWh and kW.

On the other hand, regarding kW balance based on the firm peak output of hydropower plans, it can be said that additional diesel power plants would be necessary to install before and after the commissioning of the Naradaw project in the Ranau-Kundasang Grid to meet peak power demand.

(3) Naradaw project site was selected from 20 sites which were studied previously. Topographic survey, geological investigation and environmental impact assessment were carried out in the project area. JICA Team prepared Technical Specifications for each of the investigation works and advised the works.

(4) The project has planned for the installed capacity 1,600 kW and consists of Liwagu intake facility and Mesilau intake facility, Liwagu pipeline and Mesilau pipeline, one penstock and powerhouse (two units of Turgo Impulse Type Turbine). Access roads to reach the intakes and powerhouse also have been planned. Short distance transmission line connected between the powerhouse and the existing line has been planned.

(5) Construction period for the project was planned as 2.5 years and construction cost of the project was estimated as M$11,500,000.

(6) Potential impact of the project on the environment is not expected to be significant if the recommendations in the EIA report are followed and appropriate mitigation and abatement measures are taken.

(7) As the results of economic and financial analyses, EEDR and FEDR are as follows.

EEDR : 10.71%
FEDR : 10.86%

4. Recommendations

(1) Naradaw project is feasible technically, economically and financially. The project is recommended to be put in service in the beginning of 1997.

(2) Detail design is needed for each structure including access roads because this report shows preliminary design.

(3) Prior to the construction, the following investigations are required for the detail design.

- Detailed route selection and centerline survey along the pipelines including access roads
- Survey of river cross-section at the intake dams.
- Seismic prospecting survey along the penstock route.

(4) For the detail design and during construction, particular attention is required for the slope protection at the steep topographical sections along the pipelines.

(5) During the construction work at the penstock route, security for the local residents who live around the route has to be considered.

Table 1 Power Demand Forecast for Ranau-Kundasang Grid from 1991 to 2015

No.	Year	Estimated Population in Kundasang -Ranau Grid	Potential Number of Consumers	Electrification Ratio (%)	Number of Consumers Electritied	*1Monthly Average Consumption Per Customers (kWh)	Annual Energy Reguirement at Consumers End (MWh)	Energy Loss Factor (%)	at Generating End			Remarks
									Annual Load Factor (%)	Annual Energy Requirement (MWh)	Annual Maximum Demand (kW)	
Historical Data	1985	26,900	5,270	38.7	2,038	116	2,836	11.7	50.1	3,210	730	
	1986	28,000	5,490	41.7	2,288	113	3,103	12.1	51.0	3,530	790	Note *1
	1987	29,100	5,700	44.0	2,507	128	3,863	6.9	50.9	4,150	930	Growth Rate :
	1988	30,200	5,920	44.6	2,640	154	4,875	8.1	49.2	5,303	1,230	1990~1995 : 6 %
	1989	31,400	6,160	44.1	2,722	152	4,971	10.1	50.1	5,532	1,260	1995~2000 : 4 %
	1990	32,600	6,390	46.3	2,960	154	5,484	9.0	51.7	6,025	1,330	2000~2005 : 3 %
1	1991	33,900	6,650	47.0	3,130	163	6,122	10.0	52.0	6,734	1,480	2005~2010 : 2 %
2	1992	35,200	6,900	49.0	3,380	173	7,017	10.0	52.0	7,719	1,690	2010~2015 : 1 %
3	1993	36,600	7,180	51.0	3,660	183	8,037	11.0	53.0	8,921	1,920	
4	1994	38,000	7,450	53.0	3,950	194	9,196	11.0	53.0	10,208	2,200	Power demand in National Park
5	1995	39,500	7,750	55.0	4,260	206	10,530	11.0	53.0	11,583	2,520	is included from 1992.
6	1996	41,000	8,040	56.0	4,500	214	11,556	12.0	54.0	12,943	2,740	
7	1997	42,600	8,350	57.0	4,760	223	12,738	12.0	54.0	14,267	3,020	
8	1998	44,300	8,690	58.0	5,040	232	14,031	12.0	54.0	15,715	3,320	
9	1999	46,000	9,020	59.0	5,320	241	15,385	12.0	54.0	17,201	3,640	
10	2000	47,800	9,370	60.0	5,620	251	16,927	12.0	55.0	18,958	3,930	
11	2001	49,000	9,610	61.0	5,860	258	18,143	12.0	55.0	20,320	4,220	
12	2002	50,300	9,860	62.0	6,110	266	19,503	12.0	55.0	21,843	4,530	
13	2003	51,600	10,120	63.0	6,380	274	20,977	12.0	55.0	23,494	4,880	
14	2004	53,000	10,390	64.0	6,650	282	22,504	12.0	55.0	25,204	5,230	
15	2005	54,300	10,650	65.0	6,920	291	24,164	12.0	55.0	27,064	5,620	
16	2006	55,800		66.0		296		12.0	55.0			
17	2007	57,200		67.0		302		12.0	55.0			
18	2008	58,700		68.0		308		12.0	55.0			
19	2009	60,200		69.0		315		12.0	55.0			
20	2010	61,800	12,120	70.0	8,480	321	32,665	12.0	55.0	36,585	7,590	
21	2011	63,400		70.0		324		12.0	55.0			
22	2012	65,000		70.0		327		12.0	55.0			
23	2013	66,700		70.0		331		12.0	55.0			
24	2014	68,500		70.0		334		12.0	55.0			
25	2015	70,200	13,760	70.0	9,630	337	38,944	12.0	55.0	43,617	9,050	
Annual Growth Rate (%)		3.1	3.1	—	4.8	3.1	8.2	—	—	8.2	8.0	

