VOLUME 2 – CHAPTER 13
IRRIGATION SYSTEM PLANNING FOR THE PLATEAU RESETTLEMENT AREA

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13 IRRIGATION SYSTEM PLANNING FOR THE PLATEAU RESETTLEMENT AREA

13.1 INTRODUCTION

Thirteen of the fifteen villages affected by the Nam Theun 2 Reservoir impoundment have chosen to be resettled on thirteen of the possible twenty five resettlement sites located on the southwestern edge of the Nakai Reservoir. Their choice was mainly based on existing administrative and cultural village boundaries of land that is known to them. As part of the resettlement package, the following irrigation facilities (per resettled household will be provided, if the irrigation system development in the first irrigation villages (Nong Boua, Bouama and Phonsavang) are shown to be feasible and sustainable.

- 0.5 ha of irrigated farm land for growing field crops, vegetables, fruit trees, possibly wet season rice and fodder for livestock consumption
- 0.16 ha of irrigated rice paddy

All-year round irrigation of the areas is required for the farm land crops. The following amounts were included in the Concession Agreement of 3 October 2002:

Irrigation and household water supply and distribution	US$ 1,673,750
Gully stop dams and head ponds	US$ 75,900

However new estimates have been prepared and the amounts for irrigation and water supply have been significantly increased to:

Irrigation, Plateau and Khamkerd District	US$ 3,348,400
Gully stop dams and head ponds	US$ 79,100
Household water supply	US$ 472,500
Total	US$ 3,900,000

This chapter identifies the possible irrigation system required for each of the reservoir resettlement sites that the Resettlers wish to move to and their preliminary cost estimate. The Pilot Village Irrigation Scheme at Area 16 is described and the Bolikhamxai Irrigation Scheme is also briefly described. The chapter discusses the further investigations required before the detail design of the individual schemes can be undertaken, the operation and maintenance of the completed schemes, and extension services.

The locations of gully stop dams and ponds have not been identified. Because of their small water storage volumes and the small catchment areas of the gullies in the project area, their use for storing water for irrigation purposes is limited. It is envisaged that they will consist of low earth embankments constructed by an excavator and the larger ones by a bulldozer. A spillway will be cut in natural ground at the side of the embankment. Topographically, there are many potential sites available and they will be of use for increasing resettlement area water resources for livestock use. It is also possible that they will be used for trapping water as reservoir levels recede in the reservoir drawdown areas. However it is preferable that there locations are chosen when:

- further local knowledge of the hydrology of the potential sites is available, and
- after village consultations on possible grazing areas.

The area of the irrigation systems is based on the expected number of affected households when relocation occurs. This number is based on a 2003 census by the Nakai District assisted by the RMU and the NTPC. The number is then increased by an annual growth rate of 3 percent applied until the year the village is scheduled to relocate. Affected are all the households from fifteen Plateau villages plus all the households from Ban Phonephanpek and an estimated 31 from Oudomsouk. The villages are scheduled to move either during the 2005/6 or 2006/7 dry seasons. Sop Hia Village will be split into:

- The recent Tai immigrants who will be resettled in Khamkerd District, Bolikhamxai Province with Nam Nian Village.
- The Vietic groups who will be resettling to a new village on the edge of the reservoir.

Table 13-1 lists the future reservoir resettlement area villages, the expected number of households, and the net and gross irrigation areas required per site. The gross area is the net irrigation areas of 0.5 ha and 0.16 ha per household increased by 10 percent to include land possibly lost by right of way for non-farm areas such as access roads, irrigation canals and drains, other natural drain lines, termite mounds, other local high spots and heritage sites. In some resettled villages, the expected number of households is still subject to further villager consultation. For example, Ka Oy villagers have chosen to move to one of three sites, Areas 19, 21 and 22, and the actual numbers moving to an individual area has not been finalized.

Table 13-1: Indicative Number of Households and Farm Plots Requiring Development in Plateau Relocation Sites (based on Table 2-2).

Area	Village	No. of households	Farm plot net area (ha)	Rice net area (ha)	Total net area (ha)	Total gross area (ha)
1	Nakai Neua	91	45.5	14.6	60.1	66.1
2	Nakai Tai	195	97.5	31.2	128.7	141.6
7	Nong Boua Kham	50	25.0	8.0	33.0	36.3
8	Sop Ma	48*	24.0	7.7	31.7	34.9
8A	Vietic Sop Hia	35**	17.5	5.6	23.1	25.4
11	Sop Phene	54	27.0	8.6	35.6	39.2
13	Thalang	70	35.0	11.2	46.2	50.8
16	Nong Boua (& Sailom, Pamanton Hamlets) and Keng Gnao, Sop Ma	50*	28.3 (actual)	8.0	36.3	39.9
17	Boua Ma	64	32.0	10.2	42.2	46.4
18	Phonsavang	32	16.0	5.1	21.1	23.2
19	Phonsavang, Sop On and Ka Oy	107	53.5	17.1	70.6	77.2
21	Done and Ka Oy	135	67.5	21.6	89.1	98.0
22	Khone Khen and Ka Oy	64	32.0	10.2	42.2	46.4
15	Oudomsouk	31	15.5	5.0	20.5	22.6
15	Phonepanpek	111	55.5	17.8	73.3	80.6
	Total	**1,137**	**571.8**	**181.9**	**753.7**	**829.1**

* of the 68 families in the Sopma (and hamlets) 48 will move to near Talang and about 20 will join the Nongboua area.
** of the 58 families in Sophia, all 35 Vietic will remain on the Plateau

Including the 51 households from Sop Hia and Nam Nian that will move to Khamkerd District, Bolikhamxai Province, the total number of households eligible for irrigation facilities is 1,188.

13.1.1 Brief Description of the Nakai Area to be Irrigated

The reservoir Resettlement Area is located within 20,600 ha of mixed forest on the southwestern side of the Nakai Reservoir. Most of the area will remain mixed forest with village and irrigation development taking place on the edge of the reservoir. Half of the resettlement sites have undulating topography and the other half are flat and gently sloping. The surface soils in the area are generally poor, acidic, sandy to sandy loams. Lower horizons are a clay loam texture. The soils in the northern areas, 7 to 13 are generally better with less sand content and higher organic matter.

The average annual rainfall over the Nakai Plateau is relatively high at 2,600 mm per year. Distribution is markedly seasonal with over 88 percent falling between April and September during the wet season southwest monsoon period.

13.1.2 Irrigation Water Sources for the Nakai Plateau

The watershed areas of the streams that flow through the resettlement sites to the Nakai Reservoir are generally small resulting in non-perennial low discharges. For example, the edge of the Nakai Plateau

escarpment is typically 2 to 3-km to the southwest of a resettlement area, and then land-slopes and surface runoff are in the opposite direction. Consequently the streams that flow through the sites have not been considered as a source of irrigation water, with the exception of Area 16. The Pilot Village Irrigation Scheme at Resettlement Area 16 has utilized the Houay Malai, with a watershed area 11.41 km^2. This is one of the largest watersheds and the development of the irrigation system necessitated the inclusion of an earth dam and spillway as well a pump station.

The chosen irrigation water source is the Nakai Reservoir which can vary in elevation by 12.5 m throughout the year. The full supply level is El. 538 from August to November during high rainfall years. The minimum operating level is El. 525.5 in May/June during low rainfall years. The average rainfall year minimum elevation is predicted to be El. 526.5. As the resettlement villages irrigation areas are above the full supply level of El. 538, pumping is required. For the purposes of pump design, the minimum reservoir elevation has been considered as El. 526. However lower reservoir elevations can be accommodated by a pump station sump excavated at a bed level of El. 524.

A previous resettlement study, Resettlement Options for the Nam Theun 2 Hydroelectric Project, Margules Povry Pty Ltd, April 1997, vaguely considered "*blocked off reservoir areas forming water storage ponds*". The areas were blocked off by "*earth bunds constructed seasonally*". Retention basins were identified at three locations and had water storage depths ranging between 9 to 16 m. There were no further technical details given and no cost estimates. This type of retention basin has not been considered further as for earth bunds of these heights to hold water for even a single dry season, considerable volumes of earthworks will be required and compaction will not be possible under water. It is possible to construct permanent earth dams fed from the reservoir by two-way spillways. However experience from the Pilot Village Irrigation Scheme is that the combination of dam and spillway and pump station plus the required irrigation conveyance and distribution systems is prohibitively expensive.

13.2 PUMP STATIONS

13.2.1 Supply Channel

A supply channel is required to be excavated to convey water from low reservoir elevations to a pump station located on the reservoir perimeter. Pump stations located in deep water within the reservoir have not been considered as they would be more expensive to construct and have inherently more operation and maintenance problems. The supply channel bed width is a practical 1 m with side slopes of 1:1.5 (v:h) if possible. 1:2 side slopes will be necessary for deeper excavations in poorer strength materials. The sump, the point of lowest bed elevation where the pump station is located, is to be 6 x 6 m with side slopes of 1:2. The gradient of the channel bed is 0.001 m/m or 10-cm per 100 m. The bed elevation of the sump must be at El. 524 to incorporate a low reservoir elevation of El. 526 plus a further 2 m so that there is a good factor of safety clearance from the pump suction intake to the excavated sump bed elevation. Consequently there is a height of 14 m from the sump bed level to the reservoir full supply elevation of El. 538.

There may be some initial collapses of the supply channel side slopes until the banks stabilize. These will have to be cleared by earth moving machinery in the month of June, the month of lowest reservoir elevations. Therefore a 4 m wide access track is necessary along one of the channel banks at El. 527. There will be some reservoir sediment deposition at the sumps and some deposits from local runoff erosion. The deposits will only cause a problem during low reservoir years and any deposits will have to be cleared manually.

It will be attempted to minimize supply channel maximum excavation depths to avoid large earthworks volumes which will have to be properly disposed of. However the slope of the land at the proposed locations of the pump stations is frequently of low gradient and long lengths of deep excavation depths will be common and will cause excessive excavation volumes on some schemes. The supply channel will also be used as a low reservoir waterway for village fishing boats. The sump area can also be utilized as a wharf.

13.2.2 Power Supply

An electricity mains supply will be provided to all the resettlement villages and it will be extended to power the irrigation pumps. No other power source is either as convenient or more cost-effective for

powering an irrigation pump. Other sources such as diesel, wind or solar powered pumping have not been considered. The cost of the electricity supplies are not be included in the irrigation development cost estimates even though irrigation will probably be the largest user.

13.2.3 Type of Installation

Fixed pump installations can either be axial flow pumps fixed to the reservoir bank at an inclination, preferably 30°, or centrifugal pumps with horizontal shafts and significant extra reinforced concrete and other civil works. Both types involve pump impellors submersed below El.526 and driven by a motor, via a shaft coupling, located above El. 540.00. El. 540 incorporates a full supply level of El. 538 plus a 2 m freeboard for wave action and flooding. However they are considered expensive options, especially the civil works necessary for the horizontal installations. The lower cost axial flow option can have more breakdown problems associated with the long inclined shaft coupling from the motor to the pump impellors.

The preferred option is centrifugal pumps installed on floating platforms, or pontoons, that move up and down with the varying reservoir elevations. A flexible discharge hose connects the pump outlet to a steel delivery pipe fixed on the reservoir bank by reinforced concrete foundations. This delivery pipe delivers the water to a suitable high location within or near to the proposed irrigation scheme. Between El. 538 and El. 526.00, the delivery pipe must have several connection points to accommodate the varying pontoon levels. This type of installation is used extensively for irrigating from the Mekong River and its tributaries because of its lower initial cost and less maintenance requirements.

For all the schemes, two pump sets, each of half the required scheme discharge requirement, are installed on one pontoon. Therefore if one pump breaks down then the other can supply the irrigation requirements by increasing the pumping hours.

13.2.4 Delivery Pipe

Delivery pipes fixed to the reservoir bank will be steel of 15, 20, 30 or 40 cm diameter. The pipes commonly come in 6 m lengths and will be joined by bolted flanges and seals. Above the bank and leading to the header tank, steel is the preferable stronger material, however uPVC pipes will also be considered.

