# SUMMARY ENVIRONMENTAL IMPACT ASSESSMENT

# FOR THE

# NAM LEUK HYDROPOWER PROJECT

# IN

# LAO PDR

**March 1996**

## CURRENCY EQUIVALENTS

(as of 29 February 1996)

| | | |
|---|---|---|
| Currency Unit - | Kip (KN) | |
| KN1.00 | = | $0.0011 |
| $1.00 | = | KN924 |

For the purpose of calculations in this Report, an exchange rate of $1.00 = KN920 has been used.

## ABBREVIATIONS

| | | |
|---|---|---|
| ADB | - | Asian Development Bank |
| CITES | - | Convention on International Trade in Endangered Species of Flora and Fauna |
| CPAWM | - | Center for Protected Areas and Watershed Management (MAF) |
| DiF | - | Division of Fisheries (MAF) |
| DOF | - | Department of Forests (MAF) |
| EdL | - | Électricité du Laos |
| EGAT | - | Electricity Generating Authority of Thailand |
| EIA | - | Environmental Impact Assessment |
| FSL | - | Full Supply Level |
| GNP | - | Gross National Product |
| IMPE | - | Institute of Malarialogy, Parasitology and Entomology (MOH) |
| IUCN | - | World Conservation Union (Switzerland) |
| LSFCP | - | Lao-Swedish Forestry Cooperation Program |
| LWU | - | Lao Women's Union |
| MAF | - | Ministry of Agriculture and Forestry |
| MIH | - | Ministry of Industry and Handicraft |
| MOH | - | Ministry of Health |
| MOL | - | Minimum Operation Level |
| NBCA | - | National Biodiversity Conservation Area |
| NOFIP | - | National Office for Forest Inventory and Planning (MAF) |
| NLHDP | - | Nam Leuk Hydropower Development Project |
| O&M | - | Operation and Maintenance |
| PKK | - | Phou Khao Khouay (Protected Area) |
| SFE3 | - | State Forest Enterprise No. 3 |
| Sida | - | Swedish International Development Agency |
| STD | - | Sexually Transmitted Diseases |
| STENO | - | Science, Technology and Environment Organization |
| TOR | - | Terms of Reference |
| UNDP | - | United Nations Development Programme |
| US$ | - | United States dollar |
| WCS | - | The Wildlife Conservation Society (New York) |
| WHO | - | World Health Organization |

## UNITS OF MEASUREMENT

| | | |
|---|---|---|
| kV | - | kilovolt |
| kWh | - | kilowatt-hour |
| MW | - | megawatt |
| GWh | - | gigawatt-hour |
| ppm | - | parts per million |
| ton/ha | - | metric ton per hectare |
| masl | - | meters above sea level |
| K | - | kip |

## NOTES

(i) The fiscal year (FY) of the Government ends on 30 September.
(ii) In this Report, "$" refers to US dollars.

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# SUMMARY ENVIRONMENTAL IMPACT ASSESSMENT

## A. Introduction

1. The Nam Leuk Hydropower Development Project (the Project) will be located in Phou Khao Khouay National Biodiversity Conservation Area (NBCA), about 80 kilometers (km) northeast of Vientiane. Unlike traditional hydropower projects, the Project aims not only to provide economic benefits while mitigating adverse social and environmental impacts, but also to substantively address the need for meaningful and long-term environmental enhancement measures. By providing the technical and financial support for Phou Khao Khouay NBCA that is now lacking, the Project will improve overall prospects for successful and sustainable conservation of the NBCA's natural resources.

2. The Project will include construction of a 45 meter (m) high dam on the Nam Leuk River, a tributary of the Nam Mang River, and will create a 12.8 square kilometer ($km^2$) reservoir that will divert water to the Nam Ngum reservoir through a 60-megawatt (MW) power station on the Nam Xan, a tributary of the Nam Ngum. The power station will utilize the 180-m difference in altitude between the Nam Leuk and Nam Xan rivers to generate electricity. The diverted flow will also be used to augment the discharge at the existing Nam Ngum power station.

3. The Project is an essential component of the Government strategy to achieve important social and economic objectives. The Project will supply electricity generated from an indigenous hydropower resource to an area of the Lao People's Democratic Republic (Lao PDR) where imported kerosene is the main commercial energy form. Excess energy generated by the Project that is not required for domestic consumption will be exported to Thailand.

4. An environmental impact assessment (EIA) which was undertaken during 1991 to 1993, was done as part of a feasibility study for the Project. The final EIA report recommended further site investigations to confirm the viability of the Project. During the supplementary site investigations, it was determined that further environmental investigations were also necessary. As a result, additional work was undertaken in 1995, resulting in a revised EIA. The basic objectives of the EIA study were to (i) gather additional information and undertake an analysis to confirm earlier findings that the Project could be done without unacceptable impacts on biological resources and social conditions (ii) revise and refine earlier proposals for mitigation and enhancement measures based on the findings resulting from the additional information gathered during the study and (iii) revise the Project design so that it would contribute to improved protection and management of Phou Khao Khouay NBCA.

5. A consultant (Sogreah Ingenierie) prepared the EIA for the Government of the Lao PDR. During preparation of the study, the consultant received active support from the following Lao agencies and organizations: (i) the Lao Women's Union (LWU), which assisted in the sociological investigations and, with Electricité du Laos (EdL), began the process of public information and involvement; (ii) the Fisheries Division, Livestock and Fisheries Department, which assisted in surveys on aquatic ecology in the upper Nam Leuk; and (iii) the Department of Biology, Dong Dok University, which carried out botanical surveys on the Nam Leuk plateau.

6. Several other organizations shared with the consultant their knowledge of the area and the results from their latest surveys, including the Center for Protected Areas and Watershed Management of the Department of Forestry, the World Conservation Union (IUCN), and the Wildlife Conservation Society (WCS).

## B. Project Description

7. The Project's principal objectives are to (i) support the optimal development of the country's power subsector; (ii) provide generating capacity to meet domestic demand and increase exports of electricity to Thailand, a major foreign exchange earner for the country; (iii) strengthen the capabilities of EdL to prepare, design, and implement environmentally sustainable projects; and (iv) strengthen the management and protection of Phou Khao Khouay NBCA.

### 1. General Layout

8. The Project will divert most of the flow from the upper reaches of the Nam Leuk River and one small tributary, the Nam Poun, to the existing Nam Ngum reservoir for the generation of electricity. Energy will be generated first at a new power station on the left bank of the Nam Xan, about 2-km upstream from where it joins the Nam Ngum reservoir, and second at the Nam Ngum power station. The general project layout is presented in Figure 1.

9. The proposed dam will be a rockfill type with an earth core and a crest level at 411.5 meters above sea level (masl). The catchment area at the dam site is 274 $km^2$. The dam will create a reservoir of about 185 million cubic meters, of which 154 million cubic meters (83 percent) is active storage. The reservoir will also receive water from the Nam Poun, a small tributary of the Nam Leuk, through a diversion weir, thus controlling an additional catchment of 49 $km^2$.

10. At full supply level, the reservoir will have an area of 12.8 $km^2$. At minimum operation level, the area will be only 5.1 $km^2$ with 31 million cubic meters (dead storage).

11. The water intake will be a significant distance upstream of the dam, where the Nam Leuk is closest to the Nam Xan River (which corresponds to the shortest tunnel length). The operating maximum discharge will be 39 cubic meters ($m^3$) per second(s).

12. The headrace tunnel will be 2,830 m long with an excavation diameter of 4.90 m. The surge tank will be as close as possible to the downstream end of the headrace tunnel, with an underground shaft of 9 m diameter between 367.0 and 402.0 masl and an outdoor reservoir of 21 m diameter between 402.0 and 412.5 masl.

13. The penstock will consist of a steel lined section in a tunnel from the surge tank to the valve chamber (length 305 m) followed by an outdoor steel section of 458 m leading to two branches of 20 m length for each unit. The diameter is 3.40 m from the surge to the bifurcate and 2.40 m in the branches.

14. The power plant will house two vertical Francis turbines for a maximum rated output of 60 MW. The total expected production of the scheme will be 230 gigawatt-hours (GWh) per year, including the related additional production at Nam Ngum.

Figure 1. Nam Leuk Catchment Area

15. Access road development will include:

(i) upgrading the existing Thabok-Muang Hom public road (39.4 km), including reinstating the decking over the Nam Leuk;

(ii) upgrading the access road (12.7 km) to the water intake, from the junction with Thabok-Muang Hom road;

(iii) constructing of an access road (about 9 km) to the power house, from the road to the water intake down to the power house along the escarpment this road will also give access to the adit and the surge tank;

(iv) upgrading the access road (about 16 km) to the dam site, starting from the Thabok-Muang Hom road, including a bridge over the Nam Poun; and

(v) upgrading the access road (about 6 km) that leads to the Nam Poun diversion and will branch from the access road to the dam site just after the Nam Poun bridge.

16. Each road will have a width of 3.5 m for traffic plus 1.0 m shoulders. Except for the road joining the water intake road to the power station, which has to be fully constructed (9 km), all other access roads already exist.

17. The 115-kilovolt transmission line from Nam Leuk will run southeast to Thabok along the Muang Hom road and will then follow the Vientiane-Pakxan road down to Bungkan substation where it will cross the Mekong and be connected to the Thai grid. The transmission line length will be 85 km from Nam Leuk to Pakxan and 11 km from Pakxan to Bungkan.

### 2. Project Implementation Schedule

18. Project construction is scheduled to start in November 1996 and to last approximately 34 months, with the commissioning of the units in August 1999.

## C. Description of the Environment

### 1. Topography, Geology, Mineral Resources, and Soils

19. The Nam Leuk watershed is in an elevated dissected plateau that is bounded to the north by an escarpment above the southeastern shore of the Nam Ngum reservoir, and dominated to the west by a steep mountainous area (Pha Sang mountain, 1,666 m and Pha Kongkhao mountain, 1,458 m). At the dam site, the river is contained within a valley surrounded by low hills with moderately steep slopes.

20. Geological conditions are generally consistent over the Project area, mainly composed of sandstone interbedded with siltstone and mudstone. According to the Department of Geology and Mines, no investigations for oil or mineral ores are being conducted or are anticipated in the Project area, as mineral resources of economic interest are unlikely to exist.