Table 2 Summary of Construction Cost

	Description	Local Currency (M$)	Foreign Currency (M$)	Amount (M$)
1.	Civil Engineering Works	6,099,000	o	6,099,000
	1.1 Preliminaries	200,000	o	200,000
	1.2 Liwagu Intake Facilities	509,000	o	509,000
	1.3 Mesilau Intake Facilities	647,000	o	647,000
	1.4 Liwagu Pipeline	2,284,000	o	2,284,000
	1.5 Mesilau Pipeline	543,000	o	543,000
	1.6 Penstock	813,000	o	813,000
	1.7 Powerhouse	175,000	o	175,000
	1.8 Access Road	928,000	o	928,000
2.	Electrical and Mechanical Works	400,000	2,750,000	3,150,000
3.	Transmission Line	140,000	o	140,000
4.	Project Land Cost and Compensations	250,000	o	250,000
5.	Engineering and Management (10% of above total)	690,000	275,000	965,000
6.	Contingencies	731,000	165,000	896,000
	10% of Civil Engineerings Works	610,000	o	610,000
	5% of Electrical and Mechanical Works	20,000	138,000	158,000
	5% of Transmission Lines	7,000	o	7,000
	10% of Project Land Cost and compensations	25,000	o	25,000
	10% of Engineering, Management and Commissioning	69,000	27,000	96,000
	Grand Total	8,310,000	3,190,000	11,500,000

