CHAPTER 4

ANTICIPATED ENVIRONMENTAL IMPACTS

4 Approach and Method of Identifying and Assessing Environmental Impacts

The identification of environmental impacts was done using the following methods:

- Previous and other similar projects - the EIA team referred to the EIA reports and empirical information from similar projects in Sri Lanka, e.g., Upper Kotmale Hydropower Project, Kukule Ganga Hydropower Project
- EIA reports of similar projects in other parts of the world, e.g., India, China
- Checklists - *Checklist of Environmental Characteristics – Document 5* prepared by Department of Environmental Affairs, Republic of South Africa
- Published documents – *Environmental Assessment Source Book Volume II Sectoral Guidelines,* published by the Environment Department, The World Bank
- Expert judgment – the consultants held several rounds of discussions to identify the impacts
- Modified Leopold Matrix - The EIA consultants engaged in an exercise using a modified version of Leopold Matrix to identify the impacts and also to assess the significance. The process identified is given below

The impact identification was largely limited to the Project Impact Area (PIA) as identified in Section 3.0 in Chapter 3. However, the impact area may be either expanded or reduced depending on the impacts that are already provided in the TOR.

The result of this exercise identified thirteen (13) significant negative impacts and four (4) positive impacts.

Table 4-1 Identified significant impacts

Type of Impact	The Description of the Impact	Assessed Impact
NEGATIVE		
1	Temporary lowering of ground water affecting domestic uses	57 house holds will be affected. ➔ (4.7.14, p4-1)
2	Temporary reduction in agricultural production (paddy) to lowering of ground water	139.2 ha (Rice field and vegeTable field) ➔ (4.8.3, p4-38)
3	Impact on the integrity of the existing tunnel	Blasting is controlled by the use of appropriate specific charges in the blasting rounds to limit peak particle velocity not exceeding 2cm/sec. ➔ (4.8.2, p4-37)
4	Pollution of surface water from tunnel discharge and other construction sites	10 locations are estimated as possible impact area. But no houses will be affected. ➔ (4.2.1, p4-6)
5	Increase in work related accidents	Traffic accidents, tunnel accidents, fire etc.➔ (4.8.1, p4-37)
6	Reduction of forest cover at dumping sites	Reduction of forest cover is 8.14 ha ➔ (4.3.7, p4-18)
7	Disturbance of some species due to noise and other activities	During construction some species will be affected. ➔ (4.3.1, p4-16)
8	Soil erosion due to tunnel muck dumping and access road construction	Length of the rubble is 1253 meter ➔ (4.1.1, p4-2)

Type of Impact	The Description of the Impact	Assessed Impact
9	Ground Water Pollution	➔(4.2.1, p4-6)
10	Disturbances to the community from the workers	➔(4.7.2, p4-28)
11	Damages to Road due to increase of heavy traffic	Affected road is 18 km, 4 years. ➔ (4.7.12, p4-31)
12	Disturbance to elephant migration	Migration routes from Power Station to Randenigala Reservoir will be affected during operation. ➔ (4.3.4, p4-16)
13	Loss of private land at tunnel muck dumping site in Kohombagana	5.79 ha would be affected by temporally facilities in Kohombagana. ➔ (4.7.6, p4-29)
POSITIVE		
1	Reduce carbon fuel/foreign exchange savings	15,169.40 ton of CO2 will be saved by this project.➔(4.16.1, p4-46)
2	Injection of capital to the local economy	➔(4.16.2, p4-46)
3	Increase in regional employment opportunities	➔(4.16.3, p4-47)
4	Building a positive impression on the project	➔(4.16.4, p4-47)

The following assessment will be based on the conclusions of the above Table. While all impacts defined in the TOR will be discussed, only those that were considered to be significant are assessed in detail and followed through to the mitigation and monitoring discussed in the next two chapters[9].

4.1 Soil Erosion and Siltation (Significant)

4.1.1 Surface runoff, soil erosion, siltation, hazards, sedimentation of river basin during construction of project components including the transmission line

A few project activities may disturb the land surface. These include preparation of temporary accommodation for construction workers, construction of a small extent of roads, installation of penstocks, sand mining operations and tunnel muck dumping. (Figure 4-1) Most of these activities are confined to small areas, and located on the lower parts of the slope or on flat areas. Therefore, no potential threat of accelerated soil erosion will result from the project activities. As tunnel mucks will be used for aggregates, a separate quarry for the project is not necessary.

A limited amount of soil erosion may occur at the sand mining site during the mining period. But this is unlikely to create a siltation problem in the Victoria Reservoir. The site selected for sand mining is located on the bed of the Ma Oya, a tributary of the Mahaweli Ganga, which joins the Victoria reservoir at Mailapitiya. There is a sizable deposit of sand size material spread over an area of about 24ha. It is a flat to moderately sloping reach of the river. During the peak flows of the river, this area is inundated by Victoria water creating a suiTable environment for deposition of the bed load of the stream. The water level of the reservoir is the effective base level of the river which cannot erode its bed below the base

[9] The significant impacts identified in the matrix exercise have been indicated as such next to the headings within parenthesis.

level. It is however possible that there will be increased deposition of sand once again after the removal of sand from the deposit. It can therefore be said that sand mining from the river bed will reduce the potential of siltation of the storage area of the Victoria Reservoir.