21. A general characteristic of the watershed is the very limited depth of weathered materials. As a result, soils are generally shallow, sandy, and of low fertility. This characteristic is important in understanding the hydrological behavior of the Nam Leuk River during the dry season, as discussed below.

## 2. River Hydrology

### a. River System

22. The Project area is under the influence of the southwest monsoon, and the wet season from May to October yields about 95 percent of the annual rainfall. Some of the dry season months (November to April) may be completely devoid of rainfall. Rainfall is generally orographic and increases from about 1,600 millimeters (mm)/year in the Vientiane plain to about 2,700 mm/year in the Project area.

23. At the dam site, the Nam Leuk catchment area is 274 $km^2$. Further downstream, the river system has the following characteristics:

(i) After a succession of rapids, the riverbed is broken 20 km downstream of the dam site by the Thad Leuk waterfall, variably 3 to 5 m high, where a streamflow and rainfall gauge station has been established. At Thad Leuk, the catchment area is 488 $km^2$;

(ii) Four km downstream of the Thad Leuk waterfall, the Nam Leuk receives a main tributary, the Nam Gnang, which drains a catchment area of 328 $km^2$. The proposed Nam Mang 3 Hydropower Project, presently at the feasibility stage, would be in the upper Nam Gnang. At the confluence of the Nam Leuk and Nam Gnang, the catchment area is 557 $km^2$;

(iii) Twelve km downstream from this confluence, the Nam Leuk joins the Nam Mang, which has a catchment area of 1,300 $km^2$ and is a tributary of the Mekong. The northernmost villages along the Nam Leuk are situated on this lower stretch of the river, between these two confluences.

### b. River Flows

24. The discharges in the Nam Leuk system are influenced by two major factors, the geology of the watershed and the rainfall pattern. The basement rock is composed of layers of siltstones and sandstones. A prevailing characteristic of the weathered soil layer above the basement rock is its extreme thinness, less than 2 m on average. Considering also its high permeability, the soil layer in the catchment area stores very little water after rainfall. As a result, the discharge in the river system is highly variable, with a fairly rapid discharge following rainfall during the wet season, while during the dry season most of the tributaries and the upper Nam Leuk stop flowing.

25. However, the central and lower portions of the Nam Leuk River do have a base flow during the dry season. This base flow comes mainly from the underground flow. The geological investigations have shown that the basement rock, mainly sandstone, is intensively interbedded with permeable materials. Geologically and topographically, the Nam Leuk acts like a drain for the basement rock throughout the catchment. This role was confirmed by the hydrological investigation carried out during the detailed design.[1]

26. Average monthly flows of Nam Leuk at the dam site are given in Table 1 for a normal, a dry, and a wet year. The Nam Poun shows the same behavior as the Nam Leuk. At the site of the proposed diversion weir, its mean monthly discharge is 2.5 $m^3/s$.

**Table 1: Average Monthly Flows at Dam Site ($m^3/s$)**

| Nam Leuk | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average year | 0.3 | 0.2 | 0.1 | 0.1 | 1.6 | 21.0 | 38.0 | 47.0 | 41.0 | 15.4 | 1.5 | 0.6 | 13.9 |
| Dry year | 0.2 | 0.1 | 0.1 | 0.1 | 1.0 | 7.3 | 16.0 | 44.0 | 39.0 | 9.2 | 1.2 | 0.4 | 10.0 |
| Wet year | 0.2 | 0.4 | 0.2 | 0.2 | 2.4 | 35.0 | 38.0 | 77.0 | 49.0 | 25.0 | 2.3 | 0.8 | 19.3 |
| Nam Poun | | | | | | | | | | | | | |
| **Ave. Year** | 0.05 | 0.03 | 0.02 | 0.03 | 0.3 | 3.8 | 6.8 | 8.4 | 7.3 | 7.3 | 2.7 | 0.3 | 2.5 |

Source: EdL

### 3. Water Quality

27. Water in the river is of good quality, meeting Thailand's Class 2 level: "very clean fresh surface water suitable for consumption with ordinary water treatment, fishery, and recreation." The water is generally low in minerals during both the dry and wet season.

28. For sediment transport and siltation, the detailed design estimated an average erosion rate of 345 tons (t) per $km^2$/year. Comparative erosion rates in different catchment areas in Thailand and the Lao PDR give values ranging from 6 to 345 $t/km^2$/year, with the highest value at the Lao PDR's Se Bang Hieng watershed, which is extensively deforested and heavily cultivated. Considering the fairly extensive forest and grass cover that prevails over most of the catchment, the sedimentation estimate is considered to be conservative.

### 4. Aquatic Ecology

29. Aquatic ecology surveys were carried out in June and October 1995, including fish sampling at eight sites. Altogether, 48 fish species belonging to 16 families were collected and

[1] Carried out by Sogreah Ingenierie under Loan No. 1214-LAO(SF): Nam Song Hydropower Development, approved on 21 Dec. 1992 for $31.5 million.

identified. The number of species found at each station was variable, from 21 to 7. A total of 29 species were collected upstream of the proposed dam site and 38 species were collected downstream. Of these, 17 species were observed both upstream and downstream.

30. The cyprinid family showed the highest diversity, with 18 species. The majority of families were represented by only 1-3 species. None of the fish species collected and identified are considered as rare or internationally endangered, based on IUCN and CITES lists.

31. The studies concluded that the Thad Leuk waterfall constitutes a major barrier to fish migration. Based on this conclusion, the upper Nam Leuk does not play a significant role as a spawning or rearing area for fish populations in the lowlands.

32. During the survey, plankton and benthic fauna were also sampled for quantitative assessment and identification. Plankton densities in the upper Nam Leuk and Nam Poun are generally low, and include about 90 percent phytoplankton. The benthos is generally poor, as the river bottom is affected seasonally by strong currents in the wet season and by drying during summer months.

## 5. Terrestrial Ecology

### a. Protected Area Management in the Lao PDR

33. Protected area management in the Lao PDR is largely a human-oriented process that aims to protect areas of high biodiversity value by resolving conflicts between conservation interests and human activities. The overall objective is to improve the protection of nature by reducing and rationalizing extractive use of natural resources. This is done through a process that emphasizes dialogue between protected area staff and local residents rather than a strict reliance on law enforcement, and includes support for local development activities that are in harmony with conservation objectives.

34. Prime Minister's Decree 164 of October 1993 officially established 18 sites as protected areas (referred to in the Lao PDR as NBCAs), covering approximately 28,000 $km^2$, or more than 10 percent of the country. During the intervening period to mid-1995, the Lao-Swedish Forestry Cooperation Program (LSFCP), which has been advising the Department of Forestry, recommended elimination of one of the sites and revision of boundaries at several other sites to exclude portions of protected areas already heavily degraded and thus not worthy of national protection. The recommendation would reduce the total area of the current protected area system to 25,015 $km^2$. At the same time, 11 new areas covering a total of 10,355 $km^2$ were recommended for inclusion in the system. If accepted, this will raise to 15 percent the area of the Lao PDR under protection.

35. The Project is within Phou Khao Khouay NBCA. As initially promulgated in 1993, Phou Khao Khouay NBCA covers 2,000 $km^2$ . The LSFCP recommends, however, that the total area be reduced by 610 $km^2$ to remove sites that are heavily degraded, including portions of the Nam Leuk River catchment.

36. When the management plan for Phou Khao Khouay NBCA was prepared in 1991, the site was proposed as a multiple use management area in recognition of the intensive human use of resources occurring there, including commercial logging, road construction, and subsistence uses by local villagers. The overall objective was to provide sustainable production of water, timber,

wildlife, pasture, and outdoor recreation. The Project was listed as a possible development at Phou Khao Khouay prior to its designation as a protected area and, given the protected area's multiple use aims, the Project was not considered to be at odds with the NBCA's overall objectives. In 1993, the objectives, while still including sustainable use of resources, shifted to place more importance on biodiversity conservation. Primary emphasis was to be given to strict conservation within a core zone, tentatively located south of the Project area, with varying intensities of human use allowed in surrounding zones.

37. However, management of Phou Khao Khouay NBCA has not been satisfactory despite the presence of field staff since FY1992/93. This has in part been due to historical reasons. Until 1993, a large portion of the NBCA was under a commercial logging concession. Direct loss of forest to logging was compounded by the improved access that the logging trails provided, and especially by shifting cultivators who moved to logged areas after the logging crews departed. Based on Government evaluation at Phou Khao Khouay and other protected areas, the poor management record can also be attributed to the limited experience of field staff and the lack of a sufficient and sustainable source of funds to implement management programs. Wildlife poaching for markets and to supplement the diet of local people continues unabated, as does collection of forest products. Some sites are under shifting cultivation. Given current trends, serious degradation of the resource base at Phou Khao Khouay is likely to continue, including further loss of forests, reductions in the populations of wildlife, and loss of ecologically and economically valuable plant species. Although external assistance to strengthen management of the national protected area system is expected to increase during the coming years, Phou Khao Khouay has not been included in the envisaged support programs at any significant level of funding.

**b. Vegetation**

38. Based on the revised boundaries, Phou Khao Khouay NBCA is forested over 88 percent of its area, of which 32 percent is relatively dense, mature forest. The dense and mature forest includes approximately 132 $km^2$ of evergreen forest, 297 $km^2$ of mixed deciduous forest, and 13 $km^2$ of coniferous forest.

39. The site of the proposed dam and reservoir contains three major vegetation communities: upper dry evergreen forest (the dominant community), upper mixed deciduous forest, and temporarily unstocked lands, characterized by herbaceous vegetation that is normally the result of intensive human use. Based on CITES lists, none of the species collected and identified is considered regionally or internationally rare or endangered (see Table 2).

**Table 2: Distribution of Major Forest Types**

| Forest Type | Dry Evergreen | Mixed Deciduous | Coniferous |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Lao PDR ($km^2$) | 161,024 | 54,464 | 4,736 |
| NBCAs ($km^2$) | 9,187 | 9,481 | 654 |
| Phou Khao Khouay ($km^2$) | 459 | 498 | 197 |
| Proposed reservoir ($km^2$) | 11 | 1.2 | 0 |
| PKK (as a % of all NBCAs) | 5.0 | 5.2 | 30.1 |
| PKK (as a % of Lao PDR) | 0.3 | 0.9 | 4.2 |

Source: Department of Forestry

**c. Wildlife**

40. A wildlife and habitat survey was carried out in Phou Khao Khouay NBCA in 1994 by a team of specialists from the Wildlife Conservation Society (WCS), New York. The team concentrated mainly on large mammals, nocturnal mammals, and birds. The survey area included several different sites within the NBCA, including the proposed reservoir site.

