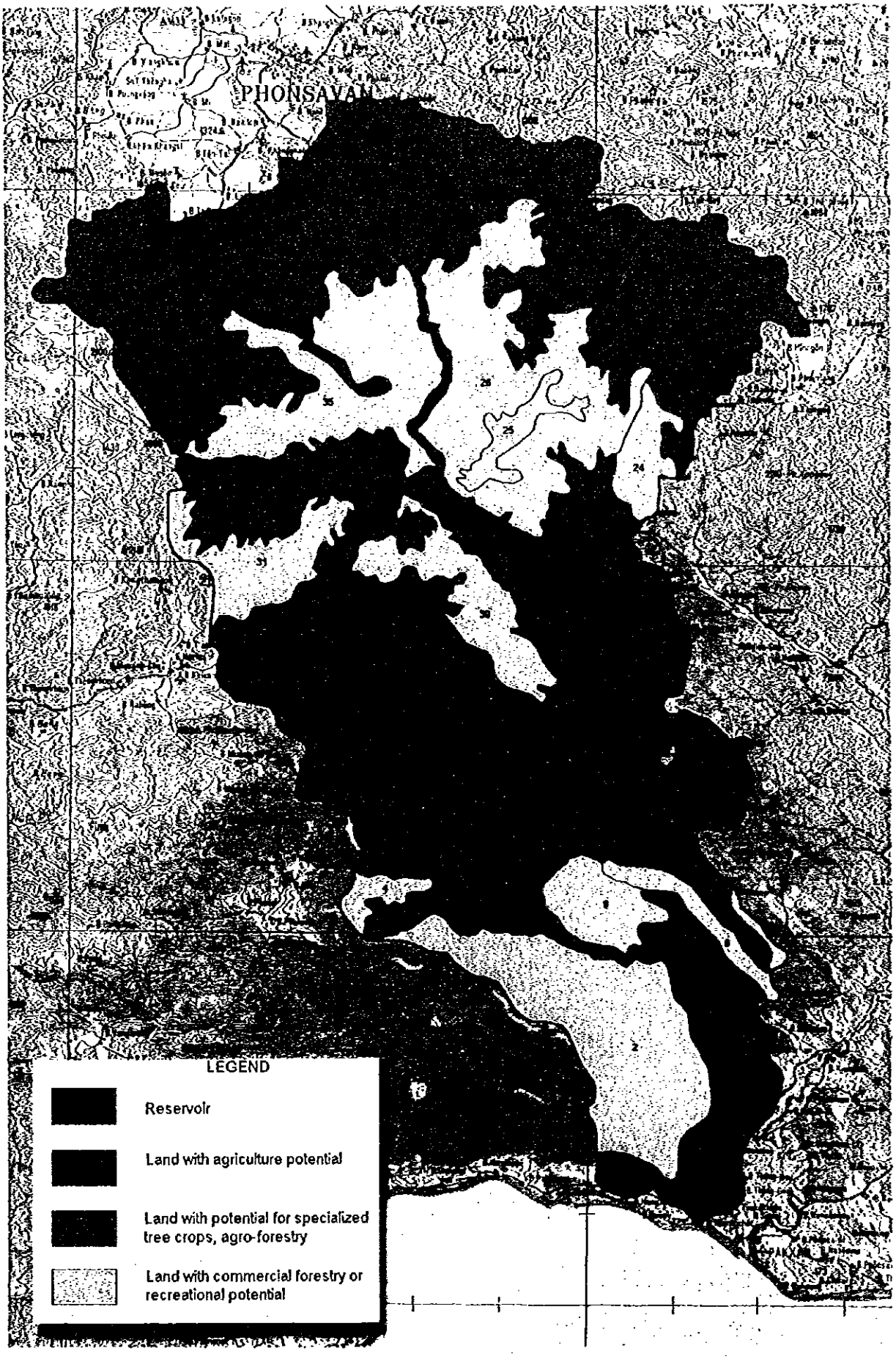
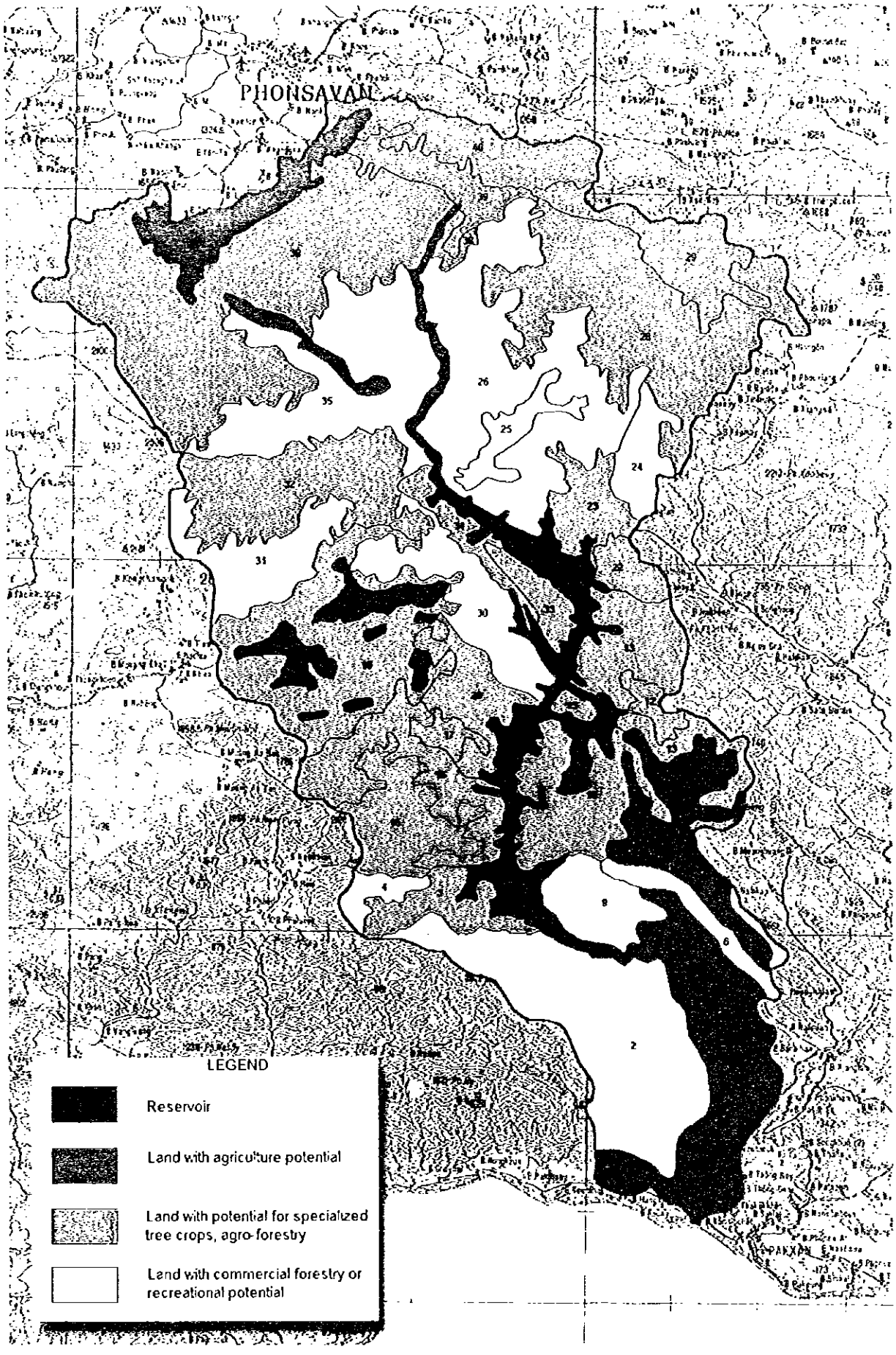
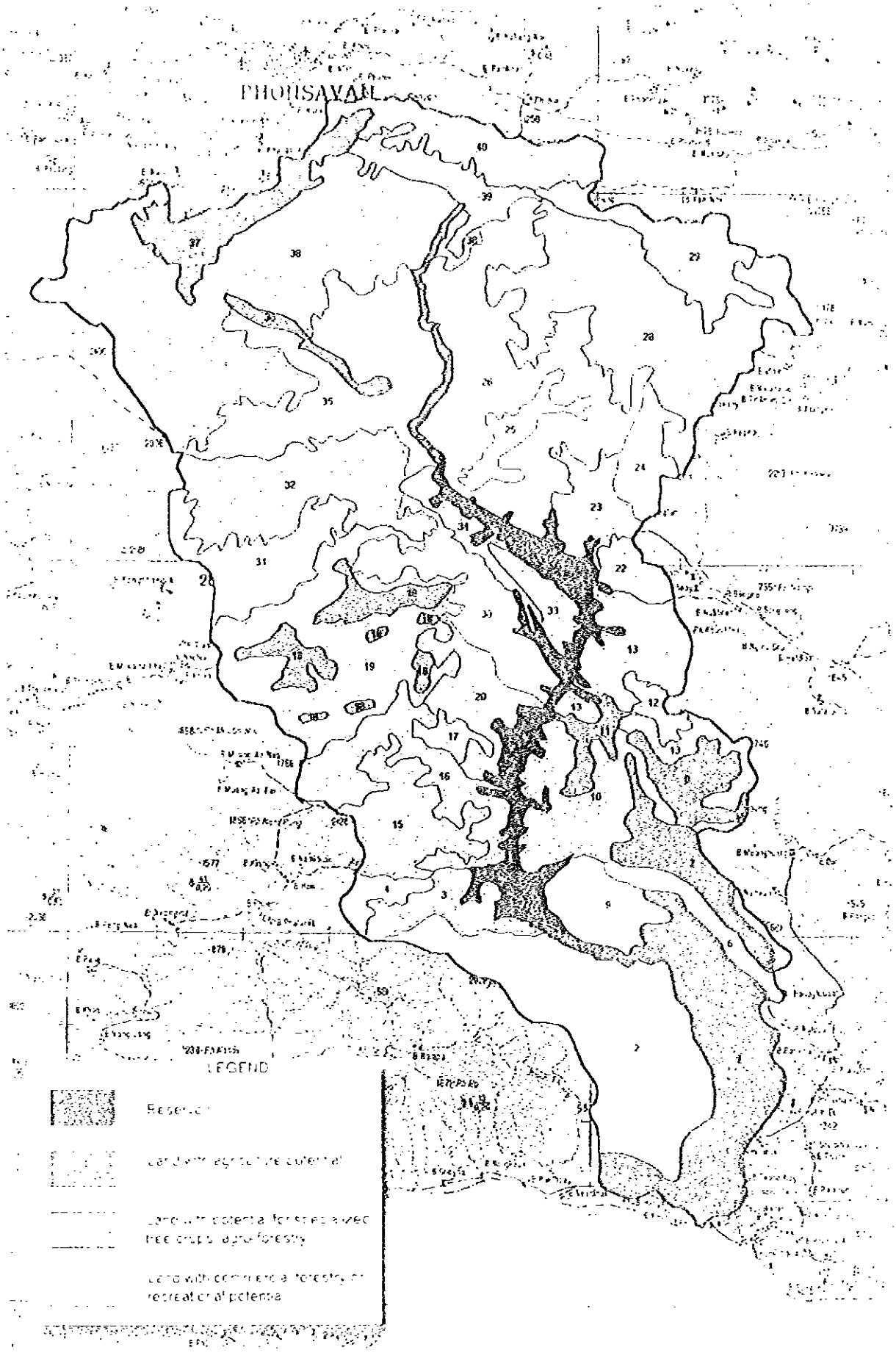


FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	FIRST ENVIRONMENTAL IMPACT ASSESSMENT	Figure 4.9
	POTENTIAL FOR DEVELOPMENT IN THE CATCHMENT AREA	