The total pump head requirement is static head plus pipe and other friction losses. There is a cost relationship between the diameter of the delivery pipe and the total pumping head requirement. For a similar irrigation requirement, the smaller the pipe diameter, the higher the water velocity in the pipe. This results in higher pipeline friction and other fittings head losses, which are measured in meters head of water. Consequently smaller diameter pipelines will have higher total pumping head and power requirements. Using a larger pipe diameter will reduce the head losses but with the long delivery pipelines required in the project area, the initial capital costs may be higher than the saving on pump and motor sizes. However it is preferable to choose the larger diameter pipes as there will be significant future savings on pump power costs over the project life. Also, the irrigation systems must have the potential for expansion to accommodate growing populations. The larger pipe diameter is desirable in this respect.

13.2.5 Header Tank/Stilling Basin

The pump station delivery pipe will discharge into a header tank or a stilling basin. A header tank is necessary for a pipe irrigation system and a stilling basin is necessary at the head of an open channel canal. Both structures will be located on high ground to enable gravity distribution. The structures will be of reinforced concrete construction. However if there is no suitable high spot relatively near the pump station, then an elevated tank will be necessary. In this case, a steel tank supported on either a steel or reinforced concrete frame will be considered.

A header tank is required for pipe distribution systems for the following reasons:

- A buffering storage between the pump discharge and the irrigation requirement as it will not be possible to select a pump with discharge exactly the same as the scheme IWR. Also, a new pump will pump more than a used pump. Similarly, the pump discharge will vary with the varying reservoir elevations, the higher the reservoir level, the less the pumping head and greater the pump discharge;
- The tank will act as a trap for any sediments that are pumped up;

- If reservoir water quality is suitable, the tank will store water for domestic use after irrigation pumping ceases. The domestic pipeline will pass through a sand filtration tank.

The header tank will have outlets for irrigation, domestic water supply, overflow and flushing. A system will be provided so that the pump operator knows when to stop the pump if the tank is overflowing. A flagged float has been installed at the Pilot Village Scheme. There will be steel rungs cast into one of the sides for access for inspection and cleaning purposes. There will be an access track to the tank.

The minimum dimensions of the header tank are those so it can store water for evening and night time domestic use. As a buffering storage the larger the better, with cost the limiting factor. Provisionally, for preliminary cost estimate purposes, a buffer of fifteen minutes over-pumping has been assumed. This can be several times more than the overnight domestic storage requirement.

For costing purposes, the header tanks have been assumed to be 2 m high, including a freeboard of 0.25 m, and of square dimensions.

For possible open canal systems in the flatter areas, the delivery pipe must discharge into a reinforced concrete stilling basin located at the head of the main canal. The velocity of the pumped water is such that it would erode an earth canal if pumped directly into it. Therefore the stilling basin is designed so that water enters the main canal at the correct elevation and at a suitable velocity so that canal erosion does not occur. It will have no buffering storage but for canal systems this is unnecessary as the open canals have inherently more storage capability within the freeboard area. It is unlikely that a stilling basin can be adapted for domestic water storage and supply.

13.3 IRRIGATION WATER REQUIREMENTS AND SCHEDULING

13.3.1 Farm Plot Crops Irrigation Water Requirements

For the non-ponded farm plot crops such as vegetables and maize, a peak net irrigation water requirement (IWR) of 4 mm per day will supply all evapo-transpiration needs during the dry season. However there will be conveyance, distribution and field application losses, the amount depending on the type of conveyance and distribution and farm plot slopes and soil types. A typical project irrigation efficiency of 70 percent has been used, equating a rounded-up gross IWR of 6 mm/day.

13.3.2 Paddy Rice Irrigation Water Requirements

The IWR for ponded rice paddies is considerably higher than for the farm plot crops. Rice grows in a standing water depth of between 10 to 15-cm. Extra irrigation water is required to cover evaporation losses from the open water as well as to compensate for percolation losses in the inundated fields. Furthermore, substantial irrigation water is required to saturate the land for land preparation. That is, softening the ground for ploughing and puddling. Puddling is the disturbance of fine clay particles that settle between lower soil particles and reduce percolation losses. For example, for paddy on heavy clay soils on the Mekong Plains, percolation rates can be between 1 to 3 mm per day. In lighter well draining soils, such as the project area, percolation rates will be significantly higher, a worst case scenario being as high as 20-cm per day. A saturation depth of water of between 20 and 25 cm is typical for land preparation. Also, the project irrigation efficiencies for rice are lower as there are higher field application losses as the water passes from terraced paddy to terraced paddy.

For the light soils in the project area, the percolation losses for paddy must be carefully considered. Even with good irrigation practices there will be percolation losses. However for other non-ponded crops, efficient irrigation practices can largely eliminate percolation losses. Unless there is significant clay content in the soil, it is recommended that dry season paddy rice irrigation is not considered. The high percolation losses will cause an increased IWR, higher capital costs, long pumping hours and the possible leaching of nutrients from the soil.

The following has been assumed for the hydraulic design of the irrigation systems:

- There are areas with soils with clay content in the Resettlement Area that can be developed for paddy production. These are mostly in the northern area sites;

- However their percolation losses will be higher than the heavy clay soils normally used for paddy. Therefore wet season production only has been considered. That is, supplementary irrigation water is supplied when rainfall does not meet the crop requirements;
- After a few years of land preparation and puddling, the percolation losses will reduce. If they remain high, then the land is used for growing field crops. If they reduce to a suitable level, then dry season double cropping of rice can be attempted.

Estimating the percolation losses without the results of infiltration rate tests and area field experience is difficult. For example, at the Theun Duane Demonstration Farm the soils are light and dry season rice trials required considerable pumping and low yields. After taking into account effective rainfall, a moderately high 6 mm/day has been used which results in a peak net supplementary IWR of 8 mm/day. Then taking into account the various system efficiency and field application losses of 60 percent, a gross IWR of 13 mm/day has been assumed.

It is possible that dry season rice production can be undertaken in reservoir drawdown areas after some bunding to trap the receding water. There will be some fine silt deposition that will increase soil fertility and reduce percolation. However it is difficult to predict how much production is possible and it has not been included in the resettler livelihood options.

13.3.3 Domestic Water Supply

Whenever possible, and if the reservoir water is of suitable quality, the irrigation system should incorporate additional water supply for domestic use other than drinking. This requirement is 50 liters per person per day. Assuming a household of 6 persons and taking an example of 50 households in a village, 15 m^3/day is required. Over 12 hours pumping, an extra discharge of 0.35 l/s is required. This is a small percentage of the irrigation requirement and does not need to be included when making the pump selection. It can be easily delivered from a header tank during the day and by a few extra minutes pumping at the end of the day to fill the header tank.

13.3.4 Pumping Hours and Water Duty

1 mm/day IWR equates to 10 m^3/ha/day of water. Therefore a 6 mm/day IWR equates to 60 m^3/ha/day and 13 mm/day equates to 130 m^3/ha/day of water. The estimation of water duty or liters per second per hectare (l/s/ha), for estimating pump capacity and dimensioning conveyance pipes or canals, depends on the number of irrigation hours practiced per day. The more hours, the lesser the pump capacity and canal dimensions and the lower the capital cost. The fewer the hours the greater the capacity and the higher the construction costs. For the Pilot Village Scheme, eight hours a day was used for farm land crops. However when including wet season rice areas this must be increased to twelve hours per day.

Consequently for twelve hour irrigation, the following water duties have been assumed:

- Farm plot crops, 1.39 l/s/ha, say 1.4 l/s/ha;
- Wet season rice, 3 l/s/ha.

13.4 IRRIGATION DISTRIBUTION SYSTEMS AND FARM LAYOUTS

13.4.1 General

The type of the irrigation conveyance and distribution system depends on the topography of the area:

- Undulating, irregularly sloping land require buried pipeline systems;
- Flat and gently sloping land is irrigated by trapezoidal shaped open channel systems.

The locations of the farm and rice lands and farm layouts will be determined after more consultation with the Resettlers and further topographic survey and investigations on soil types. As stated previously, the rice lands must be in the flatter areas with heavier clay soils. There are some existing shifting cultivation areas and they will be more suitable for agriculture.

Farm and village access roads are required within the areas, the cost of which has not been included in the irrigation development estimates.

13.4.2 Canal Systems

A typical canal distribution system has main, secondary, tertiary and quaternary canals. However for the small resettlement schemes, not all this order of canals may be required. A system also has canal structures to control the discharges and water levels within the system including turnouts, checks, and check/drops. Conveyance structures such as culverts and siphons will be required to convey water under roads or drains.

An open canal system is generally preferable for wet season paddy because of the higher water duty required and the high cost of uPVC pipes. It has been assumed that the rice land is located on the lower, flatter slopes adjacent to, or near to, the farm land. Then the same pump station, delivery pipe and header tank or stilling basin is used for both farming systems.

In the flatter and more gently sloping areas a series of regular sized blocks can be designed and prepared. As the farm land plots are 0.5 ha, a simple 50 m by 100 m farm size is recommended when possible with the irrigation supply canal traversing the 50 m length. The distance between the canals must be about 106 m to include land for the right of way of the canal, field drain at the end of the plot and a walkway along the canal bank.

The flatter central and southern sites have the more sandy soils and the open canals will suffer more than average from seepage losses. Canal lining is the conventional strategy for reducing losses and must be considered. There is wide range of lining alternatives ranging from low permeability clay or earth layers, through plastic membranes to hard surface linings such as concrete or brick. Clay lining is preferred, that is excavating between 0.3 to 0.5 m below the canal bed level and then backfilling with compacted low permeability earth material. This will be considerably cheaper than concrete lining which can suffer from cracking.

The inclusion of drainage systems is normally an integral part of irrigation and small open channel trapezoidal section drains will need to be included at the end of the farm plot in the flatter areas. However for the more sloping areas with light free-draining soils and small farm areas, drainage considerations are minimal.

13.4.3 Buried Pipelines Systems

A typical buried pipeline system will use uPVC and smaller-diameter high density polyethylene (PE) pipes and has valves for flushing accumulated debris from pipe low spots and trapped air from high spots. Other fittings will include gate valves, clamps, junctions, tees, elbows and reducers. In the undulating areas, the farm layouts will be irregular, the Area 16 Pilot Village Scheme being a good example. There, no two farm plots are of the same shape and long pipeline lengths are required to convey and distribute the water throughout the area.

The pipes will be laid on sand bedding. Concrete anchor blocks, also known as thrust blocks, are necessary to transfer any forces in the system to the surrounding soil and prevent any pipe movement leading to disruption of the joints and subsequent leakage. Typical locations of anchor blocks are at all bends greater than 15°, changes in pipe diameter, tees and junctions, in-line valves and at the end of the line.

After construction of the buried pipelines, the routes will be marked by 1 m high pre-cast concrete posts painted white.

13.4.4 Farm Inlets and Terracing

Each farm plot will have its own farm inlet structure. At the Pilot Village Irrigation Scheme the farm plots are of various shapes and slopes. Consequently a unique type of farm inlet has been installed so that various farm plot irrigation techniques can be practiced and tested. Every plot has a 6 cm diameter PE pipe taking off from the buried pipe distribution branch line to the top of the plot. At the end of this pipe there are three outlets. One outlet is to a small concrete tank used for filling watering cans. The second outlet is for attaching small-diameter hose pipes for overhead irrigation methods and the third is for attaching larger diameter pipes for conveying water further away from the outlet, particularly down some of the steeper slopes and avoiding soil erosion.

This type of multi-purpose farm inlet has many fittings and is relatively expensive and similar outlets cannot be installed at all the resettlement irrigation schemes. The type of outlet at individual schemes will depend on the shape and slope of the plots and the type of irrigation technique to be practiced. On the flatter plots, where surface irrigation can be fully practiced, a much simpler structure can be installed. For example, a small mortared brick outlet box and a gate valve for regulating the supply. On open channel systems, a small gated precast concrete structure will be prefabricated and installed.

In the undulating areas terracing of farm plots will be required. Terracing will reduce soil erosion and water losses thereby improving irrigation field efficiencies and reduce pumping costs. Terracing must be carefully designed and undertaken to preserve the current soil fertility level. The use of large earth moving equipment will be avoided. Small tractors with front blades can be used in some areas but with the general project poor soils, the best suited method is for the farmers to gradually level the land over a period of years. At the Pilot Village Scheme, irrigation technicians work closely with the farmers on terracing survey, design and earth moving. The cost of terracing has not been included the irrigation cost estimates.

