11. Irrigation Development Associated with the Project Development

11.1. Present Irrigation System

In the Upper Cagayan River basin, the Magat Dam for multi-purpose is under construction in the Magat River. With the completion of the dam, an area of about 10,200 ha will be newly irrigated. The beneficiary area of this project encompasses Cordon, Diffun and Saguday at the southern tip. In the meantime, any irrigation project to use the river flow of the Diduyon River is not envisaged, because the riverbed of the Diduyon River is located at lower elevation. Only waters taken from the mountain streams are used for small scale irrigation.

On the lower reaches of the confluence of the Diduyon River with the Cagayan River, most of the rice fields and farm lands are rain fed except the area benefitted by the Magat Project. The water from the Cagayan River is almost not utilized for irrigation, because the riverbed of the Cagayan River is at lower elevation.

The Cagayan River basin has fertile lands and wide hilly regions. Those lands and hilly regions will be irrigated step by step, using the water of the Cagayan River, which will result in an increased yield of the food.

11.2. Possibility of Developing Irrigated Area by Utilization of River Flow in the Diduyon River

About 1,000 ha of irrigable land (No.1 Area) is available on the left bank side of the Diduyon River and about 2,000 ha (No.2 Area) on the right bank side. The locations of those areas are shown in Fig. 11-1.

The No.1 Area is a small- and medium-scale hilly land. The distance from the Diduyon Reservoir to the No.1 Area is as long as 25 km. If the irrigation water is pumped up from the river

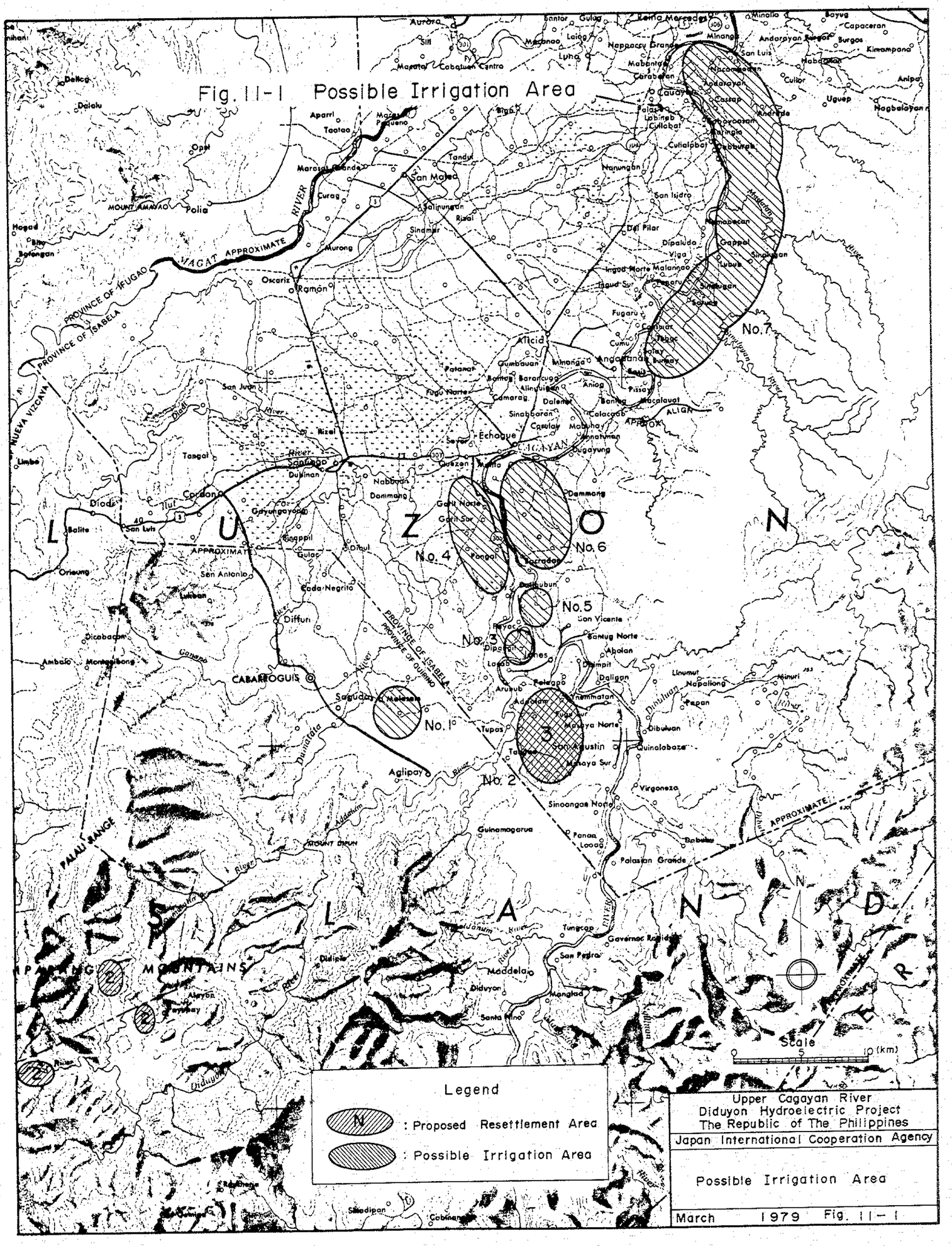
with elevation 100, the water channel for irrigation will have to pass through a wide hilly region with elevation 170 on the way. In view of this, the No.1 Area is not feasible technically and economically.

The No.2 Area is very distant from the Diduyon reservoir just like the No.1 Area. Accordingly, 2 pumping stations will be required for construction along the Diduyon River. The irrigation to this area should be limited to lower than elevation 130. The river water will be required to be re-pumped up by another pumping stations for water supply to higher elevations. The reclamation of the No.2 Area, as it is a hilly wilderness, will include a large volume of trees cutting, stumping and earth cutting and banking. The cost of the development of the No.2 Area was estimated on a preliminary basis. The economic study based on the preliminary cost estimates indicates that the development of the No.2 Area is not economical.

11.3. Possibility of Developing Irrigation Area on the Both Banks of the Cagayan River

The five irrigable lands (total area about 13,000 ha) were identified on the both banks of the Cagayan River. The locations of them are shown in Fig. 11-1. 20% to 30% of the areas envisaged for the development are rain fed and the remainder is used for the farm land. The areas are comparatively plain lands located at 15 to 20 m above the riverbed. The economic study of those areas concludes that it will be economical with the river flow regulated by Diduyon.

Fig. II-1 Possible Irrigation Area



12. Economic and Financial Studies

The approach and method of the economic and financial studies of the project were discussed with the NAPOCOR's personnel in charge and agreed on as mentioned hereunder.

12.1. Economic Evaluation

To evaluate the economic feasibility of this Project, the dual-fired steam power plant under plan at Batangas will be adopted as alternative equivalent power source. The economics of the project will be evaluated by the internal rate of return. Sensitivity analysis will be made with respect to variations in the types of thermal power plant, oil-fired steam power plant, combined cycle steam power plant and gas turbine power plant as well as variations in the construction costs and thermal fuel prices.

Furthermore, the systemwise analysis of the economics of the project will be made by incorporation into the NAPOCOR Generation Expansion Plan.

12.2. Financial Analysis

The financial analysis will be made for the purpose of: 1) clarifying the capital cost and financial costs required for implementing the Diduyon Project, 2) examining the financial viability and 3) analyzing the financial impact given by the Project.

For the analysis, the following works will be done.

a) Setting up the investment program and capital procurement program in accordance with the construction schedule.

b) Scheduling the repayment and payment of interest.

c) Assessing the financial viability of the Project by the financial internal rate of return.

d) Updating the NAPOCOR's financial forecast with the NAPOCOR's Generation Expansion Plan modified with the inclusion of the Diduyon Project.

13. Preliminary Comparison of Project Development Plans

13.1. Plans Slated for Comparison

Based on the results of the field reconnaissance and using the existing 1/50,000-scale maps, the following plans for the dam site, dam type, tailrace location, waterway route and waterway type were slated for comparison. The comparative plans are shown in Figs. 13-1 and 13-2.

