1. INTRODUCTION

1.1 CONCLUSIONS AND RECOMMENDATIONS

The twentieth century has come to an end now, a century in which people have aimed to achieve a stable growth of their national economic power leaving no stone unturned, even under any kind of political system. People debated on conflicting matters lying between nature conservation and natural finite resources development under the absolute national target, and people proceeded a national development to obtain the maximum public interest through the best way judged by a sense of value in age.

The large scaled dam development has expedited a national economic growth in all countries. However, the risks which come with the development have had an effect not only on natural and social environments but on state control and investors due to its own development scale.

Under the above understanding, we have started the Study on the Project aiming to implement the Environmental Impact Assessment in the course of groping a dam development procedure for the benefit of future generations.

Generally, tasks of the large scaled dam are multifarious; flood protection, irrigation, industrial and municipal water supply and hydroelectric power. However, the history of its development is not long, only around 50 years since its beginning. Therefore, the short history has not created debate concerning environmental aspects caused by their large scale and consequent serious effects.

On the other hand, some advanced countries involved with many large scaled dams with 50 years of history have postponed and disconnected the proposed dam development schemes to finish the large dam's tasks for national development. Therefore, the large dam development cannot keep a further balance with human life in the surrounding natural and social environments, so we, and anybody related with the development, should be seriously concerned.

However, on one hand, some advanced countries lost significance in the dam development, and on the other hand it is a fact that some developing countries need it as a tool for their national development. Accordingly, we had provided them not only financial aid but also the intellectual assistance to judge the priority of development from the environmental standpoint. The judgements were on the basis of understandable national development policy on national interests from the other countries by an effective utilization of rich water resources under the best geopolitical advantages.

As a conclusion of the above, the Study Team proposes to construct "the Millennium Dam" at the end of the Study. We named a dam of the Nam Ngiep-I HEPP as "the Millennium Dam" on ground of our oath to recover "the silent rivers" in the next century, not by the reason of our memorial to propose it at the end of this century.

Therefore, in order to that the proposal of "the Millennium Dam" may be worthy for coming ages, the detailed procedures to reach the conclusion were shown in the report hereinafter.

The conclusion reached both to minimization of environmental impacts at the extent, and realization of an economic-viable and financially attractive development, is the universal truth for the coming hydropower development. Consequently, the alternative with FSL at EL.320m is proposed to select the most promising development scheme for the Project.

This conclusion was made on the recent worldwide circumstance and with understanding that the development should be made on the international rule even in the developing countries. However, on the other hand, there is a different recognition that it is still permissible greatly for the developing countries to give national developments the highest priority in order to maximize their own benefits.

The Study has not been carried out in line with the theme of choice between "Environmental Conservation" and "Promotion of National Development". But, the same will probably come to the main theme by shaping up of the Project. The scale of the Project, which constructs the permanent structure, is determined based on the sense of value at that time. Especially, for the Project likely to be implemented by IPP, the minimization of risks is a key factor for determination of the development scale.

Therefore, the extent and scopes for further investigation and study should not be limited only for the medium scale development of FSL.320m.

1.2 BACKGROUND OF STUDY

Lao PDR has a land area of 236,800km^2 and a population of 5.26 million (estimated in July 1998). The 90% of the working population was in rural areas and engages in agricultural work. GDP (Gross Domestic Product) grew at an annual rate of 7.6% from 1994 to 1998. GDP per capita in 1997 was about US$370.

Total installed capacity of power generation in 1999 was 576MW, which consisted of 561MW of hydropower and 15MW of diesel power. The latest plant is the Houayho HEPP (capacity 150MW) which started the commercial operation on September 3, 1999 as an IPP project. Among the hydropower plants, the Nam Theun-Hinbun HEPP (capacity 210MW and annual production 1,635GWh) completed in April 1998 overtook the Nam Ngum 1 HEPP (150MW and 990GWh) as the largest in Lao PDR. The fourth largest plant is the Xeset HEPP, which has 45MW of installed capacity and produces 180GWh of energy annually.

Annual total energy consumption in 1995 was 337GWh. Consumption of energy is growing at the annual rate of 8 to 10% and future growth of demand and the maximum output of energy is assumed to be 214MW and 818GWh in 2005, 329MW and 1,213GWh in 2010 and 506MW and 1,783GWH in 2015, respectively.

Lao PDR is selling surplus hydropower energy to Thailand, which has a lack of power supply. Earnings from those sales was US$29 million in 1994, which was an especially high-water year, and US$24 million in 1995. It is the second most promising source of income for Lao PDR.

The Government of Lao PDR exchanged MOU (Minutes of Understanding) in 1995 for 25 hydroelectric power projects to be developed on a BOOT basis (Build-Operation-Owned-and-Transfer) and power from those projects is all scheduled to be sold to Thailand. Lao PDR has a policy to positively develop their abundant hydropower potentials, especially the projects close to Thailand and Vietnam, which are scheduled to be developed for selling power to those countries.

The Nam Ngiep-I Hydroelectric Power Project was first studied by French consultant, Sogelerg Sogreah with an untied loan from the French government. He executed a Pre-F/S (Pre-Feasibility Study) from 1989 to 1991 and the first report was prepared in January 1991. Two (2) reports of the updated Pre-F/S were issued in February 1992 and November 1995. Salient features of the recommended scheme in the Pre-F/S are as follows:

Table 1.1 Salient Features of Recommended Scheme in Pre-F/S

Reservoir	Catchment area at dam site	3,700 km^2
	Annual average basin rainfall	2,960 mm
	Annual mean runoff	210 m^3/s (6,620 million m^3)
	Average run-off coefficient	0.61
	Probable maximum flood (PMF)	15,900 m^3/s
	Mean annual sediment flow	374 t/km^2 / year
	Reservoir area	156 km^2
	Gross reservoir capacity	7,200 x 10^6 m^3
	Effective storage volume	4,200 x 10^6 m^3
Dam	Dam type	Concrete faced rockfill dam
	Dam height & length	185 m, 620 m
	Dam volume	13.9 x 10^6 m^3
	Dam crest level	EL.367.0m
	Full supply level	EL.360.0m
	Spillway crest level	EL.346.5m
	Minimum water level	EL.330.0m
	Spillway capacity	8,730 m^3/s
	Installed capacity / annual total energy production	440 MW / 2,900 GWh

1.3 PURPOSE OF STUDY

In October 1996, the Government of Lao PDR made an official request to the Government of Japan to conduct a feasibility study of the Project, including review of the studies carried out under Pre-F/S resulting in a possible alternative for the hydropower development scheme due to its high economic factor and good accessibility to Thailand. The American developer Shlapac annulled the MOU in July 1996, which was exchanged in January 1991.

In response to the request, it was decided to dispatch a project formation mission with conditions at the internal meeting for the possible environmental impacts on resettlement and deforestation due to its large scaled dam development. The Government of Japan dispatched the mission in November 1997 and required consent with the conditions resolved at the meeting. GOL agreed on (i) an implementation of a basic study focussing on EIA (Environmental Impact Assessment) prior to a usual F/S, and (ii) an establishment of Public Involvement (PI) through a comprehensive development procedure with free access to information including local people and NGO consultation. Following his consent, the Government of Japan decided to dispatch a preliminary mission to discuss and conclude the scope of works with the Government of Lao PDR.

Though the mission was dispatched from late February to early March 1998 and pre-studied survey items and the schedule for the Study, GOL reserved signing on the agreement during the mission due to a tight schedule. Upon dispatching a consequent mission in late March 1998, the agreement was reached on March 27, 1998 between GOL and GOJ.

The objective of the Study is to work out the most recommendable reservoir type hydroelectric power project. However, in a study of this kind, an Environmental Impact Assessment (EIA) survey is mainly carried out to evaluate the environmental impact and to assess the possible mitigation measures for both the existing scheme and the alternative plans. Based on the results, both the Japanese and Laotian governments will mutually agree whether or not the Study should continue to the second stage on detailed investigation.

As this Draft Final Report has proposed to continue studying for the second stage, the F/S grade design and the detailed investigations are required to be carried out in addition to the continuous hydrological survey and the environmental survey. The detailed investigations include an aero-photo geological survey covering the whole proposed reservoir area and a geological survey with core-boring investigation at the proposed dam site, which have not been executed in this first stage.

It is also one of the major objectives to achieve transfer of technology and training of the counterpart personnel of HPO/MIH through and during the Study. As it is scheduled to invite a trainee to Japan for several weeks each year, the chief counterpart of HPO finished the first year program in Japan from late March 1999 for about one month. For the second year, the other counterpart personnel visited Japan late October for about one month.

1.4 WORK PROGRESS OF STUDY

The Study has been conducted since late July 1998 to January 2000 for 18 months in two (2) fiscal years focussing on the Environmental Impact Assessment (EIA) survey as shown in Figure 1.1.

The Environmental Assessment Committee (EAC) was organized by JICA as an advisory panel and was independent of the Study Team. The EAC meetings were held prior to each General Workshop by five (5) members consisting of Laotian, American and Japanese members with a Japanese hydropower specialist as a coordinator. The substantial EIA survey has been carried out divided into the 1st Fiscal Year (December 1998 to March 1999) and the 2nd Fiscal Year (May to September 1999) by the Laotian sub-contractor, who was selected through the local competitive bidding (LCB).

First Fiscal Year

The field investigation of the 1st Fiscal Year was commenced by dispatching the Study Team to Vientiane in Lao PDR on August 10, 1998. Right after arrival, a joint site inspection by a large helicopter content was performed on August 10, 1998 flying over the proposed reservoir area, and the Inception Report was explained to HPO/MIH for their approval on the contents. Explanation, discussion and some pending matters on the contents of the Report were compiled into the Minutes of Meeting, which was conducted at the signing ceremony held on August 17,

1998 with acknowledgement of related peoples including the Vice-Minister of Industry and Handicrafts, Ambassador of Japan Embassy, etc.

The 1st General Workshop for Inception Report was carried out in the capital Vientiane on November 26-27, 1998 after submission of the Progress Report at the end of October 1998. That compiles the Initial Environmental Examination (IEE) results, the Environmental Impact Assessment (EIA) survey progress, installation of the hydrological observation equipment, the GPS survey in the reservoir area and the alternative study progress of hydropower plan, etc. The Workshop was held during the 2nd Field Investigation to explain the contents both of the Inception and Progress Reports aiming at the exchange of views with local people and NGOs by a positive challenge for free access to information. During the Workshop, it was proposed (i) to hold a Site Workshop at the proposed reservoir area apart from the General Workshop in capital, (ii) to carry out a ground survey in the Thaviang Sub-District which is the key area for the Project at the upstream area of the reservoir and (iii) to deliver promptly the reference papers for the prospective participants prior to the Workshop.

The 1st Site Workshop was held both at B.Dong of the Thaviang Sub-District in the upstream of reservoir and B.Sopyouk in the downstream with the attendance of HPO/MIH counterparts and the Study Team with a large helicopter. It was aimed at public consultation of the methodology and purpose of the Study. However, the villagers were highly interested in the Project because of possible resettlement due to alternative study results.

The Interim Report was submitted as the study results of the 1st Fiscal Year at the end of March 1999, which compiles the Interim Report of EIA survey, the ground survey results in the Thaviang Sub-District, the hydrological observation results and the alternative interim study results of hydropower plan, etc.

Second Fiscal Year

The field investigation of the 2nd Fiscal Year was commenced by dispatching the Study Team to Vientiane in Lao PDR on May 18, 1999. The 2nd General Workshop was held in Pakxan, Bolikhamsay Province near the junction of the Nam Ngiep River and the Mekong River on June 9-11, 1999, aiming to present the Interim Report. Questionnaires concerning the requirements and questionnaires on the regional development plan of the Project and the resettlement aspects were raised more than that in the previous General Workshop in Vientiane due to the attendance of many local governors and residences moved by a large helicopter in addition to the definite contents of the Project. It was requested (i) to submit the draft Final Report earlier than the schedule for the next Workshop, (ii) to execute an additional investigation on the proposed resettlement area by local government and (iii) to hold the Site Workshop providing a gender expert.