13.5 INDICATIVE IRRIGATION SYSTEM FOR EACH RESETTLEMENT SITE

13.5.1 General

Following villagers' indicative choice of resettlement site, a desk study was undertaken on the possible irrigation system layouts for each resettlement site, on the basis that access to irrigation and domestic water is actually one of the main determinants of final resettlement site choice.

The plans that follows, on a background of the currently available 1:25,000 scale maps, shows the approximate irrigation area site boundaries based on topography and the area required by each village site, and the proposed location of the supply channel, pump station, delivery pipe and main canal or pipeline. Village populations, farm areas and irrigation water requirements are explained, and brief description of the irrigation system and estimated cost is provided.

At the time the maps were prepared, the expected village populations were based on a RMU census of 1998 plus an annual growth rate of 2.2% applied over 7 years to 2005. However the expected populations are now based on a 2003 census and a 3% annual growth rate until either 2006 or 2007. Also households that were previously considered ineligible have now been included. Therefore the number of households and consequent irrigation areas are now higher than when the maps were prepared. The data accompanying the maps has been revised but the boundaries and areas shown on the maps have not been amended to suit the new figures. However when topographic survey and mapping is undertaken, a larger area than the boundaries shown on the maps will be covered and the scheme designs will be based on the revised figures.
The boundaries of the Resettlement Areas shown are not definite in that, for example, no village has chosen to be resettled to Area 12. Consequently the boundaries of Areas 13 (Ban Thalang) and 11 (Ban Sop Phene) can be extended into Area 12.

Maps have not yet been prepared for the Oudomsouk and Phonepanpek irrigation systems in Area 15. They were included in the program at a later date. The irrigation systems will be located in areas relatively close to the NT2 Headrace Channel to the Power Conduit Intake Structure and it is preferable and possible that the Supply Channels from low reservoir areas to the two pump stations will start at the Headrace Channel. Also, that number of Oudomsouk households is still not clearly known. However general descriptions of the schemes are included.

13.5.2 Preliminary Construction Cost Estimates

Preliminary construction cost estimates have been prepared. Unit rates from the construction contract for the Pilot Village Irrigation Scheme have been modified. Assuming that the construction of the schemes will be tendered in lots and not individually, they have been modified to reflect the considerably larger contract quantities involved.

The average cost per hectare for the Plateau schemes is estimated at about US$ 3,900. Not included are the cost of investigations and design, UXO clearance and the electricity transmission lines to power the pumps. These items are covered in various other sections of the Social Development Plan.

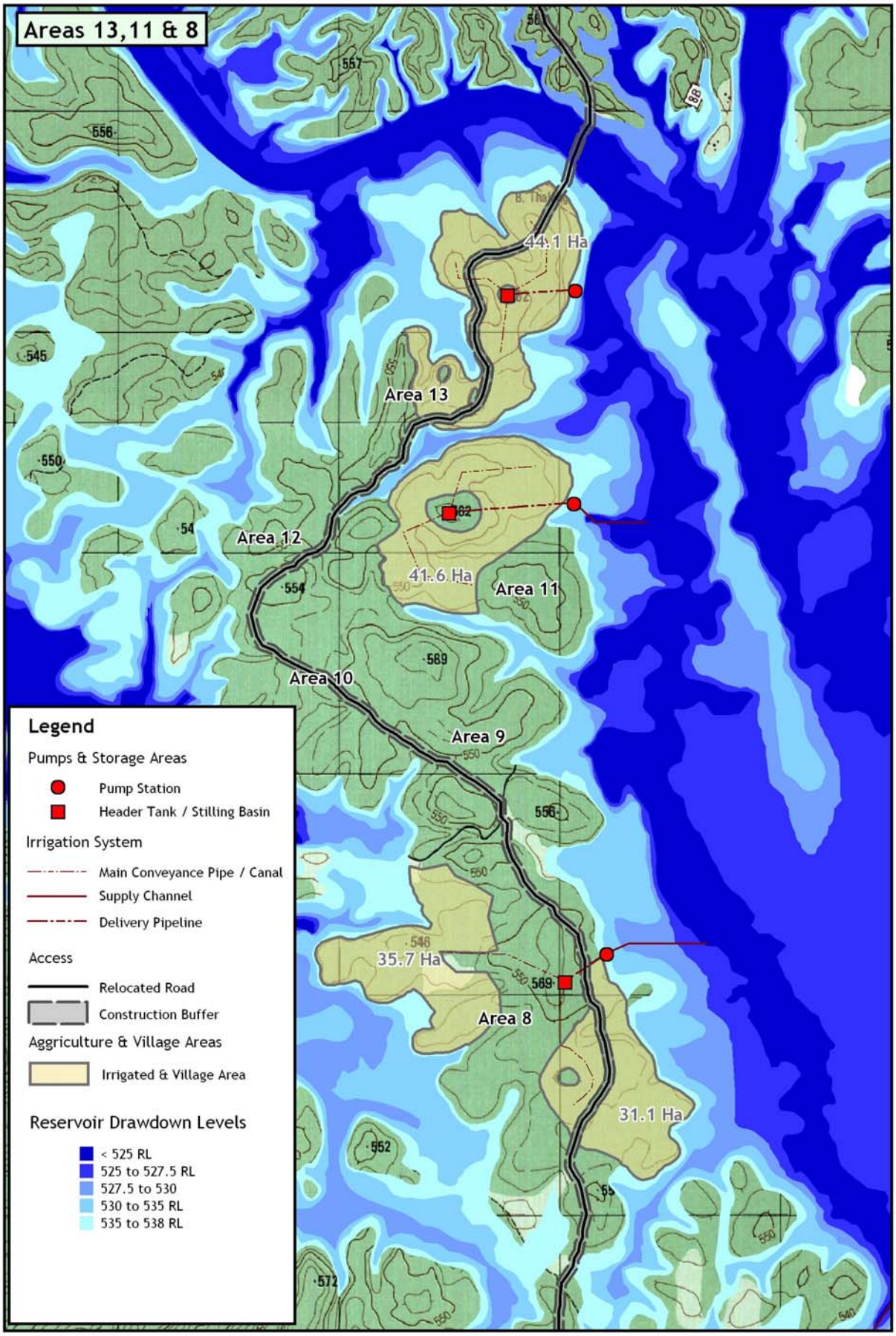
AREA 13: Ban Thalang

Number of households: 70 households
Approx. Housing Area: 6.9 ha

Farm Land Net Area: 35 ha Rice Net Area: 11.2 ha Total Irrigation Net Area: 46.2 ha
Total Irrigation and Village Gross Area: 57.7 ha
Farm Land IWR: 49 l/s Rice IWR: 33.6 l/s Total IWR: 82.6 l/s

Area Description: Irregular shape and undulating with some steep grades. Forest, some high quality, with bamboo and shrubs. Good soils observed. Limited area available for village and irrigation development.
Area bisected by relocated Road 8B. Large Project bridge will be construction at northern end across the Nam Theun. Villagers wish to be relocated adjacent to Road 8B and bridge entrance for increased trade and passenger services.
Limited low slope drawdown area due to proximity of Nam Theun and Houay Kalet deep channels on north and eastern boundaries respectively.

Irrigation System: This is one of the more difficult areas for irrigation development because of limited available area. It is a small site cut by the relocated Road 8B and the bridge entrance must be kept clear. Pontoon pump station located on east side of area. Good location available on bank of Houay Kalet with minimum excavation for supply channel. 2 centrifugal units pumping total of 84 l/s and total head of 23 m. Total pump motor requirement is 38-kw.
Long, 340 m, 30-cm diameter, steel delivery pipe to a reinforced concrete header tank at high spot at about El. 550.
PVC buried pipe gravity distribution possible to most of central and northern areas. 3 main lines from header tank in northeast, west and southern directions. Careful design and construction required when traversing Road 8B. Extensive terracing required on steeper slopes. Estimated cost about US$ 152,500 at about US$ 3,300 per hectare.


Areas 13,11 & 8
44.1 Ha
Area 13
Area 12
41.6 Ha
Area 11
Area 10
Area 9
35.7 Ha
Area 8
31.1 Ha
Legend
Pumps & Storage Areas
Pump Station
Header Tank / Stilling Basin
Irrigation System
Main Conveyance Pipe / Canal
Supply Channel
Delivery Pipeline
Access
Relocated Road
Construction Buffer
Aggriculture & Village Areas
Irrigated & Village Area
Reservoir Drawdown Levels
< 525 RL
525 to 527.5 RL
527.5 to 530
530 to 535 RL
535 to 538 RL

AREA 11: Ban Sop Phene

Number of households: 54
Approx. Housing Area: 6 ha

Farm Land Net Area: 27.0 ha Rice Net Area: 8.6 ha Total Irrigation Net Area: 35.6 ha
Total Irrigation and Village Gross Area: 45 ha
Farm Land IWR: 37.8 l/s Rice IWR: 25.8 l/s Total IWR: 63.6 l/s

Area Description: More regular shape, undulating, with forest and dense undergrowth. Good soils observed across the area. Limited drawdown area available because of high slopes off eastern boundary down to Houay Chaloy.

Irrigation System: Pontoon pump station located on east side of area. 60 m long supply channel required. 2 centrifugal units pumping total of 64 l/s and total head of 31 m. Total pump motor requirement is 40-kw. Long, 520 m, 30-cm diameter, steel delivery pipe to a reinforced concrete header tank at high spot at El. 562.
Straightforward PVC buried pipe gravity distribution possible from central point to most of the area apart from undulation in western and southeastern extremities. 2 pipes from header tank in northeast and southwest directions.
Estimated cost about US$ 144,400 and cost per hectare about US$ 4,100.

AREAS 8 and 8a: Ban Hat Khamphane and Sop Ma to Area 8 and Vietic Sop Hia to Area 8a

	Area 8	Area 8a
Number of households:	Assume 48 households	35 households
Approx. Housing Area:	5.4 ha	4.5 ha

Area 8
Farm Land Net Area: 24 ha Rice Net Area: 7.7 ha Total Irrigation Net Area: 31.7 ha
Total Irrigation and Village Gross Area: 40.3 ha
Farm Land IWR: 33.6 l/s Rice IWR: 23.1 l/s Total IWR: 56.7 l/s

Area 8a
Farm Land Net Area: 17.5 ha Rice Net Area: 5.6 ha Total Irrigation Net Area: 23.1 ha
Total Irrigation and Village Gross Area: 30 ha
Farm Land IWR: 24.5 l/s Rice IWR: 16.8 l/s Total IWR: 41.3 l/s

Area Description: Irregular shapes and undulating. Mixed forest throughout. Variable sandy loam soils with better quality in hardwood areas observed. Area bisected by relocated Road 8B. Low slope drawdown areas available on both sides. Areas relatively far from existing Road 8B. There are some old logging tracks in the area but access road works for construction will be required.

Irrigation Systems: Assume separate irrigation systems. Area 8 pontoon pump station located on eastern side of area and Area 8a on western side.
Area 8 requires a long, about 400 m, supply channel. 2 centrifugal units pumping 58 l/s and total head of 33 m. Total pump motor requirement 38-kw. 360 m long, 20-cm diameter, steel delivery pipe to header tank at high spot at El. 569. Apart from Road 8B dividing the area, straightforward PVC buried pipe gravity distribution to most of the area possible. Estimated cost US$ 121,600 at about US$ 3,850 per ha.
Area 8a requires a shorter, 100-m long supply channel to a pontoon pump station delivering 42 l/s at 32 m head, total power 26-kw. Long, 500m, 20-cm diameter steel delivery pipe required. Buried PVC pipeline gravity distribution system possible. Estimated cost US$ 107,800 at about US$ 4,700 per ha.