13.1.1. Dam Site

a) No. 1 Dam Site

i) The riverbed on the dam site is wide, and the slopes of the mountains on the both banks are gentle.

ii) The dam volume will be larger than the two other sites.

iii) Accordingly, this site has been dismissed from the further study.

b) No. 2 Dam Site

i) This dam site was proposed to be given first priority in the Report on Reconnaissance Study of Upper Cagayan River Hydroelectric Development Project prepared by NEWJEC in March, 1978.

ii) The construction of the dam on this site will create a reservoir of larger capacity.

iii) The ground surface on or around the site is weathered and does not expose rocks, except partial exposure of bedrocks on the riverbeds of both banks.

iv) The measurement of the dam axis carried out during the field reconnaissance done in July to August, 1978 indicates that a specific height between the top of the ridge on the left bank and the riverbed is 80 m,

which is lower than the specific height measured on a topographic map on the scale of 1/50,000.

v) The width of the valley at the height of 70 m above the riverbed is 530 m.

vi) The ridge on the left bank extends in a length of 500 m, at the height of about 80 m above the riverbed.

c) No.3 Dam Site

i) Our previous reconnaissance survey concluded that this dam site is inferior to the No.2 Dam Site in the economics, because the riverbed elevation of this site is lower by about 50 m than the No.2 Dam Site.

ii) The field measurement carried out in the latest field reconnaissance indicates that the difference in the riverbed elevation between the No.2 Dam Site and the No.3 Dam Site is only about 30 m.

iii) The width of the valley at the height of 80 m above the riverbed, although the detailed survey is not yet completed, is estimated to be about 350 to 400 m.

iv) There is a weathered saddle part at the ridge on the right bank. Considering its geologic and topographic features, a fault may probably strike on this part.

v) The riverbed and both banks are almost covered by exposed hard rocks of agglomerates.

13.1.2. Dam Type

a) No.2 Dam site

i) The ground surface on the site is generally weathered. Any bedrocks are not seen at the 4 to 5 m cutting part of the logging road.

ii) Bedrocks with a shearing force (about 8.5 kg/cm^2 for a 100 m high dam) required to support a concrete dam are considered to exist considerably deep under the ground.

iii) A sufficient quantity of core materials for the dam embankment is available at the valley on the left bank 1 km upstream of the dam site.

iv) Diorites distributed 3 km upstream of the dam site or agglomerates distributed 4 km downstream of the dam site will be able to be used for rock materials and concrete aggregates.

v) The weathered zone of the dam foundation consists of clayey and impermeable agglomerates.

vi) The ridge on the left bank is suitable for the construction of the spillway.

vii) Considering the above features of the dam site, a rockfill dam is proposed for this site.

b) No.3 Dam Site

i) The riverbed and both banks consist of hard rocks.

ii) Concrete aggregate or rock material is available in a sufficient quantity at the quarry site on the right bank downstream of the dam site.

iii) Core material will be procured from the 500 m high mountain on the right bank downstream of the dam site or from the right bank ridge 1 km upstream of the dam site.

iv) Natural fine aggregate is not available near the dam site.

v) The saddle part on the right bank is suitable topographically for the construction of the spillway.

vi) The installation of a cable crane for concreting the dam will have some disadvantage, because the both banks are not parallel and the span of the valley is considerably longer at the upper elevation of the site.

vii) Considering the above feature of the dam site, both types of rockfill dam and concrete dam will be considered for comparison.

13.1.3. Tailrace Location

i) Our economic analysis indicates that the length of a tailrace tunnel to be constructed profitably is about 100 to 120 m for obtaining an 1 m head.

ii) The riverbed gradient ranges in 1/140 at the riverbed elevation 160 to 180, 1/110 at EL 180 to 200, 1/70 at EL 200 to 220, and 1/61 at EL 220 to 240.

iii) The abovementioned indicates that the best location of the tailrace construction is at the riverbed elevation 180 to 200.

13.1.4. Waterway Route

a) Right Bank Route

i) A distance between the river course and the boundary of watershed is as narrow as about 4 km.

ii) The slope of the right bank from the top of the mountain to the river is almost of the same gradient.

iii) Small valleys exist in a row on the mountain side.

iv) The river course bends to the left.

v) The slope of the right bank becomes gentle from 3 km downstream of the confluence of the Didipio River and the Diduyon River.

b) Left Bank Route

i) There are many 1,000 m high-independent peaks on the left bank.

ii) Tributaries flow between the independent peaks and join the Diduyon River.

iii) There is a plain at elevation 600 to 700 along the river.

iv) The slope of the mountain on the left bank is gentler than the right bank.

c) Selected Route

The left bank route is easier for the construction of an access road to the construction adits and the provision of a spoil bank. And the length of the waterway from the intake to the tailrace to be constructed on the right bank will be 21 km, while the length of the waterway to be constructed on the left bank will be 14 km. Accordingly, the left bank route is proposed as the waterway route.

13.1.5. Powerhouse Type

a) Conventional Type Powerhouse One-stage Development Plan (Scheme 1)

i) The tailrace will be constructed at the riverbed elevation 180 to 200.

ii) There is a spacious river terrace at the riverbed elevation 190 on the left bank just upstream of the confluence of the Didiowan River and the Diduyon

River. The powerhouse and the switchyard will be able to be constructed on this river terrace.

iii) A ridge coming down from EL 800 to the river terrace extends straight. This ridge will give the shortest route for penstock line from the surgetank to the powerhouse.

iv) The headrace will have to pass with a small meander of the Didipio River, because the elevation of the headrace tunnel is near to that of the Didipio River.

v) The route presented in Figs. 13-1 and 13-2 was selected for this powerhouse development plan, considering the abovementioned feature and the topographic conditions.

b) Conventional Type Powerhouse Two-stage Development Plan (Scheme 2)

i) The Didipio River with a long river length flows into the left bank of the Diduyon River. The waterway to be constructed on the left bank will be long, because it will have to take a roundabout route, keeping away from the Didipio River.

ii) The catchment area of the Didipio River is as large as 70 km^2 which occupies 15% of the catchment area of the No.3 Dam Site.

c) Lower Stream Underground Type Powerhouse Development Plan (Scheme 3)

i) The length of the penstrock for the Conventional Type Powerhouse Development Plan will be as long as 2.15 km. To reduce this length will serve to reduce the construction cost.

ii) In order to reduce the length of the penstock, the powerhouse will be constructed underground and the tailrace will be elongated.

iii) The construction of the underground powerhouse will result in the increase in the construction costs of the penstock tunnels, powerhouse air-conditioning, tailrace extension, equipment transport road and others.

d) Upper Stream Underground Type Powerhouse Plan (Scheme 4)

i) The location of the underground powerhouse can be selected rather unrestrictedly, because the penstock route, powerhouse site, and tailrace route are not influenced by the topography on the ground.

ii) The location of the surgetank will be restricted somewhat by the topography on the site, considering the elevation of the headrace tunnel.

iii) The waterway route from the intake to the tailrace will be able to be made shortest by the construction of the underground powerhouse.

iv) The waterway route will be interrupted by the Didipio River on the way, therefore, the surgetank will be constructed at EL 700 near the Didipio River.

v) The penstocks and powerhouse will be constructed underground, and the long tailrace will extend to the outlet.

vi) This plan is superior to the Lower Stream Underground Plan in a point that the waterway route length is shorter.

vii) The disadvantages of this plan are the new construction of an access road and the excavation of an inclined adit for the construction of the tailrace.

13.2. Method for Preliminary Comparative Analysis of Plans

13.2.1. Plans Slated for Comparison

a) Dam

i) No.2 Dam

ii) No.3 Dam

b) Waterway

i) Conventional type powerhouse one-stage development plan.

ii) Conventional type powerhouse two-stage development plan.

iii) Lower stream underground type powerhouse development plan.

iv) Upper stream underground type powerhouse development plan.

13.2.2. Basic Data used for Comparison

a) Topographic Data

i) Topographic maps on the scale of 1/50,000

ii) Topographic maps on the scale of 1/250,000

iii) The result of survey carried out during the latest field reconnaissance from July to August, 1978 was used for determination of the cross-section of the No.2 Dam Site.

iv) A difference in the riverbed elevation between the No.3 Dam Site and the No.2 Dam Site was assumed to be 30 m which was surveyed actually in the latest field reconnaissance.

b) Geologic Data

i) Existing general geologic map

ii) Result of surface geologic reconnaissance made from July to August, 1978.

c) Discharge Data

The discharge at the dam site was computed by the catchment area ratio, using the discharge data measured at Pangal for a period of 11 years.

d) Cost Estimates

The construction costs of the development plans were estimated on the basis of the prices in 1977. The construction costs were broken down into preliminary construction, reservoir, headrace, powerhouse foundation, powerhouse super-structure, main electromechanical equipment, and transmission and substation. Besides those direct costs, the engineering fee, administration cost, contingency and interest during construction are included in the construction costs.

13.2.3. Procedures for Comparison

a) Comparison of Dam Sites

i) The conventional type powerhouse one-stage development plan was used for the comparison of the dam sites.

ii) The No.2 Dam was assumed to be a rockfill dam, and the No.3 Dam a rockfill dam as well as a concrete dam.

iii) The dam height was varied within H.W.L. 670 to 680.

b) Determination of Optimum Size

The optimum size of the project has been studied and determined with the dam site and dam type which were screened out by the comparison under a) above.

c) Comparison of Powerhouse Plans

Two underground type powerhouse plans and two conventional type powerhouse plans each of which will be equipped with the optimum size determined in b) above were compared to select the optimal powerhouse plan.

13.2.4. Technique for Economic Study

Those plans were evaluated by the cost-benefit analysis.