Figure 1 Peak Power Demand in Ranau - Kundasang Grid

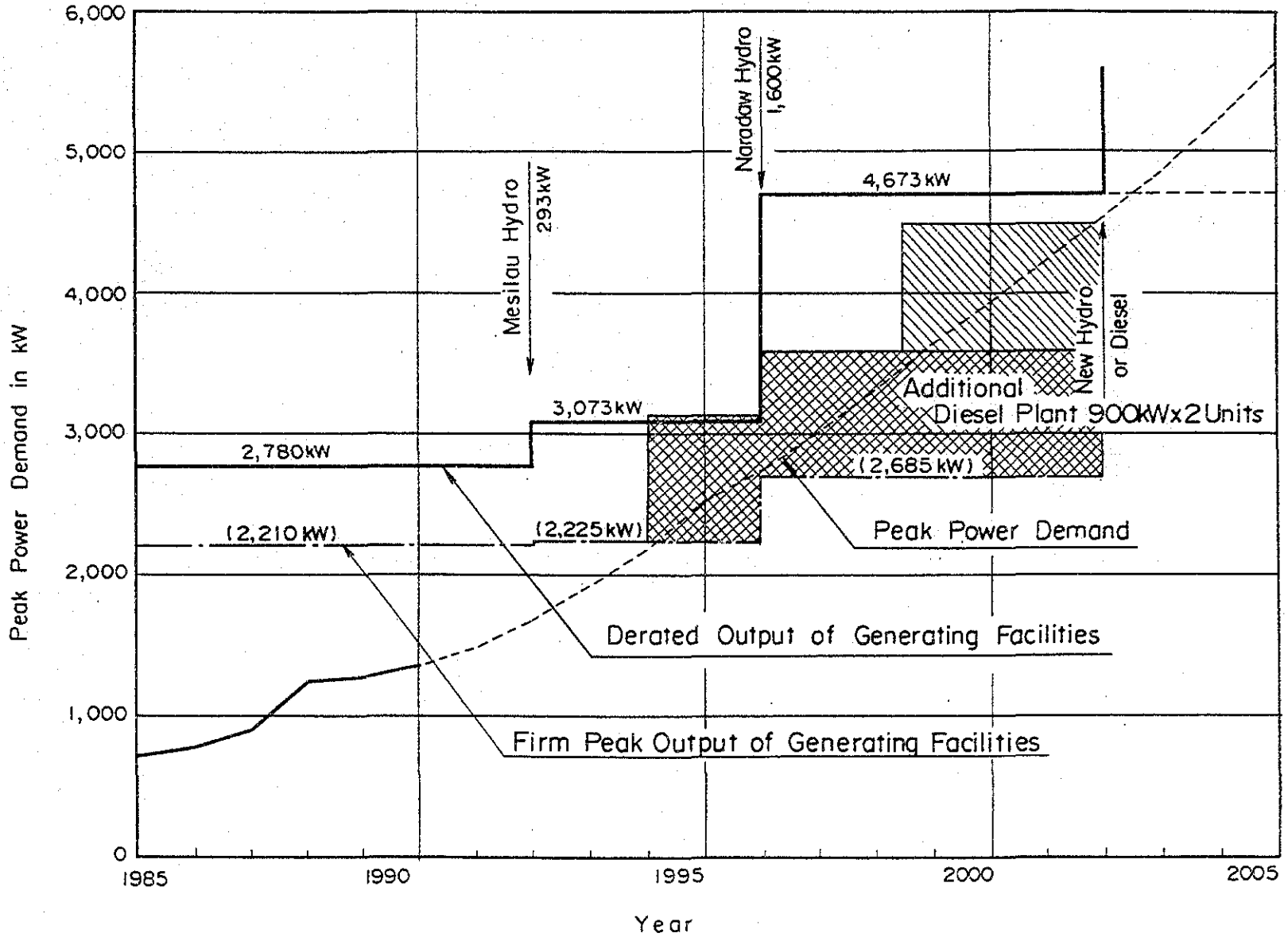
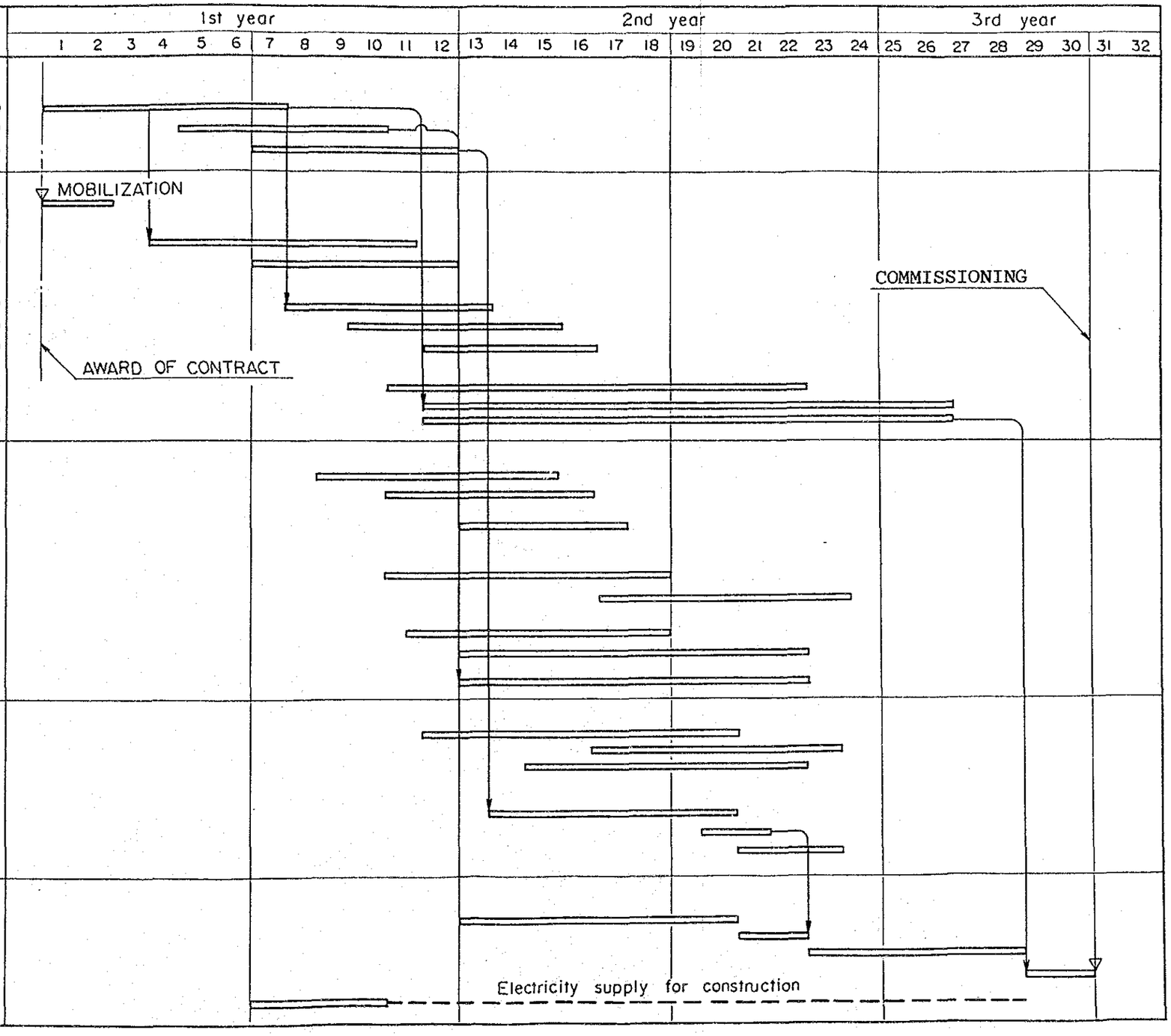
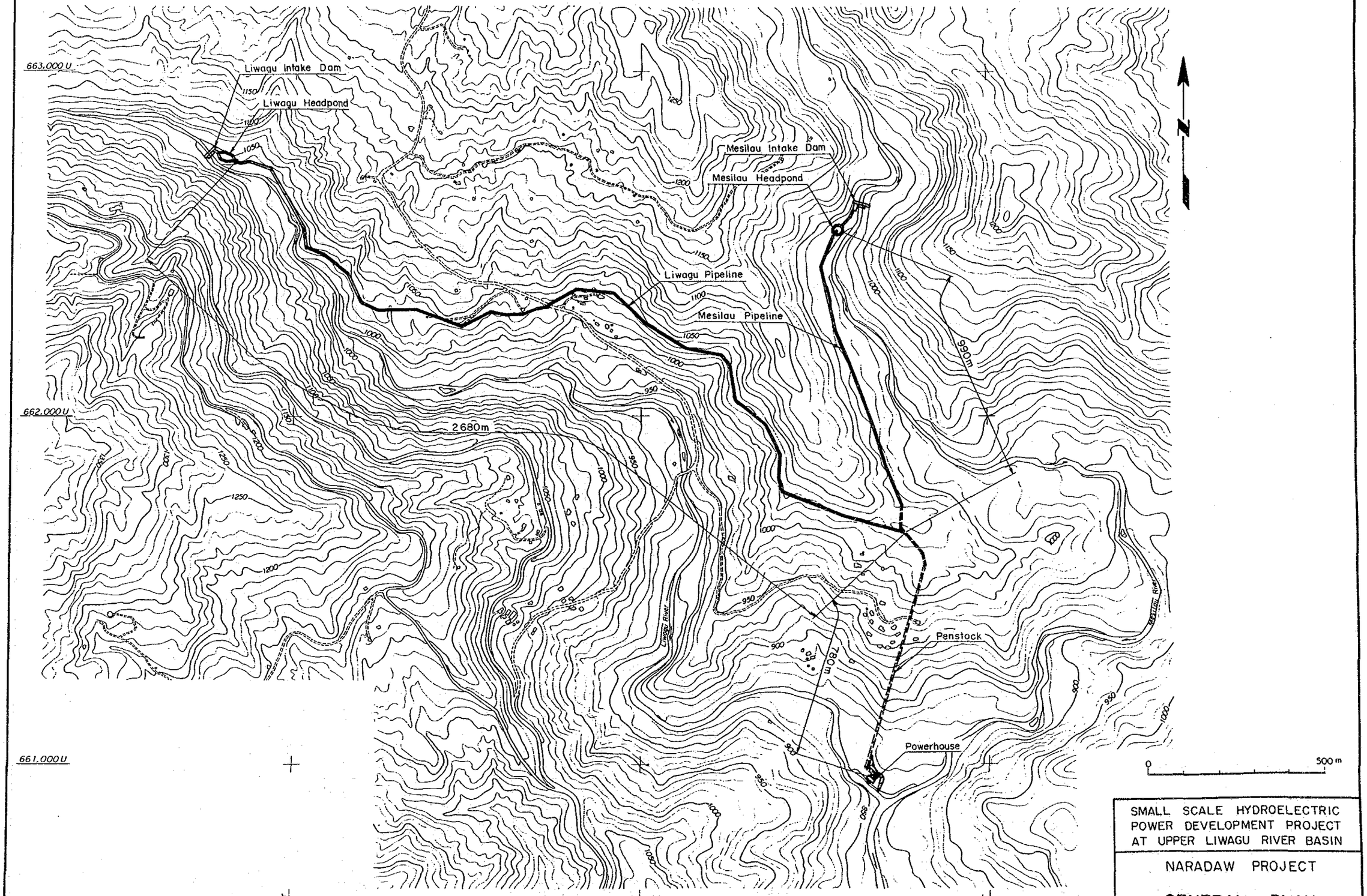