AREAS 7 and 7a: Ban Nong Boua Kham

Number of households: 50
Approx. Housing Area: 5.5 ha

Farm Land Net Area: 25 ha Rice Net Area: 8 ha Total Irrigation Net Area: 33 ha
Irrigation and Village Gross Area: 42 ha
Farm Land IWR: 35 l/s Rice IWR: 24 l/s Total IWR: 59 l/s

Area Description: Two small irregular shaped undulating areas. Mixed forest throughout, some of high quality hardwood, some with dense undercover. Good soils and some small streams perhaps suitable for domestic water supply development observed.
Area 7 bisected by relocated Road 8B. Villagers wish to reside alongside this road.
Large areas of low slope drawdown areas available on both sides.

Irrigation System: The villagers chose Areas 7 and 7a because their predominant occupation is cattle production and they wish to use the large adjacent drawdown areas for cattle grazing. Consequently Area 7 is far from low reservoir elevations and for irrigation development, will require a long length of supply canal. Area 7a is too small and even farther from low reservoir levels and has not been considered for irrigation.

Area 7 requires a pontoon pump station located on eastern side. Long, about 880 m, supply channel required to pump station sump. 2 centrifugal units pumping total of 60 l/s and total head of about 35 m. Total pump motor requirement is 40-kw.
Long, 700 m, 30-cm diameter, steel delivery pipe to a header tank at high spot around El. 555.
Irregular shaped irrigation area on eastern side of Road 8B. Buried pipe gravity distribution possible.
Estimated cost approximately US$ 191,600 at about US$ 5,800 per ha. Second highest cost per ha because of long supply channel and delivery pipe.

AREA 2: Ban Nakai Tai

Number of households: 195
Approx. Housing Area: 16 ha

Farm Land Net Area: 97.5 ha Rice Net Area: 31.2 ha Total Irrigation Net Area: 128.7 ha
Total Irrigation and Village Gross Area: 157 ha
Farm Land IWR: 136.5 l/s Rice IWR: 93.6 l/s Total IWR: 230.1 l/s

Area Description: Undulating area with mixed forest throughout. Generally sandy loam soils observed with better quality soils in hardwood areas. Poorer soils observed on high spots. There is a spiritual site in the area. New village location either adjacent to old village or along Road 8B for passing trade and passenger reasons. Existing rainfed paddy area on northeastern boundary which can be utilized when reservoir levels recede.

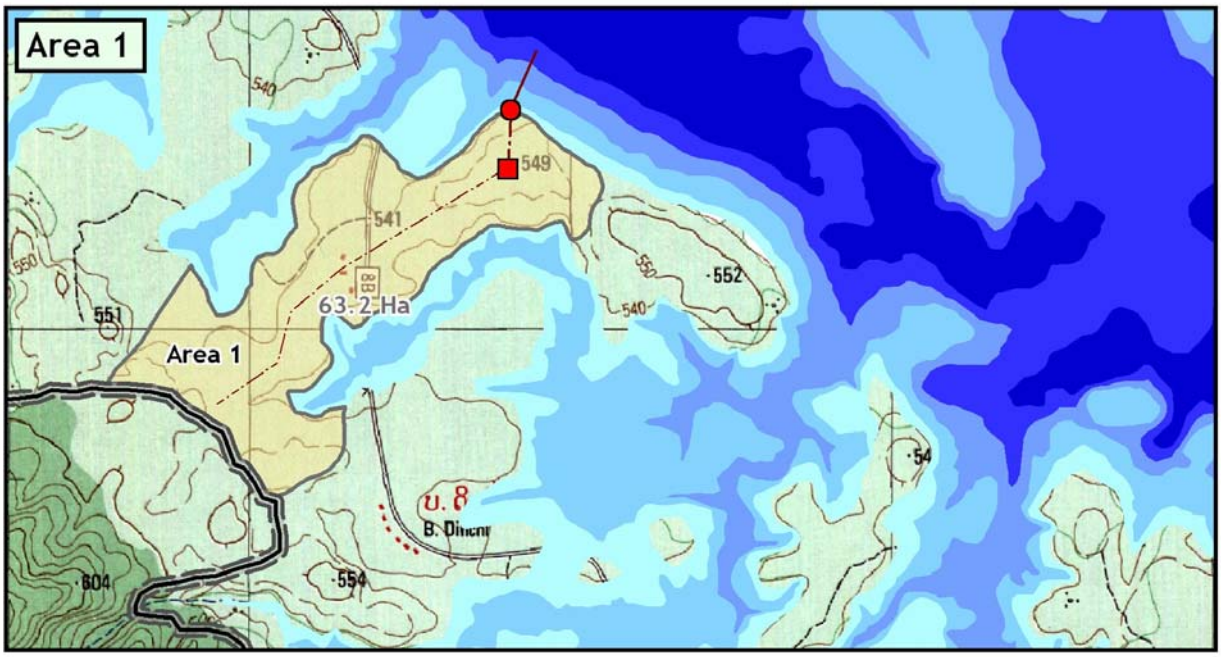
Irrigation System: Largest Resettlement Village irrigation scheme in difficult area to develop. Larger area than shown on the map will be surveyed.
Pontoon pump station located on north side of area. Long, about 460 m, supply channel from existing stream to pump station sump. 2 centrifugal units pumping total of 230 l/s at total head of about 32 m. Total pump motor requirement is 146-kw.
Very long, 1.11-km, 40-cm diameter steel delivery pipe required to pump water to high ground around center of the area.
Area gently undulating and pipe distribution systems required. Two systems required, one flowing towards reservoir and one irrigating area north of Road 8B. Distribution to some areas not possible, such as northeast area near to reservoir above El. 545. Good draw down areas available on both sides.
Preliminary estimated cost US$ 432,000 at about US$ 3,400 per ha.

AREA 1: Ban Nakai Neua
Number of households: 91
Approx. Housing Area: 8.4 ha

Farm Land Net Area: 45.5 ha Rice Net Area: 14.6 ha Total Irrigation Net Area: 60.1 ha
Total Irrigation and Village Gross Area: 75 ha
Farm Land IWR: 63.7 l/s Rice IWR: 43.8 l/s Total IWR: 107.5 l/s

Area Description: Irregular "boot" shape, mostly flat with two high spots on north and northwestern perimeters. Some cleared areas and houses but mixed softwood forest predominates. Sandy loam soils observed.
Low slope drawdown areas available on northeastern and southwestern sides.

Irrigation System: Larger area than shown on the map will be surveyed. Pontoon pump station located on most northern edge of area. About 130 m long supply channel from low swampy area to pump station sump. 2 centrifugal units pumping total of 108 l/s at total head of about 27 m. Total motor requirement is 56-kw.
150 m long, 30-cm diameter, steel delivery pipe required to pump to header tank.
The design of an open channel canal conveyance and distribution system will be attempted. Distribution to most of southwestern area possible from a Main Canal flowing down a central ridge with a series of tertiary canals either side. Not consider highest northeastern area at El. 552. If after detail topographic survey more undulations are found and a buried pipe system is required, then this northwestern area will be considered. Also will then have to consider an elevated header tank with smaller tanks located on various high spots.
Preliminary estimated cost US$ 192,200 at about US$ 3,200 per ha.



AREA 16: Ban Nong Boua/Sailom/Pamanton Hamlets and Ban Keng Yao/Sop Ma Hamlets (Pilot Village Irrigation Scheme)

Number of households: 50 (30 in pilot village households plus 20 other households).
Approx. Housing Area: 11 ha, established

Farm Land Net Area: 28.3 ha (actual) Rice Net Area: 8 ha Total Irrigation Net Area: 36.3 ha
Farm Land IWR: 40 l/s Rice IWR: 24 l/s Total IWR: 64 l/s

Area Description: Irregular, undulating to steep, area which will form 3 connected islands after reservoir inundation. Was thinly forested. Sandy loam soils prevail.
Limited low slope drawdown areas available.

Irrigation System: Pilot village irrigation scheme constructed during 2002/3 dry season for farm land area of 17.7 ha for 28 households, later increased to 30. Extension of pipe distribution systems required for further 10.5 ha of farm land for 20 households. Estimated cost to complete farm area US$ 23,300. Estimated cost of further riprap protection on dam downstream slope before Nakai Reservoir inundation and modifications to the delivery pipeline is about US$ 16,000.

The proposed paddy area is a relatively flat area to the south of the Pilot Village. Pontoon pump station located on central-eastern edge of area. A long, 329 m supply channel required to pump station sump from Pilot Village reservoir. 2 centrifugal units pumping total of 24 l/s at a total head of 17 m to a stilling basin in center of ridge. Total motor requirement is 10-kw. 140 m long, 15-cm diameter, steel delivery pipe required.
Area is flat and open channel canal system will be attempted first. Distribution to most of area possible. Estimated cost approximately US$ 61,700 at about a high US$ 7,700 per ha due to long supply canal required for a small 8 ha area.

Total area estimated cost is about US$ 298,870. It is the highest cost per ha, US$ 8,200, because of the necessity of a dam and spillway for the Pilot Village Irrigation Scheme.

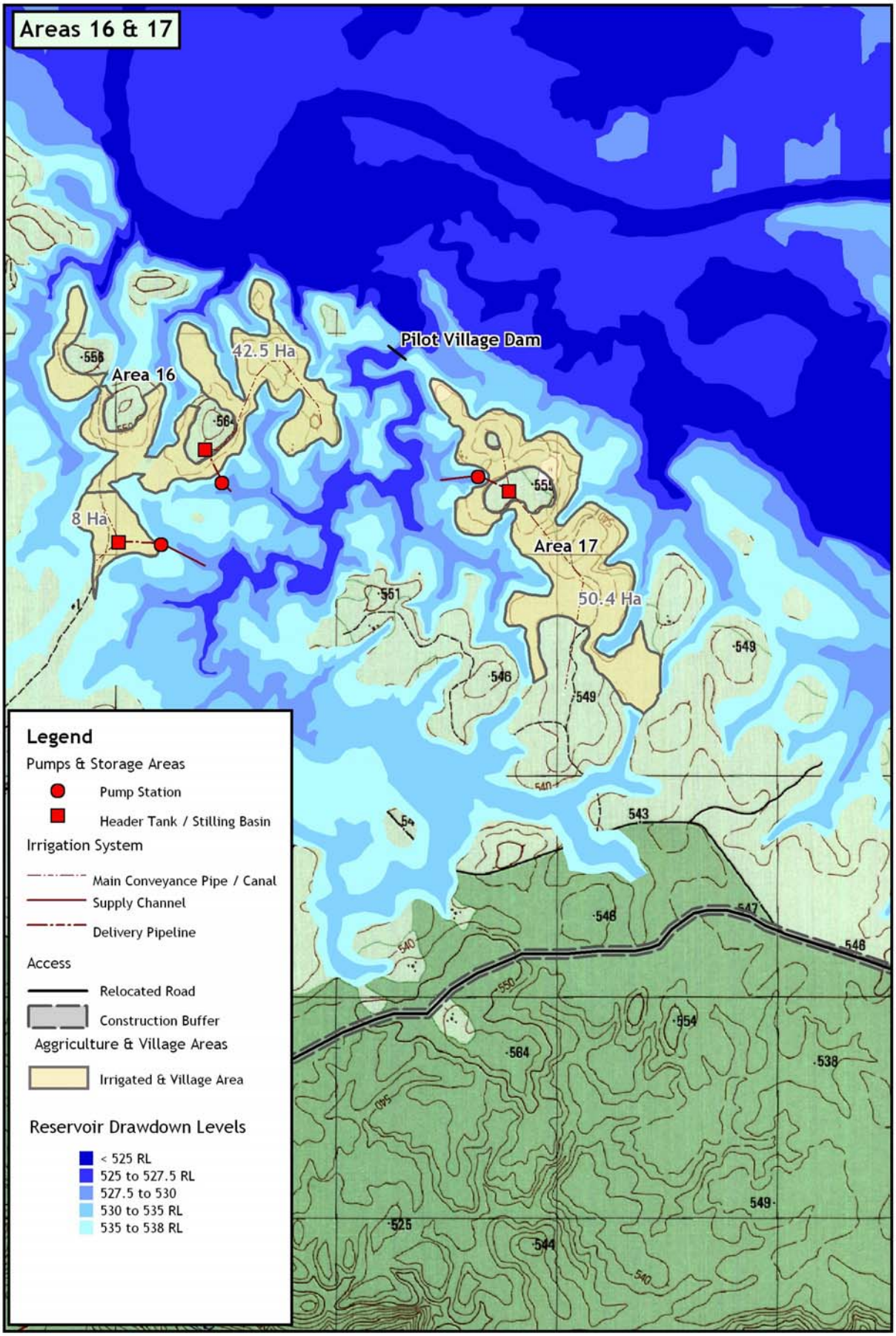
AREA 17: Ban Boua Ma

Number of households: 64
Approx. Housing Area: 6.5 ha

Farm Land Net Area: 32 ha Rice Net Area: 10.2 ha Total Irrigation Net Area: 42.2 ha
Total Irrigation and Village Gross Area: 53 ha
Farm Land IWR: 44.8 l/s Rice IWR: 30.6 l/s Total IWR: 75.4 l/s

Area Description: Irregular shape, undulating in north, sometimes steeply, and flatter in the central and southern areas. Mostly thin forest and dense undergrowth with some cleared areas. Sandy loam soils observed, similar area to Pilot Village area.
Low slope drawdown areas available on two sides of area.

