other economic development programs in Laos, and it is not functioning as the motive power of activating the economy of Laos. The output of the Xe Set Hydroelectric Power Plant which has been developed with great effort may not be fully used in Laos due to the power demand status of the neighboring areas, and a considerable portion of the energy output is to be exported to Thailand.

(b) Major Existing Hydroelectric Power Facilities

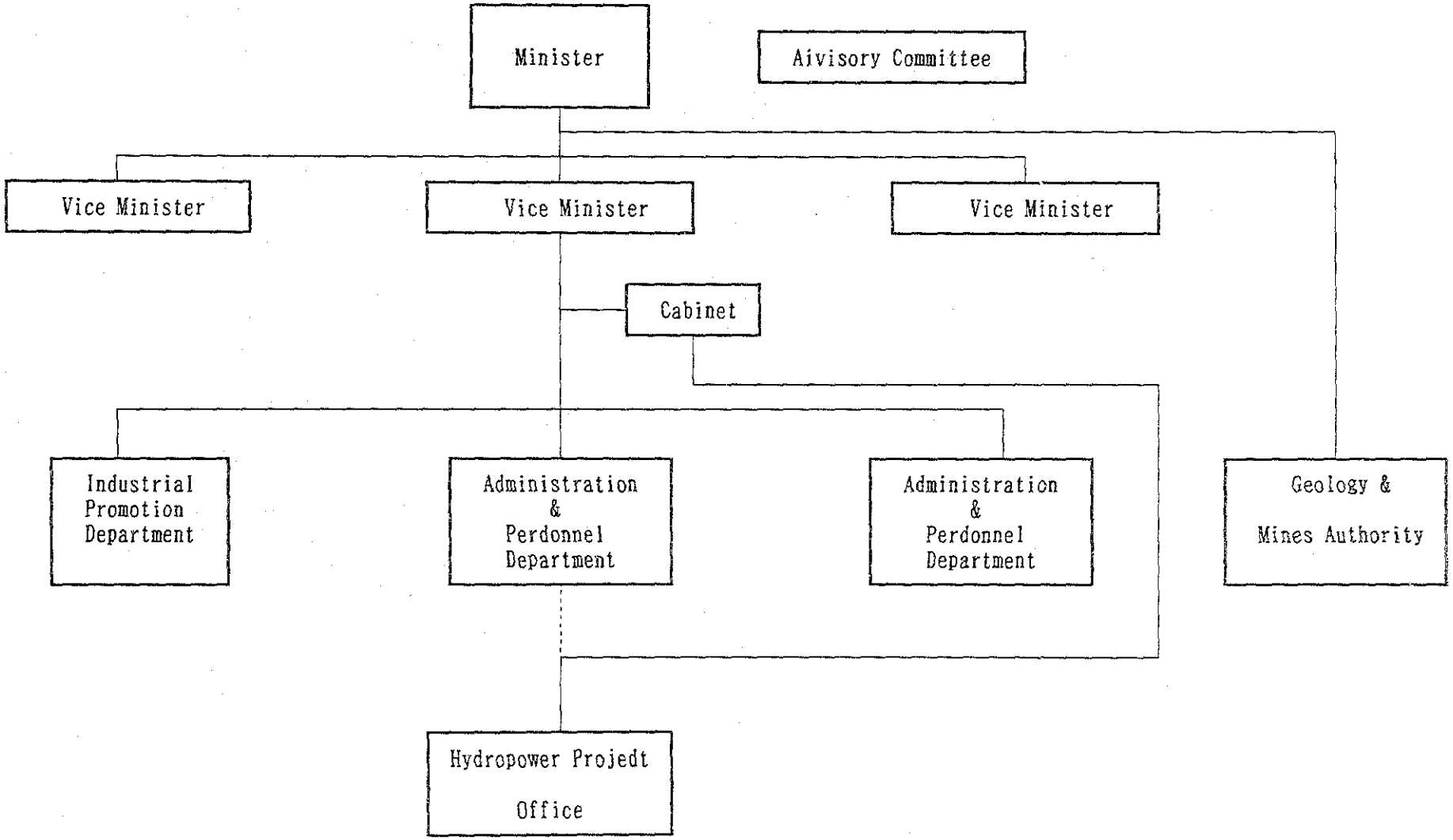
All existing power generation facilities in Laos are controlled by the Electricity Authority (EDL), which is under the Ministry of Industry and Handicraft (MIH), and they include the following power plants. (See Figure-2)

i) Nam Ngum Dam Power Plant (Vientiane Province)

As well known, the largest power generation facility in Laos today is the Nam Ngum Dam & Power Plant which is located to the northeast of Vientiane City at a distance of 2 hours' ride by car. The Phase 1 power generating facility of the Nam Ngum Power Plant, 30 MW output, was completed in December of 1971. Thereafter, the power plant was expanded for three times until 1984, and the full capacity of 150 MW was commissioned to service in March, 1985.

The dam is a concrete gravity type, with crest length of 470 m, and the dam height is 75 m above the foundation rock. The elevation of full water level of the reservoir is 212 m, impoundment area is 370 km^2, the gross storage capacity is 7 billion m^3, and the effective storage capacity is 4.7 billion m^3. The effective head is 35 m, average discharge is 310 m^3/s, and the total installed capacity is 150 MW. 80% of the annual energy generation of 820 GWh is exported to Thailand, and only the remaining 20% is consumed in Vientiane City and the Vientiane plain. However, it is planned to construct a transmission line to the old capital city of Luang Prabang in near future.

Figure-2 Organization of Ministry of Industry and Headicraft (Jan.15.1992)



(Source : M I H Project Manager)

Japan has substantially contributed to the construction of this power station. Based on this historical relation, the repair work of No.3 and No. 4 generating units have been implemented recently under the grant assistance of the Japanese Government.

ii) Selabam Hydroelectric Power Plant (Champassack Province) (SPE-I Project)

The Selabam Hydroelectric Power Plant was constructed in 1988 on the Xe Don River, at a location which is approximately 35 km to the north of Pakse City. The installed capacity is 2,040 kW (three, 680 kW units). However, only 1,420 kW of output is currently available. In response to the request of Pakse City which is a load center, a construction work was started this year to expand the output to 3,000 kW. The expansion project is financed by the IDA loan. This expansion work is scheduled to be completed by the end of June, 1993, and the work is supervised by the Tata, an Indian consultant. The existing facility will be removed after the expansion work is completed.

iii) Xe Set Hydroelectric Power Plant (Salavane Province) (SPE-I Project)

There are two diesel power plants, one with the installed capacity of 210 kW (made in U.S. in 1979) and another with the installed capacity of 200 kW (made in U.S.S.R. in 1980) in Salavane Town which is the capital of the Salavane Province. With completion of the Xe Set Power Plant (which is located 30 km to the east of the town), it is being planned to move the U.S. made generator to the project site of the Xe Don II Hydroelectric Power Plant which is currently in the planning stage, while the U.S.S.R. generator will be left as a spare generating facility.

It is planned that the Xe Set Hydroelectric Power Plant will supply Salavane Town, its surrounding areas, and Pakse City, and at the same time export the surplus power generated in wet season by a 115 kV transmission line via the border town of Chong Mek on the Thailand side. The power plant was completed in late 1990. Its installed capacity is 45 MW. This project was financed by the bilateral assistance fund of Sweden as well as the ADB loan and the UNDP grant. The contract of the construction work was concluded in October, 1988, and construction work was started in January, 1989. The power plant type is run-of-river with regulating pondage. It was designed and the construction supervised by the Nordic, a Norwegian consultant.

iv) SPE-I Project[Note 17)]

The expansion project of the Selabam Hydroelectric Power Plant and the construction of the Xe Set Hydroelectric Power Plant have been implemented as a part of the Southern Province Electrification Project Phase I (SPE-I) of the Government of Laos, and the these works are still continuing. The southern provinces here means the six provinces of Champassack, Savannakhet, Salavane, Khammouan, Sekong and Attapeu.

So far, the two provinces at northern side out of the six provinces referred to above is supplied with electric power which is sent from Thailand since 1973 by a transmission line crossing the river bed of the Mekong (22 kV). In other provinces, however, there are some diesel power generation facilities in cities and towns, and latent power demands in local areas are not met.

Under the circumstances, the Government of Laos started this project with the objective of improving the power supply conditions in the Champassack Province and the Salavane Province by securing the IDA credit in 1987. This SPE-I

Project is scheduled to be completed by 1993. With completion of this project, the power supply condition in Pakse and Salavane Cities will be remarkably improved, and also it will become possible for the Government of Laos to gain foreign currency by selling electric power to Thailand.

v) Small Hydroelectric Facilities in Other Areas

Currently, there exists a very small hydroelectric facility, a run-of-rive type hydroelectric power plant (330 kW x 3) on the Nam Dong River running at the outskirts of Luang Prabang City in northern Laos. Also, there is a small hydroelectric facility with Polish made equipment, having the installed capacity of 102 kW in Paksong Town of southern Laos. The Tat Lang Hydroelectric Project (the installed capacity of 1.2 MW with 23 km of 22 kV transmission line), which is located near Xieng Khuang, the provincial capital city of the Xieng Khuang Province adjoining the Luang Prabang Province, should have been completed by 1990 under grant cooperation of Burgaria.

(c) Export/Import of Electricity

As we have discussed at the beginning of this Section, the future possibility of hydroelectric power development in Laos depends on, from a broad point of view, whether or not the neighboring nations, in particular, Thailand, need to buy electricity from Laos in the near future. The stage of development of electric power in Laos is so infantile that we have to draw this pitiful conclusion when contemplating power development of medium scale or larger.

Also pitiful is the fact that cities, towns and villages along the Mekong River have to depend on diesel power generation, or buy electricity from Thailand across the river, because the hydroelectric development is retarded in spite of abundant potential sites.

i) Electricity Export and Import between Thailand
(Export of energy of Nam Ngum and import in southern Laos)

Today, the hydroelectric power is the second largest export item of the Laos Government. That is, approximately 80% of the energy generated at the Nam Ngum Power Plant (with 150 MW installed capacity) is exported to Thailand by a transmission line that crosses the Mekong River, and the fiscal revenue owing to this export is the most important item only next to the export of timber. Although the production of hydroelectric energy is largely influenced by precipitation, the export of electricity in the average accounts for 25% of the total export.

On the other hand, a small amount of electricity is imported from Thailand to the Savannakhet Province and the Khamouane Province by means of a transmission line that crosses the river bed of the Mekong River. The data released by the EDL (1988) are as presented below (Table-15). The amount of export of the Nam Ngum energy to Thailand is 10.6×10^6 US dollars in fiscal 1987, and 15.7×10^6 dollars in the fiscal year of 1988.

Table-15 Energy Export from the Nam Ngum Power Plant to Thailand and Energy Import from Thailand to Southern Laos

Fiscal Year / Energy	1984	1985	1986	(presumed) 1987	(plan) 1988	(plan) 1989	(plan) 1990
Annual Energy Generation of Nam Ngum (GWh)	891.0	906.6	867.3	566.0	716.7	870.7	870.7
Consumption of Nam Ngum inside Laos(GWh)	129.8	130.4	124.9	125.5	146.2	157.9	173.7
Loss of Nam Ngum Energy (GWh)	51.5	60.0	58.9	53.8	54.8	56.6	60.0
Total Export (GWh)	709.7	716.3	683.6	387.2	515.7	655.5	636.3
Import from Thailand (GWh)	16.6	17.6	17.2	17.9	18.3	18.2	19.2

(Source: World Bank "Lao P.D.R. Country Economic Memorundum Sept 21, 1988, presented by EDL")

The Xe Set Power Plant (45 MW) was commissioned late last year, and a part of its output is now transmitted to Thailand via Pakse. In future, however, when the power demands in Pakse City and other areas of Laos increase in the future, power will be imported, instead of exported, from Thailand in dry seasons when the output of the Xe Set Power Plant is reduced.

A power plant which has the potential of exporting electric energy to Thailand, other than Xe Set, is Nam Theun II Hydroelectric Power Plant (with output of 300 MW in Phase 1, and with final output of 600 MW) which is being planned in Khammouan Province.

This run-of-river type power plant project is designed to utilize the high head of 350 m which is available between the

adjacent Se Bang Fai River, and is expected to produce inexpensive and abundant electric energy (to be 4,630 GWh upon completion). After this power plant is developed, most of its energy generation, except for the portions which are consumed in Thakhek City, Savannakhet City, etc. will be exported to Thailand. The Feasibility Study of this Project has been completed.

However, the understanding on the precious values of wild animals and forests thriving in this area has grown rapidly in recent years, thereby raising opposing opinions against formation of a large reservoir. For this reason, the Government has conceived two alternative plans which will not be such target of environmental argument. One alternative is to install a weir at the immediate downstream site of the proposed site of the Nam Theun dam, transport water to the edge of a cliff through a relatively short water channel, and let this water be discharged to the adjoining Nam Hin Boun River with a high head, thereby realizing a run-of-river type power plant (120 to 150 MW). The other alternative is to make Nam Theun II dam a low dam, guide the water to a cliff with a long water channel, and discharge the water to the adjoining Se Bang Fai River with a high head. The Government plans to have NORCONSULT of Norway (who provided the consulting service for Xe Set Power Plant) conduct a survey.

As other plans related to Thailand, there is the substation plan for provinces around Vientiane Province, by which the two towns of Xanakham and Pakxan can receive electric power from Thailand across Mekong River in the future (SPE II)[Note 18)], and this plan will be discussed later. There is possibility that large and medium hydroelectric power development projects will be implemented in Laos in the future, but in all cases, the status in electric power market of Thailand and the unit price in power sale contract between the two nations will influence the economic and financial

feasibility of the project. The system of electricity tariff agreement with Thailand will be discussed later.

ii) Possibility of International Trade of Electric Energy with Neighboring Nations Other Than Thailand

Since 1975, the diplomatic relation between Laos and Vietnam has become closer. However, there is no export/import of electric energy at present between Laos and Vietnam. Nor there is energy trade between People's Republic of China or Myanmar.

However, in the development of the Nam Theun Hydroelectric Project, it would be possible to export a part of the energy generated by this project to Hanoi regions of Vietnam. When the development of the Red River of Vietnam progresses, and the Son La Hydroelectric power project is developed after the expansion project of the Hoa Binh Hydroelectric power project is completed, the possibility of exporting its output to Thailand via Laos will be studied. There is also a possibility that a small portion of the energy of the Yali Falls Hydroelectric power project in the central Vietnam is exported to Laos across the border. On the other hand, it is possible that energy generated by power plants of medium or large capacity in the northern, central and southern part of Laos is exported to Vietnam. In addition, hydroelectric projects involving the transfer of river water between different nations could be realized in the border areas of Laos and Viet Nam. The diplomatic relation between the People's Republic of China and Laos has been improved recently, and this may attract more attention on the possibility of development of power generation sites to the north of Luang Prabang (in particular, the main stream of the Mekong and the Nam Tha River, Nam Ou River, etc.). However, a substantial fund is required for the development of these sites, and its economic feasibility is somewhat doubtful since a long distance power transmission is required to

deliver the power to China. Nevertheless, the efforts for identification of promising hydroelectric development sites in these countries have just been started.

