

VOLUME 3 – CHAPTER 5

DESCRIPTION OF SOCIAL IMPACTS

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5 DESCRIPTION OF SOCIAL IMPACTS

5.1 INTRODUCTION

The Xe Bangfai area is typical of many lowland areas in Lao PDR with its dependency on paddy cultivation and fishing. The reliance on the Xe Bangfai as a source of food and water is a central aspect of livelihoods for the communities. Fish are an important item in their diet as a source of protein, vitamins and minerals. The majority of fish are consumed locally, although about 23 % surveyed families reported to gain some cash income from fishing. In addition to the importance of rice and fishing, dry season riverside gardens supply vegetables for local consumption, and crops for household consumption, animal feed and some sale.

The environmental impacts of the NT2 Project on the Xe Bangfai River will have a range of both positive and negative impacts on the riparian communities and their livelihoods. These impacts can be usefully divided into two categories, as follows:

Physical impacts:

- erosion threatening riverside assets such as houses, shops and some cultural sites;
- higher dry season flows prohibiting dry season crossing of the river;
- impacts on the use of XBF waters for various domestic purposes; and
- a positive impact on the ability to navigate up and down the river.

Production impacts - and thus income and nutritional impacts:

- impacts on the fish catch and aquatic product gathering from the mainstream Xe Bangfai;
- possible positive impacts on fisheries and aquatic products in connected wetlands and backwater areas;
- impacts on the gardens and crop fields currently cultivated on the sloping banks of the (dry season) river; and
- positive impact of higher river flows facilitating more and cheaper irrigation.

The prediction of these impacts and losses now (as described in this SDP) and up to COD can only be an indicative estimate. Only after COD when these impacts occur and are monitored can we obtain a more accurate understanding of the exact losses.

The 89 villages along the affected stretches of the Xe Bangfai (see Chapter 2) were populated in 2001 by approximately 7,096 households and about 40,600 people. Figure 2-1 shows the location of the potentially impacted villages along the Xe Bangfai. For an analysis and determination of impact, the villages along the Xe Bangfai (and the Xe Noy villages affected backwater) have been nominally divided into four zones of impacts, as follows (and as located in Figure 1-1):

- **Upstream of the upper** Xe Bangfai (upstream of the Downstream Channel confluence with the Xe Bangfai);
- **Upper** Xe Bangfai (from downstream channel confluence to the Phu Soy 'gorge');
- **Mid** Xe Bangfai (from Phu Soy gorge to just before Xe Bangfai flood plain);
- **Lower** Xe Bangfai (the region of the Xe Bangfai floodplain).

Most of the data and analysis in this chapter is presented disaggregated into these zones, except for fisheries which does not consider backwater villages in the Upstream zone, and along the Xe Noy in the middle zone.

5.2 IMPACT FROM FLOODING – LOWER XE BANGFAI

The results of the SMEC study (see Chapter 4, Section 4.4.6) has been analysed in terms of impacts on agricultural lands. It was considered that the areas under more than 1 m of water during the 1.6 ARI flood events, without the additional release from the Project, will not be further impacted in terms of agricultural production, as, even without the additional release from the Regulating Pond, they are already under too much water to enable such production. The focus is therefore put on the areas that are currently subject to a flood of less than 1 m, and represented on Figure 5-1.

The model indicates that 5,230 ha of land will be put under more than one meter of water because of the additional release of 315 m³/s. The average duration of this additional flooding is 3.6 days per year. The agricultural production on these areas is likely to be impacted.

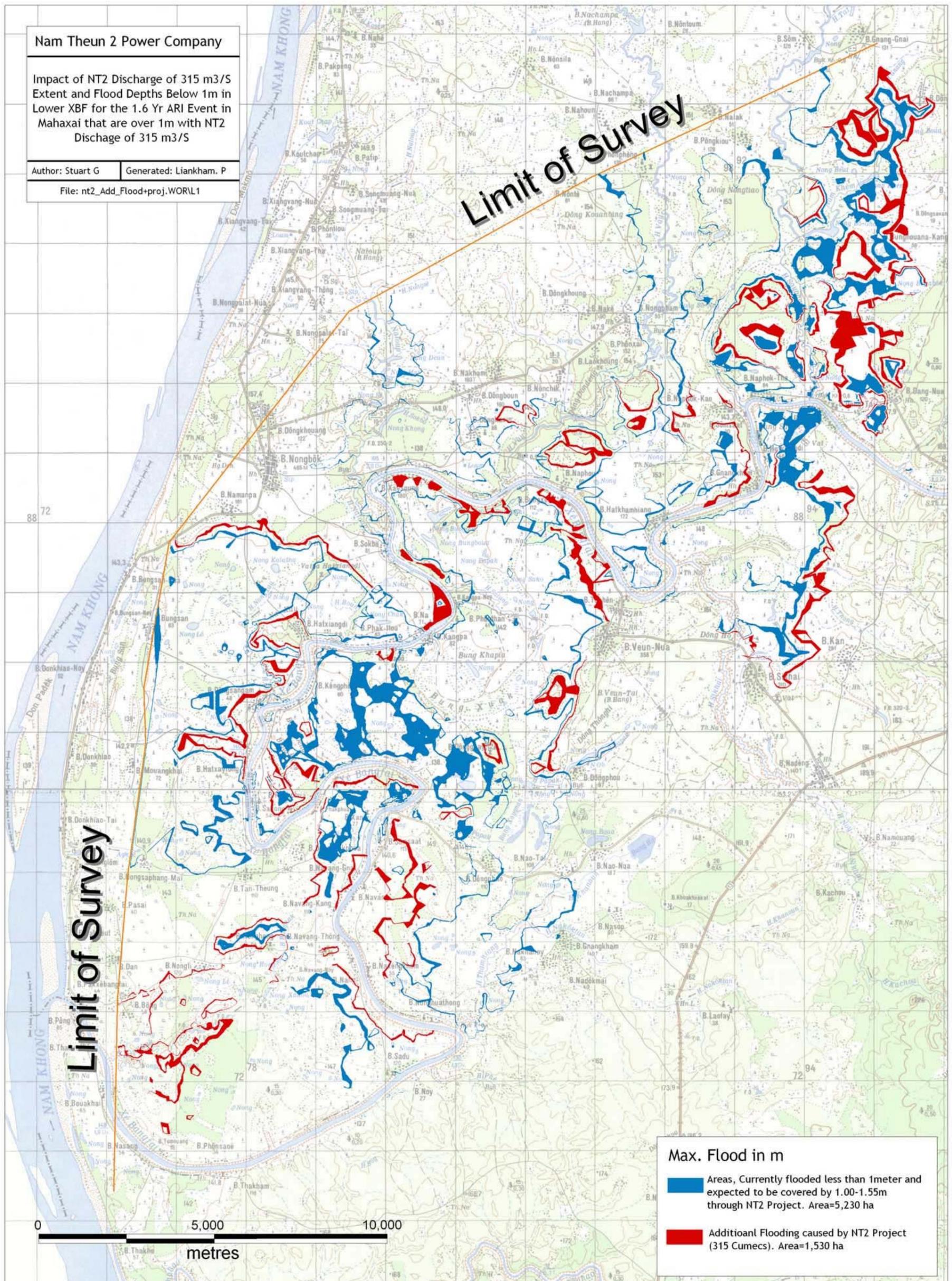
In addition the model indicates that 1,530 ha of land will be flooded due to the discharge from NT2 Project during an average of 3.6 days per year. However, these areas will be under less than 50 cm, therefore not threatening rice paddy production.