Irrigation System: Pontoon pump station located on west side of area pumping from Pilot Village reservoir as no other Nam Theun reservoir low water area nearby. 230 m supply channel required to pump station sump requiring extensive excavation volume. 2 centrifugal units pumping total of 76 l/s and total head of 27 m. Total motor requirement is 40-kw.
240 m long, 30-cm diameter, steel delivery pipe to a header tank at high spot above El. 550.
PVC buried pipe gravity distribution to most of the area possible.
Estimated cost approximately US$ 156,240 at about US$ 3,700 per ha.


Areas 16 & 17
Pilot Village Dam
Area 16
42.5 Ha
8 Ha
Area 17
50.4 Ha
Legend
Pumps & Storage Areas
Pump Station
Header Tank / Stilling Basin
Irrigation System
Main Conveyance Pipe / Canal
Supply Channel
Delivery Pipeline
Access
Relocated Road
Construction Buffer
Aggriculture & Village Areas
Irrigated & Village Area
Reservoir Drawdown Levels
< 525 RL
525 to 527.5 RL
527.5 to 530
530 to 535 RL
535 to 538 RL

AREA 18: Ban Phonsavang

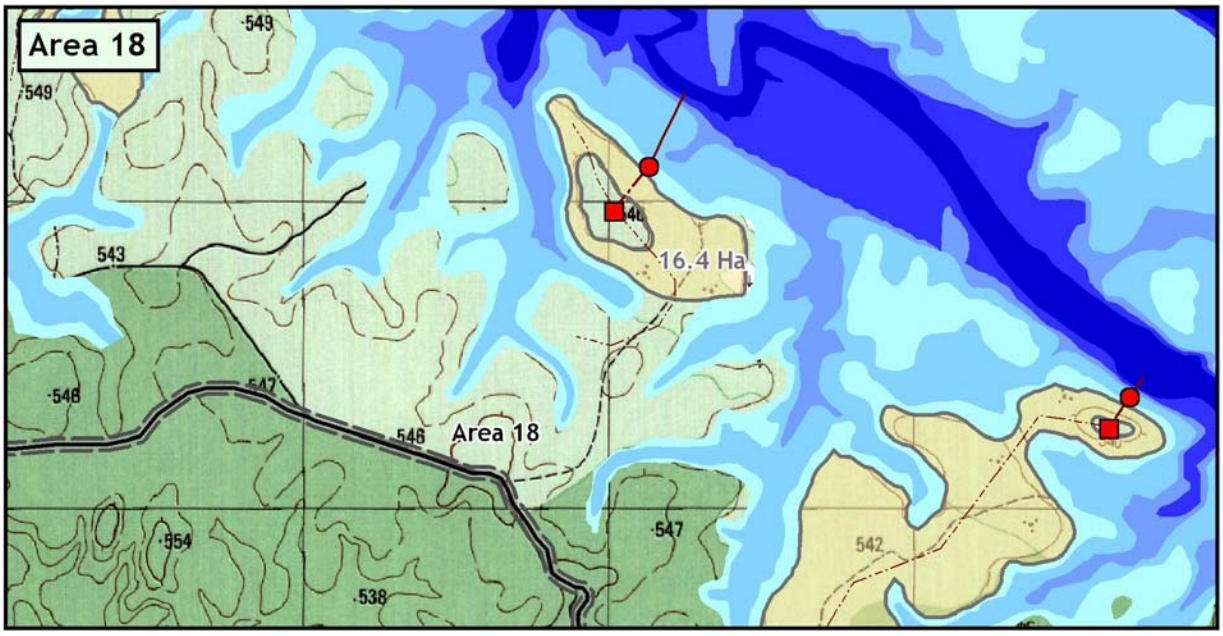
Number of households: Assume maximum of 32. To be finalized as some wish to move Area 19.
Approx. Housing Area: 4.2 ha

Farm Land Net Area: 16 ha Rice Net Area: 5.1 ha Total Irrigation Net Area: 21.1 ha
Total Irrigation and Village Gross Area: 27.4 ha
Farm Land IWR: 22.4 l/s Rice IWR: 15.3 l/s Total IWR: 37.7 l/s

Area Description: Theun Duane Demonstration Farm is located in this area. Topographic survey and mapping undertaken in 2004 shows that a much larger area than shown on the map below is available above the El. 538 and El. 540contours.
However it is still an irregular shape with undulations. Thin mixed forest with shifting cultivation areas. Sandy loam soils observed.
Extensive low slope drawdown areas available on three sides.

Irrigation System: Demonstration Farm is supplied by a moveable pump pumping from Theun Duane via a PVC delivery pipe to small steel header tank elevated on a platform. Then PVC pipe gravity distribution to four adjacent plots. Impossible to extend this system for a larger area as the header tank will have to be considerably larger and with higher elevation. It may be possible to combine the new system with the existing system.

Pontoon pump station located on northern edge pumping from Theun Duane. 200 m supply channel required to pump station sump requiring deep cut and extensive excavation volume. 2 centrifugal units pumping total of 38 l/s and total head of 22 m. Total pump motor requirement is 16-kw.
250 m long, 20-cm diameter, steel delivery pipe to a header tank at El. 545.
Pipe distribution system to all of the area possible.
Estimated cost approximately US$ 104,920 at the third highest cost per ha at about US$ 5,000 because of large supply canal excavation volume and small irrigation area.



AREA 19: Ban Sop On/Ban Phonsavang/Ban Ka Oy

Number of households: assume a total of 107. Possibly some more from Ban Phonsavang and Ban Ka Oy may wish to move to this area.

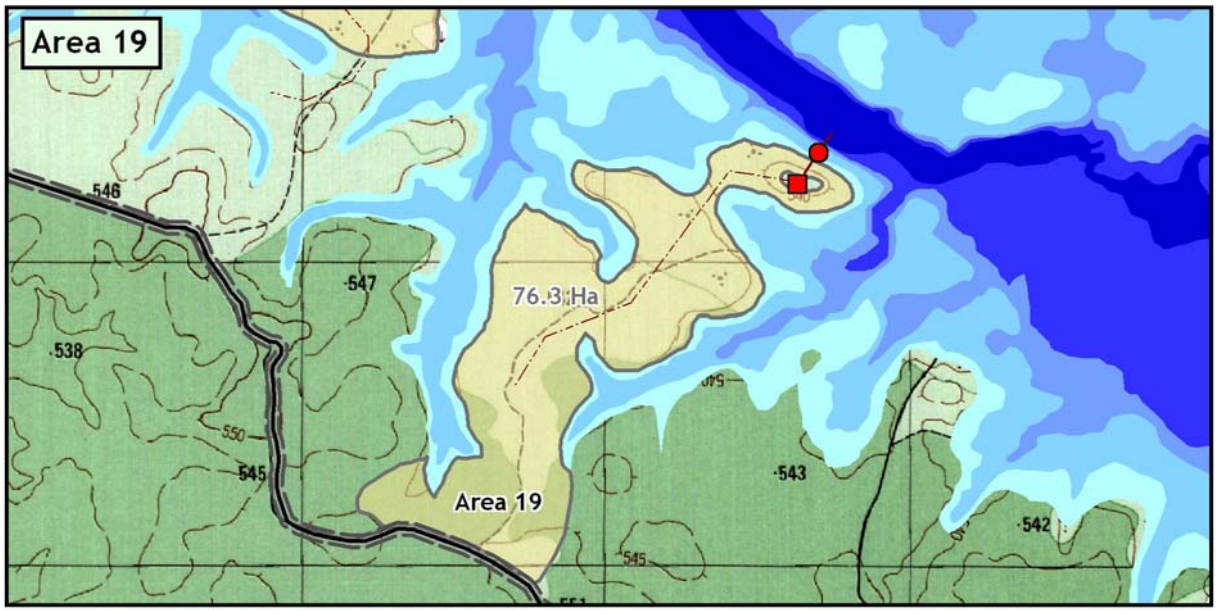
Approx. Housing Area: 10 ha

Farm Land Net Area: 53.5 ha Rice Net Area: 17.1 ha Total Irrigation Net Area: 70.6 ha
Total Irrigation and Village Gross Area: 87.2 ha
Farm Land IWR: 74.9 l/s Rice IWR: 51.3 l/s Total IWR: 126.2 l/s

Area Description: Very irregular shaped area, mostly flat with some undulations. Mixed softwood forest with shifting cultivation areas. Poor sandy loam soils observed.
Low slope drawdown areas available on three sides of area. Significantly larger area than shown below will have to be surveyed and mapped.

Irrigation System: Only one high spot was shown on the map. However later digitized satellite imagery showed that there were more minor undulations within the area. Therefore, probably will have to pump to an elevated header tank located on the high spot near the northern reservoir perimeter.

Pontoon pump station located on most northern edge also pumping from Theun Duane. Short, 100 m long supply channel to pump station.
2 centrifugal units pumping total of 128 l/s with total head of about 26 m. Total pump motor requirement is 62-kw.
80 m long, 20-cm diameter, steel delivery pipe, perhaps combined with uPVC pipe, to elevated header tank.
Buried pipe distribution system to most of the area possible. Main pipeline through center of area with branches on either side.
Estimated cost approximately US$ 223,300 at about US$ 3,200 per ha.



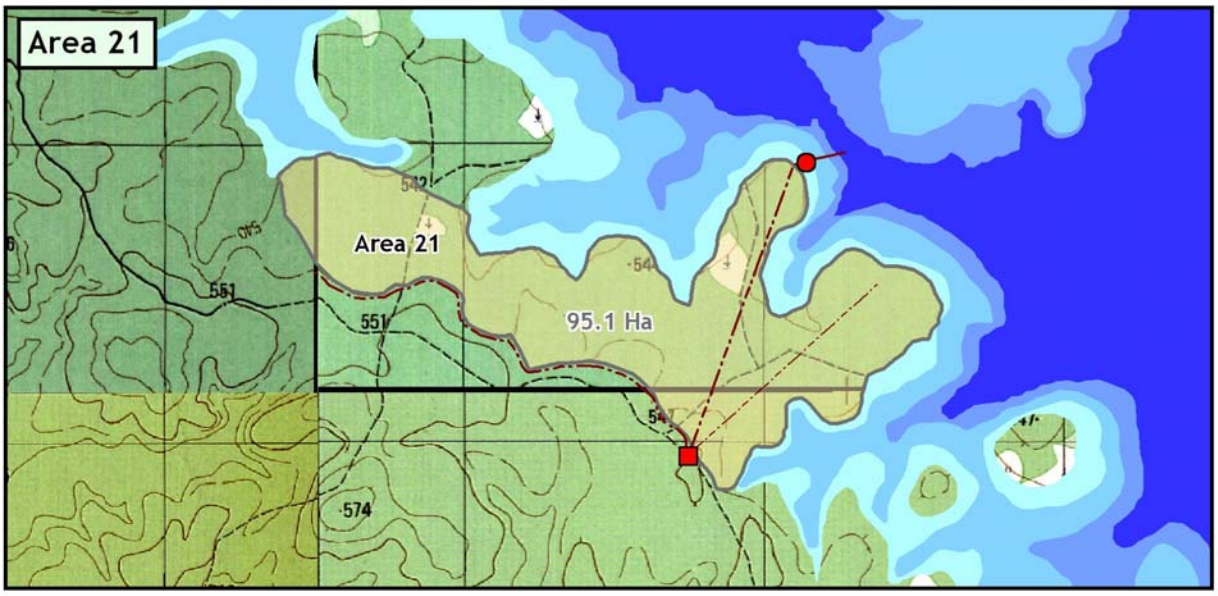
AREA 21: Ban Done/Ban Ka Oy

Number of households: Assume a total of 135, possibly some more from Ban Ka Oy.
Approx. Housing Area: 11.5 ha

Farm Land Net Area: 67.5 ha Rice Net Area: 21.6 ha Total Irrigation Net Area: 89.1 ha
Total Irrigation and Village Gross Area: 109.5 ha
Farm Land IWR: 94.5 l/s Rice IWR: 64.8 l/s Total IWR: 159.3 l/s

Area Description: Gently sloping towards reservoir. Mixed forest with some cleared areas. Poor sandy loam soils observed.
Low slope drawdown areas available on three sides.