In the Yunnau Province, the construction of the Manwan Dam (concrete gravity) project with the installed capacity of 1,250 MW is under way on the Lancang River which is the upstream part of Mekong main stream. It is estimated that the final installed capacity will be 1,500 MW. The height of this dam is 126 m. The Government of PRC also plans to construct another dam j.e., the Xiaowan Dam (300 m high, the dam type not yet determined yet). This dam will create a storage of 15.6 billion m^3, and the installed capacity in the initial stage of development will be 3,200 MW, or 4,000 MW in combination with the upper stream project. These are really large projects, and there is a fairly high possibility that such a cascade projects will be implemented both on the main stream and the tributaries of the Mekong River within the Yunnau Province.

When the development of the Mekong main stream progresses in future, the development of large dams in China on the main stream and tributaries of Mekong will create benefit of inflow and the increase of power generation of dam projects in the downstream area. Negotiations will be conducted between China and downstream riparian countries such as Laos concerning the allocation of such benefit. This will also be the case for prominent dams development sites that exist on the Mekong mainstream along the border with Myanmar.

1.3.3 Power Sector in the Third 5-Year Plan

(1) Projected Investment in Power Sector

The future economic development of Laos heavily depends on the development of its infrastructures, and the electric power development

is one of the most important facet. It is being planned to spend 50% of the public investment of 720.8 x 106 US dollars of the Third 5-Year Plan on the preparation of infrastructures. In this Plan, the investment on electric power facilities is regarded as the key to the expansion of export, acceleration of industrialization, and expansion of irrigation agriculture, and the total amount is the largest only next to the investment on transportation facilities (refer to Table-16).

Table-16 Infrastructure Investment Program of Laos (1991 - 95)

Item	Investment Amount	%
Transportation	252.3	70.0
Electric Power	60.4	16.8
Communication	40.1	11.1
Water Supply and Sewage	7.4	2.1
Total	360.2	100.0

(Source: "Policy Framework for Public Investment Programme", Nov. 1990, by Laos Ministry of Finance and Economic Planning)

(2) Investment Target

The targets of the investment referred to in the above table are defined as below in the "Policy Framework" which has been worked out by the Ministry of Finance and Economic Planning of the Government of Laos in late 1990.

i) A number of projects shall be implemented to introduce electrification to the local areas in Vientiane Plain.

ii) Local electrification programs for southern Laos and other areas shall be promoted.

iii) The transmission line from the Nam Ngum to Luang Prabang (115 kV) shall be constructed.

iv) In order to maximize the values of existing power facilities, the existing power plants, substations, transmission lines, distribution networks and others shall be repaired and expanded, and the supervisory system for enhancement of economy shall be strengthened.

v) The large scale hydro-electric power projects shall be surveyed and planned (among other projects, the Nam Theun II Project will cost 3 times the current total annual investment on electric facilities).

(3) Revision of Electricity Unit Price and Intensification of Control

In addition to the strenuous effort for promotion of the above development promotion programs, the Government of Laos intends to implement the following measures, if it is possible.

i) Raising the current domestic tariffs in accordance with the rise of export energy unit price.

ii) Improvement of administration of the EDL.

(4) Need for Assistance by Foreign Nations

The EDL declares the expected amount of investments presented in Table-10 which are required to attain the targets of the above mentioned plans, and stresses that the assistance by western nations, including Japan, and international financing agencies is essential. It is expected that the success of Cambodia Peace Conference held in Paris (October, 1991) will give favorable effects on Laos.

1.3.4 Electric Power Development Projects Feasible in Near Future

The electric power development plans in Laos, except those related to rural electrification (of small scale), are under the jurisdiction of the Ministry of Industry and Handicraft, and HEC subjected to it.

In the following Paragraphs, some descriptions are presented on the development projects which are expected to be implemented, and the projects on which some surveys have been conducted and further studies are scheduled in preparation for implementation in the near future (Excluding the large international projects such as the Pa Mong, the Pak Bang, the High Luang Prabang, the Pak Lay, the Bung Kan, the Thakhek, the Ban Koum and the Khone Falls).

(1) Projects for Which Feasibility Studies Have Been Completed

(a) Nam Theun II Run-of-River Type Hydroelectric Power Project

As described before, the advantage of this project has been known for a long time, and Japan was interested in this project since the end of 1950's. Recently, the Motor Columbus, a Swiss consultant recommended this project in 1987 - 88, and the Snowy Mountain Engineering Company of Australia has completed a feasibility study in December, 1990.

This project is a run-of-river type power generation (with the installed capacity of 300 MW in Phase 1, and with the final installed capacity of 600 MW). The outline of the project is such that a concrete dam having dam height of approximately 50 m and crest length of 340 m will be constructed at a location 45 km downstream to Ban Signo Village on the Nam Theun River, to create a reservoir having a gross storage capacity of 2,740 x 106 m^3. The water is diverted to the Nam Kathang River, a tributary of the neighboring Se Bang Fai River, through headrace channel, headrace tunnel and pressure tunnel at a flow rate of 108 m^3/s in Phase 1 and 216 m^3/s in Phase 2. With the head of approximately 365 m, this scheme will provide 300 MW power (2,495 GWh) in Phase 1, and 600 MW power (4,530 GWh) in the final phase. In Phase 1, Two units of 150 MW water-turbine generator will be installed, and the power output will be transmitted along the main stream of the Mekong River to Thakhek City by a 230 kV transmission line.

Another 230 kV transmission line which will extend from Thakhek City across Mekong River (with the total length of 327 km) will be connected to the power system of EGAT at Loi Et Town. Inside Laos, it is possible not only to supply Thakhek City, but to transmit the power to Savannakhet and further down to the southern provinces. As the discharged water of the power plant will be re-regulated before being discharged to the Mekong River, the river flow condition at the downstream of the confluence of the Se Bang Fal River and the Mekong main stream may be improved in dry seasons. However, some concerns are raised concerning the effect on wild animals and plants, and the effect of the increase of water flow before re-regulation to the people living along the both banks of the Se Bang Fai Tants. For this reason, the study of the Alternative described in Page I-1-31 was started. NORCONSULT may probably start investigation of this Alternative. Therefore, it is anticipated that the implementation of the Nam Theun II Project will not be started for the time being.

Another high dam project, named the Nam Theun I, which is to be located at the downstream of this project site on the Nam Theun River and just upstream of the confluence with the Mekong main-stream, is being contemplated by the Mekong Committee.

The detailed design of the Nam Theun II Project are being suspended for the time being, but cost of this detailed design is estimated to be 6,000,000 US dollars, and it is expected that the assistance funds of western nations will be made available in addition to the financing of the World Bank, Asian Development Bank and UNDP. (UNDP has already committed 1,000,000 US dollars.) This cost include environmental assessment and geological survey costs. The construction cost has been calculated as 340 x 10^6 US dollars for Phase 1, and 165 x 10^6 US dollars for Phase 2.

(b) Nam Ngum-Luang Prabang Transmission Line Construction Plan

This is a project stipulated as Item (iii) of the 5-Year Plan, for construction of a 115 kV, 220 km long transmission line (including two, 115/22 kV substations). It is being planned to be financed by 11.2 x 10^6 US dollar of ADB load, 0.96 x 10^6 US dollar of Swiss grant, and 1.72 x 10^6 US dollars of government investment. Upon completion, not only Luang Prabang, but towns in the northern Vientiane Province such as Vang Vieng and Kasi, which are located along the transmission line route, can be supplied with electric power. It is scheduled to start construction by the end of July, 1992.

(c) Xe Don II Dam Type Hydroelectric Power Project

The feasibility study of this project (to be financed by the IDA loan) was included in the electrification program of the southern provinces in SPE-I. The result of this feasibility study was disclosed in March, 1991 jointly by the Nihon Koei and the Sogreah. According to this study, it is planned to construct a concrete gravity dam (approximately 46 m high) to generate power with the installed capacity of 54 MW. A part of the annual energy generation of 315 GWh (to be supplied by 3 generators) will be consumed in Pakse City, but most of the energy will be transmitted (for a distance of 86 km) to Nong Mek Town in Thailand which is located on the right bank of Mekong River approximately 60 km to the upstream of Pakse City. It has been estimated that 108 x 10^6 US dollars of foreign currencies, and 27.8 x 10^6 US dollar (equivalent) of domestic currencies, or a total fund of 135.8 x 106 US dollars is required for the construction. Whether this projects is implemented or not will be determined by the result of negotiation on the unit price of exported energy of the Nam Ngum Hydroelectric Power Plant.

(2) Major Projects for Which Survey will be Continued or Started

(a) Nam Theun I Dam Type Hydroelectric Power Project

The Mekong Committee is contemplating to revise the pre-feasibility study of this project which has been implemented in 1985. The items of revision are mainly the studies on socio-economic effect, environmental impact, and relocation of residents. What have been clarified by the past study are that the generating capacity of the Nam Theun I will be 1,500 to 2,000 MW, and that there is practically no population or agricultural land to be flooded by the impoundment although the gross storage capacity of the dam will reach 14.5×10^6 m^3. The cost of revising the study, as mentioned above, will exceed 300,000 US dollars.

(b) Nam Mang III Power Generation/Irrigation Project

This project has also been once identified by the Mekong Committee. This Study Mission visited the proposed power plant site by making use of spare time. In this project, it is planned to utilize the high head available between the adjacent Nam Ngum River tributary to create a power generation with an installed capacity of 22 MW. The generated energy of approximately 110 GWh will be fed to the Nam Ngum power transmission system, and at the same time used to irrigate paddy fields that spread in the eastern plain of Vientiane Province. Recently, the North Korea attempted an expedition survey. It is reported that ADB decided to finance this project. It is also reported that the installed capacity will be expanded to 45 MW.

In the feasibility study, the foreign currency portion of the construction cost is estimated at 550,000 US dollars. However, there is some doubt concerning the economy of this project, because the amount of river flow is small.

(c) Nam Xong Power Generation, Irrigation/Diversion Project

The Nam Xong River is a tributary of the Nam Song river which joins the Nam Lik River at a location to the north of Phone Hong, the capital city of Vientiane. According to the result of a survey conducted jointly by the HEC and the Leader of this Study Mission, it is possible to installed a dam of approximately 20 m in height at a gorge of the Nam Xong River located upstream to Vang Vieng City, to create a power output of 1,000 kW, and at the same time to irrigate farm lands to the downstream of the site. But this plan was later abandoned, because it was decided to implement the Nam Ngum-Lung Prabang Power Transmission Project. On the other hand, the output of the Nam Ngum Power Plant can be increased by approximately 45 MW if the water of the Nam Xong River is diverted to the upstream side of the Nam Ngum Reservoir by constructing a diversion channel for a distance of several kilometers, according to the feasibility study performed in 1990 by two British consultants, the Lahmeyer International and the Beca Worlley. The result of this study indicated that the economic feasibility of this project depends on the extent of raise of the unit price with which the energy of the Nam Ngum is exported. It is scheduled that another feasibility study will be conducted soon by these two companies. Similarly, a diversion work from the Nam Leuk River to the upstream of the Nam Ngum Reservoir is also conceivable, and the same consulting firms studied this concept. The economic feasibility of this project will also depend on the unit price of energy sale to Thailand.

(d) Nam Nhiep I Dam Type Hydroelectric Power Project

The Mekong Committee has formulated a plan of constructing a 185 m high dam and generate 255 MW of power at a site which is 55 km to the upstream of the confluence of the Nam Nhiep River, a tributary of the Mekong River which joins the mainstream at a location upstream of Pak Sone Town, and the Sogrea of France has conducted a feasibility study on this plan last year. Another feasibility study will soon be conducted by the Bonneville of

U.S. The current plan is to build a concrete gravity dam 160 m in height, and the power generation capacity is conceived to be 420 MW to 500 MW.

(e) Nam Ngum II Dam Type Power Plant Construction Project

In a paper plan of the Mekong Committee, there was a conception to construct a dam 165 meter or so in height right at the end of the back water of the Nam Ngum Reservoir, and generate 260 MW of power by a power plant to be constructed right below the dam. The Motor Columbus of Swiss studied this plan in 1987 together with the Nam Theun II Project, and proposed a final installed capacity of 420 MW for this power plant. A feasibility study will be conducted on this plan by the Bonneville of U.S. soon.

(f) Nam Khan I, II Hydroelectric Power Projects

On the Nam Khan River, which is an tributary of Mekong River that joins the mainstream at Luang Prabang, there are two promising dam site to the upstream of the High Luang Probang Dam even if this dam is realized.

The Mekong Committee presumes that the installed capacity of these two proposed projects will be around 100 MW each. In 1986, the Sweco Power of Sweden reviewed this Nam Khan II Project for an assumed installed capacity of 50 MW, and concluded that there is no economic feasibility. It is reported that the feasibility study will be repeated with an assumed installed capacity of 100 MW.

(3) Projects in SPE-II Plan

The EDL is trying to implement the "Provincial Grid Integration Project", SPE-II, as the extension of SPE-I Plan. The outline of SPE-II is as described below according to a report released by the Tata, an Indian consultant, in May, 1991.

(a) Construction of Transmission Lines for Electrification in Southern Four Provinces (Champassak, Svannakhet, Salavane and Khommoune)

(i) Champassak Province	Extension of 22 kV transmission lines for 187 km and other projects.
(ii) Savannakhet Province	Extension of 22 kV transmission lines for 64 kV and other projects. Construction of a 115 kV overhead transmission line to replace the existing 22 V line connecting to Thailand through river bed.
(iii) Salavane Province	Extension of 22 kV transmission lines for 78 km.
(iv) Khammoune Province	Extension of 22 kV transmission lines for 27 km. Construction of a 22 kV overhead line to replace the existing 22 kV line connecting to Thailand through river bed.

(b) Construction of New Power Network for the Southern Two Provinces (Se Kong and Attapeu)

(i) Power will be supplied to Se Kong Town via Thateng Town by branching the transmission line (22 kV) from the Xe Set Power Plant.

(ii) A diesel power plant and substation will be installed in Attapeu Town, and the surrounding areas will be supplied with electric power by stepping up the voltage to 22 kV.

(c) Power Supply to the Two Provinces of Vientiane and Borikhamxay (Which are near Vientiane City, across the Mekong River)

Electrification and power development plans in the Vientiane Province and neighboring provinces:

(i) Power Transmission Plan from Loei (Thailand) to Xanakham Town (Vientiane Province)

This is a plan which is stipulated as one of the objectives of the Third 5-Year Plan of the Government [Note-18].