Figure 2

CONSTRUCTION SCHEDULE

DESCRIPTION	Unit	Q'ty
I. PREPARATORY WORKS		
ACCESS ROAD		
Liwagu Intake	m	2,200
Mesilau Intake	m	1,700
Powerhouse	m	1 560
II. CIVIL WORKS		
LIWAGU INTAKE		
Excavation	m^3	940
Concrete	m^3	650
LIWAGU HEADPOND		
Excavation	m^3	400
Concrete	m^3	380
Embankment	m^3	960
LIWAGU PIPELINE (L=2,680m)		
Excavation	m^3	940
Concrete	m^3	430
Pipeline	m	2,680
MESILAU INTAKE		
Excavation	m^3	450
Concrete	m^3	740
CONNECTING PIPELINE (L=90m)		
MESILAU HEADPOND		
Excavation	m^3	3,500
Concrete	m^3	300
MESILAU PIPELINE (L=990m)		
Excavation	m^3	160
Concrete	m^3	80
Pipeline	m	990
PENSTOCK		
Excavation	m^3	2,400
Concrete	m^3	90
Penstock Installation	m	780
POWERHOUSE		
Excavation	m^3	3,000
Concrete	m^3	130
Powerhouse Building	LS	1
III. E/M EQUIPMENT		
Design and Manufacturing		
Transport		
Erection		
Tests and Commissioning		
IV. TRANSMISSION LINE	km	1