Irrigation System: Second largest irrigation area and survey and mapping will be for a larger area than shown on the map.
Pontoon pump station located on northern-most boundary near to Theun Kalang. Short 85 m long supply channel to pump station sump. 2 centrifugal units pumping total of 160 l/s with total head of about 24 m. Total pump motor requirement is 74-kw.
Long, 1,070 m, 40-cm diameter, steel delivery pipe to southern location stilling basin.
The design of a canal system will be attempted first with one main canal located alongside the route of the existing track. The other main canal can follow a northeastern route back towards the reservoir. Perhaps extensive canal lining required.
Estimated cost approximately US$ 317,100 at about US$ 3,600 per ha.



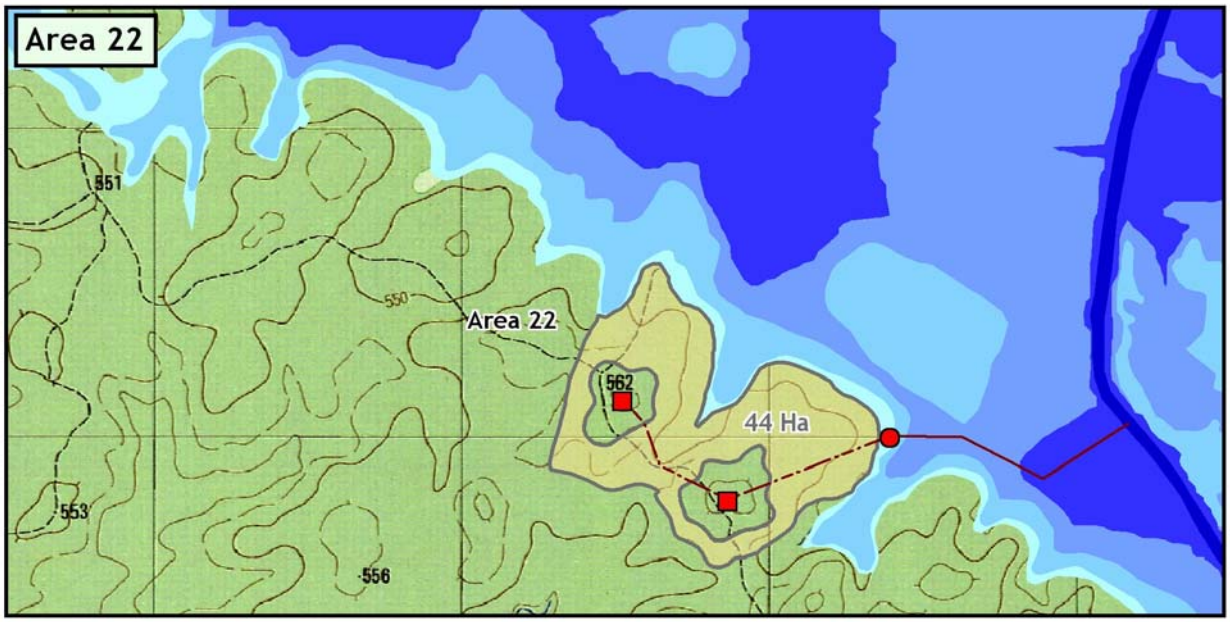
AREA 22: Ban Khone Khen/Ban Ka Oy

Number of households: Assume a total of 64, again possibly some more from Ban Ka Oy.
Approx. Housing Area: 6.5 ha

Farm Land Net Area: 32 ha Rice Net Area: 10.2 ha Total Irrigation Net Area: 42.2 ha
Total Irrigation and Village Gross Area: 53 ha
Farm Land IWR: 44.8 l/s Rice IWR: 30.6 l/s Total IWR: 75.4 l/s

Area Description: Undulating area. Mixed forest. Sandy loam soils, more sandy on ridges. Large low slope drawdown area available north of the area.

Irrigation System: Larger area than shown on the map will be surveyed and mapped. Pontoon pump station located at southeastern-most end of area near to a small tributary of the Nam On. Long, 850 m, supply channel along tributary to pump station sump requiring extensive excavation. 2 centrifugal units pumping total of 78 l/s and total head of about 30 m. Total pump motor requirement is 44-kw. Also long, 560 m long, 30-cm diameter, steel delivery pipe to header tank. Buried pipe distribution system possible. Secondary header tank and distribution system may be required on adjacent northwestern hill with spot level shown of El. 562. Estimated cost approximately US$ 184,500 at about US$ 4,370 per ha.



AREA 15: Oudomsouk and Ban Phonepanpek

The two irrigation areas will be located on areas of available land north of both the town and village. After reservoir inundation the areas will become peninsulas during reservoir full supply elevations. North of the two peninsulas are larger areas that will become islands after inundation. The NT2 Power Conduit Intake Structure is located between Oudomsouk and Phonepanpek and the Headrace Channel to the Structure will be located between the two peninsulas. The Headrace Channel is an obvious place for the start of the two irrigation Supply Channels. They will be of relatively short length and will have the best access to reservoir low water elevations of all the Resettlement Irrigation Schemes. However the final designs of the Headrace Channel have not yet been prepared and it will have to be agreed by all interested parties that the designs can be modified to include the irrigation Supply Channels.

There will be massive volumes of spoil from the excavated Headrace Channel that will be properly disposed of. Some of this spoil can be used for land fill to connect the two peninsulas to two more northern islands. Then there will be a significantly large enough area to locate the irrigation systems.

Both of the areas are close to the Pilot Village Irrigation Scheme at Area 16 and it is assumed that similar type schemes can be developed. That is, pumping to a header tank and buried pipe distribution to individual farm plots.

Oudomsouk

Number of households: 31, not final

Farm Land Net Area: 15.5 ha Rice Net Area: 5 ha Total Irrigation Net Area: 20.5 ha
Total Irrigation Gross Area: 22.6 ha
Farm Land IWR: 21.7 l/s Rice IWR: 15 l/s Total IWR: 36.7 l/s

Area Description: Undulating area with some steep slopes. Mixed forest with some cleared areas. Sandy loam soils observed. Low slope drawdown area available.

Irrigation System: Pontoon pump station located at western side of area. 2 centrifugal units pumping total of 38 l/s and total head of around 28 m. Total pump motor requirement around 20-kw.
300-m long 20-cm diameter steel delivery pipe to header tank and buried pipe distribution system.
A provision of US$ 90,100 at about US$ 4,400 per ha has been included.

Ban Phonepanpek

Number of households: 111

Farm Land Net Area: 55.5 ha Rice Net Area: 17.8 ha Total Irrigation Net Area: 73.3 ha
Total Irrigation Gross Area: 80.6 ha
Farm Land IWR: 77.7 l/s Rice IWR: 53.4 l/s Total IWR: 131.1 l/s

Area Description: Mildly undulating area with some steeper slopes on edge of western side. There are three high spots in the area. Mixed forest, mostly thin, with some cleared areas. Sandy loam soils observed. Limited low slope drawdown area available.

Irrigation System: Pontoon pump station located at western side of area. 2 centrifugal units pumping total of 132 l/s and total head of around 30 m. Total pump motor requirement 78-kw.
30-cm diameter, 520-m long steel delivery pipe to header tank located nearly centrally in the area. Buried pipe distribution system to most of area possible.
The preliminary estimated cost is US$ 231,300 at US$ 3,200 per ha.

13.6 BOLIKHAMXAI IRRIGATED SITE

Some of the households from Ban Sop Hia and all the households from Ban Nam Nian wish to be resettled near Lak Sao, Khamkerd District, Bolikhamxai Province. Results of 8 June 2003 consultations with the RMU Manager are presented in Table 13-2.

Table 13-2: Preferred Location of Villagers from Sop Hia and Nam Nian Villages.

Village	Preferred Location & Number of Households		
	Lak Sao (Khamkerd)	Nakai Reservoir	Elsewhere
Sop Hia	21	32	4
Nam Nian	26	0	0
Totals	**47**	**32**	**4**

For planning purposes, the number of households considered for development is fifty-five. Each household will be allocated 1.5 ha of irrigated land, therefore a net irrigation area of 82.5 ha is required. Allowing for a 10% increase for land lost by non-farm areas, a 90.75 ha gross scheme area is required to be established.

The Khamkerd District officials have proposed two possible areas for village and irrigation development:

1. Houay Sot Irrigation Scheme: BPKP has prepared drawings and a design report for 63 ha scheme.
2. Nam Pan Irrigation Scheme: Khamkerd DAFO have prepared a preliminary assessment report.

The Houay Sot scheme was not considered feasible. It was only 63 ha in extent, and the Houay Sot stream has low dry season flows and the design shows two earth embankment dams required to irrigate the area. The estimated cost was high, over US$ 454,000 or US$ 7,200 per hectare. Also, the irrigation area is located near to a river that is known to cause flash-flood damage along its banks.

The second area proposed is along the banks of the small Nam Pan river, about 12 km north east of Khamkerd District Center. The DAFO development report and irrigation concept design shows an earth dam 780 m long and 29 m high with a high spillway and main canal intake structure. A less expensive option has been identified and an irrigation area of around 150 ha as shown in Figure 13-1.

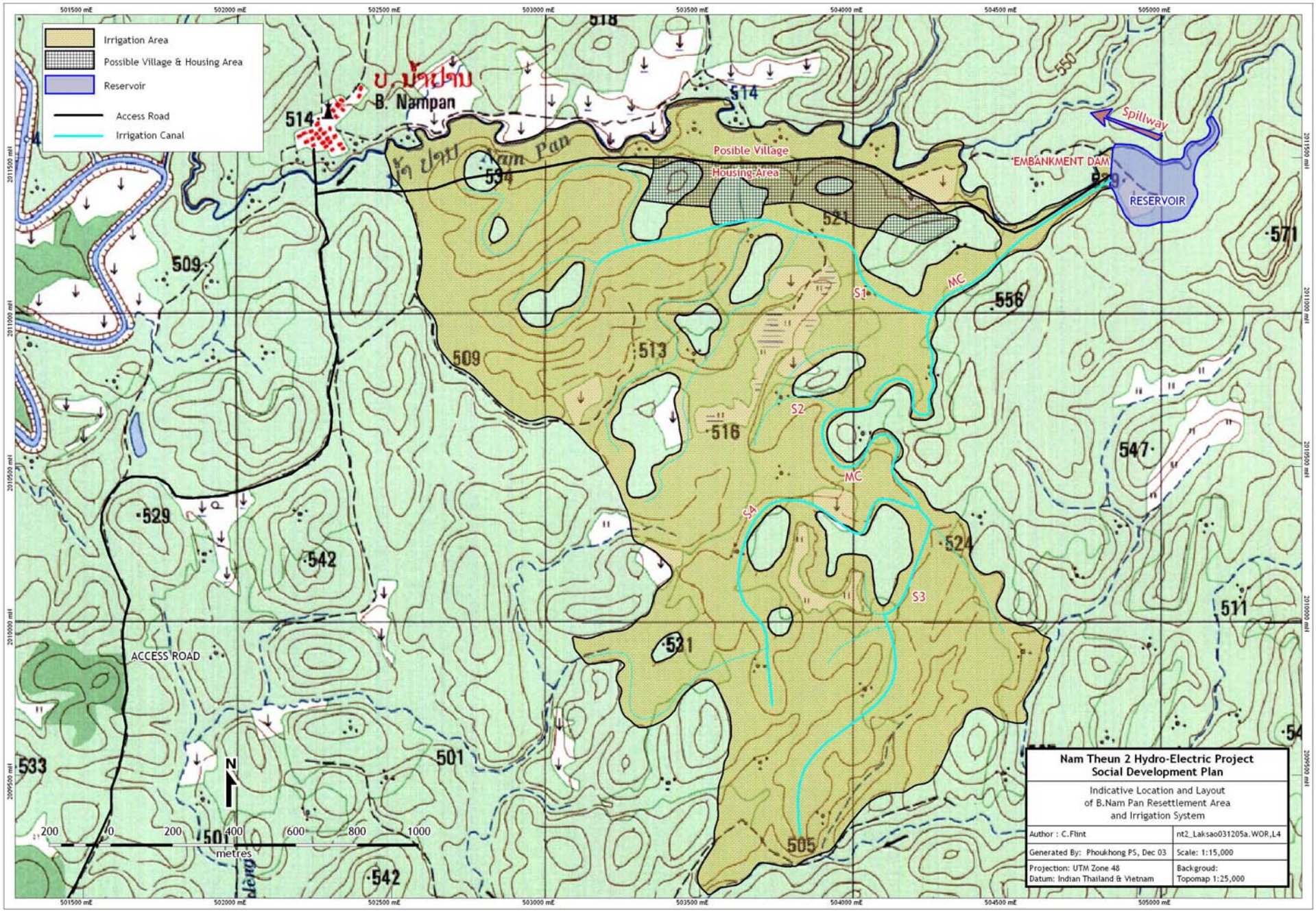
The revised proposal includes:

- Irrigate only below the 530 masl contour and a cropping pattern of wet season rice and dry season vegetable and field crops.
- An embankment dam about 190 m long and 10 m high located on the Nam Pan. A reinforced concrete spillway. If no storage is proposed, the dam will be smaller.
- A gravity canal system distribution system including a main canal, 4 secondary canals and a series of tertiary canals.
- The inclusion of households from the existing Ban Nam Pan as they will have traditional land-rights in the area.

Exercises based on the topographical survey maps will be sufficient as a pre-feasibility study. For a feasibility study, further investigations are required including: geotechnical, for the dam foundation and borrow pits; hydrology, including Nam Pan mean monthly and flood discharges; soils in the irrigation area; and cost comparisons of various options on cropping patterns, dam storages and command areas.

The preliminary estimated construction cost is about US$ 400,000 not including survey and mapping, the feasibility study, detail design, UXO survey and clearance. More information on the Nam Pan irrigation scheme can be found in Appendix M, Khamkerd Resettlement Village Site Planning, of Volume 2 of the Social Development Plan.

Figure 13-1: Indicative Location and Layout of Nam Pan Resettlement Area and Irrigation System



13.7 PILOT VILLAGE IRRIGATION SCHEME

13.7.1 Introduction

It was decided to implement a pilot resettlement village so that many resettlement procedures can be tested and improved upon before full resettlement takes place. This is particularly significant for agriculture and irrigation as many of the identified resettlement areas are undulating with poor sandy soils. The poor soils must be improved by agricultural techniques and different methods can be attempted.

The Pilot Village Irrigation Scheme is located in Resettlement Area 16 about 3-km east of Oudomsouk, the Nakai District Center. The resettlers are from Ban Nong Boua, Ban Sailom and the Pamanton Hamlets. Later, some households from Ban Sop Ma and Keng Gnao may also will relocate to this area. The village housing and irrigated garden areas consist of basically four hills that will become connected islands once reservoir impoundment takes place. The hills are irregularly shaped and the soils have been identified as sandy loams. Access roads were cleared and housing and farm plots established. The villagers commenced cropping their plots during the 2002 wet season and the irrigation scheme was constructed during the 2002/3 dry season. An electricity supply is in place.

The Pilot Village irrigation scheme consists of 17.74 ha for twenty nine households later increased to thirty. In the 2005/6 dry season the conveyance and distribution pipe systems will be expanded and the Area 16 total net irrigation farm land area will be 28.24 ha for fifty households.

The Houay Malai is a small stream located adjacent to Area 16 flowing to the Nakai Plateau. After investigations, it was decided that this stream would be developed for the irrigation water source. The stream is not perennial, but a dam constructed on it can store sufficient water for irrigating dry season crops. After Nakai Reservoir impoundment it will be inundated nearly every year. However, as the reservoir recedes, it will trap and store water for the dry season months of low reservoir elevations even when the reservoir has receded far from the area.

13.7.2 Irrigation Scheme Components

Earth Dam and Spillway on Houay Malai

The earth dam is an impervious homogeneous embankment with a crest length of 86 m, a crest width of 5 m at elevation El. 532. The upstream and downstream slopes are 1:2.5 (v:h). The upstream slope has riprap protection on a sand and gravel bed. The downstream slope is protected by sodding and will require riprap protection before the impoundment of the Nakai Reservoir. The crest is protected by a gravel laterite camber. The spillway is a trapezoidal channel excavated through sandstone with a reinforced concrete structure to maintain the spillway crest at El. 529.50. The channel is 31 m wide with 1:2 side slopes and can discharge a 50-year return period flood of 60 m^3/s while maintaining a minimum freeboard of 1.3 m. It is estimated that the dam will store about 800,000 m^3 of water. This is sufficient to also supply the adjacent Area 17 irrigation scheme with water.

Supply Canal, Pump Station, Delivery Pipe and Header Tank

A supply canal, 420 m long, 2 m bed width, 1:1.5 side slopes and variable depth, was required to convey water from the reservoir to the pump station sump during low reservoir elevations.

The pump station lifts the irrigation water from the reservoir to a reinforced concrete header tank. A pontoon mounted centrifugal pump is able to discharge a peak irrigation water requirement of 29 l/s at a total head of 40 m. The pump is driven by a 22.5-kw electrically driven motor. A 285 m long, 20-cm diameter steel pipe delivers the water to the header tank, storage capacity 56 m^3, at elevation El. 554. The header tank is located above the housing area and is also used for storing water for non-potable domestic use. This domestic water supply passes through a filtration system.

Buried Pipe Conveyance and Distribution Systems

The irrigation conveyance and distribution systems is by buried pipelines because of the undulating area topography. The header tank is at such an elevation that the pipe systems can convey and distribute, by gravity, irrigation water throughout the irrigation area to the farm plots.

Conveyance pipelines are 20 or 16-cm diameter uPVC pipes. From the main lines, the water is distributed by high density polyethylene pipes varying from 10 to 6-cm diameter at the farm inlet. Each farm plot has its own multi-purpose farm inlet so that various irrigation methods of the plots are possible.

13.7.3 Pilot Village Scheme Cost

Pre-qualification and local competitive bidding procedures were undertaken involving Contractors from Vientiane and Thakek. A Contractor from Thakek was awarded the contract at a contract price of US$ 143,269. However it was later decided to construct a larger dam downstream so that it could also be a water source for the adjacent Area 17. This, and improvements to the farm inlet design and pipeline systems caused cost escalations resulting in a final cost of US$ 197,800.

To complete the remaining 10.5 ha before the next resettlement, the conveyance and distribution pipeline systems must be extended at an estimated cost of about US$ 23,300. Before Nakai Reservoir inundation their must be extra rip rap protection placed on the downstream slope of the dam embankment. Also extra connections will be required to the steel delivery pipeline as the pontoon range of elevations will increase. This extra work is estimated at US$ 16,000.

Also required is an 8 ha rice paddy area. An area has been provisionally identified south of the pilot scheme and the estimated development cost is US$ 61,700. The final scheme estimated cost is US$ 298,870. For the total 36.3 ha scheme, this equates to US$ 8,200 per ha. If the cost of the dam and spillway is deducted from the total, the cost is about US$ 5,600 per ha.

13.8 CHALLENGES IN PREPARING PRELIMINARY DESIGN AND BUDGET

13.8.1 Contours on Topographic Maps

The maps used for the study are scale 1:25,000 prepared from aerial photographs taken from December 1992 to January 1993. These maps show 10 m contour intervals with the flatter areas showing 5 m contour intervals. The flatter and gently sloping Resettlement Areas must have an open canal distribution system. For paddy irrigation, the lowest order canal should have a water level, or command, 15 to 20-cm above the rice field. Therefore 10-cm contours are required. Consequently it is impossible to prepare accurate cost estimates for open canal systems with 5 m contour interval maps.

Similarly, for the supply channels required for conveying water from the low reservoir elevations to a pump station sump, it is difficult to accurately estimate the canal excavation depths and volumes.

13.8.2 Soils and Irrigation Potential

Soils are of major importance for assessing irrigation potential and development requirements. Information on the soils in the areas is limited to a few samples and general observations with no detailed mapping available. As stated previously, paddy rice requires soils with a significant clay content to reduce the percolation rate. It has been assumed that paddy areas are found in the individual sites adjacent to the farm plot areas.

13.8.3 Location of Village Housing

The exact locations of the village housing areas within the Resettlement Areas are not as yet known. In the smaller areas with undulating terrain, for example northern Area 8, the location of the housing is important. Similarly for a large village population such as Ban Nakai Tai in Area 2.

It has been assumed that housing areas are clustered and kept separate from farm and paddy irrigation areas for community reasons. However some villagers may wish for their houses to be located next to their farm plot. Alternatively many of the villagers will wish the village to be located alongside Road 8B and the Resettlement Road for increased trade and passenger services from passing vehicles.

The village housing area has been estimated, based on the Pilot Village layout, at 0.07 ha per household for housing and access roads plus 2.0 ha per village for the school, market, workshop, clinic, community center and rice mill. On the maps shown, the housing, farm and paddy land has been combined (apart from Area 18). The exact location of houses and other buildings will be decided after topographic survey and mapping and in consultation with the resettlers.

13.8.4 Route of Road 8B

Road 8B, from Ban Oudomsouk to Ban Thalang, will be inundated after reservoir impoundment. It will be relocated to pass through, or south of, the central and northern resettlement areas. There will be large bridge constructed over the Nam Theun at Ban Thalang. South of Ban Oudomsouk a similar design standard access road will be constructed for the construction of Saddle Dams and to the Resettlement Villages.

Road 8B will be a Standard B two-lane road of formation width 7 m. The final total right of way will be more than 20 m and in places over 40 m when considering side drains, shoulders and cut and fill slopes. The roads alignment is likely to be adjusted during construction, which is not due for completion until December 2007. This inherently gives problems for the detailed planning of layouts for small 100 x 50 m farm plots or 40 x 40 m paddy plots in the smaller resettlement areas in undulating terrain, particular the northern areas 7, 8, and 13. A road cutting through the center of an irrigation area will increase costs through:

- Pipe or canal lines will have to be conveyed under the road by the construction of culvert or siphon structures;
- The culverts and siphons will have additional hydraulic head loss thus affecting the design of the system upstream of the structure.

Thus, the road construction and irrigation construction will have to be closely coordinated in these resettlement sites.

13.8.5 Land Availability

Land is available for the irrigation systems and village housing areas at all the sites except at Area 13. After reservoir inundation Area 13 will become a small peninsula divided by the relocated Road 8B. South of the main irrigation area there is ridge that will prevent irrigation distribution to the most southern part. However Area 13 is adjacent to the Nam Theun deep channel and the farmers will have good access for fisheries. Consequently it is likely that the Ban Thalang villagers will concentrate on fisheries and there will be less demand for irrigation.

The available land is tight in the following areas:

- Area 11, Ban Sop Phene. This area is undulating and gravity distribution from a central header tank will not be possible to two high spots to the east and southwest (and these will thus be managed as rainfed plots;
- Area 7, Ban Nong Boua Kham. This area is also undulating, irregular in shape and cut by the relocated Road 8B. The villagers chose Areas 7 and 7a because their predominant occupation is cattle production with the view to use the large adjacent drawdown areas for cattle grazing. Consequently Area 7a is far from low reservoir elevations and for irrigation development, will require a long length of supply canal with deep cuts and excessive excavation volumes. Area 7a is also small and has not been considered for irrigation;
- Area 2, Ban Nakai Tai. This is the largest scheme with 194 households and 157 ha is required for the new village and irrigated land.