41. A total of 157 bird species was found in Phou Khao Khouay, including 12 "key[1] species". Three key species were observed in the vicinity of the Project area.

(i) **The Malayan night heron** is a resident bird whose preferred habitat is dense swampy forest, reeds, and bamboo. It is also known to occur in Dong Hua Sao NBCA, where it is reported as common in some lowland areas, and in Xe Pian NBCA.

(ii) **Jerdon's baza** is a resident in the southern Lao PDR. Its preferred habitat is forest edge, and it is also reported in the Houei Nhang Forest Reserve on the outskirts of Vientiane.

(iii) **The Javan frogmouth**, a resident at low elevations in Thailand, prefers secondary forests and is also thought to occur in Phou Sang He NBCA and in Xe Pian NBCA.

42. Mammal surveys were undertaken while walking trails. Results of the surveys indicated that Phou Khao Khouay has a diverse large mammal population, although densities are low, probably as a result of hunting. Of about 25 mammal species confirmed, few of them are key species for conservation. Unfortunately, the highest priority species such as tiger and rhinoceros are almost certainly extinct in Phou Khao Khouay.

43. Some key species have been observed or are expected to occur within or near the Project area. These include the following:

(i) **Bears**: Both key bear species present in the Lao PDR are considered vulnerable (IUCN and CITES) but are widely distributed throughout the Lao PDR. Their presence has been reported by more than 90 percent of villagers interviewed at various protected areas throughout the country.

1 Species considered to be of local, national, or international importance.

(ii) **Slow Loris**: The slow loris is present in Phou Xang He NBCA (where it is abundant); Dong Hua Sao NBCA; and Xe Pian NBCA (where it is widespread).

(iii) **Clouded Leopard**: This species is perhaps the least abundant of the four key species on this list, on a national scale and regionally. Its range includes all of the Lao PDR, with a preferred habitat of dense forest.

(iv) **Sambar Deer**: Widely distributed in the country, this deer is hunted intensively for meat (available in urban markets), and its antlers are exported as trophies.

44. In summary, Phou Khao Khouay NBCA contains low densities of several nationally or internationally threatened wildlife species. Continuing hunting and habitat destruction have significantly reduced the populations of most of these species, and may have led to the extinction of tiger and rhinoceros. Seven key mammal and bird species are known to occur in the area of the proposed dam and reservoir, but most are widespread in the Lao PDR and neighboring countries, and Phou Khao Khouay NBCA is not considered as critical for the survival of any of these species.

## 6. The Human Environment

45. Two villages are in the immediate vicinity of the Project facilities. Ban Nam Leuk is on the plateau 3 km from the proposed reservoir site and water intake structure. Ban Khengsan is below the plateau along the Nam Xan River. The power station and a borrow area will be located partly on paddy fields in Ban Khengsan.

46. Two other villages are located nearby Ban Kengsan but are farther from the Project facilities: Ban Thamdin, which is downstream of the proposed power station, and Ban Nongmouang, which is upstream of the proposed power station. The total population of the four villages is 1,172 people in 181 households. Approximately half the population is under 15 years of age. The size of the villages ranges from 20 households in Ban Nam Leuk to 59 in Ban Nongmouang. These villages were reportedly established during the latter half of the 1970s and the early 1980s following the end of the war. Based on the socioeconomic survey, the two major reasons for moving to this area were the lack of agricultural land at the household's former location and official resettlement. With the exception of Ban Nongmouang, the villages are dominated by Lao Soung or highland ethnic groups that have now largely abandoned their shifting cultivation practices.

47. The highland ethnic minority groups tend to differ linguistically and in terms of culture and social organization from the dominant Tai/Lao majority population of the Lao PDR. The cultural differences have been exacerbated by historical, ecological, and economic processes. To a large extent, the highland ethnic minorities are relatively disadvantaged groups especially in terms of their education and health status and access to economic resources. Farming is the main activity in the area. All villages rely on lowland paddy fields and upland crops such as maize, beans, and pulses. The average household cultivates 1-1.5 hectares (ha) of paddy land and 1.5-2 ha of upland. Villagers report an annual rice deficit, with some severe crop losses from rodents and birds. The average rice production as reported by the District Agriculture Office ranges from 2-3.5 t/ha. Livestock husbandry, mainly buffalo, cattle, pig, and poultry, is common.

48. As is typical in the Lao PDR, while all interviewed villagers claimed to own their land,

only a few households have an official land title. There is no tenant farming in the area. The main source of income is from the sale of agricultural products, followed by off-farm income (hired labor, outside remittances from relatives). With an average of 6.5 members per household, the annual average per capita income in the four villages is approximately $160. This is rather low when compared with the national average of $250, but is common in remote rural areas of the Lao PDR. Most households fish to supplement their protein intake; about 90 percent of surveyed households reported fishing 1-3 times a week.

49. Health and sanitation conditions are poor in the Project area as in the country generally. Health sector financing in the Lao PDR is among the lowest in the world, estimated at the equivalent of $1.60/capita/year. In the Project area, none of the villages has a health clinic, and so villagers must travel to health facilities outside the area for treatment. Malaria, diarrhea, and respiratory track infections are the major causes of morbidity and mortality. Malaria is endemic throughout the Lao PDR. Schistosomiasis has not been reported from central Laos and has not developed in the vicinity of the Nam Ngum reservoir.

50. The education level is low in all four villages. From a sample population of 200 people over 6 years old, 30 percent were reported as illiterate, and females accounted for 76 percent of the total. Education is available only at the lower primary level. Ban Nongmouang has no school, and the schools in the remaining villages contain only the minimum of facilities.

51. None of the households have toilet facilities, with the exception of a few houses in Ban Nongmouang. Most of the households rely on private wells, sometimes shared among families, for their water supply. Very limited transport infrastructure exists in Longxan sub-district. The most important access is the Pakleuk-Longxan road (Muang Hom road), but without bridge facilities for crossing the Nam Xan during the rainy season. The villages do not have a dependable electricity supply.

## D. Anticipated Environmental Impacts and Mitigation Measures

### 1. Implications on Terrestrial Biological Resources and Protected Area Management

#### a. Potential Impacts

52. The Project will affect approximately 0.75 percent of the total Phou Khao Khouay NBCA area given its current boundary, or 1 percent of the total area when considering the proposed new boundary that would excise portions of the NBCA. The impoundment of the river will flood 1,278 ha of forest and grassland at full service level, including (i) 1,075 ha of dry evergreen forest, (ii) 115 ha of mixed deciduous forest, and (iii) 88 ha of grassland-bush-bare soil. The area of dry evergreen forest to be affected by the reservoir is approximately 2 percent of this forest type occurring in Phou Khao Khouay, and 0.1 percent of that occurring in all the declared NBCAs throughout the country. The affected area of mixed deciduous forest represents an insignificant fraction of the total in Phou Khao Khouay.

53. Along the transmission line, the forest area concerned is about 140 ha and consists mainly of a patchwork of degraded dry evergreen and mixed deciduous forest already logged by State Forest Enterprise No. 3 and intensively affected by swidden cultivation in the southern part of Phou Khao Khouay. The line will largely follow the Muang Hom road in order to reduce the loss of trees and the costs of access and clearing.

54. Wildlife species will be directly affected by clearing and logging of the inundation area and by clearing of the transmission line right-of-way (ROW). Of particular concern are the key species identified during the 1994 survey. While most birds and mammals can be expected to disperse at the initiation of clearing and logging, some will inevitably be trapped by Project activities. The Project is not within the NBCA's proposed core area for strict biodiversity conservation, and the reservoir and related facilities are close to the northern limit of the NBCA and thus are unlikely to affect long range movements of large mammals. The ROW for the transmission line will run adjacent to the Muang Hom road in an area extensively disturbed by past logging and shifting cultivation, and currently by poaching, so the limited additional disturbance caused by the ROW is expected to be of minor significance.

55. In addition to the direct and permanent loss of forests due to impoundment and ROW clearing, there is also potential for secondary impacts over the short term resulting from the presence of laborers, and over the long term from upgraded Project roads allowing more convenient access to the NBCA. The major potential impacts from laborers will include illegal hunting and trapping of wildlife and additional cutting of trees for fuelwood or for personal economic gain. There is also a risk that clearing of the inundation area and the ROW will involve more trees than the minimum necessary. The potential long-term impacts will be illegal hunting and gathering of forest products by outsiders as a result of the more convenient access that Project roads will provide, and an inflow of settlers along the roads, resulting in forest encroachment, slash-and-burn farming, illegal logging, and poaching. However, the roads to be used to service the Project already exist (except for a 9-km stretch down the plateau), and so any additional threat of long-term impacts due to upgrading of the roads will likely be minimal.

56. The loss of forests due to the Project could also affect local residents who rely on forest products to supplement their normal diet or income. Based on responses by local villagers to surveys by the staff of Phou Khao Khouay NBCA, the reservoir area is not central to the livelihood of local villagers, even though wildlife hunting is thought to be intense. In addition, the forest loss will be of only limited significance because thousands of hectares of equivalent forest remain available in the immediate surroundings (in theory, disregarding NBCA regulations).

### b. Actions

57. The scope of environmental action will extend beyond the Project area proper to include support for improved management and protection of Phou Khao Khouay NBCA as a whole. This will include three major components, as follows:

(i) A full-time protected area management adviser will work with the staff of Phou Khao Khouay NBCA on a daily basis for two years. This will address a major limitation identified by the Government and the EIA study—the low capacity of field staff to undertake management duties. By the end of the adviser's term, the field staff should be capable of undertaking management duties without further outside assistance. The adviser's major responsibilities will be to (a) work with the field staff to fill gaps in the socioeconomic and ecological data for the NBCA and, based on this data, to prepare an updated and revised management plan and finalize zoning of the NBCA; (b) to provide guidance on the day-to-day administration and management of the NBCA; (c) to prepare a strategy for and assist the staff in implementing a program of conflict resolution between the NBCA and local villagers; and (d)

to design and seek support for village development programs that meet both conservation and development objectives. As a logical part of this work, the adviser will work with the NBCA staff in monitoring environmental impacts of the Project, especially regarding tree removal.

