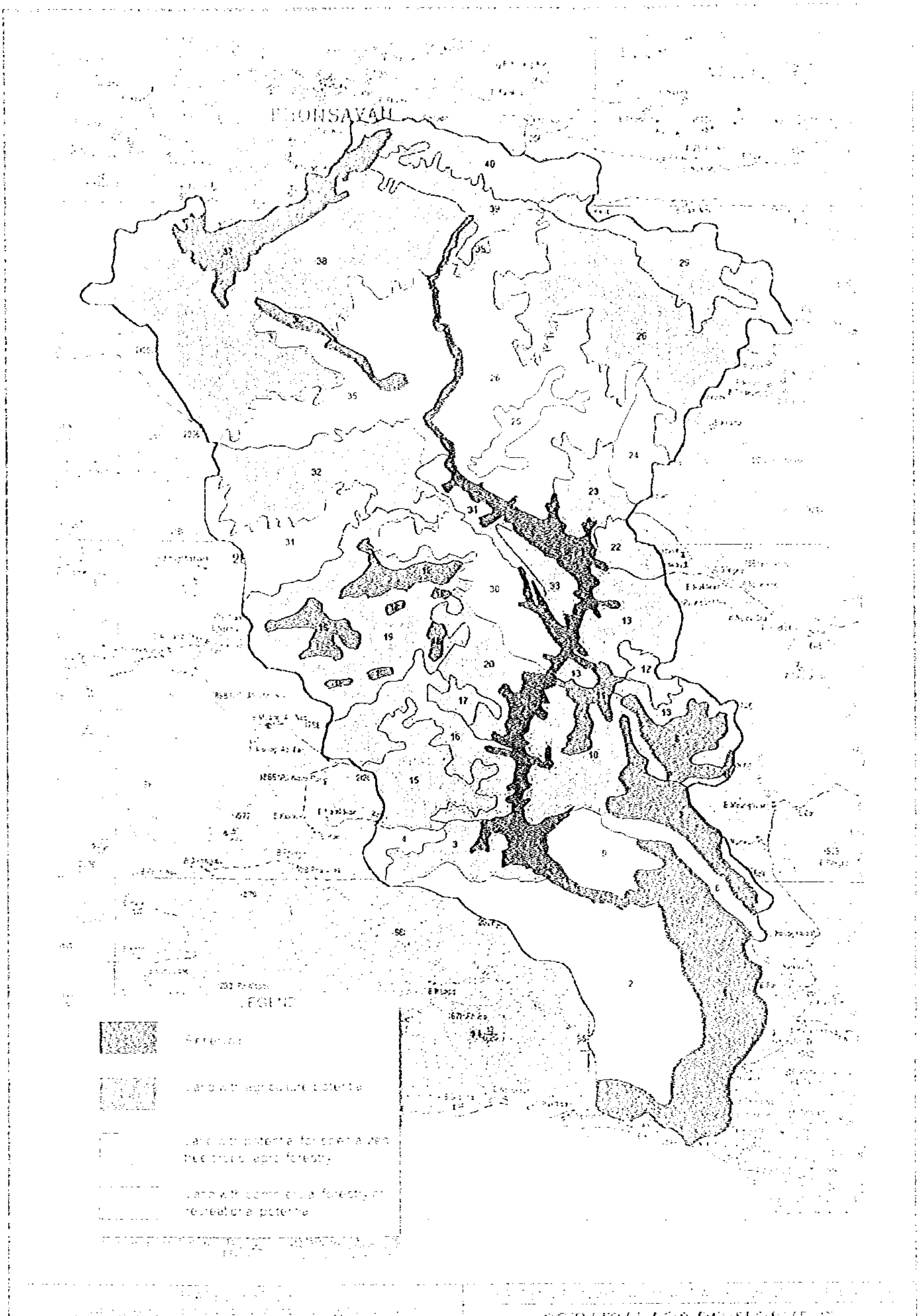


POTENTIAL FOR DEVELOPMENT
IN THE CATCHMENT AREA

However, there may be less potential considering that areas in the upper reservoir have already been extensively logged. Also, the defects found in the timber in Lao forests, the lack of a differentiated timber market, the nature of logging (i.e. untrained subcontractor felling, old equipment etc) and the difficult access to parts of the reservoir, make it unlikely that more than 20% to 30% of the potentially commercial timber would be extracted.

The overall undried above ground biomass density of 278.5 t/ha is comparable to findings of the Nam Leuk HEPP Biomass survey (289.8 undried above ground biomass density). It has to be cautioned again that results for the Nam Ngiep are from a very small number of samples in a limited area of the reservoir. In addition the lower reservoir LS5 has yet to be surveyed and from initial inspections may have a lower above ground biomass density, due to the large areas under cultivation. Of critical importance in terms of water quality is the rapidly degradable biomass which will play an important role in the early oxygen demand in the new reservoir.

(3) Wildlife

Due to the short time period of the survey it is difficult to draw definite conclusions about the relative abundance of individual species for different habitat types or ecotypes. However, even if the survey presents only a very fragmented view of the Nam Ngiep catchment, it provides a preliminary information on the general value of the area regarding biodiversity.

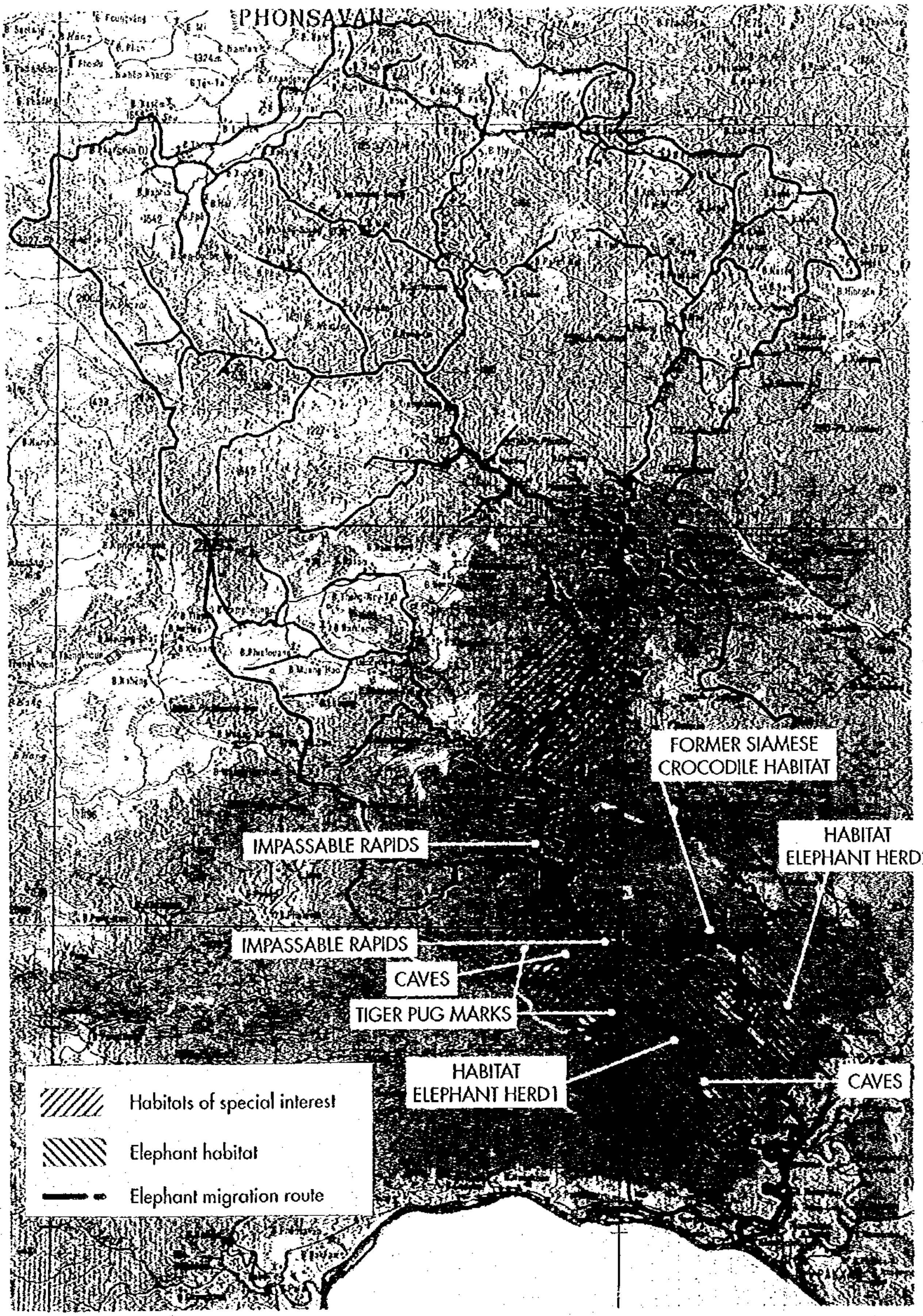
The areas traversed outside the inundation zone appeared rich in terms of species diversity and high in terms of density and could be described as a "rich community". This "rich community" of fauna may be due in part to the unusual geology of this catchment which includes large areas of eroded intrusive rock from which a particularly fertile soil is weathered, which is probably able to support more abundant and diverse food chains.

The two (2) areas where "rich communities" of fauna are found are highlighted in Figure 7.3.7.

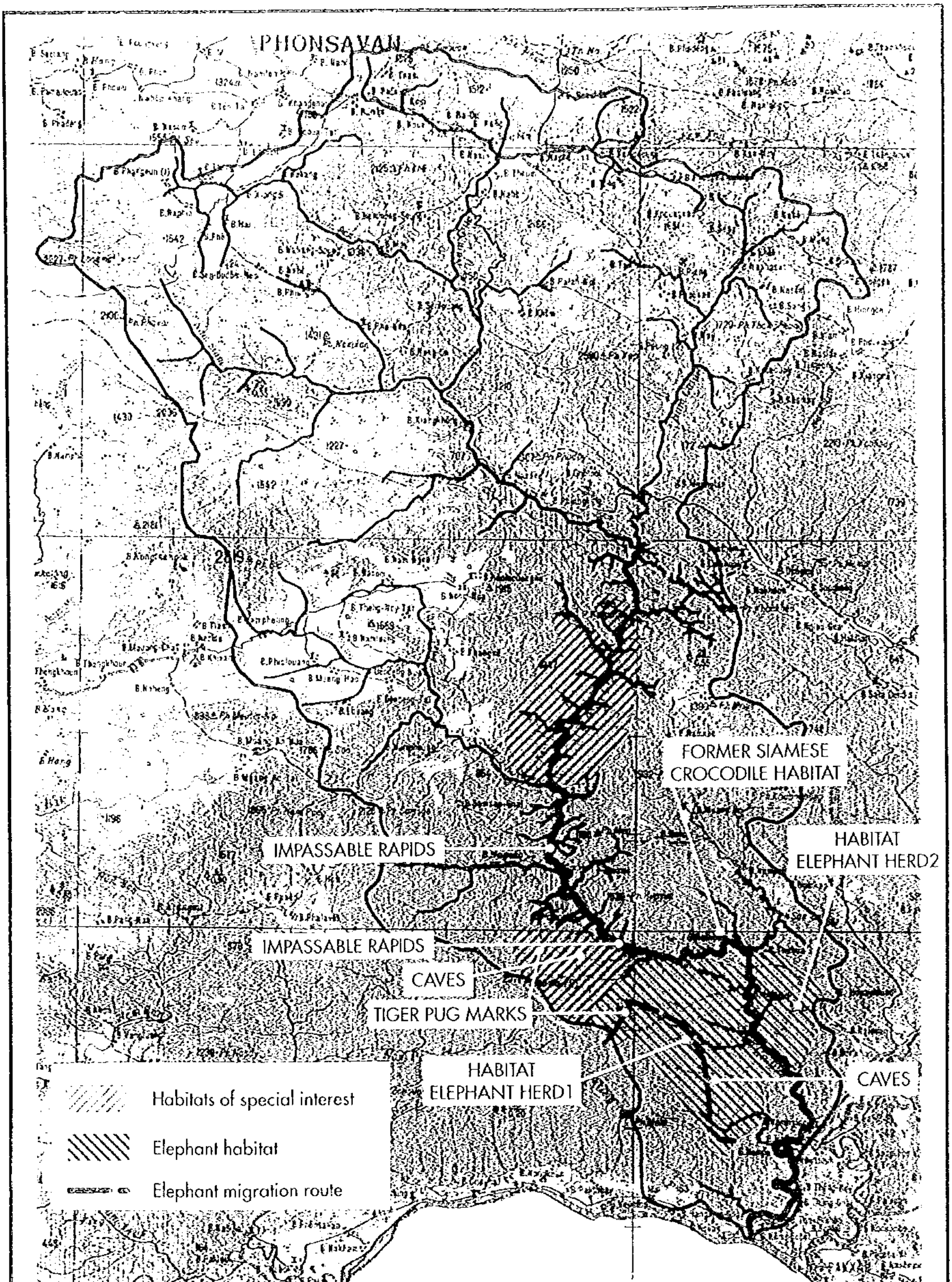
North of Ban Sopphoun up to Ban Nakang is one area. The other area is directly south of Ban Sopyouk in LS2 and LS3 and east of the Nam Ngiep into LS1. LS1 and LS2 appeared particularly rich, with evidence of at least two separate herds of Asiatic elephant of approximately 12 and 6 individuals respectively. The herd in LS2 (west of the Nam Ngiep river) migrate through the area during the rainy season and the herd in LS1 (East of the Nam Ngiep river) appears to stay in LS1 all year round. However the elephant habitat in LS1 is coming under severe pressure from logging and cultivation and their future prospects in this area do not look promising . The possible migration route of the herd in LS2 is displayed in Figure 7.3.7. Both these herds, and possibly others not yet located, would be adversely affected by the construction phase of the project, by the increases in economic activity, and by increased human populations, which the project is likely to induce.

Several species of mammals observed by the Field Team are already considered as having special conservation significance, either national or international, as presented in the following table.

National status refers to species listed as protected (1) or controlled (2) in the "Instructions on the execution of the Minister's Council Decree No.118MCC dated October 5, 1989 on the Management and Protection of Wildlife, Aquatic Animals, Hunting and Fishing".