The electrification of Xanakham district has been a pending problem of the Vientiane Province. In order to meet the power demand of Xanakham Town, although this town is not included in the southern provinces, a plan of transmitting power (for a distance of 100 km) from Loei City of Thailand on the other side of the Mekong River has been included in the SPE-II which has been recently formulated by the Tata Consultant. Two plans are currently being contemplated. One is to construct a conventional 115 kV transmission line, and another is to transmit power up to 2,000 kW by a 22 kV transmission line from Thailand, and at the same time construct additional diesel generator units in the town.

(ii) Power Transmission Plan from Bungkhan (Thailand) to Pakxan Town (Borikhamxay Province)

Similarly to the above plan, it is intended to receive power from Thailand (22 kV,50 km) by crossing the Mekong River. This plan is included in the Third 5-Year Plan. Bungkhan was one of the hydroelectric development sites (run-of-river type) in the Mekong Mainstream Project of the Mekong Committee. Now that the large scale development of the Mekong Mainstream is practically unfeasible due to fund shortage and lack of international cooperation, this power transmission plan seems to be quite appropriate.

All projects of the SPE-II quoted above are designed to meet the power demand of each Province by projecting the power

demand trends up to year 2001. On the other hand, all projects need assistance by foreign governments, international organizations or international lending institutions if they are to be realized.

1.3.5 EDL

(1) Responsibility and Organization

The EDL (Laos Electricity Authority) is under the supervision of the MIH. The EDL is responsible for the study and implementation of power generation plans so far discussed (except for very small electric power development projects), and at the same time, for the maintenance and operation of the Nam Ngum Dam and the power transmission/distribution facilities in Vientiane area. In addition, the EDL is responsible for supplying new power facilities to the Provincial Electricity Authority in each Province.

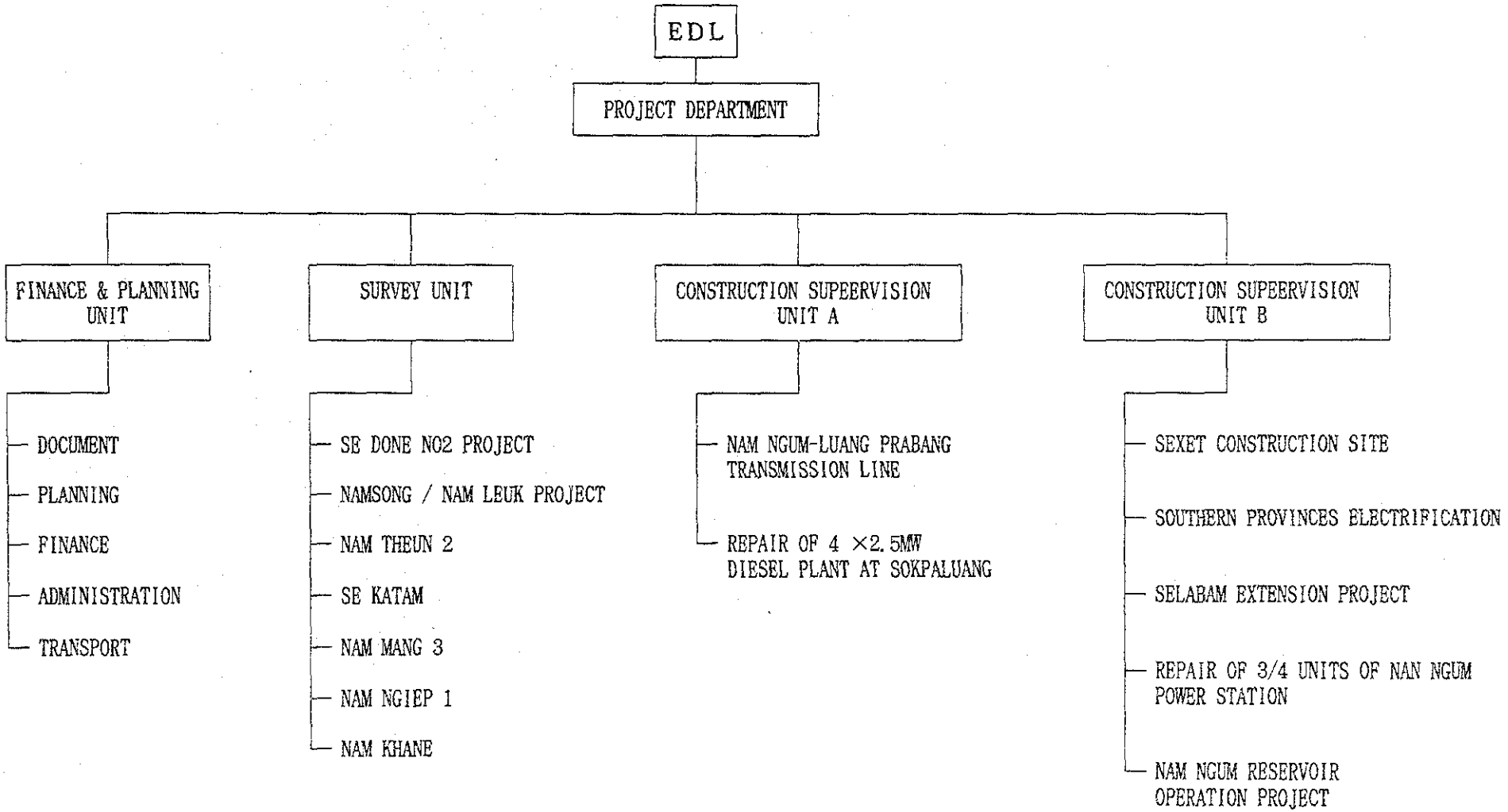
The Government provides a large amount of subsidy to the EDL. The EDL today employs some 1,350 personnel. 3.5% of the employees are engineers and 10% technicians. The organization in charge of projects in the EDL is illustrated in Figure-3 (as of 1991).

(2) Electricity Tariff

(a) Current Tariff

So far, the source of electric power production of the EDL is the Nam Ngum Power Plant. The output of this power plant was sold at a unit energy price of 0.03 US$/Kwh until September 30, 1991, and at the same time, it was supplied to domestic customers at 0.01 to 0.02 US$/kWh.[Note 11] As a matter of fact, the cost of supplying power to domestic customers is higher than the cost of exporting power to Thailand. That is, the power is supplied to the domestic users at a cost which is lower than the actual production cost.

Figure-3 Organization of Project Department EDL (1991)



Note : EDL has 22 Departments (Source : EDL 3rd Quarterly Report, 1990 EDL Project Dept. Sep.1990)

(b) Necessity of Revision of Tariff

The reasons why the EDL, as a whole, could earn some profit, despite the fact that the domestic tariff was suppressed to a low level, are the following two.

- The amount of energy sold to Thailand is much larger than that consumed domestically.

- A part of the construction cost of the Nam Ngum was provided by grant, and the associated loans have been reimbursed almost entirely.

However, the loan to the EDL from abroad is increasing as the EDL develops new projects, and for this reason, the dividend which the EDL pays to the Government is decreasing. The Government intends to improve this situation, and there is opinion in the Government that the subsidies to the EDL should be stopped, and it should study the possibility of separating the sections of the EDL in charge of power generation and power distribution to establish different companies.

Today, the power consumption inside Laos is steadily increasing, and this implies that the tariff, which has been suppressed at low levels should be raised, and the power supply facilities must be developed and the transmission/distribution systems should be expanded in order to alleviate the current situation in which the development of industries are being impeded by shortage of electric power supply. It is reported that the current rate of energy loss in the domestic distribution systems amount to 19%. The expansion of transmission/distribution facilities to improve this situation must be paid off by raising the electricity tariff. In other words, the raise of electricity tariff is also necessary for expansion of transmission and distribution networks.

From the point of view of developing new power supply sources, the unit cost of the energy exported had to raised so that the power development projects are economically feasible. (Thailand today is in such a situation that she has to develop more power within her own country or import power from Laos, and if Thailand develops its own power sources, the generating cost should be higher than the price at which it is buying power from Laos. The Government of Laos is negotiated with Thailand by requesting Thailand to use the output of the Nam Ngum as peak power. For Thailand, it would be easier to buy a higher priced power from Laos if the power is used to meet the peak demand.) When we analyze the economic feasibility of hydroelectric development projects in Laos, small hydro projects have no economy, generally speaking. As for medium scale development projects, the number of sites which can be evaluated as economical under the current tariff system is not many. Raising the export price of electric energy can improve the economic feasibility of medium scale hydroelectric development projects which opportunities are abundant in Laos.

The raise of electricity tariff, both domestically and for export, has been most important issue of today, together with the raise of timber price, for the Government of Laos.Based on the above reasons, the Government of Laos has been contemplating to raise the domestic tariff in steps of 40% every year during the period of the Third 5-Year Plan. At the same time, the Government pushed forward the export price negotiation with the Government of Thailand.

The electricity price negotiation between DEL and EGAT of Thailand ended in August, 1991, and the price system, as described below, became effective on October 1. The term of this new agreement is 4 years, being effective until September 30, 1995. (The new agreement was signed on September 26, 1991.) It is expected that the financial status of DEL will be improved by this new agreement.

The details of electric power export revenue for EDL under the new tariff agreement are illustrated in Table-18. On the other hand, the tariff levels for the power purchased from Thailand for Savannakhet Province and Khammouane Province in the south are high, being 6.30 US¢/kWh for peak hours, 3.82 US¢/kWh for partial peak hours, and 3.15 US¢/kWh for off-peak hours. However, the amount of energy is negligibly smaller than the energy sold at Nam Ngum, with the monthly import approximately 100,000 kWh. The export unit price of Xe Set power is low, being 2.9 US¢/kWh. As Xe Set Power Plant has been just completed, no revision of tariff is currently contemplated.

2. Requirements for Development of the Area under This Plan and Past Activities Leading to This Survey

Chapter I 2. Requirement for Development of the Areas under This Plan and Past Activities Leading to This Survey

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List of Tables

2. Requirement for Development of the Areas under This Plan and Past Activities Leading to This Survey

The responsibility of this Study Mission is to develop the outline of the comprehensive development plan for the Xe Namnoy Basin in the Bolaven Plateau to supply electric power for the development of two provinces of Xe Kong and Attapeu, and to identify the feasibility of the development of its tributary, the Xe Katam River, in this overall development concept. In the following Sections, we describe the courses of events that led to the survey of requirement of the Xe Katam development, and the activities performed by our Study Mission.

2.1 Requirement of Development of Xe Katam Small-scale Hydroelectric Power Development Project

2.1.1 Electrification Plan for Southern Provinces and Sekong and Attapeu Provinces

In developing its Second 5-Year Plan (1988 -1990), the Government of Laos has relaxed its traditional policy of concentrating the development efforts to the areas in and around Vientiane Province, and placed focus on development of local regions. In this context, the Government decided to place the highest priority of regional development on the inland area which comprises the six provinces of Champassak, Savannakhet, Salavane, Khammouan, Sekong and Attapeu.

As described in Paragraph 1.1.3, the two provinces of Savannakhet and Champassak have larger population among the six provinces, while the two provinces of Khammouane and Salavane have approximately half as much population. The three provinces, Khammouane, Savannakhet, Champassak have well known cities, which are provincial capitals, along the mainstream of the Mekong River, Thakhek, Savannakhet and Pakse, respectively, and the latter two cities have been prosperous for a long time.

It is needless to say that the keys to the development of the southern provinces is the development of electric power supply sources and expansion and improvement of transmission/distribution facilities. The Government has attempted in 1983 to realize electrification of the three provinces of

Savannakhet, Champassak and Salavane based on its Southern Provinces Electrification Project Phase 1; SPE-I. As the result of this effort, the development of the Xe Set Hydroelectric Power Plant (45 MW) in the Salavane Province has been completed, and the expansion program of the Selabam Hydro and the feasibility study of the Xe Don II Hydro are incorporated into this electrification program, with the former project now in progress, and the latter completed in early 1991.

As the Second 5-Year Plan is completed and the Third 5-Year Plan started in 1991, the Government accelerated the construction of the Selabam Hydro to complete a 3 MW power generation facility, and as discussed in Paragraph 1.3.4 (3) of the preceding section, decided to implement the Provincial Grid Integration Project SPE-II. The major objective of SPE-II Project are as presented in Paragraph 1.3.4 (3), and it includes the plan to meet the future electric power demand of Se Kong and Attapeu. The reasons of this inclusion are as presented below.

As discussed in Paragraph 1.1.3, the two provinces of Se Kong and Attapeu have the lowest population density in Laos[Note 19)]. The Se Kong Province adjoin to the Central Vietnam, and the Attapeu Province to both the Central Vietnam and the Northeastern Cambodia. These two provinces are not very far from the northeastern region of Thailand, but one of the most isolated area in Laos due to inadequate transportation and communication facilities.

The Government of Laos today hopes to succeed in the development of the new city of Se Kong. Strenuous efforts are being made to develop the Se Kong Province with emphasis on promotion of agriculture and live-stock industry[Note 20)], development and afforestation of forests, and development of mines[Note 21)] (with the written order of priority). For the Attapeu Province, it is attempted to promote agriculture, forestry[Note 22)], mining, agricultural product processing industry and lumber industry.

The Government of Laos designated the Se Kong Province in 1985 as the model district for promotion of development of the southern provinces. For this purpose, the Government segregated Se Kong Province from the Salavane Province, and selected the Ban Mo site, which is located on the right bank of the Xe kong River in the basin that spreads to the east of the cliff of the

Bolaven Plateau, to create a new town of Se Kong as a center of the development of this province. In Se Kong Town, the office building and residence of the Governor of the Se Kong Province have been completed, and there are rows of new wooden residential houses along the town streets. The town population is currently 15,000, but the inflow of colonists is rapidly increasing since late 1990's.

The main town of Attapeu Province is Samakyxay Town on the Xe Kong River, which is not far from 3 towns, such as Xaysetha town on Xe Kaman River, a tributary of the Xe Kong River. The town of Xaysetha has been historically known as the key station on the road connecting to Cambodia and Vietnam, and there is the tombs of ancient royal family which ruled this town. The Government of Laos is attempting to develop, for the time being, a relatively new town of Samakyxay as a center of agriculture, forestry and mining industry.

To summarize, the two cities of Se Kong and Attapeu are given the position of important bases for the development of the southern provinces by the Government of Laos. The status of electric power facilities in Se Kong and Attapeu is described in detail in Chapter 3, and not discussed here, but these two towns are currently equipped with diesel power generation facilities which can meet the current demands. However, the latent power demands in these two towns are high, in order to meet the lighting demands for the residences, the agricultural product processing industries of small scale, and irrigation of farm lands. In Se Kong Town, in particular, there is concern that the power supply condition will become even tighter as the incoming colonists are increasing since late 1990's. In addition, as these two towns are located remotely, with inadequate transportation facilities, the supply of diesel plant parts and fuel is not being smoothly done, and stable power supply can not be maintained in rainy seasons. This condition impedes industrialization and irrigation efforts, and smooth regional development can not be expected unless this power supply condition is remedied.