In addition, it is possible that the extended duration of the flood event on average by 3.6 days per year, could put at risk some of the 2,497 ha of land, which will be under a depth of water varying from 0.75 m to 1 m if the flood takes place before the paddy has been able to grow sufficiently in height.

The current use of the land will have to be confirmed as productive agricultural land during the rainy season.

The increased flood plain created because of the additional release of water could impact positively fish production in the area.

Figure 5-1: Extent of Additional Flooding Caused by NT2 Project and Areas where NT2 Project Impacts lead to Flooding Level Increase from 0.5-1.0 m to 1.0-1.5 m.



5.3 IMPACTS ON NAM THEUN DOWNSTREAM AND TRIBUTARIES UPSTREAM OF THE NAKAI DAM

5.3.1 Nam Theun Downstream Area

The expected impacts on the fisheries in Nam Theun Downstream Area are presented in Section 4.7.2 (Chapter 4). The expected annual loss in the area is 164,000 kg, which with the current fish price at US\$ 0.8 / kg is equivalent to US\$ 131,000 (see Table 5-1).

Table 5-1: Estimated Loss on Fish Catch in Nam Theun Downstream Area.

	Estimated decline in annual fish catch	
	kg/year	US\$/year
NT Mainstream	62,901	50,321
Nam Phao and tributaries	83,908	67,126
Nam Gnouang	14,813	11,850
Nam Ngoy	2,331	1,865
Total	163,953	131,162

5.3.2 Tributaries Upstream of the Nakai Dam

Fish catches in the NNT NPA are already impacted by the presence of the TH dam which impedes the upstream migration of long distance migrant fishes from the Nam Kading and Mekong. The majority of the fish catches in the NNT NPA will therefore probably consist of medium distance migrant species that adopt dry season refuge in the Nam Theun mainstream and non-migratory/short distance migratory fish species that are residents of the NNT NPA. The non-migratory/short distance migrant fish species will be unaffected by the Project. Only those species that refuge in the mainstream Nam Theun during the dry season then move into the NNT NPA during wet season will be affected by the physical presence of the Nakai dam and the conversion of the riverine environment to a lacustrine.

Based on the assumption that approximately 40% of the current fish catch in the NNT NPA consists of either long or medium distance migratory fish, and the impact on those migratory species is 80% due to the combination of the physical presence of the Nakai Dam and the conversion of a riverine to a lacustrine habitat, the overall impact on fish catches could be up to 35%. A similar severity of impact was observed in the Nam Gnouang after the closure of the TH dam (Schouten et al. 2004). However, as observed in Nam Ngum, many fish species that will adapt to the new lacustrine conditions will still continue to undertake migrations up the tributaries during spawning periods. Increases in the population of these fish species should buffer any impacts on the fish catch in the NNT NPA. Therefore an overall impact of 15% has been estimated.

Fish catch data for the villages within the NNT NPA is currently not available. Therefore the estimated value of the fish loss in the NNT NPA is based on the 2001 NPA population data (SEMFOP 2004) and a mean of the mean annual household fish catches for the Nam Theun tributaries of Nam Phao, Nam Phouang/Nam Phiat and Nam Kata (LARReC 2004). Based on a household population of 1,092 and a mean annual fish catch of approximately 72 kg/HH/yr, the value of the annual loss in the NNT NPA fisheries for a 15% impact is USD 9,400 or USD 79,000 in terms of Net Present Value.

To help mitigate any negative impacts on the fish catches in the NNT NPA a fish rescue programme will be implemented to collect those individuals blocked by the Nakai Dam and transport them to tributary confluences of the Nakai Reservoir to allow them to complete the remainder of their migration. The fisheries resource management component of the SEMFOP will also help to lessen the magnitude of the impact.

Because the upper NT is in the NPA, it is included in the biodiversity assessment and community consultation that will be undertaken as part of the SEMFOP. Fish populations, migration patterns, and livelihoods will be assessed at that time. Alternative livelihoods will be developed as part of the livelihood

program in the SEMFOP. The approach taken is a proactive development program to compensate for and restore livelihood losses.

The collection of aquatic products within the NNT NPA will not be affected by the Project.