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC	FIRST ENVIRONMENTAL IMPACT ASSESSMENT	Figure 7.3.7
JAPAN INTERNATIONAL COOPERATION AGENCY	**AREAS OF SPECIAL INTEREST FOR BIODIVERSITY**	



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC	FIRST ENVIRONMENTAL IMPACT ASSESSMENT	Figure 7.3.7
JAPAN INTERNATIONAL COOPERATION AGENCY	**AREAS OF SPECIAL INTEREST FOR BIODIVERSITY**	

International Conservation status refers to the IUCN Red List of Threatened Animals (1990) ranked as Endangered (1), Vulnerable (2) or Rare (3). It refers also to the CITES Trade Categories (1993) for species listed (x) in its Appendix 1 (species already severely threatened by trade) or 2 (species that may be threatened by trade).

Table 7.3.6 Mammals and Reptiles observed having Conservation Significance

English Name	Family	Species	Conservation Status		
			IUCN	CITES	LAOS
Serow	Bovidae	Capricornis sumatraensis		x	1
Stump Tailed Macaque	Cercopithecidae	Macaca arctoides		x	2
Rhesus Macacque (>20)	Cercopithecidae	Macaca mulata		x	2
Phayre's Langur	Cercopithecidae	Presbytis phayrei			1
Sambar	Cervidae	Cervus unicolor			2
Common Barking Deer	Cervidae	Muntiacus muntjak			2
Asiatic Elephant	Elephantidae	Elephas maximus	1	x	1
Leopard Cat	Felidae	Felis bengalensis		x	2
Marbled Cat	Felidae	Felis marmorata		x	2
Tiger	Felidae	Panthera tigris	1	x	2
Bush Tailed Porcupine	Hystricidae	Artherurus macrourus			2
Malayan Pangolin	Manidae	Manis javanica		x	
Lesser Giant Flying Squirrel	Sciuridae	Petaurista elegans			2
Lesser Mouse Deer	Tragulidae	Tragulus javanicus			2
Malayan Sun Bear	Ursidae	Helarctos malayanus	2	x	1
Asiatic Black Bear	Ursidae	Selenarctos thibetanus	2	x	1
King Cobra		Ophiophagus hanah		x	1
Reticulate python		Python reticulata		x	2
Water Monitor		Varanus salvator		x	2

7.4 IMPACT ANALYSIS AND MITIGATION MEASURES

7.4.1 ENVIRONMENTAL IMPACTS SCREENING

The first stage of the analysis consists in the screening of all potential impacts, which may result from the project implementation. The following Table 7.4.1 presents a summary of all impacts anticipated from the Project according to the 3 periods of the project life, construction, filling and operation and according to the main zones affected.

7.4.2 IMPACTS DURING CONSTRUCTION PHASE

(1) Impacts on Land Use

The project construction sites are all located around the dam site, with perhaps the exception of some quarries not yet identified. This is a positive point as one site is more easy to control. It is anticipated a total need of 250 to 500ha, mainly in a non-agricultural area. No significant compensation for land is expected at construction sites.

Both alternatives require only 10km of new access road which represents only about 20ha of land including disposal and borrow areas. The compensation cost is estimated at about US$ 47,000.

Both alternatives require also the development of 110km of transmission line for which the cost for land acquisition (for the towers) and an additional compensation for the right of way below the line has been estimated at US$ 24,000.

(2) Impacts on Water Quality

In case of inappropriate handling or storage of chemicals or petroleum products on the construction site, release in river water may affect more than 5,000 persons living in the downstream area, and who use the river for drinking and cooking. The same may happen with an inappropriate sanitation system in the workers camps with release of pathogens.

Except for a small village located 10km downstream of the proposed dam site, most of the villages are within 30 to 50km distance from the dam. However, the dilution provided to the Nam Ngiep River by its downstream tributaries is too low (less than 25% before confluence with the Mekong River) to mitigate any accidental pollution. Considering that after filling the reservoir, the water released will not be suitable for consumption for a few years, it is recommended to consider the implementation of alternative water supply for these villages. Based on 100 pumps for 20 households, the estimated cost is US$250,000.

Table 7.4.1 IMPACTS IN DOWNSTREAM AREA AND CONSTRUCTION ZONES

DEVELOPMENT PHASE	IMPACTED FIELD	TYPE OF IMPACT	CAUSES	CONSEQUENCES	CRITERIA CONSIDERED FOR ASSESSMENT	PROPOSED MITIGATION
CONSTRUCTION PHASE	AQUATIC SYSTEM	Water pollution by accidental release of chemical	Storage and handling of chemicals on construction site (mainly oil products)	Temporary effect on aquatic ecology and fisheries	Type of pollutant Dilution of pollutant at various distance from release	Appropriate storage & handling of chemicals Compensation
					Occurrence of event and severity Local fish consumption	Compensation
		Water pollution by release of pathogens in river	Inappropriate sanitation system of workers camps	Hazardous use of river as source of domestic waterbh	Type of pathogens (survival time) Flow velocity Population at risk Water use	Design of sanitation system Contract obligation for contractor Compensation
		Excessive sediment load	Inappropriate prevention measures during earthworks	Temporary effect on aquatic ecology and fisheries	Load SS Period (DS more affected) Occurence	Construction methods Compensation
		Permanent pollution by chemicals	No treatment of effluents from batching plant before release in the river	Effect on aquatic ecology and fisheries	SS and pH of river water Distance from release	Sedimentation and buffering ponds
	LAND SYSTEM	Impact on land use at construction sites	Implementation of project sites: construction sites, camps, quarries, disposal areas	Loss of natural resources Loss of grazing land Loss of agricultural land	Areas required & location Land use	Design to minimize needs Land acquisition & compensation
			Construction of access roads and Transmission lines	Loss of natural resources Loss of grazing land Loss of agricultural land Disturbance to wildlife	Areas required & location Land use Areas of interest for wildlife	Adjust route to minimize effects on valuable land Land aquisition
	SOCIAL	Local employment and income	Opportunities for unskilled workforce: earthworks, clearing	Improved income for local population	Workforce availability in the villages according to season Priority to local villagers Recruitment procedure	Give priority to local villagers for employment on project sites
		Public safety	Transport of equipment and materials, intense truck traffic	Noise Dust emission Accidents and injuries risk for villages crossed by road	Measures required to minimize the risk	Design Traffic regulations and signs Watering of roads during DS Reduce traffic at night
			Concentration of in-migrants in the construction area	Risk of epidemic diseases Dissemination of HIV and water related diseases	Prevention program and monitoring	Public Information and awareness program
					Design and organization of camps facilities	Hygiene in the camps Medical control, equipment, monitoring
RESERVOIR FILLING	AQUATIC SYSTEM	Reduction of river flow	Impounding of the reservoir	If no riparian release (RR), 100% of aquatic habitat and fisheries destroyed for 3-5 years If riparian release, part of fisheries and habitats preserved	Appropriate RR Duration of filling and period Expected reduction of fish catches	Compensation
				Water shortage downstream	Alternative water supply	Compensation
				Irrigation impaired	% of affected rainfed and irrigated production	Compensation for loss
		Alteration of water quality	Flooding of vegetation and soils in the reservoir	Water anoxic after few months of filling	Duration of filling Organic matter available in reservoir and decay kinetic	Partial only Reservoir clearing
				Unsuitable for domestic use Unsuitable for livestock use	Alternative water supply Village/HH numbers	Compensation
	SOCIAL	Resettlement of reservoir population	Impounding of the reservoir	Potential impacts on land use and on host population	Location and availability of land, Development planning of host or nearby villages	Mitigation measures to be addressed in RAP
		Employment and regional economy	End of construction works	Reduction of workers population and related local economic activities	Number of workers Average contribution to local economy	Public information
		Impaired river transport	Reduction of flow during filling	River transport impossible because of low flow, even with riparian release of 20 cumecs	Number of boats on the river Contribution to the local economy	Compensation
RESERVOIR OPERATION	AQUATIC SYSTEM	Irregular daily flows	Production of intermediate & peak energy (16 hrs/day)	Destruction of aquatic habitats and fisheries Erosion of river channel	100% loss of fisheries 100% loss river transport	Re-regulation pond or compensation
				Danger for people and livestock	High risk of accident	Warning system Re-regulation pond
		Regular seasonal flows	Energy production is stable year long	Improve dry season flow of Mekong	NNG flow as % of MKG flow	Not required
				Improve river transport in dry season	Number boats Increased level of river	Not required
				Provides high potential for dry season irrigation during both wet & dry season	Average discharge Land suitability Location for pumping station(s)	Not required
		No significant increase of flow in wet season	Run off is stored in the reservoir	No attraction of migrating fishes in early wet season Loss for fisheries	Nb of migrating species observed Importance in catches	Compensation for loss
		Low to very low sediment load in the water	Sediment is deposited in the reservoir	Water flow more erosive, mainly during dry season Risk of river bed erosion	Role of backwater effects from Mekong Risk possibly minimized by slow velocity of flow	River protection structures if required
		Short term anoxic water release	Decomposition of flooded vegetation & soil organic matter	Short term release of anoxic water, unsuitable for domestic & livestock	Expected duration of problem is 4 to 7 years according to FSL alternative	Pre-impoundment reservoir clearing Res. Management
				Destruction of D/S fisheries as function of DO level	Re-aeration rate of water DO concentration at distance from dam	Alternative fisheries development Financial compensation
		Long term seasonal release of anoxic water	Stratification of reservoir Reservoir management	Unsuitable water for domestic and livestock use Effect river fisheries	Period of event: probably October to January, when reservoir level highest	Multi level water intake
		Long term accidental or permanent pollution of water	Development of population and industries around reservoir and in catchment	Unsuitable water for domestic use or for other uses.	Level of risk Type of pollution	Strategic plan for watershed control
	LAND SYSTEM	Loss of river bank gardens	Increase of river level by about 1 m in dry season with potentially more erosive waters	Loss of lower part of the river bank gardens (flooding or erosion)	Initial area of gardens potentially impacted Average crop production	Compensation

Table 7.4.2 IMPACTS IN INUNDATION ZONE AND CATCHMENT AREA

DEVELOPMENT PHASE	IMPACTED FIELD	TYPE OF IMPACT	CAUSES	CONSEQUENCES	CRITERIA CONSIDERED FOR ASSESSMENT	PROPOSED MITIGATION
CONSTRUCTION PHASE	AQUATIC SYSTEM	No significant impact anticipated				
	LAND SYSTEM	Impact on land use	Implementation inside the future reservoir of quarries, camps and disposal sites	Localized loss of natural resources, grazing land	Limited impact; areas required for construction purposes	Early compensation and land acquisition procedures
	SOCIAL	Local employment and income	Clearing of reservoir Collection of forest products	Improved income for local population	Workforce availability in the villages according to season Priority to local villagers Recruitment procedure	
		Resettlement of affected population	Flooding of the reservoir area	Development of new sites for resettlement to be completed before reservoir impoundment	Population, ethnic groups, needs for livelihood re-development	Resettlement Plan & Compensation for transitory period
RESERVOIR FILLING	AQUATIC SYSTEM	Loss of river habitats as permanent stream and rapids	Creation of reservoir	Loss of fast water habitats Disruption of river integrity	Presence of migratory species	Compensation by contribution to conservation trust fund
		Alteration of water quality	Flooding of areas rich in organic matter	Anoxic conditions of water resulting in fish kills Fish population taking refuge in upper tributaries	Carrying capacity of initial river area	Compensation by contribution to conservation trust fund
				Possible loss of rare fish species	Presence of rare species	Conservation of areas of similar biological value
				Water inadequate for domestic supply purpose (drinking/bathing)	Existing/resettled population around reservoir	Alternative water supply
				Water inadequate for livestock supply	Population around reservoir & estimated number livestock heads	Alternative water supply if required
	LAND SYSTEM	Loss of terrestrial habitats with associated flora and fauna	Inundation of the reservoir area	Loss of rare plant species	List of plants observed in the area	Conservation of substitute habitats
				Loss riverine habitats rich in bird diversity	Length of river flooded Areas of interest for biodiversity	Conservation of substitute habitats
				Loss of rare terrestrial fauna	List of animal species with conservation status	Conservation of substitute habitats
				Drowning of animals during inundation phase	Large mammals possibly at risk Velocity of flooding Pre-impoundment clearing Presence of islands	Pre impoundment program (clearing) Animal rescue program during reservoir filling
		Loss of forest products	Inundation of the reservoir area	Loss of existing forest timber	Type & location of forested areas Commercial timber density	Pre-impoundment logging
				Loss of existing non-timber forest products	Type & location of forested areas Importance in population income	Collection program associated with pre-impoundment vegetation clearing
		Loss of production systems and dwellings	Inundation of the reservoir area	Loss of houses, built-up private & community structures & infrastructures, of cultivated areas and grazing land	(See details in operation stage)	Planned resettlement and compensation
		Loss of mineral production	Inundation of the reservoir area	Loss of sand and gravel production; Possibly gold (not reported)?	Population affected Areas of interest	Provide households with substitute income
		Floating debris	Inundation of cleared area; Only part of wood biomass totally burnt	Threat for water intake and later for boat transport and fishing	Volume of trunks/branches Areas for landing and transforming	Preparation and implementation of a removal program
	SOCIAL	Population livelihood not yet re-established	Displacement of population to new sites just before flooding	New production systems to be implemented	Resettlement Action Plan	Assistance and compensation
RESERVOIR OPERATION	AQUATIC SYSTEM	River system permanently flooded	Creation of the reservoir	Loss of river aquatic products	Area of flooded river system	No mitigation
		Low water quality after filling (short term)	Decay of vegetation biomass and soil organic matter	Problem expected to last 4 (FSL 320) to 7 (FSL 360) years	Evaluation of vegetation biomass Pre-impoundment clearing plan	Vegetation biomass clearing may reduce duration of problem
				No reservoir fisheries until the end of water quality problem	Possible duration of problem Time required in other reservoirs to reach stable reservoir fisheries conditions	Net protein compensation to affected population
		Seasonal long term low water quality	Turn over of stratified reservoir	May limit intensification of fish production using floating cages	Risk of seasonal turn over due to the physiognomy of reservoir	Adjust production schedule in accordance with turn over occurence
		Gain of aquatic resources	Creation of the reservoir; Improvement of epilimnion quality	Increased productivity and potential for fisheries	Potential yield after stabilization of reservoir conditions	Development of a reservoir fisheries program
				Gain from fisheries intensification	Fish cages, fish species production according to management	Preparation of a reservoir fisheries intensification plan
		Increased sediment load in the water	Uncontrolled development in the catchment area resulting in increased erosion	Reduction of reservoir storage and related project life	Dead volume of the reservoir Erosion rate per km²	Strategic plan for watershed control
				Increased sedimentation at the tail of the reservoir May result in higher backwater effects with flooding of fields and built up assets	Hydraulic engineering of river levels Resettlement levels	Decrease FSL or increase resettlement level
		Presence of a long water body	Reservoir creation	Potential for transport of goods and persons	Lakeshore population	Not justified
		Reservoir access restricted by seasonal draw down of 30 m.	Reservoir management for energy production	Loss of potential benefit from transport part of the year (dry season)	Distance from lake shore in wet and dry season	Appropriate berthing facilities adapted to 30 m draw down
		Creation of temporary draw down areas	Reservoir management for energy production	Impaired landscape, possible sites for water related diseases	Draw down area is 54 km² (FSL 360) or 44 km² (FSL 320)	Management Plan for draw down areas
		Reservoir safety	Safety of public transport boats and on reservoir shores	Risk of drowning	Magnitude of transport on the reservoir	Installation of signs Inspection of boats for public transport
		Creation of new wetlands	Reservoir management for energy production	Potential for increased production of aquatic products and improvement of aquatic biodiversity	Location of potential wetlands Draw down area & topography	Management of wetland production Conservation status for key areas
		Creation of new spawning areas	Reservoir management for energy production	Increased fish production and biodiversity	Location of potential areas	Conservation status for key areas
		Improvement of reservoir water quality	Stabilization of reservoir water quality after 10 years	Economic gain of clean domestic water supply	Lakeshore population after 10 years estimated 12 per km of perimeter.	Not justified
				Economic gain of water supply for livestock	Livestock population based on human population;	Not justified
				Economic gain for reservoir side gardens irrigation	75% lakeshore household have garden (or 1.5 garden/km of reservoir bank)	Not justified
				Economic gain for irrigation along reservoir side	1 ha irrigation/km of reservoir shore	
		Long term eutrophication of reservoir	Nutrient inflow from a developed catchment	Development of aquatic weeds and floating vegetation which affects turbines, evaporation and reservoir productivity	Expected Phosphorus loading Magnitude of draw down Residence time for water	Watershed control Removal of vegetation if required
	LAND SYSTEM	Economic loss of future land resource harvest	Reservoir creation	Economic loss of timber resource	Area flooded, type of forest Annual average production	No mitigation
				Economic loss of non timber resource	Area flooded, type of forest Average annual value	No mitigation
				Economic loss for bamboo	Area flooded Density of bamboo	No mitigation
				Economic loss of future rainfed crop production	Area flooded Average production	No mitigation
				Economic loss of future dry season irrigated production	Area flooded Average production	No mitigation
				Economic loss of riverbank gardens	Household affected Average annual production	No mitigation
				Economic loss of grazing area	Number of livestock & cattle to move reflects grazing area	No mitigation
		Financial loss of developed land by displaced people	Reservoir creation	Loss of rainfed paddy fields	Area	Compensation for unmovable asset and 3 years production
				Loss of irrigated paddy fields	Area	Compensation for the unmovable assets plus 3 years
				Loss of gardens (fruits and vegetables gardens)	Area or unit	Compensation for unmovable assets plus