Following the 2nd General Workshop, the 2nd Site Workshop was held at the center of downstream area of the proposed dam site, B.Somseuam (B.Muanmai) of Bolikhan District on June 24, 1999. During the Workshop, the Study Team explained mainly the potential impacts and possible mitigation strategies of river water fluctuation due to dam construction, since their impacts are quite different from that in the reservoir area, where the previous Site Workshop was held.

The 1st Draft Final Report was submitted at the end of September 1999, compiling the Draft Final Report of EIA survey, the minutes of both the 2nd General and Site Workshops and the 2nd

EAC meeting and the alternative final study results of the hydropower plan, etc. After compilation of the comments by MIH/HPO during the presentation of the 1st Draft Final Report in October 1999, the 2nd Draft Final Report with executive summary was submitted in mid-November 1999. The Study Team recommended to proceed the medium-scale dam development in the Report.

Following the 3rd EAC meeting on December 3-8, 1999, the 3rd General Workshop was held in Vientiane on December 9-11, 1999 with about 120 participants. This time also, as a large helicopter was prepared for transportation of the villagers and the local government officers, they understood an intention of MIH/HPO and JICA to have respect for opinions by local peoples. At the Workshop, the comment was raised (i)a concentration among a flexibility of the development scale decision prior to a detailed field survey for the next stage F/S, (ii)requirements on definite conditions of compensation for resettlement, and (iii)execution of a rural development in line with the resettlement action plan.

Following the General Workshop, the 3rd Site Workshop was held at the 3 villages, where had been held the Workshop previously. According to the prior site visit by the Gender Specialist and unlimited number of participants, the number of participants at both villages in the reservoir was over 200 people and a half of them were women. The women's speaking attracted attention at all Site Workshops, they proposed a sufficient compensation and a rural development as they would obey the governmental judgement if they should move.

January 2000, the Study Team made a field survey in Thailand ad Vietnam for research of their current economic and power market conditions, and the field reports and analysis results had been contained in this Final Report.

In upcoming March, the discussion meeting for the execution of the next stage F/S is scheduled to be held in Vientiane between JICA and MIH/HPO based on this Final Report.

Report Submission

All the Study Reports submitted prior to the Final Report are shown below:

Table 1.2 Submitted Study Reports

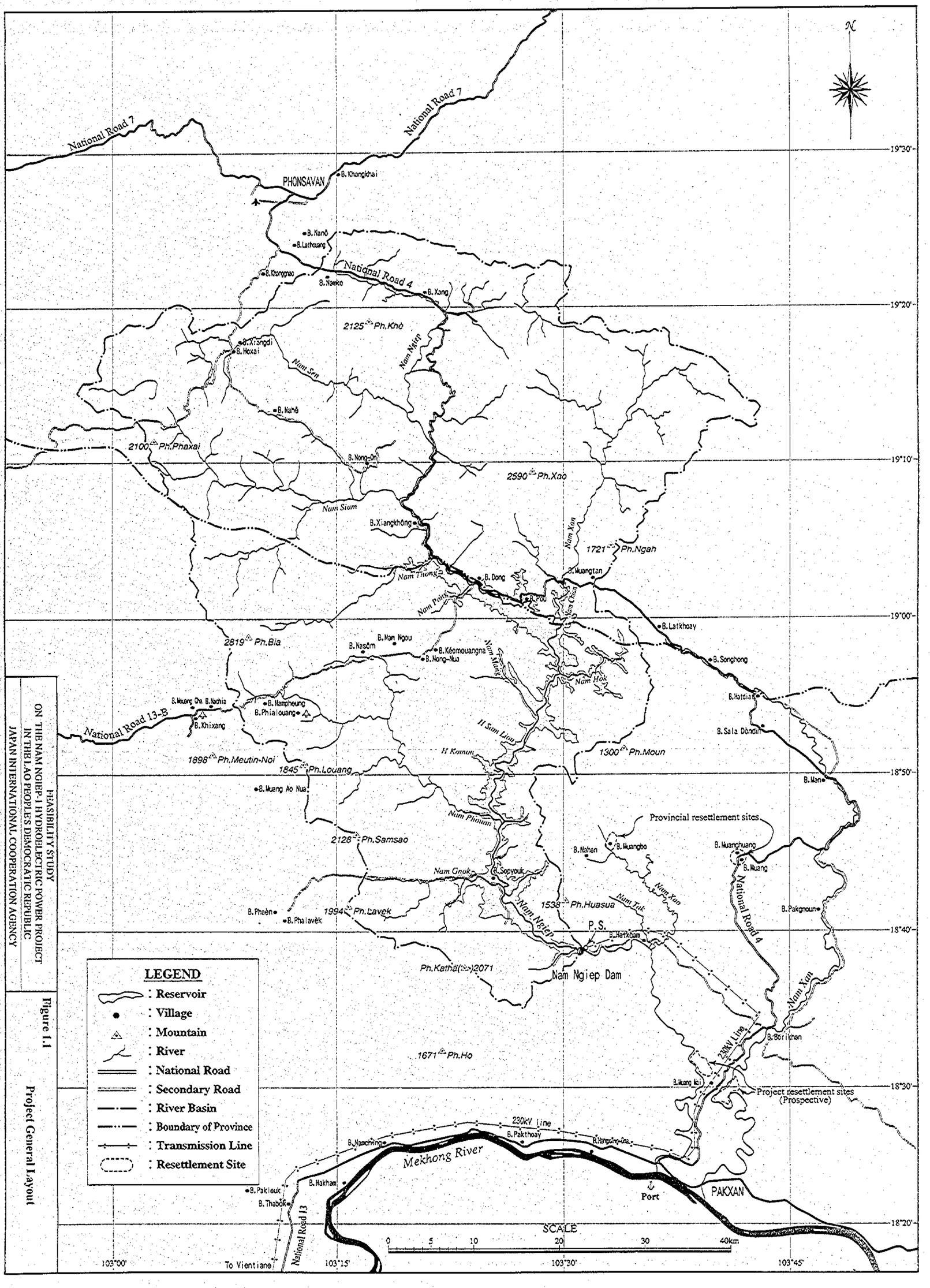
No.	Report Title	Date of Submission
1.	**Inception Report**	August 1998
2.	Draft Execution Plan of EIA Survey	August 1998
3.	Tender Documents of EIA Survey	September 1998
4.	Contract of EIA Survey	December 1998
5.	**Progress Report**	October 1998
6.	Supporting Report (A) : IEE Report	October 1998
7.	Supporting Report (B) : Execution Plan of EIA Survey	October 1998
8.	**Interim Report**	March 1999
9.	Supporting Report (A) : Interpretative EIA Interim Report	March 1999
10.	Supporting Report (B) : Sub-Contractor's EIA Interim Report	March 1999
11.	Supporting Report (C) : Data Book of Hydrological Observation	March 1999
12.	**1st Draft Final Report (Main Report)**	September 1999
13.	Supporting Report (I) : First EIA Report	September 1999
14.	Supporting Report (II) : Environmental Management Plan	September 1999
15.	Supporting Report (III) : Preliminary Resettlement Plan	September 1999
16.	Supporting Report (V) : Records during Field Investigations	September 1999
17.	**2nd Draft Final Report (Main Report)**	November 1999
18.	2nd Draft Final Report (Executive Summary)	November 1999

1.5 COMPOSITION OF STUDY REPORTS

The Final Reports consist of the main report, the executive summary and the supporting reports (5 volumes). The supporting reports contain not only the environmental assessment report as the major scope of work but also the data book for the minutes of meetings for Environmental Assessment Committee and General and Site Workshops, with separate volumes for easy multiple use. The composition of the study reports is as shown below:

Table 1.3 Composition of Study Reports

Vol. No.	Report Title	Contents	Japanese	English	
			JICA	JICA	MIH
1.	Main Report	-	O	O	O
2.	Executive Summary	-	O	O	O
3.	Supporting Report (I)	First EAI Report	-	O	O
4.	Supporting Report (II)	Preliminary Environmental Management Plan	-	O	O
5.	Supporting Report (III)	Preliminary Resettlement Plan	-	O	O
6.	Supporting Report (IV)	Sub-contractor's Field Investigation Report	-	O	O
7.	Supporting Report (V)	Records during Field Investigation	-	O	O

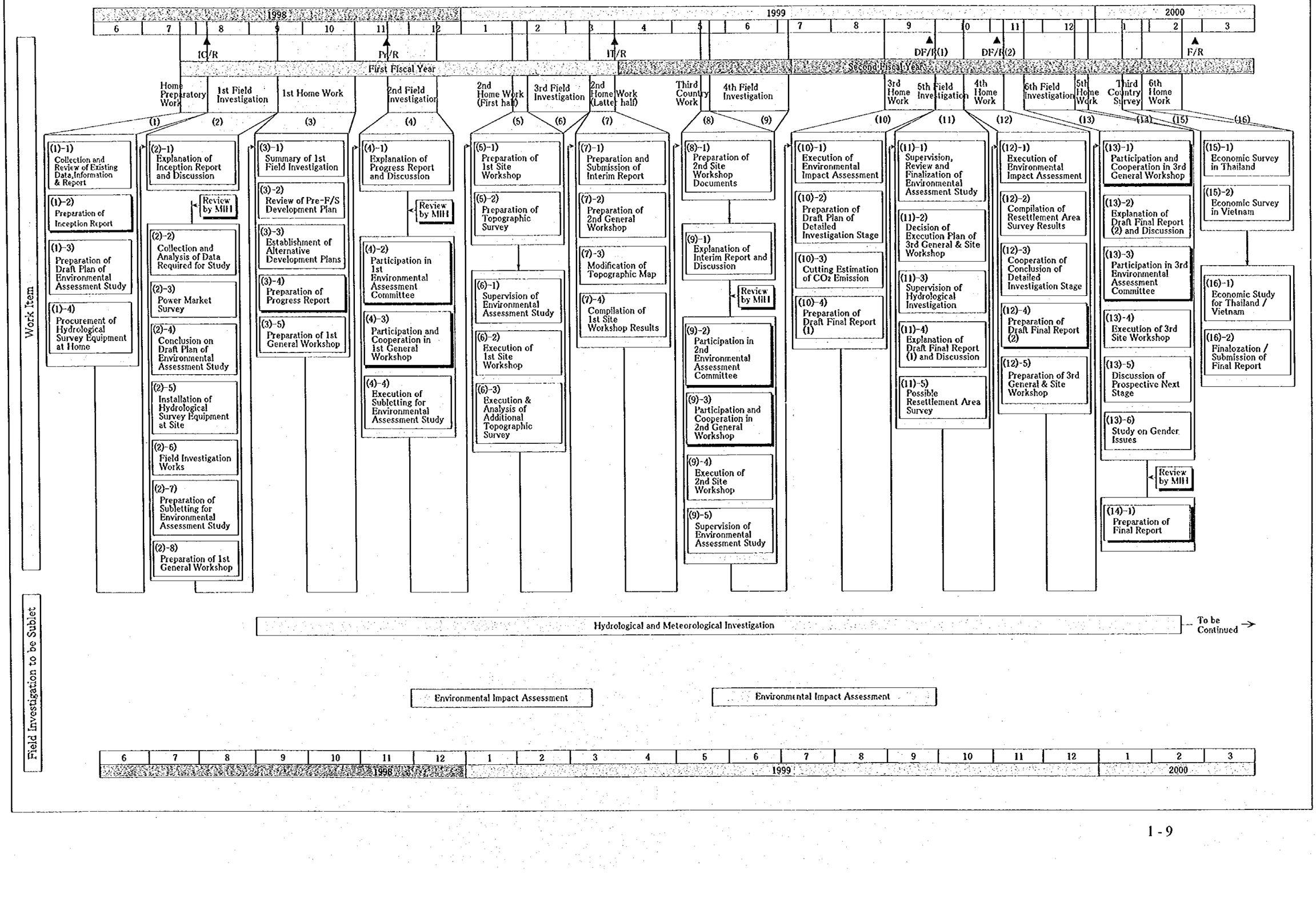


FEASIBILITY STUDY
ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT
IN THE LAO PEOPLES DEMOCRATIC REPUBLIC
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 1.1

Project General Layout

Figure 1.2 Feasibility Study of the Nam Ngiep - I Hydroelectric Power Project Overall Work Flow



2. GEOPHYSICAL SURVEY

2.1 GENERAL

Existing maps used for the Study are of 1:50,000 scale (contour 20m pitch, as of 1967) and 1:100,000 scale (contour 40m pitch, as of 1982). However, since both types of maps are made by aerophoto surveys (photo scale: 1:60,000), accuracy of the counter line is assumed to be ±10m. Therefore, it is expected that the elevations in the counter map and actual elevation do not conform with each other, which will cause large discrepancies between the proposed reservoir inundation area and the actual one. In this context, checking and survey on the existing counter map elevation were executed through GPS (Global Positioning System) single point survey at the 1st Field Investigation in August to September 1998.