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 4.9
	POTENTIAL FOR DEVELOPMENT IN THE CATCHMENT AREA	



POTENTIAL FOR REVEGETATION
IN THE CATCHMENT AREA

Table 4.18 Identified Trees in the Nam Ngiep Catchment

Family	Species	Lao Name	Area
Anacardiaceae	Allospondias lakonensis	Ho	2,3,10
Anacardiaceae	Choerospondias axillaris	Meu	14
Anacardiaceae	Mangifera sp.	Muang pa	2,3,5,9
Anacardiaceae	Melanorrhoea sp.	Na:m kiang daeng	2,3
Anacardiaceae	Spondius cytherea	Kok	3,10,21,34
Annonaceae	Polyalthia memoralis	Haek	2,3,5,9,14
Annonaceae	Polyalthia simlarum	Nyang de:n	2,3,5,9,10
Apocynaceae	Alstonia scholaris	Tin pe:t	2,14,2,3
Apocynaceae	Wrightia tomentosa var. cochinchinensis	Mu:k muk	2,3
Bignoniaceae	Oroxylum indicum	Lin mai:	14
Bignoniaceae	Stereospermum chelnoides	Khae say	2,3
Bignoniaceae	Stereospermum fimbriatum	Khae foy	2
Burseraceae	Canarium kerii	Leuam	2,21,34
Burseraceae	Canarium sp.	Nyang kai:	2,3
Combretaceae	Terminalia catappa	Hu kwang	10
Combretaceae	Terminalia chebula	So:m mo	2,3
Combretaceae	Terminalia chebula var. citrana	So:m mo	2,3,5,9
Combretaceae	Terminalia myriocarpa	Khaew neua	14
Comretaceae	Terminalia belerica	Haen	3
Coniferae Araucariaceae	Cunninghamia sinensis	Long leng	2,3
Datiscaceae	Tetrameles nudiflora	Sa: phu:ng	2,3,10,14
Dilleniaceae	Dillenia kerrii	San khaeng	2,3,21,34
Dilleniaceae	Dillenia sp.	San phao	14
Dipterocarpaceae	Anisoptera cochinchinensis	Bak	3
Dipterocarpaceae	Anisoptera costata	Bak	2
Dipterocarpaceae	Anisoptera robusta	Bak	2,10
Dipterocarpaceae	Dipterocarpus alatus	Nyang khao	2,10
Dipterocarpaceae	Dipterocarpus costatus	Nyang daeng	2
Dipterocarpaceae	Dipterocarpus intricatus	Nyang sa baeng	2,3
Dipterocarpaceae	Dipterocarpus turbinatus	Nyang daeng	2
Dipterocarpaceae	Hopea ferrea	Khaen hin	2,3,5,9,10
Dipterocarpaceae	Shorea harmandii	Khaen kha: nyom	2
Dipterocarpaceae	Shorea hypochra	Khaen khai:	2
Dipterocarpaceae	Vatica cinerea	Si khao	2,3,5,9,10
Dipterocarpaceae	Vatica dyeri	Si peuak bang	2
Dipterocarpaceae	Dipterocarpus tuberculatus	Kung	2,3,14
Ebenaceae	Diospyros chevalieri var. mekongensis	Koh	14
Ebenaceae	Diospyros decandra	Cha:n	2
Ebenaceae	Diospyros ehretioides	Heaun kwang	2
Ebenaceae	Diospyros embryopteris	Na:ng haeo	2,3
Ebenaceae	Diospyros filipendula	Kho leuang	3
Ebenaceae	Diospyros mum	Na:ng da:m	2,3
Ebenaceae	Diospyros rubra	La:ng da:m	2,3,5,9,10
Elaeocarpaceae	Elaeocarpus integripetalus	Kok don	14
Elaeocarpaceae	Elaeocarpus robusta	Bi mi	3,10,14
Elaeocarpaceae	Elaeocarpus siamensis	Mu:n	3
Elaeocarpaceae	Elaeocarpus sp.	Pi tong	2,3
Euphorbiaceae	Aporosa sp.	Meuat do:ng	3
Euphorbiaceae	Aporosa sphaerosperma	Meuat nyai:	2
Euphorbiaceae	Baccaurea oxycarpa	Fai:	2,3
Euphorbiaceae	Bischoffia javanica	Kho:m fat	2,3,5,9
Euphorbiaceae	Chaetocarpus castanocarpus	Bo:k khay	2,14
Euphorbiaceae	Croton joufra	Pao:	2,3
Euphorbiaceae	Hura crepitans	Pho tha: le	2,3,5,9,14
Euphorbiaceae	Mallotus cocinchinensis	Lat kua	21,34
Euphorbiaceae	Mallotus philippinensis	Khi mon	2
Euphorbiaceae	Microdesmis casaeriaefolia	Du:k khai	2,14
Euphorbiaceae	Microdesmis sp. (?)	Du:k khao	2,3,5,9
Euphorbiaceae	Phyllanthus emblica	Kham pom	3
Euphorbiaceae	Trewia nudiflora	Pop	10,14
Euphorbiaceae	Trewia nudiflora	Pop	14
Fagaceae	Castanopsis fleuryi	Ko mong	21,34
Fagaceae	Castanopsis hystrix	Ko deng	2,3
Fagaceae	Castanopsis laotica	Ko daek	5,9
Fagaceae	Lithocarpus trimcatus	Ko deauy	2

Family	Species	Lao Name	Area
Flacourtiaceae	Hydnocarpus anthelmintica	Ka bao:	2,3,10,14
Gramineae	Dendrocalamus brandisii	Ho:k	21,34
Gramineae	Schizostachyum zollingeri	Hia	2,3,14,21,34
Gramineae	Thyrsostachys sp.	Hae	14,21,34
Gramineae	U	Kong pi	2,3
Gramineae	U	Luang khao: khway	2
Guttiferae	Calophyllum sp.	Nyang so:ng	3,5,9,10,14
Guttiferae	Garcinia ferrea	Kua:k	2
Guttiferae	Garcinia multiflora	Phong	2,3,14
Hypericaceae	Cratoxlylon polyanthum	Tiu leuang	2
Hypericaceae	Cratoxlylon prunifolium	Tiu daeng	3
Lauraceae	Chisocheton sp.	Kuang	14
Lauraceae	Cinnamomum iners	Si khai: to:n	3
Lauraceae	Cinnamomum litsaefolium	Chuang	2
Lauraceae	Lauraceae sp.	Kuang daeng	14
Lauraceae	Litsea glutinosa	Mi tho	2,3
Lauraceae	Litsea polyantha	Mi do:ng	2,3
Lauraceae	Litsea sp.	Mi me:n	2,14
Lauraceae	Nothaphoebe umbelliflora	Ya bong	2
Leguminosae	Adenanthera microspenna	La:m ta khway	2,3
Leguminosae	Adenanthera pavonina	La:m	5,9
Leguminosae	Adenanthera sp.	La:m ta kai:	2,3,5,9
Leguminosae	Albizzia lebbekoides	Khang hu:ng	14
Leguminosae	Albizzia lucida	Sa: khae:	3,10,14
Leguminosae	Dalbergia cochinchinensis	Pa: do:ng khao	10
Leguminosae	Dalbergia cultrata	Ka bo	2
Leguminosae	Dalbergia kerrii	Ket	2,3,5,9
Leguminosae	Dalbergia nigrescens	Pa: do:ng khao	2,3
Leguminosae	Desmodium gyrans (?)	Du:k khlat	2
Leguminosae	Erythrina ovalifolia	Thong lang	2,3,21,34
Leguminosae	Leucaena sp.	Ka:nthin	5,9,14
Leguminosae	Ormosia cambodiana	Kha khi mu	2,3,5,9,14
Leguminosae	Parkia streptocarpa	Hua lo:n	21,34
Leguminosae	Pithecellobium clypearia	Sa: thon	2
Leguminosae	Pterocarpus macrocarpus	Du	5,9
Leguminosae	Sindora cochinchinensis	Tae ho	2,3
Lythraceae	Lagerstroemia angustifolia	Peuay dok khao	2,3,14
Lythraceae	Lagerstroemia anisoptera	Khaew neua	2
Lythraceae	Lagerstroemia balancae	Peuay lan	5,9,10,14,21,34
Lythraceae	Lagerstroemia calyculata	Peuay dok khao	14
Lythraceae	Lagerstroemia floribunda	Peuay na:m	14
Lythraceae	Lagerstroemia sp.	Peuay en	3,14
Magnoliaceae	Michelia alba	Cham pi	2,3,14,21,34
Mavaceae	Bombax albidum	Ngiu pa	2,3
Mavaceae	Hibiscus macrofilus (?)	Po khao	2
Meliaceae	Aglaia euphoriodes	Daeng do:ng	2
Meliaceae	Aglaia merostela	Kong	5,9,14
Meliaceae	Aphanamyxis cochinchinensis	Kong ta seua	2,14,21,34
Meliaceae	Aphanamyxis polystachya	Ta seua	5,9
Meliaceae	Chukrassia tabularis	Nyo:m khao	2
Meliaceae	Dysoxylum procerum	Kong ta seua	14
Meliaceae	Melia azedarach	Ka: dao sang	2,3
Meliaceae	Toona febrifuga	Nyo:m hom	2,3,10
Meliaceae	Toona sinensis	Nyom fot	2,3,10,14
Moraceae	Antiaris toxicaria	Nong	2,3,10,14
Moraceae	Artocarpus asperula	Hat	2,3,14,21,34
Moraceae	Artocarpus lakoocha	Hat mi	3
Moraceae	Artocarpus sp.	Hat lai:	2,3
Moraceae	Broussonetia papyrifera	Po sa	21,34
Moraceae	Ficus gibbosa	Hai:	2,5,9
Moraceae	Ficus hispada	Deua pong	10
Moraceae	Ficus sp.	Hai: kham	2,3,10,14
Moraceae	Streblus asper	So:m pho	14,21,34
Myrtaceae	Eucalyptus sp.	Si khai: to:n	2
Myrtaceae	Eugenia compongensis	Va khi no:k	2
Myrtaceae	Eugenia jambolana	Va so:m phu	2,3
Myrtaceae	Eugenia logiflora	Va choy	2

Family	Species	Lao Name	Area
Myrtaceae	Eugenia sp.	Va kaew	2,3
Myrtaceae	Eugenia/syzygium spp.	Va	2
Palmae	Arenga saccharifera	Tao tat	2,3
Palmae	Caryota mitis	Tao hang	21,34
Palmae	Wallichia gracillis	Tao	2,3
Platanaceae	Platanus kerrii	Peuay na:m	14
Rhizophoraceae	Carallia brachiata	Bo:ng na:ng	2,3,5,9,14,21,34
Rhizophoraceae	Carallia lucida	Bo:ng na:ng	2
Rubiaceae	Anthocephalus chinensis	Sa:ko	14,21,34
Rubiaceae	Gardenia erythroclada	Muy daeng	2
Rubiaceae	Nauclea orientalis	Kan leuang	2
Rubiaceae	Sarcocephalus cordatus	Kan leuang	2,5,9
Rutaceae	Zanthoxylum sp.	Khaen kheua	2
Sapindaceae	Pometia eximia	Kuang	2,3,10,14
Sapindaceae	Pometia pinnata	Ko	2,3,10
Sapindaceae	Xerospermum laoticum	Kho laen	2,3
Sapotaceae	Achras sapota	Mak la:mut	14
Simarubaceae	Ailanthus malabarica	Nyo:m pa	2,3,5,9
Simarubaceae	Ivingia harmandia	Bo:k	2,10
Sonneratiaceae	Duabanga grandiflora	Te:n	2,3,10,14,21,34
Sonneratiaceae	Duabanga sonneratioides	Ling ngo	3,14
Sterculiaceae	Heritiera javanica	Hao	2,3,21,34
Sterculiaceae	Pterocymbium dussaudii	Po dan	14
Sterculiaceae	Sterculia alata	Po daeng	2,3
Sterculiaceae	Sterculia sp.	Po tae	2,5,9,14
Sterculiaceae	Sterculia thorelii	Po daeng	2,3,14
Ternstroemiaceae	Anneslea fragrans	Kaem o:n	2,3
Ternstroemiaceae	Schima wallichii	Mi	21,34
Tiliaceae	Grewia paniculata	Khom so:m	2,3
Tiliaceae	Grewia sp. (?)	Po ka: hok	2
Tiliaceae	Pentacme burmanica	Si siat	3

4.6.4. TIMBER AND VEGETATION BIOMASS

4.6.4.1. COMMERCIAL TIMBER VOLUMES

Three sampling sites to assess timber volumes have been surveyed to date in the inundation zone. The preliminary results are detailed in the following table.

Table 4.19 Commercial Timber Volumes

Sample Site Number	Land System	Area (km2)	Total Number of stems per hectare	Number of commercial stems/ha	Average Stem Diameter Breast Height at 1m	Cu.m Hectare (commercial timber volume)
1	14	32	15	3	33.7	9.7
2	14	32	178	83	54.5	396.3
3	21	80	43	8	51.1	35.0
Mean			79	31	46.4	147.0
Standard Deviation			71	37	9.1	176.6
Mean (excluding 2)			**29**	**6**	**42.4**	**22.4**
Standard Deviation (excluding 2)			**14**	**3**	**8.7**	**12.7**

Sample site 2 was in a particularly dense patch of forest. Only about 5% of the inundation zone surveyed is covered by forest of this density. The reservoir-wide density of commercial timber will be between 15 and 35 m^3/ha.

It has to be cautioned that these results are from a very small number of sampling sites in a limited area of the inundation zone. In addition the lower reservoir LS5 has yet to

be surveyed. From visual inspections it seems to have much lower timber volumes due to the large areas under cultivation.

The results to date (excluding sample plot 2) suggest that there could be approximately 40 stems per ha to be extracted with a maximum of 30-35m^3/ha to be removed. Again it has to be stated that the more densely populated areas of the upper and lower reservoir have yet to be surveyed. The defects found in the timber in Lao forests, the lack of a differentiated timber market and the nature of logging (i.e. untrained subcontractor felling, old equipment etc), make it unlikely that more than 30-50% of the potentially commercial timber would be extracted from the reservoir area.