For remaining impacts on fish and fisheries, a penalty system may be implemented, making the contractor responsible for accidental spill and in charge of paying compensation to downstream villagers.

(3) Impacts on Air Quality

Impact concerns mainly fumes from heavy machinery and dust. The first cause should not be significant. For the second one, dust may be controlled by watering regularly construction sites and roads inside the villages. Grass cover on spoil areas may limit dust emission by wind.

7.4.3 IMPACTS DURING FILLING PHASE

The filling event is probably the most important and impacting stage of a hydropower project. Indeed, this is the short time during which,

(i) the hydrology of the downstream system is be abruptly modified,

(ii) the water quality of the system is strongly altered, and

(iii) the population in the reservoir area must be resettled.

(1) Impacts on River Hydrology

As soon as the dam is closed, the downstream area faces drastic change in flow.

Table 7.4.3 Change in Flow during Filling with 20 m^3/s Riparian Release (Mean year)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Munagmai	Before	69	58	50	46	80	217	276	680	419	196	124	76
	After	30	28	27	27	32	52	60	119	81	48	38	31
Mekong Conf.	Before	72	61	53	49	84	228	290	714	440	206	130	80
	After	33	31	30	29	36	63	74	154	102	59	44	35

As shown in Table 7.4.3, changes in the downstream river are particularly important in the wet season, with up to 82% reduction in monthly average flow for a mean year.

Simulation of reservoir filling was done based on inflow and various riparian releases. It shows that with a 20 m^3/s riparian release, the FSL.360 reservoir fills in 13 to 25 months according to the year (wet or dry) and in 16 months for a mean year. The FSL.320 reservoir fills in 3 to 15 months, with only 3 months for a mean year. The speeds of both cases, 0.4m/day and 1.6m/day, are slower than a referential speed of 4 to 5m/day, which is generally given as a safe filling speed against failure of embankment slope.

By increasing the riparian release to 50 m^3/s, to reach FSL.360, it takes 18 months instead of 16 with 20 m^3/s. The difference is not so large to give the opportunity to adapt at best the riparian release for the benefit of population and project.

It is recommended that a study be carried out during the next stage of the Project development in order to optimize the riparian release during the filling period. The objective is to preserve as much as possible fisheries and the use of the river by the population (mainly transportation and irrigation).

(2) Impact on Land Use

A major impact of the filling event is on land use, as presented in the following Table 7.4.4 and on the two attached Figures 7.4.1 and 7.4.2.

Table 7.4.4 Distribution of Land Use in Inundation Zone

Land Use	Area (ha)	
	FSL.360m	FSL.320m
Evergreen forest	830	450
Deciduous forest	8,950	4,480
Forest regrowth	1,200	380
Shrubland	2,890	1,770
Cultivated land	950	310
Total area	14,820	7,390

The alternative FSL.360m affects almost twice land area as the alternative FSL.320m and 3 times more cultivated area. All compensation costs related to this area are detailed in the Preliminary Resettlement Plan section of this report.

The flooding of the forest will affect habitats and wildlife, but also will represent an economic loss for all the products, which will be lost: timber, non timber forest products (medicinal plants, fruits, material, value for animals and conservation) and more globally, the forest as a carbon storage.

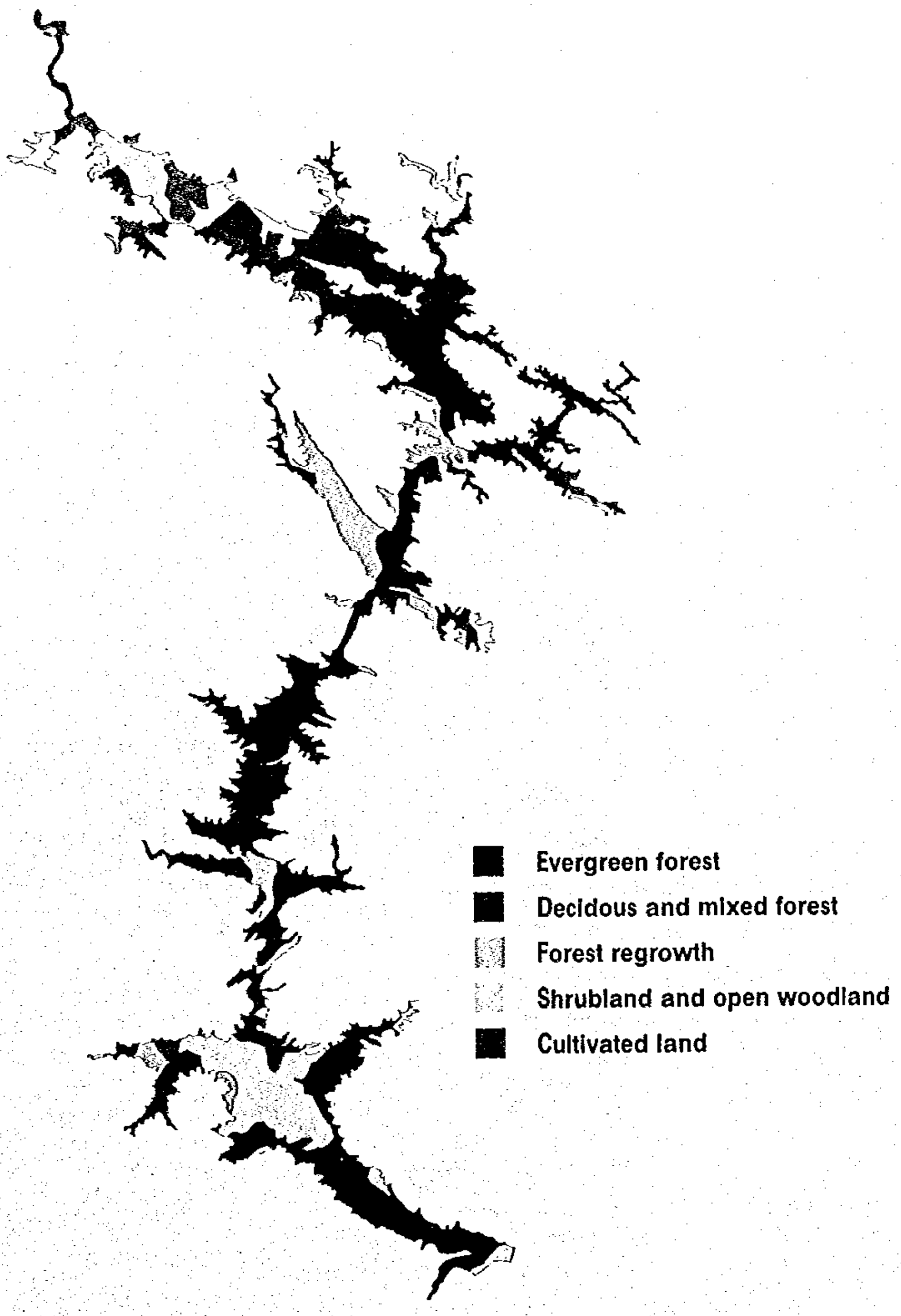
At FSL.360m, 9,780ha of forest representing a timber volume of 290,000m^3 will be flooded against only 148,000m^3 for FSL.320m (4,930ha forest).

As the water level will raise fast during the first few months of the filling (about 140m in 3 months, 2.3m/day the first month), it is probable that animals become trapped on temporary islands or stranded. It is recommended to implement a rescue program for animals during filling. Such program has been implemented four years ago in French Guyana, during the filling of the Petit Saut reservoir. Such a program over 2 years is estimated at US$250,000 for FSL.360m and US$170,000 for FSL.320m.

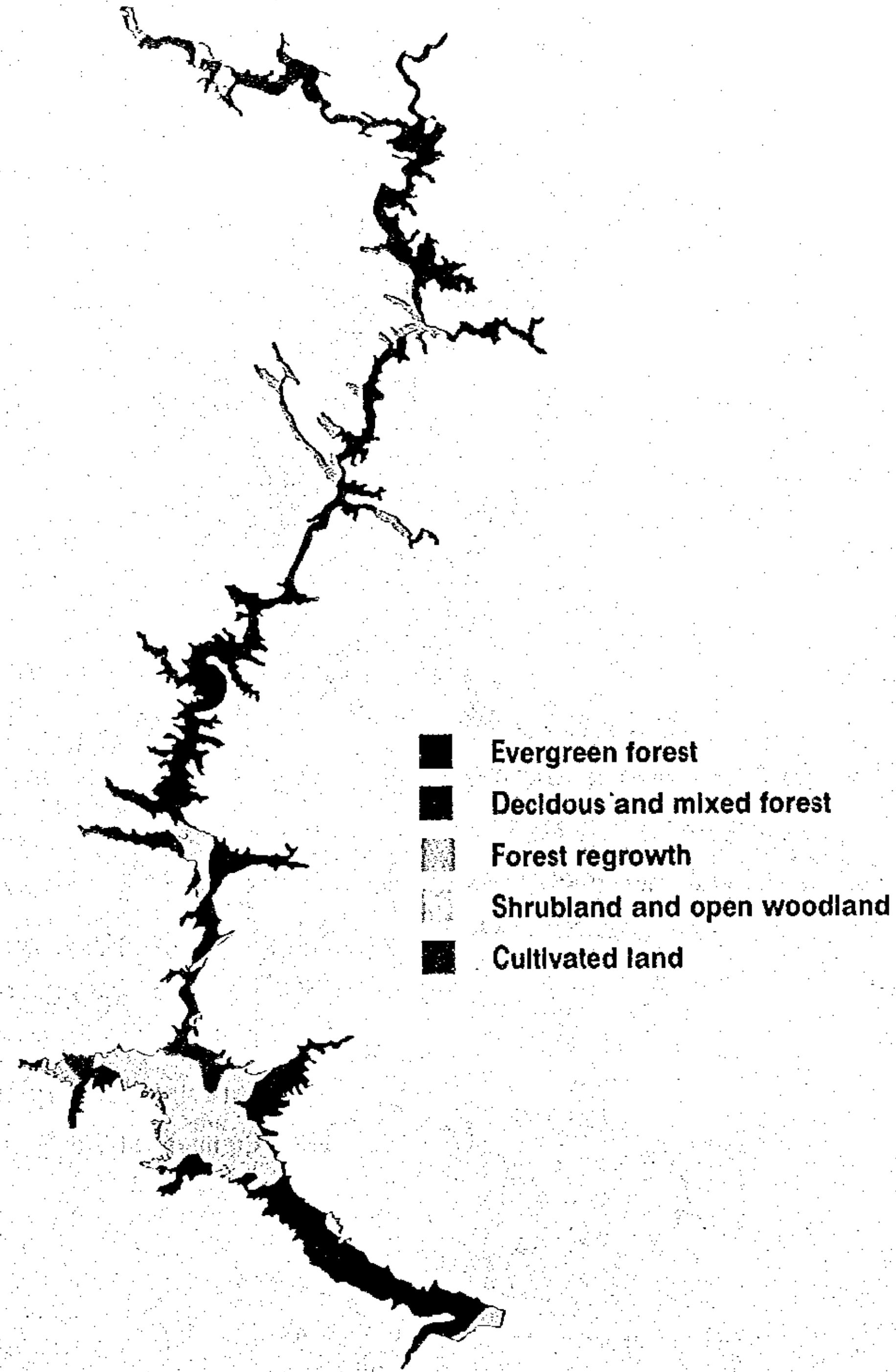
(3) Impacts on Water Quality

This is a key impact of this stage, unfortunately not limited to the filling period. The severe alteration of water quality will last for at least few years during the operation phase.