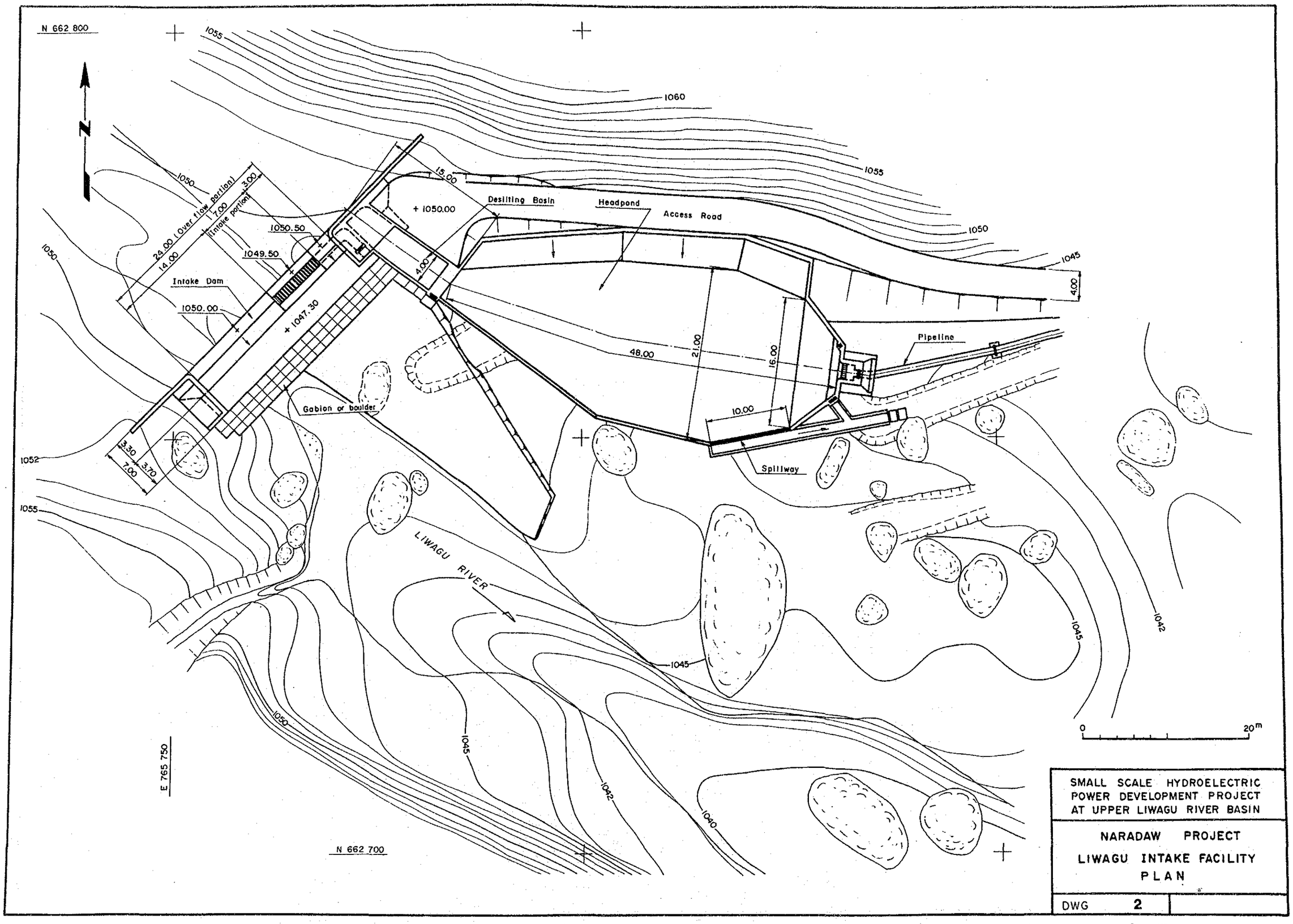


SMALL SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN

NARADAW PROJECT

GENERAL PLAN

DWG 1



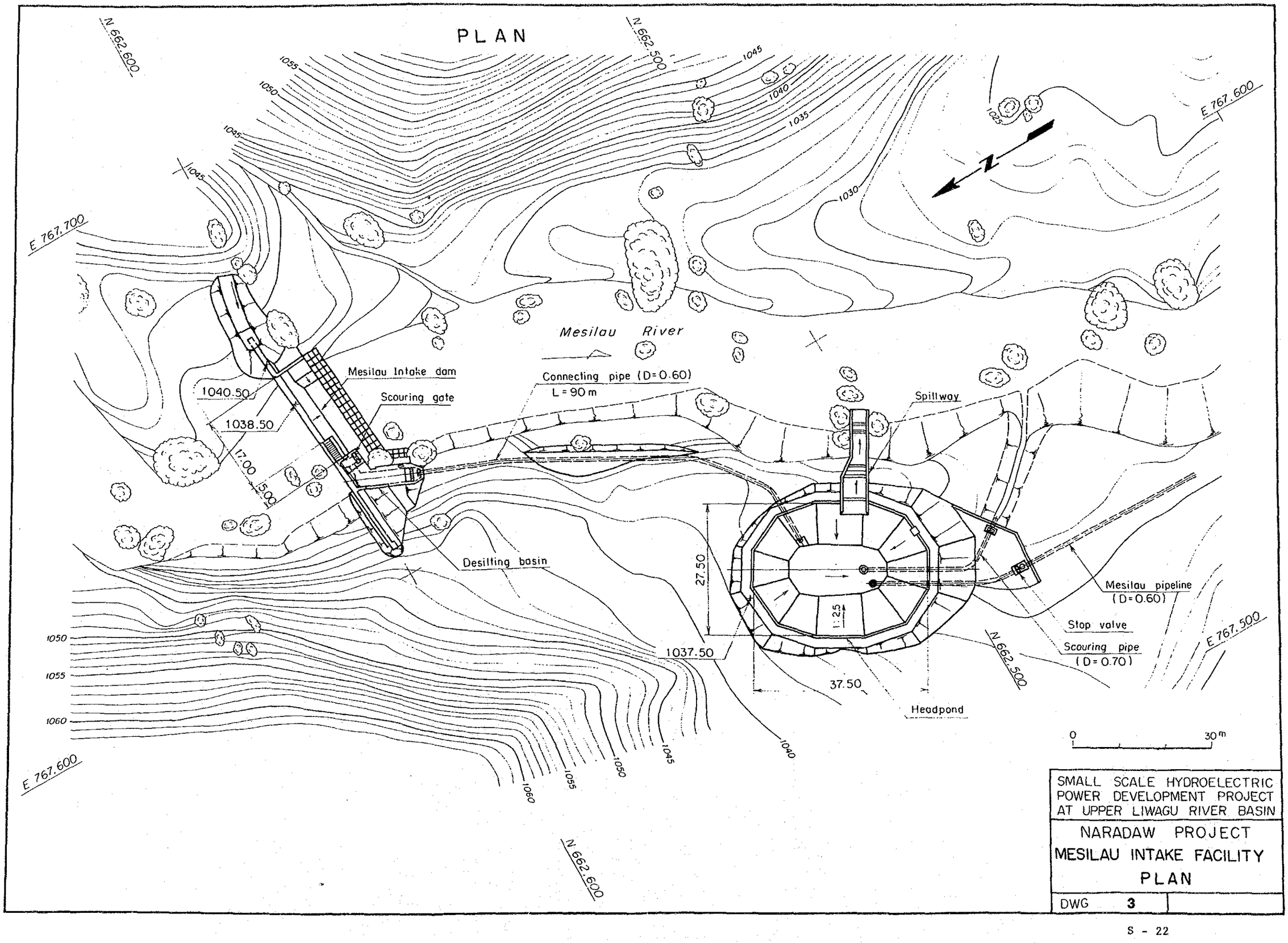
SMALL SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN

NARADAW PROJECT

LIWAGU INTAKE FACILITY PLAN

DWG 2

PLAN



SMALL SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN

NARADAW PROJECT

MESILAU INTAKE FACILITY

PLAN

DWG 3

PLAN

N 661.600

N 661.400

N 661.200

N 661.000

E 767.800

E 767.600

30.00

90.00

516.00

31.00

85.00

Mesilau pipeline

Beginning point of penstock

Liwagu pipeline

Penstock

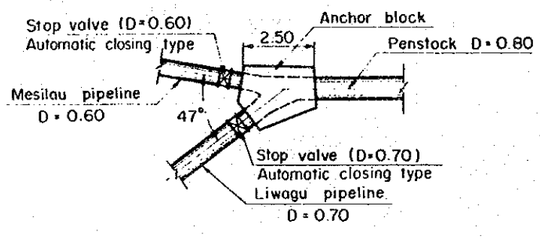
"A"

"B"

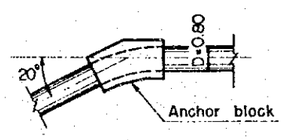
"C"

LIWAGU RIVER

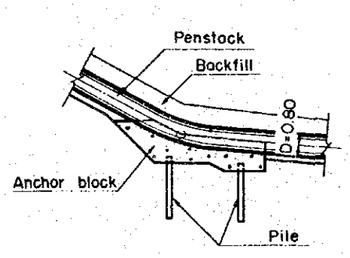
DETAIL "A"
(Plan)



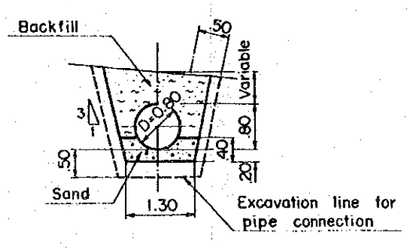
DETAIL "B"
(Horizontal Bend)



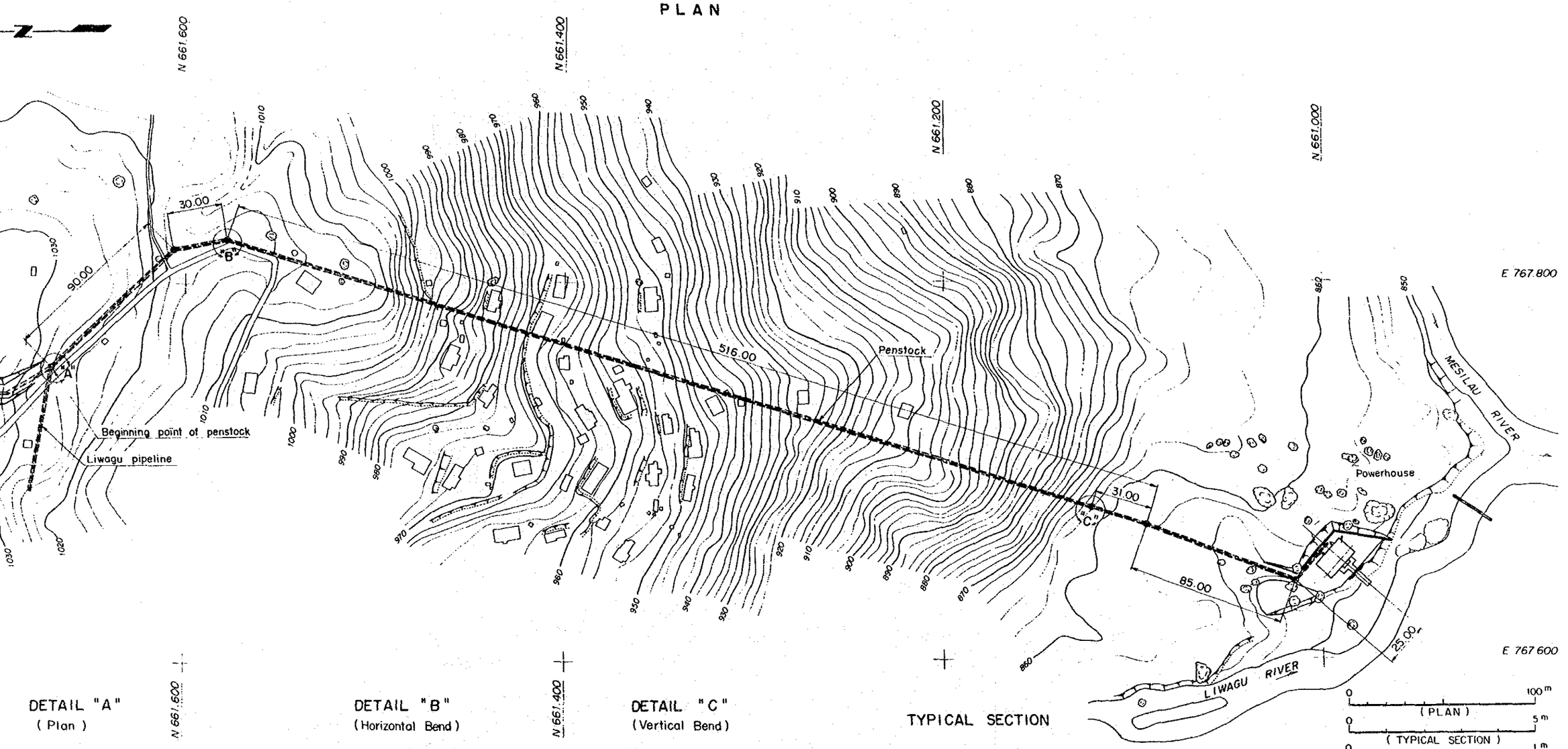
DETAIL "C"
(Vertical Bend)