13.8.6 Preliminary Cost Estimates

Preliminary cost estimates for the reservoir resettlement schemes and the Nam Pan Scheme in Bolikhamxai Province have been prepared. The estimates are based on outline designs prepared from 1:25,000 scale maps and will change after topographic survey and mapping, soil surveys and the preparation of detail designs and drawings. Some comments on this subject are as follows:

- Supply canal excavation: This may reduce through refining the canal alignment through lower elevations not shown on the maps such as unmarked natural drainage lines. It will increase if the locations of the natural low reservoir areas are farther than the El. 538 contour than shown on the maps. Then the supply channel will have to be longer. Also the costs will be increased if the excavation encounters strata of hard rock that cannot be ripped by a bulldozer and blasting is required.
- Pontoon pump station: This should not have significant change.

- Steel delivery pipes: The steel pipe estimate is about 16 percent of the total cost and is a significant item. Regarding length, the worst case has been taken. If the pipeline route passes through more undulations not shown on the maps, then more bends will be required and earthworks and concrete quantities will increase. If during detail design the pipeline is found to be too long, and also affecting pump station costs too much, then elevated header tanks, located nearer the pump station, will be considered.
- Header tanks and stilling basins: If these are located at ground level and not elevated, then there should be little change. Anyway, an increase in these estimates will not significantly increase the overall cost estimate.
- Pipeline and canal distribution systems: These are the least accurate estimates as there is a combination of field crops and rice requiring different irrigation layouts and water requirements. The estimates can increase significantly if the irrigation areas as shown on the preceding maps have to be more spread out than shown. For example there may be unsuitable soils within the areas shown and a system has to be more spread out thus increasing conveyance costs. If the topography of a particular site is found to be not suitable, then perhaps secondary pumping is required.

13.8.7 Scheme Expansion to Accommodate Growing Populations

The irrigation systems should have the potential for expansion to accommodate growing populations after resettlement. With open channel canal systems canal discharges can initially be increased by increasing flow depth and reducing the freeboard. Later it can be increased by remodeling either by increasing the depth or bed width. With pump and buried pipe schemes, it is more difficult and expensive. As stated previously, land for expansion is available at most sites with the exception of Area 13. It is tight at Areas 11,7 and 2.

In engineering terms, the systems can be expanded in the following ways:

Supply Canals A 1 m bed width is sufficient for much larger schemes.

Pump Stations Pumps are typically replaced every fifteen years. They can be replaced with larger pumps.

Delivery Pipes Steel delivery pipe diameters will be conservatively designed. They can accommodate larger discharges without undue increases in velocity and head losses that would affect the pump discharge.

Header Tanks The volume of the header tanks may have to be increased if the buffering storage proves to be insufficient resulting in frequent switching off of the pumps or overflow wastage.

Pipe Systems Branch lines can be extended. Main lines are more difficult. Plastic pipes, correctly installed, can last fifty years. If the main lines need increased discharge, then extra parallel pipes will be required.

13.9 PRELIMINARY COST ESTIMATES

13.9.1 General

Preliminary cost estimates for the reservoir resettlement schemes and the Nam Pan scheme in Khamkerd District, Bolikhamxai Province have been prepared. The total estimated cost for the reservoir schemes is US$2,948,400 and the Nam Pan scheme is US$400,000, a total of US$3,348,400. The average cost per hectare for the reservoir schemes is around US$3,900 and for Nam Pan is US$2,700. For the reservoir schemes there is a variation from around US$3,200 at Area 19, one of the larger areas, to around US$8,160 for Area 16, which necessitated an extra dam and spillway for the Pilot Village Scheme.

13.9.2 Changes to Cost Estimates After Detail Design

After further topographic survey and investigations and detail design the estimates will change. Some comments on this subject are as follows:

- Supply canal excavation: This may reduce through refining the canal alignment through lower elevations not shown on the maps such as unmarked natural drainage lines. It will increase if the locations of the natural low reservoir areas are farther than the El. 538 contour than shown on the maps. Then the supply channel will have to be longer. Also if the excavation meets strata of hard rock that cannot be ripped by a bulldozer and blasting is required, then an increased excavation unit rate will be required.
- Pontoon pump station: This should not have significant change.
- Steel delivery pipes: At about 13 percent of the total cost of the reservoir schemes, this is a significant item. Straight lines of pipe have been assumed, however if a pipeline route passes through undulations not shown on the maps, then extra bends are required and earthworks and concrete quantities will increase. If the pipeline is found to be too long, and affecting pump station costs too much, then elevated header tanks, located nearer the pump station, will be considered.
- Header tanks and stilling basins: If these are located at ground level and not elevated, then there should be little change. Elevated tanks will be more expensive. However an increase in these estimates will not significantly increase the overall cost estimate.
- Pipeline and canal distribution systems: These are the least accurate estimates as there is a combination of field crops and rice requiring different irrigation layouts and water requirements. Survey and mapping of the areas are not complete and the areas may be significantly more undulating than shown on the maps. The estimates can increase significantly if the irrigation areas as shown on the preceding maps have to be more spread out than shown. For example there may be unsuitable soils within the areas shown and a system has to be more spread out thus increasing conveyance costs. If the topography is found to be significantly more undulating than assumed, then perhaps secondary pumping will be required.

Consultations with villages - both those which will have gained experience in the first three schemes) and those from other villages - will also be a crucial aspect of review and improvements to the designs of irrigation systems, and especially for the on-farm distribution systems.

13.10 FURTHER INVESTIGATIONS REQUIRED

13.10.1 General

The following surveys are required for the identification of the most suitable areas for irrigation development and the detail design of the irrigation schemes:

- Topographic survey and mapping including establishing bench marks and control points and the leveling of spot heights to establish contour lines;
- Soil survey and mapping to determine soil types, fertility and infiltration criteria;
- Geotechnical investigations to determine the nature and strength of lower ground horizons. For the resettlement schemes, the geotechnical investigations are limited to the alignment of the supply channels as there are no weirs or dams involved. These investigations are limited to determine if rock excavation is required or not, and to determine if the proposed side slopes of 1:1.5 are suitable in deep excavations and need to be increased.

Consultation with Resettlers and village participation is an integral part of the general planning and design process.

13.10.2 Village Consultations

There will be further consultation with the Resettlers. With regard to irrigation development, this is required to:

- For the villages that all households do not wish to move together, Sop Ma, Phonsavang and Ka Oy. Determine exactly how many households wish to move to individual area;
- Further defining the preferred exact location of the village housing. For example, whether it is adjacent to Road 8B or the reservoir boundary. This is important in all areas, but particularly for the sites where the area is limited such as Areas 13 and 7. Also there will be access roads to the housing area and the location of future roads will affect the design of the irrigation distribution system;

- They will have knowledge of the area, perhaps limited in some cases, and the locations of the farm and paddy areas may be further defined;
- Once the maps are prepared, the farmers will participate in the preparation of the layouts, particularly when there are alternative layout options available.

13.10.3 Topographic Survey and Mapping

Detailed terms of reference for the survey and mapping have been prepared, and include the following requirements:

- Permanent bench marks are primary control points. There will be at least four bench marks per area and six in the larger areas. They will all be located above El. 538;
- A closed traverse survey is required to locate the coordinates of the bench marks and establish a series of secondary control points. These can be wooden pegs. The traverse will be located as close to the El. 538 contour as possible;
- A density of 25 spot levels per hectare for the preparation of contour maps;
- Maps are prepared on a scale of 1:5,000. Contour lines are drawn at 0.5 m intervals. For detailed village and irrigation planning, maps are prepared to a 1:2,000 scale. In the undulating areas 0.5 m contour intervals are drawn. In the flat, gently sloping areas where canal systems are required, 0.1 m intervals are required;
- The reservoir survey and mapping contracts will include the installation of beacons demarcating the reservoir full supply elevation of El. 538. The beacons will be of 1.5 m long concrete posts painted white.

The first topographic surveys where undertaken in early to mid 2003 (Ban Phonsavang and Oudomsouk) and surveys in the remaining plateau resettlement sites, and Nan Nam Pan, will be undertaken from October 2003 to March 2005.

13.10.4 Soil Survey and Mapping

To arrive at a reasonably accurate determination of the agricultural potential of the soils in the different areas for the different crops, soil surveys and mapping are required before detailed planning. Also infiltration tests are required, particularly for identifying paddy areas but also for estimating canal infiltration losses and determining whether canal lining is required or not.

13.11 OPERATION AND MAINTENANCE AND EXTENSION SERVICES

13.11.1 Operation and Maintenance

The Resettlers currently have limited experience with irrigated agriculture and practices. However, they are now gaining this experience in Ban NongBoua (Pilot Village) and will the also in Ban Bouama and Phonsavang. NTPC TA will train villages - both classroom and in-field - in both irrigation system management, operation and maintainence and in irrigated agriculture water use (this is already underway in Ban NongBoua).

Irrigation scheme operation and maintenance (O&M) activities are vitally important to ensure an equitable supply of water to all scheme areas and scheme longevity, and the NTPC TA will provide training and support to address this issue. Funds to cover O& M costs, amd GoL staff participation will be covered by the "Social and Environmental Remediation Fund" (SERF). The maximum fund amount is US$ 7,500,000 made up of US$ 300,000 per annum for 25 years. Of this, US$75,000 per annum has been indicatively allocated to the maintenance and repair of the pump stations and system as a whole, and a subsidy on the cost of electricity..

The maintenance of the on-farm irrigation facilities and the system operation is the responsibility of the farmers. Maintenance activities for buried pipe systems are less than required for canal systems. Activities include the flushing out of pipelines, while for canal systems, canals and drains need to be cleaned and repaired. The pump stations must be kept clean and the pumps regularly greased. The flexible hoses and electric cables require attention as the pontoon will be constantly moving with the varying reservoir elevations. The main operational item is turning the pump off and on so that each farm plot within the

system has an equitable water supply sufficient for crop growth. In the undulating areas it is important that not too much water is applied as this may cause soil erosion problems.

All the farmers receiving water from either the same header tank, or main canal or main pipeline will receive assistance with the formation of a Water Users Group. When there is more than one group they will join together to form a Water Users Association. A typical Group and Association have a Chairman, Secretary, full-time Pump Operator and Water Master/Bailiff and Treasurer. The Treasurer will become critical after the 25 years of SERF when the villages will have to pay for there own power and pump station costs. The Group or Association will receive training in the dynamics of irrigation including crop water requirements and soil moisture parameters. Assistance will be given with the preparation of operational timetables. There will be some initial problems but after a couple of irrigation seasons the Group should be able to able to achieve optimum scheme operation and irrigation efficiencies. The schemes are not large and do not cover more than one village. Consequently no significant O&M problems are envisaged.

Similarly, after a couple of seasons, the Group or Association should be able to distribute on-farm maintenance activities such as canal cleaning throughout the beneficiaries within the Group.

13.11.2 Extension Services

As stated previously, the Theun Duane Demonstration Farm and the Pilot Village Irrigation Scheme have been established. Both are located on areas of sandy soils and by the time of full resettlement and reservoir impoundment, there will be considerable experience gained and an agriculture knowledge-base for the areas established.

Chapters 6 and 7 in Volume 1 and Chapters 12 and 18 in Volume 2 provide details on the extension service and support to be provided to the villagers. These service will be provided rather intensively during the relocation and transition period, and phased out gradually to normal levels..

The Agricultural Development Program includes the following strategies:

- Soil fertility improvement through increased application of organic matter
- Institutional support through Government organizations;
- Identifying suitable cropping patterns;
- Organizing the marketing of fruits and vegetables;
- The training of farmers in irrigated rice production techniques.

The above strategies are already being practiced at the Ban Nong Boua Pilot Village (a report of which is due in early 2005);

13.12 SCHEDULE FOR IRRIGATION INFRASTRUCTURE

Table 11-3 in Chapter 3 and Table 18-3 in Chapter 18 present the main activities of the Resettlement Infrastructure Program in which irrigation infrastructure is included.

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