The main cause of water alteration is the decay of the organic water content in the flooded vegetation and the upper layer of the soil. A part of this biomass is soft (foliage, twigs) and has a very fast decay, over 2 to 3 years. The remaining part of the biomass consists in wood (timber, large branches, large roots) which decays slowly over 15 to 20 years or more. The critical period is the decay of soft biomass, as huge quantities of organic matter will consume all the dissolved oxygen in water, killing the aquatic life. The following table gives a preliminary estimate of biomass in the reservoir area:



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC	First Environmental Impact Assessment	Figure 7.4.1
JAPAN INTERNATIONAL COOPERATION AGENCY	Land Cover in Reservoir Area (FSL 360)	



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

First Environmental Impact Assessment

Figure 7.4.2

Land Cover in Reservoir Area (FSL 320)

Table7.4.5 Estimated Biomass in Reservoir Area

Items	Biomass (t/ha)		Area (ha)		Total Biomass (in '000 t)			
					FSL360m		FSL320m	
	Soft	Hard	FSL360	FSL320	Soft	Hard	Soft	Hard
Evergreen forest	28.9	185.9	830	450	24.0	154.3	13.0	83.7
Deciduous forest	28.9	185.9	8,950	4,480	258.7	1663.8	129.5	832.8
Forest regrowth	28.9	111.5	1,200	380	34.7	133.8	11.0	42.4
Shrubland	28.9	55.8	2,890	1,770	83.5	161.3	51.2	98.8
Cultivated land	23.1	0	950	310	21.9	0.0	7.2	0.0
Total area	-	-	14,820	7,390	-	-	-	-
Total above ground	-	-	-	-	422.8	2,113.2	211.8	1,057.6
0-5 cm top soil	9.8	1.8	14,820	7,390	145.2	26.7	72.4	13.3
0-25 cm top soil	20.7	16.1	14,820	7,390	306.8	238.6	153.0	119.0
Total with 5 cm soil	-	-	-	-	568.0	2,139.8	284.2	1,070.9
Total with 25 cm soil	-	-	-	-	729.6	2,351.8	364.7	1,176.6
Note:	(1) Cultivated land soft biomass estimated 80% of forest soft biomass value. (2) Forest regrowth hard biomass is 60% of forest hard biomass value. (3) Shrubland hard biomass is 30% of forest hard biomass value							

There is no solution to avoid temporary alteration of water. The main mitigation is to try to limit its intensity and its duration. The only possibility is a pre-impoundment clearing, combined with a commercial logging.

Based on the recent clearing experience of the Nam Leuk reservoir, a rapid clearing and burning may reduce the soft vegetation biomass by 88% when burning is 100% efficient. Most of the time, (as measured for the Nam Leuk HEPP) unburned biomass and regrowth reduce the efficiency of the process to a total reduction of about 77% to 80% in soft biomass. This is the best case with a short duration of clearing (few months). For longer duration, a lower growth may be expected as regrowth becomes more significant, measured at more than 3 tons/ha/year (dry weight).

Regarding the biomass from the soil, no practical solution exists to reduce it. The effect of clearing in terms of percent biomass reduction will be quite different according to the depth of soil concerned. The actual situation will probably be between this range of 5 to 25cm according to the local area (soil texture, slope, located in draw down zone or not).

For hard biomass, the clearing and logging operation can hardly remove more than 50% of the original volume. However, if complemented by a collection program of floating debris after impoundment, this result may be improved.

Based on these remarks, the minimum soft biomass expected in the reservoir area is shown in Table 7.4.6.

Table 7.4.6 Potential Maximum Reduction of Biomass in Reservoir Area

Biomass in '000 tons	Layer	Total soft biomass		Total hard biomass	
		FSL 360	FSL 320	FSL 360	FSL 320
Before clearing	with soil 0-5 cm	568.0	2,139.8	1,070.9	284.2
	With soil 0-25 cm	729.6	2,351.8	1,176.6	364.7
After clearing	with soil 0-5 cm	229.8	1,083.3	542.1	114.8
	With soil 0-25 cm	391.3	1,295.2	647.8	195.3
Biomass reduction (as a % of initial situation)	with soil 0-5 cm	59.54	49.37	49.38	59.61
	With soil 0-25 cm	46.37	44.93	44.94	46.45

Further studies are obviously required in order to optimize the cost of clearing with the benefits expected. It is worth mentioning that clearing operation is not only necessary for water quality aspects but also for the future management of the lake regarding tourism and fisheries development opportunities. Some areas may require to remain uncleared to provide habitats for fishes and some protection against fishing, as in spawning areas.

The Nam Leuk HEPP (the reservoir=1,300ha) was totally cleared by hand by the local population (400 persons) in 5 months at an average cost of US$420/ha. On this basis, the clearing of the whole reservoir for Nam Ngiep may represent a cost of about US$5 to 6 millions for the FSL.360m and about US$ 2 to 3 millions for FSL.320m.

During the filling period and probably the following years, the water quality in the reservoir and released downstream will be anoxic, with fish kills and the probable suspension of fishing activities in the river and in the reservoir. A compensation will be required for the population from the reservoir area and for the population of the downstream villages.

It is recommended to study the possibilities for a fishery intensification program in the downstream area which provide to the population a fish production independent from the river. As discussed later, the problems of water quality in the downstream area will probably have much longer effects on the population than those of the reservoir.

In the downstream area it is recommended to carry out during the next stage of the project a hydraulic study to assess the various conditions for the re-aeration of water and to propose some specific equipment or structure to improve it. Then, it is recommended to implement a specific study of water quality to identify precisely the effect of re-aeration provided by the re-regulation pond, by any structure implemented for that purpose and by the natural re-aeration of the river flow.

If the situation of water quality is unsurprisingly acute in a short term, various computations show that the improvement of water quality will be fast and that the situation in the reservoir will be reasonably good in the long term, at least for the active superficial layer of the reservoir. This is discussed in next section. All intensity of water quality problems is shown in Figure 7.4.3.

7.4.4 IMPACTS DURING OPERATION PHASE IN INUNDATION ZONE[1]

The reservoir will be a highly dynamic system with regular changes of level and area according to season and to the inflow conditions.

(1) Temporary Inundation Zone (Draw-Down Areas)

The first question is to assess the change of reservoir area and the extent of draw down areas which may provide a basis for adapted land development: agriculture, grazing land, wet land. The following Figures 7.4.4 and 7.4.5 present, for each alternative the location and extent of draw-down areas.

The following table provides the maximum draw-down area expected for each alternative and under different hydrological years:

[1] All areas computed from Landsat Satellite imagery in 1997.