5.4 IMPACT ON FISHERIES – XE BANGFAI

The two fundamental impacts of the NT2 Project that will result in impact on the fish catch of riparian and some hinterland villages are:

- (i) The impacts on the biological productivity of fish (see Chapter 3);
- (ii) The impacts on the efficiency of fishing gears and techniques, related to (a) the physical ability to catch fish in deeper water with higher water velocity, and weekly fluctuation of water levels, and (b) problems in trapping fish travelling to and from wetlands.

A third impact, which is more of an extension of a current problem is the impacts on fishing efforts, in that fishers will probably invest more time and money (more fishing gears) to try to catch the same amount of fish as before the Project, which itself may have an impact on fish yields.

5.4.1 Location and Season of Impact

Difficulties in predicting the type and level of impact are due to the difference in impact in different fishing locations and seasons. However, following extensive review of the available information, comparison with other similar projects and discussion amongst experts, it has been predicted – and used as a basis for the following analysis – that the impacts on aquatic productivity, fish catch and aquatic product collection will:

- (a) occur mainly, if not only in the mainstream of Xe Bangfai river, from its confluence with the Nam Phit (Downstream Channel) all the way to the Mekong River. That is, there will be limited, if any negative impact on fish productivity in the non-mainstream fisheries locations, and certainly no negative impact on the fishing and collection techniques in these areas)¹;
- (b) be much more pronounced in the dry season than in the wet season, as the amount of NT2 water discharge will be relatively higher in the dry season compared to the wet season, when the Xe Bangfai itself carries a lot of water; and
- (c) decrease in intensity and effect progressively downstream, and especially in the lower Xe Bangfai stretch of the river.

5.4.2 Probable Impacts on Fishing Techniques and Gears

As noted above, the impacts on fishing efficiency and use of gears will result from:

- higher and deeper water;
- faster flowing water in the dry season;
- fluctuation of water levels in the dry season; and
- less pronounced fluctuation between wetlands and main river, from wet to dry season.

The most important fishing gears, and the average catch from these gears – averaged over all 89 mainstream villages surveyed in 2001 – is presented in Table 5-2, adapted from Table 2-17, (Chapter 2, Volume 3).

While the figures in the table are indicative averages only, they show that in and around the Xe Bangfai river, as elsewhere in the Lao PDR, fishing methods and fishing gears are extremely diversified. Many fishing gears are only seasonally used and only in specific aquatic habitats, and thus fishing gears and techniques will be affected to varying degrees by the Project. The following are some examples of how the NT2 Project might affect some fishing gears and techniques:

¹ NT2 has adverse impacts on fish productivity and fish yields in the mainstream of Xe Bangfai and not in any locations outside Xe Bangfai mainstream, such as floodplains, tributaries, ephemeral streams, ponds, pools, and puddles, in which the NT2 may well have positive impacts on fish yields.

- Fixed gillnets may be difficult to set at locations with high water velocity, especially in the reaches immediately downstream of the confluence with the Nam Phit. However, fishers already set gillnets in periods of high flow during the wet season and sheltered areas may still provide opportunity for gillnets to be set;
- Setting nets or traps across tributaries may also not be as effective with the NT2 Project as they rely on seasonal reduction in flow in the Xe Bangfai channel, which will not be as pronounced with the NT2. However, due to the weekly fluctuation of water levels in Xe Bangfai by the Project, fisheries in the backwaters of the tributaries probably will become lucrative when water levels decline during each week-end;
- Hook and line fisheries will only be affected by the weekend fluctuation in water levels, the hooks with bait set before the decrease in discharge could be left stranded in the air instead of positioned in the water;
- Cast netting will probably be significantly affected by rise of water levels in Xe Bangfai during the dry season, as this method is employed by people without boats, by wading into shallow waters;
- In addition, during the first few years after operation, river bank erosion may result in branches, roots and other debris flowing down the river which could block or otherwise damage fishing gears.

Table 5-2: Monthly Catch of the more Important Gears, in and outside the Xe Bangfai, in Two seasons (Kg/HH/month).

Gear type	Dry season		Wet season		Total	Possible NT2 Impact on gear use in the Xe Bangfai mainstream only
	XBF River	Wetlands etc.	XBF River	Wetlands etc.		
Mesh Nylon Gillnets	9.4	1.2	4.3	5.7	122.5	still usable, but affected by fast water
Single hook and line	1.9	0.7	3.0	3.9	56.6	still usable
Cast Net	3.1	1.6	1.0	1.7	43.2	not usable
Nets with Handles	0.8	1.2	3.4	1.4	41.2	not usable
Scoop nets	0.9	1.4	0.5	1.0	22.9	currently not used much in mainstream
Long Line, multiple hooks	1.5	0.4	1.5	1.2	28.0	still usable, but affected by fast water
Bamboo Traps	0.1	0.3	0.3	1.8	15.2	still usable in places
Large Bamboo Cylinder Traps	0.0	0.1	0.1	0.6	5.0	not used much in mainstream
Push net with handle	0.1	0.1	0.1	0.3	3.1	not used much in manatee,
Falling Door Trap	0.1	0.0	0.2	0.1	3.1	may not be usable

However, while the NT2 discharges will have a negative effect on some fishing gears, the gears and techniques used are diverse and it is expected that some villagers will adapt by using other techniques that will be not or little affected by the Project. Such techniques include drift nets, beat nets, long lines with multiple hooks (taking into account discharge fluctuations), falling-door traps, cylinder traps, shallow water fish baskets, and lift nets. Villagers will also change the dimensions of gillnets and their mesh size, and adapt new techniques to catch fish during the week end especially to be effective when water levels fluctuate.

The improved use of the most effective gears in the mainstream will often require a boat, and thus it is these people who will best adapt to the change in conditions of the fisheries in the Xe Bangfai mainstream. On the other hand it will be those who currently focus on wetlands fisheries who may benefit from the possible improved catches in these areas.

