

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 4

**NAM NGIEP CATCHMENT**

Table 4.4 Computed Flood Discharges (in m<sup>3</sup>/s) in the Nam Ngiep

| SITES       | S (km <sup>2</sup> ) | T=2 yrs | 10 yrs | 20 yrs | 50 yrs | 100 yrs | 1000 yrs | 10000 yrs | PMF    |
|-------------|----------------------|---------|--------|--------|--------|---------|----------|-----------|--------|
| Muang Mai   | 4,320                | 1,545   | 2,865  | 3,445  | 4,220  | 4,820   | -        | -         | -      |
| Ban Hatieun | 3,748                | 1,447   | 2,701  | 3,226  | 3,952  | 4,514   | -        | -         | -      |
| Dam site    | 3,700                | 1,448   | 2,704  | 3,230  | 3,956  | 4,519   | 6,530    | 8,730     | 15,900 |

Notes: T= Return Period in years, PMF= Probable Maximum Flood

According to villagers and officials interviewed during the field visits, it seems that the Nam Ngiep River is exceptionally overflowing during the rainy season in the Mekong plain. As everywhere in the plain, the role of tributaries in a flood event can hardly be disconnected from the level situation of the Mekong at the time of the event. These tributaries can hardly generate significant flood (in extent and in duration) by themselves. Flooding occurs mainly when the Mekong is abnormally high, thus impeding the flow from the tributaries. However, in the downstream plain, some areas on the right bank (in front of B.Phonsi, B.Thakokken) may be flooded from overflowing of a small tributary.

## 4.4. WATER QUALITY

### 4.4.1. SAMPLING SURVEYS

During the present Feasibility Study, 4 sampling missions were scheduled in January, March, June and late August 1999.

Sampling surveys were carried out in 4 stations, from upstream to downstream:

1. Nam Siam river at Ban Xiengkhong, the major tributary of the Nam Ngiep in the upper catchment,
2. Nam Ngiep at Thavieng (Ban Dong)
3. Nam Ngiep at Ban Hat Kham (gauging station)
4. Nam Ngiep at Muang May (gauging station)

The catchment area controlled by each of these stations is given below.

Table 4.5: Controlled Catchment at Water Quality Sampling Points

| Station | Controlled area (km <sup>2</sup> ) | Comments  |
|---------|------------------------------------|---|
| 1       | 514                                | Representative of upper catchment tributaries   |
| 2       | 2,360                              | Representative of upper Nam Ngiep               |
| 3       | 3,750                              | Representative of Nam Ngiep at dam site         |
| 4       | 4,232                              | Representative of lower Nam Ngiep (plain river) |

The location of the 4 sampling stations is shown on Figure 4.5. The actual location of the downstream stations could be easily identified as they are situated at existing gauging stations. In order to facilitate in identifying those in the upstream part, visual marks have been made at sampling sites.

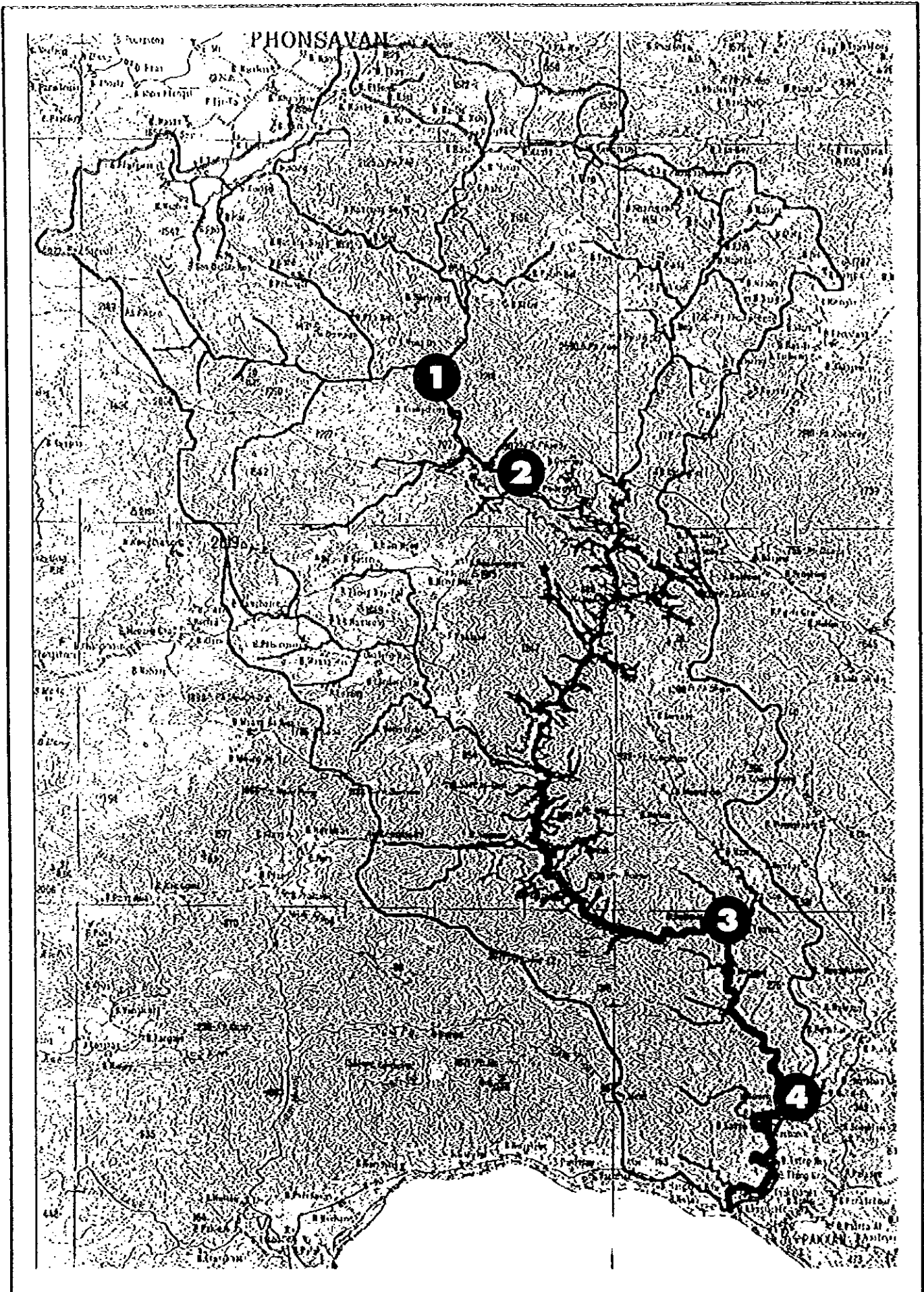


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Figure 4.5

**LOCATION OF  
 WATER MONITORING STATIONS**



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Figure 4.5

**LOCATION OF  
 WATER MONITORING STATIONS**

## 4.4.2. RESULTS

### 4.4.2.1. METHODS FOR SAMPLING AND ANALYSIS

In accordance with the TOR, analysis of samples have been carried out not later than 1 week after sampling, with appropriate preservation measure for samples. For the purpose of coherence with other existing data on water quality, it was suggested that the Consultant follows analytical procedures of the Water Quality Laboratory of Vientiane, already in charge of the Mekong Water Quality Monitoring in the Lao PDR.

Furthermore, the Vientiane Laboratory was requested to train the surveyors for water sampling, sample handling and in situ measurements. Analysis were carried out by the above-mentioned laboratory.

Analytical methods used are presented below.

Table 4.6 Analytical Methods

| Parameter            | Method   |
|----------------------|--|
| Ca, Mg and Hardness  | Complexometry(EDTA)                                      |
| Alkalinity           | Potentiometric method (end point titration)              |
| SO <sub>4</sub>      | Mackereth method   |
| Cl                   | Mercury nitrate method                                   |
| PO <sub>4</sub> -P   | Spectrophotometric method                                |
| NO <sub>3</sub> -N   | Reduction with Cd and diazotation                        |
| Si                   | Spectrophotometric, molybdo silicate method              |
| Total-Fe             | Spectrophotometric, phenantroline method after digestion |
| COD <sub>Mn</sub>    | Permanganate oxidation                                   |
| PH                   | PH meter   |
| Conductivity         | Conductivity meter                                       |
| TSS                  | Total nonfiltrable residue dried at 103-105 °C           |
| Faecal coliform test | Membrane filter technic                                  |

### 4.4.2.2. RESULTS

Main results of survey actually available are provided in the following table.

The water quality of the river is good, with close to neutral pH, high dissolved oxygen, low nutrients and low dissolved solids.

During the dry season, the nutrient content is very low, partly because the whole catchment has a limited population, and partly because during dry season, water flowing in the river is often limited to drainage water from the basement aquifer, replenished during the rainy season.

During wet season, these values increase because of the run-off, but remain on the low to normal range generally observed in this type of river.

Some coliform pollution from fecal origin is observed downstream, resulting from the presence of villages and the slow flow of the river.

Table 4.7 Results of Water Quality Monitoring

| Parameter          | Unit      | STATIONS  |       |       |       |           |       |       |       |           |       |       |       |           |       |       |       | DRINKING STANDARD |
|--------------------|-----------|-----------|-------|-------|-------|-----------|-------|-------|-------|-----------|-------|-------|-------|-----------|-------|-------|-------|-------------------|
|                    |           | Station 1 |       |       |       | Station 2 |       |       |       | Station 3 |       |       |       | Station 4 |       |       |       |                   |
| Date (1999)        |           | 8/01      | 16/03 | 22/6  | 24/8  | 8/0199    | 16/03 | 22/6  | 25/8  | 12/01     | 19/03 | 24/6  | 10/09 | 12/01     | 19/03 | 24/6  | 10/09 |                   |
| Temp               | °c        | NA        | 23.1  | 27.0  | 25    | NA        | 22.9  | 30.0  | 24    | NA        | 27.4  | 24.6  | 26.2  | NA        | 27.1  | 25.0  | 26.8  |                   |
| PH                 |           | 8.10      | 7.39  | 7.79  | 8.18  | 7.61      | 7.91  | 7.58  | 7.68  | 7.84      | 8.56  | 7.75  |       | 7.81      | 8.26  | 7.52  | 5.56  | 5.8-8.5           |
| TDS                | mg/l      | NA        | 39    | 44    | 40    | NA        | 63    | 33    | 40    | NA        | 56    | 36    | 27    | NA        | 57    | 36    | 28    |                   |
| DO                 | mg/l      | NA        | 7.8   | 7.56  | 6.75  | NA        | 8.0   | 7.50  | 6.84  | NA        | 7.3   | 7.98  | 6.80  | NA        | 8.0   | 7.62  | 7.00  |                   |
| Conduct            | ms/m      | 13.5      | 7.2   | 8.03  | 8.07  | 9.8       | 11.2  | 6.30  | 8.02  | 9.9       | 9.87  | 6.64  | 5.8   | 9.4       | 10.2  | 6.64  | 5.9   | -                 |
| Ca                 | mg/l      | 15.16     | 7.76  | 0.592 | 14.4  | 11.28     | 13.96 | 0.421 | 11.6  | 11.60     | 12.18 | 0.446 | 7.1   | 13.94     | 12.54 | 0.455 | 7.2   | -                 |
| Mg                 | mg/l      | 8.78      | 2.00  | 0.220 | 3.89  | 3.91      | 4.09  | 0.206 | 2.7   | 5.56      | 3.12  | 0.193 | 1.50  | 4.88      | 2.98  | 0.202 | 1.56  | -                 |
| Na                 | mg/l      | NA        | 0.03  | 0.074 | 1.40  | NA        | 0.035 | 0.049 | 2.6   | NA        | 0.042 | 0.052 | 1.265 | NA        | 0.043 | 0.077 | 1.288 |                   |
| K                  | mg/l      | NA        | 0.01  | 0.036 | 0.312 | NA        | 0.009 | 0.031 | 0.273 | NA        | 0.012 | 0.045 | 0.468 | NA        | 0.012 | 0.033 | 0.468 |                   |
| Cl                 | mg/l      | 0.42      | 2.00  | 0.007 | 0.014 | 0.28      | 0.70  | 0.018 | 0.011 | 0.35      | 1.54  | 0.016 | 1.750 | 1.19      | 0.84  | 0.018 | 1.820 | <250mg/l          |
| SO <sub>4</sub>    | mg/l      | 1.92      | 3.74  | 0.074 | 0.011 | 1.06      | 6.00  | 0.064 | 0.019 | 2.88      | 2.40  | 0.078 | 3.36  | 2.40      | 2.98  | 0.066 | 3.504 | <400mg/l          |
| NO <sub>3</sub> -N | mg/l      | 0.001     | 0.002 | 0.127 | 0.068 | 0.001     | 0.001 | 0.126 | 0.086 | 0.023     | 0.018 | 0.147 | 0.138 | 0.314     | 0.110 | 0.134 | 0.140 | <10mg/l           |
| PO <sub>4</sub> -P | mg/l      | 0.014     | 0.020 | 0.088 | 0.011 | 0.011     | 0.008 | 0.059 | 0.019 | 0.01      | 0.003 | 0.018 | 0.015 | 0.009     | 0.003 | 0.019 | 0.015 | -                 |
| Hardness           | mg/l      | 64.9      | 27.8  | 40.60 | 52.2  | 44.5      | 52.0  | 31.35 | 40.4  | 42.9      | 43.5  | 31.95 | 24    | 47.1      | 43.9  | 32.85 | 24.5  | <300mg/l          |
| CaCO <sub>3</sub>  | mg/l      | 67.9      | 34.4  | 37.6  | 43.4  | 48.2      | 53.6  | 27.1  | 16.3  | 43.1      | 42.6  | 28.9  | 19.45 | 44        | 44.0  | 28.2  | 19.4  | <350mg/l          |
| TSS                | mg/l      | 1         | 87    | 6.58  | 38    | 1         | 20    | 486   | 53    | 2         | 12    | 140   | 180   | 1         | 14    | 88    | 196   | -                 |
| Tot-Fe             | mg/l      | 0.152     | 0.68  | 0.256 | 0.143 | 0.146     | 0.36  | 0.359 | 0.499 | 0.171     | 0.45  | 0.307 | 0.346 | 0.244     | 0.39  | 0.606 | 0.338 | <0.3mg/l          |
| Si                 | mg/l      | 7.3       | 9.0   | 4     | 4     | 8.8       | 8     | 2     | 5     | 8.9       | 8.0   | 6     | 6.0   | 8.6       | 8.0   | 6.0   | 6.0   | -                 |
| COD <sub>Mn</sub>  | mg/l      | 0.458     | 3.8   | 3.20  | 0.589 | 0.866     | 1.2   | 5.55  | 0.568 | 0.517     | 1.2   | 0.95  | 1.2   | 0.521     | 0.9   | 0.78  | 1.0   | -                 |
| Faecal Coliform    | nb/100 ml | NA        | 3     | 2     | 2     | -         | 5     | 0     | 1     | 46        | 25    | 5     | 2     | 10        | 40    | 12    | 6     | 0                 |