Logging operations in Laos are unmechanised and not apparently very profitable. The relatively low timber volume density in the reservoir presents almost no opportunities for real profit. In addition small scale logging operations have probably already extracted the most valuable stems from the upper and lower reservoir over the past 3 to 4 years.

Logging could only become commercially viable as part of a comprehensive biomass clearance programme, if modern management and modern equipment were to be deployed.

Experience with other reservoirs shows that poorly managed logging carries the risk of generating adverse international publicity. The issue will require careful co-ordination of the numerous interest groups which control different facets of logging in the Lao PDR.

In any case, further detailed investigations during next stage of the study are required to draw an appropriate logging program.

4.6.4.2. VEGETATION BIOMASS

Three sampling sites to assess vegetation biomass have been surveyed to date in the inundation zone. The results for each sample plot are shown below in Table 4.20. Each biomass component has been converted to a density of tons per hectare undried biomass. Tree stems are shown as numbers per hectare in the large (dbh >20cm) and small (3cm<dbh<20cm) categories. The individual sampling plots have then been combined to produce the density of undried biomass for the different biomass components and the number of trees per hectare for all the sample plots.

In Table 4.21, the biomass density information has been combined and analyzed to show undried biomass densities in tonnes per hectare for different decomposition types of biomass, and their total weights for the inundation zone.

Table 4.20 Density of Biomass Components

Sample Site	LS	Quadrate	Litter tons/ha	Low Veg tons/ha	Dead Wood tons/ha	Live Bamboo tons/ha	Dead Bamboo tons/ha	Lianas tons/ha	Tree Stems tons/ha	Tree Foliage tons/ha	No. Large Trees	No. Small Trees
1	14	1	6.2	4	0	40.6	14.6	0	21.3	9.3	0	2000
2	14	1	7.0	2.1	0	3.6	4.3	0	334.8	12.8	400	800
3	21	1	5.8	1.8	8.2	0	0	13.2	334.9	11.5	400	400
Mean			6.3	2.6	2.7	14.7	6.3	4.4	230.3	11.2	266.7	1066.7
Standard Deviation			0.5	1.0	3.9	18.3	6.1	6.2	147.8	1.4	188.6	249.4

Table 4.21 Rapid and Slowly Degradable Biomass (undried)

	Area (ha)	Rapidly Decomposed Biomass		Slowly Decomposed Biomass		All Biomass	
		Density Tons/ha	Total Weight ('000 t)	Density Tons/ha	Total Weight ('000 t)	Density Tons/ha	Total Weight ('000 t)
ALL	14,820 (FSL)	45.5	709.8	233	3,634.8	278.5	4,344.6

The overall undried above ground biomass density of 278.5 tonnes per hectare is comparable to findings of the Nam Leuk Biomass survey (289.8 undried above ground biomass density). It has to be cautioned that these results 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.

4.6.5. 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. In addition the area surveyed was rather limited when taking into account the size of the catchment. Forty land system units were identified from analysis of 1:50,000 scale maps of which only 13 (LS 1, 2, 3, 5, 6, 7, 9, 10, 14, 16, 20, 21 and 34) have been traversed. Mainly due to problems of access and security, it was not possible for the survey team to traverse any more of the LS's. This survey will therefore present only a very fragmented view of the Nam Ngiep catchment.

The rate at which animal sounds and/or signs were encountered were much higher than was found in comparable surveys made in the Xe Kaman basin, in Xaignabouli (SFE6) Province, western Vientiane Province (SFE9) and in the Middle Nam Leuk Basin. 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.

A list of birds sighted in the catchment is listed in following Table 4.22. A list of mammals and reptiles sighted in the catchment is presented in Table 4.23.

Table 4.22 List of Birds Observed in the Nam Ngiep Catchment

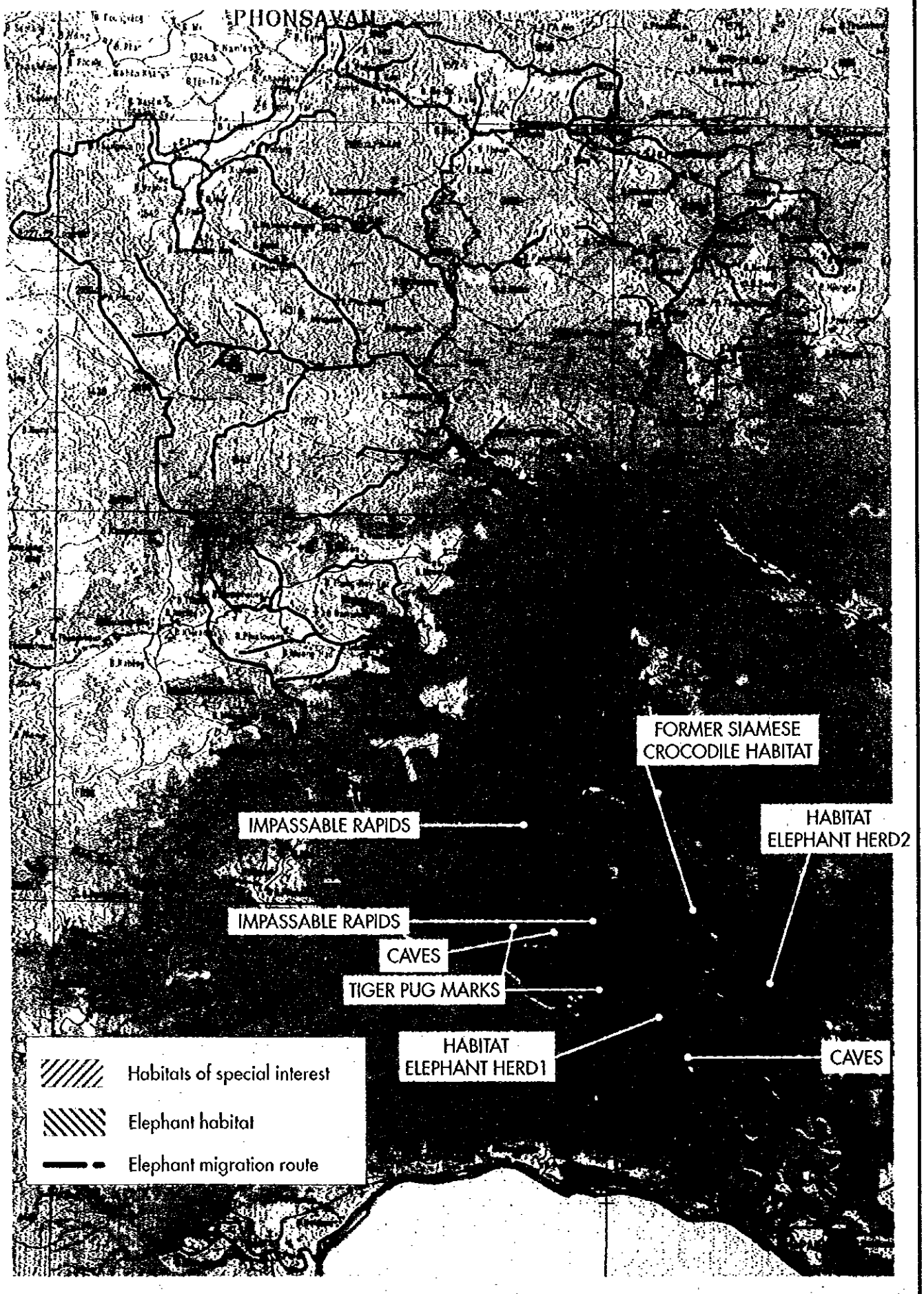
Species Name	English Name	Type of sightingCall	Direct Sighting	Pug Marks	Scratching	Eggs	Feather	Specimen	Observed in Land System	Observed in Habitat Type
Accipitridae										
Accipter badius	Shikra	1	8	0	0	0	0	0	1,5,20	Riverine, Forest
Icthyophaga nana	Lesser Fish Eagle	0	12	0	0	0	0	0	5,14,21	Riverine
Spilornis cheela	Crested Serpent Eagle	0	1	0	0	0	1	0	2,5	Riverine
Alaudidae										
Mirafra javanica	Singing Bushlark	1		0	0	0	0		1	Forest
Alcedinidae										
Alcedo euryzonia	Blue Banded Kingfisher	0	8	0	0	0	0	0	5,14	Riverine
Alcedo Meninting	Blue Eared Kingfisher	0	2	0	0	0	0	0	5,14	Riverine
Ceryle lugubris	Crested Kingfisher	0	1	0	0	0	0	0	14	Riverine
Halcyon chloris	Black Capped Kingfisher	0	3	0	0	0	0	0	1,2,5	Riverine
Lacedo pulchella	Banded Kingfisher	0	0	0	0	0	0	1	14	Riverine
Apodidae										
Apus pacificus	Fork Tailed Swift	0	5	0	0	0	0	0	5	Riverine
Ardeidae										
Butorides striatus	Little Heron	0	16	0	0	0	0	0	5,14,21	Riverine
Egretta intermedia	Plumed Egret	0	3	0	0	0	0	0	1	Riverine
Ixobrychus cinnamomeus	Cinamon Bittern	0	1	0	0	0	0	0	5	Riverine
Bucerotidae										
Anthracocerus albirostris	Indian Pied Hornbill	1	10	0	0	0	0	1	1,14,20	Riverine, Forest
Campephagidae										
Pericrocotus cinnamomeus	Small Minivet	2		0	0	0	0	0	1, 2	Forest
Capitonidae										
Megalaima asiatica	Blue Throated Barbet	9	0	0	0	0	0	0	2,3,5	Riverine, Forest
Megalaima asiatica	Blue Eared Barbet	2	1	0	0	0	0	0	5,20	Forest
Megalaima chrysopogon	Gold Whiskered Barbet	9	1	0	0	0	0	0	1,5,20,21	Riverine, Forest
Megalaima faiostricta	Green Eared Barbet	2	0	0	0	0	0	0	3	Riverine, Forest
Megalaima franklinii	Golden Throated Barbet	1	0	0	0	0	0	0	5	Riverine
Megalaima haemacephala	Coppersmith Barbet	3	0	0	0	0	0	0	1,5	Riverine
Megalaima incognita	Moustached Barbet	1	0	0	0	0	0	0	3	Forest
Megalaima rafflesii	Red Crowned Barbet	1	0	0	0	0	0	0	10	Forest
Megalaima spp.	Barbet	5	0	0	0	0	0	0	1,2	Riverine, Forest
Caprimulgidae										
Caprimulgus indicus	Grey Nightjar	0	7	0	0	0	0	0	1,5	Riverine
Chloropseidae										
Chloropsis cyanopogon	Blue Winged Leaf Bird	0	0	0	0	0	0	1	14	Riverine
Columbidae										
Chalcophaps indica	Green Winged Pigeon	1	2	0	0	0	0	0	1,5	Riverine
Ducula badia	Mountain Imperial Pigeon	1	2	0	1	0	0	0	1,10	Forest
Streptopelia orientalis	Oriental Turtle Dove	1	1	0	0	0	0	2	1,5,10	Forest
Streptopelia tranquebarica	Spotted Dove	0	1	0	0	0	0	1	14	Riverine
Treron bicincta	Orange Breasted Pigeon	0	1	0	0	0	0	0	10	Forest
Treron curvirostra	Thick Billed Pigeon	0	1	0	0	0	0	1	2,20	Forest
Treron vernans	Pink Necked Pigeon	1	2	0	0	0	0	1	1,2,21	Forest
Corvidae										
Corvus macrorhynchos	Large-Billed Crow	0	1	0	0	0	0	0	1	Forest
Pica pica	Black-Billed Magpie	5	0	0	0	0	0	0	1, 2	Forest
Dendrocitta vagabunda	Rufous Treepie	1	0	0	0	0	0	0	1	Forest
Crrpsirina temia	Racket-Tailed Treepie	1	0	0	0	0	0	0	1	Forest