5.4.3 NT2 Impact's Dependence on Fishing Effort and Fish Catch

The complexity of the assessment of impacts of the NT2 Project on household fish is that it is not only the NT2 Projects impacts on aquatic productivity that will be important, but that there are (and will be) other impacts on fish catch due to fishing efforts, which themselves have an impact on aquatic productivity. Thus, the line of Project Impacts leading to impacted Fish Productivity leading to impacted Fish Yield/Catch is not a linear relationship of causes and effects.

5.4.3.1 Fish catch variation due to location and population

Households living in the riparian villages along Xe Bangfai fish and collect aquatic products not only inside the main channel of Xe Bangfai, but also in streams and ponds, and on floodplains. Most of the households do not own a boat and usually fish close to their village area.

The average household fish catch differs from village to village depending on the existence of productive aquatic habitats near the villages such as (a) wetlands, and (b) deep pools in the Xe Bangfai mainstream. Some villages have less deep pools in their village area and other villages are blessed with many deep pools. In addition, the average household fish catch will differ on an annual basis due to environmental variations (and other influences) resulting in variable fish productivity from year to year.

The size of villages and number of households per village varies largely along Xe Bangfai and thus the competition for the fisheries resources varies, higher where there are higher populations. Thus, the average annual household fish catch differs from village to village also due to this issue. The average population growth in Xe Bangfai River Basin is about 2.5 to 3 % per year. Household fish catch declines year by year, as a result of natural population growth, but in some villages household fish catch also declines as a result of influx of new households that take up fishing in Xe Bangfai. In some villages that have large influx of households from other areas, households invest more and more money and time to catch the same or less quantity of fish. Not surprisingly, as an important outcome of the Socio-Economic Survey held in 2001, households consider over-fishing as the main threat to their annual fish catch.

5.4.3.2 Fish catch variation due to gears and markets

Introduction of nylon monofil gillnets in Lao PDR has resulted in increased opportunities for villagers to catch fish. Increased access to markets has provided more opportunities for households to sell fish and thus incentive to catch more fish – and thus put pressure on the fisheries resources. When access to markets increases, households that used to fish for consumption only increase their fishing efforts to earn extra cash income. Households use more fishing gears and spend more time to try to catch more fish for more cash income.

The above social factors and impacts which will occur irrespectively of the NT2 Project implementation significantly complicates the assessment of the impacts of NT2 on household fish catch. Household catch fluctuates annually, but it is already declining over time. NT2 will have negative impacts on mainstream Xe Bangfai fish productivity, but such impacts will occur on top of background impacts on fish productivity.

Assuming that all households fish at (or close) to the maximum sustainable yield just before COD, households may likely change their fishing gears and fishing efforts after COD².

5.4.3.3 Fish catch variation due to fishing practice effect on ecology and productivity

As explained below, there is a series of cyclical causes and effects, mainly of them going on now and not related to the NT2 Project, such as the growing number of fishers and increasing fishing efforts which have an influence on basic fish productivity as well as fish catch. Fish yields obtained in one year can have severe impacts on fish yields in subsequent years, an effect of what is commonly known as over-fishing or unsustainable fisheries.

The impacts on the annual household fish catch by interception of fish migrations can be significant³ and it is likely that a process similar to that observed in the Nam Hinboun occurred in Xe Bangfai during

² Downstream of Theun-Hinboun powerhouse households living along Nam Hinboun increased their number of gillnets by as much as a factor 3 after start of operation of the powerhouse. Number of fishing households at each village stayed more or less constantly along Nam Hinboun and household catch was severely impacted.

³ An example of the complexity of impacts between fish yields and fish productivity is the catch of Pba Soi in Nam Hinboun during the last 6 years of operation of the powerhouse. When water recedes from the flood plains and ephemeral streams, Pba Soi start migrating from these habitats up into Nam Hinboun. Entrepreneurs run large scale fisheries to block off ephemeral streams and drains from floodplains to intercept Pba Soi migration. Some of these large scale fishing practices catch as much as 1,000 kg of Pba Soi per day during the peak days of migration. Households living along Nam Hinboun try to catch the remaining Pba Soi that managed to pass the large scale fisheries. Households catch on an average between 30 and 90 kg of Pba Soi within a period of two weeks each year. This fish is small young-of-the-year with a length of not more than 10 cm. Households process their Pba Soi catch by fermentation into Padek for later consumption. In September 2003, households could not catch any Pba Soi. The year 2003 was a dry one, and most probably Pba Soi productivity was not as high as in normal years and the time and duration of

2003-2004, and the Pba Soi migration in the Xe Bangfai is even higher than the Nam Hinboun as a result of larger areas of flood plains. In other words fish yields can have considerable impacts on fish yields.

5.4.4 Environmental Impacts Not Related to the NT2 Project

In addition to these background social impacts on fish yields, there are a range of socio-environmental impacts on fish yields (see Chapter 3) which are and will continue to occur irrespective of the NT2 Project, including:

- land uses (with the conversion of forests and floodplains into paddy, fish spawning and nursery areas as floodplains reduce and forest creeks turn into paddy drains);
- river bank erosion (utilization of river bank vegetation for firewood, bamboo, and fishing gears, and conversion of river banks into vegetable gardens);
- sedimentation (shifting cultivation and loss of top soils that ultimately end up in rivers);
- agriculture development (low dissolved oxygen concentrations in rivers in Thailand and Lao PDR can be detected downstream of farms and agricultural land after high floods each year); and
- irrigation (reduction of water discharges as a result of irrigation; water demand of 5,306 hectares of existing irrigated dry season paddy along Xe Bangfai is conservatively estimated at 7.5 m³/sec, while the measured median natural discharge in Xe Bangfai at Mahaxai during the month of April is only 10.3 m³/sec);

5.4.5 Current Level of Harvest of the Fisheries Resource 'Maximum Yield'

The impact of the NT2 Project on fish catch will depend partly on the extent (the %) that the impacted communities are currently (immediately prior to COD) harvesting productive potential of the fisheries resources. This linkage between impact or effect of the NT2 Project and the 'efficiency' of pre-project catch by the various villages can be summarised as follows:

- communities whose current fishing effort results in a catch which is at or near the maximum sustainable yield for that area will be more impacted, as there is less buffer; while
- communities whose current fishing effort results in a catch which is somewhat below the maximum sustainable yield for that area will be less impacted.