2.1.2 Scale and Requirement of Development of Xe Katam Hydroelectric Power

Sufficient supply of electric power is indispensable for industrial development and improvement of livelihood in the two towns of Se Kong and Attapeu. In the SPE-II Project of the Government of Laos, it is stipulated that the power generated by the Xe Set Hydroelectric Power Plant is transmitted to Se Kong Town via Thateng Town. For Attapeu Town, it is planned to install diesel generator plant and substation facilities inside the town. However, the problems of electric power supply shortage in these two towns can be completely resolved if the Xe Katam Hydroelectric Power Plant is commissioned. This is the very requirement for the Xe Katam Hydroelectric Project

The location of the Xe Katam Project is ideal, since the distance of power transmission from this site to Se Kong Town is 50 km, to Attapeu Town 73 km. As already mentioned, the output of the Xe Set Power Plant (45 MW) can not only be transmitted to Thailand across the Mekong River via Pakse City, it can meet the power demand in Pakse City, Salavane City and their surrounding areas. Although it has been planned that the output of the Xe Set power plant also supply Se Kong City, it was assumed in this development plan of the Xe Katam Hydroelectric Power Plant that the demand of Se Kong Town is met by an independent supply system, and the final scale of development was planned as 6,000 kW.

As it is clarified in Chapter 3, the power demand of Se Kong and Attapeu together is estimated to be around 2,000 kW in the near future. It would be appropriate to develop the Xe Katam Hydroelectric Power Plant with the capacity of this scale, considering the amount of river flow near the proposed power plant site in dry season. This project will substantially contribute to the industrial development and improvement of livelihood of these two towns as soon as it is completed. The interrelation of this project with the power transmission plan referred to the above will be determined by the Government of Laos in some future time based on the economic and engineering judgement on when and in how the Xe Katam Power Plant will be expanded. The Xe Katam River is a tributary of the Xe Namnoy River, as described in Chapter 2. In this survey, the whole basin of the Xe Namnoy River has been roughly studied mainly based on maps only, and the development plan for the whole Xe Namnoy

basin must be studied in more detail in future. The optimal scale of development and the pace of development must be examined after implementing such detailed studies, and taking into account the transmission plan referred to above.

2.2 Past Activities Leading to This Survey and Its Outline

2.2.1 Past Activities Leading to This Survey

According to the "Report of Preliminary Study on the Xe Katam Small Hydroelectric Development Project" issued in November, 1990 by the Mining and Industry Planning and Survey Division of the JICA, the Government of Laos has studied 16 small hydroelectric development projects throughout Laos in the Second 5-Year Economic And Social Development Plan (19886 to 1990). Based on this study, the Government of Laos has requested the Government of Japan in May, 1989 for the feasibility study of the Xe Katam Project based on the reason that this project contributes to the development of the Bolaven Plateau which is a promising agricultural area in the southern region of Laos. Upon this request, the JICA has dispatched the Contact Mission (headed by Mr. Hayao Adachi) to Laos in March, 1990, to confirm the content of request and conduct an expedition survey of the project site. Based on this study, the JICA has dispatched the Preliminary Study Mission to Laos and concluded S/W with the Government of Laos.

2.2.2 Outline of Survey

The Electric Power Development Company, Ltd., has submitted the proposal of survey of this plan to the JICA in October, 1990, started preparatory works in November, and formulated the Inception Report in December. In this Report, the schedule of basic items of this Survey, and the sharing of works between the MIH of the Government of Laos and JICA Study Mission are defined. Concerning the survey schedule, the survey works were divided into three stages, the Identification Stage, Field Investigation Stage and Preliminary Stage. The Survey started in December, 1990, and completed in March, 1992.

The details of survey schedule prescribed in this Report are presented in Table I-2-1 and Table I-2-2.

The First Study Mission entered Laos on December 2, 1990 according to this survey schedule, and immediately started discussions with MIH. The Study Mission stayed in Laos until early January of 1991, and implemented the field surveys which are required for the Identification Stage and a part of surveys included in the Field Investigation Stage.

The second site survey was conducted from February 1, 1991 to the middle of May. The actual works for the collection of hydrology, meteorology, geography and geology data have been started, and surveys were conducted to formulate the development plan of the Xe Nammoy Basin, to determine the optimum sites for water intake and power generation at the Xe Katam Site, and to determine the transmission line route to the load centers. Then, studies were performed in Japan during April and May, and the specialists of geographical survey and geological analysis were dispatched to the site in June.

In July, the studies on hydrology, meteorology, environment, geology, etc. were continued. Then, the report editing work was performed from August to December. The Final Draft Report, thereupon completed, was submitted to His Excellency MIH Minister Soullvong Daravong on October 1, 1992. This Draft Report was then examined and approved by the officials concerned. Thus it is scheduled that the Final Report will be delivered by mail by the end of March, 1992.

The personnel met by the Team during the study are listed in Table I-2-3 and Table I-2-4.

Table I-2-1 Schedule of the Study (1/3)

Item	Year	1990	1991												1992			
	Month	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
	Rainy season																		
(1) IDENTIFICATION STAGE																			
① Review of collected data and preparative study for reconnaissance in Laos																			
② Collection and review of existing data and reports																			
③ Power Survey																			
a) Survey on existing power supply and transmission facilities, including operations thereof																			
b) Review and analysis power consumption growth and characteristics of power consumption pattern																			
c) Review and analysis of energy demand and peak demand from 1991 to 2005																			
④ Site reconnaissance																			
a) Ground surface survey on topography and geology at the project site and its vicinity including access road																			
b) Preliminary hydrological study																			
c) Preliminary study on environmental impact, resetllement and compensation																			
⑤ Identification of project sites																			
a) Formulation of alternative schemes and their optimization in consideration of total development of the Xe Namnoy river basin																			
b) Site selection of project components																			
c) Preliminary layout of project facilities																			
⑥ Programme preparation of the subsequent field investigation																			

Legend : Preparation period; Field Investigation; Work in Laos by MIH; Work in Laos by Contractor; Work in Japan; Work in Japan by Contractor

Table I-2-1 Schedule of the Study (2/3)

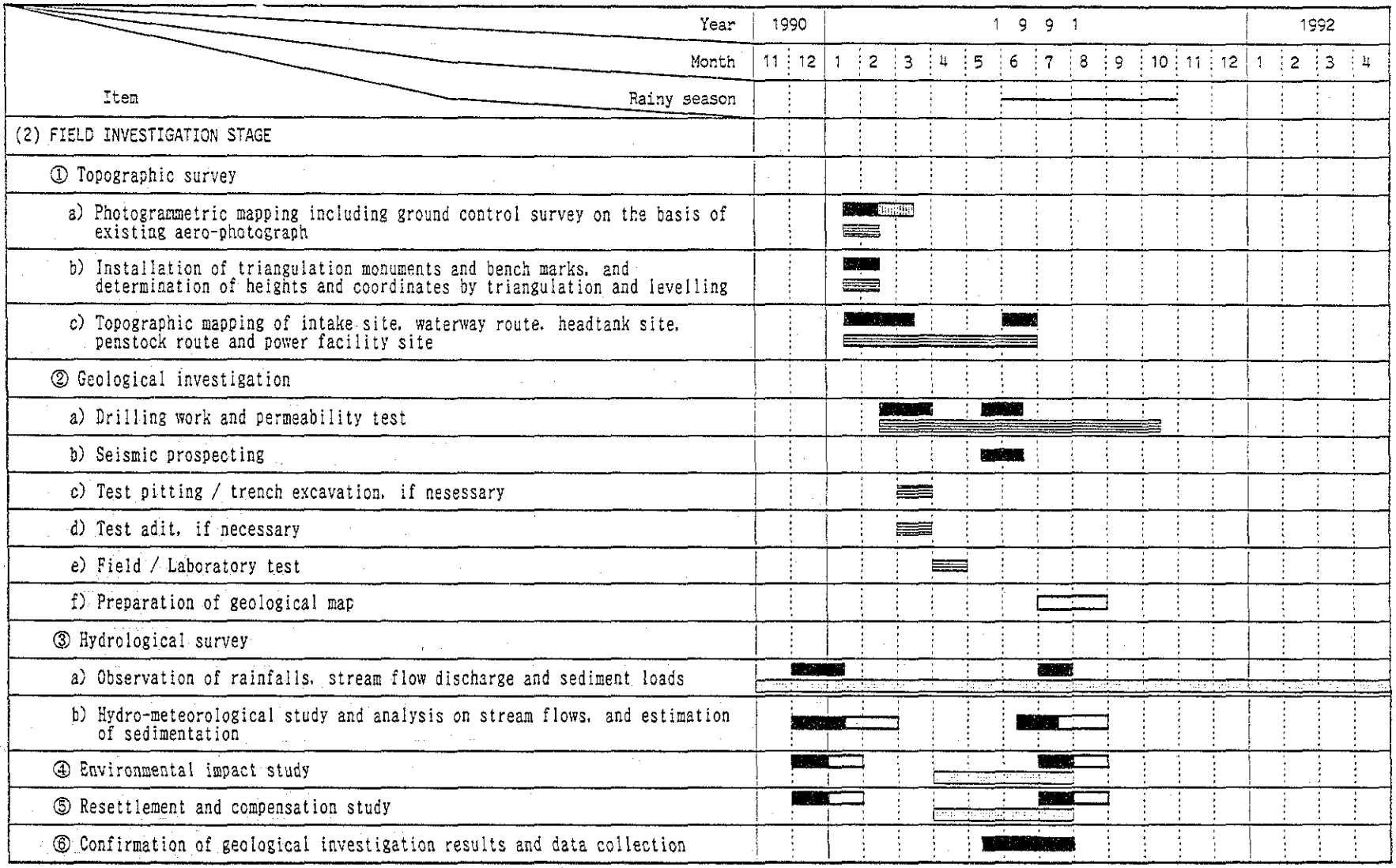

Table I-2-1 Schedule of the Study (3/3)

Item \ Year / Month / Rainy season	1990		1991												1992			
	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
Rainy season								———	———	———	———	———						
(3) PRELIMINARY DESIGAN STAGE																		
① Formulation of development plans										▭	▭							
② Comparative study and selection of an optimum plan											▭							
③ Preliminary design												▭						
④ Cost estimation												▭	▭					
⑤ Formulation of project implementation schedule													▭					
⑥ Economic analysis													▭	▭				
⑦ Financial analysis													▭	▭				
Reports																		
① Inception Report	▽																	
② Progress Reports				▽		▽												
③ Interim Report										▽								
④ Draft Final Report														▽■				
⑤ Final Report (including Summarized Final Report)																		▽

Legend : —— Preparation period ■ Field Investigation ▭ Work in Laos by MIH ▭ Work in Laos by Contractor
▭ Work in Japan ▭ Work in Japan by Contractor

Table I-2-2 Overall Man-Maneuvering Schedule

Title	Name	Period: 1990 11	12	1991 1	2	3	4	5	6	7	8	9	10	11	12	1992 1	2	3
Team Leader	Hiroshi Hori		1.0	0.5	0.5	0.2				0.5						0.5		
Economist	Tetsuya Fukuda									0.5						0.5		
Environmental Expert	Yoshiaki Noda		0.8							1.0								
Civil (design) Engineer	Yoshiki Munetake		0.8													0.5		
Civil (design) Engineer	Hidekazu Yokoyama								0.5									
Civil (planning) Engineer	Junichi Asano		1.0	0.5	0.5	0.2												
Civil (hydrometeorology) Engineer	Shigeru Nakamura		1.0	0.5					0.5	0.5								
Electrical (transmission) Engineer	Hiroshi Kagami				0.5													
Electrical (planning) Engineer	Takehisa Sakai		0.8															
Engineering Geologist	Isao Shimizu		0.8		0.5	0.5			0.3	0.7								
Engineering Geologist	Hajime Watanabe				0.5	1.0			0.3	0.7								
Survey Specialist	Kuniaki Takamatsu		0.8	0.5	0.5													
Survey Specialist	Yutaka Kokufu			0.5	1.0	0.5				1.0								

Note : Field Work Home Work

Table I-2-3 List of Personnels met by the Team during the 1st Tour Period

A. In Lao P.D.R.

1. Ministry of Industry & Handicraft (MIH), Laos

Mr. Soulivong Daravong	Acting Minister
Mr. Khammone Phonekeo	Vice Minister
Mr. Khamsing Ngonvorarath	Senior Advisor
Mr. Damdouane Phomduangsy	Director of Cabinet
Mr. Bounkeuth Thammavongsa	Advisor
Mr. Somsack Phrasonthi	Civil Engineer & Project Manager, Xe Katam Project
Mr. Theodore M. Ford	Advisor (sent by ADB)

2. Ministry of Economy, Planning and Finance (MEPF), Laos

Mr. Chantavong Saignasith	Director, Capital Investment
Mr. Bounthavy Sisouphanthong	Action Director, Statistical Center

3. Ministry of Agriculture & Forestry, Laos

Mr. Langsy Sayvisith	Director, Irrigation Dept.
Mr. Koun Sengdara	Director, Meteorology & Hydrology Dept.
Mr. Khamthong Soukhathammavong	Meteorology & Hydrology Dept.
Mr. Thongphon Vonosyprasom	Chief, Technical Section
Mr. Vongdara Keomuongchanh	Deputy Chief, Technical Section
Mr. Nitharah Somsanith	Planning Section
Mr. Souane Silavong	Chief, Pakse Office
Mr. Seng Chang	Chief, Paksong Office

4. Hydropower Engineering Consultants (HEC), Laos

Mr. Thongsamouth Lunammachack	General Manager
Mr. Seng Panyasiri	Civil Engineer
Mr. Viraphanh Nandavong	Civil Engineer
Mr. Sithanh Vongsiry	Civil Engineer
Mr. Moon Chanthaboon	Survey Specialist
Mr. Saykham Soukvanheuang	Survey Specialist
Mr. Sayasack Vongsack	Hydrologist
Mr. Sounanh Sinolak	Hydrologist
Mr. Tongphath Inthavong	Engineering Geologist
Mr. Sisavath Chanthaluxay	Electrical Engineer

5. Electricite du Laos (EDL), Laos

Mr. Houmphone Bulyaphol	General Manager
Mr. Outhay Ondavong	Deputy Manager, Project Dept.
Mr. Viraphone	Project Dept.
Mr. Phaxay Kod-asa	Administrator, Project Dept.
Mr. Sisouvanh Souvannaphasy	Site Manager, Xe Set
Mr. Ingvar Y. Hildebrand	Project Advisor
Mr. Khamsong Phongsavan	Deputy Manager, Project Dept.
Mr. Phetsanovlok	Director of EDL, Saravan
Mr. Lao	Director, Pakse Xe Set Office

6. Se Kong Province

Mr. Yao Phonevanhtha	Governor of Province
Mr. Vannavong	Staff, Education
Mr. Somsi	Staff
Mr. Khanthong	Staff, Finance
Mr. Vila	Staff, Finance
Mr. Somsakhunh	Staff, Health
Dr. Sitha	Staff, Health
Mr. Bounchanh	Staff, Health