(ii) Financial assistance will be provided for priority management and protection programs identified during the management planning process. This will help to address another major limitation to improved NBCA management. This support will include funds for running expenses and implementing management programs, and will be provided annually during the Project's construction phase. The level of support is based on current estimates of annual management expenses plus an additional sum for undertaking new programs.

(iii) When the Project becomes operational, approximately 1 percent of the annual proceeds from the sale of electricity will be provided to support Phou Khao Khouay management. The precise amount to be provided will depend on an assessment of the previous year's management achievements and a projection of requirements for the following year. However, the total annual contribution is expected to be about $100,000. This is likely to be in excess of funds required for Phou Khao Khouay, and so a plan will be formulated to place the remaining funds in a "conservation fund" to be used for priority conservation programs nationwide. The precise mechanism for establishing and managing the fund will be decided in consultation with the government, the Global Environment Trust, and other organizations that are exploring ways to establish a national conservation fund.

58. Regarding impacts on forests within the Project area, funds will be provided from sale of the logging concession within the inundation area to reforest and rehabilitate priority sites within the NBCA that have been degraded due to past commercial logging and shifting cultivation. Selection of the sites will be guided by a plan that has already been prepared by Phou Khao Khouay staff after a review and revision by the protected area management adviser, if necessary. The total area to be rehabilitated will not be less than 2,000 ha.

59. Logging and clearing of the reservoir will be contracted to a logging company through tendering. Detailed schedules and obligations of the contractor will be clearly specified in the contractual documents. The main obligations will include (i) a survey of the reservoir area to confirm minimum stands of commercial logs and distribution of areas for commercial logging; (ii) delineation and preparation of basic logging and clearing plans for the reservoir area; (iii) clear physical demarcation of the areas within the reservoir to be logged and cleared through ground surveys; and (iv) supervision, monitoring, and control of logging activities. Similarly, the transmission line ROW will be clearly staked and closely monitored to ensure that additional tree cutting is not done.

60. Checkpoints will be established on the Muang Hom road to ensure that timber and other forest products are not being removed illegally, though consideration will be given to subsistence needs of villagers as dictated by the NBCA management plan. It is expected that a few villagers from Ban Nam Leuk will be recruited and trained as park rangers to assist the Project in patrolling parts of the Project area that could be especially vulnerable to poaching. Kerosene will be provided to work camps to avoid use of wood for heating and cooking. Immediately following

construction, all secondary access will be destroyed and revegetated.

61. Many of the same measures will also ensure that wildlife are not exploited during Project construction. In addition, the contractor will be held responsible for wildlife poaching by laborers. If a laborer is found in possession of wildlife species or other protected forest products, the contractor will be fined according to existing Lao law and the laborer will be dismissed; the same will apply to Project staff.

62. A small capture and release program will be undertaken, if necessary, for mammals trapped by logging and clearing operations. A plan for such activities will be prepared by CPAWM with assistance from the protected area management adviser.

### 2. Alteration of River Flows

63. The diversion of water from the Nam Leuk catchment to the Nam Ngum catchment will change the flow characteristics of the river system.

#### a. Controlled Catchment

64. The catchment controlled by the dam is 323 $km^2$. As shown in Table 3, the ratio between the controlled and uncontrolled catchment decreases from the dam site to downstream areas. The magnitude of hydrological changes will follow the same pattern.

**Table 3: Relative Importance of the Project Controlled Catchment Area**

| Location | Catchment Area | | Uncontrolled Area |
|---|---|---|---|
| | Total ($km^2$) | Controlled ($km^2$) | (% of Total C.A.) |
| Dam Site [a] | 323 | 323 | 0 |
| Thad Leuk | 488 | 323 | 34 |
| Before N. Gnang confluence | 557 | 323 | 42 |
| After Nam Mang confluence | 1,874 | 323 | 83 |

[a] N.Leuk + N. Poun catchments.

Source: Sogreah Ingenierie

#### b. Nam Leuk Flows

65. The alteration of flows in the Nam Leuk will be heavily influenced by the special geological characteristics of the area, as described in Section C. The most profound dewatering of the Nam Leuk River will take place between the dam site and Thad Leuk waterfall. During the rainy season, the flows will be reduced almost proportionally to the related percentage of remaining active catchment area, and will create conditions similar to those currently experienced during the height of the dry season (February through April). This will result in average flows of 1 percent or less from June through October compared with the current rainy season flows. Spilling will occur only once every two to three years and will not significantly change the average monthly discharges.

66. The impact will gradually diminish downstream of the dam. At Thad Leuk (20 km downstream), the average monthly flow (AMF) will be reduced to about one third of pre-Project conditions from mid-May to mid-November. Downstream of the Nam Gnang confluence, the AMF will be reduced to 53 percent (in June) and 58 percent (July to October) of the pre-Project flow. If the Nam Mang 3 project is also implemented, these values will be reduced to approximately 41 and 50 percent of natural flow, respectively.

67. During the dry season, for discharges up to 0.5 $m^3/s$, the river flow primarily comes from groundwater sources. Upstream tributaries naturally dry up during the dry season, except when a shower occurs, and do not contribute to the base flow. The base flow is independent from occasional surface water events and will not be affected by the dam. Therefore, during the months when the AMF at Thad Leuk is lower than 0.5 $m^3/s$ (January to mid-May), the Project will not adversely affect river flows. Drainage from the dam (estimated at 0.2 $m^3/s$) and the higher percolation rate in the sandstone basement rock due to the presence of the reservoir are expected to result in slightly increased AMF during March and April.

68. Average monthly flows with and without the Project are compared in Table 4.

**Table 4: Average Monthly Flows in the Nam Leuk System Before and After Project**

| Location | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| At Dam Site | | | | | | | | | | | | |
| Before ($m^3/s$) | 0.35 | 0.23 | 0.12 | 0.13 | 1.9 | 24.8 | 44.8 | 55.4 | 48.3 | 18.1 | 1.8 | 0.7 |
| After ($m^3/s$) (minimum) | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2[a] | 0.2 | 0.2 | 0.2 | 0.2 |
| % Flow remaining | 57 | 100 | 166 | 153 | 10.5 | 0.8 | 0.4 | 0.3 | 0.4 | 1.1 | 11 | 28 |
| Thad Leuk Waterfalls | | | | | | | | | | | | |
| Before ($m^3/s$) | 0.5 | 0.3 | 0.18 | 0.19 | 2.8 | 37.7 | 68.1 | 84.2 | 73.4 | 27.5 | 2.7 | 1.0 |
| After ($m^3/s$) (minimum) | 0.5 | 0.3 | 0.18 | 0.19 | 1.1 | 12.9 | 23.3 | 28.8 | 25.1 | 9.4 | 0.9 | 0.5 |
| % Flow remaining | 100 | 100 | 100 | 100 | 39 | 34 | 34 | 34 | 34 | 34 | 33 | 50 |
| Downstream Nam Gnang Confluence | | | | | | | | | | | | |
| Before ($m^3/s$) | 2.8 | 2.1 | 1.9 | 2.6 | 13.6 | 52.1 | 107.1 | 131.3 | 114.2 | 42.8 | 9.6 | 4.4 |
| After ($m^3/s$) (minimum) | 2.8 | 2.1 | 1.9 | 2.6 | 11.9 | 27.5 | 62.1 | 76.1 | 66.1 | 24.9 | 8 | 3.9 |
| % Flow remaining | 100 | 100 | 100 | 100 | 87 | 53 | 58 | 58 | 58 | 58 | 83 | 89 |

[a] Occurrence of spilling once every two years.

Source: EdL

### c. Effects on The Nam Ngum System

69. The major concern regarding the Project's impacts on the Nam Ngum system is the chance for flooding caused by diverting the Nam Leuk. This possibility was examined for both the Nam Xan River and the Nam Ngum reservoir.

70. An average flow of about 15 $m^3$/s will be discharged in the Nam Xan River, only 1.5 km before it reaches the Nam Ngum reservoir. Peak discharge, when both turbines are operating, will be 39 $m^3$/s. Hydraulic studies show that the maximum level increase at the tailrace outlet will be only 20 centimeters (cm) for minimum discharge in the Nam Xan (100 $m^3$/s) and will become insignificant when the Nam Xan has discharges higher than 1,000 $m^3$/s. Therefore, the Project is not expected to result in floods along the river, and will improve low flow conditions along this short stretch of river during the dry season.

71. The Nam Leuk catchment area at the proposed dam site is equivalent to 3.7 percent of the Nam Ngum catchment. The additional discharge from Nam Leuk will raise the level in Nam Ngum reservoir by only a few centimeters, far below the level fluctuations that now occur in the reservoir; the reservoir's normal wave zone is at least 50 cm, and may reach 2 m at the shorelines during strong winds. The danger of flooding, therefore, is remote, and is further minimized because the average maximum reservoir level at the end of the rainy season is 208 masl, well below the full service level of 212 masl. Since its impoundment in 1968, the Nam Ngum reservoir has reached full service level only twice, during the exceptional hydrological years of 1994 and 1995.

### d. Potential Impacts on Aquatic Ecology And Fisheries

72. Downstream of the tailrace, the Project's impact on aquatic communities of the Nam Xan River and Nam Ngum reservoir will be insignificant because of the limited effects expected on the flow pattern. Downstream of the proposed dam site, the magnitude of impacts will vary according to the river section.

73. Upstream of the dam, the habitat will change from free flowing to impounded water. Although the EIA studies indicated that the fish populations in this stretch of river are already low and the number of species relatively small, the change in hydrological conditions will affect resident species that are unable to adapt to impounded conditions. Of the species found upstream of the dam site, six are commercially harvested in the Nam Ngum reservoir. Thus it is anticipated that these species will develop in the Nam Leuk reservoir with a higher productivity than observed now, as they will benefit from the presence of a permanent water body. Immediately downstream of the dam, the year round flow will be similar to conditions during the height of the dry season, and so will be less favorable to fish. Therefore, some species may be lost from the upper stretches of the Nam Leuk River, and the populations of other species may decline. However, because Thad Leuk waterfall acts as a major barrier for fish migration in the Nam Leuk River, construction of the dam 20 km upstream of the waterfall is unlikely to affect migration and the development of lowland populations.