However, according to the results of GPS survey, which will be described below, there were no relations between the two (2) elevations of the GPS surveyed point and the point on the existing map. Consequently, the attempt to estimate the lowest elevation of the village and field failed by applying the GPS surveyed points at represented villages. The inundation of the Thaviang Sub-District is the largest concern among the social environmental aspects of the Study. In this context, an additional ground survey to identify accurately the distribution and elevation of both villages and fields was proposed to be executed at the 1st Environmental Assessment Committee meeting prior to the 1st General Workshop in November 1998. Following JICA's approval on the Study Team's requirements to carry out the inevitable ground survey, it was performed during the 3rd Field Investigation in February 1999.

Prior to execution of the ground survey at Thaviang Sub-District, the survey schedule was established by grasping the latest distribution of villages and fields by SPOT satellite pictures purchased. These pictures are taken by a satellite launched at the height of 832km by France SPOT in 1997, by which various analyses and mapping are possible.

As a result of the above two (2) geophysical surveys, the prospective inundated area at the Thaviang Sub-District by FSLs of the proposed reservoir was applied to the alternative studies.

2.2 GPS SURVEY IN PROPOSED RESERVOIR

2.2.1 GENERAL

Considering the fact that (i) local survey companies had poor experiences on GPS Survey, and (ii) ordinal traverse survey took a long time since there was no road along the river, the Study Team brought survey equipment from Japan, hiring local supporting staffs in cooperation with HPO's counterparts, and executed direct survey using a small helicopter for transportation.

Target regions of GPS single point survey were decided to be the existing benchmarks in the proposed reservoir and its vicinity area, along rivers and villages etc. A ground leveling survey was also executed starting from the benchmark in Pakxan up to the upper most area of the proposed reservoir (the Thaviang Sub-District), and elevation adjustment of GPS single point was executed for more accuracy. During the survey works, material collection also was done to confirm inundated villages.

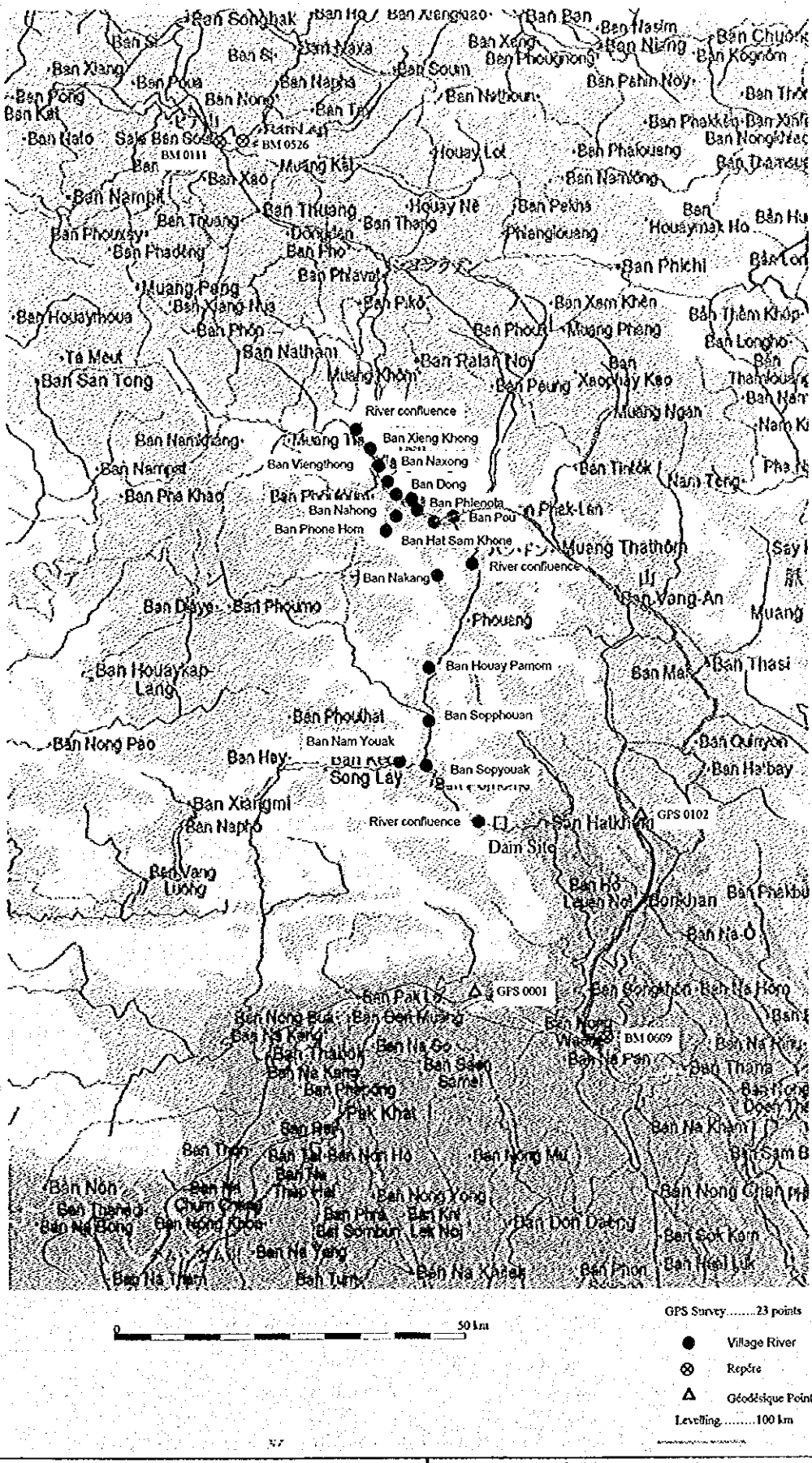
For the purpose of adjustment of the proposed reservoir area and storage volume measured by the existing map, the same elevations as the GPS survey points were also derived from 1:50,000 existing map to compare with the results of the GPS single point survey. However, differences between those points were not uniform. At some points GPS survey elevation was 33.88-2.32m higher than the existing map and 15.36-0.85m lower in other points. It was thereby judged to be inappropriate to adjust reservoir area and storage using these differences.

The extent of the geophysical survey carried out during the 1st Field Investigation was for a total of twenty-three (23) points of the GPS survey and ground leveling survey made for the stretch of 100km long between Pakxan and the Thaviang Sub-District as shown in Figure 2.2.1 and Table 2.2.1 below:

Table 2.2.1 Feature of Geophysical Survey

Survey	Item	Extent	Remarks
GPS Survey Point	Existing Base Point	5	Red paint was coated on the stakes except for one part.
	River Water Level Point	3	
	Village Point	15	
	Total Point Number	23	
Extent of Leveling Survey	Beginning Point (Pakxan)	Existing BM (GPS 0102)	Distance between Beginning point and End point was about 100km. Survey was made simultaneously by two parties with open survey method to keep a required accuracy.
	End Point (Thaviang)	B.Hatsam Khone	

The following table shows the comparison of an execution plan and actual works. Around 30 point survey works were planned, however, 23 points were done. The reason is that, in addition to the fact that the works were done in the rainy season, which limited the flight route of the helicopter and extended flight time of the helicopter, the helicopter could not land due to the increase in water level in the river. By taking the countermeasure to change the planned GPS points to others, GPS surveyed points covered the whole of the proposed reservoir.



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC	Figure 2.2.1 Survey Area Map
JAPAN INTERNATIONAL COOPERATION AGENCY	

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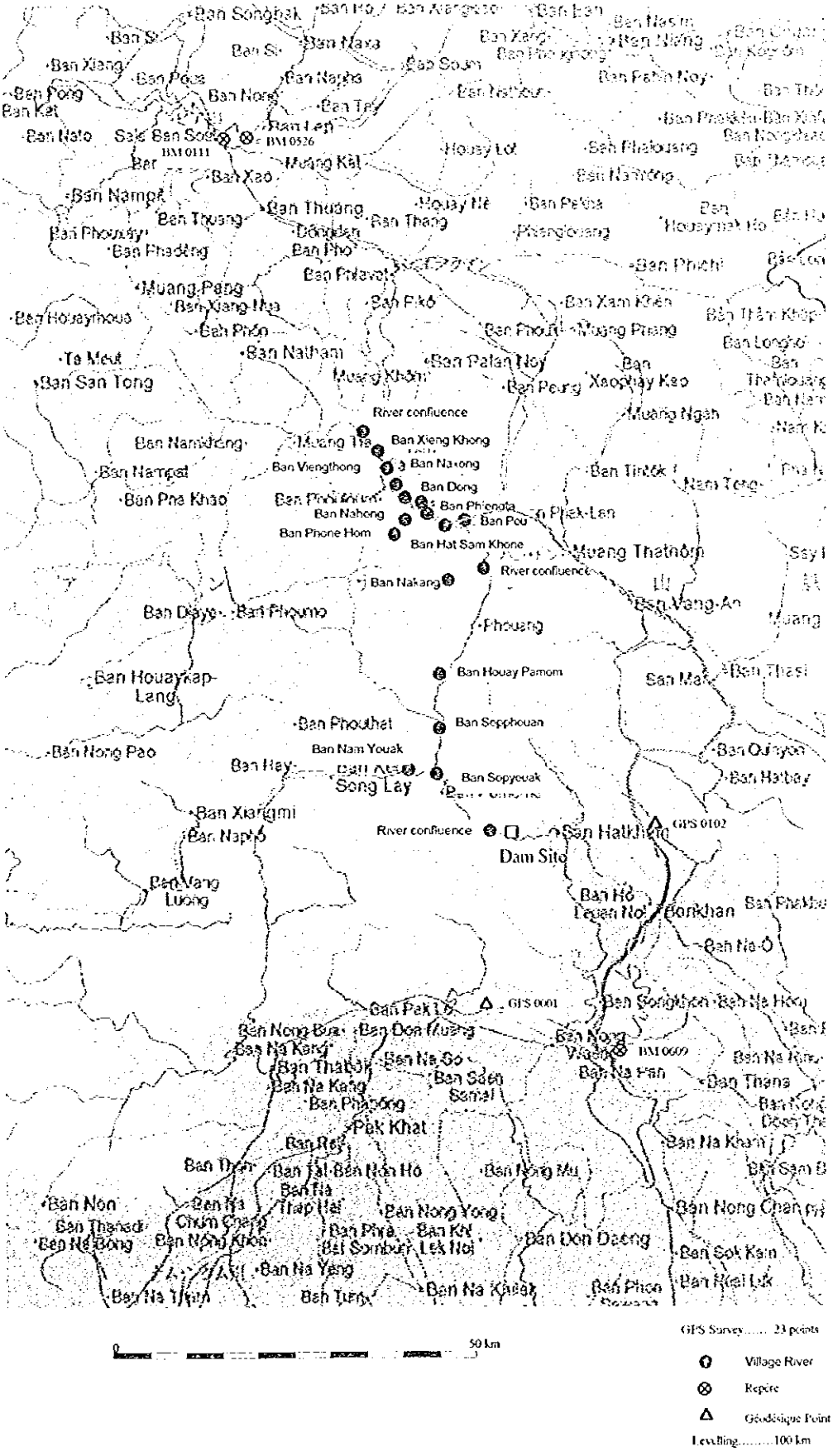


FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC	**Figure 2.2.1** **Survey Area Map**
JAPAN INTERNATIONAL COOPERATION AGENCY	

Table 2.2.2 Comparison between Execution Plan and Actual Works

Survey Item	Implementation Plan	Actual Works
Number of survey point	30 in total (10 points along the river at 10 km intervals, 20 points at dam site, villages, basin, depressions, etc.)	23 in total (Existing benchmark 5 points, 3 points along the river, 15 points in the village)
Leveling survey	About 100 km Pakxan to Thaviang	From Pakxan to B.Hatsam Khone (Thaviang)
Leveling accuracy	1:10,000	No change

2.2.2 GPS SURVEY

(1) Given Points and Base Points for GPS Survey

Given points and base points for GPS survey are as shown in the table below:

Table 2.2.3 Given Points for GPS Survey

Purpose of Point	District	Given Point
For X-Y coordinates	Pakxan	GPS 0102, GPS 0001
For elevations	Pakxan	GPS 0102, GPS 0001, BM 0609
	Phonsavan	BM 0111, BM 0526

Table 2.2.4 Base Points of GPS Survey

No.	Item	Standard
1.	Height	Mean sea water level
2.	Base ellipse	Everest and Krasovskie
3.	Method of projections	UTM, 48 zones (Everest)

(2) Villages and River Water Level Measurement surveyed by GPS

Among the total of 18 villages, which will be inundated for the case of FSL EL.360m, 15 villages were surveyed by GPS. And, river water level of the Nam Ngiep River was observed for the following three (3) confluence points with branch rivers:

Table 2.2.5 River Water Levels Observed

No.	Branch River	Survey Point	Elevation (m)
1.	Nam H.Katha	At 1km u/s of proposed dam site	EL.197.15
2.	Nam Chian	5km d/s of confluence	EL.294.76
3.	Nam Slam	200km u/s of confluence	EL.362.64

(3) Time Schedule for GPS Survey

Confirmation of coordinates for the existing base points (bench marks, triangulation points, GPS survey points), field reconnaissance and observation for the points to be newly established, its adjustment, etc were performed with the following time schedule:

Table 2.2.6 Time Schedule of GPS Survey

No.	Works	Schedule (in 1998)	Site
1.	Field reconnaissance	August 14-27	Pakxan, B.Hat Sam Khone, B.Phone Hom, Base Points
2.	GPS base point survey	August 26	Pakxan
3.	GPS new point survey	August 28 to Sept 3	Proposed Reservoir
4.	Data adjustment	Sept 5 to 7	-

(4) GPS Survey Equipment and Calculation Method

GPS survey was executed by using three (3) units of 4000SSE (Trinble-brand) for the benchmarks and new base points, and definite values of elevation were determined with adjustment for the readings.

Longitudes and latitudes of the respective points were calculated based on the Krasovskie and Everest ellipses. Plane coordinates were computed by 48-zones of UTM conforming to the Everest ellipse.

GPS survey network, the survey schedule and the survey results showing the daily time table actually applied for the survey and machine Nos. set out at the points were given in the Supporting Report (VI).

2.2.3 GROUND LEVELING SURVEY

(1) Given Points Adopted and Villages for Ground Leveling Survey

GPS 0102 was given as the Base Point for the ground leveling survey. The elevation of this point has been determined in advance by the simplified ground survey.

Elevations of the given points (i) and (ii) in the table below were first measured and were provided as reference benchmarks for the ground leveling survey. As for the villages in (iii) and (iv), these elevations were roughly measured based on the intermediate point levels taken in the ground survey, because these points are located near the route of the ground survey.

Elevations of two villages in (v) and (vi) have not been observed by this ground survey, but it has been confirmed that these villages lie on intermediate levels of the respective adjacent villages at up and downstream areas.

Table 2.2.7 Villages Selected for Ground Leveling Survey

No.	Point	Villages	Remarks
(i)	GPS 6	B.Pou	Reference benchmark
(ii)	GPS 7	B.Hat Sam Khone	Reference benchmark
(iii)	-	B.Naphang	Assumed EL.322m - 323m
(iv)	-	B.Nam Long	Assumed EL.363m - 364m
(v)	-	B.Phong yeng	Assumed EL.327m - 330m
(vi)	-	B.Naxai	Assumed EL.330m - 340m

(2) Schedule of Ground Leveling Survey

Confirmation of the location of the reference benchmark at GPS 0102 was made in the field reconnaissance. A ground leveling survey was performed by using two (2) units of NA2000 (Wild-Brand), and elevations at two (2) points of GPS 6 and GPS 7 were measured. However, the elevations of other points were obtained by GPS survey in relation with the measured elevations for GPS 6 and GPS 7 and determined with a level adjustment. The actual schedule set up for ground leveling survey was as shown in the following table:

Table 2.2.8 Time Schedule for Ground Leveling Survey

Schedule (in 1998)	Works	Site
August 26	Field reconnaissance	Existing bench marks
August 27 to September 9	Ground survey	Pakxan to Thaviang
September 10 to 14	Data adjustment	Vientiane

2.2.4 LEVEL DIFFERENCES BETWEEN GPS SURVEY AND READ ON MAPS

A comparison was made for the elevations of villages measured by GPS survey and the reads on the existing topographic maps of the scale 1:50,000. As a result, there are remarkable discrepancies between the survey and read as shown in the table below, with +33.88m as the highest and –15.36m as the lowest discrepancy.

Table 2.2.9 Discrepancy of Elevations Between Survey Result and Read on Existing Map

Point Name	Survey Location	Measured EL. (m)	EL. read on Map (m)	Difference (m)
GPS1	River confluence	197.15	198	-0.85
GPS2	Ban Sopyouak (primary school)	245.48	260	-14.52
GPS3	Ban Sopphouan	261.22	250	11.22
GPS4	Ban Nakang	354.98	352	2.98
GPS5	5km downstream from junction of rivers	294.76	280	14.76
GPS6	Ban Pou	318.92	295	23.92
GPS7	Ban Hat Sam Khone	326.15	296	30.15
GPS8	Ban Phiengta	322.65	312	10.65
GPS9	Ban Nahong	341.88	308	33.88
GPS10	Ban Phone Hom	368.32	366	2.32
GPS11	Ban Dong (grass land)	327.24	310	17.24
GPS12	Ban Dong (school ground)	335.65	319	16.65
GPS13	Ban Naxong	330.44	321	9.44
GPS14	Ban Viengthong	339.40	330	9.4
GPS15	Ban Xieng Khong	361.72	360	1.72
GPS16	about upstream from junction of rivers	362.64	378	-15.36
GPS17	Ban Houay Pamom	274.59	280	-5.41
GPS18	Ban Nam Youak (primary school)	271.12	275	-3.88
Additional	Ban Nam Long	abt. 363.75	350	13.75
Additional	Ban Naphang	abt. 322.53	315	7.53

2.3 GROUND SURVEY AT THAVIANG SUB-DISTRICT

2.3.1 GENERAL

This ground survey was carried out within the limit of the Thaviang Sub-District upstream of the proposed reservoir where, it will be inundated widely in case of the large-scale dam scheme. The purposes are the correction of the existing 1:50,000 map at the Thaviang Sub-District by a cross section survey and the establishment of accurate elevations.

In detail, additional survey points are extended for cultivating lands in the Thaviang Region from GPS 6 to GPS 14, which were established during the 3rd Field Investigation in February 1999.

These points were connected by a traverse survey, elevations of which were given to the extended additional points by a leveling survey so the number of villages and area of cultivating land to be inundated are grasped for the respective FSLs.

The Study Team brought survey equipment from Japan same as the previous GPS survey in the 1st Field Investigation, hiring local supporting staffs in cooperation with HPO's counterparts, and executed a direct survey using 4WD vehicles for transportation.

2.3.2 PREPARATORY WORKS

For the smooth execution of the ground survey at the Thaviang Sub-District, the modification of topography was made on the map of 1:50,000 scale by using SPOT-Satellite Pictures, by which the target of size more than 10m can be read. As accuracy of the altitudes read by the SPOT-Satellite Pictures was not so high, the topography was adjusted by the results of the traverse survey, which not had been revised before survey.

A vector conversion is made for the scanned existing 1:50,000 scale map, and geographical objects and contour lines were digitized by a computer graphic software. The modified map was used for the ground survey in the 3rd Field Investigation.

2.3.3 FIELD SURVEY WORKS

Traverse survey and cross section survey were carried out based on the GPS points staked during the 1st Field Investigation for the cultivation area developed at the Thaviang Sub-District of 20km long stretch along the Nam Ngiep River from B.Viengthong to B.Pou. And, elevations of those survey points were measured by a direct leveling survey and offset survey. The schedule of respective survey works was as shown below:

Table 2.3.1 Work Schedule of Geophysical Survey

Kind of Survey	Work Item	Actual Schedule (in February 1999)
Traverse Survey	Site reconnaissance	6 - 7
	Measurement	6 - 15
	Computation	6 - 7
Cross Section Survey	Measurement	7 - 16
	Computation	14 - 18
Leveling Survey	Measurement	18 - 21
	Computation	21 - 23

(1) Traverse Survey

By referring GPS 11 and GPS 12, an eccentric point P-1 was staked in the schoolyard at B.Dong, and an open traverse survey was made in three (3) directions to B.Viengthong, B.Phonehom and B.Pou based on the point P-1. Total length of the traverse survey was about 20km.

The equipment used for the traverse survey were Topcon GTS505 (2 sets) and Topcon GTS305 (1 set).

(2) Cross Section Survey

On the traverse survey line provided during the 2nd Field Investigation along the Nam Ngiep River, a total of 16 base points were newly provided for a cross section survey. From the base points, an offset was extended in the cultivating land neighboring the respective base points and a point leveling survey was carried out to determine an average elevation of the respective villages and cultivating lands by using a total station system.

The equipment used for the cross section survey were Topcon GTS 505 (2 sets) and Topcon GTS 305 (1 set).