There is a greater threat of siltation of the reservoir from the accelerated erosion on cultivated lands but this is not induced by the proposed project. Although people are practicing some form of soil conservation, it is grossly inadequate to arrest the problem. While check dams are found in many of the GN Divisions on steeply sloping lands, they are inadequate. Consequently, the soil washed down from the slopes end up in the reservoirs.

Almost all of the PIA belongs to the VRR Sanctuary. A detailed management plan for the Sanctuary has been prepared by the Department of Wildlife Conservation (DWLC). It is therefore necessary that the project works in close collaboration with the DWLC and implement the existing environmental management plan. In fact, with or without the project, a better system of land management is urgently required for the area and the project will supply much needed financial and technical inputs for the popularization of conservation farming in the area surrounding the project. The success of this endeavour will provide impetus to similar developments in adjoining areas.

Table 4-2 Length of Tunnel Muck Embankments susceptible to Erosion

Name	Length (m)
M1	214
M2	465
M3	218
M4	102
M5	254
Total	1,253

Under the proposed Project no new transmission lines will be constructed, because the existing transmission lines constructed under the Phase I Project has sufficient capacity to accommodate the proposed expansion.

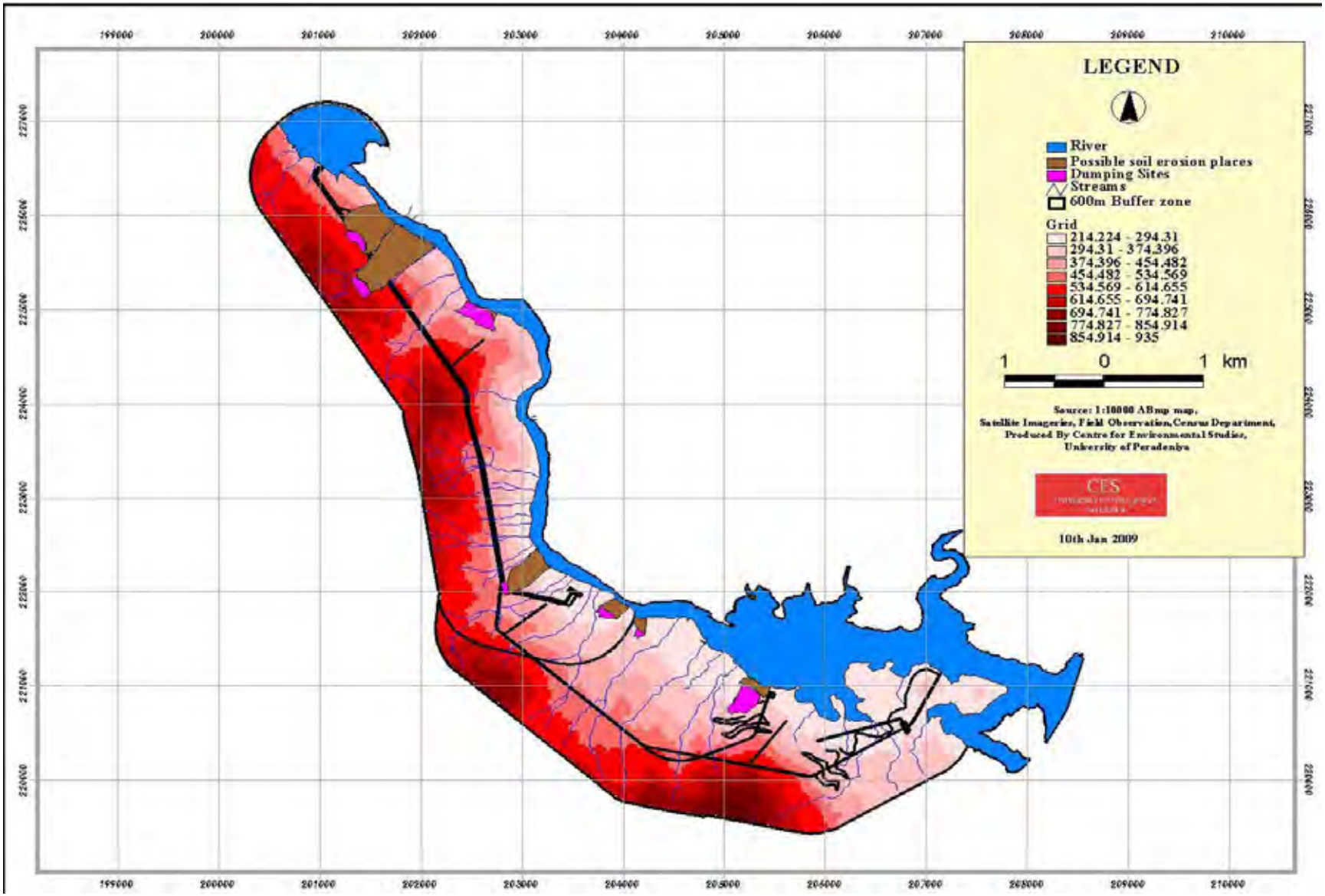

Figure 4-1 Possible erosion points

4.1.2 River bank erosion during construction and operation of the project

The proposed project will not change the current flow regime of the Mahaweli Ganga. Therefore, it will not increase or decrease river bank erosion during the construction or operation periods of the project. The existing Victoria diversion effectively cuts the water flow into the Mahaweli River limiting the flow to a trickle which is mostly derived from seepage, local drainage and the inputs from the small tributaries. Construction of dams across rivers leads to degradation of the river bed below the dam as it has already happened under Victoria Phase I. However, the increased water level of the Mahaweli below the power house after commencement of the proposed project may lead to bank erosions for some time until it gets stabilized. However the net impact of this erosion on the Randenigala reservoir is negligible.

4.1.3 Impacts during construction of access road and rehabilitation of access roads

Road construction under the project is limited to a few access roads to the sites for dumping muck, sand mining, and portal of access adits. Already there is a good network of roads in the area which may have to be resurfaced and strengthened for heavy vehicular traffic. These activities may disturb the surface soil and wildlife habitats but will be confined to the construction period. The area is not free of such disturbances at present because the resident population of the area is engaged in similar destructive activities. However, measures would be introduced in the mitigation program to minimize these impacts.

4.1.4 Slope failure and land slides due to heavy earth work