74. The reduction of flow downstream of Thad Leuk will be significant during the rainy season, when only one third of the pre-Project flow will remain. This will occur over a short distance, until the Nam Leuk is joined by the Nam Gnang. Despite this reduction, the remaining average monthly flow will still be significant, between 13 to 29 $m^3$/s, sufficient to support fish populations. Where the Nam Gnang joins the Nam Leuk, the flow during the rainy season will be 53 percent in June and 58 percent from July to October compared to pre-Project conditions, with expected discharges ranging from 25 to 76 $m^3$/s. During the four driest months of the year (January to April), the Project will not alter the natural flows, and the river will maintain the average monthly flows now observed at Thad Leuk and downstream.

### e. Potential Impacts on River Related Activities

75. As the additional inflow to the Nam Ngum reservoir from the Project is expected to have insignificant effects on lake levels, it will have no adverse impact on existing land use by lakeshore communities. Similarly, the Project will not significantly modify the discharge of the Nam Xan River during the rainy season and is unlikely to affect existing river use.

76. Five villages are near the Nam Leuk River downstream of the confluence with the Nam Gnang (28 km and more below the dam site). Potential sources of adverse impacts include reduction of fish catch from the river, disruption in river transportation, and reduction of domestic water supplies.

77. Commercial fishing was not reported in these villages during the socioeconomic survey, though some villagers occasionally sell their catch at local markets. Subsistence fishing is carried out in the rivers during the dry season, generally 2-4 days a week for a few hours each day. The fish catch is quite meager, averaging approximately 150-200 grams/fisher/day as directly observed during the socioeconomic survey and reported by other recent surveys.[1] The depth of water and strength of currents discourage fishing in the rainy season, when flooded paddy fields are fished instead. Given the low average fish catch, the amount of water remaining in the river during the dry season, and the limited human population, any decrease in fish populations that the Project may cause is not expected to have a significant adverse impact on local protein intake. Fishing is uncommon above the Thad Leuk waterfall.

78. There were no irrigation systems reported in either the lower Nam Xan or in the lower Nam Leuk-Nam Mang system. According to the Department of Irrigation, no irrigation development has been identified or is anticipated in these areas. The domestic water supply is unlikely to be affected by the Project, as all downstream villages rely on private wells for their supply. The Project will not significantly affect subsurface water levels.

79. Passengers and goods are commonly transported by river between villages of the lower Nam Leuk-Nam Mang during the dry season. River transportation is uncommon during the rainy season because of the rapid river flow and the lack of boat engines in most households. The Project will have no adverse impact on river transportation as it does not significantly alter discharges in the dry season on the vicinity of downstream villages. The reduction of flows early in the wet season is expected to somewhat extend the period of safe boating on the river.

80. Tourism activities in the Project area rely mainly on the Thad Leuk waterfall. The Project is not anticipated to have detrimental impacts on Thad Leuk's tourism potential during the dry season because river flows will remain unaltered. During the rainy season, the waterfall will be less spectacular, but this is not expected to significantly detract from Thad Leuk as a tourism attraction because reasonable flows will be maintained.

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1 See for instance the EIA prepared under Loan No. 1214-LAO(SF): Nam Song Hydropower Development, approved on 21 Dec. 1992 for $31.5 million.

### f. Actions

81. Underground drainage and unavoidable leakage below the dam will maintain average monthly dry season flows at Thad Leuk that are at least equivalent to those prevailing under pre-Project conditions. Provision has been made to release water from the dam in order to maintain this flow if, during exceptionally dry years, the discharge drops below 0.2 $m^3$/s which corresponds to the average flow during the driest month of a normal year.

82. To ensure that fishers from the four villages near the Nam Leuk River below the dam site are not adversely affected by the Project, fish surveys will be continued during the construction phase. If the surveys determine that the fish catch is dropping, and this is affecting the well being of villagers, supplementary measures will be undertaken in cooperation with local officials and Phou Khao Khouay staff. Surveys during the Project's operation phase will be done by protected area staff as a part of their normal monitoring program. In addition, the Project will support preparation of a fisheries management plan for the Nam Leuk reservoir. The plan will be developed in light of the survey findings, the NBCA's management objectives, and any constraints placed on fisheries management by power plant operations.

## 3. Water Quality

### a. Potential Long-term Impacts

83. The water quality of the upper Nam Leuk is excellent and is not anticipated to deteriorate in the foreseeable future if appropriate catchment management is implemented through Phou Khao Khouay NBCA management planning and implementation, which will be supported under the Project. The retention time of water in the reservoir will be short, 3.2 months, which means the water in the reservoir is renewed about four times per year.

### b. Potential Short-term Impacts

84. Approximately 1,534,500 $m^3$ of excavation will be required during construction, of which all but 300,000 $m^3$ will be at the dam site. The remaining spoil will be generated at the headrace tunnel and related sites in the Nam Xan area. The rockfill quarry will be within the reservoir boundary, thus restricting physical damage to an area that will be inundated. The risk of significant erosion from the access roads is limited because all but one road will simply require upgrading. The access road to be constructed between the water intake site and the power station (9 km) will cause erosion if proper engineering is not undertaken.

85. A major short-term water quality issue is related to the flooding of 12.8 $km^2$ (at full service level) of forest. If not cleared, the drowned organic matter will decay during the first few years after impoundment and could result in the release of anoxic waters that are lethal for fish and aquatic animals. A simulation of oxygen concentration in the reservoir has been carried out based on the balance between oxygen inputs from inflow on its consumption by the decay of organic matter, and on the management of the reservoir for energy production. Results show that (i) if the reservoir is not cleared prior to flooding, the dissolved oxygen deficit may occur up to five months per year, with low dissolved oxygen levels during the other months, which is incompatible with fish development; and (ii) if the reservoir is cleared before impoundment almost no anoxic conditions will occur. No water quality impacts are expected from the comparatively small discharge into the Nam Xan River and Nam Ngum reservoir.

86. Reservoir shape is also an important factor. In dendritic reservoirs, water renewal can be retarded and can result in substandard water quality. The area that would most likely develop stratification and anaerobic conditions is just upstream of the dam, where it could result in an almost stagnant body covering about 80 ha.

87. During construction there will be potential water quality impacts from washings from production of concrete, fuel, and oil, and from wastes generated at the camps. There are no geological deposits of salts or other soluble minerals, and so an increase of water salinity in the reservoir is not expected.

### c. Actions

88. A detailed management plan for all borrow and spoil areas will be prepared based on guidelines to be provided in the Environmental Management Plan. In the Nam Xan valley, spoils will be disposed of in the borrow area and the site will be rehabilitated according to the land-use pattern existing prior to excavation. This will include rehabilitating paddy lands and monitoring to ensure that production reaches at least a level equivalent to the current level. At the dam site, spoils will be disposed of just upstream of the dam in the dead volume of the reservoir area. Strict engineering norms will be followed to ensure that spoils do not enter the river prior to inundation. Bioengineering techniques will be employed at all access roads.

89. To limit the risk of anoxic conditions that could affect aquatic ecology and eventually the concrete and steel structures of the dam, the following measures will be supported by the Project: (i) the main core of the reservoir will be logged for commercial species, and the remaining vegetation cleared and burned; (ii) bottom waters from the deepest section of the reservoir will be flushed through the dam's bottom outlet to remove as much of the remaining organic material as possible; this operation will be combined with flood events involving a significant spilling in order to dilute the organic load and thus minimize downstream impacts; and (iii) the potential dead volume area just above the dam will be reduced by disposing of excavation spoils there. In addition, water monitoring activities will be carried out during and after the filling of the reservoir to ensure that downstream water quality is not adversely affected.

90. During project construction, water pollution control measures such as appropriate siting of fuel storage intercepting and treating of gravel washings, and provision of sanitation measures at the camps will be implemented. These measures will be attached to the contractor's documents as contractual obligations.

## 4. Implications On Land Use And Settlements

### a. Area Requirements

91. In summary, 1,570 ha of land will be required by the Project, including all facilities, the reservoir, borrow areas, and access roads. Of this, approximately 40 ha will be required only during the construction phase, while the remainder will be used permanently by the Project.

### b. Potential Impacts On Cultivated Areas

92. As initially proposed in the Project design, the operator's village and contractor installations were to be located on the right bank of the Nam Xan near Ban Kengsan, requiring the

acquisition of 9 ha of paddy fields and the temporary use, for at least three years, of an additional 16.5 ha. The EIA study indicated that this impact could be avoided by siting these installations in an area that is used sparingly, mainly for grazing.

93. On the left bank of the Nam Xan, and still within Ban Kengsan, 20-40 ha will be required for the production of sand and gravel. About 60 percent of the area is used for paddy. A maximum of 1.5 ha will be permanently affected by the power station. Along the Nam Leuk, in the upper reach of the future reservoir area, less than 2 ha of scattered small paddy fields belonging to Ban Nam Leuk residents will be flooded. Re-siting of the operator's and contractor's facilities will result in a significant decrease in the amount of paddy land to be affected by the Project. The current estimate of paddy land required by the Project (including for transmission line tower foundations), with resiting of these facilities, is 3.5 ha for permanent acquisition and 20 ha for temporary use during the construction phase.

94. The transmission line to Pakxan will run for 57 km in the cultivated Mekong plain. Land required by the Project will include 20 $m^2$ for each transmission tower foundation, or a total of approximately 0.5 ha for the 240 towers to be placed there.

### c. Potential Impacts on Built-Up Properties

95. The Project will not require resettlement. No houses are affected either within the reservoir area or along the Nam Xan. A maximum of three or four field shelters (used during the agricultural season) may need temporary relocation in the future borrow area on the left bank of the Nam Xan. No other private or community buildings will be affected, nor will roads or other public infrastructure. The transmission line route avoids groups of houses and villages and will follow international standards to avoid impacts on buildings.

### d. Potential Impacts on Ethnic Minorities

96. Three of the four villages identified as the most affected under the Project are populated by highland ethnic minority communities who traditionally practiced swidden cultivation, although most communities have now abandoned those practices. However, very few hold land titles. Thus, these communities are vulnerable to being displaced when improved services such as clinics, roads, and electricity result as a direct benefit of the Project. In similar situations in other areas of the Lao PDR, land prices have increased, attracting investors from outside the areas and resulting in progressive eviction of local families without land titles.