Species Name	English Name	Type of sighting/Call	Direct Sighting	Pug Marks	Scratching	Eggs	Feather	Specimen	Observed in Land System	Observed in Habitat Type
Cuculidae										
Phaenicophaeus tristis	Green-Billed Malkoha	2	2	0	0	0	0	0	1, 2	
Centropus sp.	Coucal	1	0	1	0	0	0	0	1, 2	Riverine
Centropus bengalensis	Lesser Coucal	2	1	0	0	0	0	0	1,2,5	Riverine
Centropus bengalensis	Greater Coucal	0	2	0	0	0	0	0	14	Riverine
Dicruridae										
Dicrurus aeneus	Bronzed Drongo	1	2	0	0	0	0	1	5,14	Riverine
Dicrurus macrocercus	Black Drongo	1	3	0	0	0	0	0	1,14,21	Riverine, Forest
Dicrurus paradiseus	Greater Racket Tailed Drongo	6	12	0	0	0	0	0	1,2,5	Riverine
Dicrurus remifer	Lesser Racket Tailed Drongo	0	1	0	0	0	0	0	14	Riverine
Eurylaimidae										
Psarisomus dalhousiae	Long Tailed Broadbill	0	1	0	0	0	0	1	14,20	Riverine, Forest
Hirundinidae										
Delichon dasypus	Asian House Martin	1	10	0	0	0	0	0	1,14	Riverine
Hirundo rustica	Barn Swallow	0	47	0	0	0	0	0	1,2,14	Riverine
Motacillidae										
Motacilla cinerea	Grey Wagtail	0	5	0	0	0	0	0	5,14	Riverine
Dendronanthus indicus	Forest Wagtail	0	0	2	0	0	0	0	1	Riverine, Forest
Muscicapidae										
Cyornis unicolor	Pale Blue Flycatcher	1	0	0	0	0	0	0	2	
Nectariniidae										
Aethopyga siparaja	Crimson Sunbird	1	0	0	0	0	0	1	5,20	Forest
Nectarinia asiatica	Purple Sunbird	1		0	0	0	0	0	1	
Oriolidae										
Irena puella	Asian Fairy Blue Bird	1	0	0	0	0	0	3	3,5,14	Riverine, Forest
Phasianidae										
Arborophila brunneopectus	Bar-Backed Partridge	1	0	0	0	0	0	0	1	Forest
Arborophila davidi	Scaley Breasted Partridge	3	2	0	1	0	0	1	1,14	Forest
Gallus gallus	Red Junglefowl	2	3	0	1	2	0	7	1,2,3,21	Forest
Lophura diardi	Siamese Fireback	0	10	0	0	0	0	1	1,10	Forest
Polyplectron bicalcaratum	Grey Peacock Pheasant	7	0	0	0	0	0	4	2,3,5,14, 16,20	Forest
Francolinus pintadeanus	Chinese Francolin	0	1	0	0	0	0	0	1	Forest
Pittidae										
Pitta phayrei	Eared Pitta	0	0	0	0	0	0	1	5	Forest
Pitta cyanea	Blue Pitta	1	0	0	0	0	0	0	1	Forest
Psittacidae										
Psittacula alexandri	Red Breasted Parakeet	0	1	0	0	0	0	0	14	Forest
Psittacula eupatria	Alexandrine Parakeet	0	1	0	0	0	0	0	5	Riverine
Psittacula finschii	Grey Headed Parakeet	0	20	0	0	0	0	0	2	Forest
Psittacula roseata	Blossom Headed Parakeet	1	51	0	0	0	0	0	1	Riverine, Forest
Pycnonotidae										
Criniger flaveolus	White Headed Bulbull	0	0	0	0	0	0	1	14	Riverine
Criniger flaveolus	White Throated Bulbull	1	0	0	0	0	0	0	20	Forest
Pycnonotidae										
Criniger pallidus	Puff Throated Bulbull	2	1	0	0	0	0	0	1,2,14	Riverine
Hypsipetes flavala	Ashy Bulbull	3	2	0	0	0	0	0	1,2,14,21	Forest
Hypsipetes thompsoni	White Headed Bulbull	0	5	0	0	0	0	1	5	Forest
Hysipetes charlottae	Buff Vented Bulbull	2	0	0	0	0	0	4	2,14,20	Riverine
Pycnonotus atriceps	Black-Headed Bulbul	1	0	0	0	0	0	0	1	Riverine, Forest
Pycnonotus eutilotus	Puff Backed Bulbull	3	0	0	0	0	0	0	2,5	Riverine

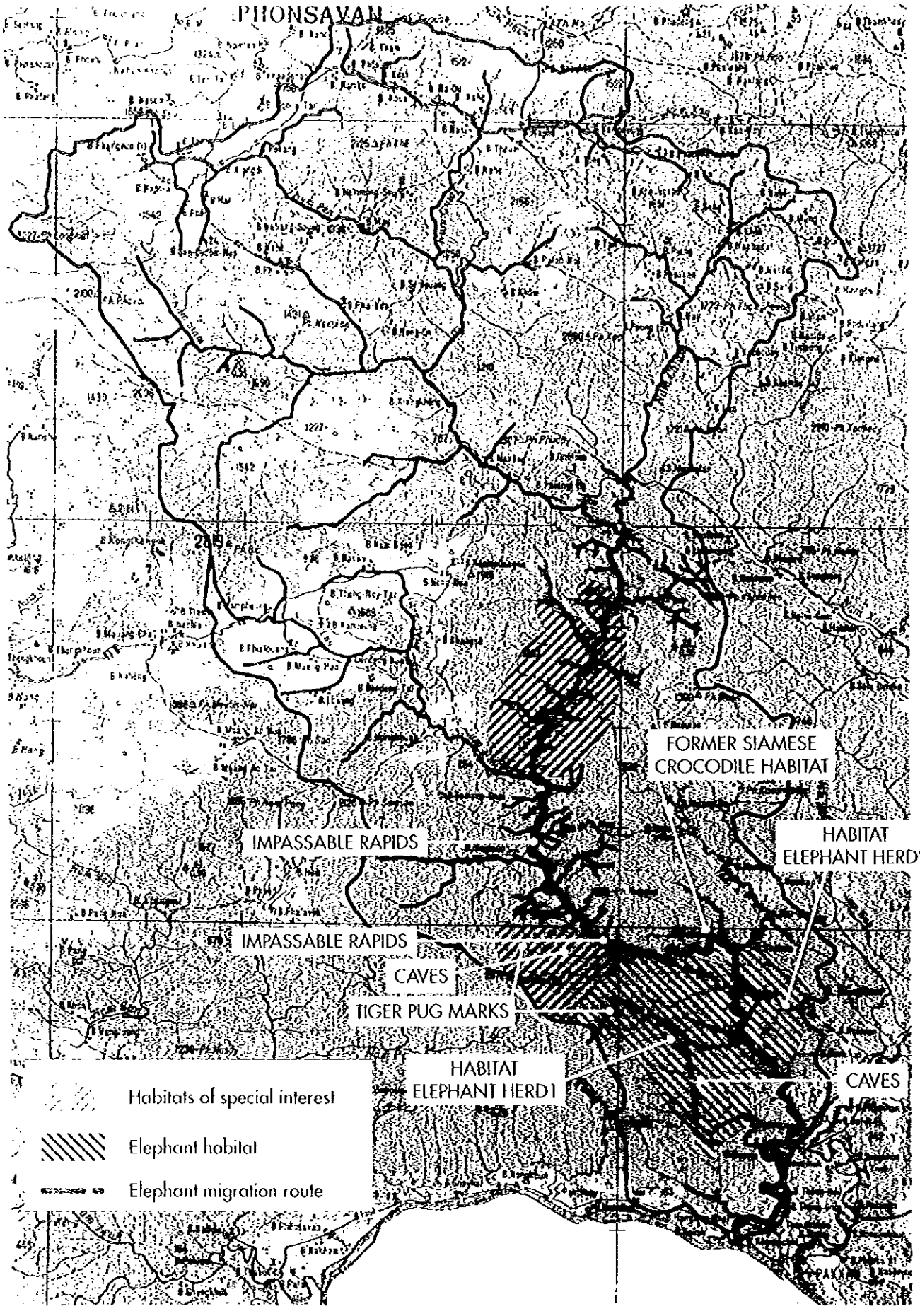
Species Name	English Name	Type of sighting/Call	Direct Sighting	Pug Marks	Scratching	Eggs	Feather	Specimen	Observed in Land System	Observed in Habitat Type
Pycnonotus finlaysoni	Stripe Throated Bulbull	0	1	0	0	0	0	1	1,14	Riverine, Forest
Pycnonotus flavescens	Flavescent Bulbull	1	1	0	0	0	0	0	3,21	Riverine, Forest
Pycnonotus jocosus	Red Whiskered Bulbull	0	0	0	0	0	0	1	14	Riverine
Pycnonotus melanicterus	Black Crested Bulbull	8	3	0	0	0	0	0	1,3,5,14, 20	Riverine, Forest
Pycnonotus simplex	Cream Vented Bulbull	1	0	0	0	0	0	0	5	Riverine
Pycnonotus striatus	Striated Bulbull	2	0	0	0	0	0	0	2,10	Forest
Rallidae										
Amaurornis phoenicurus	White Breasted Waterhen	0	1	0	0	0	0	1	5,14	Riverine
Rostratulidae										
Rostratula benghalensis	Greater Painted Snipe	0	1	0	0	0	0	0	14	Riverine
Strigiformes										
Ninox scutulata	Brown Hawk Owl	0	0	0	0	0	0	1	14	Forest
Otus scops	Common Scops-Owl	1	0	0	0	0	0	0	1	Forest
Otus spilocephalus	Mountain Scops-Owl	0	1	0	0	0	0	0	1	Forest
Sturnidae										
Aplonis panayensis	Philippine Glossy Starling	1	0	0	0	0	0	0	1	Forest
Gracula religiosa	Hill Myna	3	3	0	0	0	0	0	1,2	Forest
Sylviidae										
Phylloscopus davisoni	White-Tailed Leaf-Warbler	1	1	0	0	0	0	0	1	Forest
Seicercus burkii	Golden Spectacled Warbler	0	0	0	0	0	0	1	14	Riverine
Timalidae										
Gampsorhynchus rufulus	White Headed Babbler	1	0	0	0	0	0	0	16	Forest
Garrulax chinensis	Black Throated Laughingthrush	1	0	0	0	0	0	0	16	Forest
Yuhina gularis	Stripe Throated Yuhina	1	0	0	0	0	0	0	5	Riverine
Yuhina nigrimenta	Black Chinned Yuhina	1	0	0	0	0	0	0	5	Riverine
Garrulax leucolophus	White-Crested Laughingthrush	4	0	0	0	0	0	0	1, 2	Forest
Trogonidae										
Harpactes duvaucelii	Scarlet Rumped Trogon	0	0	0	0	0	0	1	20	Forest
Turdidae										
Copsychus malabaricus	White Rumped Shama	3	0	0	0	0	0	1	1,2,14	Forest
Myiophoneus caeruleus	Blue Whistling Thrush	0	0	0	0	0	0	1	5	Forest
Zoothera marginata	Dark-Sided Thrush	1	0	0	0	0	0	0	1	Forest
Turnicidae										
Turnix suscitator	Barred Buttonquail	0	0	0	0	0	0	2	2	Forest
Turnix tanki	Yellow Legged Buttonquail	2	0	0	0	0	0	0	2,20	Forest

The two areas where "rich communities" of fauna are found are highlighted in Figure 4.10. 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 elephants 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 4.10.



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 4.10
	AREAS OF SPECIAL INTEREST FOR BIODIVERSITY	



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 4.10
	AREAS OF SPECIAL INTEREST FOR BIODIVERSITY	

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.

Table 4.23 Mammals and Reptiles Observed in the Nam Ngiep Catchment

Species Name	English Name	Type of sighting: Faeces	Calls	Pug Mark	Direct sight	Specimen	Scratching post	Trail	Nest	Diggings	Observed in Land System	Habitat Type S=HILLS-DES, H=HIGH ALT; L=LOW ALT; R=RIVERINE; F=DENSE FOREST; FL=FLOODLAND; N=NONG, C=CAVE; O=OPEN WOODLAND
MAMMALS												
Bovidae												
Bos gaurus	Gaur	0	0	9	0	0	0	0	0	0	1	L,F
Capricornis sumatraensis	Serow	2	0	2	0	2	0	0	0	0	2,3,9	S,H,F
Cercopithecidae												
Macaca assamensis	Assamese Macaque	2	0	1	80	1	0	0	0	0	2	S,H,L,R,F
Macaca arctoides	Stump Tailed Macaque	0	0	0	3	0	0	0	0	0	3,16	S,H,F
Macaca mulata	Rhesus Macacque	0	0	0	>20	0	0	0	0	0	10	S,H,F,N
Presbytis phayrei	Phayre's Langur	0	0	0	0	1	0	0	0	0	2	S,H,F
Spp.	Monkey	0	0	3	0	0	0	0	0	0	2,14	S,H,F
Cervidae												
Cervus unicolor	Sambar	0	0	9	2	0	0	0	0	0	1,2,3,5,14	S,H,L,R,F,N
Cervus porcinus	Hog Deer	0	0	4	0	0	0	0	0	0	1	O,F
Muntiacus feae	Fea's Barking Deer	0	0	2	0	1	0	0	0	0	2,14	S,H,L,R,F,O,N
Muntiacus muntjak	Common Barking Deer	0	0	3	0	3	0	0	0	0	2,3,5,14	S,H,L,R,F,O,N
Muntiacus spp.	Barking Deer	1	3	14	0	0	0	0	0	0	1,3,5,16,21, 33	S,H,L,R,F,O,N
Spp.	Deer	4	0	27	0	0	1	0	0	0	3,14,21,33	S,H,L,R,F,O,N
Elephantidae												
Elephas maximus	Asiatic Elephant	38	0	21	0	0	0	7	2	1	1,2	H,L,F,N,O
Felidae												
Felis bengalensis	Leopard Cat	0	0	0	0	1	0	0	0	0	5	Unknown
Felis marmorata	Marbled Cat	0	0	0	0	1	0	0	0	0	5	Unknown
Felis spp.	Cat (Leopard or Fishing)	0	0	0	1 (Trap camera)	0	0	0	0	0	2	S,H,F,R
Felis spp.	Cat (small)	0	0	4	0	0	0	0	0	0	3,5,14	S,H,L,R,F,O,N
Felis spp.	Cat	0	0	3	0	0	0	0	0	0	21	R,F
Felis temmincki	Asian Golden Cat	0	0	0	0	1	0	0	0	1	5,14	S,H,R,F
Panthera tigris	Tiger	0	0	2	0	0	0	0	0	0	2	S,H,R,F
Hipposideridae												
Hipposideros lekaguli	Dr. Boonsong's Roundleaf Bat	0	0	0	0	4	0	0	0	0	3	C
Hystricidae												
Arthérurus macrourus	Bush Tailed Porcupine	0	0	2	0	1	0	0	0	2	2,3,5,14	S,H,L,R,F,FL,C
Hystrix brachyura	Malayan Porcupine	0	0	0	0	0	0	0	0	1	1	O,L,F
Manidae												
Manis javanica	Malayan Pangolin	1	0	1	0	3	0	0	0	3	1,3,14	Unknown
Muridae												
Mus spp.	Mouse	0	0	0	1	0	0	0	0	0	2	H,F
Pteropodidae												
Cynopterus sphinx	Greater Short-Nosed Fruit Bat	0	0	0	0	1	0	0	0	0	14	C
Macroglossus sobrinus	Greater Long-Tongued Fruit Bat	0	0	0	0	1	0	0	0	0	14	N
Megaerops ecaudatus	Tailless Fruit Bat	0	0	0	0	3	0	0	0	0	14	C
Rousettus amplexicaudatus	Geoffroy's Rousette	0	0	0	0	3	0	0	0	0	14	N
Rhinolophidae												
UNIDENTIFIED	Horseshoe Bat	0	0	0	30	0	0	0	0	0	2	C
Rhizomyidae												