7. Attapue Province

Mr. Thongdam Chanthaphone	President of Province
Mr. Vinay Pongphommavong	Vice President
Mr. Sinay Mienglavanh	Deputy Director, Administrator
Mr. Lintha	Staff, Foreign Office
Mr. Bounthary Koumalasy	Civil Engineer
Mr. Sithat	Staff, Industry & Trading
Mr. Fongsamut	Staff, Electricity

8. Ban Nongmek

Mr. Douane Khambounhevang	Chief, No. 5 Administrator Area (B. H. Kong)
Mr. Nane Munluang	Chief, Police

9. UNDP, Laos

Ms. Takeko Iinuma	Programme Officer

10. Snowy Mountains Engineering Corporation Ltd. (N. Theun)

Mr. David H. Rogers	Project Manager

11. Norconsult (Xe Set Hydropower Project)

Mr. Sverre Edvardsson	Resident Engineer
Mr. Ole P. Dahlberg	Senior Mechanical Engineer
Mr. Pivind Nicolaysen	Electrical Engineer

12. Marusima Agua System Corp.

Mr. Yukio Nagata	Site Manager, Xe Set Project

13. Japanese Embassy

H. E. Mr. Shigemi Ando	Ambassador
Honorable Mr. Yukuto Murata	Counsellor

Mr. Haruo Matsumoto	1st Secretary
Mr. Shinji Nagashima	1st Secretary
Mr. Hirobumi Taniguchi	2nd Secretary
Mr. Motoyoshi Suzuki	Specialist on Economy
Mr. Ishida	Staff
Mr. Kazushige Matsuo	Irrigation Expert, Tha Ngon (JICA)

B. Bangkok, Thailand

1. Mekong Committee, UN, Bangkok

Mr. Chack Lankester	Executive Agent
Mr. Thaipuk Thammongkot	Senior Hydrometeorologist
Mr. Takashi Kawai	Senior Irrigation Engineer
Mr. Hayao Adachi	Development Specialist (JICA)
Mr. N. Kuniyasu	Irrigation Engineer

2. Electricity Generating Authority of Thailand (EGAT), Bangkok

Mr. Swarng Champa	Deputy General Manager, Hydropower and Transmission System Development
Mr. Kraidej Ansusinha	Director, Transmission System Engineering Dept.
Mr. Bhisit Anantasanta	Assistant General Manager, Transmission System Development Dept.
Mr. Taweesak Mahasandana	Director, Hydropower Engineering Dept.
Mr. Kittivatana Sutcharitphong	Director, Civil Maintenance Dept.

Table I-2-4 Additional List of Personnel Met by the Team

1. Department of Geology and Mines, Laos

Mr. Manomay Vilayhongos	Chief, Inv. Prom & Management Division
Mr. David K. Jordt	Chief Technical Adviser
Mr. Gary Humphrey	Senior Geophysicist, Scintrex Pty. Ltd.
Mr. André Miknevicius	Mining Engineer, MBA Senior Lecturer at Univ. de Liage

2. Electricite de Laos, Laos

Mr. Viraphonh Viravong	Director, Project Dept.

(mentioned in Progress Report No. 1 with last name and title inadvertently omitted)

3. Se Kong Province

Mr. Kamphong Phonchalevn	Vice President of Se kong Province
Mr. Sida Souvannasane	Chief of Provincial EDL
Mr. Bounmy Khenlitthi	Deputy Director of Provincial Administration

Note and Bibliography for Chapter I

Note

1. The total length of the border of Laos with Vietnam is 1,950 km, the border with Thailand 1,730 km, the border with Myanmar 230 km, the border with China 420 km, and the border with Cambodia 490 km.

2. The total length of the Mekong River is 4,200 km which is the 11th longest in the world, its drainage area is 795,000 km^2 or 23rd in the world, and the annual discharge is 475,000 x 10^6 m^3 which is the 10th in the world. Mekong River is an international river which flows through 6 nations of China, Myanmar, Laos, Cambodia and Vietnam. The source of the river is on the Tibet Plateau, and the river flows through the Yunnan Province of China, passes along the northeastern border of Myanmar and the boarder between Laos and Thailand, then flows across Cambodia, and forms a wide delta in southern Vietnam before pouring into the South China Sea.

3. The northern mountain ranges of Laos were formed in Archaeozoic, Proterozoic, Paleozoic and Mesozoic eras, and they form highest mountains in the lower basin of the Mekong River (Laos, Thailand, Cambodia and Vietnam). The elevation near Phong Saly at an upstream of the Nam Ou river is 2,800 m. These mountains are generally rise more than 600 from river bed and generally form steep slopes having angles over 30 degrees.

   The Annan Mountain Range that entails from the northern mountain ranges are fold mountain ranges that were formed in the Paleozoic era and then eroded with lapse of time.

4. Laos is not frequently visited by typhoons, but it suffers typhoon once in a while. For example, in September, 1966, the areas surrounding the capital city of Vientiane and the upstream areas were attacked by tropical low pressure and typhoon, which brought a heavy rain to the City, as well as by the flood which frequency was once in 50 years.

5. Let us take the example of the Se Kong Province. The population of the Province is 57,000 according to the governmental statistics of April, 1985. According to what the Governor of the Se Kong Province told to the Study Mission (October, 1990), 70% of the actual Provincial population of 57,000 are Lao Theung Race. They are divided into 14 ethnic groups. When we classify this total Provincial population into districts, there are 15,000 people in Se Kong Town, 18,000 in Dakchong Town, 11,000 in Thateng Town, and 13,000 in Kaleum Town. These towns are separated by distance of 50 km to 140 km, and the citizens communicate between these towns by using radio sets employing solar batteries.

6. The loss of forests by forest burning agriculture in Laos is reported to be 200 ha to 300 ha per year. The countermeasure against this situation is to have the state-own agricultural lands, provide residential houses to have the citizens stay in the allotted land, guide them to engage in stable farming, and give education on environmental protection.

7. Drought was experienced consecutively for 2 years in 1987 and 1988, and 40,000 tons of grains was imported in 1987, and 150,000 tons were imported in 1988 (with the domestic production of grains in husks being 1,000,000 tons). However, the grain production recovered to 1,400,000 tons in 1989 and 1990.

8. By the end of June, 1990, the Government opened the "Supreme People's Assembly" and admitted private ownership and rights to inherit and contract. Banking was also authorized. On the other hand, as the nationally owned factories have not been performing well due to limited capital, difficulty of procuring raw materials, and low productivity, it was decided to encourage market economy in the future as much as possible. Because of the above changes, it is expected that investment from the outside, especially western nations, will be increased and industrialization accelerated if the foreign currency exchange law is revised.

In reality, however, there still seems to be various difficulties. For example, concerning the investment of Thai business to Laos, it is reported that the number of registered companies of Thai capitals was increased to 700 by 1989 owing to the new policy of the Lao Government adopted in 1986, but many of them dropped out later, because the legal system of Laos was inadequate for capitalistic business, the custom duties were high, the government agencies were not necessarily inefficient, the foreign currencies were restricted to be returned to the home country, there was inflation, and the domestic taxation was high.

9. During 1989, 9,000 tons of goods were imported to Laos via the Da Nang harbor. The amount of goods transported from Vietnam to Laos is increasing, being 2,800 tons in 1981, 40,000 tons in 1982, and 80,000 tons in 1983.

10. The Yunnan Province of China has concluded a 5-year economic agreement with Laos. The Yunnan Province held an exhibition in Vientiane City in July, 1990, and exhibited heavy machinery, pumps, refrigerators, small water turbines, power generation equipment, etc. A joint study by China and Laos was conducted to examine possibilities on the navigation in the reaches which extend 700 km on the Mekong mainstream. It has been identified by this study that navigation of small vessels, no more than 200 tons, will become possible in this section if some dredging works are done and rocks were removed. The ship transportation between Kunming in China and Luang Prabang City. The construction of the northern section of Route 13 was discussed for the first time after the invasion of Vietnam into Cambodia. It is reported that construction of this road will be started soon.

It was decided that the Deputy Foreign Minister of Laos will permanently attend the Provincial Committee of Luang Namtha Province of northern Laos to maintain liaison with the Yunnan Province. It is reported that China promised to intensify the diplomatic relation between China and Laos, and suppress the anti-government movement against Laos Government.

11. According to the survey conducted by the Study Mission in December, 1990, the market price of diesel oil in Vientiane City was around 0.45 US dollars per liter (315 kip/l). It is reported, however, that this price started to climb rapidly in 1991 (being 450 kip/l in Se Kong Town). The unit price of diesel power generation was 0.67 US dollars per month (470 kip/month) per lamp in Attapeu, and it was 0.85 (600 kip/month) in Se Kong Town, but it is being forced to modify this tariff in 1991. These towns are far from any highway, and transportation is possible in dry season but it is difficult in rainy season, and suffering from shortage of oil supply. On the other hand, the electricity tariff in Vientiane City is quite different owing to the power supply from the Nam Ngum Hydro Plant. For private customers, the tariff is 0.10 US$/kWh (7.5 kip/kWh) up to consumption of 200 kWh, and surcharge of 0.014 US$/kWh (10 kip/kWh) is applied to the exceeding portion. It is reported that, for a certain private residential customer living in Vientiane City consumes 800 kWh/month. In this case, the tariff he must pay is 7.5 kip x 200 kWh + 10 kip x 600 kWh = 7,500 kip/month,or 10.7 US$/month. It is not clear, however, whether he is a typical residential customer.

12. It is reported that the mining cost of the Bo Chan coal is 14.85 US$/ton, (10,400 kip/ton) and it costs 7.4 US$/ton (5,200 kip/ton) to transport it to Vientiane City.

13. The chaff (rice hulls) is utilized in Indonesia and other places as pozzolanic agent of cement.

14. Table-10 and Table-11 have been formulated by Mission Leader by himself while he worked as chief planning engineer of the Mekong Committee.

15. There are some rivers in Laos which are located outside the Mekong Basin and have hydroelectric potential. For example, the Nam Het River at the northern area of Laos is a tributary of the Song Ma River joining the mainstream at an upstream part. Also, the Nam Neul River is an upstream tributary of the Song Ma River. The Nam Het River and the Nam Neun River are located outside the Mekong Basin and have some hydroelectric potential. In particular, the Nam Het River has a

development site at a location from which electric power can be supplied to Sam Neua, which is an important local city of Laos.

16. According to "Policy Framework for Public Investment Program" issued by the Ministry of Finance and Economic Planning of Laos in November, 1990, the total capacity of electric power facility in Laos, including the 45 MW capacity of the Xe Set Hydro Plant, is 208 MW (with annual energy generation of 800 to 1,000 GWh), which is a little different from the figure in this text.

17. SPE-I is financed by 19.8 x 106 SDR of the IDA loan and 5.34 x 106 US$ of fiscal investment (according to an agreement made in February, 1988). The content of this project is as listed below.

- A 115 kV, 115 km long transmission line between the Xe Set and the Xong Met and a building (completed)>

- Pakse 115/22 kV substation building (completed).

- The 22 kV electrification plan for Savannakhet, Champassack and Salavane Provinces (including construction of support structures at 1,000 locations between SVK and Kengkok for 76 km distance). (Under construction as of May, 1990.)

- Construction of power distribution system for 800 households in Pakse and Salavane Towns, including 286 km of 0.4 kV lines and 452 km of 22 kV lines and transformers.

- Concrete pole factory in Pakse (completed).

- Wooden pole construction work in Pakse Town (completed).

- Study for expansion of the Selabam Power Plant by 3 MW.

- Feasibility study of the Xe Don II Power Plant.

18. Concerning the electrification plan of Xanakham Town of Vientiane Province (along the Mekong River, upstream of Vientiane City), the Study Mission Leader and the HEC engineer have surveyed a potential hydroelectric development site on nearby the Nam Me River, and concluded that this site is not suitable for economic development because there is practically no river flow in dry seasons.

At that time, this area of the Xe Katam Town had 62 settlements with population of 22,800 and 4,000 households. This area was a rich agricultural land where 6 ton/ha of paddy can be harvested without providing fertilizer, and diesel power units of 372 kW, 194 kW and 90 kW were equipped in small rice polishing mills, a 90 kW power unit in a lumber factory, and there was a 150 kW diesel generator for public service. It was planned then to provide lighting for 16,000 people, to construct additional lumber factories, to construct new cotton factory and furniture factory, and to develop a mine.

19. According to the on-site survey of the Study Mission, the population of the Se Kong Province is 57,000 as of December of 1990, which is practically the smallest population as a province, only comparable to the population of the Bokeo Province which is at the northern end of Laos. It was also found out that the population of Attapeu Province was 78,750 as of December, 1990, and this was the third most sparsely populated province.

20. According to the Governor of the Se Kong Province: "For the time being, the study of classification of land utilization is the most urgent item. Also, it is necessary to increase the harvest by promoting agriculture. It must be avoided to rush things, but we hope to not only fill the demand inside the Se Kong Province, but sell agricultural products to other provinces and neighboring nations in the near future.

21. "The Se Kong Province has abundant reserves of mineral resources. We have already asked for assistance of foreign nations for development of copper, silver and gold, and also requested the Unites States to assist us in pollution study because we are concerned on contamination of air

and water. Concerning coal, Japanese specialists have already conducted a survey, and this investigation will be fully committed in 1991. But this is the beginning of the full investigation of mineral resources in the Se Kong Province", said the Governor of Se Kong (December, 1990).

22. The wish of the Attapeu Province is to irrigate the paddy field (14,500 ha) that spreads on the sides of Se Kong which is currently fed by rain water. A small hydroelectric plant with 200 kW capacity is to be installed for the Huay Somong Irrigation Project, i.e., the irrigation project, around Sanamxay Town which is on the Se Kong River to the downstream of Xaysetta City. The equipments of this power plant was supplied from Japan. The construction of the project was started in 1988, and was scheduled to be completed by January, 1991, but construction was prolonged because the supply of agricultural equipment from Japan was delayed. The 200 kW small hydro will not only be used for irrigation but supply the lighting power to the neighboring 13 villages.

Bibliography

1. Lao P.D.R: Report on the Economic and Social Situation Development Strategy and Assistance Requirements, Vol. 1 & 2, Geneva, May 1983.