(3) Land Leveling Survey

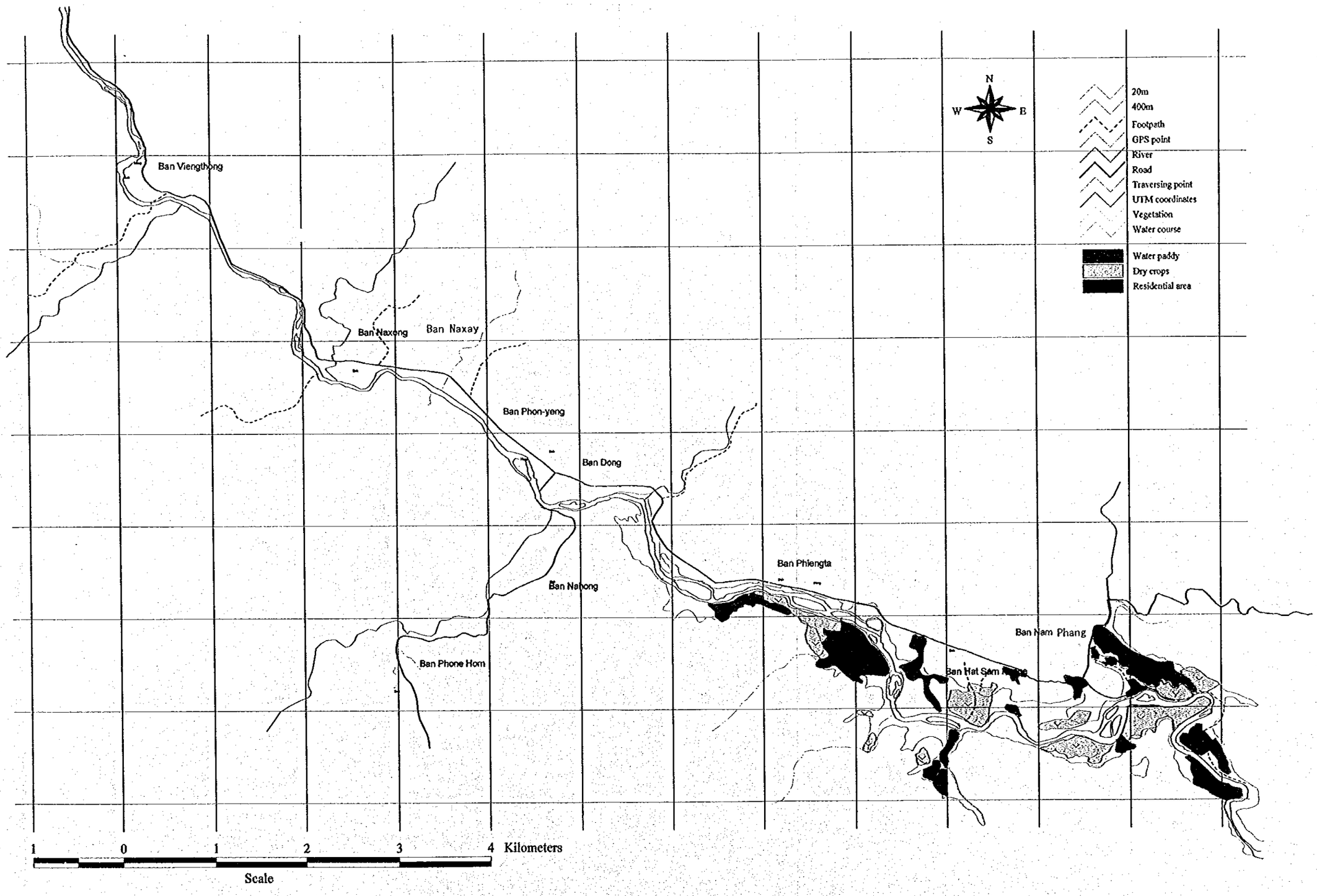
The land leveling survey was started from the GPS 7, of which elevation was given based on the Bench Mark at Pakxan, and elevation adjustment of the respective GPS points and survey of elevation for the cross survey points were made.

The equipment used for the land leveling survey was WILD Auto Level (1 set).

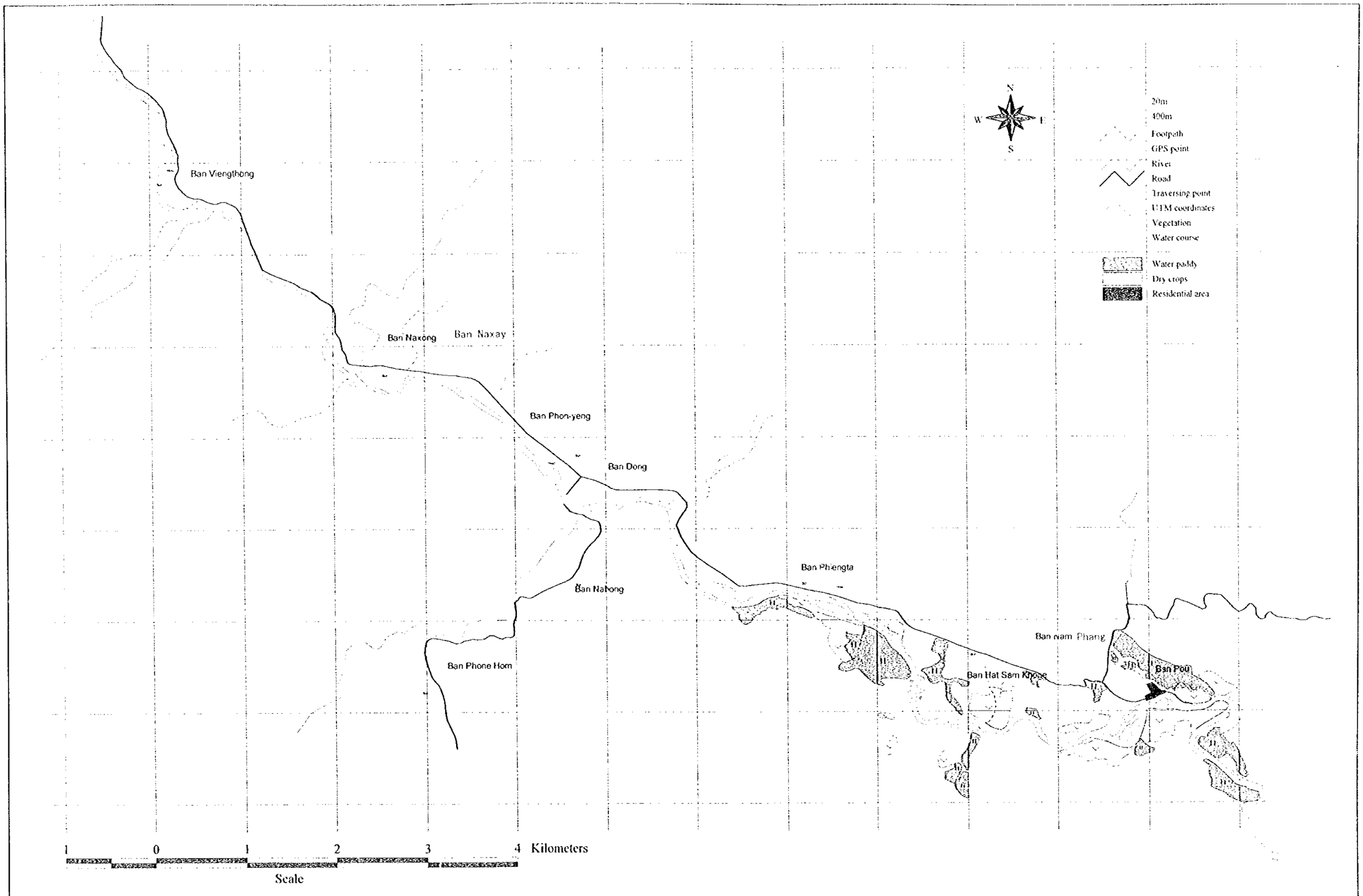
2.3.4 RESULT OF FIELD SURVEY

It was revealed that there were 0.2m to 0.9m of discrepancy on the GPS point elevations between the results of the previous survey and direct land leveling survey at the 3rd Field Investigation. As the error of the round-survey at the 3rd Field Investigation was 25mm for the one-way distance of 20km, it was judged that the accuracy of the survey was higher than the previous and quite satisfactory. Therefore, the inundation area of cultivating land and the number of villages were determined based on the result. The inundation area maps of cultivation land based on the survey results at different FSLs were given in Figure 2.3.1 and Figure 2.3.2 respectively for EL.320m, and EL.360m.

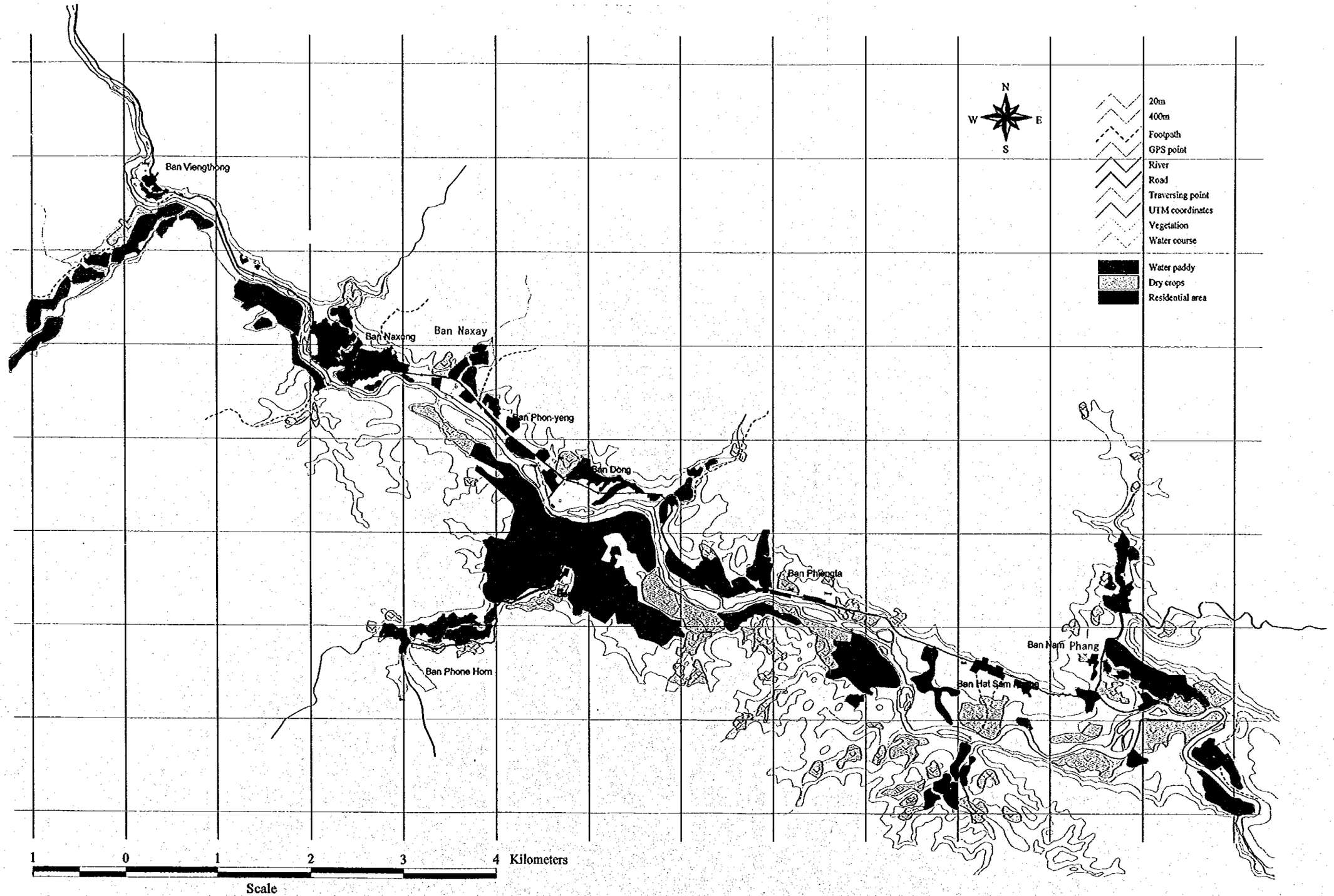
Other inundation area maps for EL.300m, EL.340m and EL.380m and the coordinate list of the observed survey points and observed point-elevation map are shown in the Supporting Report (VI).



