CHAPTER V

5. ALTERNATIVES

Comparison is made of two feasible alternatives for the proposed project including site, technology, and operational alternatives. The alternatives are compared in terms of their potential environmental impacts, capital and recurrent costs, suitability under local conditions, and institutional, training and monitoring requirements. For each alternative, the environmental costs and benefits are quantified to the extent possible, economic values are attached where feasible, and the basis for the selected alternative is stated.

5. 1 Dam site alternatives

During preparation of the Pre-feasibility Study Report for the Lower Sesan 2 HPP, field investigations, and using topographical documents, two dam site alternatives were concentrated on for study as follows:

- **Dam site 1 (T1)**

T1 is located about 1.5km at the downstream of confluence position between Sesan river and Srepok river where the bedrock is exposed at the riverbed. The axis of the dam is determined by coordinates at two points A1, B1:

- Point A1: X= 1501683.8921; Y = 322110.1821
- Point B1 : X = 1498460.8761; Y = 310728.6154

- **Dam site 2 (T2)**

T2 is located about 6.5km downstream of T1. The geological coordination of two points on the axis of dam is determined as follows:

- Point A2: X= 1498115.9843; Y = 304717.7029
- Point B2: X = 1504888.6765; Y = 305626.4297

At dam site 2, two options of powerhouse location is considered for the project:

- (i) option 1: powerhouse located on riverbed (T2-1)
- (ii) option 2: powerhouse located on left bank (T2-2)

The characteristic of the riverbed from site T1 to T2 is a rather gentle slope (average slope of this river section is 0.0008), the terrain elevation difference is about 5m; the river bottom at site T1 and site T2 is 47m and 41m respectively.

Due to appearance of rock block so water surface curve between T1 and T2 is not different much (about 0.9m in November- December 2007). However, a large difference on water surface curve at T2 and downstream of waterfall at area of Phluk hamlet (outlet of powerhouse in option T2.2). Based on measurement result in December 2007, water surface difference is 3.1m. If outlet of waterway arranged at

downstream of cascade/waterfall, electricity yield of powerhouse can be increased remarkably because this different head is taken full advantage.