2. IBRD: Lao PDR. country Economic Memorandum, Washington, D.C., USA, Sep. 1988

3. Economist: Indochina Country Report No. 1 & 3, 1900, London, UK, 1990

4. Economist: Indochina Country Report 1990 - 1991, London, UK, 1990

5. UN: Development of Water Resources in the Lower Mekong Basin, Flood Control Series No.12, Bangkok, 1957

6. Mekong Committee: Mekong Work Programme, Jan. 1991

7. Mekong Committee: Inventory of Promising Tributary Projects in the Lower Mekong Basin, Vo.1.11. Laos, Bangkok, Sept. 1970

8. WATCO: Lower Mekong Water Resources Inventory, Gaanderen, the Netherlands, July 1984

9. Ministry of Economy Planning and Fiance, Lao P.D.R. Policy Framework for Public Investment Program, Lao P.D.R, Vientiane, Nov. 1990

10. NORCONSULT: Xeset Hydropower Project Feasibility Study Report, Norway, Feb. 1984

11. NORCONSULT: Xeset Hydropower Project Feasibility Optimization Report, Norway, Feb. 1985

12. NORCONSULT: Xeset Hydropower Project Final Design Report, Norway, Jan. 1988

13. Mekong Secretarial: Socio-economic Study, Xeset Hydropower Project, Lao P.D.R., Bangkok, Mar. 1989

14. Nihon Koei.Sogreah: Xedon 2 Hydroelectric Project Draft Final Report Vol.1, Japan/France, Jan. 1991

15. Mekong Secretariat: Se Bang Fai Plain, Prefeasibility Study of Floodway and Small Structures, MKG/R.454, Bangkok, Jan. 1984

16. SMEC: Nam Theun River Basin Prefeasibility Geological Study Report, Australia, Mar. 1984

17. SMEC: Nam Theun 2 Hydroelectric Project Feasibility Study Executive Summary, Vol.1, Engineering, Vol.1.2, and Environmental Assessment, V81.4, Australia, Nov. 1990

18. SMEC: Energy Market and Transmission Study in Thailand, Vol.1, Electric Power and Energy Requirements in Thailand, Australia, Aug. 1984

19. EDL, Lao P.D.R.: 3rd Quarterly Report of Project Department, Vientiane, 1990

20. TATA: Southern Provinces Electrification Project Phase II Report Vol. I, II, Bombay, India, Oct. 1990

21. TATA: Provincial Grid Integration Project (SPE II) Final Report Vol.I, II, III, Bombay, India, May 1991

22. Asian Institute of Economy: Composition of Construction of Three Indo-China Nations, Asian Economy Publishing Co., Tokyo, 1984 (Japanese language)(by Tetsusaburo Kimura)

23. JICA: President Status of Tha Ngon Pilot Farm, Laos, Journal of Kyoryoku Johho, Tokyo, 1990 (Japanese language) (by Masamoto Yasuo).

Chapter II Development Potential of Xe Namnoy River Basin

CHAPTER II DEVELOPMENT POTENTIAL OF XE NAMNOY RIVER BASIN

In Chapter II, the hydropower potential over the Xe Namnoy River Basin is examined prior to the study of small-scale hydroelectric power project with a purpose of electricity supply to the towns of Sekong and Attapeu. This examination aims to formulate the development plan of the Xe Namnoy River Basin in which the small-scale development plan should be established taking into consideration on the future development plan of large scale hydropower projects in the basin.

Firstly, the natural conditions, topography, geology and hydrology, of the Xe Namnoy River Basin are described in Section 1. Then, the hydroelectric power potential of the Xe Namnoy River Basin is examined in Section 2.

1. Topography, Geology, Meteorology and Hydrology of Xe Namnoy River Basin

Chapter II 1. Topography, Geology, Meteorology and Hydrology of Xe Namnoy River Basin

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1. Topography, Geology, Meteorology and Hydrology of Xe Namnoy River Basin

1.1 Topography of Xe Namnoy River Basin

The Xe Namnoy River is a stream with a catchment area of 1,500 km^2 covering the central to southeastern part of the Bolaven Plateau which is of a long, roughly rectangular shape (length 100 km, width 50 km) stretching with comparatively little relief from northwest to southeast at elevations from 900 to 1,300 m.

The somewhat westward area of the central part of this Bolaven Plateau forms a gently-sloped cone with Paksong Town (EL. 1,300 m) at the center. Therefore, streams such as the Xe Set River and the Houay Champi River flow down radically from Paksong Town at the center, and the Xe Katam River and the Houay Makchan Gani River among these, which are tributaries of the Xe Namnoy River, flow mainly to the southeast.

Meanwhile, the southeastern part of the Bolaven Plateau through which the Xe Namnoy River mainstream flows, forms a basin opened up at the north side with the central portion being of lower elevation than the fringes of the plateau. That is, the perimeter of the plateau has continuous hills of 1,000 to 1,100 m, and the central part through which the Xe Nammoy River flows has gently sloped hills of elevation 700 to 900 m. The major streams seen at this southeastern part of the Bolaven Plateau are the Xe Namnoy River mainstream and its tributary, the Houay Katak Tok River.

The Xe Namnoy River mainstream, consists of midstream and upstream stretches of elevations from 1,000 to 700 m, and a downstream stretch of elevation from 700 to 200 m. The midstream and upstream stretches at elevations 1,000 to 700 m are where the Xe Namnoy River meanders down gently to the north. On the other hand, at the downstream stretch, the course turns to the east with the river gradient 1/20, in places 1/10, to become a torrential flow with a sudden drop to around EL. 300 m, after which the river gradient becomes gentler at about 1/80 - 1/100.

The left-bank tributary of the Xe Namnoy River, the Houay Makchan Gnai River, merges with the Xe Namnoy River at EL. 700 m, just before the Xe Namnoy River becomes a swift stream, while the left-bank tributary Xe Katam River and the right-bank tributary Houay Katak Tok River merge with the Xe Namnoy River at elevations 300 to 250 m where the flow becomes gentle.

There exist areas suitable for large-capacity reservoirs at the midstream stretches of the Xe Namnoy River mainstream and the right-bank tributary Houay Katak-Tok River, and it is possible for large-scale or medium-scale reservoir-type hydroelectric power development projects to be planned.

In contrast, tributaries of the Xe Namnoy River such as the left-bank Xe Katam, Houay Makchan Gnai River, etc., lack suitable sites for reservoirs, and development would mainly be in the form of small-scale run-of-river power projects.

1.2 Geology of Xe Namnoy River Basin

The general geology of the Xe Namnoy River Basin may be summarized as follows (see Fig. II-1-1):

The Bolaven Plateau through which the Xe Namnoy River flows belongs to the Bolaven Tectonic Zone in the intracontinental superimposed structures. The geology of the Bolaven Tectonic Zone consists of the following in order from underlying formations.

- Tholam Formation

  Early to Middle Jurassic. Consists of red conglomerate, sandstone, and calcareous shale. Distributed at parts of low elevation such as Attapeu and Sekong in the surroundings of the Bolaven Plateau.

- Champa Formation

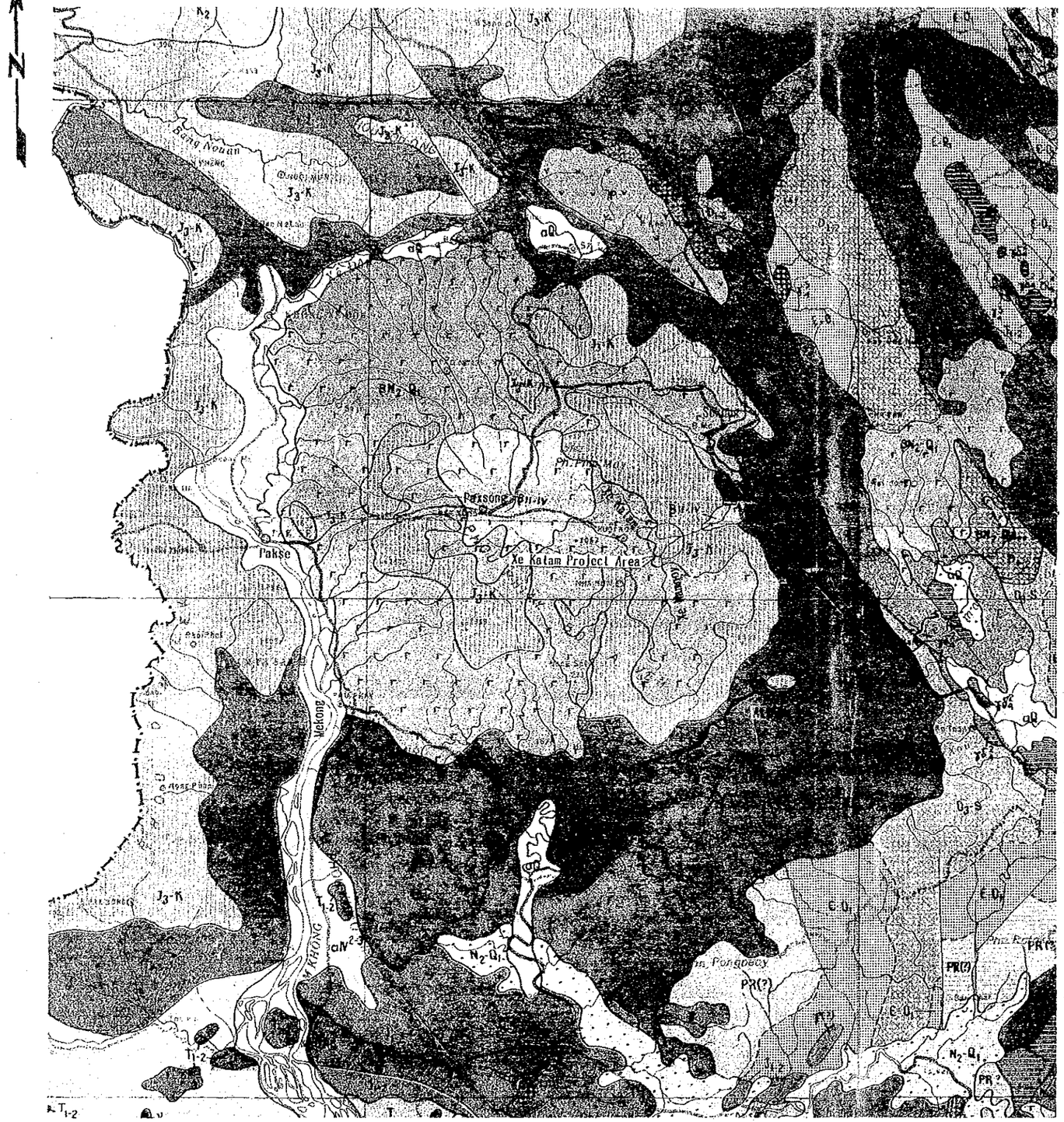
  Later Jurassic to Cretaceous. Consists of red conglomerate, sandstone, siltstone, and clay-stone. Forms the skeleton of the Bolaven Plateau.

- Volcanic Products

  Pleiocene to Pleistocene. Consists of basalt and basaltic laterite. Distributed at the surface layer of the Bolaven Plateau with Paksong at the center.

It is estimated that Later Jurassic to Cretaceous red conglomerate, sandstone, siltstone, and claystone are distributed widely at the Xe Namnoy River mainstream and the right-bank tributary Houay Katak-Tok River. On the other hand, it is estimated that Pleiocene to Pleistocene basalt is mainly distributed at the left-bank tributaries of the Xe Namnoy River, the Houay Makchan River, and the Xe Katan River.

Geotectonically, faults described in literatures are not distributed in the Xe Namnoy River Basin, while in Landsat imagery, prominent lineaments (patterns made up of faults, joints, straight-line topography eroded along geological boundaries), and karst landforms are not interpreted.



Note:
This map is compiled from "Geological Map of Kampuchea, Laos and Vietnam(1/1,000,000)- INTERGEO-1988-"

L E G E N D

CENOZOIC

- **QUATERNARY**
  - Q — Boulder, cobble, gravel, sand, debris
  - θ II-IV — Basalt
- **TERTIARY**
  - N_2 — a:Clay, silt, sand, pebble, gravel, laterite; b:Basalt, lateritic-basalt
  - P — a:Conglomerate, sandstone, siltstone

MESOZOIC

- K_2^b — Rock salt, gypsum, anhydrite, claystone, siltstone; Donghen formation
- J_3-K — Red conglomerate, sandstone, siltstone, claystone; Champa formation
- J — Red conglomerate, sandstone, calcareous shale; Tholam formation
- T — Conglomerate, siltstone, sandstone, sale, limestone; Manggiang formation

PALEOZOIC

- C-P — Limestone
- C — Shale, chert, siltstone, sandstone, limestone, coal seams
- D_1 — Red sandstone, shale, conglomerate; Tanlam formation
- O_3-S — Andesite, rhyolite, tuff; Songca formation
- ε-O_1 — Schist, sandstone; Suoimai formation

PROTEROZOIC

- PR — Gneiss, amphibolite, micaschist, phyllite
- PR_1 — Amphibole-biotite gneiss, amphibolite, migmatite