13.3. Comparative Analysis of Dam Site and Dam Type

13.3.1. Comparison between the No.2 Dam and the No.3 Dam

In case the H.W.L. is made lower than EL 670, the regulating capacity of the dam will be extremely lessened. On the other hand, it is impossible topographically to make the H.W.L. higher than EL 680. Therefore, the comparative analysis of the No.2 Dam and the No.3 Dam both as rockfill type was made in the range of EL 670 to EL 680. The following presents the result of the comparison.

	No.2 Dam	No.3 Dam
Reservoir H.W.L. (EL)	670 - 680	670 - 680
Turbine discharge (m^3/sec.)	68.8 - 85.6	80.4 - 93.6
Effective head (m)	442.8 - 448.6	438.9 - 446.6
Max. output (MW)	259.7 - 327.4	301.5 - 356.4
Generated energy (GWH)	891.6 - 943.5	939.8 - 976.6
Total construction cost (10^6₱) (Excl. Transmission line)	2,750 - 3,189	2,924 - 3,262
B/C	1.226 - 1.237 - 1.231	1.279 - 1.277 - 1.282
B-C (10^6₱)	59.7 - 71.0	78.6 - 88.7

This table indicates that to make the H.W.L. for the No.2 Dam and the No.3 Dam higher will bring more economics and that the No.3 Dam will be more economical than the No.2 Dam, irrespective of the H.W.L.

13.3.2. Study of Dam Type for the No.3 Dam Site

The dam type was studied in the range of EL 670 to EL 680. The results of the study is summarized as follows:

		Rockfill type	Concrete type
Reservoir H.W.L.	(EL)	670 - 680	670 - 680
Turbine discharge	(m^3/sec.)	80.4 - 93.6	80.4 - 93.6
Effective head	(m)	438.9 - 446.6	438.9 - 446.6
Max. output	(MW)	301.5 - 356.4	301.5 - 356.5
Generated energy	(GWH)	939.8 - 976.6	939.8 - 976.6
Total construction cost (Excl. Transmission line)	(10^6₱)	2,924 - 3,262	2,748 - 3,154
B/C		1.279 - 1.277 - 1.282	1.360 - 1.326
B-C	(10^6₱)	78.6 - 88.7	95.5 - 99.1

This table shows that to make the H.W.L. higher will bring more economics irrespective of the types of the dam, and the concrete type is more economical than the rockfill type.

13.3.3. Dam Site and Dam Type Slated for Further Detailed Investigations

The above result shows that the No.3 Dam Site developed with a concrete type dam will be optimum for the Project. But the difference in the B-C value between the No.3 Dam and the No.2 Dam is only 18 million to 12 million Pesos, which are equivalent to 5 to 3% of the total construction cost. Such difference in the construction costs corresponds to the difference of 15 to 10% in the dam volume. The small difference in the construction cost may be offset by the result of the further detailed field investigations. Therefore, the difference in the B-C value which is based on the existing data of less accuracy will not justify the final determination of the dam site and dam type. It is therefore recommended that the further detailed field investigations should be carried out for the No.2 Dam Site and the No.3 Dam Site.

13.4. Comparative Analysis of Powerhouse Plans

13.4.1. Comparison of Plans Slated for Comparison

With the selecting of the No.3 concrete type dam, H.W.L. 680, the powerhouse plans were compared.

The result of the comparison of the plans is presented on the following table.

Item \ Powerhouse type	Unit	Open Type				Underground Type	
		One Stage Development	Two Stage Development			Lower Stream Plan	Upper Stream Plan
			Upper stream P/S	Lower stream P/S	total		
Catchment area	km^2	477	477	547	-	477	477
Turbine discharge	$m^3/sec.$	93.6	93.6	98.4	-	93.6	93.6
Intake water level	EL (m)	680	680	330	680	680	680
Outlet water level	EL (m)	190	330	190	190	190	190
Total Head	m	490	350	140	490	490	490
Effective Head	m	446.6	331.5	120.7	452.2	453.2	456.9
Firm peak output	MW	330.9	245.6	89.5	335.1	335.8	338.6
Max. output	MW	356.4	264.5	101.3	365.8	361.7	364.6
Generated energy	GWH	976.6	724.9	290.6	1,015.5	991.0	999.1
Length of headrace tunnel	km	12.49	5.10	5.55	10.65	12.49	5.38
Length of penstock	km	2.15	1.39	1.07	2.46	0.72	0.72
Length of tailrace	km	0.27	0.30	0.65	0.95	1.74	6.97
Total length	km	14.91	6.76	7.27	14.06	14.95	13.07
Total Const. Cost	10^6₽	3,154	2,596	715	3,311	3,237	3,168
B/C		1.326	1.196	1.647	1.294	1.312	1.351
B-C	10^6₽	99.1	49.1	44.5	93.6	97.1	107.2

The above table shows that the most economical development plan is the Upper Stream Underground Type Powerhouse Plan and the second one is the Conventional Type Powerhouse One Stage Development Plan. The Conventional Type Powerhouse Two Stage Development Plan will be able to create the maximum output of 365,800 kW and generated energy of 1,015 GWh which are larger than the other development plans, augmented by the discharge of the Didipio River. On the contrary, the surplus benefit of the Conventional Type Powerhouse Two Stage Development Plan is less than the other plans because the power station equipment will be installed at two powerhouses and the extension of the penstock for this plan will be longer.

The difference in the cost-benefit analysis between the Lower Stream Underground Plan and the Upper Stream Underground Plan are mainly caused by the difference in the total length of the tunnels. The tunnel of the Upper Stream Underground Powerhouse Plan is shorter by 1.9 km than the Lower Stream Plan. Adopting the same layout from the dam to the surgetank as for the Conventional Type Powerhouse One Stage Development Plan, the length of the penstock line in the Lower Stream Underground Plan will be almost one third of the former plan. But the latter plan will entail the increase in the construction costs of the powerhouse cavern, access road to the cavern for transformer installation, cable duct, ventilator hole, drainage facilities, adit, etc. The total construction costs of the underground type become higher than the Conventional type.

13.4.2. Powerhouse Development Plans Slated for Further Detailed Investigations

The above comparative study shows that the Upper Stream Underground Type Powerhouse Development Plan will be the most suitable scheme. But the site condition of this underground plan has not yet been explored in a sufficient detail.

It is very difficult to judge the geologic condition of the cavern of the underground powerhouse only from the surface reconnaissance survey. There is a possibility that the result of the drilling work and/or test aditting may reveal an inadequacy for the development. It will take more time and cost more for the exploration of the test adits than scheduled at present, because the exploration of the test adits is inevitable for the development of the underground powerhouse.

Taking into account the above mentioned, the future field investigations will be made mainly for the Conventional Type Powerhouse Development Plan. But it is recommended to include some field investigations of the Upper Stream Underground Type Powerhouse Development Plan.