No heavy earthwork is involved in the project except the dumping of tunnel muck at selected locations. These dumps have a potential for sliding if not properly managed. The loose material among the mucks could slide downslope and end up in the reservoir. This has to be mitigated and the method of mitigation is described under impact mitigation. General slope failure and land slides caused either by natural factors or unsustainable landuse practices such as Chena are problems already affecting the area. A few years ago there were widespread land slides in the area due to unusually high rains. Most of these slides have occurred outside the PIA. The only project activity that could increase the landslide potential of the area is the tunneling activity. Rock blasting in the tunnel could create vibration destabilizing the surface soil.

4.1.5 Potential seismic impacts

The Victoria reservoir and the tunnel have been in existence for nearly 3 decades with no serious seismic activity recorded by the network of seismic monitors installed there. The proposed project does not increase the capacity or the volume of the reservoir and therefore the project will not increase the seismicity of the area. Seismic activity unrelated to the project may occur due to geophysical reasons. The proposed project will not increase the potential hazard level of the Victoria system.

4.2 Water Resource & Water Quality Impacts

Waste water is produced during mining operations. The water is used in drilling, blasting and mucking operations. The waste water is contaminated with rock particles, lubricants, fuel and chemicals. Tunnel waste water should not be allowed to pollute the local streams. The rain

water eroding rock and soil dumps can release sediments to the streams thereby polluting the latter.

4.2.1 Surface water quality and ground water quality (Significant)

During the construction period, no major water flows are expected in the streams and thus the flow rates in streams will be about the same as before. There will be almost no upstream impacts from this project. However, the following events may negatively affect both the surface and ground water quality of the area:

(i) erosion and runoff caused by construction activities, including forest cleared areas and accidental water releases;
(ii) sanitary effluents from the construction camps;
(iii) oil and chemical spills from machinery and vehicles; and
(iv) leaching of ammonia and nitrogen from the tunnel blasting and spoil rock deposits.

Table 4-3 Waste water impact area

Type of water pollution	Location	Control measures	Number of affected houses
Leaching of ammonia and nitrogen	Adit, Dumping site	Settling basin	0
Oil and chemical spills	Batching plant	Chemical treatment and Settling basin	0
Sanitary effluents	Construction Buildings	Settling tank and effluent treatment	0
Turbid water	Sand mining area	Settling basin	0

Figure 4-2 provides the location of wastewater impact points.

Untreated or poorly treated wastewater releasing into the surrounding water courses, a surface water source or a groundwater source have many consequences. Major consequences that could arise from receiving waters from excessive waste released can be listed as,

- Dissolve Oxygen (DO) depletion due to organic waste, leading to low DO condition and ultimately to septic conditions
- Spread of waterborne diseases (through domestic wastewater but not with the process related to mining wastewater)
- Nutrient enrichment causing algal bloom leading to accelerated eutrophication
- Toxic pollution from poisonous compounds such as halogens, heavy metals, etc.
- Changes in psychical and chemical properties such as in pH, conductivity, color, turbidity, taste, odor temperature, etc., of receiving waters making them unsuiTable for use.