Species Name	English Name	Type of sighting Faeces	Calls	Pug Mark	Direct sight	Specimen	Scratching post	Trail	Nest	Diggings	Observed in Land System	Habitat Type S=HILLSIDES, H=HIGH ALT; L=LOW ALT; R=RIVER/NE, F=DENSE FOREST; FL=FLOODLAND, N=NONG; C=CAVE, O=OPEN WOODLAND
Rhizomys spp.	Bamboo Rat	0	0	0	0	0	0	0	0	4	3,14,20	S,H,L,R,F,FL,O
Rhizomys sumatrensis	Large Bamboo Rat	0	0	0	0	2	0	0	0	0	3,14	S,H,L,R,F,FL,O
Sciuridae												
Callosciurus caniceps caniceps	Grey-Bellied Squirrel	0	0	0	0	5	0	0	0	0	2,3,5,14	S,H,L,R,F,FL,O
Callosciurus finlaysoni	Variable Squirrel	0	3	0	1	1	0	0	0	0	1,2,5	S,H,L,R,F,FL,O
Callosciurus flavimanus pranis	Belly Banded Squirrel	0	0	0	0	1	0	0	0	0	1	O
Callosciurus flavimanus thai	Belly Banded Squirrel	0	0	0	0	1	0	0	0	0	14	L,F
Callosciurus flavimanus zimmeensis	Belly Banded Squirrel	0	0	0	0	6	0	0	0	0	3	S,H,L,R,F,FL,O
Dremomys rufigenis	Red-Cheeked Squirrel	0	0	0	0	2	0	0	0	0	14	S,H,F
Lariscus insignis	Three-Striped Ground Squirrel	0	0	0	1	0	0	0	0	0	2	S,F
Petaurista elegans	Lesser Giant Flying Squirrel	0	0	0	0	1	0	0	0	0	14	S,F
Hylopetes phayrei	Phayre's Flying Squirrel	0	0	0	0	1	0	0	0	0	1	H,S,F
	Squirrel	0	5	0	1	0	0	0	1	0	2,3	S,H,L,R,F,FL,O
Suidae												
Sus scrofa	Common Wild Pig	0	0	22	1	3	0	0	0	3	1,2,3,5,14, 21	S,H,L,R,F,FL,O
Tragulidae												
Tragulus javanicus	Lesser Mouse Deer	0	0	1	0	2	0	0	0	0	1,5,14	S,H,L,R,F,O
Tragulus spp.	Mouse Deer	1	0	1	2	0	0	0	0	0	3,5,7	S,H,L,R,F,O
Tupaiidae												
Tupaia glis	Common Treeshrew	0	0	0	0	2	0	0	0	0	10,14	S,F
Tupaia spp.	Treeshrew	0	0	0	1	0	0	0	0	0	16	R,O
Ursidae												
Helarctos malayanus	Malayan Sun Bear	1	0	2	0	0	0	0	0	0	1,14	S,F,L,H,O
Selenarctos thibetanus	Asiatic Black Bear	2	0	5	0	0	0	0	1	5	1,2	S,H,F
UNIDENTIFIED	Bear	0	0	1	0	0	0	0	0	0	5	L,O
Viverridae												
ArctogaliDa trivirgata	Three-Striped Palm Civet	0	0	0	0	4	0	0	0	0	5,14	S,H,L,R,F,FL,O
UNIDENTIFIED	Civet	5	1	8	0	1	0	0	0	0	2,3,14,21	S,H,L,R,F,FL,N,O
Viverra zibetha	Large Indian Civet	0	0	0	1	1 (Trap camera	0	0	0	0	3,14	F,N
REPTILES												
Agamidae												
Physignathus cocincinus	Asian Water Dragon	0	0	0	1	10	0	0	0	2	1,5,10,14	O,R
Boidae												
Python reticulata	Reticulate python	0	0	0	1	0	0	0	0	0	2	R,O
Colubrine												
Pytas carinatus	Black Rat Snake	0	0	0	1	0	0	0	0	1	3,5	R
Rhabdopsis subminiatus	Red-Necked Keelback Snake	0	0	0	1	2	0	0	0	0	3,7,16	O
Elapidae												
Cobra spp.	Cobra	0	0	0	1	0	0	0	0	0	2	R,O
Ophiophagus hanah	King Cobra	0	0	0	0	1	0	0	0	0	7	O
Scincidae												
Mabuya multifasciata	Sun Skink (3)	0	0	0	0	3	0	0	0	0	2	
Varanidae												R
Varanus bengalensis	Yellow Tree Monitor	0	1	5	3	1	0	0	0	1		
Varanus salvato	Water Monitor	0	0	0	0	1	0	0	0	0	14	L,R

Several species of mammals observed by the Field Team are already considered as having a special conservation significance, either national or International, as presented in the following Table 4.24.

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 5/10/1989 on the Management and Protection of Wildlife, Aquatic Animals, Hunting and Fishing"*.

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 4.24 Mammals and Reptiles with Conservation Status

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	1
Bush Tailed Porcupine	Hystricidae	Artherurus macrourus			2
Malayan Pangolin	Manidae	Manis javanica		X	2
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	1
Water Monitor		Varanus salvator		x	2

4.7. SOCIAL AND ECONOMIC ENVIRONMENT

4.7.1. REGIONAL SOCIOECONOMIC BACKGROUND

The NNPP is in a region consisting of the southern portion of Xieng Khouang Province, primarily Khoune District; Eastern Xaysomboon and Hom District and Western Thathom District in Xaysomboon Special Zone; and Bolikhan and Pakxan Districts in Bolikhamsay Province.

The population of this region, upstream and downstream from the proposed dam site is over 110,000 persons in 250 villages.

Table 4.25 Summary of Estimated Regional Population and No. Villages

DISTRICT	POPULATON	VILLAGES
UPSTREAM		
Khoune	30,000	21
Xaysomboon	11,600	23
Thathom	7,500	33
Hom	6,600	31
Subtotal Upstream:	*55,700*	*108*
DOWNSTREAM		
Bolikhan & Pakxan	54,600	140
Subtotal Downstream:	*54,600*	*140*
TOTAL:	110,300	248

While the population upstream and downstream from the dam site is approximately even, the downstream area has transportation advantages that don't exist upstream. Highway 13 S, a paved highway that has been upgraded for some years, links the downstream area to Vientiane along the low-lying Mekong plain, access to Thailand across the Mekong is assured, and there is considerable boat traffic north and south along Nam Ngiep and Nam Xan Rivers. Rural electrification, already existing along Highway 13 S, is currently being put in place along Highway 4 northward to the district capital at Bolikhan. Irrigation has been expanding in the downstream region for some years, mainly through pumping stations placed directly on the Nam Ngiep to a limited extent but primarily on the Nam Xan. In general, the area downstream is developing at a rate that is not seen north of the dam site.

North of the dam site, while highways exist on the map, they have to date not for the most part been upgraded. Security issues are prominent in all the districts included in the region, and populations have tended to concentrate along roadsides partly for this reason. In general, subsistence agriculture is the rule, with little scope given the current restrictions in communication for commercialization. UXO contamination is a major factor of life and limits agricultural development, even reclaiming fields that were used prior to the Indo China War. In the neighboring Nam Ngum watershed area, per capita GDP was found to be around US$56, compared to US$390 for the Lao PDR overall.[1] This would probably apply to the upstream area of the NNPP as well.

4.7.2. PROJECT AREA SOCIOECONOMIC BACKGROUND

4.7.2.1. INUNDATION IMPACT ZONE

The entire NNHP Reservoir Area will be within the *Khetpiset* (Special Zone) Xaysomboon. Formerly part of Vientiane and Xieng Khouang Provinces, Xaysomboon was set up on July 23, 1994 to give the area special preference for community development. *Lao Soung* represent the majority of the population in the area (45%) followed by *Lao Theung* (35%) and *Lao Loum* (20%). The steep and rugged terrain of the area has been largely stripped of its primary forest cover, and extensive grass lands and bush fallow mixed with active swidden plots prevail on the hillsides. A proliferation of narrow river valleys supports irrigated rice production on terraced fields.

[1] BCEOM. 1999. *Final Nam Ngum Watershed Management and Development Strategic Framework.*

The *Upper Reservoir Area* of the proposed NNHP is within Thathom District, in Taviang Sub-District. With a population of approximately 7,500 people living in 33 villages, Thathom District has the second lowest population in Xaysomboon. The present National Route 4 to be upgraded to National Road 1 passes through the proposed Upper Reservoir area. The government plans to extend the national network with a center spine National Road 1. This road is strategically important for the social economic development of the country and will run from the northern-most point of Lao's border with China to Cambodia in the south, adding another 1,000km to the network.

The Upper Reservoir Area will also benefit from the transmission line route for the ADB-financed Power Transmission and Distribution Project, since line is along National Route 4. The district will have a even more strategic location when National Road 5 is completed, linking Thailand through Vientiane to Vietnam. The junction of NR 5 and NR 1 will be in the Taviang Sub-District of Thathom, the Upper Reservoir Area of the NNHP.

It's possible that with better transportation facilities in the Upper Reservoir Area, and with the high population density relative to cultivable land area in China and Vietnam, there could be an excellent potential in *niche* market items grown at high tropical elevations, in addition to more common place products such as cattle and beef, or reservoir fisheries.

The *Lower Reservoir Area* of the proposed NNPP is within Hom District, Xaysomboon. The District's population is approximately 6,600 people living in 31 villages, making it the least populated district in Xaysomboon. Hom District is 90% *Lao Soung* with some *Lao Theung* and *Lao Loum* making up balance.

4.7.2.2. CATCHMENT IMPACT ZONE

Most of the NNHP's catchment area is in Xieng Khouang Province, north of the proposed reservoir. Xieng Khouang is divided into seven districts (Paek, Kham, Khoun, Phoukood, Nonghet, Mork, and Phaxay), five of which are located on a mixture of lowland and hilly areas, and two within mountainous areas. The altitude is at an average of 1,200m in the central Xieng Khouang plateau and "means an excellent climate – not too hot in the hot season, not too cold in the cool season and not too wet in the rainy season." *Lao Loum*, *Lao Theung* and the *Lao Soung*, are respectively 60, 8 and 30% of Xieng Khouang's population.

While the Provincial capital at Phonsavan is without good road access, leaving the Xieng Khouang plateau relatively isolated and remote, currently a major road reconstruction program is underway to remedy this situation; and an ADB-financed Power Transmission and Distribution Project is bringing electrification to Phonsavan for the first time.

Both of these developments have implications for the development of the NNHP's proposed Upper Reservoir area, since the upgrading of National Road 1 will incorporate the old National Route 4 that passes through the villages in the proposed Upper Reservoir. The transmission line route for the above electrification project, from the Nam Leuk Hydroelectric Project, will pass through the Upper Reservoir Area and

extend rural electrification the Upper Reservoir villages as well.