Fig. 13-1

Plan of Alternative Alignments of Waterway

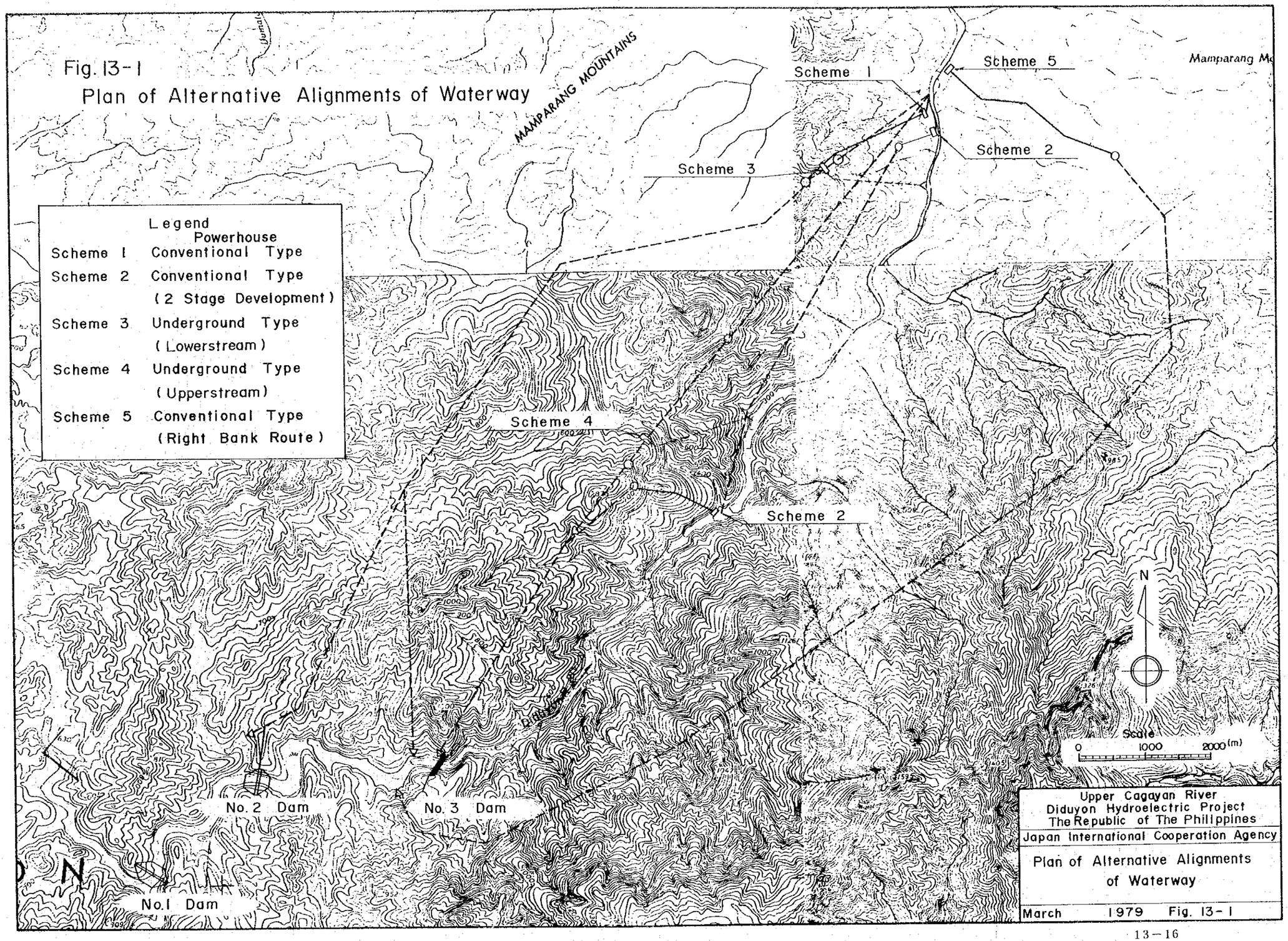
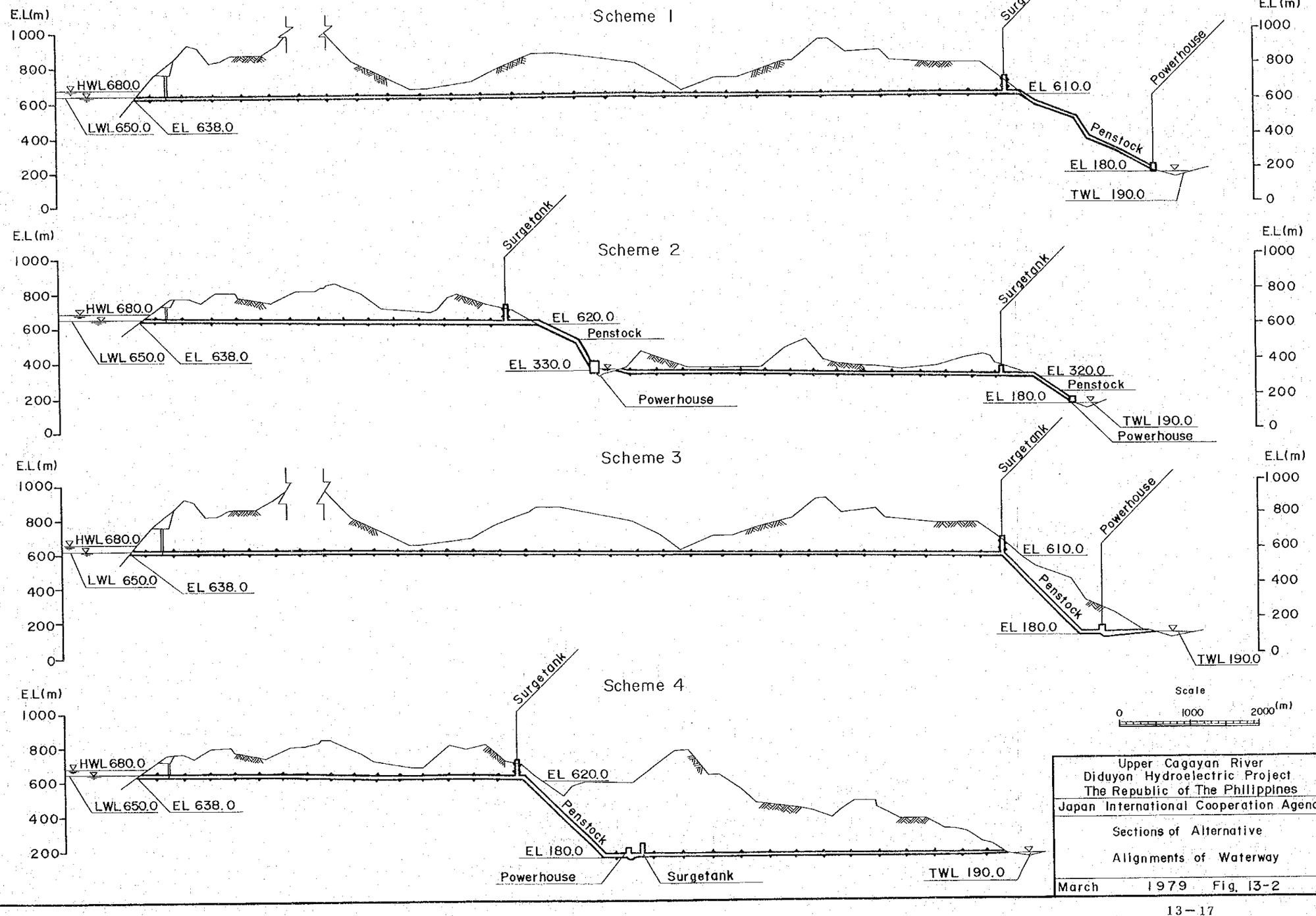


Fig. 13-2 Sections of Alternative Alignments of Waterway



Upper Cagayan River Diduyon Hydroelectric Project The Republic of The Philippines	
Japan International Cooperation Agency	
Sections of Alternative Alignments of Waterway	
March	1979 Fig. 13-2

14. Field Investigation Program

14.1. General

a) The objective of the detailed field investigation works described herein is to obtain the topographic and geologic data necessary for making the feasibility design of the Project. The works include production of larger scale topographic maps, subsurface explorations by seismic prospecting, drilling and test aditting and also various tests of construction materials. The works are being or will be carried out by NAPOCOR or its local contractors under the supervision of the experts of the JICA Study Team as shown in Figs. 14.1 & 14.2.

b) The geologic investigations will be focused on the Dam Site No.3. The investigations of the No.2 Dam Site which is considered as the alternative site will be concentrated to the riverbed foundation and weathering condition of the dam abutment which are key points for the design of the dam. The difference in the relative height between the No.2 Dam Site and the No.3 Dam Site and the cross-sections of the both sites closely relates to the quantities of the constructions. Accordingly, the topographic surveys of both sites with the necessary scale should be carried out.

c) The investigation so far conducted indicates the necessity of further detailed investigations on the available volume of fine materials which can be used for the concrete aggregates and the core material. This problem will be a key in the decision of the dam site and the dam type. Accordingly tests of core material and concrete aggregate are recommended to be carried out.

d) As far as the waterway and powerhouse concern, the investigations will be mainly carried out on the Conventional Type Powerhouse One Stage Development Plan. At the same time, some investigation works will also be done for Upstream Underground

Type Powerhouse Plans.

14.2. Production of Topographic Maps

The existing maps presently used for the preliminary comparison are on the scale of 1/50,000. Larger scale topographic maps are required to be produced for the feasibility design. The proposed topographic surveys are outlined hereunder.

a) Production of 1/5,000 scale topographic maps of major structures sites and their vicinities.

The 1 to 5,000 scale maps are to be used for the field investigation programming. The maps are to be produced, using the existing 1/15,000 scale aerophotos.

i) Map scale - 1 : 5,000
ii) Mapping area - 6.4 km^2
iii) Area coverage - Two (2) dam sites, tunnel route, penstock route and powerhouse site
iv) Location - See Fig.14-1.

b) Production of 1/1,000 scale topographic maps of major structures sites and their vicinities

These maps will be used for the planning and designing of the project structures, temporary construction facilities, and preparation of program and schedule of main works and other associated works. The maps are to be produced by the ground survey.

i) Map scale - 1 : 1,000
ii) Mapping - 5.92 km^2
iii) Area coverage - See Fig.14-1.

c) Production of 1/10,000 scale topographic maps of the Project area

The maps are to be used for the project output study, construction programming and planning, feasibility design, reservoir

area study, transportation and access road planning, and resettlement programme. The maps are to be produced with the aerophotos to be taken newly or with the use of the existing 1/15,000 scale aerophotos.

i) Map scale - 1 : 10,000

ii) Aerophotographing - 300 km^2

iii) Mapping area - 300 km^2

iv) Area coverage - See Fig.14-1.