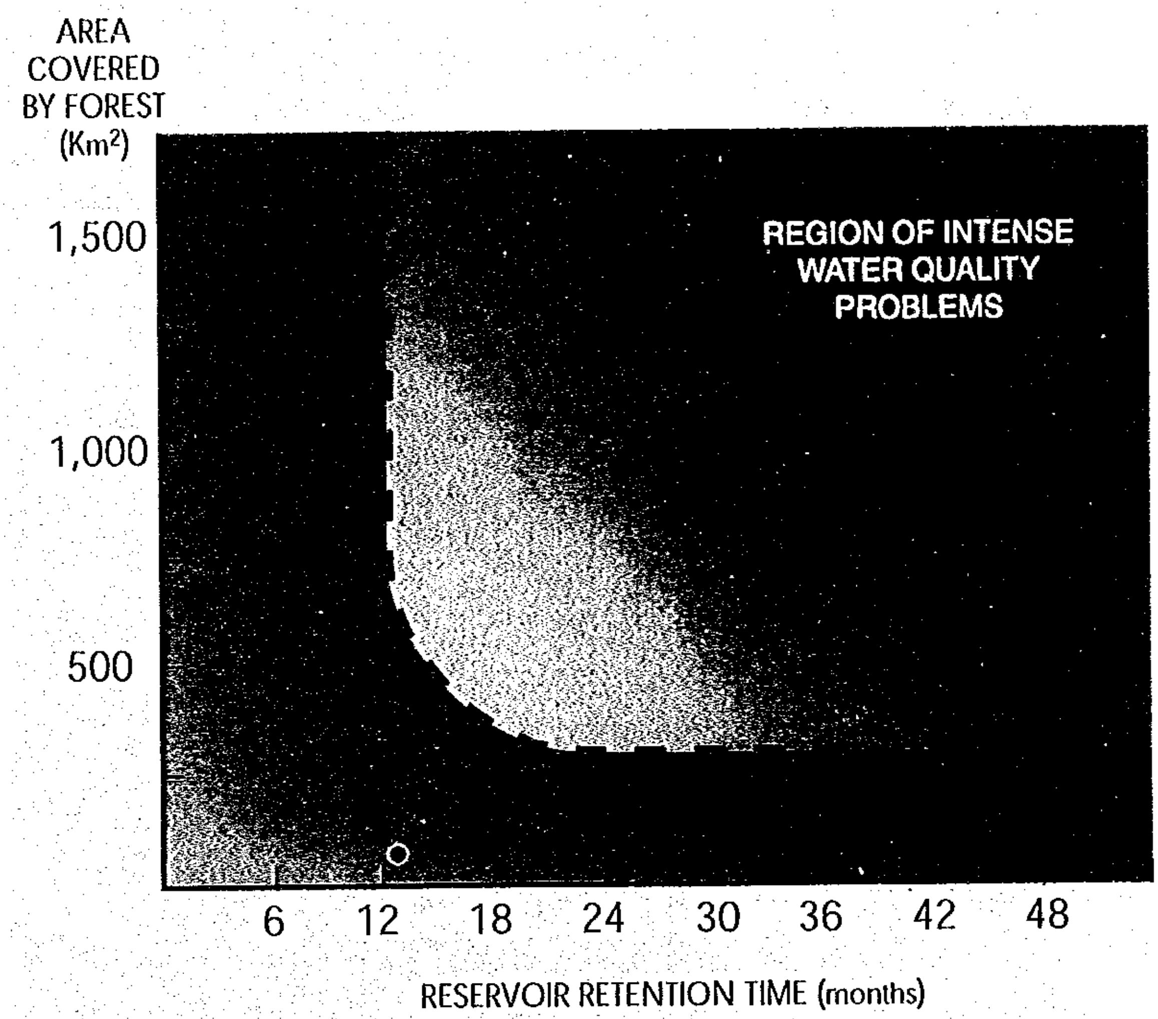
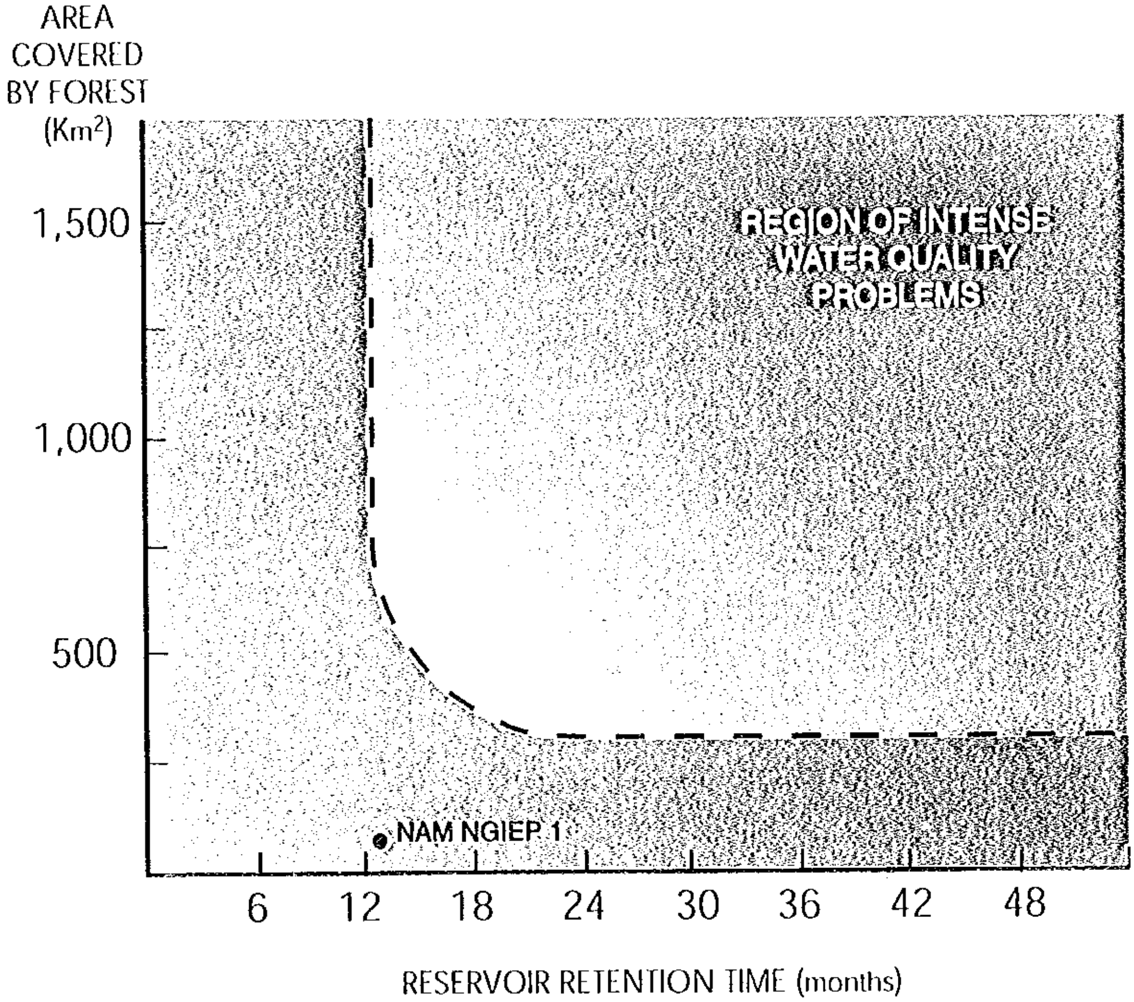
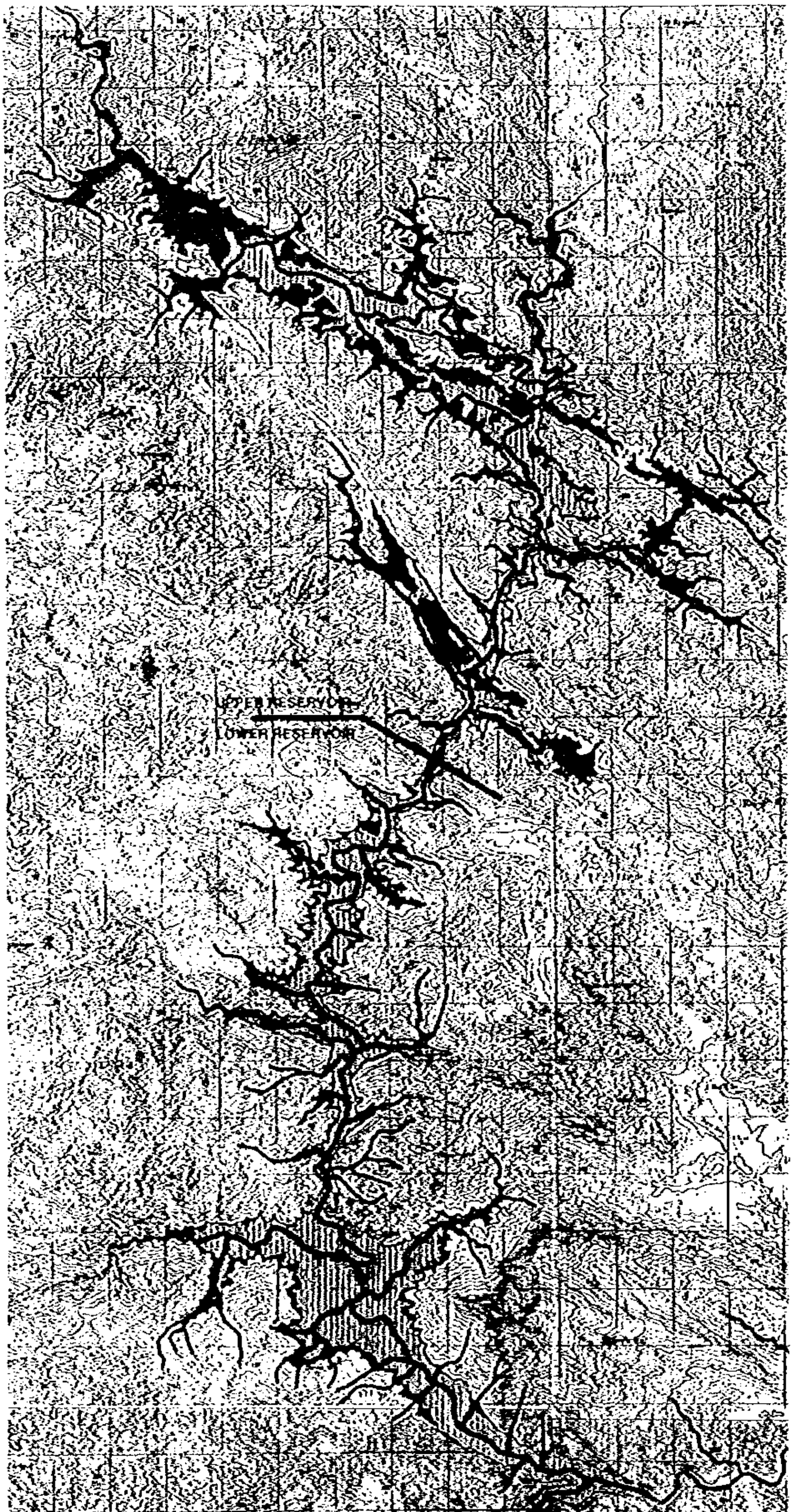
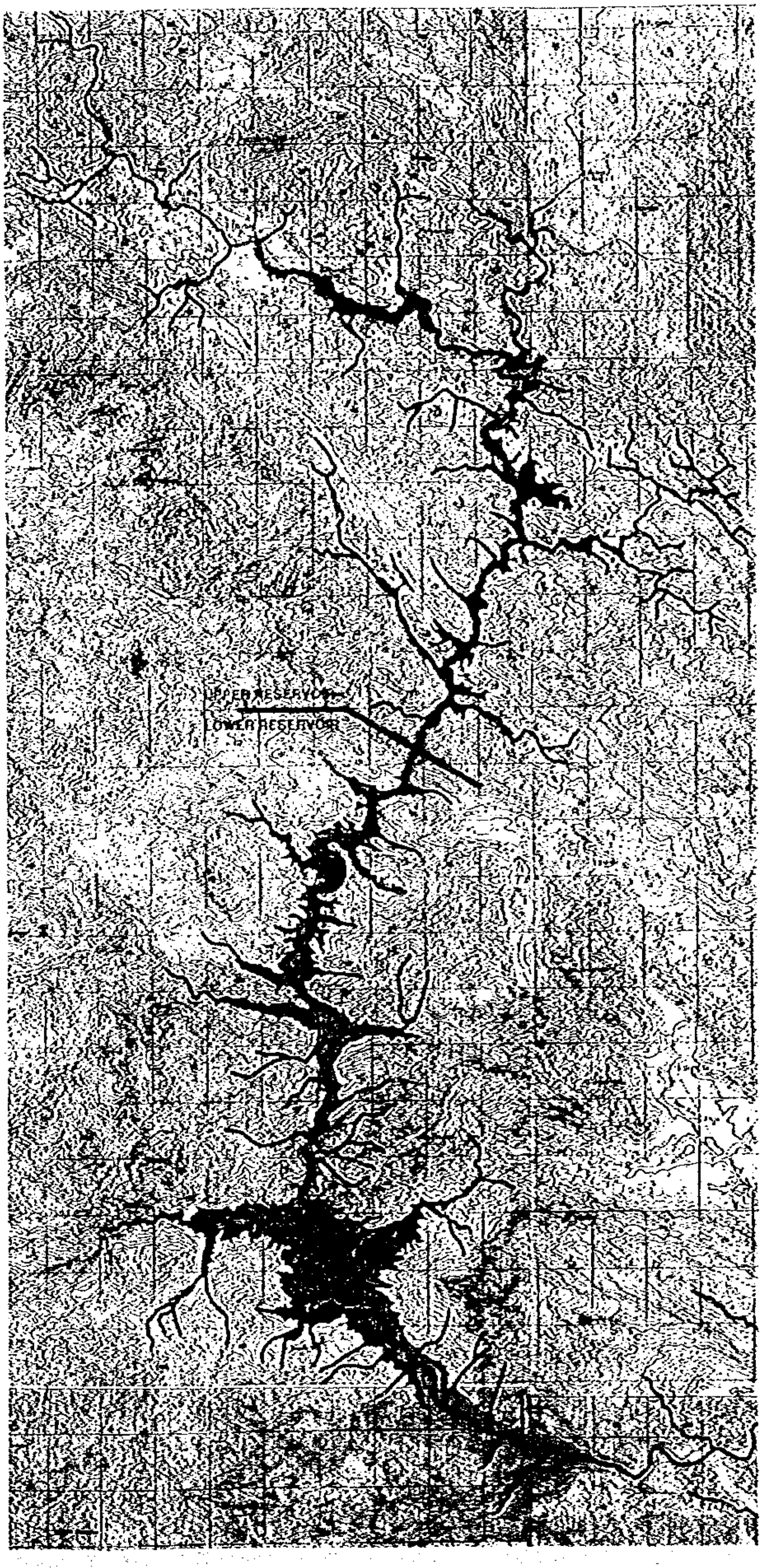


Figure 7.4.3
Water Quality as a Function
of reservoir Retention Time


AREA
COVERED
BY FOREST
(Km²)
1,500
1,000
500
REGION OF INTENSE
WATER QUALITY
PROBLEMS
NAM NGIEP 1
6
12
18
24
30
36
42
48
RESERVOIR RETENTION TIME (months)



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC	FIRST ENVIRONMENTAL IMPACT ASSESSMENT	Figure 7.4.4
JAPAN INTERNATIONAL COOPERATION AGENCY	DRAWDOWN AREAS FOR FSL 360m	



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

JAPAN INTERNATIONAL COOPERATION AGENCY

FIRST ENVIRONMENTAL IMPACT ASSESSMENT | Figure 7.4.5

DRAWDOWN AREAS FOR FSL 320m

Table 7.4.7 Distribution of Maximum Draw-Down in Reservoir

Location	Areas in ha	FSL 360	FSL 320
Upper Reservoir	FSL Area	7,210	2,130
	MOL Area	3,960	440
	Maximum Drawdown	3,250	1,690
Lower Reservoir	FSL Area	7,610	5,250
	MOL Area	6,440	2,830
	Maximum Drawdown	1,170	2,420
Total Reservoir	FSL Area	14,820	7,380
	MOL Area	10,400	3,270
	Maximum Drawdown	4,420	4,110

The maximum draw-down for the whole reservoir is about the same for both options, but with a different distribution in the Upper and the Lower Reservoirs.

The potential for the agricultural development of these zones depends on several factors, as soil condition, local topography and duration of the exposition. Further detailed studies are required to analyze the first two parameters. However, a simulation of the reservoir operation over the first 5 years of operation provides the fluctuation of the draw-down area according to the period of the year.

Two major conclusions are obtained as shown below:

(i) The alternative FSL.320m provides much wider draw-down areas than the FSL.360m, because the management of a smaller reservoir results in a maximized use of the active volume, with an annual maximum draw-down level magnitude higher than observed for the FSL.360m alternative.

(ii) Rice cultivation cycle covers 120 days or 4 months. With a security margin, it may be considered that only areas exposed for 5 months are potentially suitable for paddy. The result of simulation is provided in the following Table 7.4.8:

Table 7.4.8 Availability of Draw-Down Area (ha)

Alternative	Area available for	Year 1	Year 2	Year 3	Year 4	Year 5
FSL.360	3 months	1,200	1,600	1,600	1,500	1,700
	4 months	800	1,400	1,400	1,200	1,400
	5 months	500	1,100	1,200	900	1,200
FSL.320	3 months	2,000	3,000	2,900	3,000	3,100
	4 months	1,500	2,500	2,500	2,500	2,500
	5 months	1,000	2,000	2,000	1,800	2,000

Depending on the alternative, a total area of 1,000 to 2,000ha is exposed 5 months a year. If 30% of this area is suitable for paddy, it represents a potential of 300 to 700ha for development. Vegetable gardening, which requires less duration (60 to 90 days) may be considered on much wider areas. Additional studies are required to assess more precisely the potential in conjunction with the resettlement plan.

(2) Permanent Inundation Zone

The permanent inundation zone concerns the lake itself limited by the MOL contour line. Deep lakes are generally stratified. That means the water body will be split into two parts:

(i) A superficial layer of water (the epilimnion), about 20m thick which will become quickly well oxygenated. This is the layer where algae, plankton and fish develop.

(ii) Below this layer, the water body of the reservoir will receive no oxygen and will be the place where decay of organic matters happens. This is the *hypolimnion*, where no fish or other aquatic life can develop, except anaerobic bacteria releasing methane gas and sulfur hydrogen. The water there shows a lower temperature, and a lower pH, which may create corrosion problems for the equipment. Both layers area separated by a line, which is called the thermocline.

In large lakes, such stratification may turn over once a year, when colder water inflow and colder air temperature affect the water body. There is a mixing, detrimental for the upper layer and which results often in serious fish kills, but positive for the bottom layer which release part of its dissolved gas and receives some oxygen, thus reducing the corrosiveness of the water.

Due to its depth higher than 100m for both alternatives, the Nam Ngiep reservoir will certainly be stratified. Its very narrow and long shape is probably a limiting factor for a general seasonal turnover of the lake, as observed in the Nam Ngum reservoir, a much wider reservoir. Turn over may affect only parts of the reservoir, were a large tributary may destabilize the thermocline. Figure 7.4.6 shows the risk of the thermocline, while this has to be investigated in further details during next stage of the study.