That is, it will depend on whether households (just before COD) are fishing at the maximum sustainable yield, or whether they are fishing under or over the maximum sustainable yield⁴. If households fish well below the maximum sustainable yield before COD, impacts by the NT2 Project on abundance of fish populations may have relatively minor impacts on household fish catch after COD. If households fish at or above the maximum sustainable yield just before COD, the impacts by NT2 on abundance of fish populations may cause dramatic decreases in household fish catch after COD. If households fish at the maximum sustainable fish yield, the impacts on fish populations by NT2 form a fair representative value of decline in fish yield at downstream locations.

5.4.6 Summarised and Cumulative Impact on Fish Catch on the Xe Bangfai

By taking into account:

- (a) the environmental impact of the NT2 Project discharge into the Xe Bangfai (see Chapter 3);
- (b) an understanding of the non-NT2 specific background environmental impacts;
- (c) the impacts of the NT2 Project on efficiency of gear and fishing techniques;

migration was affected. Normally, Pba Soi passes upstream villages in Nam Hinboun within a period of 2 weeks. It could be that Pba Soi passed the villages in much less densities over a longer period of time and households could not detect Pba Soi as in normal years. Thus, household fish catch along Nam Hinboun was affected in 2003; households could not catch between 30 and 90 kg during this dry year. However, the next dry season, households along Nam Hinboun experienced a bumper harvest that they never had since start of operation of Theun-Hinboun powerhouse. Pba Soi that normally is caught in September appeared to escape from being caught and had the opportunity to grow and increase in weight during the subsequent dry season, after which households enjoyed the increase of dry season fish productivity with high fish catches. Fish yields and fishing efforts determine fish productivity.

⁴ The maximum sustainable yield of one year is that portion of fish productivity that can be harvested without causing decline of the fish yields in the following years.

- (d) an understanding of non-NT2 specific impact of fishing practices on fish productivity; and
- (e) the experience of similar projects

... a predicted maximum impact in fish catch has been developed for the different stretches of the Xe Bangfai river, as detailed in Table 5-3 below.

Table 5-3: Summary of predicted % impact of the NT2 Project on current fish catch

Zone	Dry season		Wet season	
	in XBF	out XBF	in XBF	out XBF
Upstream of Upper XBF	0 %	0 %	0 %	0 %
Upper XBF	80 %	0 %	80 %	0 %
Mid XBF**	70 %	0 %	50 %	0 %
Lower XBF 1	60 %	0 %	30 %	0 %
Lower XBF 2	45 %	0 %	10 %	0 %
Lower XBF 3	30 %	0 %	10 %	0 %
Average	60 %	0 %	41 %	0 %

** Note: fish catch of backwater affected villages on the Xe Noy are predicted not to negatively impacted.

This 'ball park' estimate of the maximum potential impact of NT2 on annual fish yields at villages located along Xe Bangfai between the confluences with Nam Phit and the Mekong River has been used to further compute an indicative impact on the kilograms of fish catch, based on the current fish catch data obtained from the 2001 socio-economic (and fisheries) survey (see Chapter 2). Thus, Table 5-4 presents the estimated impacts by the NT2 Project on existing fish catch by riparian households in Xe Bangfai, while Table 5-5 presents the estimate of the impact of the NT2 Project on existing fish catch (in the mainstream Xe Bangfai) by hinterland households.

To recap on the analysis above, this predicted impact on weight of fish catch is based on the following data and assumptions:

- The Xe Bangfai mainstream (below the confluence of the Downstream Channel) can be divided into 5 fisheries impact zones of approximately 30 kilometres each: (i) Upper Xe Bangfai, (ii) Middle Xe Bangfai, (iii) Lower Xe Bangfai 1, (iv) Lower Xe Bangfai 2, and (v) Lower Xe Bangfai 3;
- The predicted severity of impacts by NT2 on fish yields is based on the prediction of recession of riverbanks (SMEC, 2002). While impact prediction also takes lesson learned from the Theun Hinboun Project, the predicted decline in fish yield in the two lower zones (Lower Xe Bangfai 2 and Lower Xe Bangfai 3) is considerably lowered because the Xe Bangfai is longer than Nam Hinboun, and Nam Hinboun has additional impacts on fish yields by tin mine discharges;
- While fish catch from the mainstream of Xe Bangfai will be impacted by the NT2 Project as a result of the major changes in the aquatic food chain, thus resulting in lower fish productivity, households will not only change their fishing efforts, but this change in fishing will be required less with the gradual decline of water depth and water level fluctuation from Upper Xe Bangfai to Lower Xe Bangfai 3;
- There are a number of people who fish in Xe Bangfai mainstream but live far from the mainstream, in the hinterland villages identified during a survey in 2004, and it is estimated that the hinterland household fish catch is about 60 % of the household fish catch by riparian households.