## 4.5. AQUATIC ECOLOGY AND FISHERIES

### 4.5.1. AQUATIC ECOLOGY

#### 4.5.1.1. SURVEY METHODOLOGY

Fishes are one of the most widely distributed, most easily harvested and cheapest protein sources in tropical area (Kottelat 1997). The inland fishes diversity in Southeast Asia is very high, with about 900 species known from the mainland Southeast Asia (Kottelat, 1989). The total number of species recorded or expected from the Mekong, includes about 1,200 species, but the actual number of species perhaps is much greater (Rainboth, 1996). Large areas are still not surveyed (Kottelat, 1997).

Very few data on fishes in Lao have been published in the scientific literature. French ichthyologists have published a few scientific papers on fishes with a few species since 1940 and Taki (1974) has compiled a synopsis of fishes of Laos. Since then, some information on fishes of the Nam Ngum reservoirs was collected, and some fish species were identified in certain rivers of Laos, such as Nam Leuk and Nam Mang basin, Nam Theun and Xebang Fai basin. At present, there is a fish species survey on-going in the Mekong basin carried out by Dr. Walter Rainboth, but the result is not yet published. Also Dr. Maurice Kottelat currently compiles Fishes of Lao PDR; it is expected that this publication will be completed in the end of this year (1999). As for fishes in Cambodia about 500 species have been described by Dr. Rainboth (1996). These published papers are used as guideline for this study.

This report presents the observation on fish species obtained from direct fishing and from fishermen catches observation during the field investigation. The distribution of fish species along the Nam Ngiep main stream and some of its tributaries at the Upper and Lower Reservoir and Downstream of the proposed dam site are also presented.

Fish samples were collected, observed and identified from 21 stations along Nam Ngiep River and its tributaries, including 9 stations of the Upper Reservoir, 5 stations in the Lower Reservoir area and 7 stations in the downstream area. Additional information on fish species was obtained from observation at Ban Phonyeng market and also from the fishermen's catches in the villages of the Upper and Lower Reservoir. These stations are presented on Figure 4.6

The first fish survey was carried out around the end of December 1998 until mid of January 1999 for Upper and Lower Reservoirs and beginning of April 1999 in the downstream area.

The second fish survey was carried out in the end of July and beginning of August 1999, mainly in the tributaries of the Nam Ngiep and in the floodplain, rice fields and ponds along the river.

The selection of the sampling station was based on various criteria as the site accessibility and the need to investigate areas representative of the river aquatic habitats diversity: pools, riffles, rapids, with different river bottoms such as gravel, rock, sand and mud.

Fish sampling was carried out in each station over a distance of about 1 to 2km upstream and downstream of the selected station. In the tributaries, sampling covered a section from the confluence going upstream to about 3 to 5km.

Samples were identified with their local and scientific names, and a picture of each species was taken. One to two specimens of each species were collected and preserved to confirm their identifications.

#### 4.5.1.2. RESULTS

Fish sampling stations are listed from upstream to downstream of the Nam Ngiep River, and the name of each station will be using the name of the nearest village to define the location of each station as described below:

| Upper reservoir          | Lower reservoir            | Downstream area                       |
|--------------------------|----------------------------|---------------------------------------|
| Station 1. B. Xiengthong | Station 10. B. Houay Pamom | Station 15. Confl. Houay Xay          |
| Station 2. Nam Theng     | Station 11. Ban Sopphouan  | Station 16. Nam Xao River             |
| Station 3. Ban Naxong    | Station 12. Nam Phouan     | Station 17. Houay Khinguak            |
| Station 4. Ban Dong      | Station 13. Nam Youk River | Station 18. Hatmakphang               |
| Station 5. B. Hatsamkhon | Station 14. Ban Sopyouk    | Station 19. Nam Pa River              |
| Station 6. Ban Pou       |                            | Station 20. NamTek River              |
| Station 7. Nam Chea      |                            | Station 21. Confluence with<br>Mekong |
| Station 8. Ban Namlong   |                            |                                       |
| Station 9. Nam Khai      |                            |                                       |



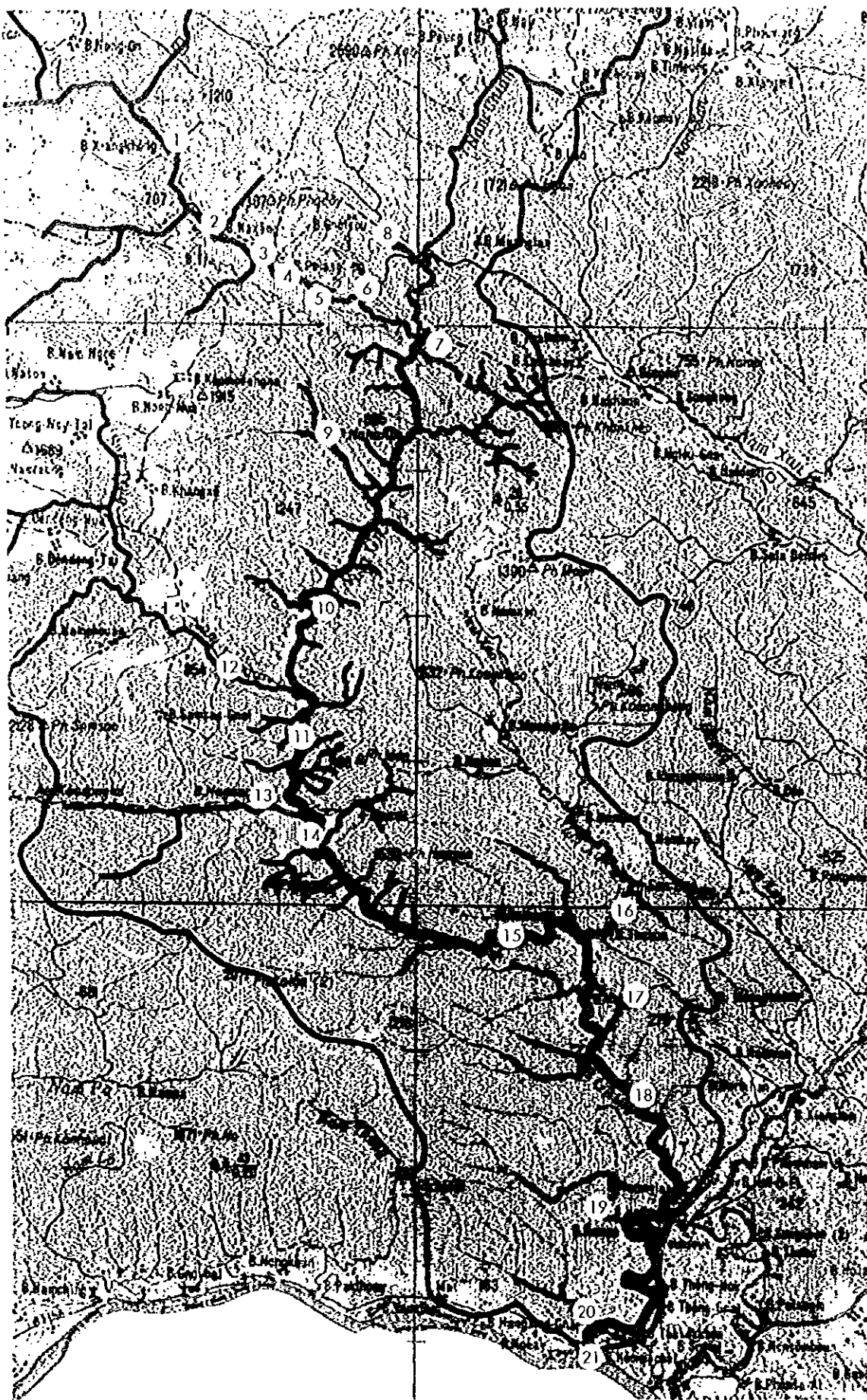
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Figure 4.6

**AQUATIC ECOLOGY  
 SAMPLING STATIONS**





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Figure 4.6

**AQUATIC ECOLOGY  
 SAMPLING STATIONS**

Results for each station are presented in the supporting report of the Subcontractor. General results for the first survey are presented in the following table.

Table 4.8 List of Fish Species Observed from 21 Sampling Stations

| FAMILY          | SCIENTIFIC NAME                  | LOCAL NAME      | COLLECTED IN DRY SEASON |                 |                 |
|-----------------|----------------------------------|-----------------|-------------------------|-----------------|-----------------|
|                 |                                  |                 | Upper Reservoir         | Lower Reservoir | Downstream Area |
| NOTOPTERIDAE    | <i>Chitala ornata</i>            | Pa Tong kay     |                         | •               |                 |
|                 | <i>Notopterus notopterus</i>     | Pa Tong ( Khao) |                         | •               | •               |
| SOLEIDAE        | <i>Euryglossa hamandi</i>        | Pa Pe           |                         |                 | •               |
| AMBASSIDAE      | <i>Parambassis siamensis</i>     | Pa Khap Khong   |                         |                 | •               |
| BELONTIDAE      | <i>Trichogaster trichopterus</i> | Pa Kadeut       |                         |                 | •               |
|                 | <i>Xenentodon cancila</i>        | Pa Sathong      |                         |                 | •               |
| PANGASIIDAE     | <i>Pangasius siamensis</i>       | Pa Yon          |                         |                 | •               |
|                 | <i>Pangasius conchophilus</i>    | Pa Souay        |                         |                 | •               |
|                 | <i>Pangasius pleurotaenia</i>    | Pa Yon Nou      |                         |                 | •               |
| SYNGNATHIDAE    | <i>Doryichthys deokhatoides</i>  | Pa Lek xi       |                         |                 | •               |
| NANDIDAE        | <i>Nandus nandus</i>             | Pa Tet xa       |                         |                 | •               |
|                 | <i>Pritolepis fasciata</i>       | Pa Ka           |                         |                 | •               |
| SISORIDAE       | <i>Bagarius yarrellii</i>        | Pa Khea         | •                       | •               | •               |
|                 | <i>Bagarius bagarius</i>         | Pa Khea Leuang  | •                       | •               |                 |
|                 | <i>Glyptothorax laosensis</i>    | Pa..            |                         |                 | •               |
| CHANNIDAE       | <i>Channa striata</i>            | Pa Khor         |                         | •               | •               |
|                 | <i>Channa luclus</i>             | Pa Khor chon    |                         |                 | •               |
|                 | <i>Channa gachua</i>             | Pa Kang         | •                       | •               | •               |
| ELEOTRIDAE      | <i>Oxyleotris marmorata</i>      | Pa Bou gnai     |                         |                 | •               |
| GOBIIDAE        | <i>Rhinogobius mekongianus</i>   | Pa Bou          | •                       | •               | •               |
| BAGRIDAE        | <i>Hemibagrus wyckoides</i>      | Pa Kheung       |                         | •               | •               |
|                 | <i>Mystus vittatus</i>           | Pa KaGneng      |                         | •               |                 |
|                 | <i>Mystus singaringan</i>        | P.KaGneng(kho)  |                         | •               |                 |
|                 | <i>Mystus nemurus</i>            | Pa Kot          | •                       | •               | •               |
|                 | <i>Pseudomystus stenomus</i>     | Pa Khee mouk1   |                         |                 | •               |
|                 | <i>Pseudomystus siamensis</i>    | Pa Khee mouk2   |                         |                 | •               |
| CLARIIDAE       | <i>Clarias batrachus</i>         | Pa Douk         | •                       | •               |                 |
| COBITIDAE       | <i>Botia nigrolineata</i>        | Pa Kheo kai 1   |                         | •               | •               |
|                 | <i>Botia modesta</i>             | Pa Kheo Kai 2   |                         | •               |                 |
|                 | <i>Botia eos</i>                 | Pa Kheo Kai 3   |                         | •               | •               |
|                 | <i>Botia longidorsalis</i>       | Pa Kheo Kai 4   |                         |                 | •               |
|                 | <i>Botia sp</i>                  | Pa Mou          |                         |                 | •               |
|                 | <i>Acantopsis sp.</i>            | Pa Hak kouay    |                         |                 | •               |
|                 | <i>Acantopsis sp.</i>            | Pa It xay       | •                       | •               | •               |
| BALITORIDAE     | <i>Schistura sp.1</i>            | Pa Phan1        | •                       | •               | •               |
|                 | <i>Schistura sp.2</i>            | Pa Phan2        | •                       | •               | •               |
|                 | <i>Schistura sp. 3</i>           | Pa Phan3        | •                       | •               | •               |
|                 | <i>Schistura sp. 4</i>           | Pa Phan4        | •                       | •               |                 |
|                 | <i>Schistura sp. 5</i>           | Pa Phan5        | •                       | •               |                 |
|                 | <i>Schistura sp. 6</i>           | Pa Phan6        | •                       |                 |                 |
|                 | <i>Schistura sp.7</i>            | Pa Phan7        | •                       | •               |                 |
|                 | <i>Schistura sp. 8</i>           | Pa Phan8        | •                       | •               |                 |
|                 | <i>Schistura sp. 9</i>           | Pa Phan9        | •                       | •               | •               |
|                 | <i>Schistura sp. 10</i>          | Pa Phan10       |                         |                 | •               |
|                 | <i>Homaloptera smithi</i>        | Pa Pem/ lithin  | •                       | •               | •               |
|                 | <i>Homaloptera sp</i>            | Pa Tithin       |                         |                 | •               |
|                 | <i>Homaloptera yunnanensis</i>   | Pa Tithin       |                         | •               |                 |
| MASTACEMBELIDAE | <i>Mastacembelus armatus</i>     | Pa Lat          | •                       | •               | •               |
|                 | <i>Macrogathus siamensis</i>     | Pa Lot          |                         | •               |                 |
| SILURIDAE       | <i>Kreptopterus cryptopterus</i> | Pa Nang         |                         | •               |                 |
|                 | <i>Ompok bimaculatus</i>         | Pa Seuam        |                         | •               |                 |
|                 | <i>Kryptopterus sp</i>           | Pa Seum         |                         |                 | •               |
|                 | <i>Wallago leeri</i>             | Pa Khoun        |                         |                 | •               |
|                 | <i>Wallago attu</i>              | Pa Khao         |                         |                 | •               |
|                 | <i>Kryptopterus sp</i>           | Pa Peek kai     |                         |                 | •               |