The risk of eutrophication (excessive nutrient building with resulting excessive development of algae and aquatic vegetation) in the long term may be assessed by using some indicators as:

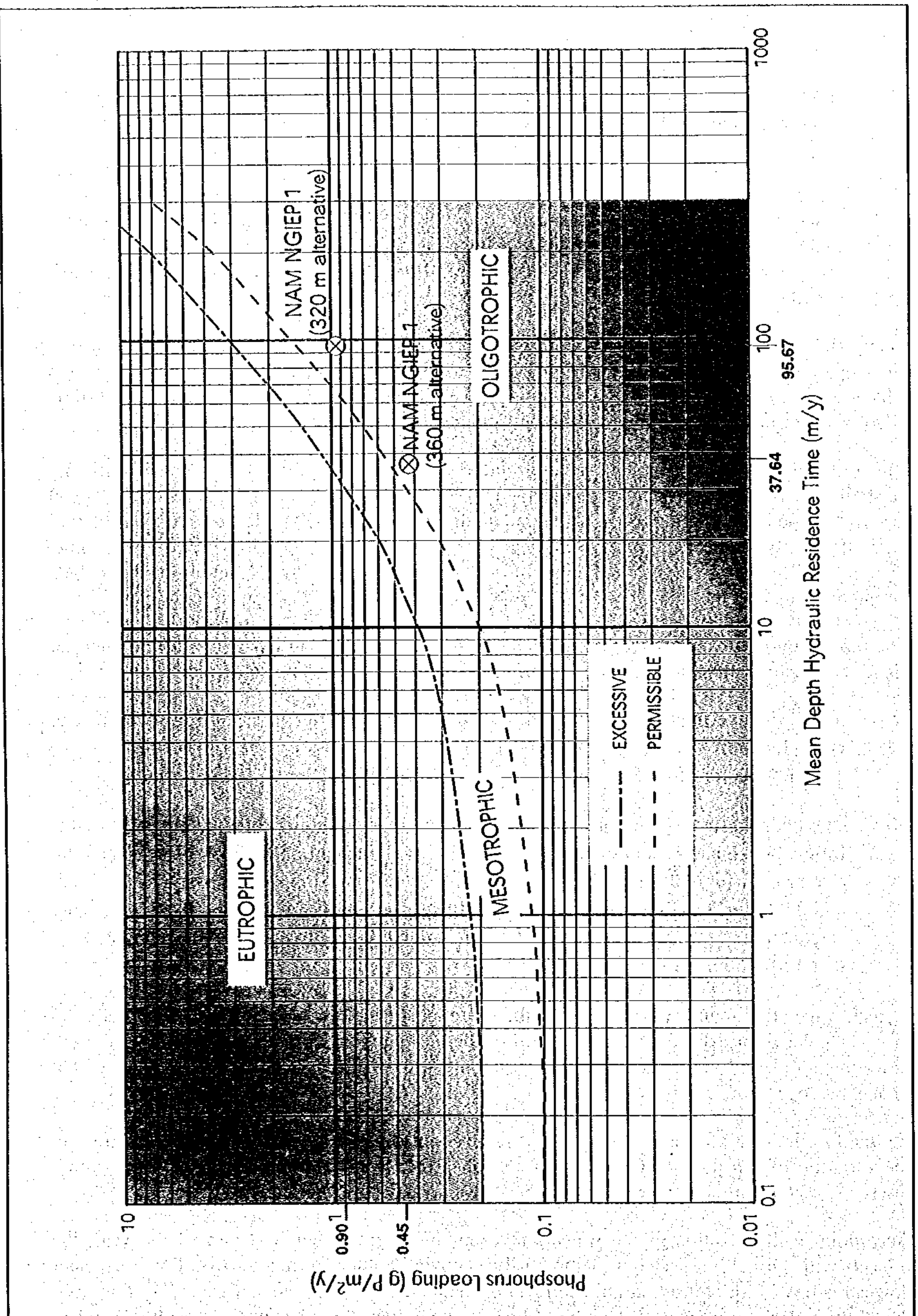
(i) The residence time of the water in the reservoir: the shorter it is, the lower the risk of eutrophication. For the Nam Ngiep-1 HEPP, this time is reasonably short, in average 13.2 months for FSL.360m and only 3.6 months for FSL.320m.

(ii) The phosphorus loading rate: this is the amount of phosphorus supplied annually by the inflow per square meter of reservoir. Phosphorus is often a limiting factor for the built up of eutrophication. It is also reasonably low for Nam Ngiep, 0.45gP/m²/year for FSL.360m and 0.90gP/m²/year for FSL.320m. This higher value for FSL.320m is linked to a higher catchment to reservoir area ratio. FSL.320m will more sensitive to catchment degradation than FSL.360m.

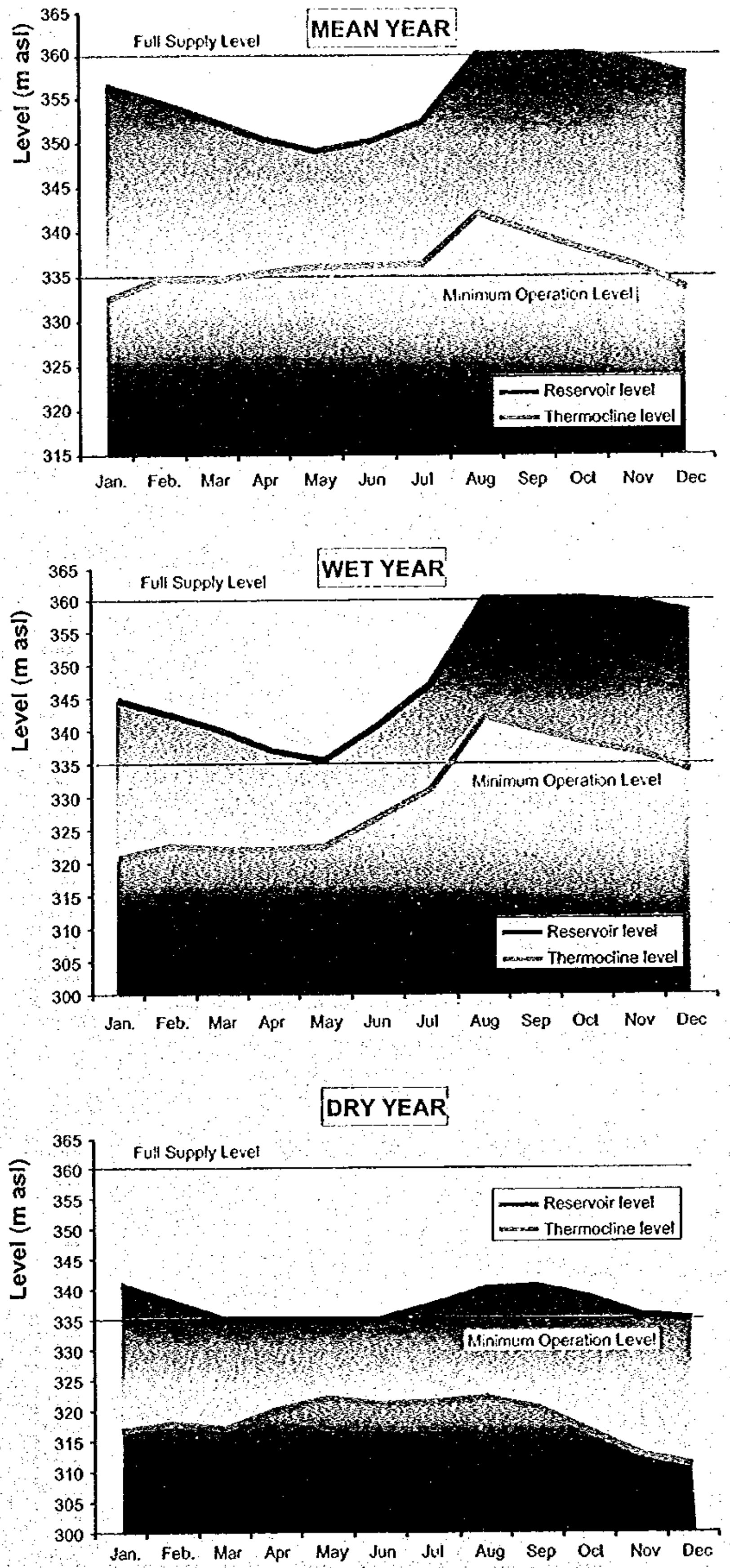
Aquatic vegetation mainly develops along the shoreline, in shallow waters. Significant variation of water level is an excellent natural control of the development of aquatic weeds. With draw-down magnitudes of more than 20m, both alternatives show low risk of excessive development of aquatic vegetation.

For the fourth question, we have carried out some simulations on the reservoir level, referring to the variation of the thermocline depth to data measured for several years in the Nam Ngum reservoir. The result is provided on Figures 7.4.7 and 7.4.8.

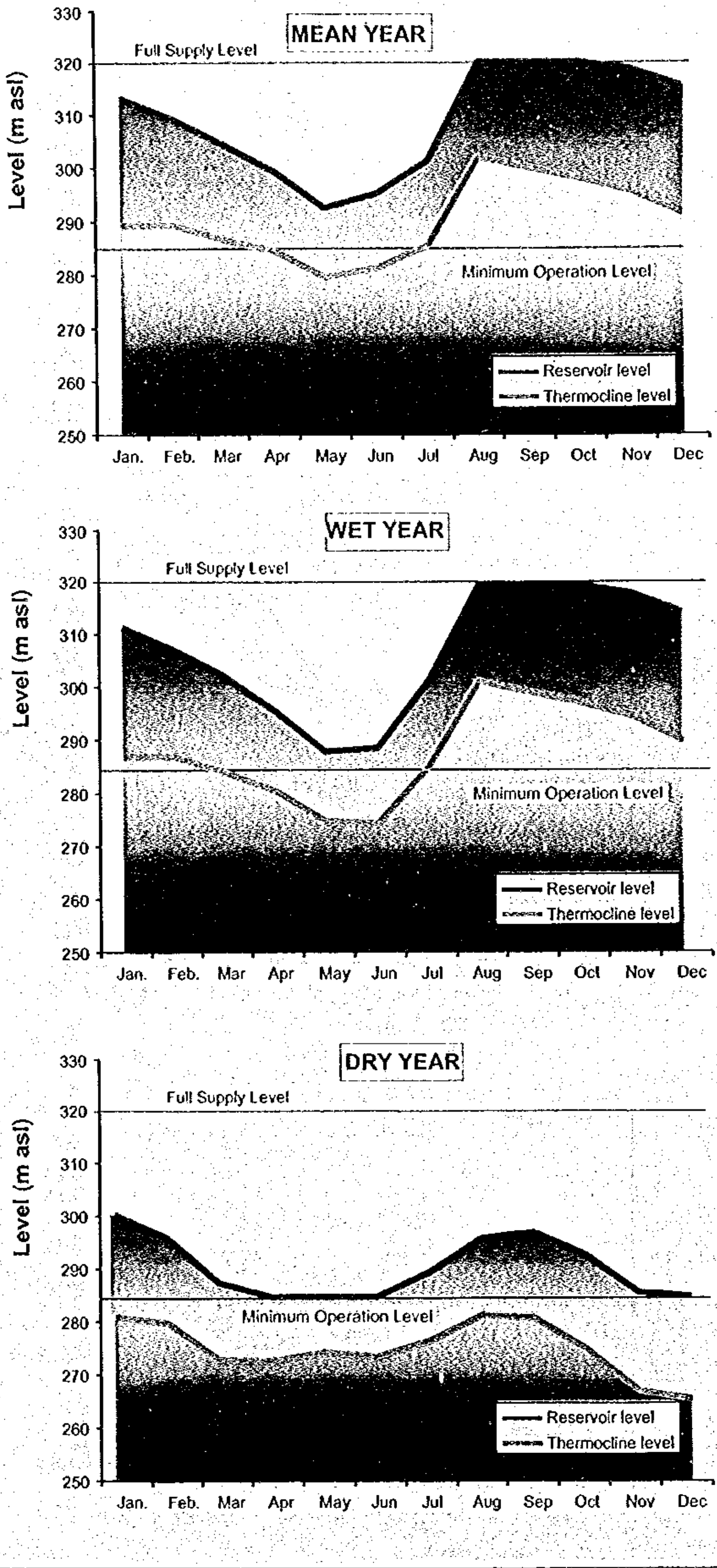
According to the position of the water intake, below the thermocline a part of the year, the project will probably discharge temporarily, anoxic, cold and acidic hypolimnion water downstream, with the release at tailrace level of methane and hydrogen sulfur gas. In this case, the program of fisheries intensification for downstream villages will become an absolute priority.



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC	First Environmental Impact Assessment	Figure 7.4.6
JAPAN INTERNATIONAL COOPERATION AGENCY	Vollenweider Phosphorus	



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC	First Environmental Impact Assessment	Figure 7.4.7
JAPAN INTERNATIONAL COOPERATION AGENCY	Evolution of Thermocline FSL360	



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC	First Environmental Impact Assessment	Figure 7.4.8
JAPAN INTERNATIONAL COOPERATION AGENCY	Evolution Thermocline FSL320	

We recommend further studies, to assess the water quality evolution in the reservoir, the risk imposed by the release of hypolimnion water (for not only people but also for electro-mechanical equipment) and the technical possibilities to improve the downstream water: hollow jet valve as proposed for NT2, special re-aeration structures at tailrace or in the re-regulation pond to increase the turbulence of flow and the release of methane.

Regarding fisheries, only the epilimnion is important. Using an empirical relationship between the depth of the reservoir and the residence time of water developed on Thai reservoirs it came that the duration of water quality problems in the epilimnion after impoundment should not last more than 6 years for FSL.360m and 2 years for FSL.320m, a very short duration which has to be considered here as an order of magnitude.

Using some models based on empirical observation of existing reservoirs in Asia, the forecast of potential open fish production gives about 11kg/ha/year for FSL.360m (or a production of about 160 tons/year) and 13kg/ha/year for FSL.320m (or a production of 100t/year). Much higher production may be expected with intensive fish culture. For example, on the Indonesian reservoirs of Saguling and Cirata (12,300ha), 10,000t were produced in 1993 from cage culture, doubling the revenue of displaced farmers.

7.4.5 IMPACTS DURING OPERATION PHASE IN DOWNSTREAM AREA

(1) Change in River Flow

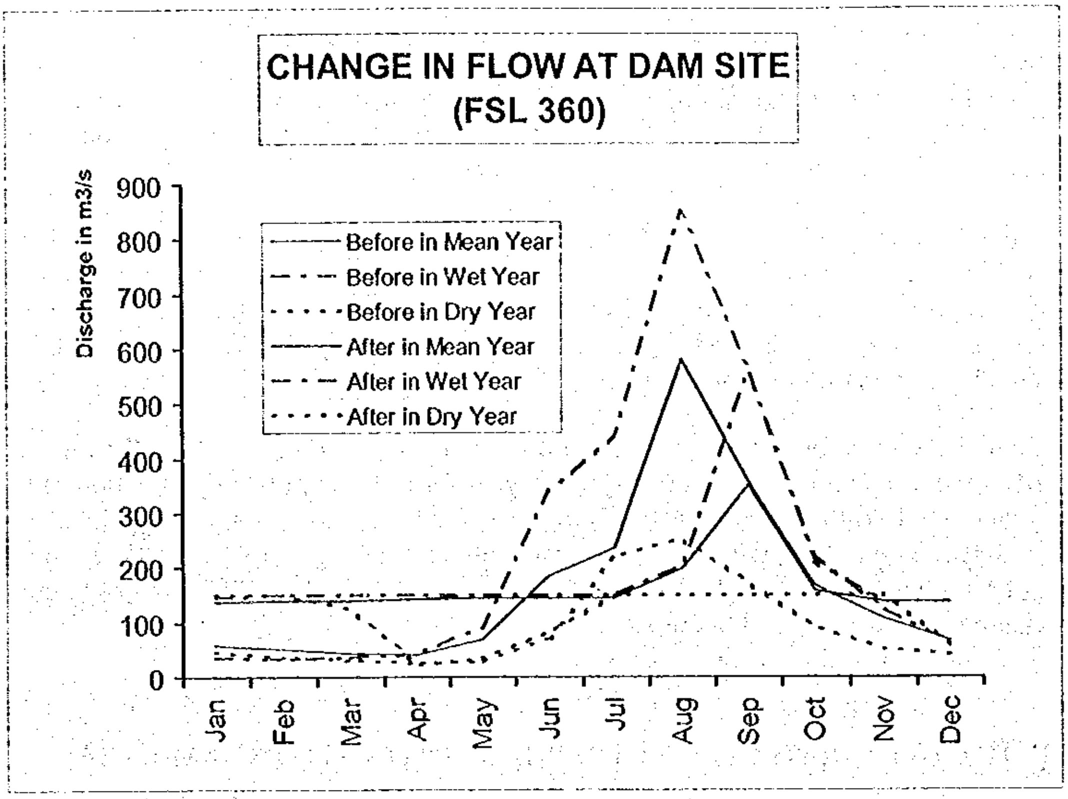
The change in river hydrology is a major impact. As already decided in the design of the Project is the construction of a re-regulation pond to regulate over the time the sudden change in discharge when turbines are operating. However, the future situation will be significantly different from the present one, as presented in the following 6 sheets of Figures 7.4.9 to 7.4.14.