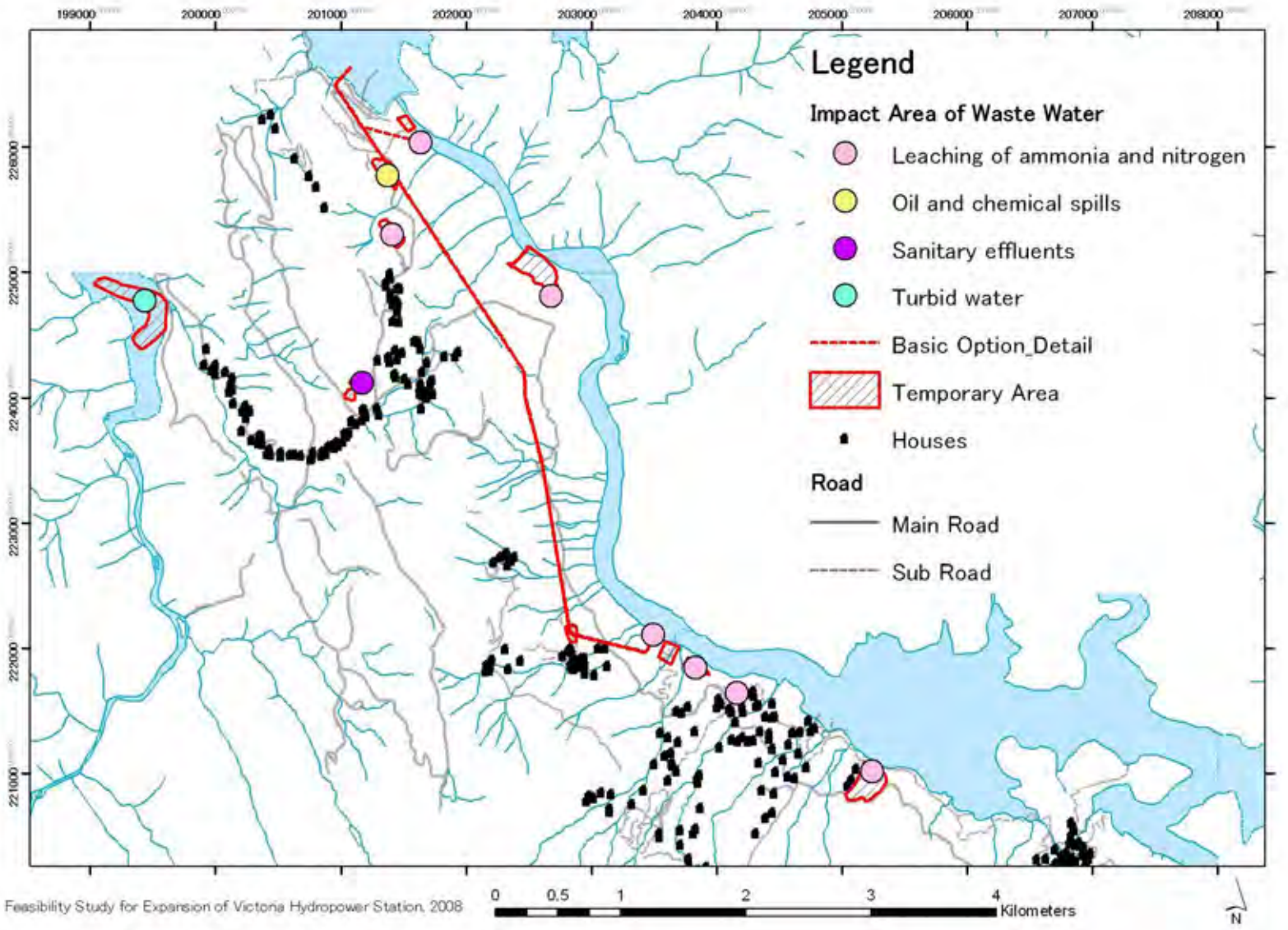

Figure 4-2 Waste water impact points

4.2.2 Changing surface water flow

The total water volume per year for power generation will not change, but the timing of utilizing water will change because of operation for peak demand. Total water release will be determined through the existing mechanism of water management which optimally uses the water among all its multidisciplinary uses such as irrigation, power generation, water supply, downstream demands, etc. Therefore, no change in the quantity or pattern of water releases is expected. However, as the purpose of the extension of the power capacity is for higher generation during the peak hours, the generation will now be limited to a few hours during the peak period within a day. The main impact of the rising water level of the tail race is the potential disruption of the movement of elephants across the stream. Section… explain this impact in detail. The water released during power production will be stored in the Randenigala reservoir and will be used for power production and irrigation releases as it has been done in the past. For this reservoir too no change in power generation pattern is made and it will be as done in the past.