14.3. Longitudinal and Cross-sectional Surveys

a) River cross-section survey in the reservoir area

The 1/10,000 scale topographic maps of the reservoir area are to be prepared by the aerial photogrammetry. The area and capacity of the reservoir will be computed based on the 1/10,000 scale maps. The river cross-section survey in the reservoir area is aimed to confirm or improve the accuracy of the 1/10,000 scale maps.

i) Location - See Fig.14-1

ii) Quantity - Five (5) sections with a total length of 8 km

b) Cross-section survey at the dam site

The survey is to be conducted for the dam site cross-sections.

i) Location - See Fig.14-1.

ii) Quantity - Six (6) sections with a total length of 4 km

c) River profile and cross-section surveys on or around the dam site

The survey is aimed to compute the correlation of the discharges with the water levels in the upstream and downstream of the dam site.

i) Location - See Fig. 14-1.

ii) Quantity - Profile : 3 km in total
Cross-section : 29 traverses,
6 km in total

d) River profile and cross-section surveys at the powerhouse site and in the vicinity of the powerhouse site (outlet)

The survey is aimed to compute the correlation of the discharges with the water levels at the powerhouse site and in the vicinity of the proposed tailrace outlet.

i) Location - See Fig. 14-1

ii) Quantity - Profile : 3 km in total
Cross-section : 29 traverses
6 km in total

e) Preparatory surveys for geologic explorations

The preparatory surveys for the following geologic explorations are to be carried out to fix the final locations of those works.

i) Drill hole location surveys.

ii) Exploratory adit location surveys.

iii) Surveys of seismic prospecting range lines.

iv) Surveys of quarrying sites of construction materials.

14.4. Geologic Explorations of Dam Sites

14.4.1. No.3 Dam Site

At the No.3 Dam Site, the bedrocks crop out at the riverbed and both banks, and any particular change in the geologic structures is not observed. Therefore, the geologic investigation works will be carried out mainly along the proposed dam axis. The drilling and seismic explorations will be carried out at the saddle part where a fault may strike there.

a) Exploratory adits

i) Location - See Figs. 14-3 and 14-4

ii) Quantity - 6 adits, Total 300 meters

b) Drilling work

To investigate the foundation rocks, two (2) inclined and six (6) vertical holes are to be drilled. Besides, five (5) bore holes are arranged for the investigation of the mountain saddle in the right bank.

i) Location - See Figs. 14-3 and 14-4

ii) Quantity - 13 holes with a total estimated length of 880 meters

c) Seismic prospecting

i) Location - See Fig. 14-3

ii) Quantity - 5 range lines with a total length of 2,300 meters

14.4.2. No.2 Dam Site

a) Drilling work

The main purpose of the geologic investigations on this dam site is to clarify the degree of the weathering and the conditions of the bedrocks.

i) Location - See Figs. 14-5 and 14-6

ii) Quantity - 3 holes with a total estimated length of 140 meters

b) Seismic Prospecting

One (1) prospecting range line is planned for the same purpose as for the drilling work.

i) Location - See Fig. 14-5

ii) Quantity - 1 line with a length of 1,000 meters

14.4.3. Quarry Site

The right bank downstream of the No.3 Dam Site and Biyoi situated at the confluence of the Diduyon River with the Kakiduguen River are to be investigated for the concrete aggregate quarry site. Biyoi will be investigated also for rock materials.

a) Drilling work

i)	Location	- See Figs. 14-7 and 14-8
ii)	Quantity	- 5 holes, totally 250 meters

b) Seismic prospecting

i)	Location	- See Fig. 14-7
ii)	Quantity	- 2 lines, totally 800 meters

14.5. Geologic Explorations of Headrace Tunnel Route

(Conventional Type Powerhosue One-stage Development Plan)

There is a little difference in the elevation between the headrace tunnel route and the riverbed of the Didipio River under which the headrace tunnel will pass. Accordingly, the covering of the tunnel route under the Didipio River is estimated to be thin. Depending on the geologic condition of the covering, the tunnel route may be changed and an aqueduct bridge may be constructed. The drilling and seismic prospecting are to be carried out in order to investigate the geological conditions of the place.

a) Drilling

i)	Location	- See Figs. 14-9 and 14-10
ii)	Quantity	- 4 drillholes, totally 160 meters

b) Seismic prospecting

i)	Location	- See Fig. 14-9
ii)	Quantity	- 2 lines, totally 800 meters

14.6. Geologic Explorations of Surgetank Site, Penstock Route and Powerhouse Sites

The geologic explorations are to be carried out for the Open Type Powerhouse One-stage Development Plan and the Upper Stream Underground Type Powerhouse Plan which were given the priority after the preliminary comparative analysis.

a) Open Type Powerhouse One-stage Development Plan

i) Drilling

a) Location	- See Figs. 14-11 and 14-12	
b) Quantity	- Surgetank :	1 hole 100 m
	Penstock :	3 holes 60 m
	Powerhouse:	3 holes 120 m

ii) Seismic prospecting

a) Location	- See Fig. 14-11	
b) Quantity	- Surgetank :	1 line 300 m
	Penstock :	3 lines 3,400 m
	Powerhouse:	4 lines 1,400 m

b) Upper Stream Underground Type Powerhouse Site

i) Drilling

a) Location	- See Figs. 14-13 and 14-14
b) Quantity	- 1 hole, 400 m long

14.7 Tests of Construction Materials

a) The available material for the core of the rockfill dam is weathered aggromerates that are distributed in the most area of the basin.

The weathering is heavily developed and its depth is estimated to range from 10 to 20 meters beneath the ground surface. However, the weathered soil, at glance, has a high moisture content and is lacking in sand particles. This character will pose problems in the dam embankment.

Samples of core materials were collected from the weathered zones at the left bank creek just upstream of the No.2 Dam Site and at the downstream area of the right abutment of the No.3 Dam Site. The collected samples were tested.

b) There are scattered riverbed sedimentary deposits in the course of the river, but the total available quantity of the deposits, especially fine materials, seems very much limited. The places of sampling of the material were designated by the experts of the JICA Study Team, and the fine aggregate tests were carried out with the collected samples.

14.8. Production of Geologic Maps

Using the 1:10,000 scale topographic map completed under the Sub-section 14.2., the geologic maps of the project area will be produced through the field surface reconnaissance survey. Expecially, the reservoir area, important structure sites and their vicinities will be investigated very carefully.

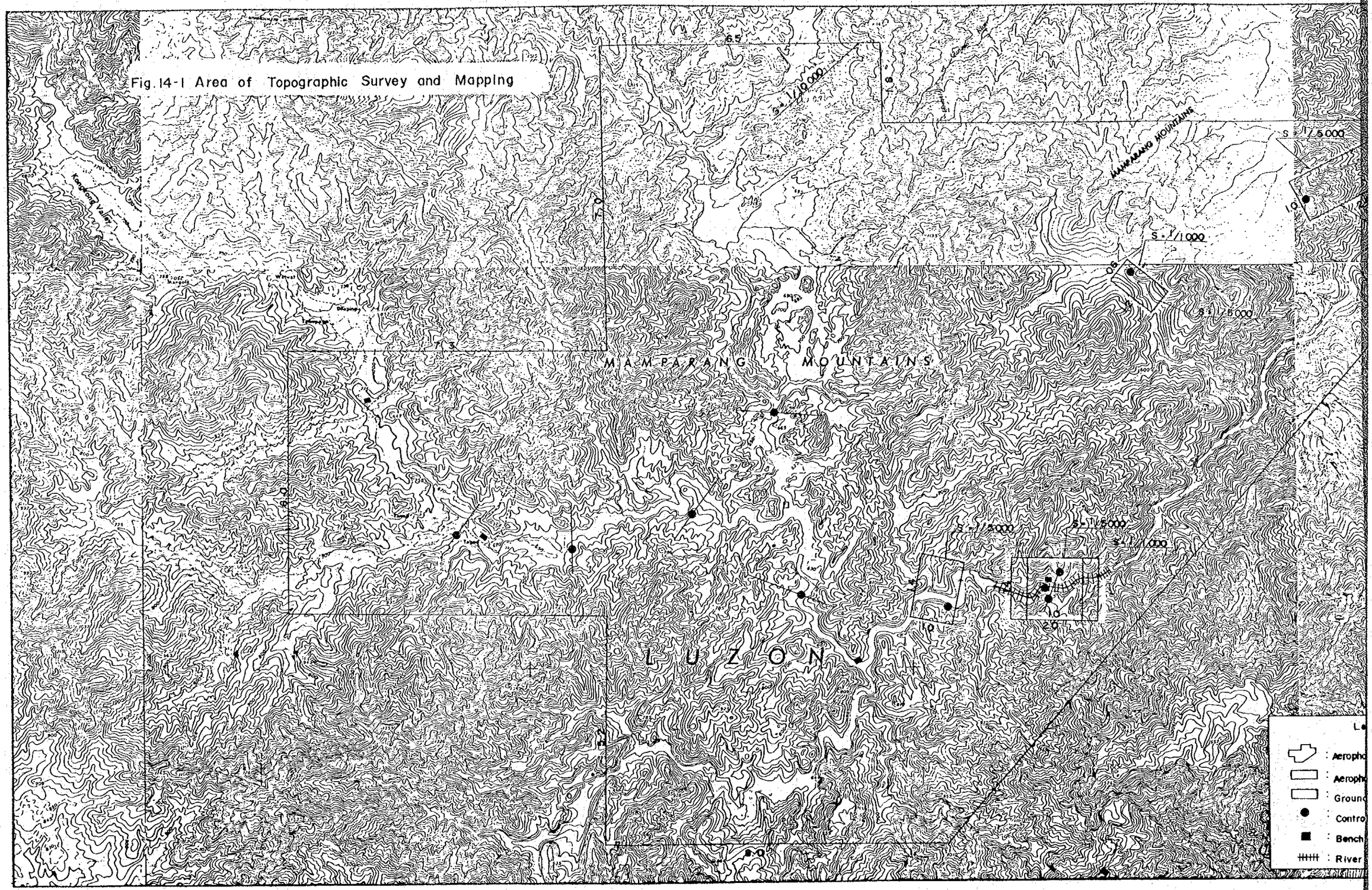
Limestones distributed in the area will be investigated with respect to the strike, dip and mode of distribution and the reservoir water-tightness will be well examined.