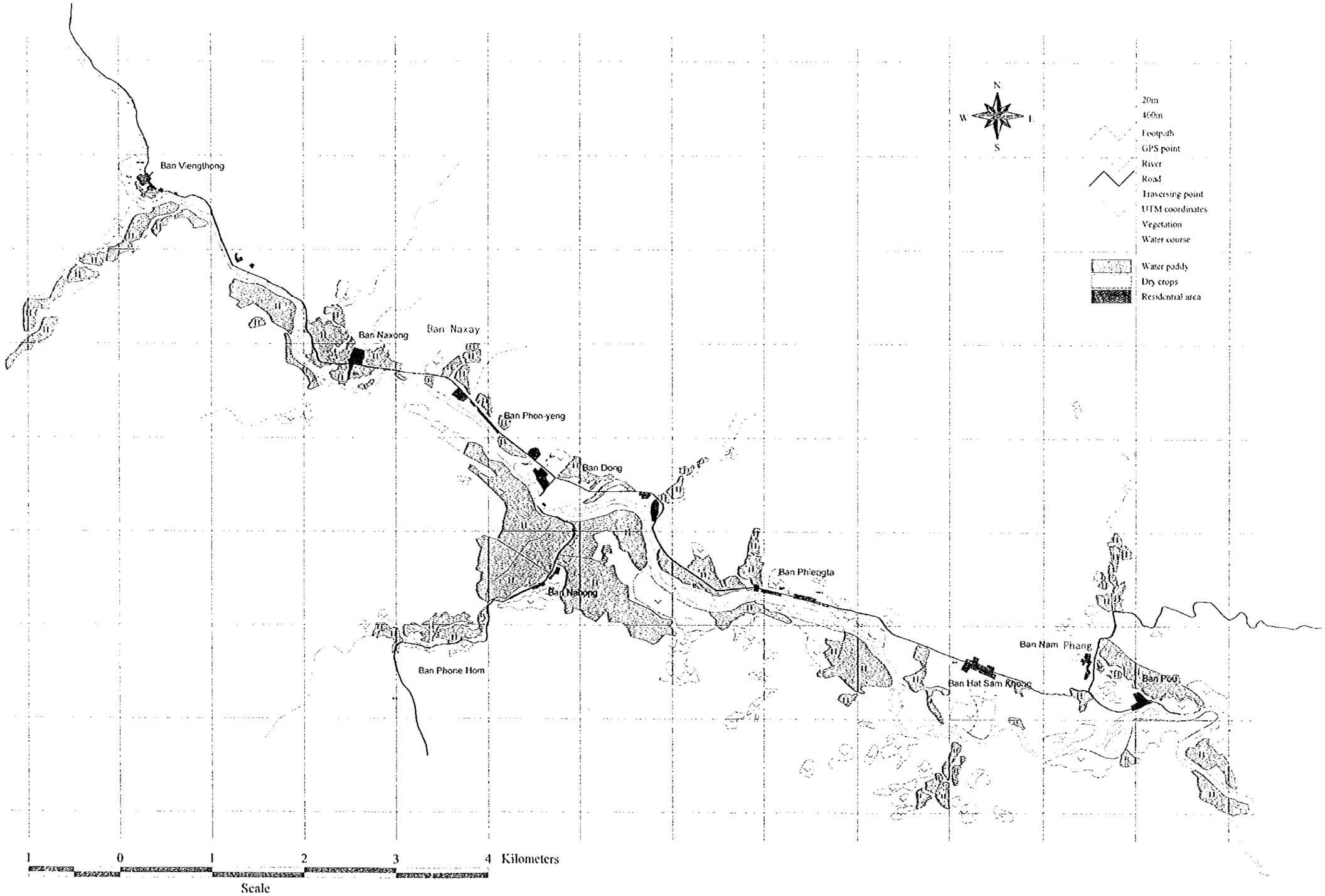
FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 2.3.1** **Inundation Area Map of Cultivation Land at FSL.320m**



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 2.3.1** **Inundation Area Map of Cultivation Land at FSL.320m**



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 2.3.2** **Inundation Area Map of Cultivation Land at FSL.360m**



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 2.3.2** **Inundation Area Map of Cultivation Land at FSL.360m**

3. GEOLOGICAL SURVEY

3.1 GENERAL

3.1.1 GEOLOGICAL DATA COLLECTION

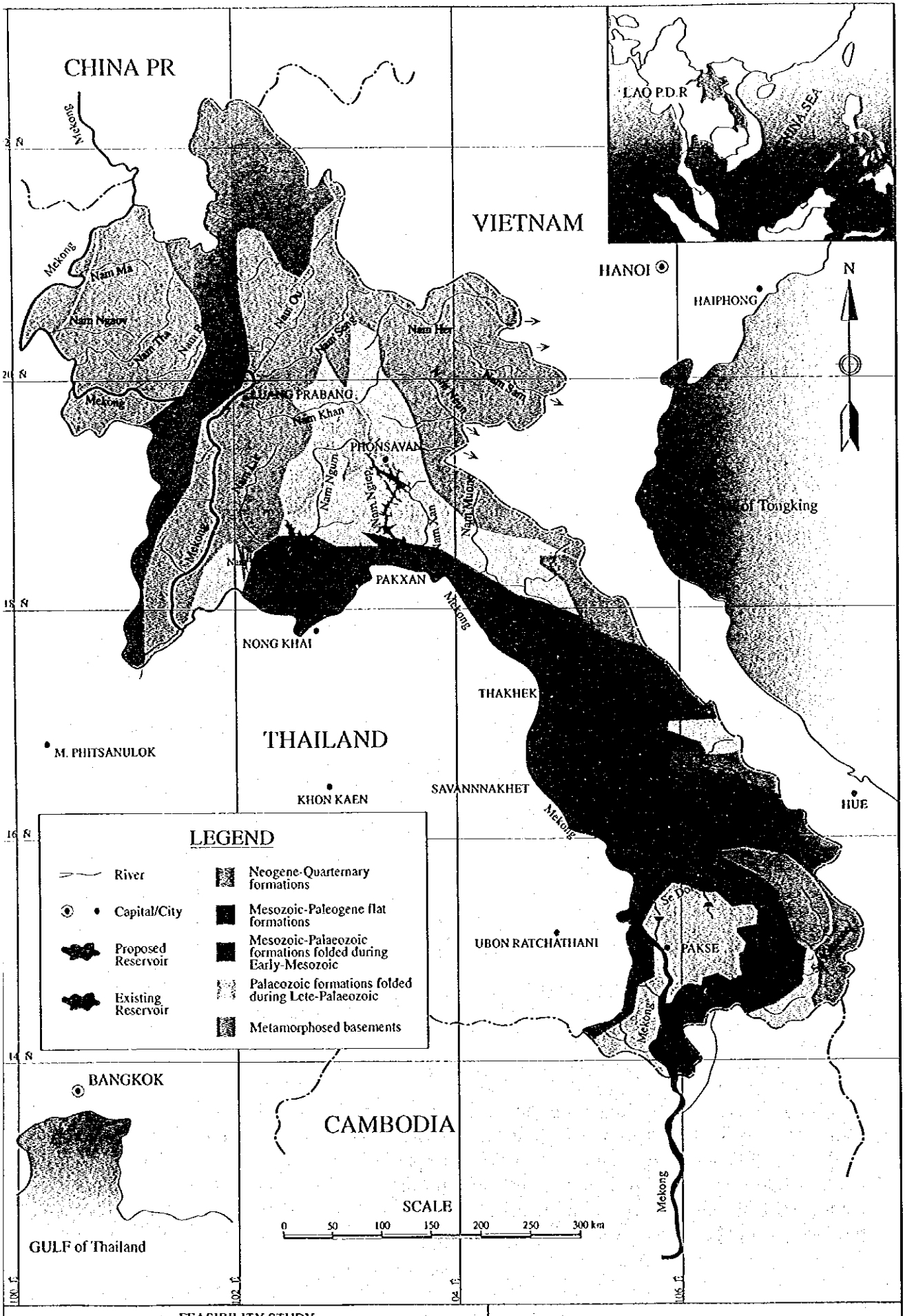
During the 1st and 3rd Field Investigations, the following geological maps and a report were collected:

Table 3.1.1 Geological Data Collection

No.	Title	Scale	Publish	Obtained by
1.	Geological Survey for Vietnam, Geology of Cambodia, Laos and Vietnam	1:1,000,000	Hanoi, Vietnam, 1991	Metal and Mining Industrial Agency, Resources Information Center Japan
2.	Report of DMR-COOP-MMAJ Joint Seminar on Application of Satellite Image Analysis in Mineral Exploration	-	17-19 February 1988, Bangkok, Thailand, p36-38 Khampha Phommakaysone	Application of Satellite Image Analysis in Mineral Exploration in Lao PDR
3.	Photo Geological Reconnaissance Map PAKSANE and BANBAN	1:250,000	1973 by the Institute of Geological Science, London	Geology and Mines, Ministry of Industry and Handicraft (MIH)
4.	Lao PDR Geological and Mineral Occurrence Map	1:1,000,000	British Geological Survey and Department of Geology and Mines	Ministry of Industry and Handicraft 1990
5.	Aerial photographs	1:30,000, in 1981		32 sheets (surrounding area of reservoir)
6.	Aerial photographs	1:25,000		8 sheets (damsite)

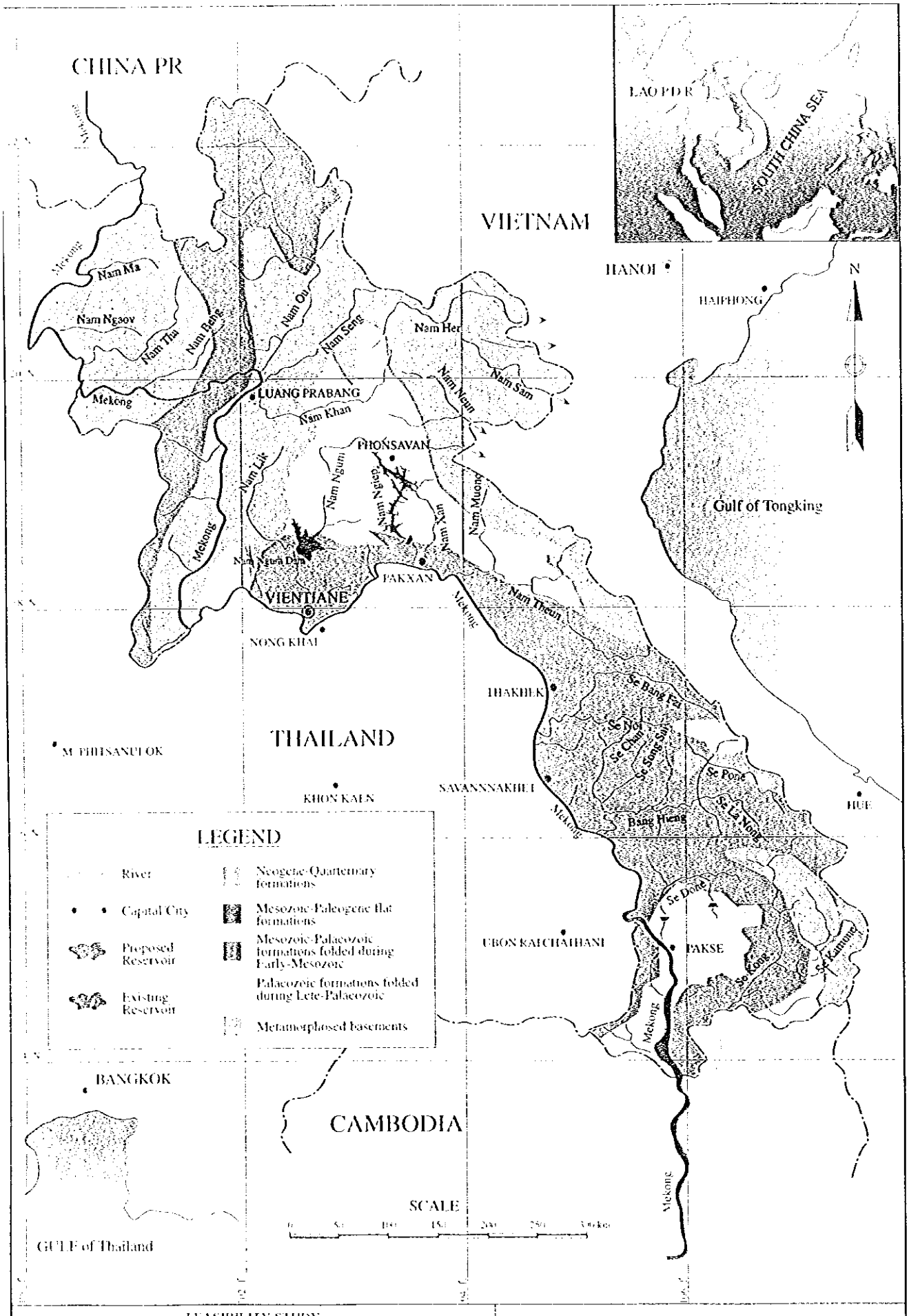
3.1.2 GEOLOGICAL STRUCTURES OF INDOCHINA

The Nam Ngiep basin is situated in the central part of LAO PDR. Mesozoic-Palaeogene flat formations are distributed around the proposed damsite where high cliffs are found with outcrops of flat or gently sloped formations. Palaeozoic formations folded and separated into blocks by faults while Late-Palaeozoic are distributed in the reservoir area. General geology is summarized in Figure 3.1.1. Lineaments (NW-SE, W-E and NE-SW) are found, which were produced by old geological structure and tectonic movements. There is no report on active faults.