97. As these communities live in rice deficient areas and land available for paddy cultivation is limited, even small amounts of land acquisition for project activities, be it on a permanent or temporary basis, could exacerbate the rice shortages in the area. The loss of forest caused by the Project could also affect the communities who rely on forest products to supplement their normal diet and income. Women's access to forest products for subsistence needs and as a source of cash income could also be affected.

98. The influx of large numbers of workers could pose some health risks, especially introduction of new diseases, outbreaks of malaria, and increased likelihood of sexually transmitted diseases and Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome. Given the immigrant workers will be mainly single males, unaccompanied by families, will most likely result in increased prostitution and the accompanying social problems.

### e. Potential Impacts on Population Movements

99. A hydropower project such as the Nam Leuk Project could generate three types of population movements:

(i) Prior to construction, the reservoir area may attract outsiders who hope to settle quickly in the area and thereby receive compensation prior to inundation. This scenario is unlikely to occur because there is no settlement within the reservoir area and because Decree 164 provides the legal basis to avoid this risk by prohibiting new settlements within a NBCA.

(ii) During construction, the Project will require outside laborers and may also attract people seeking to provide services to the laborers. When construction is completed, part of this population may remain there, resulting in accelerated clearing and creation of new settlements, possibly within the protected area.

(iii) After construction, roads to the Project sites may facilitate access to the area and may attract illegal settlers within the NBCA who may wish to take advantage of fishing opportunities in the reservoir, for example.

### f. Actions

100. To implement the Project adequately within the local social context and to equitably undertake the land acquisition and compensation process, the Project will support the creation of a consultative committee. The idea for forming a consultative committee originated during discussions with residents and officials at the Project site and, as a result of these discussions, an agreement has been reached between the Project and local representatives to create such a committee to decide and coordinate decisions related to Project implementation. These decisions will mainly concern land use and compensation issues, but will also cover other socioeconomic aspects, including health, education, rural electrification, and control of immigrants. The Committee is expected to include: (i) the Deputy District Officer, (ii) a Nam Leuk Hydropower Project representative, (iii) the District Agriculture Officer, (iv) the District Forestry Officer, (v) the District Land Department Officer, (vi) a Lao Women's Union district representative, and (vii) village chiefs from each of the four affected villages. The Project will provide for the committee's operational budget over a five-year period.

101. A social development plan will be prepared. The plan will give special emphasis to highland ethnic minority communities, and will be prepared as part of the mitigatory measures for the Project to ensure that any likely adverse impacts are mitigated and that these communities receive culturally compatible social and economic benefits from the Project.

102. The plan, now under preparation, will include (i) a description of the socioeconomic characteristics of the affected communities, (ii) an assessment of the likely direct and indirect social impacts, (iii) strategies for mitigatory measures to address both the direct and indirect social impacts, (iv) mechanisms for enhancing the social and economic benefits of the Project for these communities, (v) institutional arrangements for implementing the mitigatory measures, and (vi) monitoring and evaluation arrangements.

103. Land tenure issues will be carefully assessed, and mechanisms for land titling, as well as budget provision, will be an important aspect of the plan. Likewise, mitigatory measures for addressing the problem of rice deficiency in the area will also be developed. In light of the limited land available for paddy, land acquisition, both for temporary and permanent use by the Project, will be compensated on the basis of replacement land, when possible, rather than cash compensation. During the initial surveys, the communities indicated a preference for replacement land over cash compensation.

104. To mitigate impacts on paddy areas in the Nam Xan valley, the Project will support the following measures:

(i) The earlier design, which located the contractor's installations and the operator's village near Ban Kengsan, will be revised so that these facilities are away from the village at a new site close to the surge tank in degraded forest and grassland.

(ii) The contractor will be required to present a detailed management plan for the borrow area on the left bank of the Nam Xan in accordance with a set of obligations that will minimize the total agricultural area affected and the area under development, and that will also cover rehabilitation of agricultural land at the end of the construction period.

(iii) Monitoring of compensation and land rehabilitation success will be supported by the Project to ensure that affected villagers are not disadvantaged by the Project, and that productivity of the land after rehabilitation is at least equivalent to that observed under pre-Project conditions.

105. The Project will support detailed identification of affected individual properties including detailed surveys and the demarcation of land plots. Compensation for temporary and permanent loss of land and production at Ban Kengsan and Ban Nam Leuk will be provided by the Project following consultation and agreement between the affected households and the project consultative committee. Along the transmission line right-of-way, compensation will be considered in two cases: (i) where agricultural land falls under a transmission tower foundation, and (ii) where agricultural activity is disrupted because of activities associated with construction of the transmission line. A total of $185,000 has been allocated in the Project budget for the compensation program.

106. To maintain control of population movements and settlement in the area, the Project will assist the concerned Government agencies (primarily the District Office in the Nam Xan valley and the Forestry Department) through the following actions:

(i) The Lao Women's Union will organize an information system for Project laborers and new settlers, briefing them on the temporary status of their residence in the area and their obligation to leave after construction.

(ii) Suitable sites will be identified for these settlers, compatible with worker camp locations and small business activities such as shops and restaurants. These will be defined together with finalization of the contractor installations near the surge tank.

(iii) Over the long term, illegal settling along the access roads and around the reservoir will be prohibited through checkpoints (on the roads) and systematic patrolling by Phou Khao Khouay NBCA rangers.

(iv) The Project will request the Land Tax Office to undertake land titling at the four villages, starting with Ban Kengsan. Provision of $47,000 has been included in the Project budget to implement these programs, including $25,000 for land titling.

## 5. Public Health and Safety

### a. Potential Impacts

107. Main health risks during the construction stage are linked to (i) inadequate sanitation facilities in worker camps; (ii) introduction of new diseases, such as schistosomiasis and sexually transmitted diseases, by immigrant workers; (iii) outbreaks of malaria in the labor force; and (iv) inadequate health services in the Project area. Medium- to long-term impacts during the operation stage mainly concern the possible change in magnitude of disease distribution, primarily malaria, as a result of the creation of a reservoir. The risk would largely be limited to the immediate vicinity of the reservoir.

108. There is a low risk that schistosomiasis could be introduced to the Project area, but the possibility of infected people migrating into the Project area and the existence of the parasite's intermediate host, cannot yet be ruled out. However, because the intermediate host is not present in Nam Ngum reservoir 20 years after its creation, it is unlikely to occur in future.

### b. Action

109. Mitigation measures have mainly been framed around the Project phases. The short-term, or construction phase, measures will aim to secure public health and safety among the workers and nearby population through preventive actions and adequate facilities. The long-term, or operation phase, measures will aim to improve the general health status of the population in the region, with special attention given to potential risks concerning development of water-related diseases because of changes in the river system.

110. The following set of actions will be undertaken at the labor camps: (i) preemployment medical screening and treatment of workers if required, (ii) control of importation of diseases in the camps through regular checkups, (iii) implementation of safety regulations and facilities on construction sites, and (iv) a malaria control program to reduce the risk of a malaria outbreak, including parasite examination, provision of prophylactics, and promotion of individual protection through health education and provision of bed nets. The contractor will be required to prepare a health and safety plan based on guidelines to be provided in the Environmental Management Program.

111. Additionally, the Project will support a public health improvement program based on the control of malaria in the Project area and the improvement of local health facilities. A health education program, covering malaria, hygiene, and sexually transmitted diseases will be implemented. This task will be carried out by a competent nongovernment organization under the supervision of the Ministry of Public Health. Because of the probable temporary influx of people

into the Nam Xan valley, the Project will construct a health center in the valley. The health center will be supplied with appropriate equipment and an adequate supply of drugs, as listed in the World Health Organization's "Essential Drug List."

### 6. Archaeology and Culture

112. The Project area is not known to contain archaeological or historical relics and artifacts. The reservoir area, because of its geology, does not contain sheltering caves that could have housed prehistoric human settlements. No reference was found to any ancient historical or religious site in the Project area. No cultural or religious artifacts or sites are located on the left bank of the Nam Xan, as confirmed during the socioeconomic investigations.

### 7. Development Opportunities

113. At present, the main Muang Hom road links the Vientiane-Pakxan road to Longxan village on the left bank of the Nam Xan. However, no bridge exists on the Nam Xan, and so during the rainy season, cars, trucks, and buses cannot cross the river. The Project will construct new access to the Nam Xan valley through a bridge at Ban Kengsan. This will constitute a major benefit for the villages in the valley by providing reliable road communication with Vientiane.

114. As a policy of EdL, the villages that are the most affected by Project implementation will receive, as compensation for disturbance during the construction phase, free connection to the power network and free electricity for a period of 1-2 years. To minimize any social risk resulting from village electrification (inflow of population, raise of land prices), the supply of electricity to these villages will be provided at the same time as the rural electrification program for the Nam Xan valley.

## E. Alternatives

115. The Lao PDR relies heavily on indigenous fuelwood as a source of primary energy, and fuelwood may account for as much as 90 percent of total energy requirements. Imported kerosene is the main commercial energy form. Electricity supply in the Lao PDR is limited to about 17 percent of the population, and the domestic electricity consumption is among the lowest in Asia. Vientiane and surrounding communities account for more than 80 percent of the domestic consumption. Electricity is supplied from three hydropower stations (Nam Ngum with 150 MW, Xeset with 45 MW, and Selabam with 5 MW). Each of these is also connected to the Thai grid for export of electricity. The remainder of the electricity supply is provided by two small networks serving the provincial capital cities of Thakek and Savannakhet and their environs that are supplied from the Thai grid, and scattered small hydro and diesel generating sets serving small communities. Since the early 1980s, 70-85 percent of the total electricity generated in the Lao PDR has been exported to Thailand.

116. The country has no confirmed petroleum reserves, although exploration is being done in the south. Coal reserves are located in Vientiane and Khammouane provinces, but because of the high cost of mining and transportation, coal is exploited only to manufacture local bricks.

117. The Government's medium-term objectives for the power subsector are to (i) increase foreign exchange earnings, (ii) support private sector activities, and (iii) protect the environment. Given its limited sources of foreign currency, the Government aims to expand the

country's generating capacity in order to increase its earnings from electricity exports to Thailand. The increase in capacity combined with the expansion of the domestic transmission and distribution networks will also increase the availability of power to the domestic market and thereby support the development of private sector commercial activities. Other components of the Government's strategy include rural electrification and construction of small hydropower projects to service remote areas. The Government also intends to develop indigenous coal to reduce the use of fuelwood and prevent the degradation of forests, and to replace petroleum products. Larger hydropower schemes such as Nam Ngum 2 and Nam Theun 2, designed primarily to sell electricity to Thailand, are also under consideration.