Also, land collapses, slides and other peculiar topographic trans-formations such as curst will be investigated and recorded in detail. The result of the investigation of the land collapses, slides and topographic transformations will provide basic data for the estimate of the sediment transport.

14.9. Investigations of Sediment Transport

The investigations of the sediment transport in the Diduyon River will be carried out to obtain necessary data for the estimate of the available storage capacity of the reservoir. The investigations include the investigations and tests of the riverbed materials and suspended load density. The locations for sampling of the sediment materials are shown in Fig.14-15.

Fig. 14-1 Area of Topographic Survey and Mapping



ographic Survey and Mapping

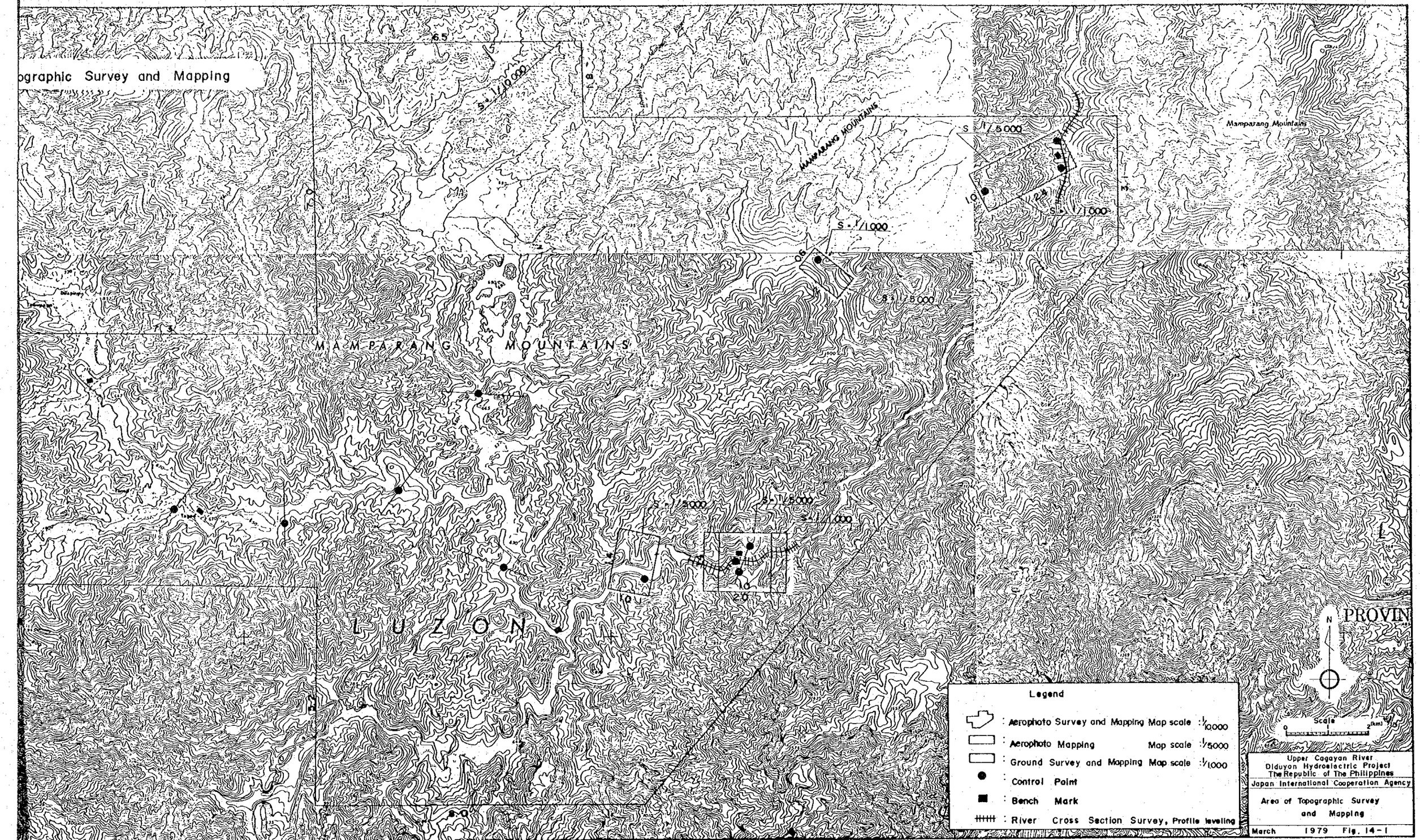
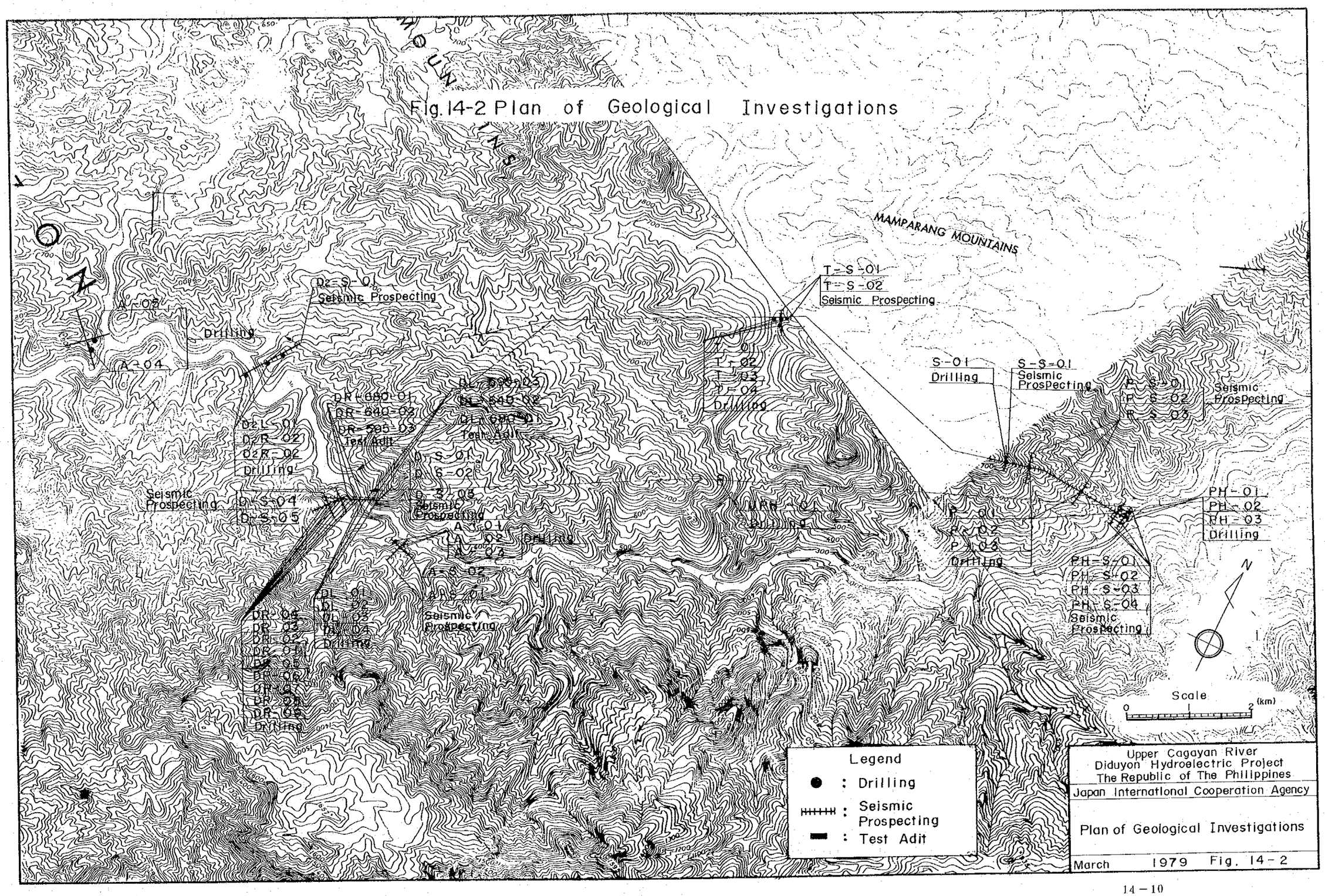