Table 5-4: Estimated Maximum Impact of NT2 Project on Existing Fish Catch by Xe Bangfai RIPARIAN Households

Impact Zone	Number of Villages Along Xe Bangfai from Confluence with Nam Phit to Mekong River	Distance from Nam Phit Confluence with Xe Bangfai	Maximum Water Level Fluctuation During Dry Season	Number of Households (HH)	Average Annual HH Fish Catch in XBF Mainstream	Annual Fish Yield in XBF Mainstream	Dry Season Fish Yield in XBF Mainstream	Rainy Season Fish Yield in XBF Mainstream	Predicted Decline in Mainstream Fish Yield During Dry Season	Predicted Decline in Mainstream Fish Yield During Rainy Season	Predicted Decline in Mainstream Fish Yield During Dry Season	Predicted Decline in Mainstream Fish Yield During Rainy Season	Predicted Decline in Annual Fish Yield	Estimated Value of Decline in Annual Fish Yield
Upper Xe Bangfai	12	0-32	4.3-5.0	852	383	326,291	225,577	100,714	80	80	180,461	80,571	261,033	208,826
Middle Xe Bangfai	5	32-71	3.5-4.1	224	296	66,275	37,776	28,499	70	50	26,443	14,249	40,693	32,554
Lower Xe Bangfai 1	18	71-100	2.2-3.5	1,960	221	433,494	205,814	227,680	60	30	123,488	68,304	191,792	153,434
Lower Xe Bangfai 2	24	100-128	0.8-2.0	2,026	130	262,639	153,737	108,902	45	10	69,182	10,890	80,072	64,058
Lower Xe Bangfai 3	11	128-145	0.0-0.6	1,017	145	147,383	94,690	52,692	30	10	28,407	5,269	33,676	26,941
TOTAL	70			6,079		1,236,081	717,594	518,487			427,982	179,284	607,266	485,813

Table 5-5: Estimated Maximum Impact of NT2 Project on Existing Fish Catch in the Xe Bangfai Mainstream by HINTERLAND Households

Impact Zone	Number of Hinterland Villages Fishing in Xe Bangfai Mainstream	Distance from Nam Phit Confluence with Xe Bangfai	Maximum Water Level Fluctuation During Dry Season	Population of Hinterland Villages Fishing in Xe Bangfai Mainstream				Number of Fishers of Hinterland Villages Fishing in Xe Bangfai Mainstream				Estimated Annual Household Fish Catch	Estimated Maximum Annual Fish Yield	Dry Season Fish Yield in XBF Mainstream	Rainy Season Fish Yield in XBF Mainstream	Predicted Decline in Mainstream Fish Yield During Dry Season	Predicted Decline in Mainstream Fish Yield During Rainy Season	Predicted Decline in Mainstream Fish Yield During Dry Season	Predicted Decline in Mainstream Fish Yield During Rainy Season	Predicted Annual Decline in Mainstream Fish Yield	Estimated Maximum Value of Decline in Annual Fish Yield
				[km]	[m]	Number Households	Number Persons	Number Men	Number Women	Estimate of Maximum Number of Households	Number Persons										
Upper Xe Bangfai	10	0-32	4.3-5.0	568	3,409	1,701	1,708	132	211	150	61	230	30,331	20,969	9,362	80	80	16,775	7,490	24,265	19,412
Middle Xe Bangfai	17	32-71	3.5-4.1	1,990	11,937	5,849	6,088	550	1,122	948	318	178	97,637	55,652	41,985	70	50	38,957	20,992	59,949	47,959
Lower Xe Bangfai 1	19	71-100	2.2-3.5	2,557	15,344	7,572	7,772	465	1,000	606	393	133	61,707	29,297	32,410	60	30	17,578	9,723	27,301	21,841
Lower Xe Bangfai 2	16	100-128	0.8-2.0	1,820	10,921	5,273	5,648	497	1,118	658	403	78	38,657	22,628	16,029	45	10	10,183	1,603	11,786	9,428
Lower Xe Bangfai 3	4	128-145	0.0-0.6	401	2,407	1,197	1,210	64	128	83	45	87	5,565	3,575	1,990	30	10	1,073	199	1,272	1,017
TOTAL	66			7,336	44,018	21,592	22,426	1,708	3,579	2,445	1,220		233,897	132,122	101,775			84,565	40,007	124,572	99,688

Table 5-6 summarizes the predicted impacts by NT2 on fish yields by riparian and hinterland villages in Xe Bangfai.

Table 5-6: Summary of estimated Weight of Existing Fish Catch and Prediction of Maximum Impacts of the NT2 on Fish Catch in the Xe Bangfai, during the Dry and the Rainy Season.

	Dry Season Catch (kg)		Rainy Season Catch (kg)		Total (kg per year)
	In XBF mainstream	Wetlands etc.	In XBF mainstream	Wetlands etc.	
<u>Riparian Households</u>					
▪ Fish Catch before Project	717,594	455,103	518,487	1,137,138	2,828,322 kg
▪ Predicted Impact by Project as % of Fish Catch	60 %	0 %	41 %	0 %	
▪ Predicted Fish Catch after Project	289,612	455,103	339,203	1,137,138	2,221,056 kg
Predicted Decline in Fish Catch (kg)	427,982 kg	0	179,284 kg	0	607,266 kg
<u>Hinterland Households</u>					
▪ Fish Catch before Project	132,122	0	101,775	0	233,897 kg
▪ Predicted Impact by Project as % of Fish Catch	64 %	0	39 %	0	
▪ Predicted Fish Catch after Project	47,556		61,768		
Predicted Decline in Fish Catch (kg)	84,565 kg	0	40,007 kg	0	124,572 kg
Total Predicted Loss of Fish after Project (kg)	512,547 kg	0	219,291 kg	0	731,838 kg

Table 5-4 and Table 5-6 reveal that for riparian or mainstream villagers, up to 607,300 kgs of the annual fish yield may be lost. This compares to the present total annual fish catch of these riparian villages of 2,828,322 kgs. Thus, about 21.5 % of the total fish catch of these villages will be impacted by NT2. This result is based on the household interviews which revealed that much more fish is caught by riparian households outside Xe Bangfai mainstream at floodplains, tributaries, ephemeral streams, ponds, and puddles than in the mainstream itself.

The annual fish yield by hinterland households in Xe Bangfai mainstream is estimated to be maximum 124,572 kgs per year. Of the total of 7,336 households living in the hinterland villages only 1,708 households, or 23.2 %, are fishing in the Xe Bangfai mainstream.

Spot checks of household fish catch along Xe Bangfai and adjustments of the ongoing fish catch monitoring will improve confidence in the prediction of impacts by NT2 on fisheries.