Current discharge from the Victoria power station is different by seasons. Daily discharge of water through the powerhouse is generally constant throughout the year. It has two peaks in the morning and in the evening. The hourly output by month is shown in Figure 4-3.

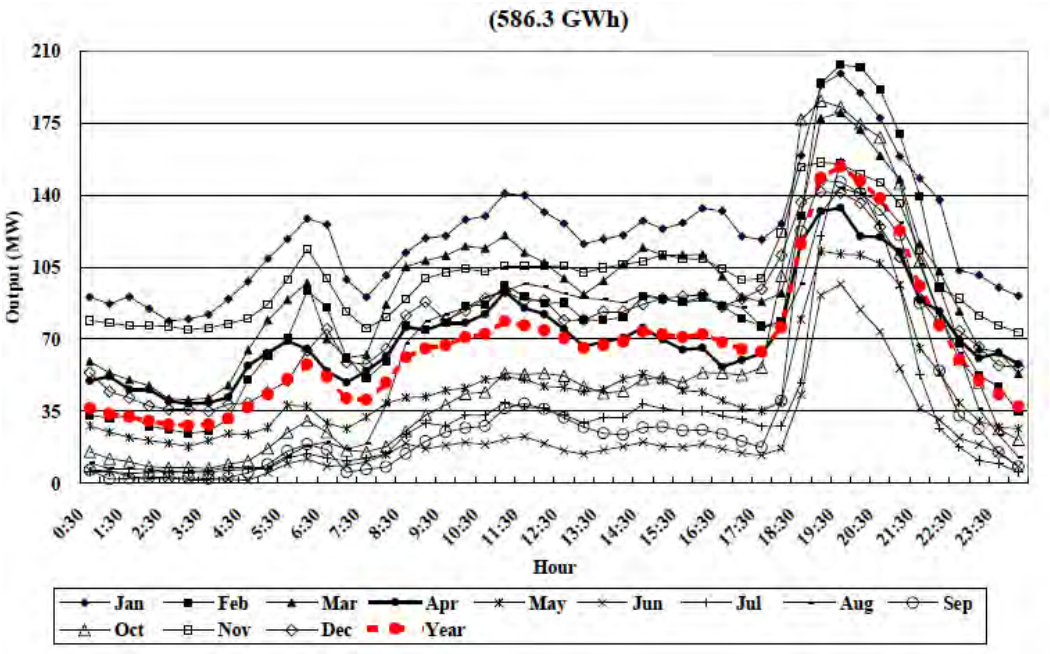

Figure 4-3 Hourly Output of Monthly Average in 2007

The planned discharge in the daily pattern except the wet season will be during the peak hours from 18:30 to 21:30. The total amount of water volume per day however will not change from before to after construction. The typical operation pattern except wet season is shown in Figure 4-4.

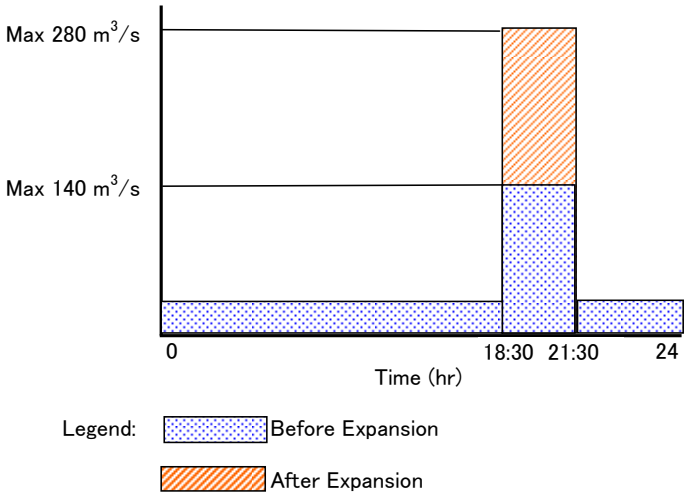

Figure 4-4 Typical Operation Pattern

Because of the peak operation, the water level between the power plant and the Randenigala reservoir will be changed. The water level simulation is given below. Cross sections illustrating the rising level of water are shown in the Annex 3.2. The location of sections are shown in Figure 4.5.

Estimated water level between power plant and Randenigala reservoir is given in Table 4.4