Fig.14-2 Plan of Geological Investigations



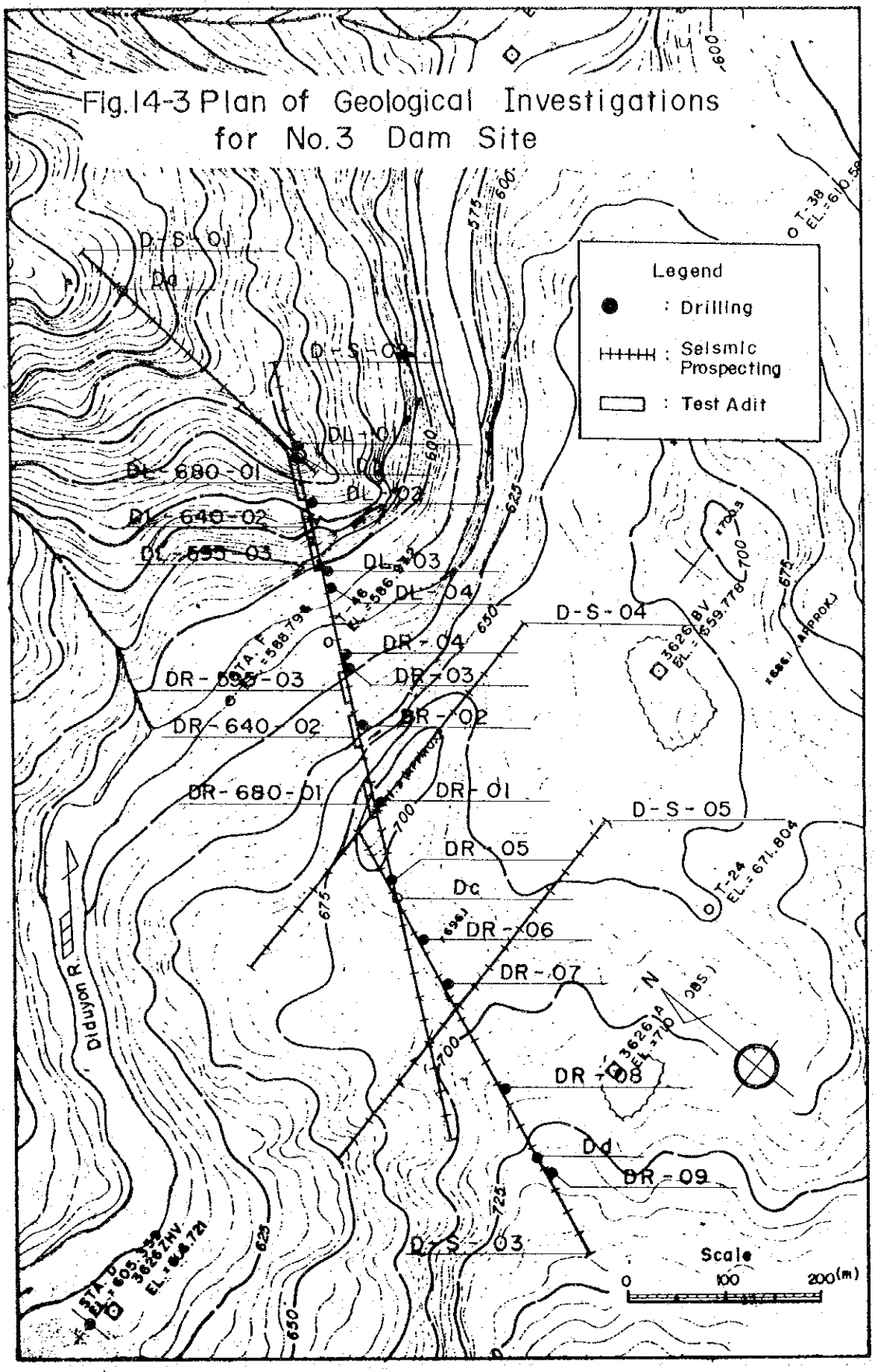
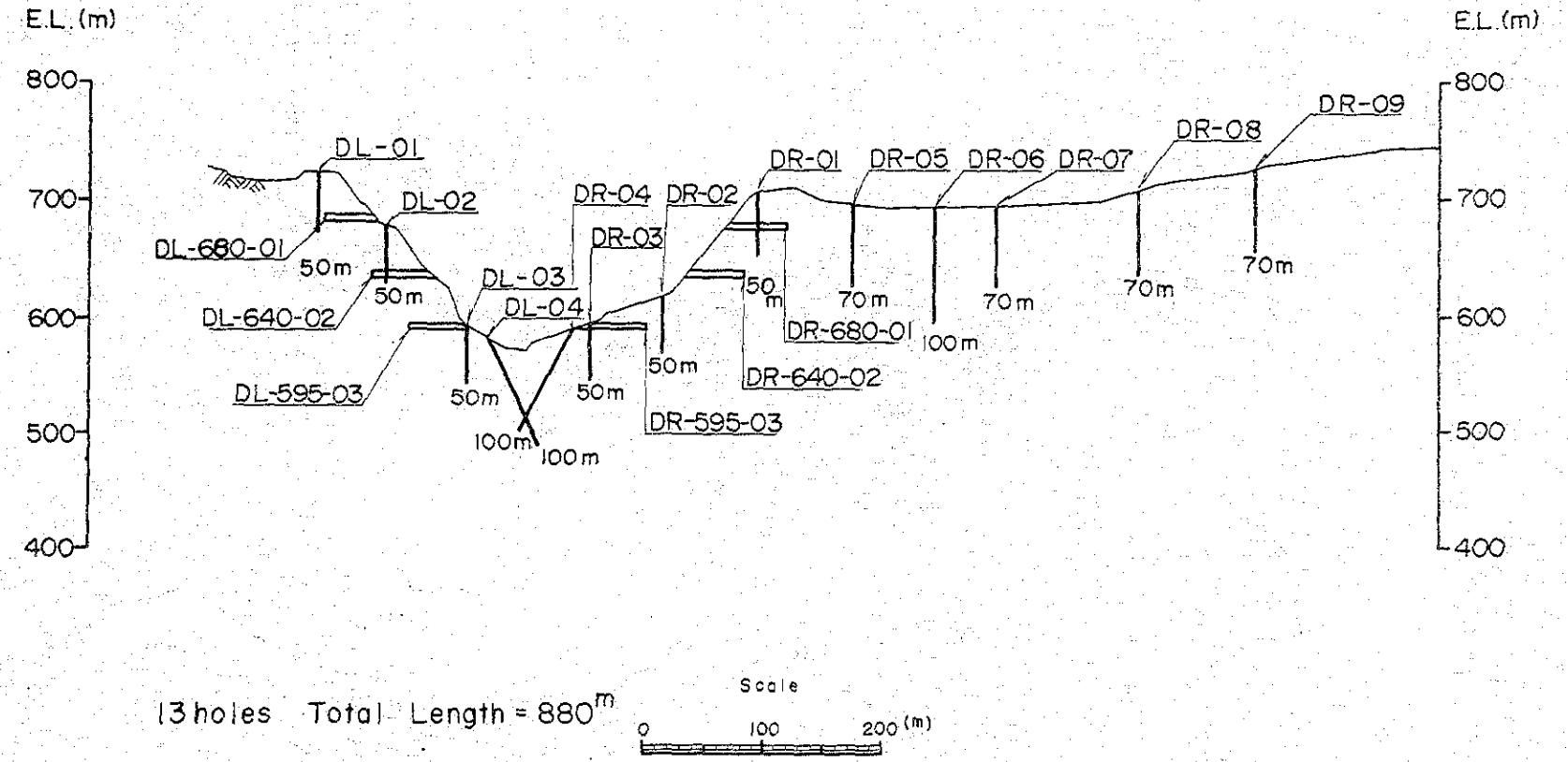