| FAMILY                         | SCIENTIFIC NAME                        | LOCAL NAME                | COLLECTED IN DRY SEASON |                 |                 |   |
|--------------------------------|--|---------------------------|-------------------------|-----------------|-----------------|---|
|                                |  |                           | Upper Reservoir         | Lower Reservoir | Downstream Area |   |
| CYPRINIDAE                     | <i>Mystacoleucus greewayi</i>          | Pa Langnam                | *                       | *               | *               |   |
|                                | <i>Mystacoleucus marginatus</i>        | Pa Ket kheng              | *                       |                 |                 |   |
|                                | <i>Scaphiodonichthys acanthopterus</i> | Pa Mom                    | *                       | *               | *               |   |
|                                | <i>Bangana sinkleri</i>                | Pa Deng                   | *                       | *               |                 |   |
|                                | <i>Bangana behni</i>                   | Pa Va (mou)               | *                       | *               |                 |   |
|                                | <i>Tor tambroides</i>                  | Pa Thol                   |                         | *               |                 |   |
|                                | <i>Tor sp.</i>                         | Pa Dam                    |                         | *               |                 |   |
|                                | <i>Osteochilus hasselti</i>            | Pa I thai                 | *                       | *               | *               |   |
|                                | <i>Osteochilus waandersii</i>          | Pa Lay kai                | *                       |                 | *               |   |
|                                | <i>Hampala dispar</i>                  | Pa Soud 1                 | *                       | *               | *               |   |
|                                | <i>Hampala macrolepidota</i>           | Pa Soud 2                 | *                       | *               |                 |   |
|                                | <i>Rasbora sp. (Holiz. red line)</i>   | Pa Siew                   |                         | *               |                 |   |
|                                | <i>Rasbora altdorsalis</i>             | Pa siew 1                 | *                       | *               | *               |   |
|                                | <i>Rasbora borapetensis</i>            | Pa Siew 2                 | *                       | *               | *               |   |
|                                | <i>Rasbora daniconius</i>              | Pa Siew 3                 | *                       | *               | *               |   |
|                                | <i>Rasbora paviei</i>                  | Pa Siew 4                 | *                       | *               |                 |   |
|                                | <i>Esomus metallicus</i>               | Pa Siew 5                 | *                       | *               | *               |   |
|                                | <i>Parachela maculicauda</i>           | Pa Siew 6                 |                         | *               | *               |   |
|                                | <i>Rasbora sp.</i>                     | Pa Siew 7                 |                         |                 | *               |   |
|                                | <i>Puntius jacobusboehlkei</i>         | Pa.....                   |                         | *               |                 |   |
|                                | <i>Puntius brevis</i>                  | Pa Khaomon                | *                       | *               | *               |   |
|                                | <i>Puntius sp. (yellow fins)</i>       | Pa Peak leuang            | *                       |                 |                 |   |
|                                | <i>Puntius sp. (black dot)</i>         | Pa Pok                    | *                       |                 |                 |   |
|                                | <i>Dangila Sp.</i>                     | Pa Khee lam               |                         | *               | *               |   |
|                                | <i>Barilius pulchellus</i>             | Pa Khanheua               | *                       | *               |                 |   |
|                                | <i>Barilius sp.</i>                    | Pa Khan heua 1            | *                       |                 | *               |   |
|                                | <i>Barbodes schwanefeldi</i>           | Pa Vienfai                |                         | *               |                 |   |
|                                | <i>Barbodes gonionotus</i>             | Pa Pak                    |                         | *               |                 |   |
|                                | <i>Barbodes altus</i>                  | Pa Leuanfai               |                         |                 | *               |   |
|                                | <i>Cirrhinus lineatus</i>              | Pa Sol                    | *                       |                 |                 |   |
|                                | <i>Cirrhinus molitorella</i>           | Pa Keng                   | *                       | *               | *               |   |
|                                | <i>Puntioplites falcifer</i>           | Pa Sakang                 |                         | *               | *               |   |
|                                | <i>Poropuntius carinatus</i>           | Pa Chart 1                | *                       | *               | *               |   |
|                                | <i>Poropuntius laoensis</i>            | Pa Chart 2                | *                       | *               | *               |   |
|                                | <i>Labeo erythropterus</i>             | Pa Phao                   | *                       | *               | *               |   |
|                                | <i>Onychostoma elongata</i>            | Pa Khing                  | *                       | *               |                 |   |
|                                | <i>Systemus orphoides</i>              | Pa Pok                    | *                       | *               |                 |   |
|                                | <i>Neolissochilus blanci</i>           | Pa Song                   | *                       |                 |                 |   |
|                                | <i>Raiamas guttatus</i>                | Pa Sanark noi             | *                       |                 |                 |   |
|                                | <i>Luciocyprinus striolatus</i>        | Pa Kouan xay              |                         | *               |                 |   |
| <i>Garra pingi</i>             | Pa Phee                                | *                         | *                       |                 |                 |   |
| <i>Garra fuliginosa</i>        | Pa Vok                                 |                           |                         | *               |                 |   |
| <i>Garra cambodgiensis</i>     | Pa..                                   |                           |                         | *               |                 |   |
| <i>Crossocheilus siamensis</i> | Pa Chi manh                            |                           |                         | *               |                 |   |
| <i>Crossocheilus sp.</i>       | Pa Cha loi                             |                           |                         | *               |                 |   |
| CYPRINIDAE                     | <i>Paralaubuca typus</i>               | Pa Tep                    |                         |                 | *               |   |
|                                | <i>Cyclocheilichthys sp.</i>           | Pa Dok ngiew              |                         |                 | *               |   |
|                                | <i>Osteochilus sarawakensis</i>        | Pa..                      |                         |                 | *               |   |
|                                | <i>Osteochilus schlegeli</i>           | Pa..                      |                         |                 | *               |   |
|                                | <i>O. melanopleurus</i>                | Pa Nok khao               |                         |                 | *               |   |
|                                | <i>Barilius sp.</i>                    | Pa Vahao                  |                         |                 | *               |   |
|                                | <i>Cosmochilus hamandi</i>             | Pa...                     |                         |                 | *               |   |
|                                | <i>Scaphognathops sp.</i>              | Pa Pien                   |                         |                 | *               |   |
|                                | <i>Sikukia gudgeri</i>                 | Pa Khao xay               |                         |                 | *               |   |
|                                | <i>Morulius chrysophekadion</i>        | Pa Phia                   |                         |                 | *               |   |
|                                | <i>Systemus partipentazona</i>         | Pa Seua noi               |                         |                 | *               |   |
|                                | TETRAODONIIDAE                         | <i>Tetraodon suvattii</i> | Pa Pao                  | *               | *               |   |
|                                |  | <i>Monotretra leiurus</i> | Pa Pao                  |                 |                 | * |
| SYNBRANCHIDAE                  | <i>Monopterus albus</i>                | Eel                       | *                       | *               |                 |   |
| ANABANTIDAE                    | <i>Anabus testudineus</i>              | Pa Kheng                  | *                       | *               |                 |   |

Notes: \* black spot at caudal base Pa Pok (black spot)

Additional species observed during the second survey (but not during the first one) are listed in the following table.

Table 4.9 Additional Species Found during 2nd Fish Survey

| Scientific name               | Local name                | Collected in Nam Ngiep |                 |             |
|-------------------------------|---------------------------|------------------------|-----------------|-------------|
|                               |                           | Upper Reservoir        | Lower Reservoir | Down stream |
| <i>Bangana lippus</i>         | Pa...                     | *                      | *               |             |
| <i>Danio sp.</i>              | Pa Siew                   |                        | *               | *           |
| <i>Rasbora rubridosalis</i>   | Pa Siew                   |                        | *               | *           |
| <i>Rasbora trilineata</i>     | Pa Siew                   |                        | *               | *           |
| <i>Hypsibabus vernayi</i>     | Pa Pak ( yellow anal fin) | *                      | *               | *           |
| <i>Hypsibabus wetmorei</i>    | Pa Pak (red anal fin)     |                        | *               | *           |
| <i>Osteochilus striolus</i>   | Pa Khee khom              |                        | *               | *           |
| <i>Parachela sp.</i>          | Pa Tep                    | *                      | *               | *           |
| <i>Garra theunensis</i>       | Pa Saak                   |                        | *               | *           |
| <i>Heterobagus sp.</i>        | Pa Kayeng                 |                        | *               | *           |
| <i>Mystus rhegma</i>          | Pa Kayeng                 |                        | *               | *           |
| <i>Cyprinus carpio</i>        | Pa nal                    | *                      |                 |             |
| <i>Osphronemus exodon</i>     | Pa Menh                   |                        |                 | *           |
| <i>Belodontichthys dinema</i> | Pa Khop                   |                        | *               | *           |
| <i>Tixotes microlepis</i>     | Pa Meo                    |                        |                 | *           |
| <i>Trichopsis vittata</i>     | Pa Matt                   | *                      | *               | *           |
| <i>Trichopsis pumila</i>      | Pa Matt                   | *                      | *               | *           |
| <i>Betta smaragdina</i>       | Pa Kall                   |                        | *               | *           |
| <i>Oreochromis niloticus</i>  | Pa nin                    | *                      |                 |             |
|                               |                           | 7                      | 14              | 15          |

#### Distribution of fish biodiversity.

Hundred and thirty-four (134) fish species have been observed from the Nam Ngiep river system. Fifty-seven (57) species are observed in the Upper Reservoir, out of which eight species are not observed in lower river sections. Seventy-eight (78) species were observed in the Lower Reservoir, out of which sixteen species are not observed in upper reservoir and downstream areas. In the downstream area, ninety-one species were observed, out of which forty-five species are not observed in the upper and lower reservoirs. These species are typical of the Mekong system. This distribution is depicted in the following table.