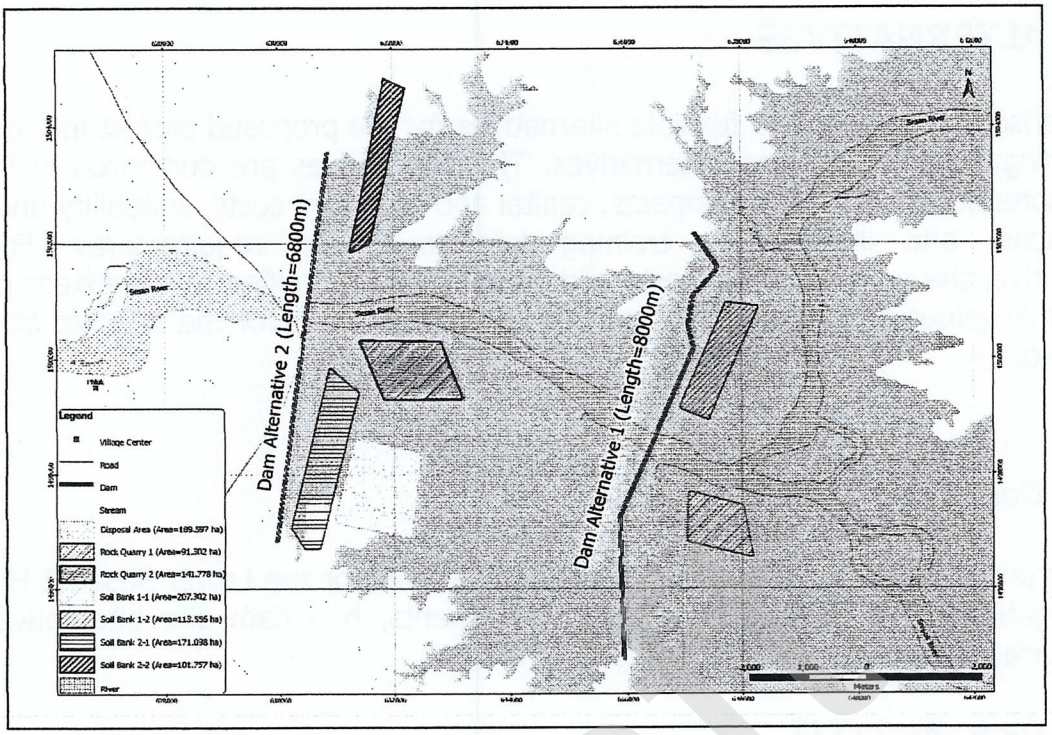

Figure 36: Location map of dam site alternative

Diversion work: For dam site alternative T2.2, works on waterway are arranged on bank, separated with headwork so its construction can be done in both flood season and dry season, it is critical path of construction schedule of project so dam site alternative 2 has better capacity to meet the general schedule of the project than dam site alternative 1 and T2.1, cost for diversion work is less than because diversion work only serves for construction in dry season, water is overflown through un-completed spillway in flood season, details see in 01.07.TC.03 and 04 of feasibility study report.

For dam site alternative T1 and T2.1: Waterway together with spillway are arranged at riverbed so diversion work must insure construction in both flood season and dry season. Thus quantity of concrete wall and cofferdam is very high, due to intensity of items arranged in high area so construction organization method has many difficulties, in addition diversion culvert located on right bank but in first construction year without temporary bridge so construction schedule will be shorter than one in site T2.2 and capacity meeting construction schedule of all project is less; details of diversion alternative see in 01.07.TC.01 and 02.

5. 2 *Topographical and geological conditions of dam site alternatives*

For the dam site alternatives, a map of scale 1:2000 has been used in the preparation of the Feasibility Study Report to assess the overall areas of the alternative dam sites and to: determine the position of the reservoir, to define damage on land/forest, gardens and households. Mapping and measurements have also been done using aerial

photograph maps with a scale of 1:10 000 with contours of 2m to ensure accuracy for design and assessment of dam site alternatives.

Along the axis of the two dam site alternatives drill-holes were made to clarify the engineering and geological conditions of the dam site alternatives. Topographical and geological investigations were considered in selection of the preferred dam site alternative. The result from the investigations showed as follows:

- The riverbed of site T1 and site T2 is 47m and 41m (m.s.l) respectively.

- Dam site alternatives have large riverbed, and the river-bank is gentle slope terrain, the area mostly flat. Therefore the length of the proposed dam is 6.5-8km.
- Geological conditions at site T1: it is located on a zone of andezite eruptive rock, the bedrock is Devonian-Carbonian age which is covered by N2-Q1 sediment and Quaternary Sediment of Holoxen age. Engineering geological conditions are favorable as andezite rock (which is exposed at riverbed), has high stability for supporting the concrete dam base, abutments has rather homogeneous overburden layer where is suitable for dam embankment.
- Geological conditions at dam site T2: the riverbed at site T2 has a very complex geology, the whole riverbed is covered by sand, rock layers of sand banks exposed on surface to be sand-stile sediment inserted with gravel of zone IIA, remaining has aQ layer about 2-4m thickness, thin layer IA1, IA2 < 1m and then zone IIA – hard rock. The geological structure is also quite different from the right bank and left bank: on the right bank is an andezite rock block and with unstable N2-Q1 sediment covering it; the left bank has unstable Quaterary Sediment covering rock of J1-2 formation. On the riverbed, a silt layer of 2-5m covers conglomerate rock of J1-2 formation. Therefore, for the spillway and concrete dam to be located on the riverbed, consolidation grout is required to treat its foundation. A soil borrow area is close to this site for construction and the rock borrow area and sand would be taken from area of site T1.
- Site T2 is located about 6.5km downstream of site T1, so the inundation area of Site T2 is larger, the number of effected household is higher. The energy would however be greater due to a higher storage volume in the reservoir.
- The road serving the construction and operation for both dam site alternatives is from National road No 78 and the length of construction and operation roads for the dam site alternatives is essentially the same.

- **<u>Quantity of main works for dam site alternatives</u>**

Based on the proposed project layout of the two dam site alternatives, the quantity and construction price of the dam site alternatives have been calculated as shown in the following table:

Table 47: Quantity of dam site alternatives

Work	Unit	Alternative T1	Alternative T2	
			Option T2.1	Option T2.2
Excavation	m^3	1,782,386	2,096,820	14,249,250
Embankment	m^3	8,443,854	9,663,040	9,629,070
Concrete	m^3	624,882	683,504	645,696
Hydro-mechanical equipment	Ton	8,720	8,781	8,808
Hydraulic-mechanical equipment	MW	400	420	480

For each dam site alternative, diversion alternatives have been considered as shown in Table 48. Each alternative has been considered so that construction targets can be met.