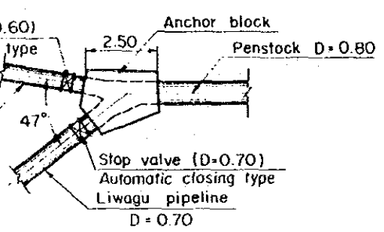
TYPICAL SECTION



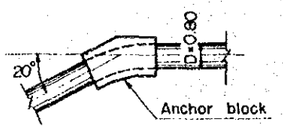
PLAN



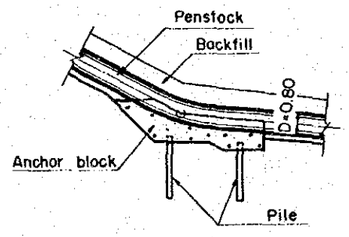
DETAIL "A"
(Plan)



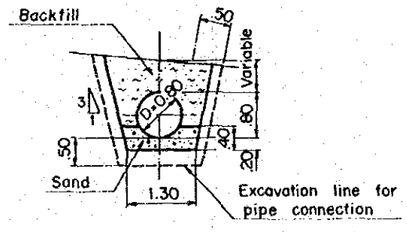
DETAIL "B"
(Horizontal Bend)



DETAIL "C"
(Vertical Bend)