Table 4.10 Distribution of Fish Biodiversity

| NUMBER OF SPECIES OBSERVED           | DISTRIBUTION OF FISH BIODIVERSITY |                 |            |
|--------------------------------------|-----------------------------------|-----------------|------------|
|                                      | Upper Reservoir                   | Lower Reservoir | Downstream |
| Only in upper reservoir area         | 9                                 |                 |            |
| Only in lower reservoir area         |                                   | 16              |            |
| In upper and lower areas             | 18                                |                 |            |
| In lower reservoir and downstream    |                                   |                 | 16         |
| Only in downstream area              |                                   |                 | 46         |
| In upper, lower and downstream areas |                                   | 29              |            |
| Total species observed               | 56                                | 79              | 91         |

#### Fish Migration and Spawning

At present, information on fish species behavior and migrations is still very limited. However, some species observed in the Upper or Lower reservoir have already been reported from other rivers in the Mekong basin where they are considered as migratory. This is the case of *Cirrhinus molitorella*; *Labeo erythropterus*; *Bangana behri*; *Bangana sinkleri*; *Kreptopterus cryptopterus*; *Mystus nemurus*; *Hemibagrus wyckoides*. (Roberts & Baird, 1995). But even the exact timing, location and distance of the migration is still uncertain.

During the first survey from December 1998 to January 1999, fish migration for spawning was reported by the interviewed villagers. Most of the species reported are those undertaking dry season migration, migrating generally over short distances e.g. from the pools to riffles or rocky riverbeds of the same river for spawning. Most of them were reported to take place in the Nam Ngiep River: *Scaphiodonichthys acanthopterus*, *Poropuntius carinatus*, *Poropuntius laoensis*, *Onychostoma sp.* *Systemus orphoides*, *Neolissochilus blanci*, *Puntius gonionotus*, *Tor sp.* *Hampala macrolepidota*.

River mouths are important feeding or spawning grounds for many species (Kottelat, 1997). As reported by the fishermen during the field survey, similar areas exist in some tributaries of the Nam Ngiep River: Nam Theng, Nam Chea in the Upper Reservoir, Nam Phouan, Nam Youk in the Lower Reservoir section.

During the wet season survey in the downstream area, fishermen also reported that Pa Koun (*Wallago leerii*) used to breed in Houay Nam Pha near station No 17 every year early September.

It is evident that after the closing of the dam, these migratory species may either i) Disappear for reasons not related with migrations (habitat destruction, over fishing, pollution, etc., ii) be unable to reproduce because they cannot complete their migrations and then disappear or iii) be able to reproduce without migration or find new migratory routes and spawning sites (Kottelat, 1997).

#### 4.5.1.3. COMPARISON WITH OTHER RIVER SYSTEMS IN LAOS

As already presented, a total of 134 fish species has been recorded during the surveys. This biodiversity compares well with some basins which have already been investigated also for hydropower development purposes.

In the Nam Leuk basin, 122 species were reported. Several surveys in the Nam Theun basin came with a fish biodiversity of 165. In Thailand, investigations on the Pak Mun gave 125 species.

Most of the species found are widely distributed in the region. However, some species not identified at species level may have more restricted distribution. Additional investigation on that matter is recommended for the next stage of the study.

#### 4.5.2. FISHERIES SURVEY

Very few data on fisheries information in Lao PDR have been published. Apart from few reports published by some projects e.g. Socio-economic Survey of Fisheries Communities in Nam Ngum Reservoir, 1992. There is still no reliable information on fishery activities throughout Laos, while it is generally recognized that fish is the first source of animal protein in rural areas (Singkham, 1995). Since the beginning of 1998, the Assessment of the Mekong Fisheries Project of the Mekong River Commission (MRC) started data collection and studies have been made throughout the Lower Mekong basin. Part of the Data will probably be available by the end of year 1999.

#### 4.5.2.1. FISHING ACTIVITIES

Fishing activities are observed in all of the 31 surveyed villages (Upper reservoir 13 villages, Lower reservoir 4 villages and Downstream area 14 villages). The number of persons fishing in each household in the Upper Reservoir is about 1.1, whereas in the lower reservoir it is 1.5. and 1.3 in the Downstream, with an average of all 3 areas of 1.3. The survey indicates that up to 68 % of the household heads interviewed fish all year long. It also appears that the percentage of villagers fishing all year long in the Lower Reservoir (80%) is higher if compared to the Upper Reservoir (67%) and only 56% in downstream.

Most of the villagers fish about 2 to 3 times a week, as detailed in the following table.

Table 4.11 Frequency of Fishing in Percentage of the Reply

| Nos. of fishing days / week |            | Upper reservoir | Lower reservoir | Downstream | All  |
|-----------------------------|------------|-----------------|-----------------|------------|------|
| 1 day                       | Dry season | 11              | 7               | 17.2       | 11.7 |
|                             | Wet season | 24              | 17              | 9.4        | 16.8 |
| 2 days                      | Dry season | 15              | 17              | 31.3       | 21.1 |
|                             | Wet season | 23              | 30              | 15.6       | 22.8 |
| 3 days                      | Dry season | 30              | 30              | 6.3        | 22.1 |
|                             | Wet season | 19              | 35              | 15.6       | 23.2 |
| 4 days                      | Dry season | 16              | 22              | 7.8        | 15.2 |
|                             | Wet season | 11              | 7               | 4.7        | 7.5  |
| 5 days                      | Dry season | 8               | 11              | 7.8        | 8.9  |
|                             | Wet season | 8               | 7               | 15.6       | 10.2 |
| 6 days                      | Dry season | 2               | 9               | 6.3        | 5.7  |
|                             | Wet season | 4               | 0               | 6.3        | 3.4  |
| Every day                   | Dry season | 2               | 2               | 6.3        | 3.4  |
|                             | Wet season | 2               | 0               | 12.5       | 4.8  |
| No reply                    | Dry season | 17              | 2               | 17.2       | 12.0 |
|                             | Wet season | 11              | 4               | 20.3       | 11.7 |

#### 4.5.2.2. FISH CATCHES

According to the villagers, the best time to catch fish in the Nam Ngiep River and the tributaries is in the dry season. This applies for the Upper as well as for the Lower Reservoirs. For the ponds it is of course in the wet season, as most dry up in winter.

Most of the villagers interviewed confirmed that fish catches are at peak in November-December in the Nam Ngiep River. May-June is also a reasonably good period for fish catches.

The survey reported a quantity of fish catches in average of 0.7 kg/fishing time/household.

#### 4.5.2.3. FISHING GEARS

Fishing gears commonly used in the survey areas are summarized in the following Table. Gillnet with hook and lines represent the most popular fishing gears. The average gillnet per household is 2.8, but in the downstream area, an average of 4.3 per household is observed. The cast net is the third most represented fishing gear, with about 1 per household. In term of number per household, hooks and lines come first with an average of 37/hh. Basket net, basket trap and funnel trap are not common

among the Lao Sung population of the lower reservoir, which uses mainly gill net, cast net and hook line.

Table 4.12 Average Number of Fishing Gears per Household Surveyed

| Types of fishing gear commonly used in the survey areas | Upper reservoir | Lower reservoir | Downstream | All  |
|---|-----------------|-----------------|------------|------|
| Gill net  | 2.0             | 2.3             | 4.3        | 2.8  |
| Cast net  | 0.9             | 0.9             | 1.2        | 1.0  |
| Scoop net   | 0.7             | 0.02            | 0.4        | 0.4  |
| Basket net  | 0.005           | 0.0             | 0.7        | 0.2  |
| Basket trap   | 0.005           | 0.0             | 2.2        | 0.7  |
| Funnel trap   | 0.3             | 0.0             | 0.4        | 0.2  |
| Hook and line   | 22.4            | 24.4            | 65.4       | 37.4 |

The boat is an important tool for fishing. Less than 33% of the investigated households have a boat. It is observed that in the downstream area, more households have a boat (44%) than in reservoir area. Only 28% of those having a boat report also a motor, the other 72% using only paddle. In the downstream area, the number of those reporting a motor boat raises to 61%. This is quite understandable as the river downstream allows boat use and transportation, a practice more limited by the rapids and the flow in the reservoir area.

#### 4.5.2.4. FISHING AREAS

Preferred fishing areas vary according to the season. During the wet season, the water depth and the strong flow may limit the practice in the main river. During this period, fishing occurs also in the smaller tributaries and in the paddy fields. The peak season for river fishing is in May-June when the discharge increases and the fish move upwards the river.

Table 4.13 Preferred Fishing Areas in the Reservoir Area (% of answers).

| Fishing areas | Seasons          |     |                  |     |
|---------------|------------------|-----|------------------|-----|
|               | Beginning of wet | Wet | Beginning of dry | Dry |
| Nam Ngiep     | 52               | 55  | 53               | 55  |
| Tributaries   | 31               | 43  | 44               | 44  |
| Ponds         | 3                | 2   | 2                | 1   |
| Others        | 13               | 0   | 0                | 0   |

#### 4.5.2.5. FISH CONSUMPTION, PROCESSING AND MARKETING

The average fish consumption per household and per year has been established at 137 kg/HH/year in the Downstream area. No consistent information was gathered from the upstream area to assess the consumption. Anyway, it should not be much different than in the downstream area. This figure is particularly close to the result of a 3 years fishery monitoring for the Nam Leuk Project, which comes to an average of 133 kg/hh/year (or 50-60 grs/capita/day)

About 47% of the villagers interviewed buy occasionally fish from the market or from other fishermen in their village. This figure is consistent with 41% of fishers who report selling occasionally a part of their catches.

The average fish price in the area varies from 2,200 kips/kg (Upper reservoir), to 7,100 kips/kg (downstream area). This may be explained by a more autarkic economy in the

upper reservoir than in the downstream area, which is more open to the national market and which reflects more rapidly the high inflation rate which prevails in the country (at the time of survey, 1 US\$ was equivalent to about 9,000 Kips).

Some of the catches are also preserved in different forms such as dried fish, smoked fish or transformed in fish paste "Padek". This type of preparation is more popular in the Lao Loum communities as shown in the survey, where 72 % of the interviewed villagers in the downstream area reported the preparation of Padek against 36% only in the Reservoir area.

Table 4.14 Marketing of Fish

|                               |                 |                 |              |      |
|-------------------------------|-----------------|-----------------|--------------|------|
| Percentage of HH selling fish | Upper reservoir | Lower reservoir | Down- stream | All  |
| % of HH selling               | 39              | 37              | 48           | 41   |
| % of HH not selling           | 61              | 63              | 44           | 56   |
| No reply                      | 0               | 0               | 8            | 3    |
| Percentage of HH buying fish  | Upper reservoir | Lower reservoir | Down- stream | All  |
| Buy                           | 59              | 35              | 48           | 47   |
| Not buy                       | 41              | 65              | 41           | 49   |
| No reply                      | 0               | 0               | 11           | 4    |
| How often buying fish         | Upper reservoir | Lower reservoir | Down- stream | All  |
| Frequently                    | 11              | 31              | 26           | 23   |
| Sometime                      | 89              | 69              | 74           | 77   |
| Reported average fish price   | Upper reservoir | Lower reservoir | Down- stream | Av.  |
| Kips/kg                       | 2200            | 2400            | 7100         | 3900 |

The percentage of villagers reporting observed fish migration nearby their village ranges from 69% (Downstream area) to 59% (lower reservoir) and 55% (upper reservoir). In the downstream area, more than 80% of the observers reported upstream migration from May to August, at the beginning of the rainy season. Downstream migration is reported from September to December. This clearly confirms the existence of fish migration in the Nam Ngiep.

Table 4.15 Observed Fish Migration

|                             |                 |                 |              |           |
|-----------------------------|-----------------|-----------------|--------------|-----------|
| Description                 | Upper reservoir | Lower reservoir | Down- stream | All       |
| Observed fish migration (%) | 57              | 78              | 72           | 69        |
| Not observed (%)            | 43              | 22              | 28           | 31        |
| Going Upstream              | 55              | 59              | No answer    | No answer |
| Going Downstream            | 45              | 41              | No answer    | No answer |

#### 4.5.2.6. FISH CULTURE

There is few fish culture practices in the project area. This is still new for many of the villagers, mainly in the reservoir area. In the absence of a market and the river being able to satisfy requirements, there was no need for the development of such practice. In the downstream area, the road connection to Vientiane and a higher urban population has raised more interest for fish culture among villagers.

A recent survey carried out in 1998 by RMR in the context of the Nam Leuk Project consisted in the identification of existing processes and trends in fishery intensification in the area of Thabok and in the Vientiane plain. Several practices have already been identified, namely: Rice field fish pond, Funnel trapping of surface drainage channel, Fish home fattening tanks, Opportunistic fish ponds, Village fish ponds, Field fish



ponds, Floating net cages.

#### 4.5.2.7. OPPORTUNITIES FOR BEING FISHERMAN IN THE FUTUR RESERVOIR.

The villagers were also asked for their interest to become a fisherman after the creation of the reservoir. If almost half (44%) of interviewed people expressed their interest in the upper reservoir, only 26% did the same in the lower reservoir.

## 4.6. TERRESTRIAL NATURAL ENVIRONMENT

### 4.6.1. SURVEY ORGANIZATION AND METHODS

The work related to the terrestrial ecology had two major objectives:

1. to provide a preliminary information on the present condition of wildlife and habitats in the project area (including the whole catchment),
2. to provide a preliminary information on the vegetation biomass and commercial timber volumes available in the reservoir area.

A first field work campaign was carried out from January 22 to February 20 by a team of 7 persons followed by a second field work campaign from April 1 to 12.

The period January 21 to March 3, 1999 was spent in analysis and identification of data and specimens collected.