Table 48: Quantity of diversion alternatives

Work	Unit	Alternative T1		Alternative T2	
		Diversion canal in flood reason	Diversion culvert in flood reason	Option T2.1	Option T2.2
Excavation	m^3	5,000,000	24,925	109,830	1,876,541
Embankment	m^3	263,100	1,467,000	632,499	263,100
Concrete	m^3	0	39,307	63,371	0

5. 3 Reservoir level (full supply) alternatives

The Lower Sesan 2 HPP project can be designed with three different full supply levels in proposed reservoir as following:

- Full Supply Level (FSL) with 80m
- Full Supply Level (FSL) with 75m
- Full Supply Level (FSL) with 70m

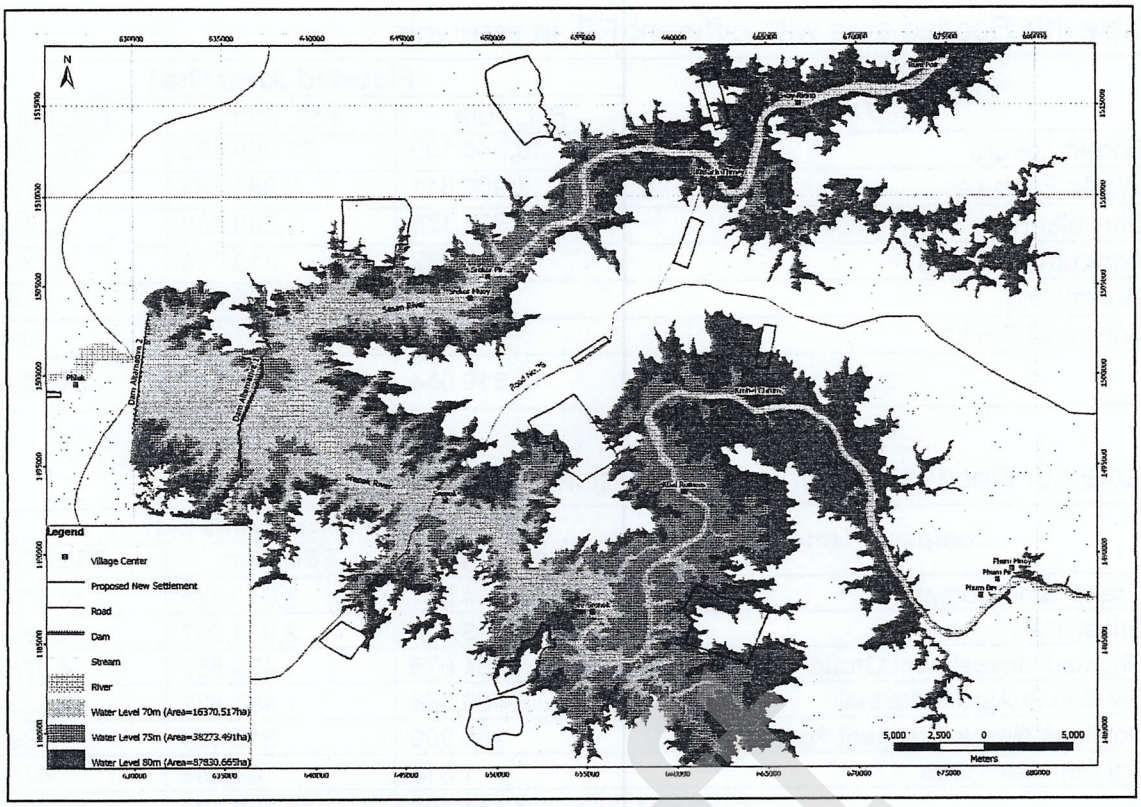

Figure 37: Full supply level alternative

With a FSL of 80m the total flooded in reservoir area is about 813.2Km^2 including water features. The existing agricultural land and settlement areas of three communes which comprise of Srekor, Talat, and Kbal Romeas in Sesan district in Stung Treng province will be completely submerged by the reservoir, and Phluk commune in Sesan district in Steng Treng and in Sre Angkrang commune in Kon Mom district in Ratanakiri province will be partly flooded in reservoir too. A big resettlement would need to occur. There would be a very high impact in social and environmental terms and therefore a FSL of 80m is not considered feasible for the Lower Sesan HPP.

With a FSL of 75m the total flooded in reservoir area is about 335.6Km2 including water features. The agricultural land and settlement areas of four communes in Sesan district in Stung Treng province will be partly submerged by the reservoir, but not flood the commune in Rattanakiri as the FSL of 80m would. Some resettlement for the households living in lower area in above communes will be needed. With the FSL of 75m a high impact in social and environmental terms can still be predicted making the feasibility of this alternative questionable.