Fig.14-3 Plan of Geological Investigations for No.3 Dam Site
Legend
: Drilling
: Seismic Prospecting
: Test Adit
D-S-01
Dd
D-S-02
DL-01
DL-680-01
DL-02
DL-640-02
DL-600-03
DL-03
DL-04
D-S-04
DR-04
DR-600-03
DR-03
DR-640-02
DR-02
DR-680-01
DR-01
D-S-05
DR-05
Dc
DR-06
DR-07
DR-08
Dd
DR-09
D-S-03
Diduyon R.
T-38 EL.=610.59
T-24 EL.=671.804
Scale
0 100 200(m)

Fig. 14-4 Section of Geological Investigations for No.3 Dam Site
(Drilling and Test Adit)



13 holes Total Length = 880m

Scale
0 100 200 (m)

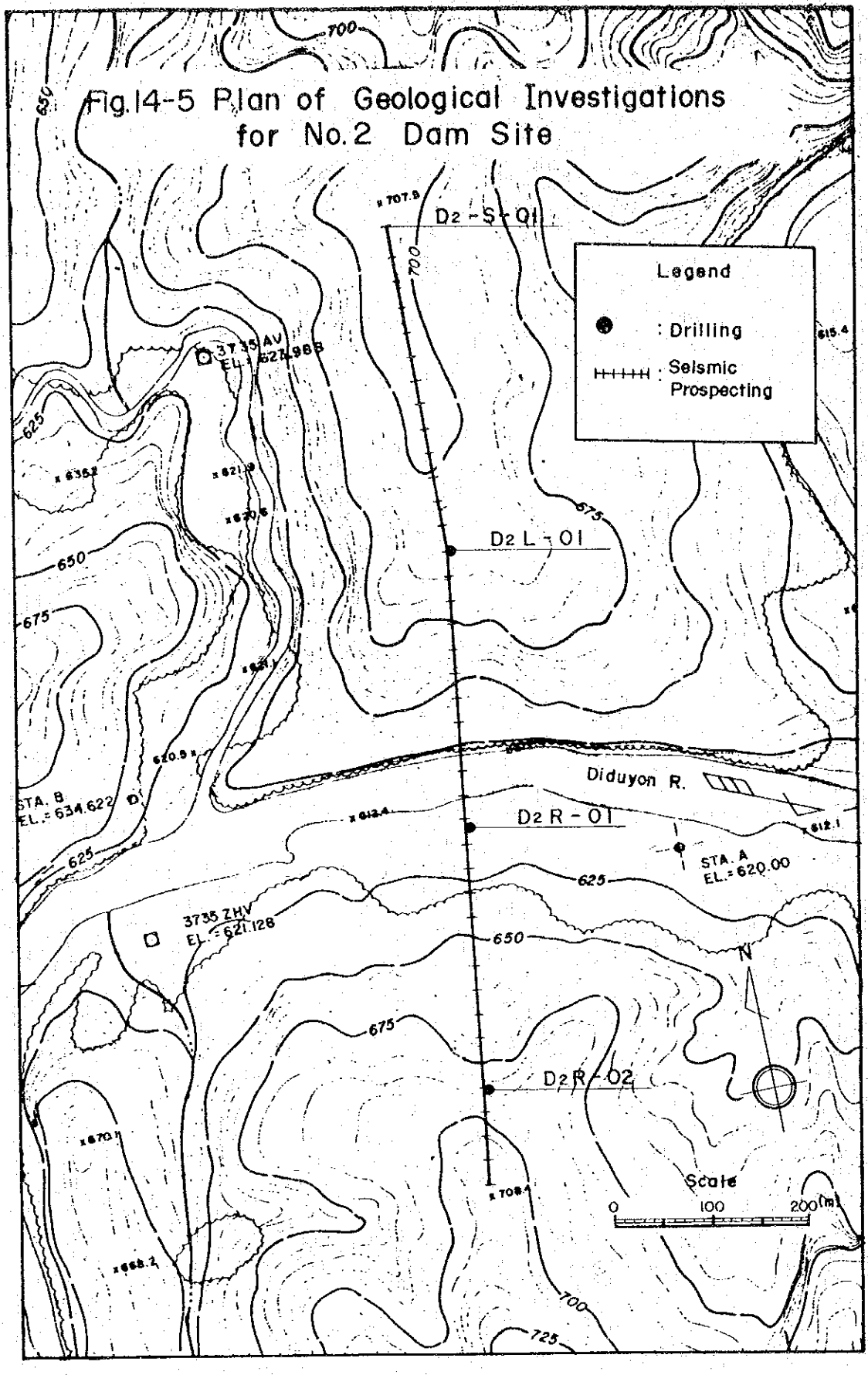
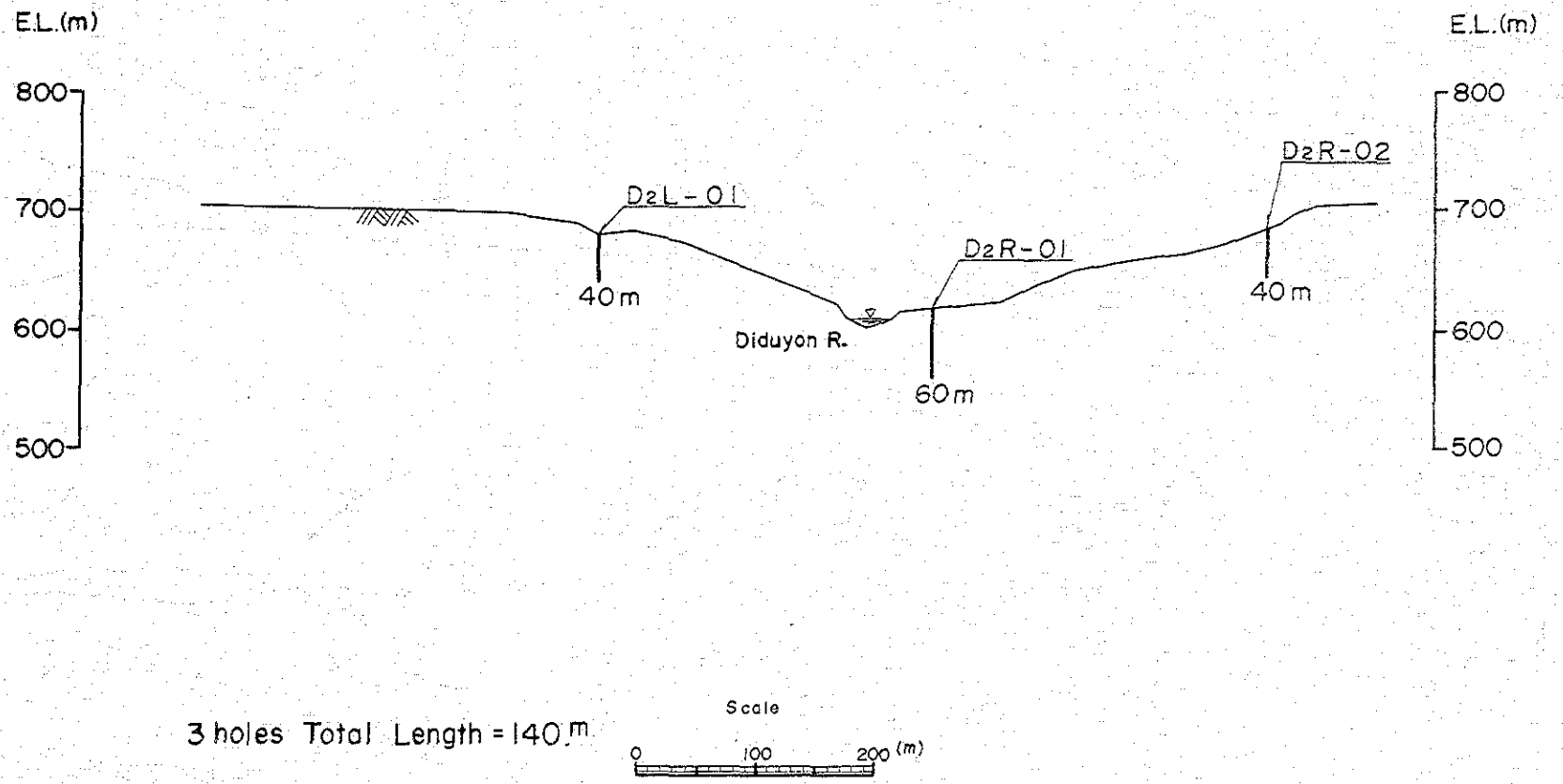


Fig.14-5 Plan of Geological Investigations for No.2 Dam Site
D2-S-01
D2L-01
D2R-01
D2R-02
Legend
: Drilling
: Seismic Prospecting
Diduyon R.
STA. A
EL. = 620.00
STA. B
EL. = 634.622
3735 AV
EL. = 624.988
3735 ZHV
EL. = 621.128
Scale
0
100
200 (m)
N
700
650
675
625
725

Fig. 14-6 Section of Geological Investigations for No.2 Dam Site



3 holes Total Length = 140 m

Scale
0 100 200 (m)