FEASIBILITY STUDY
ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT
IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 3.1.1
Geological map of Indochina



FEASIBILITY STUDY ON THE NAM NGIEP 1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 3.1.1** **Geological map of Indochina**

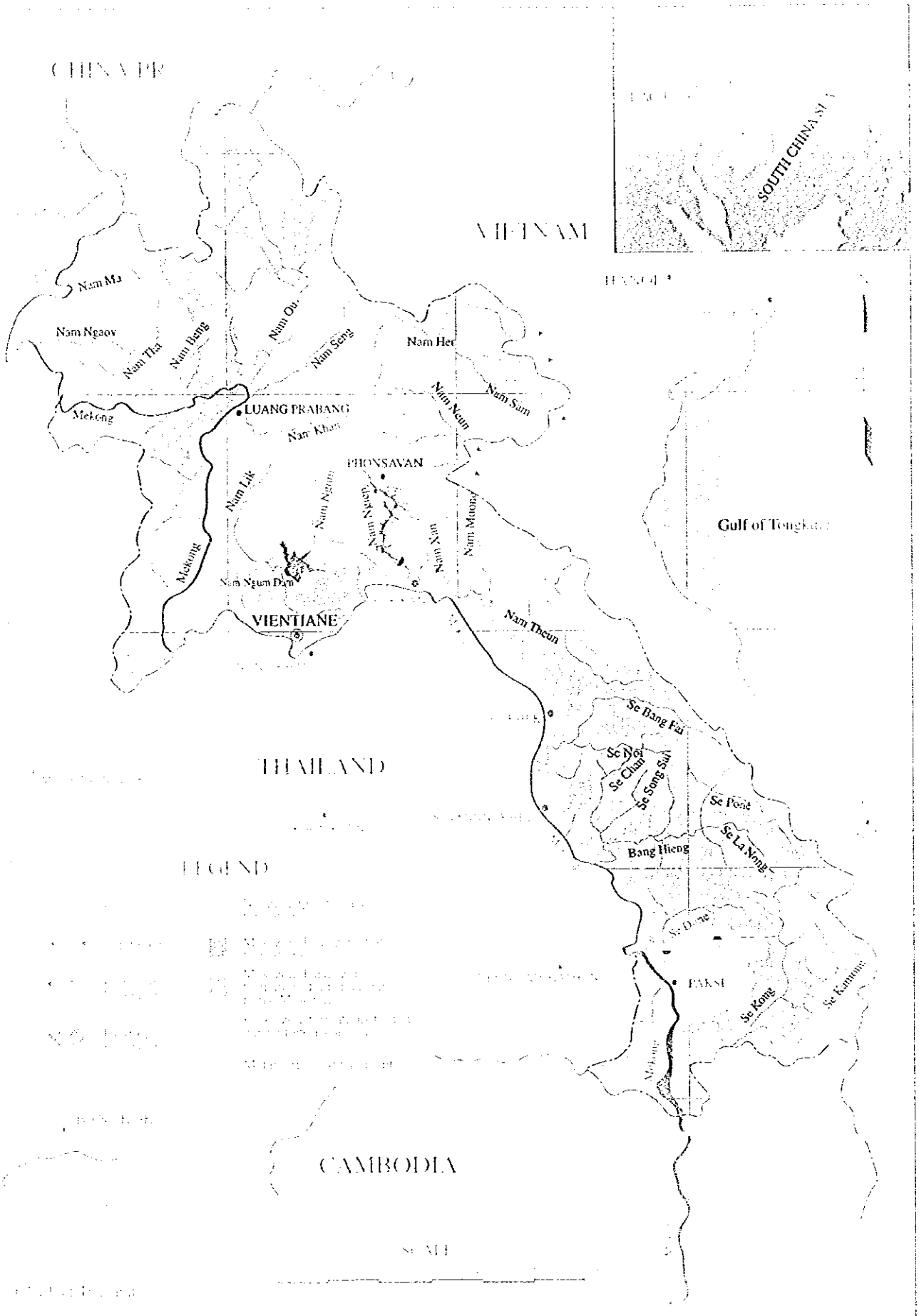
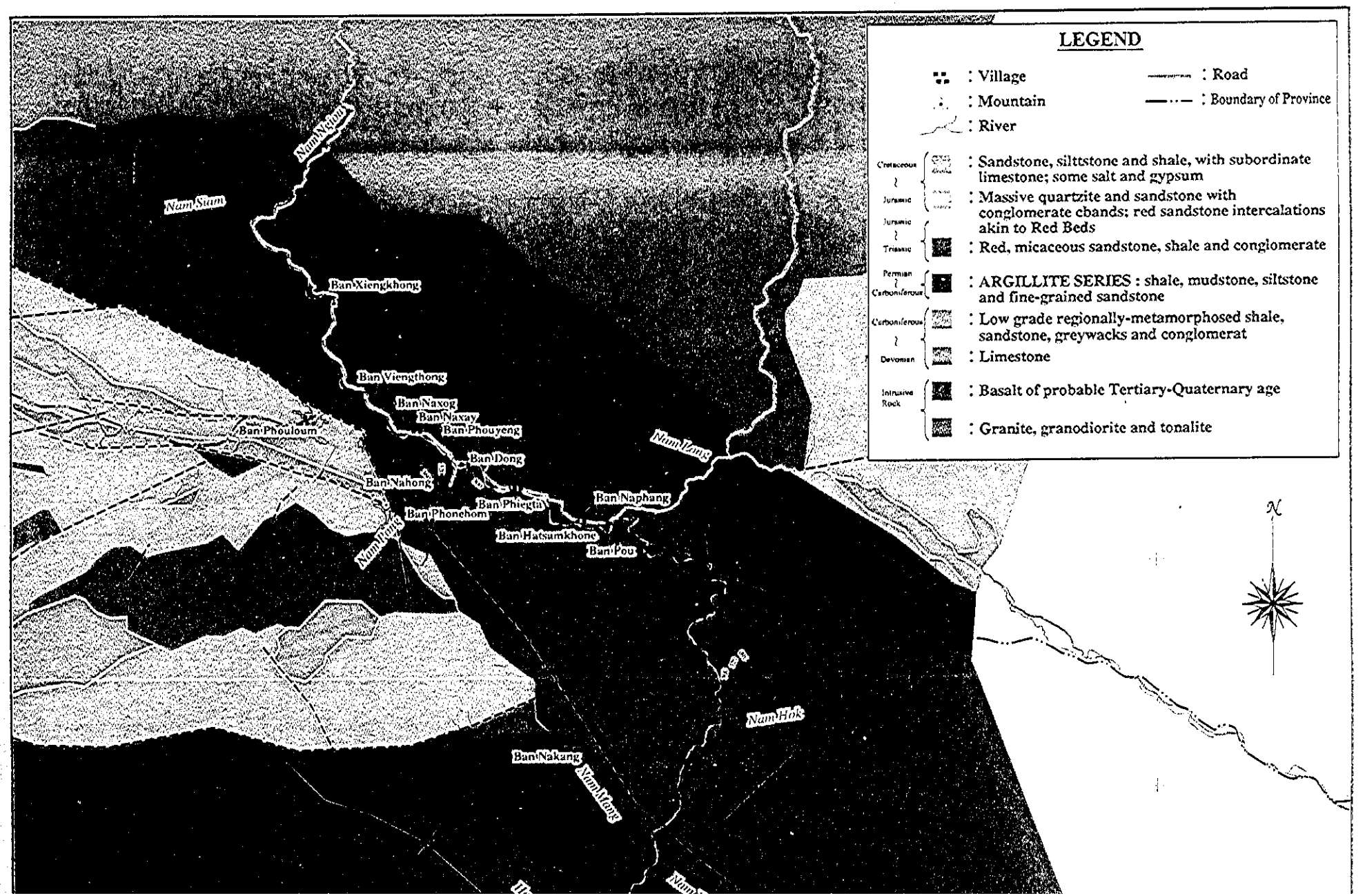