5.4.7 Impacts on the Nam Phit

The fishery of the Nam Phit / Houay Khama will be severely impacted by the Project, due to the high velocity of the water in the downstream channel, the decrease of water quality and the loss of natural habitats. It is estimated that up to 90 % of the fishery could be lost. The value of the estimated loss of fish and aquatic products is US\$ 112,000 (see Table 5-7).

Table 5-7: Summary of Weight and Value of Fish Catch and Estimated Loss on the Nam Phit

	Fish	Other aquatic animals	Aquatic plants	Total
Total catch (kg)	136,319	63,787	23,791	223,897
Value of total catch (US\$)	109,055	12,757	2,379	124,192
Estimated loss (kg)	122,687	57,409	21,412	201,507
Value of estimated loss (US\$)	98,150	11,482	2,141	111,772

5.4.8 Impacts on the Nam Kathang

The catch in Nam Gnom / Nam Kathang is currently not expected to be affected by the Project, compared to the current situation.

5.4.9 Potential Positive Impacts on Fish Yield

The increased water depth of Xe Bangfai due to the NT2 Project discharges increase somewhat the backwater effect in the ephemeral streams, tributaries, and in Xe Bangfai upstream of the confluence with Nam Phit. At these locations, fish catch will most likely increase.

It is highly likely that during the weekends when water levels are highly fluctuating, fishers will try to increase their catch by blocking such locations off with nets.

All fish yields outside Xe Bangfai mainstream between the confluences with Nam Phit and the Mekong River are not expected to be adversely impacted, but more likely to be positively impacted. Fish will try to find food in such locations that they are not able to find in the Xe Bangfai mainstream after COD.

In addition, the increased discharge of the Xe Bangfai may also result in a slightly increased area, duration, or frequency of flooding in the seasonal wetlands adjacent, and connected to Xe Bangfai, and this will contribute to an increased fish productivity and increase of fish catch from these areas, and increased catch and collection of aquatic products in the area.

5.5 IMPACTS ON AQUATIC PRODUCTS COLLECTION AND 'INCOME'

Riparian households also forage for aquatic animals as frogs, shrimps, crabs, snails, and mussels and collect aquatic vegetation, mainly for consumption. Household catches, collection and consumption of such aquatic life may reduce as a result of the impacts in the mainstream. However, in aquatic habitats such as tributaries, wetlands, floodplains, and ponds (nong) where aquatic life is not affected, villagers will still be able to collect these aquatic products.

If the impact on household income from collection of aquatic products (excluding fish) is expressed in kilograms per household, then assigning a value in terms of USD is difficult because:

- (a) all aquatic products are used mainly for household consumption; and
- (b) the range in types of products.

A kilogram of just harvested vegetation when wet may change to less than 0.1 kilogram when stored and dry. The weight of collected mussels and snails is different from the weight of consumed mussels and snails. Most of these aquatic products are collected during the dry season only, mainly by women and children, and quantities collected differ considerably per household.

A collapse in the aquatic food chain in Xe Bangfai mainstream is predicted to occur as a result of increased discharges, water depth, river bank erosion, sedimentation, and fluctuation of water levels during the dry season. Households are expected not to be able to collect aquatic vegetation, snails, mussels, and shrimps after COD. The maximum value in losses in household catch of aquatic products from Xe Bangfai mainstream is estimated to be USD 20 per household per year, assuming an average value of USD 0.3 per kilogram harvested aquatic products. These losses are expected to occur all the way to the Mekong River.

Detailed baseline data on aquatic products from the mainstream Xe Bangfai have yet to be collected, and thus the following assumptions have been made:

- An average annual loss in aquatic products valued at USD 20 per household per year for the 6,079 riparian households (population data from 2001) that live along Xe Bangfai mainstream between the confluence with Nam Phit and the Mekong River;
- An average annual loss in aquatic products valued at USD 10 per household per year for the 1,708 households (population data from 2004) that live in the so-called hinterland villages, but collect aquatic products in the Xe Bangfai mainstream.

Based on the above, it is reasonably estimated that about USD 138,490 per year would be the value of possible losses in collection and catch of non-fish aquatic products from the mainstream Xe Bangfai. This is only an indicative average, as most of the riparian and hinterland population is concentrated in the lower reaches of Xe Bangfai close to the Mekong River and aquatic products are most likely less harvested in the lower reaches of the Xe Bangfai.

5.6 IMPACT ON RIVERSIDE GARDENS

As described in Chapter 2, there are various types of crops and gardens grown on the sloping banks of the Xe Bangfai, generally established in two locations and in three main periods or seasons as follows:

Locations:

- (a) sloping mid and upper slopes of the river,
- (b) lower, and often flat slopes

Seasons:

- (a) early dry season, when the rivers discharge is decreasing, and crops are grown on the groundwater still in the upper and mid slopes,
- (b) mid to late dry season, when the river has achieved its relatively stable low flow and crops bit mainly vegetables are grown with water drain from the river,
- (c) early wets season, when the river is still low but increasing in discharge, and crops can be grown on rainfall, on the upper slopes.

The impact of the NT2 Project on these gardens will be due to two main affects:

Effect of higher water levels:

The higher water levels in the Xe Bangfai due to the NT2 project discharges will physically flood those areas in which fields and gardens are currently established on the mid and lower levels of the riverbank.

Effect of erosion and slumping:

The increased rate of erosion which may be caused by the NT2 Project discharges will erode those areas currently used as riverbanks gardens or fields. These gardens and fields can probably be re-established on the new banks of the re-formed river, but it may take some time to establish exactly how the new riverbank will be shaped.

The impact of the NT2 Project on riverbank gardens will be:

- (a) most pronounced in the upper areas of the Xe Bangfai, and less pronounced in the lower areas, due mainly to the relatively less increase in river discharge due to the NT2 Project, in the lower Xe Bangfai;
- (b) almost 100 % impact on the lower level dry season gardens, but progressively less impact on the mid and especially upper slope gardens, the impact being dependant on erosion and especially slumping;
- (c) some people will try to re-establish gardens, especially vegetable gardens., on the mid and upper slopes, although this may be difficult in the early years while the river is still establishing its new morphology;
- (d) even in the absence of an erosion effect on upper riverbank slope gardens and fields, there will be physically less room or area in which to establish these gardens and crops.