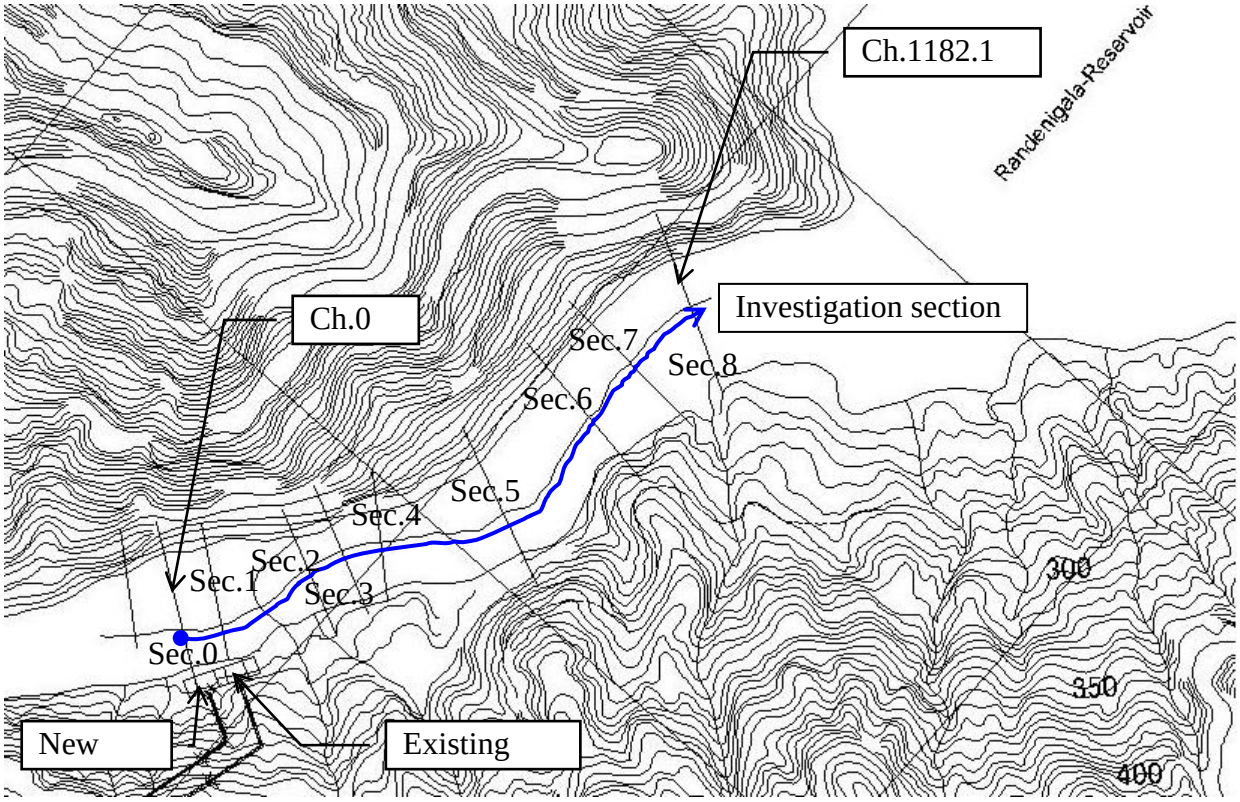

Figure 4-5 Investigation Section

Table 4-4 Investigation case

Case	WL at Randenigala Reservoir EL (m)	Discharge (m3/s)
1	209 (L.W.L)	35 (Current Operation)
		140(Current Peak Operation)
		280(Current Operation +Expanded peak operation)
2	218.3 (M.W.L.)	35
		140
		280
3	232 (H.W.L.)	35
		140
		280

Table 4-5 Difference in water level

		Ch. (m)								
		0	**67.7**	**271**	**338.5**	**407**	**664.1**	**907.7**	**1,039.8**	**1,182.1**
Case1	WL1 (m)	-	229.3	227.5	227.2	227.2	223.4	219.9	217.9	211.8
	WL2 (m)	-	230.7	228.3	228.1	227.7	224.2	220.4	218.5	213.3
	WL3 (m)	231.3	231.3	229.2	228.9	228.3	224.8	221.0	219.1	214.7
	⊿h1 (m)	-	1.4	0.8	0.9	0.6	0.8	0.5	0.6	1.5
	⊿h2 (m)	-	0.6	0.9	0.8	0.6	0.6	0.6	0.6	1.4
Case2	WL1 (m)	-	229.6	227.5	227.0	226.8	223.5	219.4	218.4	218.3
	WL2 (m)	-	230.7	228.3	228.1	227.7	224.2	220.0	218.8	218.3
	WL3 (m)	-	230.7	228.3	228.1	227.7	224.2	220.0	218.8	218.3
	⊿h1 (m)	-	1.1	0.8	1.1	0.9	0.7	0.6	0.4	0.0
	⊿h2 (m)	-	0.6	0.9	0.8	0.6	0.6	0.8	0.4	0.1
Case3	WL1 (m)	-	232.0	232.0	232.0	232.0	232.0	232.0	232.0	232.0
	WL2 (m)	-	232.0	232.0	232.0	232.0	232.0	232.0	232.0	232.0
	WL3 (m)	232.0	232.1	232.0	232.0	232.0	232.0	232.0	232.0	232.0
	⊿h1 (m)	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	⊿h2 (m)	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Here, WL1: Water level at Current Operation (Q=35m^3/s)
WL2: Water level at Peak Operation (Q=140m^3/s)
WL3: Water level at Peak Operation (Q=280m^3/s)
⊿h1: Difference in water level (WL2-WL1)
⊿h2: Difference in water level (WL3-WL2)

4.2.3 Change in ground water Table (Significant)

The cavities of weathered limestone, fissures in quartzite and open joints in the joint system control the level of the ground water Table. The locations where seepage of ground water is anticipated during tunnel construction is given in Table 3-2. (Figure 4-6) This is limited to a small area near the existing surge tank where the new surge tank too will be located. The records on the excavation for the existing tunnel provide reliable information about location and seepage flow rates of ground water.