118. The Government recently approved a public investment program (PIP) amounting to $1,520 million for 1996-2000. The first priority of the PIP is to develop the physical infrastructure, including power supply, required for economic growth. The allocation for the energy sector amounts to $240 million, or 16 percent of the total PIP, the second largest share after transportation and communication.

119. No fewer than 20 Government hydropower projects and an additional 20 private sector projects are under development or study. Fifteen of these have completed at least the feasibility stage.

120. Three alternative approaches to developing the Nam Leuk Project have been considered: (i) a do nothing alternative in which the resource remains undeveloped, (ii) an alternative design, (iii) development of hydropower at a location other than the proposed Project locations, and (iv) development of other power sources such as thermal power.

121. The do nothing alternative would leave the Nam Leuk water resource undeveloped. This would obviate the Project's negative environmental and social impacts but, because the Project is the only one in the country that can realistically begin power generation before the end of the decade, the economic and social benefits would be foregone. Given that the adverse impacts of the Project can be mitigated to an acceptable level and that the Project is expected to improve overall conservation and protection of the NBCA through support for management planning and implementation, the do nothing alternative was rejected.

122. The most likely alternative design would be a run-of-river project requiring a much smaller reservoir behind the dam. Largely because of prevailing rainfall patterns in the country, rivers tend to have very low flows outside the monsoon season. Therefore, run-of-river schemes are viable at only a very limited number of large rivers with extensive tributaries that provide sufficient year round water flow.

123. The initial design phase explored a range of generation capacities. A much larger project producing more energy would have potentially increased the Project's economic benefits but also increased environmental and social impacts. The proposed Nam Leuk reservoir, inundating an area of 12.8 $km^2$, is among the smallest of all proposed hydroelectric projects in the country.

124. Alternative locations along the Nam Leuk and in other areas of the country were not selected mainly because of the longer time required for commissioning, the increased magnitude of potential impacts, and the advantages of the proposed site at Nam Leuk, i.e., its location next to a 180 m escarpment and the opportunity to turbine the water a second time through the Nam Ngum power station to produce additional energy.

125. The only feasible technical alternative to hydropower generation in the Lao PDR at the present time is thermal power generated from lignite. A 60-MW lignite plant would have much more severe environmental impacts. More than 500,000 $m^3$ of lignite would need to be mined annually, about 100,000 $m^3$ of ash would be produced each year, and about 400,000 t of carbon dioxide would be released annually in addition to other harmful emissions such as sulphur dioxide and nitrous oxide. Construction of an oil-fired plant would contravene Government policy to reduce imports of petroleum products.

126. The transmission line corridor was selected to follow the Muang Hom road as closely as possible, thereby minimizing forest loss and allowing convenient access to the line for maintenance. Where it crosses forests, the forests are generally degraded as a result of past commercial logging and subsequent disturbance by villagers. No alternatives to the access roads were considered because all but one of the roads already exist. The scope for any altering of the new access road is limited because the road links two Project facilities whose positions are fixed. Additionally, the 9-km road will run through highly degraded forest land and grassland, thus no significant forest areas will be lost.

127. The initial Project design sited the contractor's installations and the operator's village on land that is largely used for rice cultivation. During the EIA study, an alternative site was found that will reduce permanent loss of paddy land from 12.5 ha to 3.5 ha and temporary loss from 36.5 ha to 20 ha. Borrow and spoil sites on the plateau will be located in the area to be inundated by the reservoir, thereby reducing the Project's impacts on adjacent land.

## F. Cost Benefit Analyses

### 1. Background

128. At the start of the detailed design stage of the project, the basic data on which the power plant was initially sized was reviewed completely, including complementary hydrological and topographical data. The additional information led to a reconsideration of some of the conclusions made during the initial Project studies. In particular, a complete cost-benefit analysis was done to select the most suitable size of the power plant, taking into consideration not only the selling rates of power generation to Thailand, based on different scenarios, but also considering the versatility of the plant and its ability to provide electricity to the local grid with adequate efficiency and reliability. This analysis led to the selection of a 60-MW power plant with two 30-MW units installed in the power house in order to reduce outages and to provide intermediate ranges of power generation between less than 10 MW to the maximum installed power. Furthermore, an economic and financial evaluation was carried out to confirm the Project’s viability. The following sections summarize the findings of these evaluations. Costs associated with the Environmental Management Plan are provided in detail in Section G.

### 2. Project Cost Estimate

129. For the economic analysis, the Project was considered to be exempt from taxes and duties. For the financial analysis, carried out on the same basis as the economic analysis, anticipated local taxes have been added. The Project cost estimate is summarized in Table 5.

**Table 5: Summary of Project Costs ($ million)**

| Item | | | Foreign | Local | Total |
|---|---|---|---|---|---|
| 1. | Base Cost | | | | |
| | a. | Civil Works | 46.0 | 3.7 | 49.7 |
| | b. | Hydro-mechanical Equipment | 14.6 | 0.3 | 14.9 |
| | c. | Electrical Equipment | 12.7 | 0.3 | 13.0 |
| | d. | Transmission Line | 6.5 | 0.1 | 6.6 |
| | e. | Environmental Mgt. Plan[a] | 0.3 | 0.8 | 1.1 |
| | f. | Engineering Services | 5.4 | 0.5 | 5.9 |
| | | **Subtotal** | | | |
| 2. | Contingencies | | | | |
| | a. | Physical Contingencies | 4.3 | 0.2 | 4.5 |
| | b. | Price Contingencies | 5.0 | 0.9 | 5.9 |
| | | **Subtotal** | | | |
| 3. | Interest During Construction | | | 10.2 | 10.2 |
| 4. | Service Charge | | 1.8 | | 1.8 |
| 5. | Local Tax | | | 5.1 | 5.1 |
| | | **Total** | **96.6** | **22.1** | **118.7** |
| | | Percent | 81.0 | 19.0 | 100.0 |

[A] Does not include the approximately $100,000 that will be provided annually for conservation programs from energy sales.

Source: Sogreah Ingenierie

### 3. Economic and Financial Evaluation

130. The Project is expected to meet the local demand in the Paksane grid over the next decade. In addition, it will provide electricity for other rural districts of Vientiane and Bolikhamxay provinces when the corresponding rural electrification projects are completed. Until then, the project's energy surplus will be exported to the Electricity Generating Authority of Thailand (EGAT).

131. The economic analysis was carried out using classical assumptions. The economic life of the Project is projected to be 40 years with no residual value at the end of that period. The analysis includes transmission losses of 2 percent of the total transferred power exported to Thailand and 10 percent for the local domestic sales. The Project cost is as described above. The schedule of disbursement was based on the schedule of construction proposed in the detailed engineering studies. Operation and maintenance costs have been spread over the full length of the economic life of the Project at a yearly rate of 1 percent of the total cost of the Project. The exports to Thailand both in economic and financial terms are valued at an average rate of $0.045 per kilowatt-hour (kWh), derived from the current tariff for Nam Ngum power exported to Thailand, and the bulk of exports will be during the peak and the partial peak periods. The economic benefit in the domestic market has been valued in terms of resource savings ($0.17/kWh) and consumer surplus (0.12/kWh). Considering the expected increased retail price of $0.07/kWh, the economic benefit has been valued at $0.12/kWh.

132. The financial analysis has been carried out on the same basis, considering the financial benefit only in the domestic market with an average tariff revenue of $0.07/kWh. Local taxes and duties that are anticipated to be applied to the construction contracts and to imported goods have been included in the financial costs.

133. Based on these assumptions, the economic internal rate of return (EIRR) is 11.3 percent. Because of the conservative assumptions used for the retail price and the added taxes on the construction and equipment supply costs, the financial internal rate of return (FIRR) is slightly lower than the EIRR, at 9.5 percent.

## G. Institutional Requirement and Environmental Monitoring Program

134. The EIA study has identified expected impacts and measures necessary to mitigate these impacts during the Project's preconstruction, construction, and operation phases, and programs to monitor their effectiveness. Major considerations when recommending mitigation and monitoring actions included the cost of the actions and the parties responsible for implementing them. The tables in this chapter summarize the recommended actions, their costs, the party responsible for bearing the cost (in virtually all cases, the Project), and the party responsible for implementing and supervising them. The information summarized here will be further refined and detailed in an environmental management plan that is currently being prepared (see Table 6).

**Table 6: Environmental Management Plan's Major Components**

| Sector | Measures | No. | Type | Period | Execution |
|---|---|---|---|---|---|
| NBCA Management | Strengthen NBCA mgt. & protection | * | Operational | Two Years | MOAF |
| Hydrology | Monitor existing gauging stations | 1 | Monitoring | Permanent | EdL |
| Water Quality | Pollution control | 2 | Monitoring | Construction | EdL |
| | Release bottom water | 3 | Operational | Operation | |
| | Water quality monitoring | 4 | Monitoring | Operation-3 years | EdL |
| Fisheries | Fish catch survey | 5 | Monitoring | Construction Operation-2 years | DiF |
| | Minimum guaranteed discharge | 6 | Operational | Operation | EdL |
| | Fisheries reservoir plan | 7 | Compensation | Construction | DiF/Consultant |
| Land Use | Land compensation | 8 | Compensation | Construction | LWU/EdL |
| | Land titling | 9 | Compensation | Construction | DOL |
| | Survey paddy production | 10 | Monitoring | Construction Operation-2 years | MOAF |
| | Paddy land rehabilitation | 11 | Design | Construction | Contractor |
| | Temporary settlements control | 12 | Operational | Construction Operation | LWU/EdL CPAWM |
| Forestry | Clearing reservoir | 13 | Design | Construction | Contractor |
| | Supervision of logging | 14 | Monitoring | Construction | CPAWM/NOFIP |
| | Reafforestation | 15 | Compensation | Operation | CPAWM |
| Wildlife | Animals rescue | 16 | Compensation | Construction | CPAWM/WCS |
| | Monitoring hunting ban | 17 | Monitoring | Construction | CPAWM |
| | Preliminary PKK Management Plan | 18 | Operational | Construction | CPAWM/WCS |
| | Long-term funds discussion | 19 | Operational | Construction Operation | EdL/Government |
| Soils & Erosion | Control Nam Xan management | 20 | Monitoring | Construction | EdL |
| | Control road standard | 21 | Operational | Construction | EdL |
| Public Health | Workers health monitoring | 22 | Monitoring | Construction | MOH |
| | Nearby population malaria control | 23 | Operational | Construction Operation | MOH/IMPE |
| | Health Center B. Kengsan | 24 | Compensation | Construction | EdL/MOH |
| | Malaco-ecological surveys | 25 | Operational | Operation | MOH/IMPE |
| Others | Free electrical connection to B. Kengsan & B. Nam Leuk | 26 | Compensation | Operation | EdL |
| | General environmental plan management & coordination | 27 | Operational | Construction Operation | EdL/CPAWM/ STENO |

Source: Sogreah Ingenierie

135. EdL will coordinate the plan and have overall responsibility for ensuring that the environmental management and monitoring activities are implemented. EdL will be assisted by a foreign consultant with strong experience in dealing with environmental issues related to hydropower development. As the majority of the Project's environmental impacts and associated mitigation measures will occur within Phou Khao Khouay NBCA, the NBCA field staff under the direction of the protected area management advisor will coordinate closely with EdL and play a large role in assisting with mitigation and monitoring, particularly the latter.