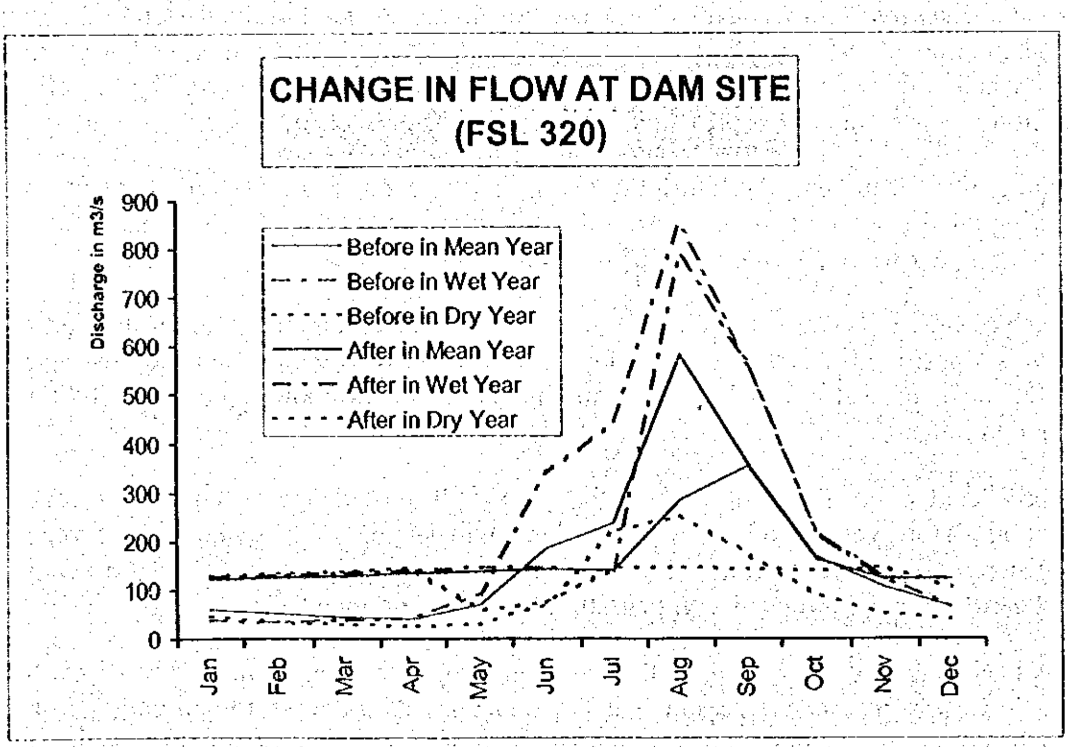
In Muangmai in a mean year, the future flow with the Project at FSL.360 will be about 3 times higher during the dry season and only half of the initial flow during the wet season. The changes may be even greater when considering a dry year situation.

This change of flow will have effects on the river use by the population. More water during the dry season is a positive impact for the development of pumped irrigation, reducing the pumping head as the level of water will be higher in the river, and providing more possibilities for additional pumping.

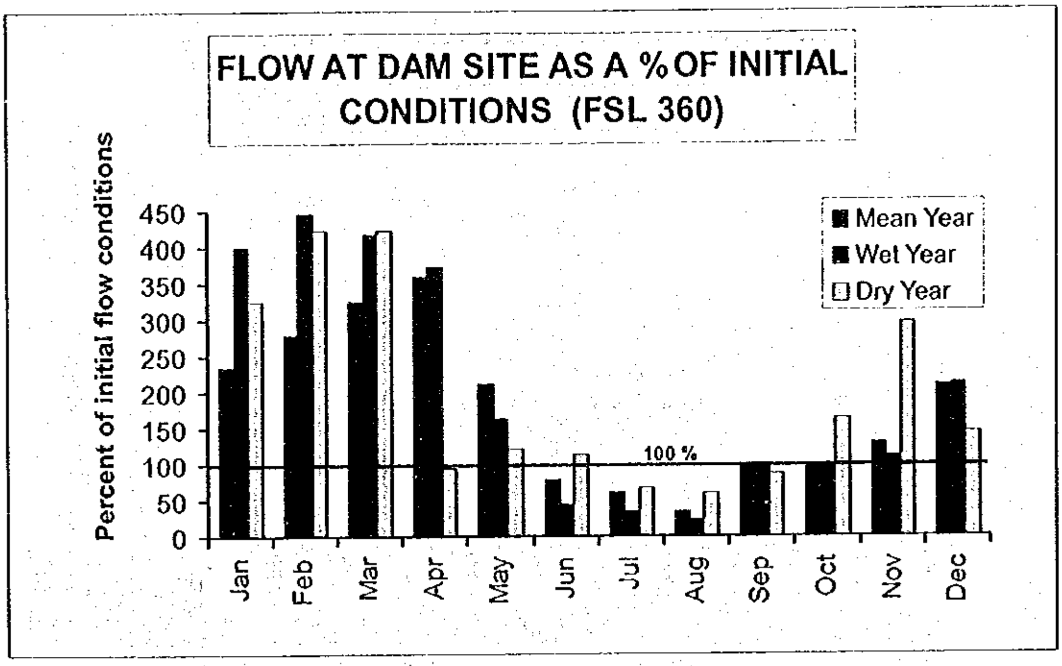
Also, more regularized flow throughout the year will provide safer conditions for river transportation. However, a higher level year long will slightly reduce the area of vegetable gardens generally developed by the villagers along the lower banks of the river. An evaluation of the lost garden area with related compensation basis is recommended.

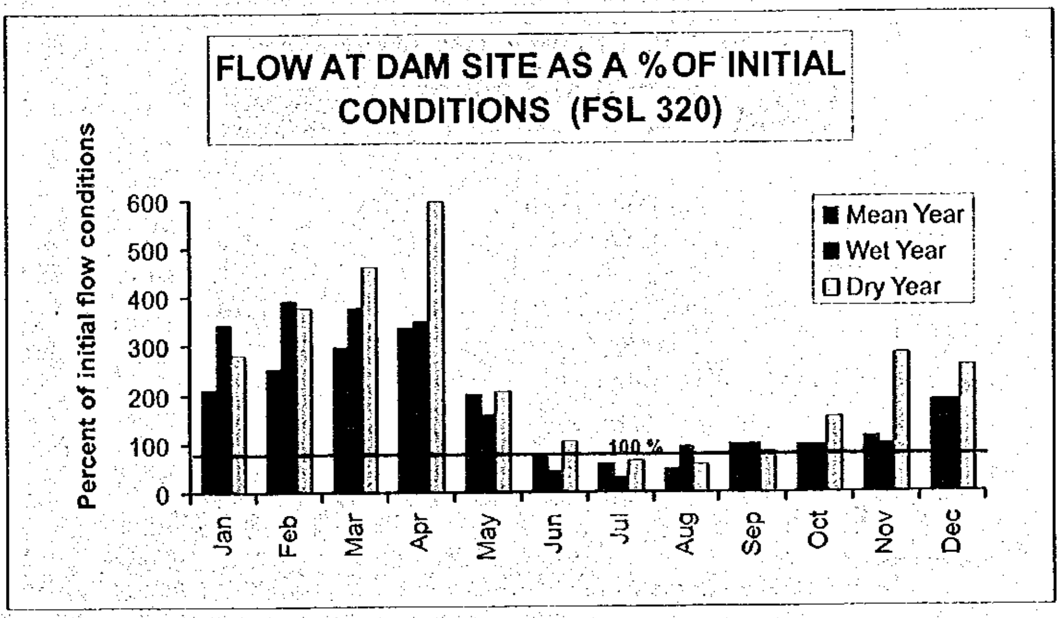
Fishing will change, not only because the dam will stop fish migration but also because the regulated flow early in the wet season will no longer act as a starter for migration from the Mekong River. But the effect of flow on the fishery component will probably be less significant than the effect of altered water quality.



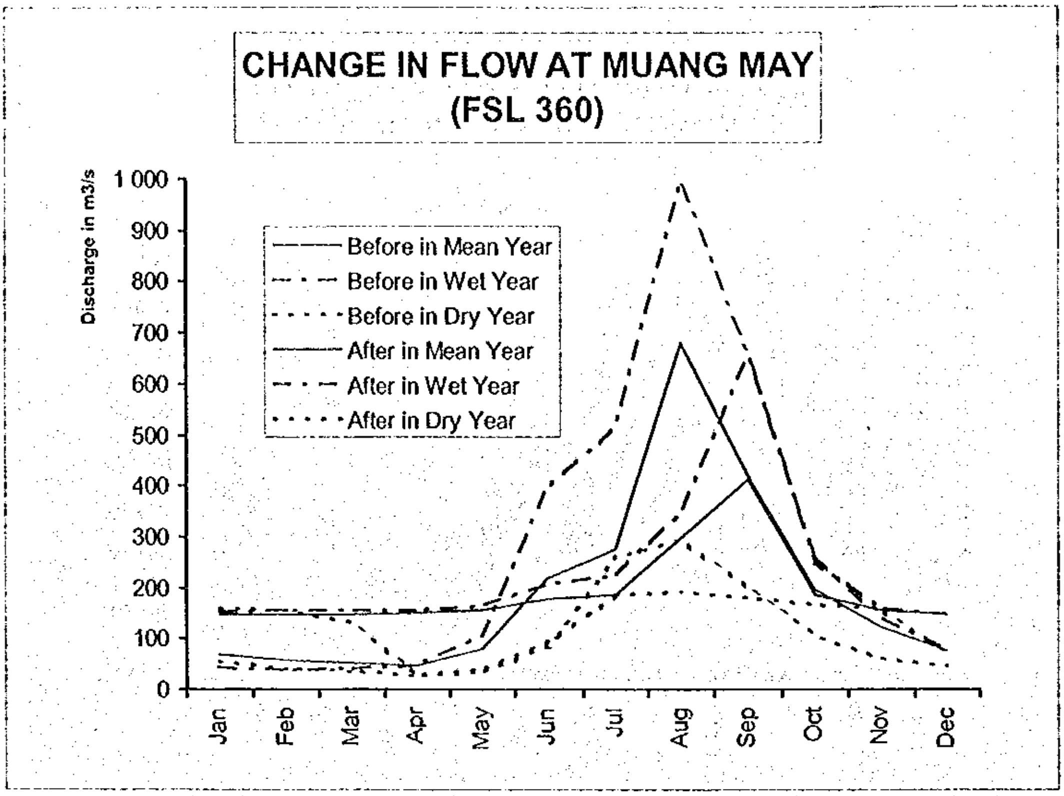


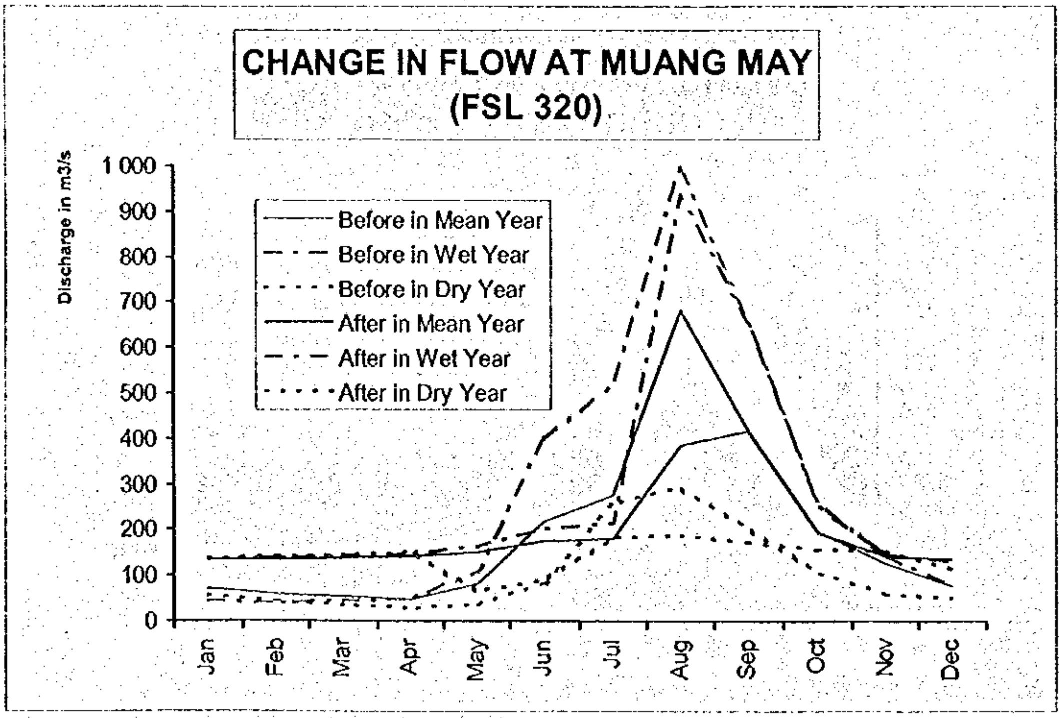
Change in Flow at Dam Site (in m^3/s)