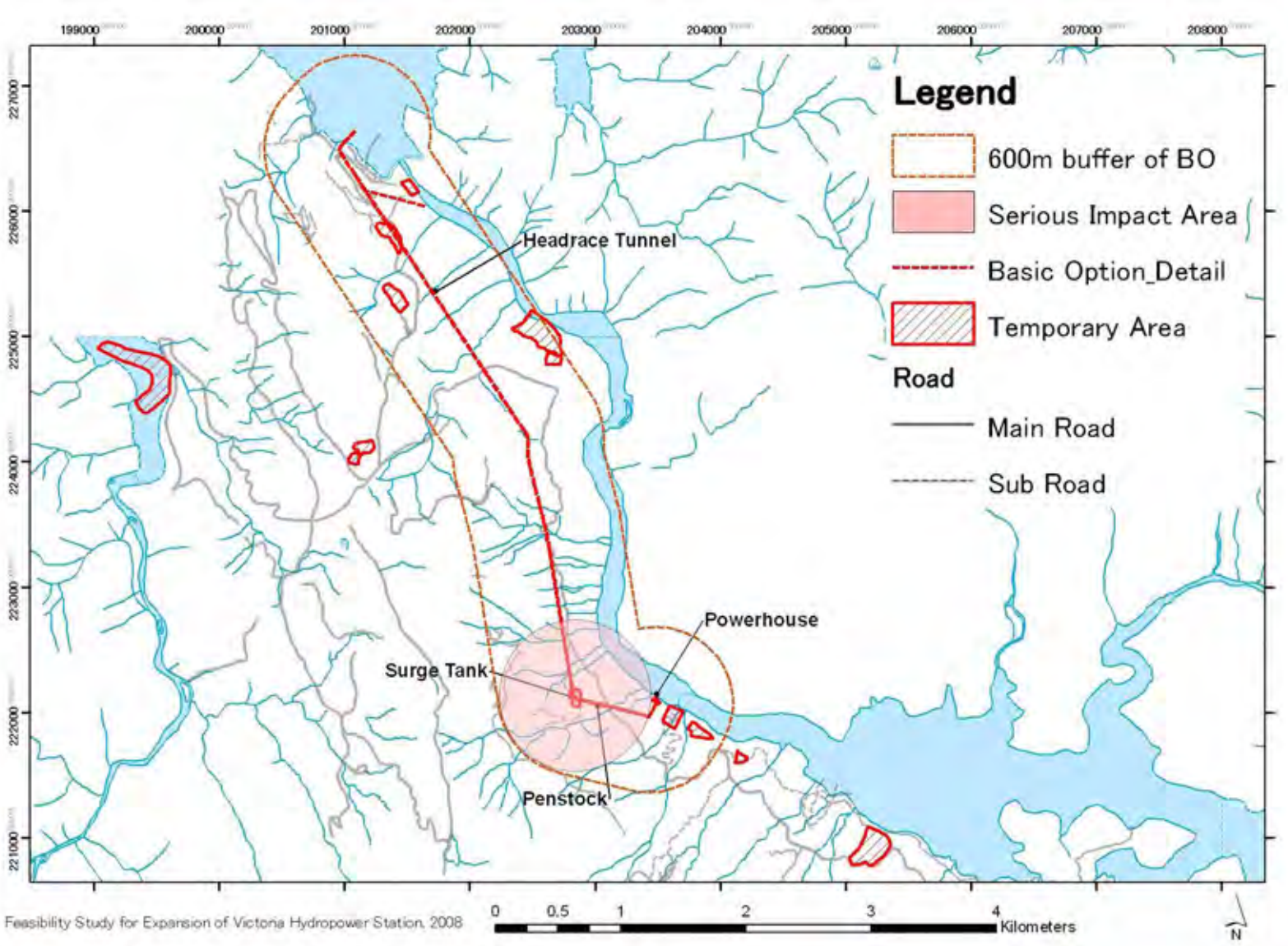

Figure 4-6 Underground water impact area

4.2.4 Disruption of surface water flow

This is not relevant as the water flow between the Victoria Dam and the Randenigala Reservoir is controlled by MASL. There are no surface operations that can affect the surface water flow. The muck dumping sites will not be located in valleys of active stream, seasonal or perennial. This is mainly to prevent rock debris from finding its way into natural streams.