#### 4.6.1.1. METHODS FOR WILDLIFE AND HABITAT SURVEY

Field methods used were more or less standard observational techniques employed in vertebrate and habitat surveys, generally applied in this type of environment. These are:

- Slow and quiet daylight movement on foot along tracks, across open glades and down rivers making visual identifications using binoculars and aural identification at frequent stopping points
- Slow and quiet night movement on foot along tracks, across open glades and down rivers making visual identifications using binoculars combined with head-mounted spotlights, and aural identification at frequent stopping points
- Baiting and the laying of scent trails. Baits used were dead pigs, live and dead chickens. These were placed in a range of locations. Baits were visited once per day. IR Camera traps were set up next to dead bait. IR Camera traps were also set up on animal tracks and beside watering holes.
- Collection and identification of bones and teeth.

- Identification of all animal faeces encountered
- Searches of sand, mud and other suitable surfaces for animals spore
- Examination of tracks for signs of animal use
- Examination of trees, particularly those in fruit, for signs of climbing animals
- Interviews with hunters, villagers and farmers, and examination of animal remains in villages.
- Commissioning local hunters to collect small vertebrates
- Opportunistic collections of small animals by all staff.

The short time available and the need to cover a large area made it inappropriate to mount a systematic trapping program, which may be however recommended for further stages of the project.

Systematic observation of geology, geomorphology, soil, drainage, erosion processes, vegetation (species, size, demography, "patterns", use & condition) land-use and potential on ground and aerial traverses.

Frequent photography of habitats to provide illustrative material.

#### 4.6.1.2. METHOD FOR VEGETATION BIOMASS AND COMMERCIAL TIMBER

It was not possible stratify vegetation in the inundation zone prior to performing the survey because clearance could not be obtained for an over flight.

Two different methods were used to estimate commercial timber volumes and vegetation biomass. Three sampling sites have been surveyed to date.

##### Commercial Timber Volumes

For each sampling site, selected a bearing (0-359°) was determined using random numbers. The survey team then marked out 100m on the appropriate bearing. All trees within 20m either side of the transect line were surveyed. Each sampling site surveyed an area of approximately 400m<sup>2</sup>.

For each tree the scientific and local name was recorded. A hand held clinometer was positioned at least 25m from the tree and, if possible, at a point slightly above the horizontal plane of the base. A narrow path was then cut through the low vegetation to afford a clear view of the trees trunk from the clinometer position. Readings of inclination were taken from:

- the base of the trunk
- 1.0m diameter breast height points
- the top cutting position as indicated by the expert tree feller

A standard diameter tape was used to measure diameters at heights of 1.0m. In addition any comments about the expected timber quality were recorded.

### Vegetation Biomass

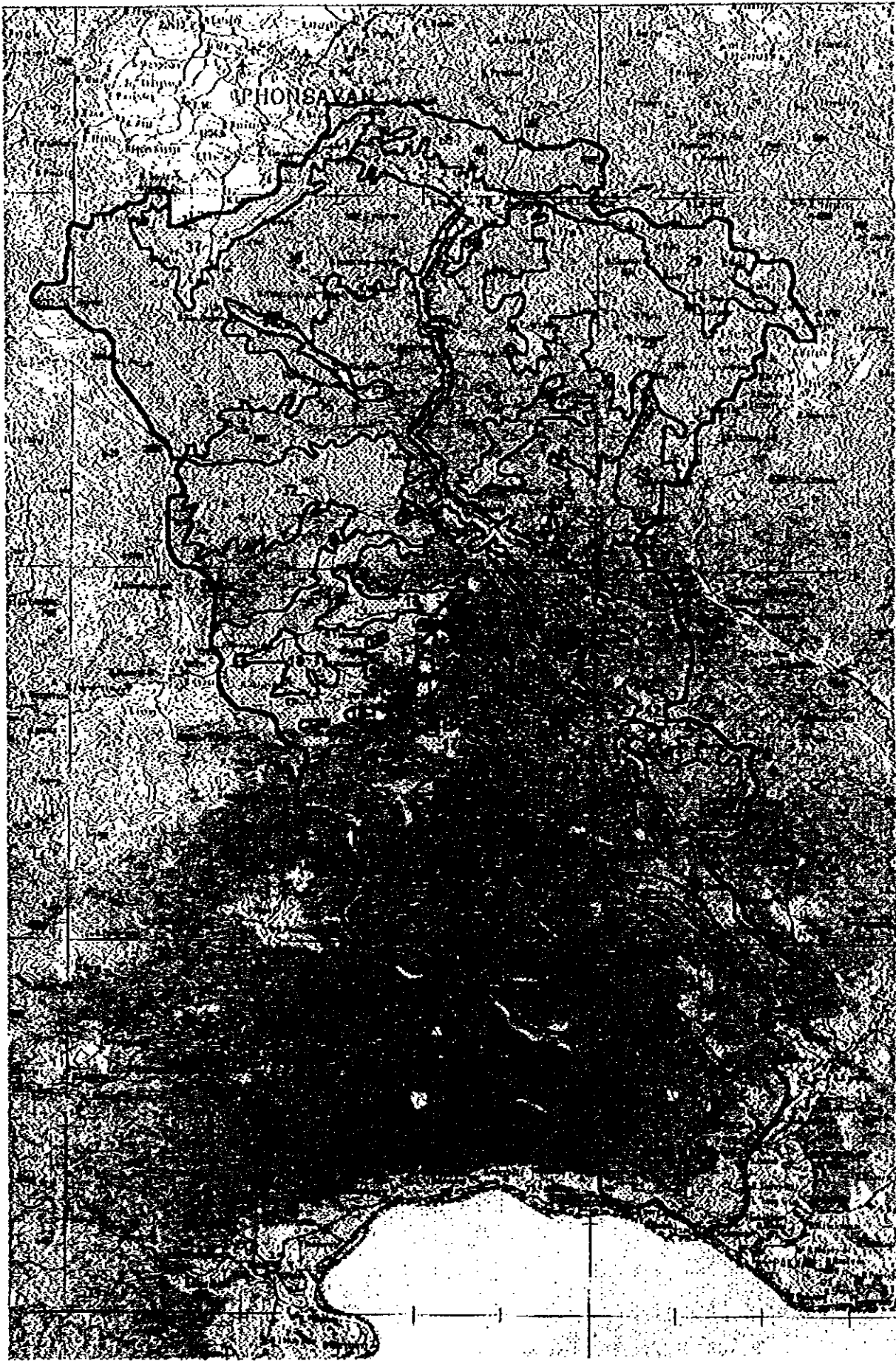
A stake was placed at each randomly selected sampling site. This has become the Southwest corner of quadrat 1 for each sample. From this stake using compass and tape, a 5x5m square was laid out with North/South and East/West sides.

For each 5x5m square all the vegetation biomass was classified, measured and recorded in distinct categories; litter, low vegetation, dead branches, dead logs, live bamboo, dead bamboo, small trees (dbh >3cm and <20cm), large trees (dbh >20cm), lianas and vines.

### 4.6.2. LAND SYSTEMS IN THE CATCHMENT AREA

The catchment was analyzed using 1:50,000 and 1:100,000 scale maps and divided into 40 land systems. A further catchment analysis has been made to describe the sub-catchments of the Nam Ngiep river. The results are presented in Table 1. A reconnaissance level description of each land system unit has been made from all sources available to the consultants and is set out in the following table.

The 40 land systems identified are presented on Figure 4.7.

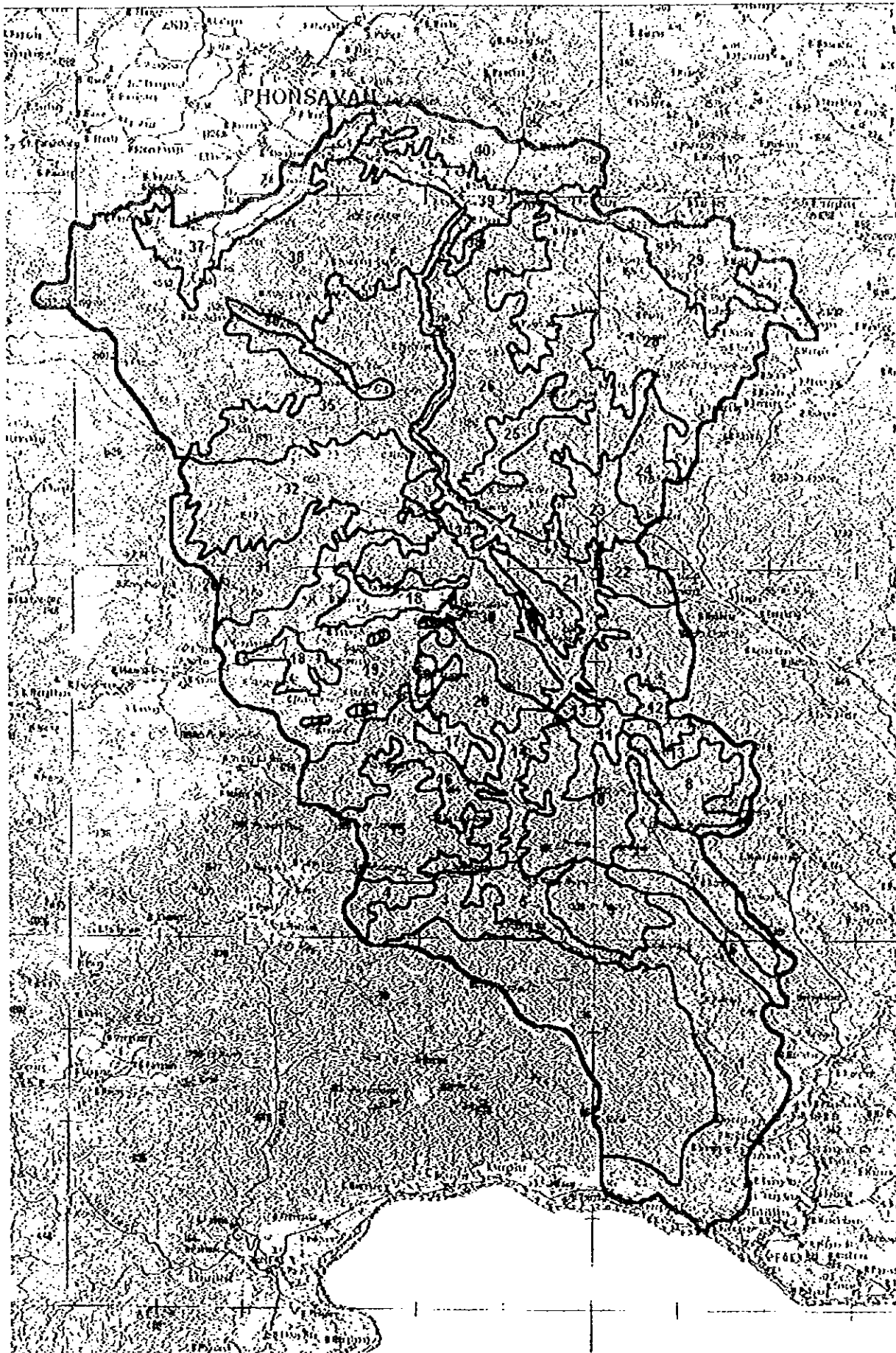


FEASIBILITY STUDY  
 ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT  
 IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC  
 JAPAN INTERNATIONAL COOPERATION AGENCY