TYPICAL SECTION



SMALL SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN

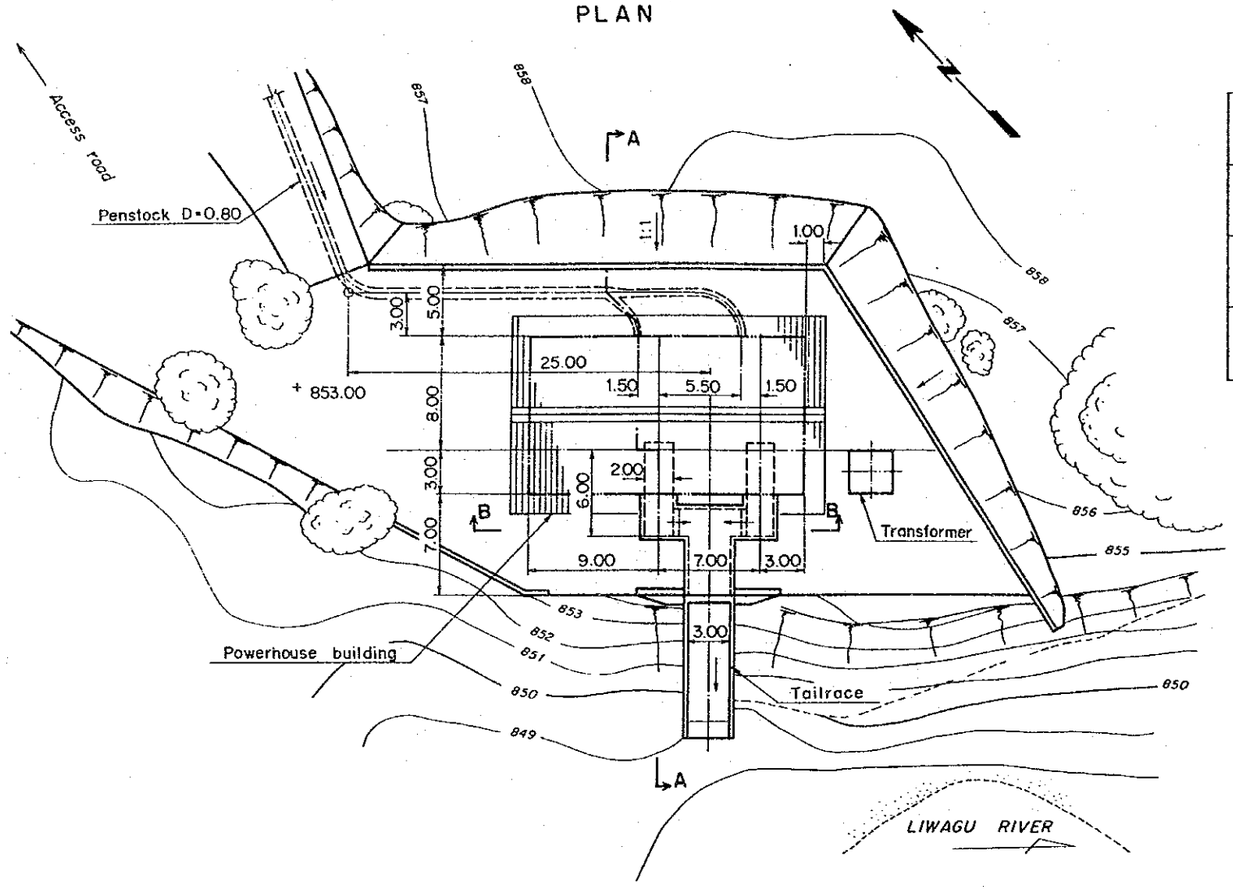
NARADAW PROJECT

PENSTOCK

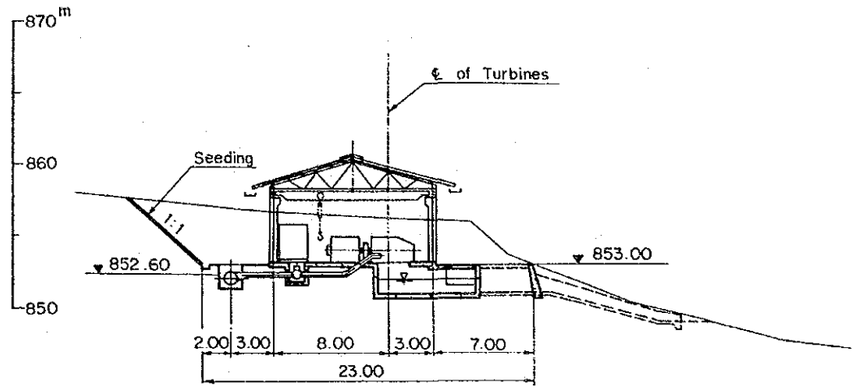
PLAN, TYPICAL SECTION & DETAILS

DWG **4**

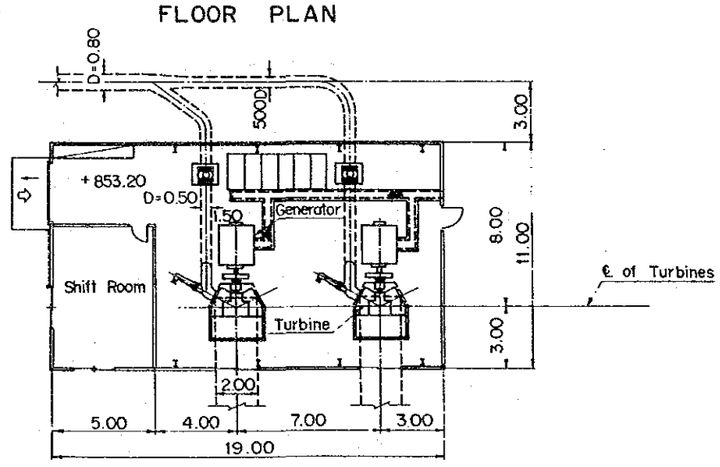
PLAN



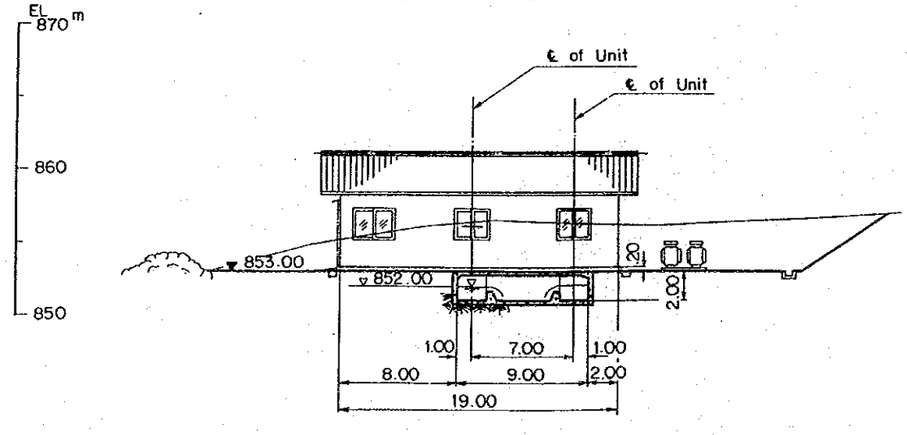
SECTION A-A



FLOOR PLAN



SECTION B-B



0 10 20 m
(PLAN & SECTIONS)

0 5 10 m
(FLOOR PLAN)

SMALL SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN

NARADAW PROJECT

POWERHOUSE PLAN AND SECTIONS

DWG 5