Figure 3.1.1

Geological map of Indochina


LEGEND
: Village
: Road
: Mountain
: Boundary of Province
: River
Cretaceous ? Jurassic
: Sandstone, silttstone and shale, with subordinate limestone; some salt and gypsum
: Massive quartzite and sandstone with conglomerate cbands; red sandstone intercalations akin to Red Beds
Jurassic ? Triassic
: Red, micaceous sandstone, shale and conglomerate
Permian ? Carboniferous
: ARGILLITE SERIES : shale, mudstone, siltstone and fine-grained sandstone
Carboniferous ? Devonian
: Low grade regionally-metamorphosed shale, sandstone, greywacks and conglomerat
: Limestone
Intrusive Rock
: Basalt of probable Tertiary-Quaternary age
: Granite, granodiorite and tonalite
Nam Ngiep
Nam Sum
Ban Xiengkhong
Ban Viengthong
Ban Naxog
Ban Naxay
Ban Phouyeng
Ban Phouloum
Ban Dong
Ban Nahong
Ban Phiegta
Ban Phonehom
Ban Naphang
Ban Hatsumkhong
Ban Pou
Nam Ngang
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Ban Nakang
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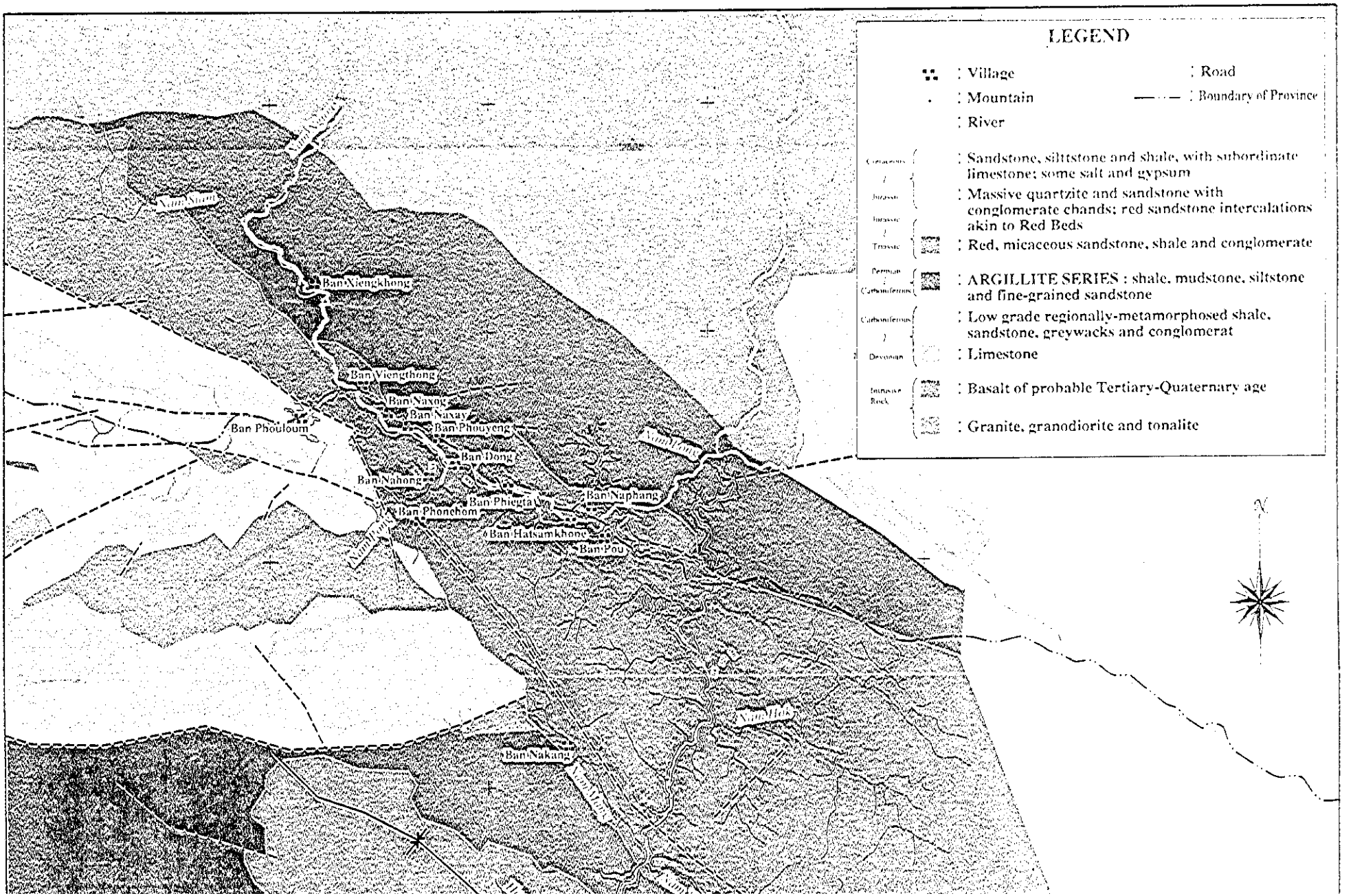
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Permian / Carboniferous : ARGILLITE SERIES : shale, mudstone, siltstone and fine-grained sandstone
Carboniferous / Devonian : Low grade regionally-metamorphosed shale, sandstone, greywacks and conglomerat
: Limestone
Intrusive Rock : Basalt of probable Tertiary-Quaternary age
: Granite, granodiorite and tonalite
Ban Xiengkhong
Ban Viengthong
Ban Naxog
Ban Naxay
Ban Phouyeng
Ban Dong
Ban Nahong
Ban Phiegta
Ban Phonchom
Ban Hatsamkhone
Ban Pou
Ban Naphang
Ban Nakang
Ban Phouloum
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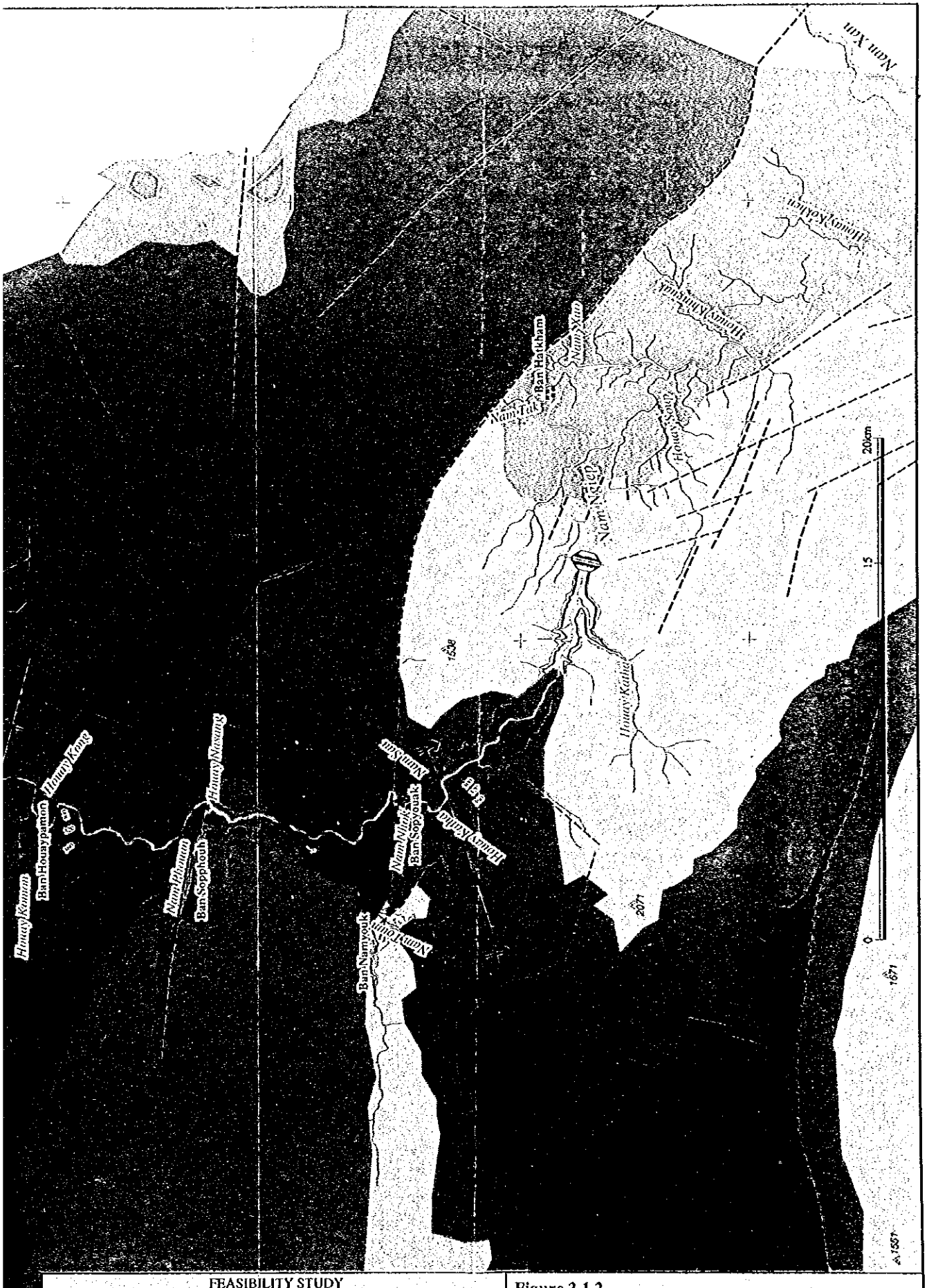
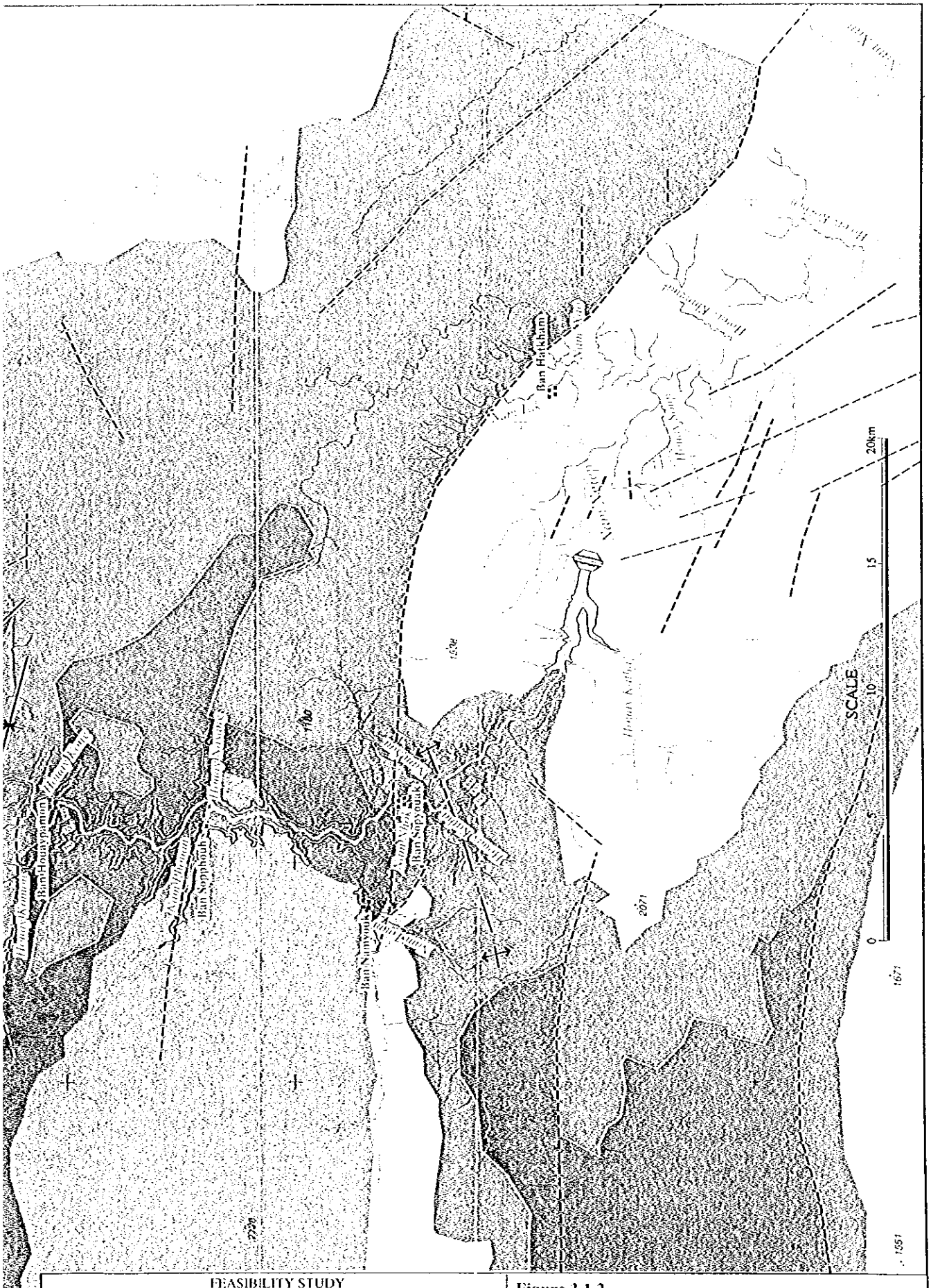


FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 3.1.2** **Geological Map in the Nam Ngiep River Basin**



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 3.1.2** **Geological Map in the Nam Ngiep River Basin**

Geological descriptions are mainly based on "Photo Geological Reconnaissance Maps PAKSANE and B.B. at scale of 1:250,000 prepared in 1973 by the Institute of Geological Science, London" and "Lao PDR Geological and Mineral Occurrence Map at scale of 1:1,000,000" both of which were compiled in England and contain more detailed field information than "Geological Survey for Vietnam "Geology of Cambodia, Lao PDR and Vietnam", at scale of 1:1,000,000, Hanoi, Vietnam, 1991.

3.1.3 GEOLOGICAL STRUCTURES OF NAM NGIEP BASIN

Geological map in the Nam Ngiep basin is shown in Figure 3.1.2, which is mainly based on photo-geological reconnaissance maps PAKSANE and B.B., but distribution of granite mass and Palaeozoic formations in the middle reach of the Nam Ngiep River are corrected according to Geological and Mineral Occurrence Map and also according to the field investigations.

Devonian-Permian, shale, mudstone, calcareous series and sandstone intruded by granite are widely distributed.

Limestone blocks are scattered as relatively small blocks in Lower Carboniferous to Devonian. Calcareous series mainly of massive limestone are not found for Permian to Upper Carboniferous in this area, which are distributed beyond north of Phonsavan to Jars plain, outside of Nam Ngiep basin. Granite is widespread as intrusive to Palaeozoic. Lower Jurassic series are distributed as graven in parallel along folded Palaeozoic basements.

Most of the rocks forming the substratum underlying the future reservoir are sedimentary. The geology of the reservoir falls basically into four (4) types.

(i) Mesozoic, Jurassic to Cretaceous flat formations with sandstones, conglomerates and mudstones are located around damsite and in the lower part of the planned reservoir area. Sandstones and conglomerates are very thick, homogeneous and massive and are found on the upper slopes where they form the crests and summits. Mudstones are interbedded with rather thin siltstones, sandstone and conglomerates.

(ii) Palaeozoic, Devonian to Permian, formations folded and separated into blocks by faults during Late-Palaeozoic are located in the middle to upper parts of the reservoir area, including shales, mudstones, sandstones and schists. They are consolidated formations and hardly permeable.

(iii) Late-Palaeozoic granites are located as intrusive to Palaeozoic formations in the middle of the reservoir area. They are highly fractured and sometimes deeply weathered. The rock is impermeable at depth.

(iv) Mesozoic, Triassic to Jurassic, sandstones, shales and conglomerates are located in the middle part of the reservoir area as graven parallel along folded Palaeozoic basements. They are partly fractured and deeply weathered. The rock is impermeable at depth.