Geological boundary: a-observed, b-inferred — Petrographic boundary

Fault: a-observed, b-inferred

0 — 50 Km

Fig. II-1-1 Geological Map of Bolaven Plateau

1.3 Meteorology and Hydrology of Xe Namnoy River Basin

1.3.1 General Situation of Southern Lao Region

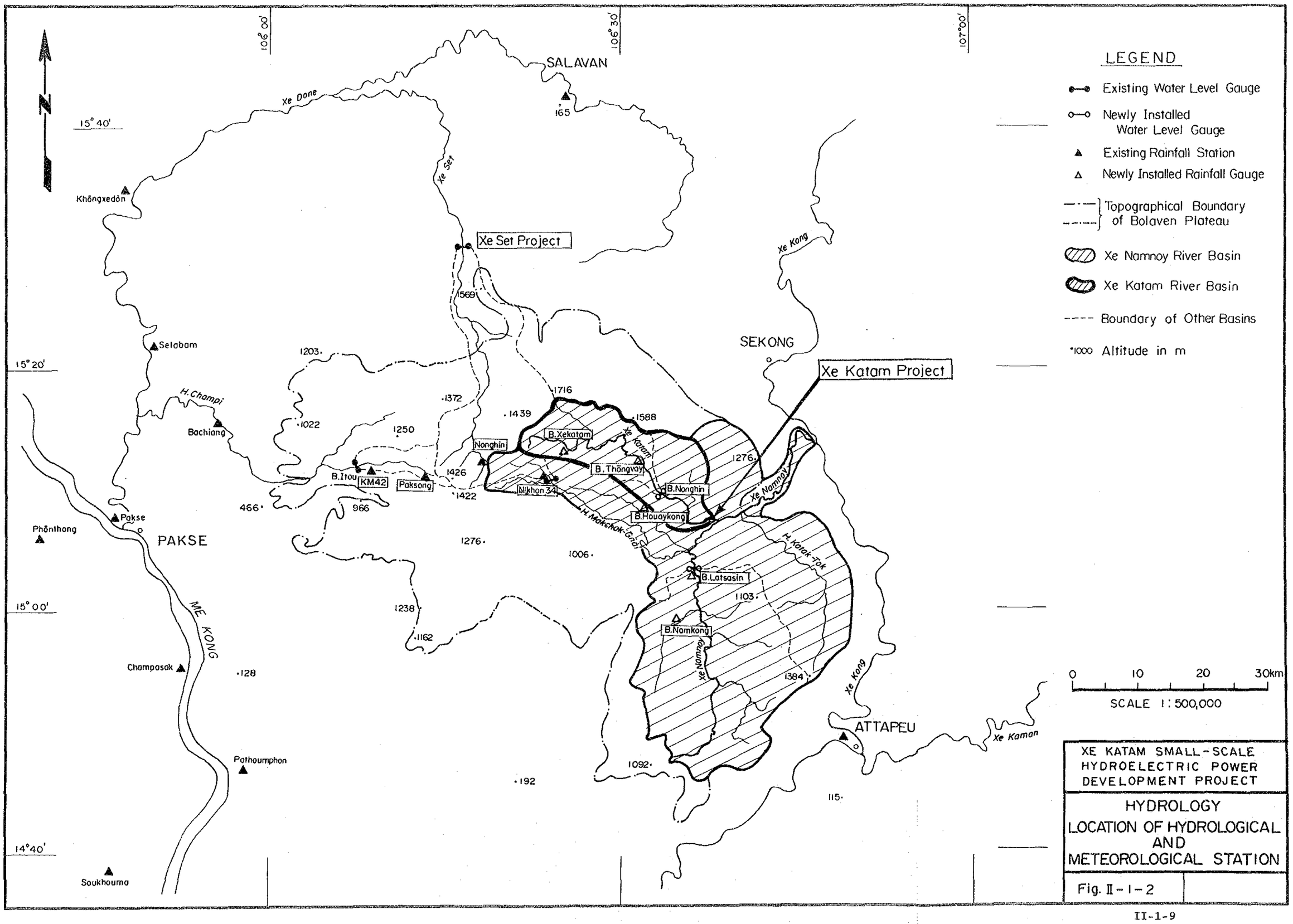
The southern part of Laos belongs to the Asian monsoonal climatic zone. The meteorology of this region can be roughly divided into two seasons, a rainy season due to southwest monsoons from May to October and a dry season due to northeast monsoons from November to April. In the rainy season, the southwest monsoon carrying moisture-laden air from the Indian Ocean strikes against the Bolaven Plateau and brings large amounts of rain to this region. On the other hand, in the dry season, dry air blows from the continent so that rainfall becomes extremely scarce. However, updrafts are liable to occur in the area of the Bolaven Plateau especially in the part west of Paksong, and there is much cloud and a little more rainfall in comparison with the surrounding area even in the dry season. The Bolaven Plateau is generally one of the most rainy area in the southeastern region of Laos, and some 3,700 mm of annual average rain fall has been observed at KM42, the location of which is 8 km west of Paksong.

According to data observed at a tributary of the Mekong in the southern part of Laos, stream runoff becomes minimum in the period from the end of March to April corresponding to the end of the dry season, and reaches maximum in the period from August to September when most of rain falls. Since rainfall is concentrated in the rainy season, there is a large variation in runoff during the year, and the monthly average runoff of a high-water month is more than 10 times greater than that of a low-water month. This characteristic might be applicable to the Xe Namnoy River, too.

In the following, the contents of meteorological and hydrological studies on the whole Xe Namnoy River Basin will be described.

1.3.2 Meteorological and Hydrological Investigations in and around the Basin

The locations of sites where meteorological and hydrological observations are being carried out in and around the Xe Namnoy River Basin are shown in Fig. II-1-2.



XE KATAM SMALL-SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT

HYDROLOGY
LOCATION OF HYDROLOGICAL AND METEOROLOGICAL STATION

Fig. II-1-2

Meteorological and hydrological investigations in the Xe Namnoy River Basin had not been carried out up till this study except for water level gauge height reading at the Nikhon34 site at the upstream part of the tributary of Houay Makchan Gani River. Therefore, in the First Field Investigations of this study, locations for installing water level recorders and rainfall gauges were selected at the sites shown in below tables and observations were started from the last third of January 1991.

Installation Sites of Water Level Recorder

	Stream	Installation Site	Installed Elevation	Catchment Area
1.	Xe Katam	Ban Nonghin	840 m	171 km^2
2.	Xe Namnoy	Ban Latsasin	720 m	537 km^2

Installation Sites of Rainfall Recorder

	Basin	Installation Site	Installed Elevation
1.	Xe Katam	Ban Xe Katam	1,060 m
2.	Xe Katam	Ban Tongvay	950 m
3.	Xe Namnoy (Tributary)	Ban Houaykong	890 m
4.	Xe Namnoy	Ban Latsasin	750 m
5.	Xe Namnoy (Tributary)	Ban Namkong	700 m

Further, stream runoffs were measured with current meters at several places including the sites where water level recorder was installed. However, on the mainstream of Xe Namnoy River, it is impossible to make discharge measurements with the present facilities in the period from June when the river became swollen to around October, and runoff data of the rainy season have not been obtained.

At present, the only meteorological and hydrological data within the basin which can be directly used for the study are those observed at the abovementioned newly installed stations and obtained by runoff measurements.

On the other hand, investigations have been carried out at the sites in the Bolaven Plateau and the surrounding area listed in Table II-1-1. Among the data from these sites, the data of rainfall on the Bolaven Plateau and the data of runoff observed on the Xe Set River which has basin within the Bolaven Plateau are especially important for analyzing the meteorological and hydrological characteristics of the Xe Namnoy River Basin.

For the runoff analysis on the Xe Namnoy River Basin, it had been considered to use the discharge data on the Xe Kong River, the mainstream of the Xe Namnoy River, and the Xe Don River which flows north of the Bolaven Plateau. However, as the result of study on these data, it was found that the runoff characteristics of the Xe Kong and the Xe Don River Basin is different from that of the rivers which have basin in the Bolaven Plateau. Therefore, discharge records on the Xe Set River was selected for the hydrological study in this report.

1.3.3 Rainfall Characteristics and Runoff Characteristics of Basin

(1) Rainfall Characteristics of Basin

The rainfall characteristics of the Xe Namnoy River Basin surmised from the abovementioned rainfall investigations and the results of field reconnaissances will be described here.

Annual rainfall record up till 1990 at existing rainfall stations in the Bolaven Plateau and the results of the rainfall observation from January to June 1991 at the newly installed rainfall stations in the Xe Namnoy River Basin and at existing stations are shown in Table II-1-2. (Daily records are given in Appendix 3.) The following trends can be conjectured from these observation results.

Table II-1-1 Existing Observatory Station in and around the Bolaven Plateau

1. Rainfall Station

Station	Altitude	Longitude	Latitud	Data Term (including months without data)	Annual Rainfall (mm)
1) in the Plateau					
KM42	1,160 m	106° 10 ' E	15° 11 ' N	1978-	3,700
Paksong Town	1,200 m	106° 14 ' E	15° 11 ' N	1963-71, 86-	3,200
Nonghin	1,280 m	106° 21 ' E	15° 13 ' N	1979-	2,800
Nikhon34	1,150 m	106° 26 ' E	15° 12 ' N	1983-	2,500
2) Around the Plateau					
Saravan	170 m	106° 26 ' E	15° 43 ' N	1964-66, 84	2,000
Khongxedon	122 m	105° 48 ' E	15° 34 ' N	1963-72, 79, 83, 88-	1,700
Selabam	117 m	105° 49 ' E	15° 23 ' N	1972-78, 80. 82-91	1,900
Bachiang	220 m	105° 54 ' E	15° 10 ' N	1989-	—
Pakse	101 m	105° 47 ' E	15° 07 ' N	1929-44, 48-91	2,100
Phonthong	125 m	105° 31 ' E	15° 08 ' N	1990-	—
Champasak	95 m	105° 53 ' E	14° 54 ' N	1980, 82-86, 89, 91	2,400
Pathoumphon	96 m	105° 58 ' E	14° 46 ' N	1965-71, 80-84, 90-91	2,100
Soukhouma	95 m	105° 48 ' E	14° 39 ' N	1980-89	2,100
Attapeu	106 m	107° 13 ' E	14° 45 ' N	1988-	1,700

2. Water Level Gauges and Formulated Discharge Records on the Rivers originating from the Bolaven Pateau

Site	River	Catchment Area	Data Term	Formulated Discharge Record
Xe Set Project Site	Xe Set	325 km²	1985-86, 88-	1985-86
Ban Itou	Houay Champi	54 km²	1985-	not formulated
Nikhon34	Houay Makchan	49 km²	1984, 1989-	not formulated

Table II-1-2 Rainfall Records in Bolaven Plateau

Rainfall Stations	Existing Rainfall Stations				Newly Installed Rainfall Stations				
	<--- West				East ---> <--- North				South --->
	KM42	Paksong	Nonghin	Nikhon34	B.Xeka-tam	B.Tong-vay	B.Houay kong	B.Latsa sin	B.Nam-kong
Annual Rainfall (mm)									
1978	3989								
1979									
1980	2347		2519						
1981	3959		3397						
1982	3939		2992						
1983	3292		2822						
1984	4776		3515	3006					
1985	4447		3466	2750					
1986	3452		3031	2477					
1987	3809	3371	2377						
1988	2986	3026	2393						
1989	3459	3229	2258	2158					
1990	3730	3123	2390	2153					
Average	**3682**	**3187**	**2833**	**2509**					
Monthly Rainfall in 1991 (mm)									
Jan.(1)	11.4	21.4	17.6	53.1	n.a.	n.a.	n.a.	n.a.	n.a.
Feb.(2)	11.7	0.3	1.2	1.4	8.0	0.0	5.5	1.0	n.a.
Mar.(3)	63.0	69.5	120.1	80.4	112.5	66.0	47.0	2.0	n.a.
Apr.(4)	140.7	294.0	156.9	n.a.	238.5	124.0	191.0	75.5	78.0
May (5)	321.5	264.0	355.6	305.7	188.5	141.5	124.5	130.5	119.5
Jun.(6)	537.8	551.1	326.4	296.1	280.0	343.5	445.0	586.5	672.5
Total 1-6	1086.1	1200.3	977.8	--	--	--	--	--	--
Total 2-6	**1074.7**	**1178.9**	**960.2**	--	**827.5**	**675.0**	**813.0**	**795.5**	--
Total 5-6	859.3	815.1	682.0	601.8	468.5	485.0 *	569.5	717.0	792.0

a) Rainfall Pattern over the Short to Mid Term

The rainfalls at two sites (Ban Latsasin, Ban Namkong) on the Xe Namnoy mainstream basin located at the southeastern part of the Bolaven Plateau indicate patterns which are different from the rainfalls at other sites located in the central part of the plateau. Hence is, rainfall is less at the southern part of the plateau from March to May, especially March and April, and in contrast, there is more rainfall than the rainfall at the central part of the plateau in June.

Also, the fact that a rainfall pattern of short duration times with a tendency for severe local rains predominant exists in common for both parts of the plateau. However, regarding days of occurrence, not much correlation can be seen in spite of the relatively short distance between the two parts. In view of this, it is conjectured that the southeastern part of the Bolaven Plateau and the central to eastern part have, over the short term, mutually independent rainfall phenomena.

b) Regional Distribution of Rainfall over the Long Term

With regard to the central part of the Bolaven Plateau, a trend is seen for rainfall to decrease on the whole from west to east. There is a possibility that the area situated at the central part to the eastern part of the Bolaven Plateau, which includes the Xe Katam River Basin, correspond to a part of the plateau with less rainfall.

With regard to difference in the trends of long-term rainfall between the southeastern and central-eastern parts of the Bolaven Plateau, it is difficult to be compared for the two regions based only on the data presently available.

(2) Runoff Characteristics of Basin

Runoff measurements by current meters were carried out at several sites on the Xe Nammoy River including tributaries at the end of December 1990, end of March 1991, and from the end of June to the beginning of July 1991. The results are given in Table II-1-3. The relationships between the specific runoffs of the various sites obtained from the results of observation are described below.

a) Results of Investigations at End of December

Measurements were made at the three sites of Ban Nonghin at the midstream stretch of the Xe Katam River, the vicinity of the intake dam site of the Xe Katam Project at the downstream stretch, and Ban Latsasin at the midstream stretch of the Xe Namnoy River. As a result, roughly similar specific runoff values of 1.05, 1.15, and 0.97 m^3/s per 100 km^2, respectively, were observed for the three sites.

b) Results of Investigations at End of March

In addition to the abovementioned three sites, measurements were made at the Ban Xekatam site at the upstream part of the Xe Katam River, a site at the downstream part of the Xe Namnoy River which is at immediately upstream of the confluence with the Xe Katam River, and the Nikhon34 site at the upstream part of the Houay Makchan Gnai River. As a result, large differences were seen in specific runoffs of the various sites.

That is, whereas the specific runoff at the downstream part of the Xe Namnoy River (0.28 $m^3/s/100\ km^2$) is roughly the same as the specific runoff of the downstream part of the Xe Katam River (0.26 to 0.28 $m^3/s/100\ km^2$), it was extremely small at approximately one third (0.09 to 0.10 $m^3/s/100\ km^2$) at the midstream part of the Xe Namnoy River. At the Xe Katam River, a trend was recognized for the specific runoff to be the larger the more upstream the point (0.34 to 0.37 at the Ban Nonghin site on

Table Ⅱ-1-3 Discharge Measurements in the Xe Namnoy Basin

Month	River	Location	C.A (km²)	Date	Discharge (m³/s)	Specific Discharge (m³/s/100km²)
a) Dec. 1990	Xe Katam	Midstream (B. Nonghin)	171	Dec. 28	1.8	1.05
		Downstream	288	Dec. 28	3.3	1.15
	Xe Namnoy	Midstream (B. Latsasin)	537	Dec. 29	5.2	0.97
b) Mar. 1991	Xe Katam	Upstream (B. Xe Katam)	49	Mar. 27	0.33	0.67
		Midstream (B. Nonghin)	171	Mar. 28	0.64	0.37
		〃	171	Mar. 30	0.58	0.34
		Downstream	288	Mar. 28	0.80	0.28
		〃	288	Mar. 28	0.78	0.27
		〃	290	Mar. 28	0.78	0.27
		〃	295	Mar. 30	0.75	0.26
	Xe Namnoy	Midstream (B. Latsasin)	537	Mar. 26	0.55	0.10
		〃	537	Mar. 31	0.48	0.09
		Downstream	784	Mar. 30	2.2	0.28
	H. Makchan	Upstream (Nikhon 34)	39	Mar. 27	0.28	0.72
c) Jun./Jul. 1991	Xe Katam	Midstream (B. Nonghin)	171	Jun. 26	6.1	3.57
		〃	171	Jul. 4	16.2	9.47
		〃	171	Jul. 7	6.3	3.68
		Downstream	288	Jul. 5	13.3	4.62
	H. Makchan	Upstream (Nikhon 34)	39	Jun. 23	1.9	4.87
		〃	39	Jul. 8	2.3	5.90

the midstream stretch, and 0.67 $m^3/s/100\ km^2$ at the Ban Xe Katam site on the upstream stretch), while at the upstream part of the Houay Makahan Gnai River, a value roughly the same as the value at the upstream part of the Xe Katam River was observed (0.72 $m^3/s/100\ km^2$ at Nikhon34 site on the upstream stretch).