136. Other Government offices will cooperate with EdL, for which they will receive funding support from the Project. These offices will include:

(i) the Science, Technology and Environment Organization (STENO), which will provide occasional oversight as the Government's major environmental policy and coordinating body;

(ii) the Ministry of Agriculture and Forestry (MOAF), which will monitor rice production in the lower Nam Xan valley;

(iii) the Division of Fisheries (DiF), which will monitor fish catches in the lower Nam Leuk River and prepare a preliminary fisheries management plan for the reservoir, assisted by a consultant;

(iv) the Department of Land (DOL), which will carry out land titling and demarcate affected paddy land;

(v) the National Office for Forest Inventory and Planning (NOFIP), which will assist in all activities related to forest planning, inventory, logging, clearing, and monitoring;

(vi) the Ministry of Health (MOH), which will monitor implementation of the Project's health components and staff the health center; and

(vii) the Institute of Malariology, Parasitology and Entomology (IMPE), which will carry out activities related to malaria control.

137. In addition, the Project will actively recruit NGOs; specifically, the Lao Women's Union (LWU) will be undertaking grassroots activities involving public participation and information, compensation, and local liaison. It is expected that Wildlife Conservation Society will continue to be available for specialized wildlife surveys and similar work. A Nam Leuk consultative committee will be formed to act as a formal link between the Project and local residents, and will include members from the central and local governments as well as village representatives.

138. Environmental management reports will be prepared by the contractor on a monthly basis as part of the Project's monthly reports for submission to EdL. Furthermore, the Project will support a formal review of mitigation implementation during the construction period at least once each year, and an environmental audit following construction. The review will include the progress of compensation and other social mitigation as well as mitigation of impacts on biological resources.

139. The total budget required for the implementation of the Environmental Management Plan is estimated at $1.058 million (see Table 7).

**Table 7: Estimated Budget for Environmental Management Plan ($,000)**

| | Pre-Construction | Construction | | | Operation | | Total |
|---|---|---|---|---|---|---|---|
| Item/Year | 0 | 1 | 2 | 3 | 1 | 2+ | |
| Fisheries | | 10 | 15 | 15 | 10 | 20 | 70 |
| Water Quality | | 10 | 1 | 1 | 8 | 12 | 32 |
| Land Use and Compensation | 60 | 74 | 51 | 51 | 26 | 20 | 282 |
| Forestry | 50 | 10 | 10 | 10 | | | 80 |
| Wildlife | 15 | 35 | 30 | 20 | 10 | 10 | 120 |
| Erosion and Spoils | 25 | 2 | 2 | 5 | 3 | 3 | 40 |
| Public Health | | 65 | 28 | 23 | 3 | 3 | 122 |
| Rural Electrification | | | | 20 | 30 | | 50 |
| Other Mgt./Monitoring | 30 | 70 | 70 | 70 | 22 | | 262 |
| **Total** | **180** | **276** | **207** | **215** | **112** | **68** | **1,058** |

## H. Public Involvement

140. Villagers have been aware of the Project through visits by EdL staff and local government officials. Further public consultation began with the implementation of the initial social assessment. During the assessment, villagers were informed of the Project, and their comments were solicited. The organization of a formal public consultation campaign started in mid-October 1995. At that time, the Project, including the environmental assessment, was sufficiently advanced to be more formally discussed with the concerned local communities, and still preliminary enough to have their comments and opinions fully considered when developing programs to mitigate the Project's adverse impacts and enhance social and environmental conditions where practicable.

141. The consultations took the form of public meetings in the Project area and were organized by EdL with assistance from the LWU. The LWU represents about 25 percent of the country's female population linked through a network that extends from the central to the village level. The LWU also has a strong role at the village level in environmental protection and education.

142. Information meetings were held in the four Project affected villages (Kengsan, Thamdin, Nongmouang, and Nam Leuk) and were held at three different levels. At the household level, at least ten households were visited in each village, and included households different from those previously consulted during the social assessment. Discussions focused primarily on the standard of living in the village and the villagers' expectations for receiving benefits from the project.

143. Meetings were also held at the village level. Participants included the chief of the village and all heads of households. The Project's objectives and design were again presented, and an open forum was held to allow the participants to ask questions of EdL representatives and to voice their concerns about the Project.

144. Finally, a meeting was held at the district level with Government representatives to keep them informed of Project developments and to gain any insights they had in terms of Project impacts on the district.

145. Four main issues were raised by local residents during these meetings:

(i) The residents requested that EdL establish a consultative and coordinating structure that would provide a formal link between the Project and local residents. As a result, EdL has agreed to establish a Nam Leuk consultative committee. The committee will operate for five years, three years to cover the Project's construction stage and an additional two years to monitor conditions—and take action where necessary—during the operation stage. The committee is expected to be officially formed before June 1996. A provisional list of committee members has been agreed, and includes (i) village chiefs from each of the four villages, (ii) the Deputy District Officer, (iii) a Nam Leuk hydropower representative, (iv) the District Agriculture Officer, (v) the District Forestry Officer, (vi) the District Land Department Officer, and (vii) a LWU representative. The detailed structure and responsibilities of the committee will be decided during preparation of the full environmental management plan.

(ii) Residents requested EdL to ensure that paddy fields on the left bank of the Nam Xan will be fully rehabilitated following their temporary use for the Project, and that productivity of the land for paddy cultivation be at least equal to the current level. In response, EdL has included as part of the Project a component to monitor paddy production following rehabilitation, through the Ministry of Agriculture and Forestry, and (based on monitoring results) will provide adequate remedial measures if production does not reach the current rate.

(iii) Regarding permanent loss of land, the residents expressed a general preference for allocation of new land rather than financial compensation. Such provisions have been incorporated into the EIA and the Project.

(iv) The Project was positively received by the villagers, especially in regard to the provision of electricity and improvement in social services and infrastructure that the Project will bring.

146. An additional public information measure to be undertaken by the project is the establishment of a documentation center in the EdL offices. The center will be available for public access to documentation related to the Project, including the EIA and other environmental reports.

## I. Conclusions

147. The Nam Leuk Hydropower Development Project is a 60-MW hydroelectric facility

located in central Lao PDR within the Phou Khao Khouay NBCA. The dam will divert water from the Nam Leuk River down a 180-m escarpment to a power station on the Nam Xan River. The diverted flow will also be used to augment the discharge at the existing Nam Ngum power station. The Project also involves the diversion of a smaller river, the Nam Poun, into the Nam Leuk reservoir. A 96-km long 115-kV transmission line will be routed to Bungkan substation in the southeast from where it will cross the Mekong and connect to the Thai grid. Power will be generated for the domestic market and for export to Thailand. The Project cost is estimated at $118.7 million, and construction is expected to begin in 1996 with a completion date of late 1999. The EIRR is estimated to be 11.3 percent and the FIRR 9.5 percent.

148. The Project's primary objectives are to:

(i) support optimal development of the country's power subsector;

(ii) provide generating capacity to meet domestic demand and increase exports of electricity to Thailand, a major foreign exchange earner for the country;

(iii) strengthen the capabilities of EdL to prepare, design and implement environmentally sustainable projects; and

(iv) strengthen the management and protection of Phou Khao Khouay NBCA.

149. Unlike traditional hydropower projects, the Project aims not only to provide economic benefits while mitigating adverse social and environmental impacts, but also aims to address the need for long-term environmental enhancement measures. Consequently, the Project will support, through the provision of technical assistance and a sustainable source of funds, improved protection and management of Phou Khao Khouay NBCA to reverse current trends toward increasing environmental degradation within the area.

150. Approximately 0.75 percent of the NBCA will be directly affected by the Project. The Project's major adverse impacts will be on the river sections downstream of the dam, which will lose a substantial amount of flow during the rainy season, although the flow in the dry season will remain unchanged. The major impact will be on fisheries and other aquatic life, primarily along the first 20 km downstream of the dam. Long-term impacts to fisheries in the Nam Mang system, of which the Nam Leuk is a part, are not expected to be significant. The major forest loss will be caused by inundation of the reservoir area where 12.8 $km^2$ of forest land will be flooded. The forest loss is not expected to disturb major wildlife populations or habitat significantly, and Project support to improve NBCA management in conjunction with the Project's environmental mitigation and monitoring components is expected to lead to an overall improvement in biodiversity conservation in the area over the medium to long term.

151. Less than 25 ha of paddy land will be required by the Project, and of this amount approximately 20 ha will be required only during the construction period. The major social benefit will be electrification of Paksane and nearby villages in Bolikhamxay province. Approximately 30,000 consumers will be served. The Project will also provide rural electrification, a health center, roads, and other services to villages in the vicinity of the Project area.

152. With effective mitigation, the Project's adverse impacts can be kept to acceptable levels, and support for the NBCA is expected to improve environmental conservation prospects in

the area. On balance, the Project design provides an acceptable level of environmental protection, serves the country's desire for development, helps meet the demand for indigenous and clean power, and contributes to national income.