Currently maize and a small quantity of rattan are exported to Vietnam. However, as pointed out by the recently published Watershed Management Study for the Nam Ngum Catchment Area, Vietnam presents an excellent potential as a future market for Xieng Khuang and the surrounding areas. This potential derives from its close proximity, historical political alignment, and high population density relative to cultivable land area. Another factor is in the Vietnamese consumer's culinary preference for a number of niche market items grown at high tropical elevations in addition to more common place products such as cattle and beef. These factors offer encouraging opportunities for upper watershed agriculture.

China is also a huge potential market for Lao produce, including all of the items demanded in Vietnam. Presently, for instance, dry season transport costs from Phonsavan to the nearest point in Yunnan Province are less than to Vientiane.

A number of efforts are underway, and more can be expected, that might tap the comparative advantage of the region, given an upgraded transportation system. IFAD is introducing fruit and nut trees – macadamia, Japanese apricots, pears, grapes, and Japanese chestnuts – through planting of tree rootstocks in Xieng Khouang Province. Also the Xieng Khouang International Farm Ltd., a private concern, has introduced a dairy cattle farm, where it provides silage for cattle stock and is producing and selling milk.[2]

Phu Bia Mining Ltd. has a mining concession that extends over a 5,000 square kilometer area centered around Phonsavanh. The area takes in most of Xieng Khouang Province and the northern part of Xaysomboon. Phu Bia is currently exploring for copper and gold, taking sediment samples from streams, ridges or other potential sites for these minerals.[3] Another concession in Kieng Khouang is held by Mekong Mining, about which the project has so far not learned much.

4.7.2.3. CONSTRUCTION SITES

There is little habitation near the proposed dam site. B.Hatieun, a small settlement around 9-10km downstream from the dam site, has been established for only about four years is slated for resettlement in the near future away from the Nam Ngiep by Bolikhan District. The villages of B.Namyouk and B.Sopyouk are even further away, approximately 15km upstream from the dam site. Therefore, it is likely that human habitation, paddy fields and so forth will not be affected by construction installations and areas for the present location of the dam, such as operator's villages, quarries, and so forth.

Some 10km of new road will be required to reach the dam site. Surveys will indicate the cultivated areas likely impacted by this road's RoW, although it is expected that most of the alignment will be through forested areas. Some minor land impacts are expected from transmission line towers.

[2] BCEOM. 1999. pp. 170-171.
[3] Handicap International. 1997a.

4.7.2.4. DOWNSTREAM IMPACT ZONE

The dam site itself, access roads, and transmission lines will be for the most part in Bolikhan and Pakxan Districts of Bolikhamsay Province. Bolikhamsay Province and its neighbor Khammuan Province to the south straddle the narrow, central 'neck' of the country, an area of moderately high mountains sloping southwest to meet the Mekong Valley. With good highway access to Vientiane and situated along the Mekong, the Downstream Area appears to be undergoing more economic growth than upstream of the dam. Its population is largely *Lao Loum,* followed by *Lao Theung* and relatively small numbers of *Lao Soung.*

Pakxan (35,000) is the capital of Bolikhamsay Province, near the mouths of both the Nam Ngiep and Nam Xan Rivers, where they feed into the Mekong River, and about 145km along National Route 13 southeastward from Vientiane. It functions as a commercial center as well as an army base (the military village of Komsipchet is on the Nam Ngiep River). On the opposite bank of the Mekong from Pakxan is the Thai town of Beung Kan. The local population is predominantly Phuan, a tribal Taï group, many of whom are Christians.[4]

The Study Team noted a good deal of agricultural development underway in Bolikhamsay Province. According to the Provincial Division of Industry and Irrigation, there were some 74 pumping stations in Province in 1998, and this was to increase to 120 by 1999. In Pakxan and Bolikhan Districts, most of the development in irrigation was using the Nam Xan River waters, through provision of electric pumps situated on floating platforms in the river itself. From maps at the provincial offices the JICA Study Team could count about 11 pumps along the Nam Xan and two on the Nam Ngiep River.

This was in conjunction with provision of electricity in 1999 along Highway 4, running north south between the Nam Ngiep and Nam Xan rivers and through Bolikhan's district headquarters. Provision of irrigation pumps was considerably more limited along the Nam Ngiep, though also taking place. The rural development strategy in villages along the Nam Ngiep was to relocate them when feasible eastward along Highway 4 and nearer the newly developed irrigated paddy fields. Highway 4 is a priority road for upgrading in the Province and will link Pakxan (and hence Vientiane) with the Upper Reservoir Area at Thaviang via B.Thasi on National Road 1 D when completed.

This expansion of irrigated paddy in Bolikhamsay Province takes place within a national context of an effort to break away from subsistence semi-natural resources economy towards market-oriented economy. Persistent rice supply problems prompted the GOL to initiate a rice self-sufficiency high-cost and high priority national program to enlarge rice-growing areas. Financing of the first phase of this initiative included purchasing pumps worth US$24 million (1997 exchange rates) and extending Bank of Lao (BOL) loans to farmers in areas suitable for paddy expansion. While the national expansion of irrigated rice went from 17,962ha in 1965 to 26,645ha in 1967, and from 71,500t to 113,500t, that for Bolikhamsay went from 80 ha to 444ha in the

[4] Cummings, Joe. 1998. p. 269.

same period and from 310t to 1,620t[5].

[5] Lao PDR. 1998. Table 24, p. 37. The yield went from 3.88 tons per hectare to 3.65 tons, compared nationally with a rise from 3.98 tons in 1965 to 4.26 tons in 1997 for irrigated rice. Maize went from 135 hectares to 940 hectares in Bolikhamsay, whereas the hectarage remain about the same nationally from 1995 to 1997.

CHAPTER - 5

IMPACT ANALYSIS & MITIGATION MEASURES

5. IMPACT ANALYSIS AND MITIGATION MEASURES

5.1. METHODOLOGY

The method for impact identification and analysis is based on two major parameters, the period in the life of the project and the area concerned.

The period is probably the most important basis for impact analysis, as activities and resulting impacts change drastically: the construction period, the filling period, and the operation period result in very different impacts, both in type, extent and magnitude.

Concerning the area, the analysis follows closely the typology of the Project area as presented in Section 4.1. For the purpose of clarity, the analysis will be carried out successively for each of the major environmental fields: land use, aquatic, biological, social.

All aspects related to social and resettlement issues are only summarized from the Preliminary Resettlement Plan, in order to provide the reader with a comprehensive understanding of the impact without referring systematically to another volume of this study.

Any impact of significant importance is analyzed and quantified for both alternatives considered in the study, FSL360m and FSL320m.

5.2. REVIEW OF ENVIRONMENTAL ISSUES

The first stage of the analysis consists in the screening of all potential impacts, which may result from the project implementation.

Tables 5.1 and 5.2 present a summary of all impacts anticipated from the Project according to the 3 periods of the project life, construction, filling and operation.

Table 5.1 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 waterph	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 5.2 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	Cleaning 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

5.3. CONSTRUCTION PHASE : IMPACTS AT CONSTRUCTION SITES

5.3.1. LAND USE AND LAND ACQUISITION

5.3.1.1. REQUIREMENTS AT CONSTRUCTION SITES

The Project will mainly consist of only one construction site, as the dam, the power house, the diversion tunnels and re-regulation structure are roughly located in the same area. Contractor's Installations, Workers camps and Operator village will most probably be built in the same zone, near the dam site. A total area of less than 100ha may be considered as a probable requirement to accommodate construction site and surrounding facilities. This is a very positive point, for subsequent monitoring of contractor's activities to have only one large site of activity.

Additional requirements must also be considered for quarries, borrow areas and disposal sites. At this stage of the Project, no detailed information is available on the location of these sites. It is expected that a significant amount of rockfill may be available from the area located immediately upstream of the dam, within the limits of the future reservoir. However, it is probable that other quarry sites will be required, at least for the high dam alternative. For sand and gravel, no information is available, but taking into consideration the large volumes required, it is doubtful that the needs can be totally satisfied locally. A possibility remains the Mekong River, from where most of the requirements for the recent Nam Leuk Project were extracted. At this stage of the study, it is not possible to estimate the area actually required for all these sites, but a range from 100 to 300ha is acceptable. About 90ha will be required for the re-regulation pond.

5.3.1.2. COMPENSATION PROCESS

There is little habitation near the proposed dam site. B.Hatieun, a small settlement around 9-10km downstream from the dam site, has been established for only about four years is slated for resettlement in the near future away from the Nam Ngiep by Bolikhan District. The villages of B.Namyouk and B.Sopyouk are even further away, approximately 15km upstream from the dam site. Therefore, it is likely that human habitation, paddy fields and so forth will not be affected by construction installations and areas for the present location of the dam, such as operator's villages, quarries, and so forth.

Some 10km of new road will be required to reach the dam site. Surveys will indicate the cultivated areas likely impacted by this road's RoW, although it is expected that most of the alignment will be through forested areas. Some minor land impacts are

expected from transmission line towers.

5.3.1.2.1. RESETTLEMENT

Since it is unlikely that human habitation, paddy fields and so forth will not be affected by construction installations and areas for the present location of the dam, such as operator's villages, quarries, and so forth, there should be no resettlement associated with the construction activities.

5.3.1.2.2. PERMANENT LAND ACQUISITION

Since it is unlikely that human habitation, paddy fields and so forth will not be affected by construction installations and areas for the present location of the dam, such as operator's villages, quarries, and so forth, the issue of permanent land acquisition associated with the construction activities should not be too serious, although there will need to be an assessment of 'traditional' uses of the area for livelihood activities and compensation made for these.

5.3.1.2.3. TEMPORARY USE OF LAND

This issue is much the same as for permanent land acquisition.

5.3.1.3. RECOMMENDATIONS

Areas to be used for quarrying, earth borrowing and spoil disposal must be situated as much as possible inside the future reservoir area, to minimize impact on land use after impoundment. As the area will be accessible by road, it may possibly offer in the future a potential for tourism development. Disposal sites should be identified during detailed design stage of the Project in coordination with potential tourism development sites.

In any case, utilization of land must give priority to the use of non cultivated and non agricultural land, in order to minimize impacts on local economy and to reduce compensation costs.

5.3.2. IMPACTS ON PUBLIC HEALTH AND SAFETY

5.3.2.1. EPIDEMIC DISEASES

There will be a high risk of epidemic diseases in the workers' population if camps are inappropriately managed. The Contractor's obligations will need to include appropriate lodging and food supply to Lao workers, with adequate water supply, sanitation system, garbage management and camps cleaning.

The increased population in malaria endemic areas and likely increase in malaria

mosquito vector populations will require a number of mitigatory measures. These might include, *inter alia*, improved diagnosis and treatment services at government health facilities; provision of mosquito nets to construction workers and the population around the NNHP reservoir; and the establishment of insecticide treatment services for surrounding communities.

HIV/AIDS is likely to be more problematic, as the influx of staff and construction workers will greatly increase the potential for HIV transmission. Mitigation efforts will need to include, *inter alia*, education programs, provision of condoms, and possibly coordination with Thai counterparts to develop a strategy for reducing transmission via truck drivers. Resources that have already been used by the Nam Leuk Hydroelectric Power Project are the UNDP/Lao PDR's recently established AIDS Trust Program Population Services International (PSI), an NGO with international expertise in this area, for provision of condoms and educational content under its UN-funded national condom social marketing project.

Other communicable diseases, including shistosomiasis,[1] opisthorchis, cholera, dengue hemorhagic fever, and the vaccine preventable diseases of measles and diphtheria may also be a threat, but these be may possibly not be on the scale of Malaria or HIV. Pre employment medical screening will need to be made compulsory, and screening for communicable diseases will necessarily be done through a Recruitment Center. Public health issues will be assessed more carefully during the course of the next stage EIA.

Construction safety and related health measures will be addressed through standard provisions made for a safety and emergency evacuation program in provisions for construction management in the contract documents. High risk of accidents and epidemic diseases will be mitigated, *inter alia*, through contractually defining the Contractors' obligations to:

- Appropriately maintain trucks
- Install speed limit signs
- Conduct road safety education programs
- Control enforcement of regulations by drivers
- Provide adequate water supplies, sanitation systems and garbage maintenance to camps;
- Conduct pre-employment medical screening; and
- Carry out measures, such as a recruitment center, to limit unplanned influx of population.

5.3.2.2. ROAD SAFETY

Increasing traffic of trucks for the transport of equipment or gravel in Pakxan and in villages along the road may result in noise, dust and a higher accident risk level for the

[1] Fortunately, schistosomiasis or bilharziasis, a disease often associated with impoundments in other tropical countries, is not found in the Lao PDR with the exception of Kong Island, in the Mekong near the Cambodian border.

population, particularly children. Contractor's obligations will need to include appropriate maintenance of trucks, installation of speed limit signs, a program of driver education, and dust control.

5.3.2.3. ELECTROMAGNETIC FIELD

It is not anticipated impact from electromagnetic fields. Indeed, from the several researches and studies monitored by the WHO on the possible relation between long exposure to electromagnetic fields and cancer, no association was clearly found and studies remain inconclusive on that matter so far. However, we consider that the TL will respect the International Radiation Protection Standards which establishes for a 230kV line, a minimum vertical distance from ground of 7.6m and of 10.5m over roads.