Based on the above prediction of what may happen after the NT2 Project, a maximum predicted impact on river bank gardens and fields is presented in Table 5-8 below.

Table 5-8: Size and Households with Riverside Fields/Gardens (2004), and Possible Maximum Impact of the NT2 Project.

District	Total HH (2004)	Riverside Crop Fields				Riverside Vegetable Garden			
		Current		Possible impact from NT2		Current		Possible impact from NT2	
		Area (ha)	No. of HH	Area as %	Area in ha	Area (ha)	No. of HH	Area as %	Area in ha
Mahaxay	1,265	103	526	80	82.5	4.01	45	100	4.01
Xe Bangfai	1,651	74	486	80	59.2	5.25	55	100	5.25
Nong Bok	2,120	41	432	40	16.4	4.34	100	70	3.01
Xaybouli	2,808	98	698	40	39.2	4.56	73	70	3.19
Total	7,844	316	2142		199.1	18.16	273		15.46

Thus, a maximum of about 199 ha of crop fields and about 15.46 ha of vegetable gardens fields, farmed by up to 1,500 households may be impacted by the NT2 Project, and may not be able to re-establish field and gardens higher up on the river bank, at least in the early years after project commissioning.

5.7 IMPACT OF EROSION ON RIVERSIDE ASSETS

5.7.1 Buildings

It is expected that the NT2 Project will cause erosion, to some extent, in the upper and mid sections of the Xe Bangfai, and it is the fixed structures in these 2 zones that will be affected. Erosion, if any, in the lower Xe Bangfai is not predicted to cause any impact to structures on the edge of the riverbank.

Various fixed assets or buildings are currently located on the banks of the Xe Bangfai, mainly some houses, but also some shops, rice barns, open rest pavilions and temples. The exact type and number of such structures located within 20 m of the brink of the Xe Bangfai riverbank, on both sides of the river has recently been surveyed, and the data is now being analysed.

With increased erosion rates along the Xe Bangfai (predicted to be up to 20 m in the early sections of the upper Xe Bangfai) there is a potential that those structures located close to the river may start to slip into the river.

For the owners of fixed assets on the edge of the riverbank structures in the mid and upper zones of the Xe Bangfai, such impact of erosion will either result in:

- (a) the construction of riverbank protection in sections of the riverbank in front of (and to protect) these structures; or
- (b) the requirement to relocate the structures further away from the edge of the riverbank.

For fixed structures which have cultural or community value, or for stretches of the river bank which have a high density of fixed structures, and where it is observed that these structures are threatened by erosion, then the NT2 Project will construct riverbank protection.

In other cases, and where relocation is feasible, the NT2 Project will assist in the relocation of buildings that are under threat from the increased erosion.

5.7.2 Irrigation Pump Installations

Increased river bank erosion may affect or erode the footing which support supply pipes carrying water from floating irrigation pumps to irrigation channels on the top of the river bank.

There are currently 19 such pump irrigation systems in the mid and upper Xe Bangfai, and this would be the maximum number of system that will be effected. In cases where the erosion is undermining the

footings then the NT2 Project will ensure protection of the supply pipe footings or reestablishment of the supply pipeline. Thus, this effect will be totally negated by Project mitigation.

5.8 IMPACT ON ACCESS ACROSS THE RIVER

As detailed in Chapter 2, some communities often cross the Xe Bangfai in dry season by various means for various reasons and by various methods – mainly walking across rapids to visit gardens and forests, but also across temporary bamboo bridges, and some low level truck and hand tractor crossings (see Table 2-25).

The increased water level in the dry season will make such seasonal temporary dry season river crossings no longer possible.

5.9 IMPACT ON PUMPING INSTALLATION MANAGEMENT

The weekly (weekend) drop in the Xe Bangfai river level, due to the cessation of NT2 Project discharges on Sundays, will require adjustments to the way irrigation pumps floating on the Xe Bangfai are connected by flexible hoses to the supply pipes carrying water up the irrigation canals on top of the river bank.

Currently, the positions (inlets) along the supply pipe that these flexible hoses are connected to changes a few times per year, as the river falls in the dry season and rises in the wet season. The hoses and connectors are not particularly sophisticated, and changing them is somewhat laborious.

After NT2 Project Commission, the river will rise and fall significantly once per week, and thus the way in which these hoses are connected and disconnected to the supply pipe footings will have to be improved to make it more practical.

In addition, there may be some 'within weekly' variations in NT2 Project discharge from the regulating pond, resulting in fluctuations of the Xe Bangfai river level of up to (about) 1 m in the upper zones. Thus, the flexible hoses currently connecting the floating pump to the supply pipe may be too short to account for such variation, which will also not be known or predicted by the irrigation pump operators. Thus, these pipes will need to be lengthened and made more flexible.

It may be that current – and certainly future – irrigation pump installations are designed and constructed as axial lift pumps, with engines situated on top of the river bank, with no flexible connectors required. This would totally void the problems described above.

5.10 IMPACT ON DOMESTIC WATER USE

The water in the areas downstream the power station might not be suitable for human consumption, or even domestic use, during the first years of operation, due to four main factors:

- increased turbidity, especially during the dry season;
- presence of organic matters, originating from the decay of the biomass on the plateau;
- possible presence of sulphur compounds (H₂S), due to anoxic decomposition of biomass, most likely during the dry season;
- difficulty to access the water during the week-end drawdown (slippery and/or eroded riverbanks).

Although some of these impacts may have a limited geographical extension, an extensive compensation program will need to be implemented, in order to maintain access to a water of domestic quality during operation of the powerplant.

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