FIRST ENVIRONMENTAL IMPACT ASSESSMENT

Figure 4.7

**LAND SYSTEMS  
 IN THE NAM NGIEP CATCHMENT**



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 4.7

**LAND SYSTEMS  
 IN THE NAM NGIEP CATCHMENT**

Table 4.16 Land Systems of the Nam Ngiep Catchment

| Land System Number | Land System Name                 | Area in sq. Km. | Mean Altitude in m. | Geology  | Geomorphology & Soils  | Recent Land-Use  | Vegetation   | Land Potential   |
|--------------------|----------------------------------|-----------------|---------------------|--|--|--|--|--|
| 1                  | Nam Ngiep Valley Terrace         | 236             | 170                 | Quaternary deposits of sand, silt & clay.  | Flat to gently undulating valley terrace with silty soils 2-3m deep.   | Extensively used for paddy & hill rice, and livestock. Heavy use for forest products.                  | Grasslands, secondary woodlands & low bushlands, with seasonally flooded swamplands near Mekong River                    | Many areas can be irrigated using regulated river. Intensive arable use to be expected.                |
| 2                  | Phu Katha Eroded Plateau         | 320             | 850                 | Jurassic & Jurassic-Cretaceous red conglomerate, sandstone, siltstone & claystone. | Very deeply incised valleys cutting plateau remnants. Soils shallow silt, with some rock pavements.                              | Flatter plateau tops have been cultivated in the past; now apparently abandoned.                       | Low secondary woodland including Pines, Dipterocarps & evergreens. Grassy glades & clearings.                            | Highest potential comes from recreational use as a site for scenic & wildlife lodges.                  |
| 3                  | Nam Gnok Noi Valley              | 68              | 520                 | Jurassic & Jurassic-Cretaceous red conglomerate, sandstone, siltstone & claystone  | Moderately sloping slightly incised valleys with soils 1-2m deep.  | Previously extensively cultivated and evidence of increased cropping now.                              | Low bamboo & secondary woodland; some recently cleared land supporting pasture.  | Perennial tree crops and pasture in agro-forestry production system.                                   |
| 4                  | Phu Nam Gnok Noi Plateau Remnant | 20              | 1000                | Jurassic & Jurassic-Cretaceous red conglomerate, sandstone, siltstone & claystone. | Very deeply incised valleys cutting plateau remnants now reduced to hilltops. Soils very shallow silt, with many exposed cliffs. | Previously cultivated on limited areas with less steep slopes; now apparently abandoned.               | Low secondary woodland including Pines, Dipterocarps & evergreens. Grassy glades & clearings.                            | Highest potential comes from recreational use as a site for scenic & wildlife lodges.                  |
| 5                  | Lower Reservoir                  | 48              | 310                 | Jurassic-Cretaceous red conglomerate, sandstone, siltstone & claystone             | Flat to gently undulating valley terrace with silty-clay soils 2-3m deep.  | Previously extensively cultivated and evidence of increased cropping now.                              | Low secondary woodland and bamboo thickets. Pasture lands and clearings. Most of the area is current or fallow cropland. | A rich arable area, with considerable potential for irrigation development.                            |
| 6                  | Say Phou Spur                    | 44              | 400                 | Jurassic-Cretaceous red conglomerate, sandstone, siltstone & claystone             | Very steeply sloping elongated whale-backs with medium to shallow soils.   | Previously cultivated on limited areas with less steep slopes; now apparently abandoned.               | Low secondary woodland and bamboo thickets.  | Limited potential for forestry & grazing.  |
| 7                  | Nam Xao Valley Terrace           | 72              | 200                 | Jurassic & Jurassic-Cretaceous red conglomerate, sandstone, siltstone & claystone. | Flat to gently undulating valley terrace with silty-clay soils 2-3m deep.  | Previously extensively cultivated and evidence of increased cropping now, with small scale irrigation. | Low secondary woodland and bamboo thickets. Pasture lands and clearings.   | A rich arable area, with considerable potential for irrigation development if water can be brought in. |

| Land System Number | Land System Name        | Area In sq. Km. | Mean Altitude in m. | Geology   | Geomorphology & Soils  | Recent Land-Use   | Vegetation   | Land Potential   |
|--------------------|-------------------------|-----------------|---------------------|---|--|---|--|--|
| 8                  | Nam Pou Valley Terrace  | 40              | 250                 | Late Triassic granite intrusives; Permian limestones with intermediate effusives; Upper Ordovician - Silurian limestone, conglomerate & schist. | Gently to moderately sloping terrace with silty soils of 1-2m depth.                                   | Previously extensively cultivated, and evidence of an increase in cropping now.   | Low secondary woodland and bamboo thickets. Pasture lands and clearings.                                   | Perennial tree crops and pasture in agro-forestry production system, with some irrigable areas, for which additional water will be required.         |
| 9                  | Phu Huasua Mountain     | 92              | 820                 | Jurassic & Jurassic-Cretaceous red conglomerate, sandstone, siltstone & claystone.  | Very steeply and steeply sloping plateau relict with silty generally shallow soils.                    | Previously cultivated on east facing less steep slopes; now apparently abandoned. | Low secondary woodland and bamboo thickets. Some small stands of older trees.                              | Limited potential for forestry & grazing.  |
| 10                 | Phu Mun/Kong-kae Mtns.  | 142             | 560                 | Triassic sandstone, siltstone, shale, marl & coal seams.  | Deeply dissected plateau remnants with shallow soils. Cliffs and sandstone outcroppings occur.         | Previously cultivated on east facing less steep slopes; now apparently abandoned. | Low secondary woodland and bamboo thickets. Some more extensive stands of older trees.                     | Moderate potential for forestry & grazing in the west. Perennial tree crops and pasture in agroforestry production systems on the low eastern hills. |
| 11                 | Nam Ma Valley Terrace   | 20              | 410                 | Late Triassic intrusives with Triassic sandstone, siltstone, shale, marl & coal seams.  | Flat to gently undulating valley terrace with silty-clay soils 2-3m deep.                              | Previously very extensively cultivated. Some apparent increase in cropping now.   | Low secondary woodland, bamboo thickets and some stands of older trees. A few pasture lands and clearings. | A rich arable area, with considerable potential for irrigation development if water can be brought in.   |
| 12                 | Upper Phu Moun Mountain | 26              | 1030                | Late Triassic intrusives.   | Moderately sloping mountain top with weakly incised drainages. Soils 1-3m deep with high clay content. | Previously very extensively cultivated. Said still to support some cropping.      | Low secondary woodlands and bushy grasslands with bamboo thickets.   | Moderate potential for livestock & forestry use. Specialised tree crops could be established. Water is main constraint.                              |
| 13                 | Lower Phu Moun Mountain | 148             | 490                 | Permian limestones with intermediate effusives.   | Moderately sloping low hills & lower mountain slopes.  | Previously supported a few areas of hill rice; now apparently not used.           | Low secondary woodland and bamboo thickets. Some more extensive stands of older trees.                     | A few areas could be developed for perennial tree crops and pasture in agroforestry production systems. Reasonable forestry & livestock potential    |
| 14                 | Middle Reservoir        | 32              | 330                 | Late Triassic intrusives.   | Flat to gently undulating valley terrace with some low hills. Silt-clay soils 2-3m deep.               | Previously moderately cropped. Now extensively cultivated on all terrace land.    | A very few old trees. Mostly pasture and cropland (current and fallow)                                     | A rich arable area, with considerable potential for irrigation development.  |

| Land System Number | Land System Name             | Area In sq. Km. | Mean Altitude in m. | Geology  | Geomorphology & Soils   | Recent Land-Use  | Vegetation   | Land Potential  |
|--------------------|------------------------------|-----------------|---------------------|--|---|--|--|---|
| 15                 | Upper Phu Samsao Mtn.        | 96              | 1140                | Antecarboniferous granites.  | Moderately sloping mountain top with weakly incised drainages. Soils 1-3m deep with high clay content.  | Previously very extensively cultivated. Lower slopes still support hill rice, maize and cassava cropping & livestock.                                    | Medium secondary woodlands, bushed grasslands and open grassland/shrubland. Isolated trees & some bamboo thickets. | Moderate potential for livestock & forestry use. Specialised tree crops could be established. Water is main constraint.   |
| 16                 | Lower Phu Samsao Mtn.        | 124             | 850                 | Antecarboniferous granites.  | Moderately and steeply sloping mountain lower slopes with moderately incised drainages. Soils 1-2m deep with high clay content.   | Previously supported a few areas of hill rice; present use not known except near Nam Gniep River, where there is increased cropping.                     | Medium secondary woodland and extensive bamboo thickets. Some more extensive stands of older trees.                | Areas adjacent to the Nam Gniep & Nam Phouan could be developed for perennial tree crops and pasture in agroforestry production systems. Reasonable forestry & livestock potential. |
| 17                 | North Nam Phouan Valley Side | 32              | 980                 | Antecarboniferous granites.  | Moderately sloping mountain side with weakly incised drainages. Soils 1-3m deep with high clay content.   | Previously very extensively cultivated. Present use not known.   | Medium secondary woodlands, bushed grasslands and open grassland/shrubland. Isolated trees & some bamboo thickets. | Moderate potential for livestock & forestry use. Specialised tree crops could be established. Water is main constraint.   |
| 18                 | Phadoy Upland Plains         | 72              | 980                 | Devonian-Carboniferous shale, sandstone, limestone, rhyolite, tufts & Silurian-Lower Devonian shale, sandstone limestone, andesite & tufts.  | Flat to moderately sloping infilled terraces with fairly deep soils.  | Recently and still heavily used for paddy rice, hill rice, wet season maize & pasture. Many villages and gardens. Apparent expansion of use in progress. | Current and fallow cropland and grasslands.  | An area with considerable potential for irrigation development if water use can be managed.   |
| 19                 | Phadoy Uplands               | 236             | 1355                | Devonian-Carboniferous shale, sandstone, limestone, rhyolite, tufts; Silurian-Lower Devonian shale, sandstone limestone, andesite & tufts; Triassic siltstone, marl, shale, rhyolite, tufts. | Complex mountain area with moderate to steep slopes & incised drainages. Some karst areas with limestone cliffs & outcroppings. Soils vary from deep to shallow, generally silty. | Recently & still heavily cropped & used for livestock.   | Low shrubland with scattered low trees; bamboo thickets on lower slopes. Current and fallow cropland               | Areas adjacent to the Phadoy Upland Plains could be developed for perennial tree crops and pasture in agroforestry production systems. Reasonable forestry & livestock potential.   |



| Land System Number | Land System Name        | Area in sq. Km. | Mean Altitude in m. | Geology  | Geomorphology & Soils   | Recent Land-Use  | Vegetation   | Land Potential  |
|--------------------|-------------------------|-----------------|---------------------|--|---|--|--|---|
| 20                 | Samlian Eastern Slopes  | 76              | 860                 | Antecarboniferous granites; Triassic siltstone, marl, shale, rhyolite, tuffs.  | Moderate to steep slopes and weakly incised drainages. Soils about 2m. with some clay.                | Recently extensively used. Use now confined to lower slopes close to Nam Gniep valley.   | Medium secondary woodland and extensive bamboo thickets. Some more extensive stands of older trees.  | Areas adjacent to the Nam Gniep could be developed for perennial tree crops and pasture in agroforestry production systems. Reasonable forestry & livestock potential.        |
| 21                 | Upper Reservoir         | 80              | 350                 | Permian limestones with intermediate effusives & Jurassic-Cretaceous red conglomerate, sandstone, siltstone & claystone. | Flat to gently undulating valley terrace with some low hills. Silty-clay soils 2-3m deep.             | Recently and still heavily used for paddy rice, hill rice, wet season maize & pasture. Many villages and gardens. Apparent rapid expansion of use in progress, with irrigation projects. | Current and fallow cropland and grasslands. Some low secondary woodland, bamboo thickets and seasonal swamps on lower Nam Mang and a few section of Nam Gniep. | A rich arable area, with considerable potential for irrigation development and crop intensification.  |
| 22                 | Nong Houd Hills         | 28              | 600                 | Jurassic-Cretaceous red conglomerate, sandstone, siltstone & claystone.  | Low hills with moderate to steep slopes and moderately incised drainages. Soils 2m deep & silty.      | Recently extensively used for hill rice production. Current use not known.   | Medium secondary woodland and extensive bamboo thickets. Some small stands of older trees.   | Areas adjacent to the Nam Gniep valley could be developed for perennial tree crops and pasture in agroforestry production systems. Reasonable forestry & livestock potential. |
| 23                 | Lower Nam Chian Valley  | 60              | 610                 | Upper Ordovician - Silurian limestone, conglomerate & schist; Antecarboniferous granites.                                | Narrow valley terrace weakly incised between moderately steep low hills. Soil depths probably medium. | Recently extensively used for hill rice production. Current use not known.   | Medium secondary woodland and bamboo thickets. Some stands of older trees. Current & fallow cropland.  | Areas adjacent to the Nam Chian valley could be developed for perennial tree crops and pasture in agroforestry production systems. Reasonable forestry & livestock potential. |
| 24                 | Phu Nang Phoun Mountain | 52              | 1160                | Antecarboniferous granites.  | Mountain with steep slopes and moderately to weakly incised drainages. Shallow soils.                 | Recently partly cropped but now abandoned.   | Medium secondary woodland and bamboo thickets. Some stands of older trees.   | Limited potential for forestry & livestock.   |

| Land System Number | Land System Name       | Area In sq. Km. | Mean Altitude In m. | Geology  | Geomorphology & Soils   | Recent Land-Use  | Vegetation   | Land Potential  |
|--------------------|------------------------|-----------------|---------------------|--|---|--|--|---|
| 25                 | Phu Xao Mtn. Clearings | 52              | 1310                | Antecarboniferous granites; Upper Ordovician -Silurian limestone, conglomerate & schists; Permian limestones with intermediate effusives.        | Moderate sloping mountain top with weakly incised drainages.  | Recently and still extensively cropped. Many livestock   | Open shrub grassland and low bushland, with bamboo thickets and stands of older trees. Current and fallow cropland.                          | Limited potential for forestry & livestock.   |
| 26                 | Phu Kabo Phu Xao Mtn.  | 316             | 1390                | Antecarboniferous granites; (Some Upper Ordovician -Silurian limestone, conglomerate & schists; Permian limestones with intermediate effusives). | Mountain sides with moderate to steep slopes. Severely eroded with moderately to weakly incised drainages. Shallow soils.                             | Recently and still partly cropped, and used for livestock production.  | Medium height dense secondary woodland and bamboo thickets. Some extensive stands of older trees.  | Limited potential for livestock; probably suitable for commercial forestry uses.  |
| 27                 | Upper Nam Ngiép Valley | 9               | 755                 | Antecarboniferous granites.  | Narrow flat valley terrace with variable depth of soils.  | Recently growing paddy rice at northern and southern ends. Some expansion of cropping taking place.  | Medium secondary woodland and bamboo thickets. Open grasslands and current and fallow croplands.   | An area with some potential for irrigation development and crop intensification.  |
| 28                 | Phu Houat Uplands      | 347             | 1380                | Antecarboniferous granites; (Some Permian limestones with intermediate effusives).   | Mountain tops with moderate and a few steep slopes. Severely eroded with weakly and some moderately incised drainages. Medium depth silty-clay soils. | Recently and currently intensively farmed for hill rice, maize and cassava. Considerable livestock populations. Narrow valley terraces are poldered for paddy rice production.   | Open shrub grassland and low bushland, with bamboo thickets and stands of older trees. Current & fallow cropland.                            | Moderate to high potential for livestock & forestry use. Specialised tree crops could be established, and incorporated into agro-forestry production systems. Water is main constraint. |
| 29                 | Upper Nam Chian Valley | 108             | 1250                | Antecarboniferous granites; Permian limestones with intermediate effusives.  | A moderate to gently sloping watershed terrace with weakly or non-incised drainages. Soils medium to deep.  | Recently and currently intensively farmed for hill rice, maize and cassava. Considerable livestock populations. Most valley terraces are poldered for paddy rice production. Substantial increases in cropping taking place. | Open shrub grassland and low bushland. A few bamboo stands, with bamboo thickets and large stands of older trees. Current & fallow cropland. | High potential for livestock & forestry use. Specialised tree crops could be established, and incorporated into agro-forestry production systems. Water is main constraint.             |