5.3.3. IMPACTS ON WATER QUALITY

The construction sites may be the origin of water pollution resulting from activities inappropriately managed and monitored. It is obvious that the incidence of water quality alteration on the construction site will probably be nil or minimum, as most of the impacts will seriously concern the downstream aquatic impact zone (DAIZ). These impacts will be discussed later in this report, the present section focussing on the possible origin of pollution which may concern sediment, chemicals (mainly petroleum products) and pathogens.

5.3.3.1. EXCESSIVE SEDIMENT RELEASE

Excess in sediment load in water may occur at the early stage of construction, when earth works start. Pre-diversion construction works, excavation works at dam site, quarrying works, sand borrowing in river bed, creation of spoil areas too close to the river bank or with unstable slopes, all these activities may have significant impacts on water sediment load.

It is most probable that excavation works for dam foundations and diversion works will increase the sediment load in the water. As these works will occur during the dry season, when the river flow is low and slow (0.1 to 0.3m/s), we may expect that sediment will deposit rapidly along the first 25km to Muangmai, thus reducing the load by the time the water reaches the populated part of the Nam Ngiep and consequently reducing the impacts. It is unlikely that this increase in sediment load may be totally mitigated at least during works in the river bed. However, the coordination of these works to reduce the duration of the impact may be recommended.

Also, high sediment loads may reach the river at the beginning of the rainy season, when heavy storms wash out unstable slopes of spoils or bare soils in the construction sites or camps, or along the access roads. In any case, strict respect of construction standards regarding slope, drainage and sedimentation ponds around disposal sites must be required from the contractor.

5.3.3.2. ACCIDENTAL CHEMICAL SPILL

During construction, large volumes of petrol products together with significant volumes of acid, explosives, toxic products (pesticides, paints, thinners or solvents) will be stored on the construction site, with related risk of accidental release or spill in the river or in the soil and eventually in the aquifer. The risk may be efficiently reduced by the implementation of preventive measures by the contractor: appropriate location of storage areas with drains and collection ponds, collection and destruction of used oils, monitoring of all hazardous products with specific handling procedures and contingency plans.

5.3.3.3. PERMANENT CHEMICAL POLLUTION RELEASE

This concerns the leakage of hazardous products from storage facilities. The risk can be minimized by appropriate storage facilities as described above, by avoiding underground storage and by monitoring. A particular attention is required for the pollution risk of the batching plants. Stabilization and neutralization ponds must be required for effluents from these plants before release in the river.

5.3.3.4. RELEASE OF PATHOGENS

This is mainly due to inappropriate sanitation facilities for the workers camps and the operator's village. Sewage must be treated and chlorinated before release in the water course. Sanitation systems relying on septic tanks must be appropriately designed and located at a reasonable distance from the river. All these obligations must be clearly detailed in the tender documents and in the Contractor's contract.

5.3.3.5. RECOMMENDATIONS

As described, the reduction of the pollution hazard can only be achieved by clear obligations of the contractor regarding the design of the facilities, their location and the development of contingency plans. The basis for these obligations must be developed during the preparation of tender documents during the Detailed Design stage of the Project. It is a part of the Environmental Management and Monitoring Plan.

5.3.4. IMPACTS ON AIR QUALITY

5.3.4.1. DUST AND SMOKE

Most of the air pollution will originate from the fugitive dust resulting from traffic on the road and earthworks and from the release of smoke from trucks and heavy equipment engines.

Most of these are easily controllable and the impacts will be temporary and of limited

significance if considered also that the Project is located in a non populated area, several km from the nearest village. Water spraying will be the primary protection measure against dust. Stabilization of spoil areas by herbaceous vegetation will reduce the risk of fugitive dust during windy days of dry season. Smoke emission from engines can also be controlled by appropriate maintenance of engines.

Additional sources of smoke will result from clearing and burning of vegetation in the construction sites, at the early beginning of the project construction, and from the burning of waste and garbage in the camps. Impact will be insignificant if burning sites for garbage are appropriately located. Aspects more specific to vegetation burning are discussed later.

5.3.4.2. NOISE

Considering the distance of the construction site from the populated area, noise should not be a problem for the population (The problem is different on the access roads and is discussed later). In case a quarry site is located nearby a village, specific measures can mitigate the impact, as for example to prohibit blasting during nighttime. Inside the construction areas, for public safety reason, noise will be maintained below standard levels (generally 50 to 85 dBA). Some noise may also be generated during the rainy season around the cables of the transmission line. But this is generally not considered as a factor of disturbance for the nearby population.

5.4. ONSTRUCTION PHASE : IMPACTS ON DOWNSTREAM ZONE

5.4.1. IMPACTS ON AQUATIC SYSTEM

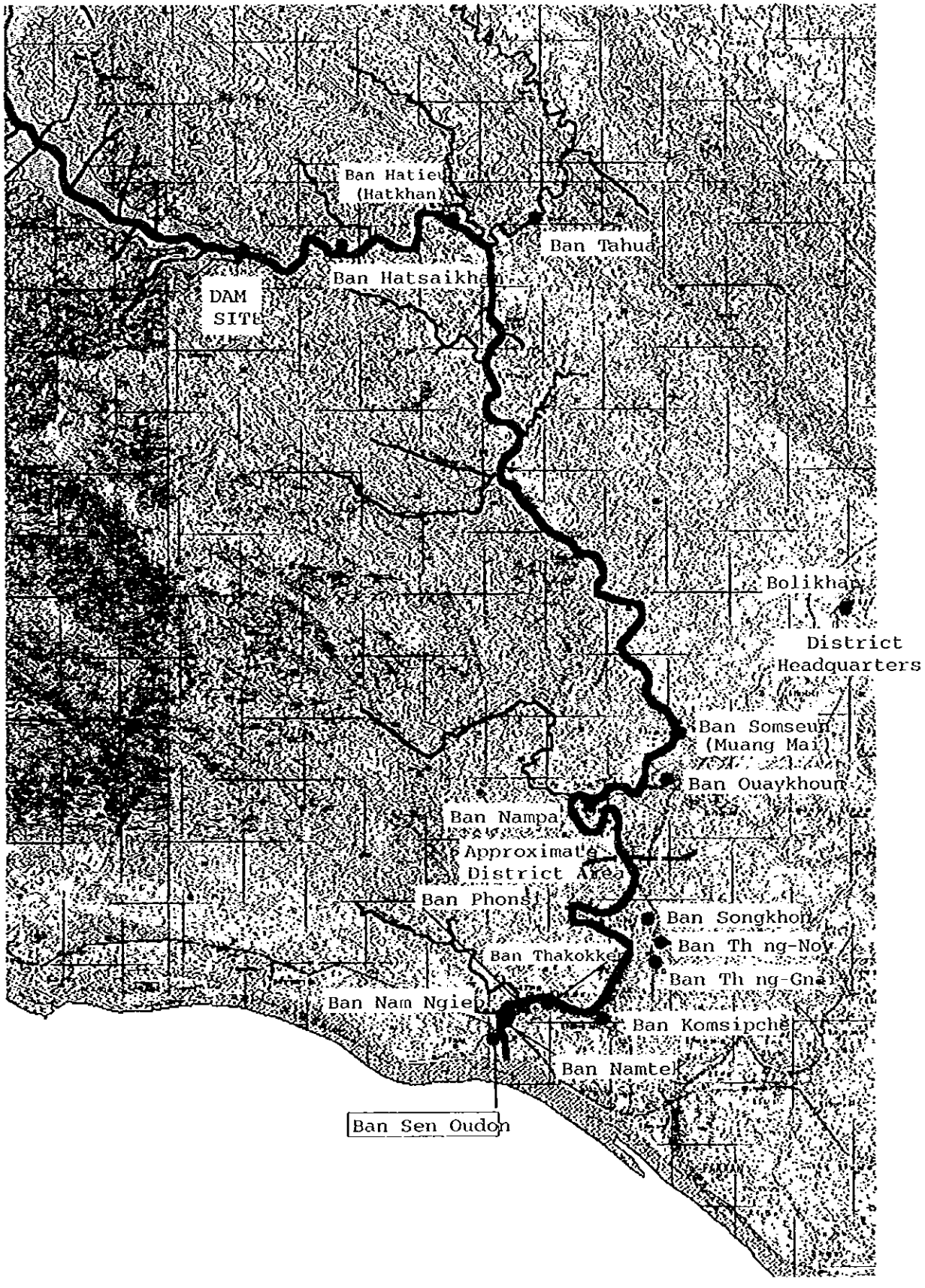
5.4.1.1. ACCIDENTAL POLLUTION OF RIVER WATER

5.4.1.1.1. DISTANCE FROM CONSTRUCTION SITES

As discussed previously, the construction site may be the origin of a pollution, which may seriously affect the river ecology and the river use by the downstream population: fishing, washing and water supply for domestic and animal purpose.

In case of an accidental spill, the intensity of the problem will depend on various parameters, including toxicity of the pollutant, discharge observed in the river at the time of event and distance from the dam (construction site). The following table gives the distance from the dam of the riverine downstream villages.

Villages of the downstream area are presented on Figure 5.1.



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 5.1
	VILLAGES OF THE DOWNSTREAM AREA	

Table 5.3 Distance of villages from dam site and dilution from tributaries

Village Name	Tributary Name	Distance Km	Household No.	Population No.	Discharge (m3/s)		Dilution (%)	
					April	August	April	August
Dam site		0			33	472	0	0
Ban Hathleun		8.9	88	533	34.5	486.8	4.5	3.1
Ban Thahua	Nam Xao	10.3	55	252	35 2	501.6	6.7	6.3
	Nam Soup	14.4			35.9	510.8	8.8	8.2
	Nam Ngoua	17.8			36.5	518.3	10.5	9.8
	H. Khingguak G	19.3			36.7	521.6	11.2	10.5
	H. Khokkhen	26.3			37.9	537.2	14.8	13.8
B. Sornseun		31.6	185	1136	38.8	549.2	17.5	16.4
B. Houaykoun		32.9	281	1632	39	552	18.2	16.9
B. Nampa		35.8	71	427	39.3	555.8	19.0	17.7
	Nam Pa	36.5			39.3	556.8	19.2	18.0
B. Nong Deng		40.5	19	112	39.7	562.0	20.3	19.1
B. Songkhon		42.9	42	239	39.9	565.1	20.9	19.7
B. Xaisomboun		47.3	50	329	40.3	570.8	22.1	20.9
B. Thong Gnai		47.8	62	340	40.3	571.5	22.3	21.1
B. Khomsipchet		50.6			40.6	575.3	23.0	21.9
B. Phonsi		51.4	48	276	40.7	576 2	23.2	22.1
B. Thakokkhen		51.4	58	349	40.7	576.2	23.2	22.1
B. Nam Tek		52.5	39	203	40.8	577.7	23.6	22.4
	Nam Tek Gnai	52.6			40.8	577.9	23.6	22.4
B. Nam Gniep		53.8	67	331	40.9	579.4	23.9	22.7
B. Sen Oudom		54.0	67	314	40.9	579.7	24.0	22.8
	Mekong confluence	55.0			41	581	24.1	22.9
Total			1,132	6,473				

5.4.1.1.2. MAGNITUDE OF POTENTIAL IMPACT

The table shows that the maximum dilution provided by the non controlled catchment (between dam site and Mekong) at the Mekong confluence is less than 25% of the outflow observed at dam site. In case of severe spill of toxic product, it is most probable that the population of all the 9 villages located along the river will be affected. In case of pollution by a product of lower toxicity, it is possible that only the nearest villages from the dam are affected, B.Hatsaikham and B.Hathieun where the dilution level is only few percent.

In case of pollution the major impacts will concern the alteration of the aquatic ecosystem with possible fish kills and the temporary impossibility to use river water for domestic (drinking, cooking and bathing) and agricultural (animal watering, irrigation of vegetable gardens) purposes.

Based on observations in the Nam Leuk area and during investigations in the Xe Kaman area, water use for drinking and cooking is about 8 l/cap/day, or a daily consumption of 52,000 l in the downstream villages.

Regarding fish consumption, surveys in the Thabok area during 3 years point out an average fish consumption of 0.05kg/cap/day. This figure is confirmed by the fishery survey in the downstream area.

These figures may provide a basis for compensation in case of an accidental pollution event. The Project must dispose of a contingency budget to face this type of situation. Distribution of potable water during the duration of the event and compensation for the loss in fisheries. A preliminary valuation may be US$ 0.1 per liter of drinking water and US$ 1 per kg of fish.

Further investigations are necessary in order to define more clearly the way to measure the magnitude of any pollution event and to attach a compensation value which will be charged to the contractor responsible. As a very preliminary idea, some computation based on river hydrology and hydraulic may provide range of pollutant concentration levels, with a cost attached to each level and based on the expected duration of the event consequences. For how many days or weeks the population cannot use river water for domestic purposes, which proportion of fish has been killed or has escaped the system and how long river fisheries will be affected.