This result is more or less in conformity with the rainfall observation results. That is, the midstream stretch of the Xe Namnoy River where there was hardly any rainfall until March had extremely low specific runoff. On the other hand, the upstream parts of the Xe Katam River and the Houay Makchan Gnai River running through the central part of the Bolaven Plateau with a relatively large amount of rainfall in March had high specific runoffs, and they became lower as the rivers flowed downstream to the east. Further, the specific runoffs are recovered at the downstream part of the Xe Namnoy River where tributaries with basins in the central part of the Bolaven Plateau come into the Xe Namnoy River.

c) Results of Investigations at End of June

At the time when field reconnaissances had been made from June to July, a considerable increase in the stream discharge was recognized at the midstream stretch of the Xe Namnoy River mainstream also. The specific runoff at this time is thought to have been higher than that of the Xe Katam River. This, also, is in conformity with rainfall observation results. In this way, it is surmised that the runoff is adequately recovered also at the Xe Namnoy River midstream and upstream stretches and the difference in specific runoffs is eliminated in the rainy season.

The considerations on the results of rainfall and runoff investigations carried out after commencing this study were described in the foregoing. However, these are based on strictly limited data, and it is difficult under present circumstances to grasp the long-term characteristics of rainfall and runoff. Considering the fact that there is no historical rainfall record in the Xe Namnoy River Basin at

all, it will be necessary to accumulate the results of investigations over a period of several years from now in order to examine the long-term characteristics of rainfall.

1.3.4 Calculation of River Runoff at Project Sites

(1) Calculation of Long-Term River Runoff

As described in 1.3.3 (2), there is a possibility that the Xe Namnoy River has different meteorological and hydrological characteristics among its sub basin of the southeastern part of the Bolaven Plateau and the central-eastern part. However, at the present time, it is difficult to calculate the river runoff reflecting the differences in the characteristics regarding the individual sties in the basin.

In this study, therefore, calculations of river runoff were made by the method indicated below for the following four sites: two sites on the mainstream of Xe Namnoy River, at Ban Latsasin in the midstream stretch and at the immediately upstream of the confluence with the Xe Katam River, and two sites on the Xe Katam River in the downstream stretch, at Ban Nonghin in the midstream stretch and at the intake dam site of the Xe Katam Project in the downstream stretch.

Method of River Runoff Calculating

i) Assuming that the Xe Namnoy River basically has approximately the same runoff characteristics as the Xe Set River which has its basin on the Bolaven Plateau, a runoff analysis of the Xe Set River Basin was performed by Sugawara's Tank Model Method in order to prepare a basic rainfall-runoff model.

ii) Focussing especially on the characteristics of runoff variations at each site during the dry season, slight modifications was made on the rainfall-runoff model of the Xe Set River examing the runoff measurement results obtained through the investigations in

this study. In this way rainfall-runoff models for the respective sites were prepared.

iii) In putting daily rainfall data to the prepared rainfall runoff models for each site, the runoffs at each site were calculated. However, where continuous data of rainfall over a long period is limited to Nonghin rainfall station at the central part of the Bolaven Plateau. Therefore, it was assumed that the rainfall distribution in the Xe Namnoy River basin was uniform. Then, the basin mean rainfalls obtained by applying a uniform rainfall correction factor to the data of Nonghin site were used in the calculations as the representative rainfall for the basins of each site. As a result of using the same rainfall correction factor for all sites, the annual average specific runoffs were calculated the same among each site.

The runoffs of each site obtained in this manner cannot be said to adequately reflect the characteristics of the basins, but may judged to be reasonable as estimates at present for the reasons given below.

- Rainfall distribution in the short term shows scattering even within the Bolaven Plateau, but long-term rainfall variations in annual units generally show trends of the same variations over fairly wide areas. It is thought this is applicable to all of the Bolaven Plateau.

- Although the period of discharge data is short, runoff variations of the dry season are reflected to a certain extent taking into account the results of runoff investigations at various sites on the Xe Namnoy River.

In accordance with the above, the 10-year average runoffs of the various sites from 1981 to 1990 were estimated as follows. Estimated monthly discharge and unit runoff duration curves (per 100 km^2) of each site are shown in Fig. II-3, 4, 5, 6 and Table II-1-4, 5, 6, 7 respectively.

Runoff Calculation Results

River	Site	Catchment Area (km^2)	Average Runoff (m^3/s)	Remarks
Xe Namnoy	Midstream (Ban Latsasin)	537	17.0	Fig.II-1-3 Table II-1-4
	Downstream (Confluence with Xe Katam)	784	24.8	Fig.II-1-4 Table II-1-5
Xe Katam	Midstream (Ban Nonghin)	171	5.4	Fig.II-1-5 Table II-1-6
	Downstream (Xe Katam Intake Site)	290	9.2	Fig.II-1-6 Table II-1-7

The runoff calculation results above are based on the runoff investigation results up to March 1991. Subsequently, a reexamination was made using additional data and results more or less the same as the above were obtained, that is about 6% larger than the above results. Consequently, it was decided not to alter the runoff data in the study of the whole Xe Namnoy River Basin dealt with in this chapter.

(2) Calculations of River Runoffs at Various Project Sites

The river runoffs of the various project sites are calculated using the runoff data of the four representative sites estimated in (1). In the calculation, conversions of runoffs were made according to the principles given below.

- Project sites in the midstream and upstream basin of the Xe Namnoy mainstream (Including Tributaries) and in the Houay Katak-Tok River Basin

  * Here, Q: River Runoff (m^3/s)
    A: Catchment Area (km_2)

Since these basins have characteristics in common topographically, river runoff at a site is calculated by converting the estimated runoff of the Ban Latsasin site with catchment area ratio.

$$Q(\text{Planned site}) = Q(\text{b. Latsasin}) \times A(\text{Planned Site})/A(\text{B. Latsasin})$$

- Project sites in between the midstream and downstream of the Xe Namnoy mainstream

  Taking into consideration the fact that variations in specific runoffs of this part are large in the dry season, river runoff at a site is calculated from using the equation below.

$$Q(\text{Planned Site}) = Q(\text{B. Latsasin}) + (Q(\text{Confluence with Xe Katam}) - Q(\text{B. Latsasin})) \times (A(\text{Planned Site}) - A(\text{B. Latsasin})) / (A(\text{Confluence with Xe Katam}) - A(\text{B. Latsasin}))$$

- Project sites in the midstream of the Xe Katam River

  River runoff at a site is calculated from the estimated runoff of the Ban Nonghin site using the equation below.

$$Q(\text{Planned Site}) = Q(\text{Ban Nonghin Site}) \times A(\text{Planned Site}) / A(\text{Ban Nonghin Site})$$

- Project sites in the downstream of the Xe Katam River

  River runoff at a site is calculated from the estimated runoff at the Xe katam intake site using the equation below.

$$Q(\text{Planned Site}) = Q(\text{Xe Katam Intake Site}) \times A(\text{Planned Site})/A(\text{Xe Katam Intake Site})$$

Fig. II-1-3 DURATION CURVE OF XE NAMNOY MIDSTREAM AT BAN LATSASIN

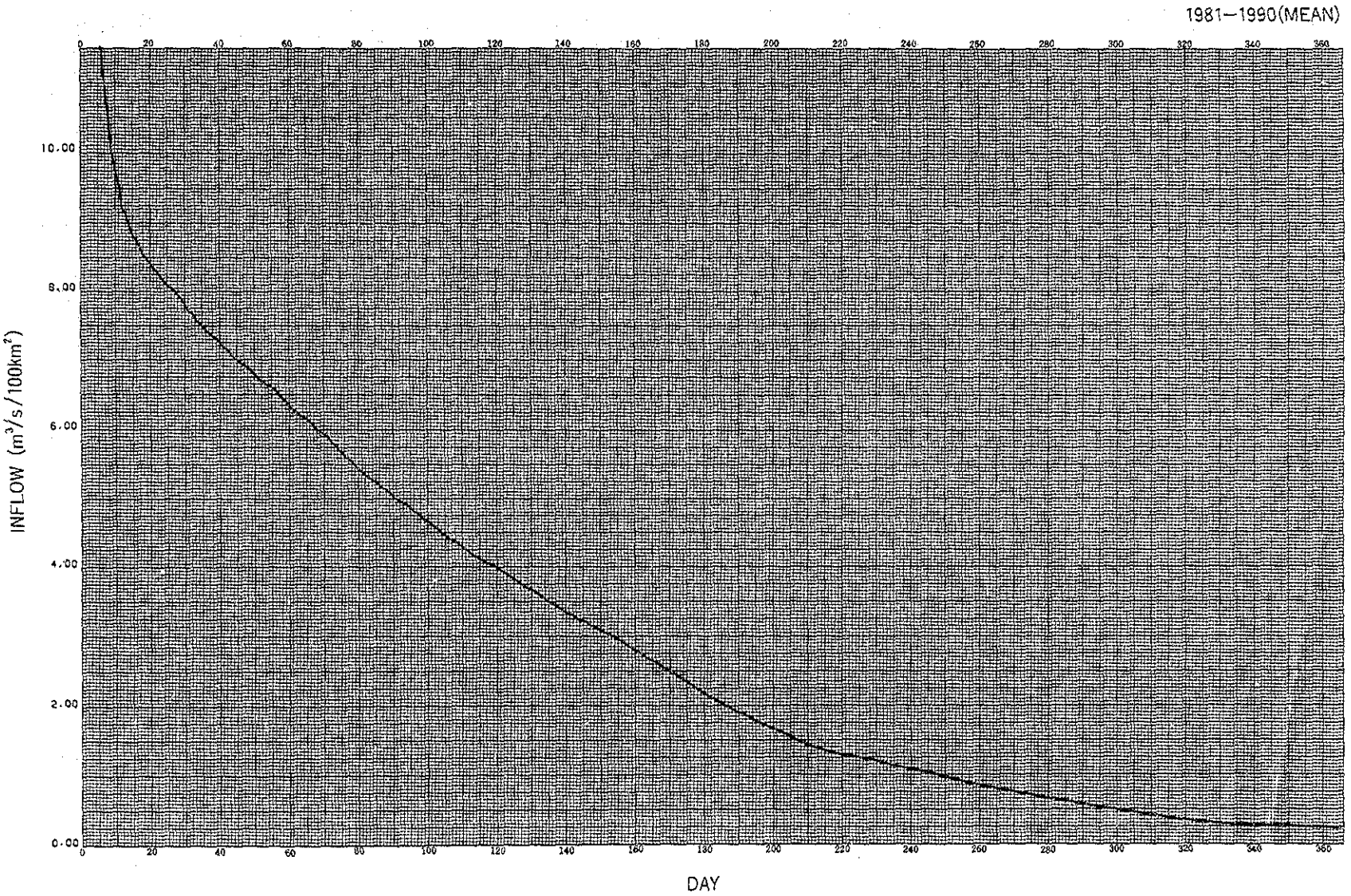


Fig. II-1-4 DURATION CURVE OF XE NAMNOY DOWNSTREAM AT CONFLUENCE WITH XE KATAM

1981–1990(MEAN)

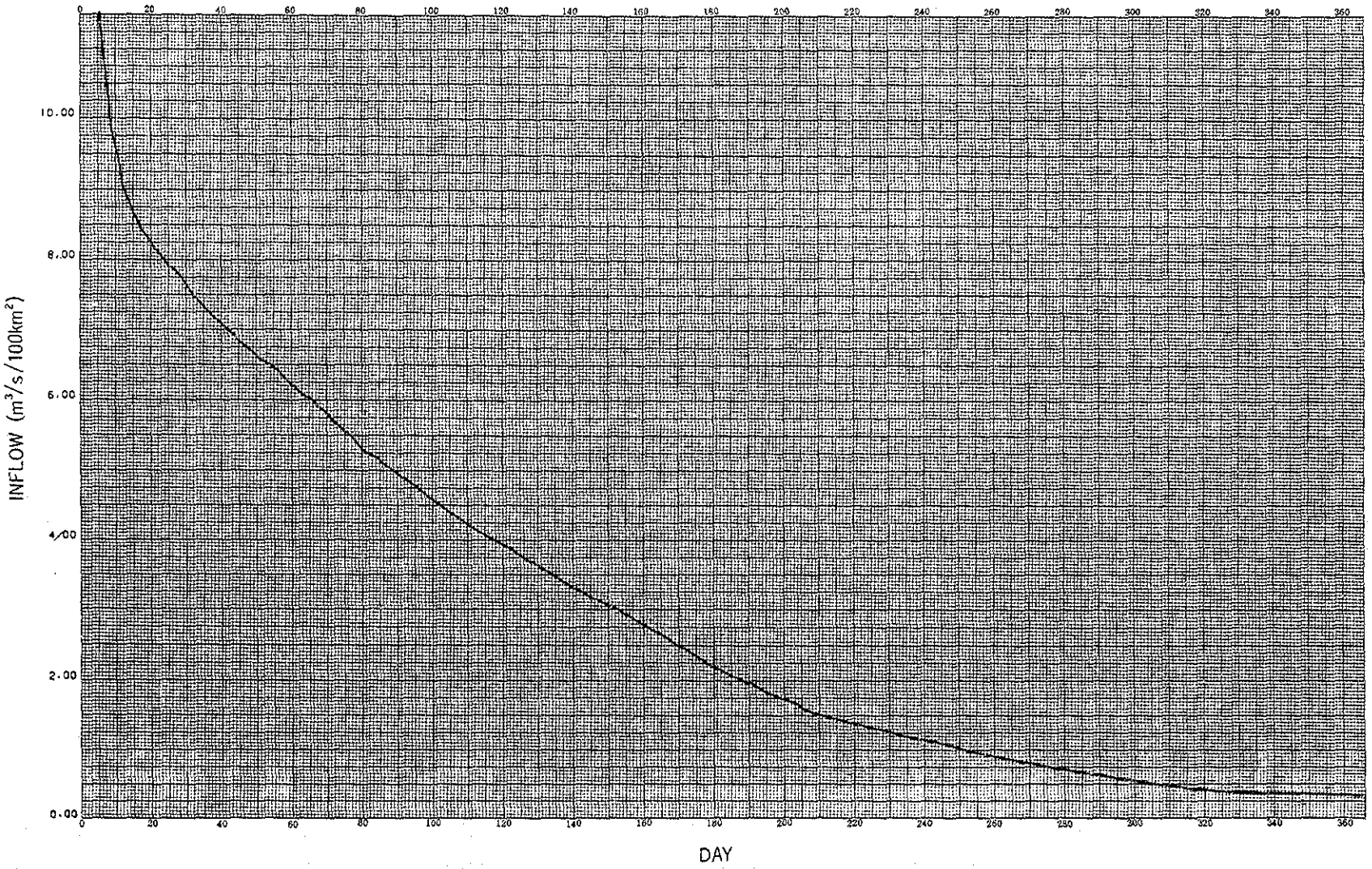


Fig. II-1-5 DURATION CURVE OF XE KATAM MIDSTREAM AT BAN NONGHIN