| Land System Number | Land System Name               | Area In sq. Km. | Mean Altitude In m. | Geology   | Geomorphology & Soils   | Recent Land-Use   | Vegetation   | Land Potential  |
|--------------------|--------------------------------|-----------------|---------------------|---|---|---|--|---|
| 30                 | Phu Tin Eastern Slopes         | 120             | 875                 | Late Triassic granite intrusives; Triassic sandstone, siltstone, shale, marl & coal seams.  | Very steep mountain slopes with moderately incised drainages. Soils shallow to medium.                                    | A few less steep slopes have been cropped in the past; now apparently abandoned.  | Medium height dense secondary woodland, with extensive areas of older trees. Bamboo thickets and some glades on old fields.                                  | Low potential for forestry use.   |
| 31                 | Phu Bia Mountain               | 100             | 2430                | Permian limestones with intermediate effusives; Devonian siltstone, shale, & limestone.   | Very steep mountain slopes with weakly to moderately incised drainages. Soils shallow to medium.                          | One or two small areas on hilltops have been cropped in the past; now apparently abandoned.   | Medium and tall dense secondary woodland and forest, with extensive areas of older trees, including Conifers. Bamboo thickets and some glades on old fields. | Medium potential for forestry use.  |
| 32                 | Nam Siam Upper Valley          | 184             | 975                 | Devonian siltstone, shale, & limestone; (Some Permian limestones with intermediate effusives & late Triassic granite intrusives.)   | Steep and moderate mountain slopes with moderately incised drainages. Soils shallow to medium.                            | Recently very intensively used for cropping; now apparently for little used.  | Open shrub grassland, low bushland & low secondary woodland. A few bamboo thickets. Current & fallow cropland.   | Medium potential for livestock and forestry in the west of the unit. Specialised tree crops could be established, and incorporated into agro-forestry production systems. |
| 33                 | Phu Xao Noi Hill               | 44              | 580                 | Permian limestones with intermediate effusives.   | Moderately sloping low hills & lower mountain slopes.   | Previously supported a few areas of hill rice; now apparently not used.   | Dense low secondary woodland and forest with extensive bamboo thickets. Some stands of older trees.  | Reasonable forestry & livestock potential.  |
| 34                 | Nam Pang Valley                | 52              | 480                 | Late Triassic granite intrusives; Triassic sandstone, siltstone, shale, marl & coal seams; Jurassic-Cretaceous red conglomerate, sandstone, siltstone & claystone.                      | Flat to gently undulating valley terrace with some low hills. Silty-clay soils 2-3m deep.                                 | Recently partly used for growing hill rice, maize & cassava, and for livestock. Now more extensively used for cropping and livestock. | Open shrub grassland, low bushland & low secondary woodland. A few bamboo thickets. Current & fallow cropland.   | High potential for livestock & forestry use. Specialised tree crops could be established, and incorporated into agro-forestry production systems.                         |
| 35                 | Nam Siam Nam Pot Lower Valleys | 240             | 1075                | Devonian siltstone, shale, & limestone; Permian limestones with intermediate effusives; late Triassic granite intrusives; Ante-carboniferous granites; Carboniferous-Permian limestone. | Mountain sides with moderate to steep slopes. Severely eroded with moderately to weakly incised drainages. Shallow soils. | Recently and still partly cropped, and used for livestock production.   | Medium height dense secondary woodland and bamboo thickets. Some extensive stands of older trees.  | Limited potential for livestock; probably suitable for commercial forestry uses.  |

| Land System Number | Land System Name     | Area In sq. Km. | Mean Altitude in m. | Geology   | Geomorphology & Soils  | Recent Land-Use  | Vegetation   | Land Potential   |
|--------------------|----------------------|-----------------|---------------------|---|--|--|--|--|
| 36                 | Nam Pot Valley Floor | 28              | 1120                | Carboniferous-Permian limestone; Permian shale, chert, siltstone, limestone, coal seams.  | Narrow flat valley terrace with variable depth of soils.   | Recently and currently intensively cultivated for paddy rice on poldered fields. Some expansion of cropping taking place. Heavily used by livestock  | Open grasslands and current and fallow croplands.  | An area with some potential for irrigation development and crop intensification.   |
| 37                 | Phonsavan Plain      | 88              | 1120                | Permian limestones with intermediate effusives; Silurian-Lower Devonian shale, sandstone, limestone, andesite & tuffs; Carboniferous-Permian limestone; (Some Quaternary deposits of sand, silt & clay.   | Flat to gently undulating plain, with weakly to very weakly incised drainages.   | Recently and currently very heavily used for cultivating rice, maize, vegetable, etc., with large numbers of livestock. Valley floors are frequently poldered. Many villages and gardens. Small scale irrigation schemes widespread. | Open grasslands and current and fallow croplands. Stands of young Pines widespread.  | A rich arable area, with considerable potential for irrigation development and crop/livestock intensification.   |
| 38                 | Phu Khe Uplands      | 544             | 1250                | Devonian siltstone, shale, & limestone; Permian limestones with intermediate effusives; late Triassic granite intrusives; Antecarboniferous granites; Carboniferous shale, chert, siltstone, limestone, coal seams; Devonian-Carboniferous shale, sandstone, limestone, rhyolite, tuffs; Silurian-Lower Devonian shale, sandstone, limestone, andesite & tuffs; | Mountain with moderate and a few steep slopes. Severely eroded with weakly and some moderately incised drainages. Medium depth silty-clay soils. Some areas of karst formations, featuring cliffs and rock outcroppings. | Recently and currently intensively farmed for hill rice, maize and cassava. Considerable livestock populations. Narrow valley paddy rice production, with irrigation based on diverted stream flows.                                 | Open shrub grassland and low bushland, with bamboo thickets and stands of older trees, including Pines. Current & fallow cropland. | Moderate to high potential for livestock & forestry use. Specialised tree crops could be established, and incorporated into agro-forestry production systems, particularly where the unit borders the Phonsavan Plain. Water is main constraint. |

| Land System Number | Land System Name           | Area In sq. Km. | Mean Altitude in m. | Geology   | Geomorphology & Soils  | Recent Land-Use   | Vegetation   | Land Potential  |
|--------------------|----------------------------|-----------------|---------------------|---|--|---|--|---|
| 39                 | Nam Ngiou Valley Floor     | 42              | 1130                | Permian limestones with intermediate effusives; Carboniferous-Permian limestone.  | A wide flat valley terrace with weakly or non-incised drainages and a few low hills. Soils medium to deep. | Recently and currently intensively farmed for hill rice, maize and cassava. Many villages and gardens. Considerable livestock populations. Most valley terraces are poldered for paddy rice production. Substantial increases in cropping taking place. | Open grassland and low bushland. A few bamboo stands. Current & fallow cropland, and groves of fruit trees. Some stands of Pine on side valleys. | High potential for livestock & forestry use. Specialised tree crops could be established, and incorporated into agro-forestry production systems. Water is main constraint. |
| 40                 | Phu Gnouan Southern Slopes | 124             | 1430                | Silurian-Lower Devonian shale, sandstone, limestone, andesite & tufts; Carboniferous shale, chert, siltstone, limestone, coal seams; Devonian red sandstone, shale, conglomerate; Devonian sandstone, shale & limestone; (Some Permian limestones with intermediate effusives). | Very eroded, moderately to steeply sloping hills, with deeply incised drainages. Soils medium to shallow.  | Recently extensively cropped. Now little cropping taking place, but heavily used by livestock   | Dense secondary woodlands and forests with Pines and Keteilaria spp.. A few stands of older trees. Some grassy glades.                           | High potential for livestock & forestry use. Specialised tree crops could be established, and incorporated into agro-forestry production systems. Water is main constraint. |
| All                |                            | 4510            |                     |   |  |   |  |   |

### 4.6.3. LAND COVER AND VEGETATION

#### 4.6.3.1. LAND COVER IN THE CATCHMENT AREA

The area surveyed was rather limited when taking into account the size of the catchment. Forty land system types were identified from analysis of 1:50,000 scale maps of which only 12 (LS 1, 2, 3, 5, 6, 7, 9, 10, 14, 16, 20, 21 and 34) have been traversed. Due to problems of insecurity, it was not possible for the survey team to traverse any more LS's. This survey will therefore present only a very fragmented view of the Nam Ngiep catchment.

The lower reservoir has small areas of secondary woodland (LS5) all seriously degraded, with extensive areas of land cleared, cultivated and logged. The middle and upper reservoir (LS14 and LS21) though less degraded (least degraded between Ban Houaypamon and the Nam Mang confluence) is still mainly covered with secondary woodland (with large areas of woodland) interspersed with areas of hill rice cultivation. In the upper reservoir the Nam Mang (tributary upon which Ban Nakang is located) most of the valley floor has been cleared for paddy rice cultivation in the last few years. Small scale logging operations are currently working in the lower, middle, and upper reservoir.

In the small areas of LS2, LS3, LS9, LS10, LS16, and LS20 surveyed the steepest slopes and ridge tops tended to have the oldest and most diverse stands of trees. Particular patches of LS2 and LS3 had the most mature stands of trees observed. The riverbanks of the Nam Ngiep in LS1 are heavily cultivated (mainly sugar cane and rainfed rice) and further from the river large areas have been subject to swidden agriculture, logging and the impacts of small to moderate numbers of elephant. Interestingly most of the bamboo flowered and seeded more or less simultaneously in LS1 and LS2 four years ago. The large quantities of dead bamboo which built up then burned in a series of severe forest fires that burnt through the areas in the following two years. Hence the degraded secondary woodland in LS1 and LS2 is characterized by a grassy rather than bamboo understorey.

The northern end of the Nam Xao Valley (LS7) has recently been almost totally cleared for a large irrigation/resettlement development project. The southern end has a mosaic of young secondary woodland interspersed with late stage regeneration on crop fields. Two old village sites were present in the southern end of the valley. In addition logging over the past 6 years has extracted all of the valuable trees in the valley and on adjacent slopes. The hills overlooking the Nam Xao Valley have all been used by shifting cultivators in the past 10-20 years, and are covered by large areas of bamboo.

The identifications of the trees observed indicate that the areas of catchment surveyed have low species diversity in comparison to other woodlands surveyed in Lao PDR (surveys in Xaignabouli (SFE6), Vientiane (SFE9) and Attapu (Xe Kaman basin). The level of diversity is comparable to the degraded woodlands of the Nam Leuk catchment. However the forests of the Nam Ngiep catchment surveyed are generally older than

those found in the Nam Leuk Catchment.

The land cover of the catchment area is presented on following Figure 4.8.

The severity and age of degradation of the land systems is presented in Table 4.17 and a list of trees identified in the respective habitat types is shown in Table 4.18.