5.4.1.2. RELEASE OF PATHOGENS

Release of pathogens will also result in the temporary ban on the use of river water for drinking or cooking purposes. Under consideration will be fecal coliforms and other pathogens which may be released in water in case of dysfunction or inadequate design of sanitation systems in the camps.

Impact magnitude is different from a chemical pollution, as bacteria like coliforms have only a limited life in water, generally not more than 48 hours to 72 hours. At a flow velocity of 0.2m/s, observed in the downstream part of the river, a pathogen pollution may still be active 35 to 52km downstream the dam, and thus concern all the downstream villages.

Such risk may be efficiently reduced by appropriate facilities in the camps and by regular monitoring of water, in the re-regulation pond for example.

All these risks plus the release of anoxic water the first few years after impounding should allow to recommend the construction of alternative water supply for all the downstream villages located along the Nam Ngiep. Based on the implementation of one hand pump for 20 households, the total cost should be US$ 200/hh or a budget of US$ 250,000.

5.4.1.3. PERMANENT POLLUTION (BATCHING PLANT)

The risk of permanent pollution release in the river is mainly related to the effluent water from the batching plants, generally very alkaline. Buffering with acid and sedimentation in ponds before release is generally sufficient to avoid problems.

5.4.2. IMPACTS ON LAND SYSTEM

5.4.2.1. ACCESS ROADS

5.4.2.1.1. AREA REQUIREMENTS

According to the Project description, only 10km of new road will be required from B.Hathieun (same as B.Hatkham) to the dam site, 33 other km consisting only in rehabilitation works. Based on a 12m width (including traffic lane and drainage), this will represent a minimum land requirement of 12ha. Additional area will probably be required for secondary accesses between construction sites, for intermediate camps, borrow and disposal sites along the road. A total land requirement of 20ha is probably more realistic.

According to what is known today on the location of the road and the land use, we may assume the following distribution: 20% of the area concerns paddy fields, 20% hill rice and 60% grazing land and shrubland. Limited clearing is anticipated, mainly near the construction site.

The road will pass close to one area identified as a potential territory for an elephant herd, which does not involve special measures for the road.

The road will also provide an all weather access to B.Hathieun, which is not the situation today. This may provide an opportunity for the development of this village but also for possible resettlement of displaced families from the reservoir area. The possible access roads are shown in Figure 5.2.

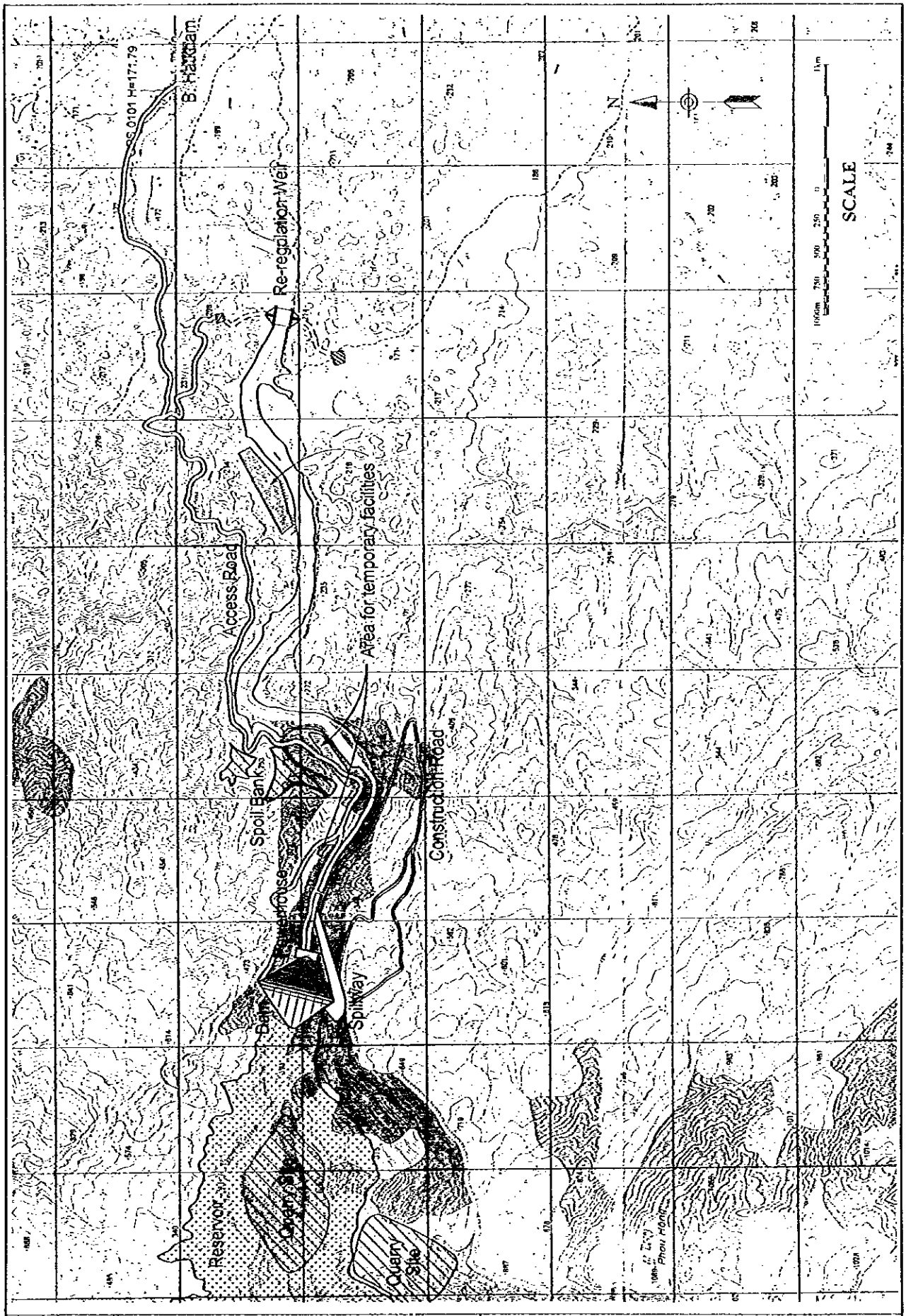
5.4.2.1.2. IMPACTS

After construction of the road, and rehabilitation of the other 33km, the traffic will probably be intense, with the transport of equipment and material. The risk of accident, dust release and noise in the villages crossed is high if no specific prevention is implemented.

5.4.2.1.3. BASIS FOR COMPENSATION

Compensation process needs to be clearly established during next stage of the Feasibility Study. However a tentative estimate is proposed at this stage. As there is no market for land, the land acquisition cost may be based on the economic production loss of the concerned area. Then the compensation value is equivalent to the Net Present Value of the annual production lost, discounted at 10%/year over 50 years (the life of the Project).

Assuming a production of paddy rice 3.5t/ha@200US$/t, hill rice1.5t/ha@200US$/t and 60kg of meat production/ha of grazing @1US$/kg, the compensation for the road comes to US$ 47,000. An additional US$20,000 may be considered for the implementation of the compensation.



FEASIBILITY STUDY
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Figure 5.2

Temporary Facilities and Access Road

5.4.2.1.4. RECOMMENDATIONS

Minimum clearing during construction and optimized location of the access road must be considered as prime objectives. All disposal or borrow areas along the road must be rehabilitated at the end of the construction. Specific obligations of the contractor must be developed in the tender documents. A prevention program is also recommended with implementation of signs, bumps and regular watering of the road, under the responsibility of the Contractor.

It is also recommended during the design of the re-regulation weir to consider the implementation of a bridge facility at this level, providing easy access to both sides of the river in an area potential relocation of displaced population from the reservoir.

5.4.2.2. TRANSMISSION LINE

5.4.2.2.1. AREA REQUIREMENTS

The transmission line includes 2 components: the tower, for which land must be purchased when located in a private property, and the right of way (ROW) between the towers, where construction and culture of trees is not authorized.

The right of way is estimated at 50m width. A tower requires about 36m² of land. With a tower every 350m, the transmission line will consist of about 320 towers. The total area to acquire is about 1.2ha. With additional needs as a post or access, it may raise to 2ha.

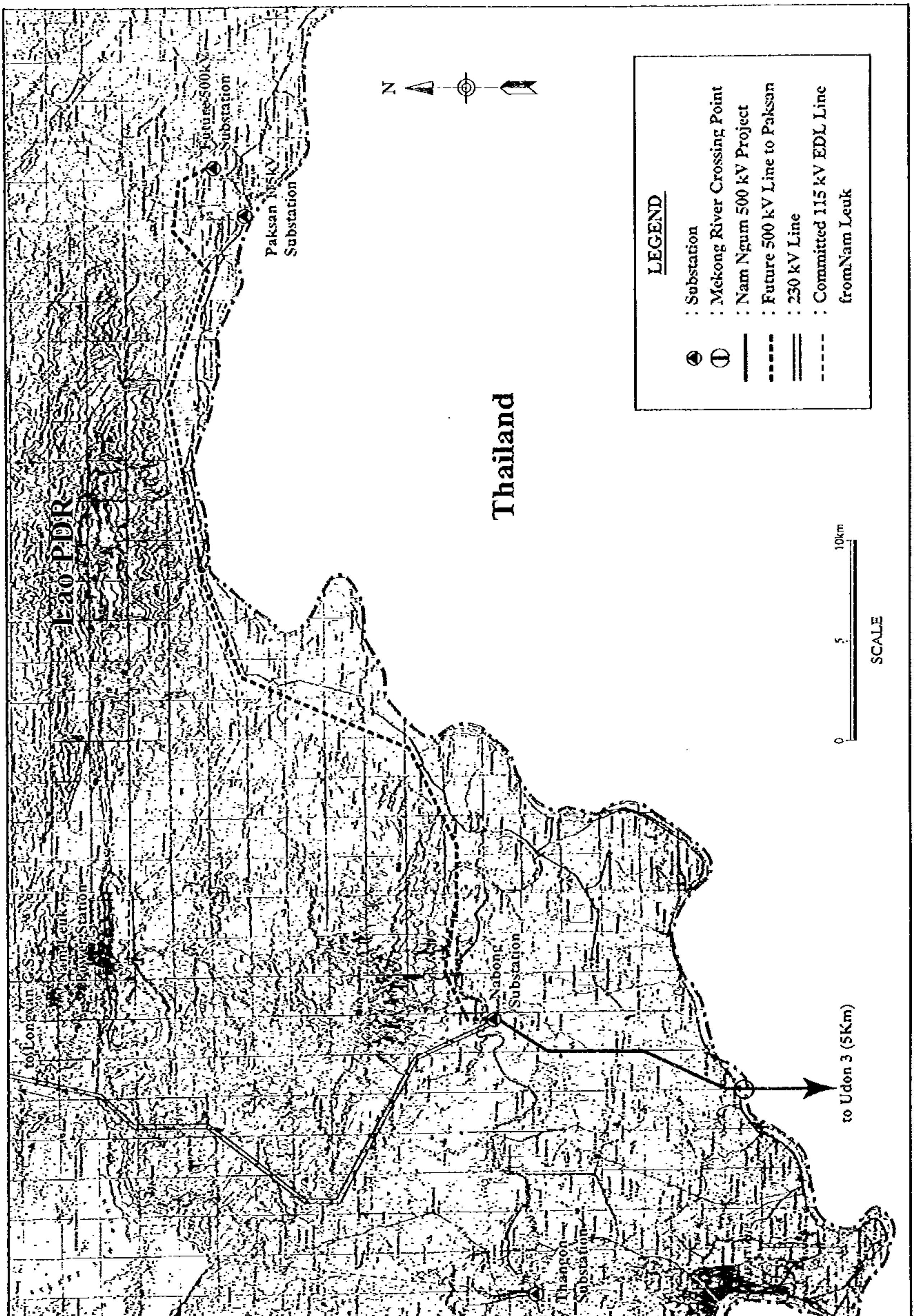
The possible transmission line route is shown in Figure 5.3.

5.4.2.2.2. SENSITIVE AREAS

The route of the line is not yet precisely defined. However, for maintenance needs, it will probably follow roads and agricultural areas. It is not expected the line to cross any protected area.

5.4.2.2.3. BASIS FOR COMPENSATION

Basis for compensation may be established in the same way than for access roads. Supposing 80% of the route in paddy area and 20% in secondary forest or bushland, an average paddy production of 5 tons/ha at 200 US$/ton, the cost of land acquisition based on the NPV discounted at 10% over 50 years will be US$ 16,000. An additional compensation of 50% may be added for the constraint imposed by the right of way, resulting in a total compensation cost of US$ 24,000, or US$ 75 per tower. This cost may double when considering the implementation of the process with the population census along the line and the elaboration of a compensation agreement with each concerned household.



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 5.3 Tentative Rout of 500 kV Line between Ban Nabong S.S and Pakxan G.S