With a FSL of 70m the total flooded in reservoir area is about 129.1Km^2 including water features. The existing agricultural land and settlement areas of four communes in Sesan district in Stung Treng province will submerge by a relatively small amount (60ha only of agricultural land) by the reservoir. Relocating some households from the lower areas to higher ground in the four communes will still however need to occur, especially in Srekor and Kbal Romeas commune. Small to medium impact into social and environmental resources can be predicted.

Table 49: Flooded area with different FSL in reservoir

Land Use Type	Flooded Area (ha)		
	FSL 70m	FSL 75m	FSL 80m
Forest covers	10,548.130	28,969.495	69,126.680
Water Features	1,906.811	2,989.653	4,572.263
Shrublands	373.178	1,290.558	3,381.214
Agricultural lands	47.922	218.714	3,136.192
Grasslands	30.617	48.109	999.900
Soils and Rocks	3.376	47.392	104.645
Total :	**12,910.034**	**33,563.921**	**81,320.894**

Table 50: Flooded area of land concession and forest concession

Company Name	Submerged Area (ha)		
	FSL 70m	FSL 75m	FSL 80m
Grand Land Company	1,914.571	3,940.235	14,419.271
Pheapimex	1,293.806	2,911.917	4,264.362
Phumady Investment Group	554.675	1,479.557	4,075.591
Siv Geach Agro-Industrial	466.046	1,467.522	3,552.017
Sopheak Nika Investment Agro-Industrial	183.909	516.474	1,039.390
Sal Sophear Trade	1.318	84.053	471.927
Total	**4,414.325**	**10,399.758**	**27,822.558**

In table 50 clearly indicated that the flooded area of the land and forest concession with FSL 70m is two times smaller than flooded area in FSL 75m. However all land and forest concession above will be submerged big or small area with FSL respectively. Therefore land conflict will be happened between the Lower Sesan 2 HPP project and land & forest concession.

Anyway the resettlement of the communities in the project area is a main factor of the social impact that must take in account in the project preparation and design. The table 51 indicated clearly with the commune name and total number of households that will relocate or resettle to the new resettlement areas according to the different FSL of the reservoir.

Table 51: Project affected households and affected peoples

No.	Commune name	Total population		Affected by project with different water level								
				FSL 70m			FSL 75m			FSL 80m		
		HH	Person	PAH	APs	%	PAH	APs	%	PAH	APs	%
1	Kbal Romeas	470	2191	157	768	**33**	453	2109	**96**	470	2191	**100**
2	Talat	648	2892	0	0	**0**	267	1229	**41**	?	?	**90?**
3	Sreko	332	1418	332	1418	**100**	332	1418	**100**	332	1418	**100**
4	Phluk											
	Dam site 1	188	824	7	29	**4**	7	29	**4**			
	Dam site 2	188	824	14	53	**7**	14	53	**7**			
5	Sre Angrang	316	1610	0	0	0	0	0	0	?	?	**20?**

Source: Data obtained from resettlement study team, PECC-1, May 2008.

According to the environmental and social impact aspect the FSL with 70m and 75m can be considered for the Lower Sesan 2 HPP project development. Based on the

technical and economical result in the feasibility study the FSL of 75m was selected for the Lower Sesan 2 HPP.

The following tables are described the major affected analysis with alternative dam site 1 and dam site 2 with full supply water level of 75m.

Table 52: Description of the major affected analysis of site 1 and site 2

Alternative of dam location	Topographical condition	Geological condition	Submerge area with FSL 75m	Total length of main dam
Site 1: 1.5km from confluent point of Sesan and Srepok	Riverbed, 47m	favorable andezite rock	335.6 km^2	8000 m
Site 2: about 6.5km downstream of site 1	Riverbed, 41m	very complex geological, unfavorable andezite, rock layers with sand on riverbanks, sand-stile sediment inserted with gravel of zone IIA, remaining aQ layer about 2-4m thickness	382.7 km^2	6833 m

Table 53: Cost of dam site alternatives

Parameters	Unit	Alternative T1	Alternative T2	
			Option T2.1	Option T2.2
Total investment capital	MUSD	667.32	710.18	815.28

Due to technical, environmental, and economic result found that the preferable alternative for the Lower Sesan 2 HPP project is dam site T1 (1.5km from the confluent point) and FSL of 75m in the reservoir.