Table 4.17 Degradation Level of Land Systems Visited

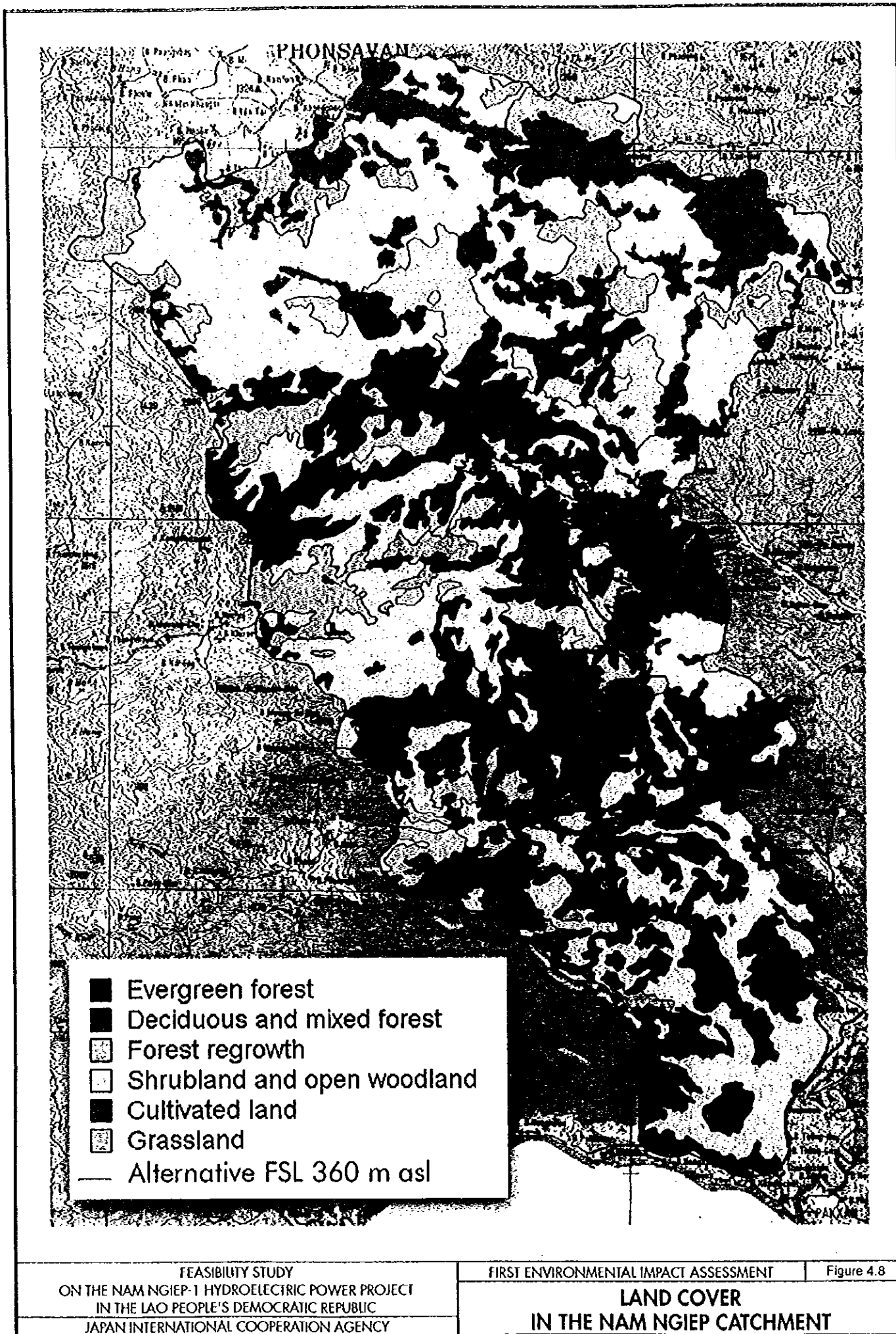
| LAND SYSTEM | TYPE OF DEGRADATION   | SEVERITY OF DEGRADATION                        | AGE OF DEGRADATION   |
|-------------|---|--|--|
| LS1         | Shifting and paddy cultivation<br>Elephant induced<br>Fire Catastrophe<br>Logging | Very Severe<br>Severe<br>Severe<br>Very Severe | 50 - 100 years to present<br>50 years to present<br>3 years ago<br>?             |
| LS2         | Shifting cultivation<br>Elephant induced<br>Fire Catastrophe<br>Logging           | Moderate<br>Severe<br>Severe<br>Moderate       | 20 years to present<br>50 years to present<br>2 years ago<br>20 years to present |
| LS3         | Shifting cultivation<br>Logging   | Severe<br>Severe                               | 40 years to present<br>20 years to present                                       |
| LS5         | Shifting and paddy cultivation<br>Logging   | Very Severe<br>Very Severe                     | 20 years to present<br>20 years to present                                       |
| LS7         | Shifting and paddy cultivation<br>Logging   | Very Severe<br>Very Severe                     | 20 years to present<br>6 years to present  |
| LS9         | Shifting cultivation<br>Logging?  | Severe<br>Severe                               | 20 years to present<br>?   |
| LS10        | Shifting cultivation<br>Logging   | Severe<br>Moderate                             | 20 years to present<br>6 years to present  |
| LS14        | Shifting cultivation<br>Logging   | Very Severe<br>Severe                          | 10 years to present<br>10 years to present                                       |
| LS16        | Shifting cultivation<br>Logging   | Severe<br>Severe                               | 20 years to present<br>4 years to present  |
| LS20        | Shifting cultivation<br>Logging   | Severe<br>Moderate                             | 40 years to present<br>?   |
| LS21        | Shifting and paddy cultivation<br>Logging   | Very Severe<br>Severe                          | 20 years to present<br>?   |

All land systems experience (and have experienced in the past) hunter-gatherer degradation pressures, which can be significant. All ecotypes have probably suffered moderate to severe degradation pressures from large populations of wild elephant until about 60 years ago.

However, as mentioned in the land system description, the potential for development in the catchment is variable according to the system considered, taking into consideration the local vegetation, geology, soils and topography. A synthesis of this potential is presented in the following Figure 4.9. This may provide a preliminary basis for the identification of suitable areas for resettlement or regional development.

#### 4.6.3.2. FLORA

The list with vernacular (lao) and scientific names of identified woody species is provided in the preliminary table below.



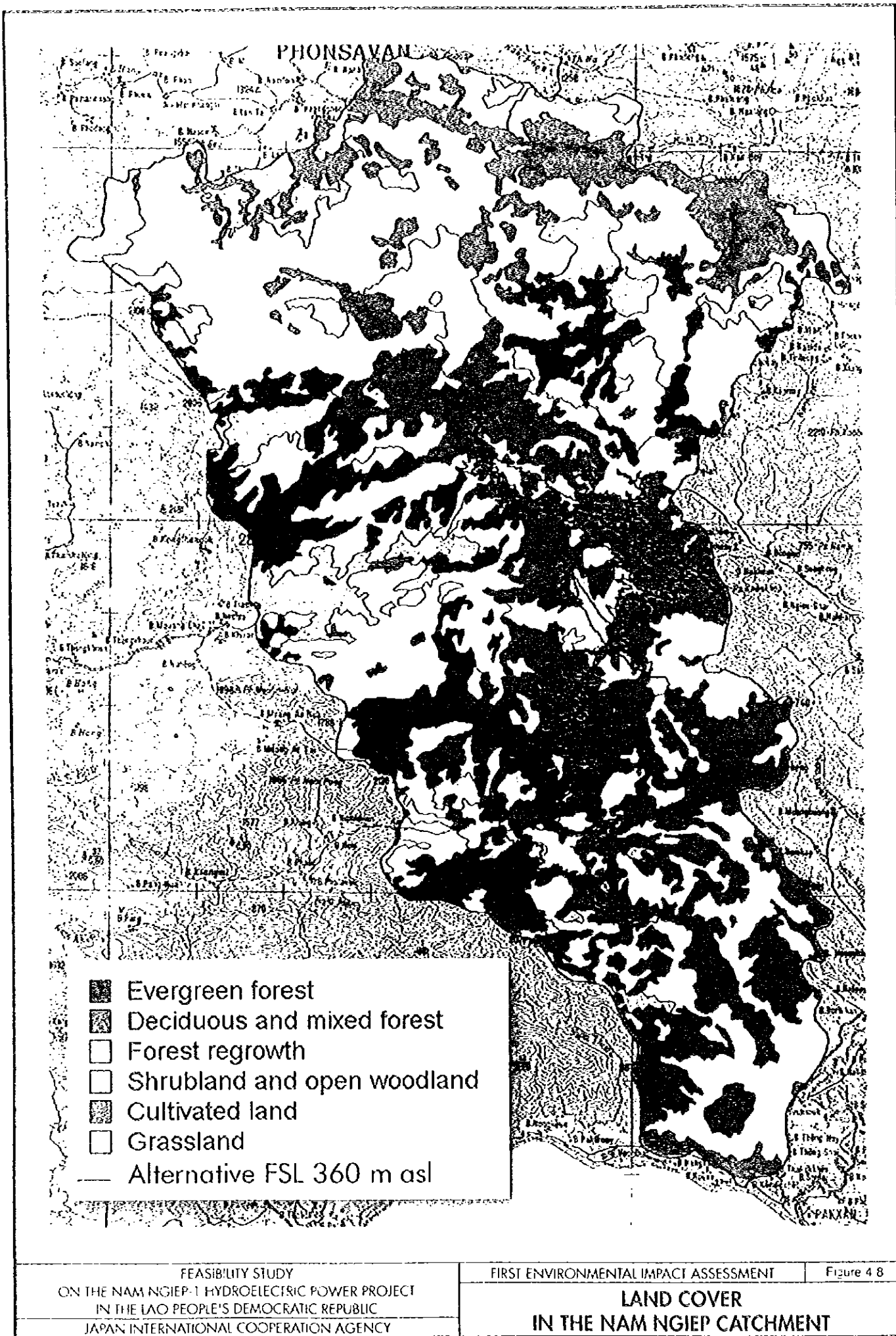
FEASIBILITY STUDY  
 ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT  
 IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC  
 JAPAN INTERNATIONAL COOPERATION AGENCY

FIRST ENVIRONMENTAL IMPACT ASSESSMENT

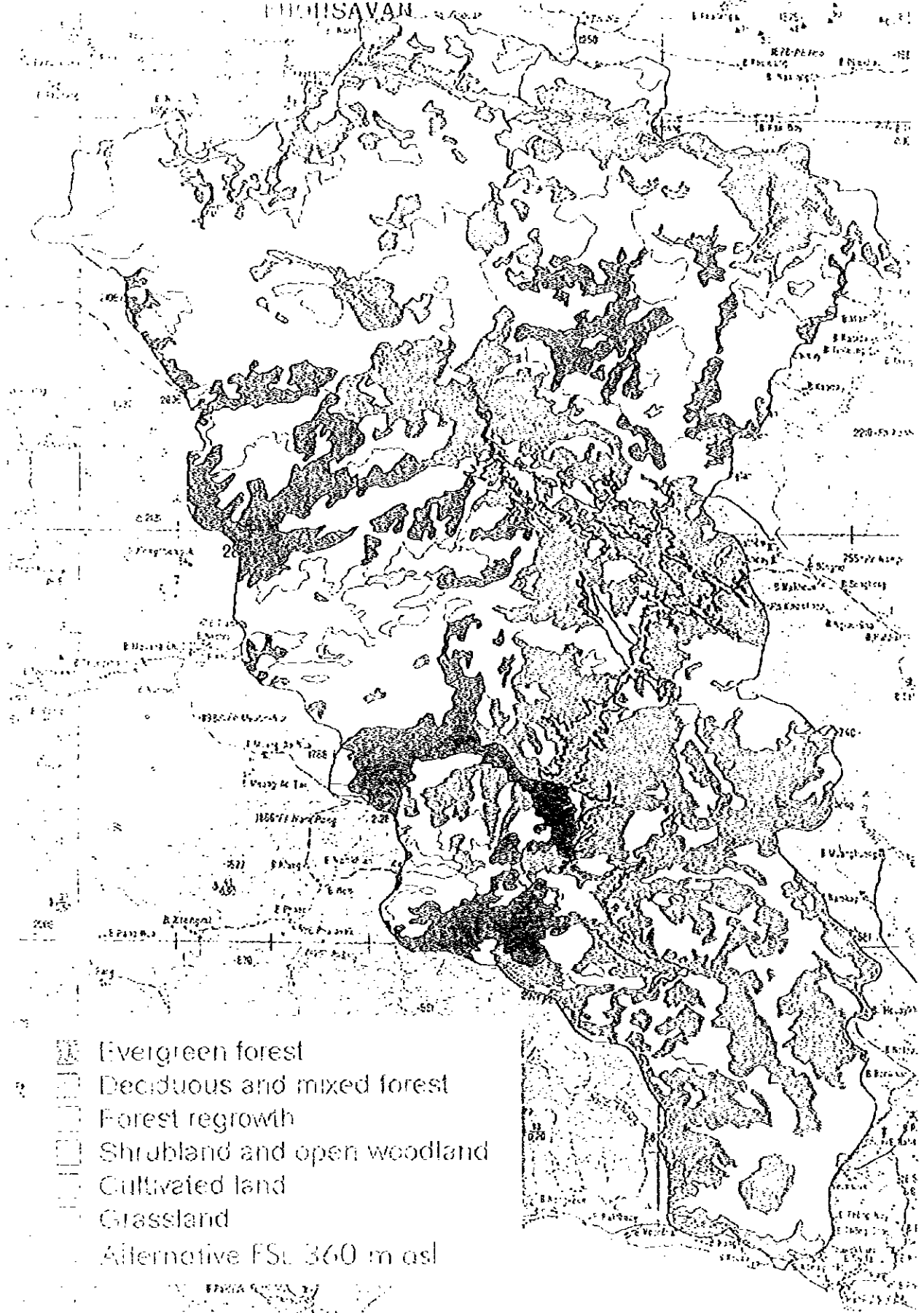
Figure 4.8








**LAND COVER  
 IN THE NAM NGIEP CATCHMENT**





PHU THAVAN



-  Evergreen forest
-  Deciduous and mixed forest
-  Forest regrowth
-  Shrubland and open woodland
-  Cultivated land
-  Grassland
-  Alternative FSU 360 m a.s.l.

LAND COVER  
IN THE NAM NGEP CATCHMENT