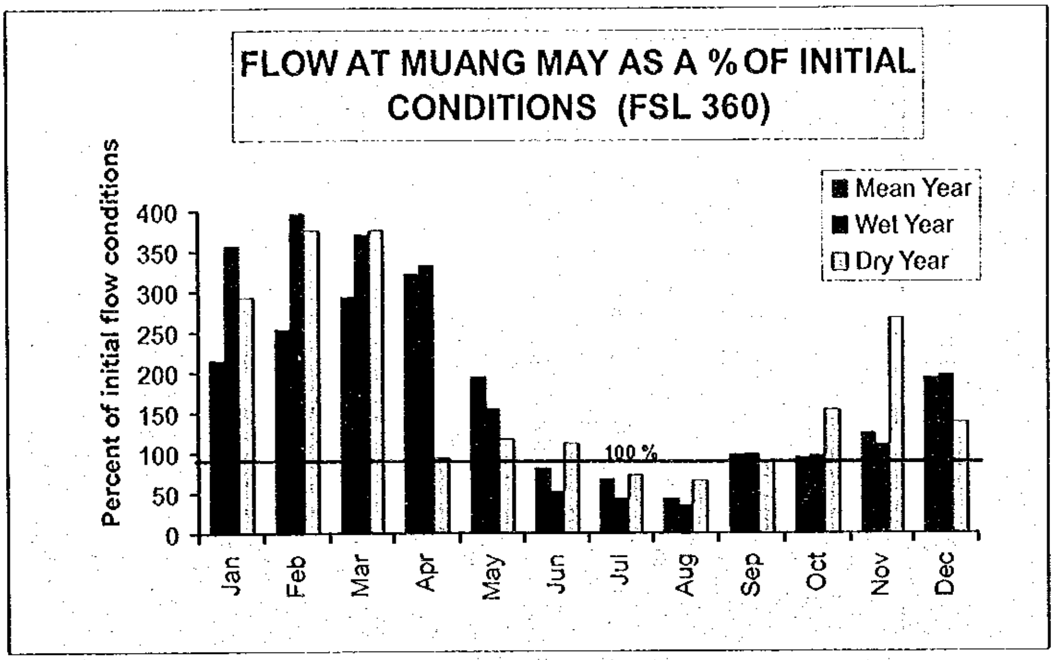


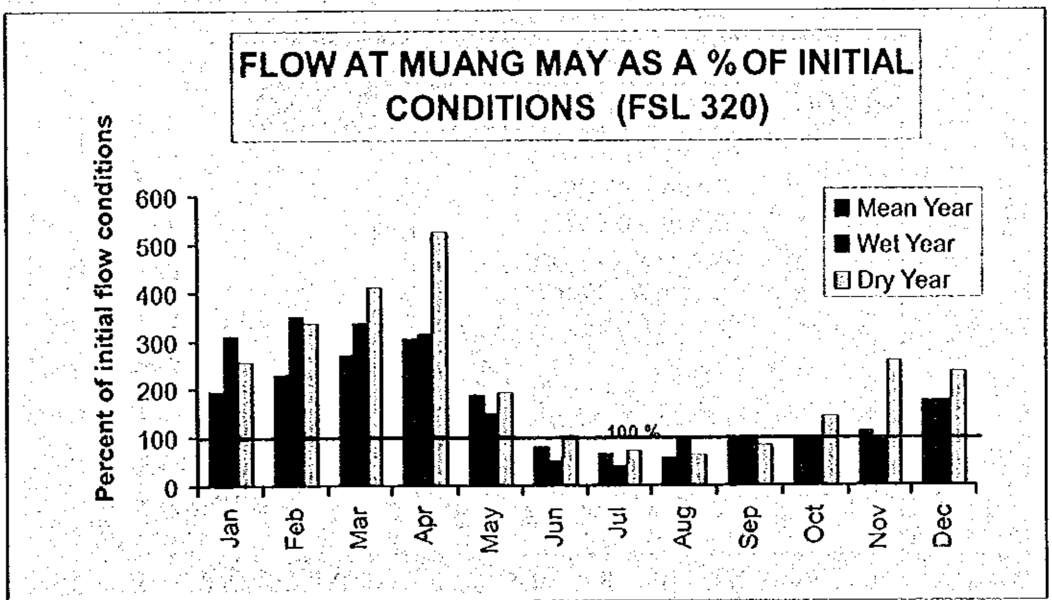
FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC	First Environmental Impact Assessment	Figure 7.4.10
JAPAN INTERNATIONAL COOPERATION AGENCY	Change in Flow at Dam Site (in %)	



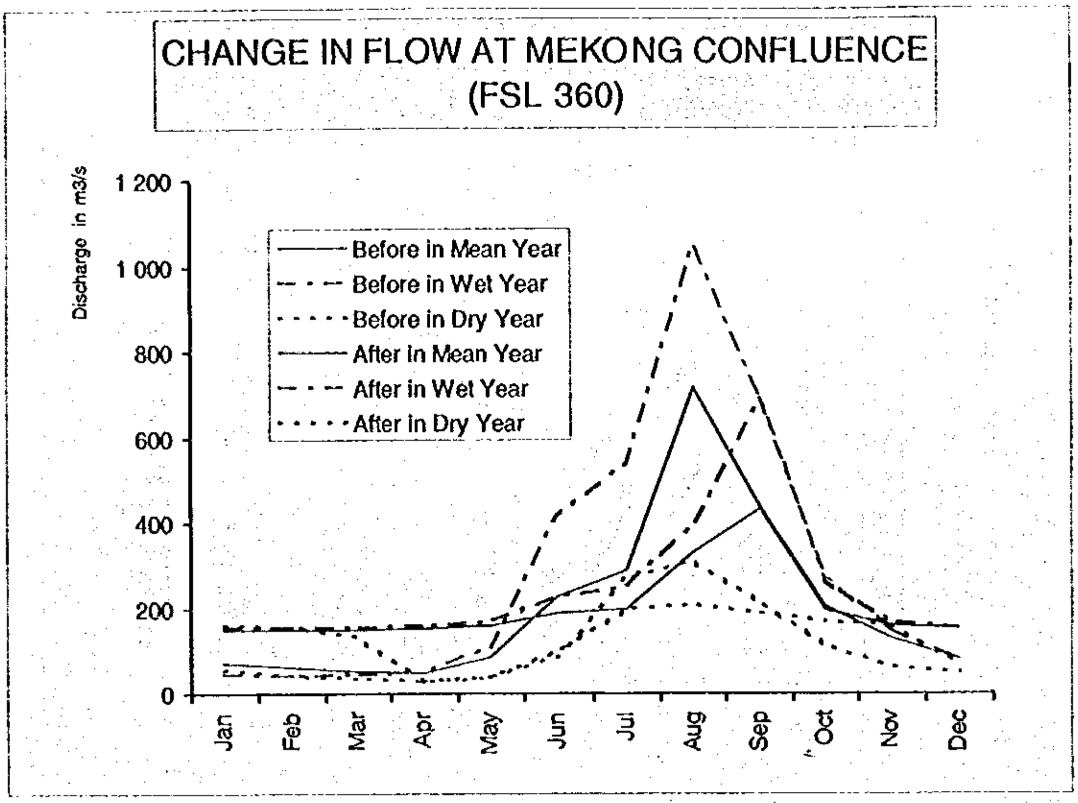


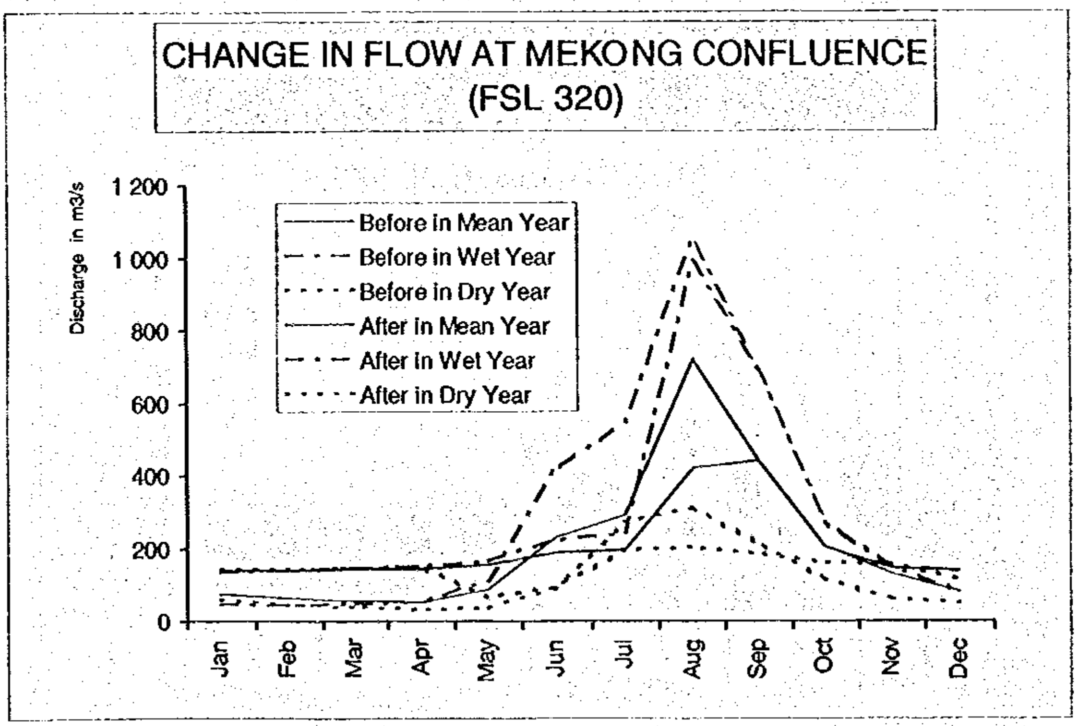
Change in Flow at Muang May (in m^3/s)



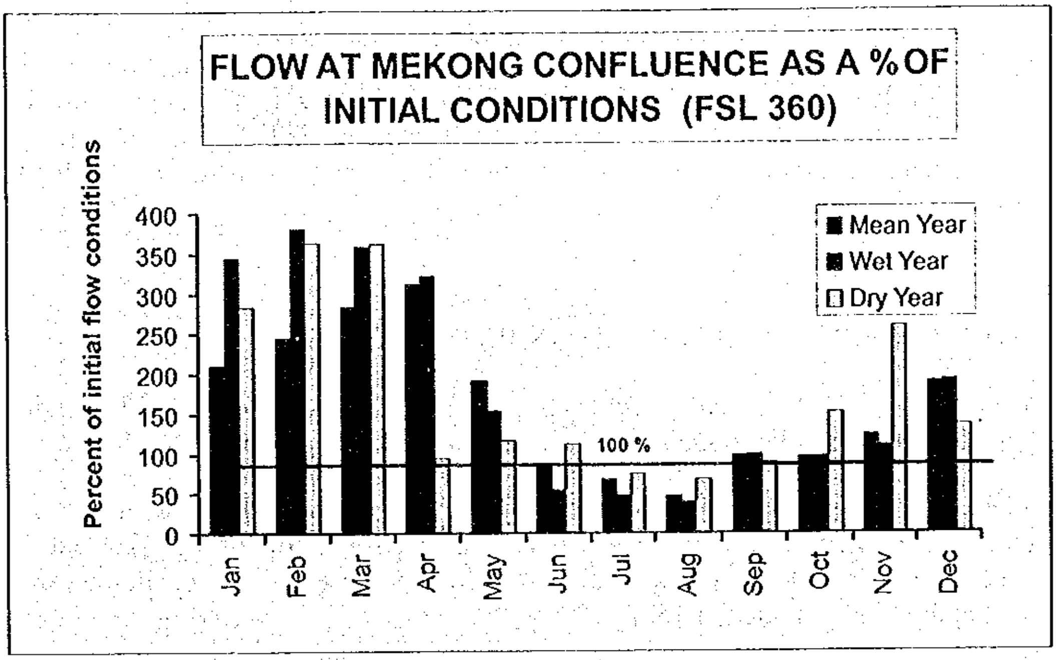


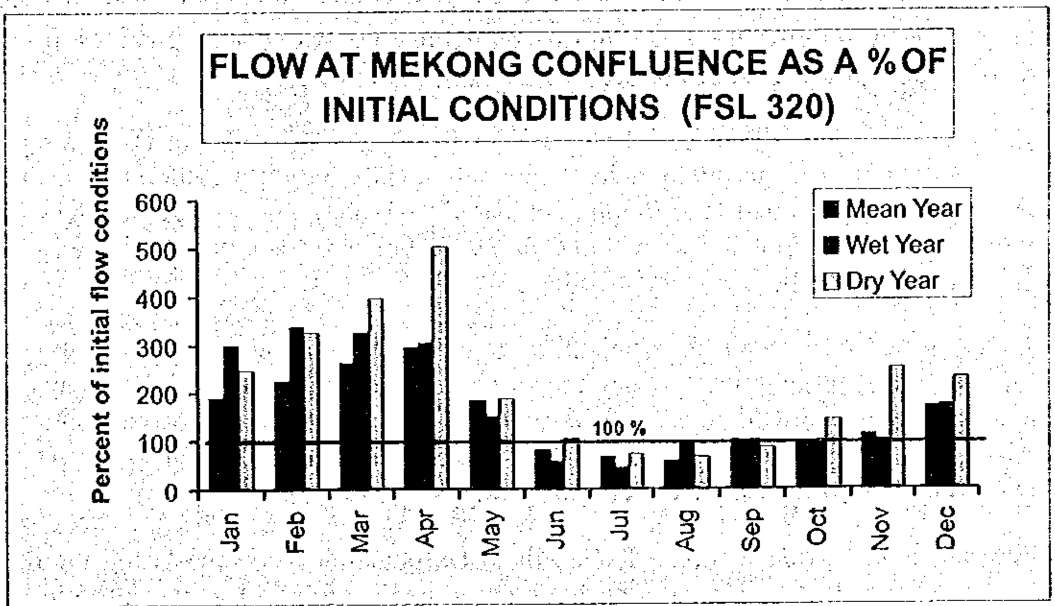
FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC	First Environmental Impact Assessment	Figure 7.4.12
JAPAN INTERNATIONAL COOPERATION AGENCY	Change in Flow at Muang May (in %)	





Change in Flow at Mekong Confluence (in m^3/s)





FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC	First Environmental Impact Assessment	Figure 7.4.14
JAPAN INTERNATIONAL COOPERATION AGENCY	Change in Flow at Mekong Confluence (in %)	