But there are some perennial surface streams that overlay the tunnel trace. Some of these streams had run dry during the excavation of the existing tunnel but had resumed normal flow with tunnel lining. Similar conditions will prevail during the excavation until the lining of the proposed tunnel.

The possibility of damming perennial streams upstream of seepage points should be explored. This will not only reduce the nuisance of ground water seepage into the operating areas of the tunnel but can divert the stream water to the lands under cultivation by these streams. It will also reduce the cost of transporting water to the affected communities.

4.2.5 Disruption of ground water flow (Significant)

As with all tunneling, including the excavation of the existing tunnel, disruption of the ground water flow during construction is unavoidable. This is unavoidable during the initial drilling and excavation period. However, the ground water level will revert to original levels and the flow will most likely be restored after lining the tunnel, thus stopping the drawdown.

There are no surface operations that can affect the surface ground water flow. The muck dumping sites will not be located in valleys of active streams seasonal or perennial. This is mainly to prevent rock debris finding its way to natural streams.

But there are some perennial surface streams that overlay the tunnel trace. Some of these streams had run dry during the excavation of the existing tunnel but had resumed normal flow with tunnel lining. Similar conditions will prevail during the excavation until the lining of the proposed tunnel.

4.2.6 Occurrence of water logging and flooding

The construction wastewater and its seepage though tunnels can increase water logging in the river reach upstream of the power station. Further, the increased discharge from power generation could lead to localized flooding conditions during the hours of power generation in the river reach downstream of the power station. This increased discharge will cause water-logging in downstream areas during non-operation hours. However, these water logged areas will get flushed off at the next operation that would occur within 24 hours.

4.2.7 Impacts on water quality during construction of project component (Significant)

Tunnel construction: the construction of the tunnel will involve dewatering operations as the tunnel is expected to intercept water baring horizons. Water seeping into the tunnel from these horizons will be collected in the working areas. Therefore dewatering of the tunnel is required. The extent of dewatering required is unknown at the moment as the preliminary geotechnical investigations are insufficient for determination. Therefore adaptive

management is required during the construction process to control the dewatering process. The tunnel drainage will contain crushed rock material and products such as concrete, oil and grease and explosives residues (mainly nitrates). Particles of pollutants will be entrained in any resulting drainage waters and any discharge of these to surface water or groundwater could cause adverse effects on the ecology through toxicity, increase in pH, increased periphyton growths due to increased nitrates, or changes to habitat through sedimentation.

Cement mixing plant; cement and wet concrete are toxic in water ways because they raise the pH, and can pollute environments in significant quantities. Storm water contaminated with cement dust or wet concrete, and spills of concrete from the concrete manufacturing area, could potentially drain to water courses in the area.

Muck Disposal: tunnel and open-air structure construction will involve the removal of large quantities of muck. This muck has to be disposed of. They will be placed at the selected disposal sites as open dumps. This open dumping will cause release of certain wastes, especially suspended solids, into the surface water sources with rainfall runoff. The quality of water will be adversely affected if tunnel muck containing unused basting materials, chemical, other wastes, etc., is released to water sources with rainfall runoff.

4.2.8 Waste generation and pollution from temporary workers camps

Domestic Waste Water
Worker camps will produce black water (toilet wastewater) and gray water (other wastewaters). If these wastes are discharged untreated to the environment, they will cause many impacts as described in section "surface water quality and ground water quality". Toilet wastewater should never be allowed into the river, as it could cause health hazards for those living downstream. Black water (toilet water) needs to be collected and treated with the necessary infiltration capacity. Gray water (washing and kitchen water) must be treated properly at the site before discharging into the open water courses.

Waste water from parking and maintenance yards
Vehicle parking and maintenance yards too will produce wastes. Measures to avoid oil and chemical spills must be taken. The machine/vehicle parking area, workshop area, and fuel and oil filling area should be restricted to one paved area where possible and equipped with a controllable drainage system so that all diffuse spills and accidental spills may be collected at all times.

Waste water
Water used in the operation of rock drills is mainly for flushing and dust suppression. Waste water released by rock drilling and other washing operations contain rock particles. The other source of waste in tunnel water is unburned and spilled explosives.

4.2.9 Impacts of water quality of the proposed, existing, and planned project activities

Increased generation capacity will increase discharge at the powerhouse. This could cause

- Increased agitation at the meeting point between this water and that of the Randenigala reservoir could increase the mixing of bed sediments causing an increase in turbidity, nutrient levels, etc. However this will be a localized effect.

- Increased agitation will increase the dissolved oxygen in water, which of course is a positive effect.

The above facts show that increased power production is not expected to cause major water quality changes. However, as the inundation area of the reach is increased, this could cause some concerns as the state of this water is not of the best quality.

4.2.10 Water pollution due to contaminated leakages from machinery

Drilling, mucking and transport equipment
Drilling, mucking and transport equipment use water in their operations. Drilling water will be contaminated with rock particles and lubricants. The transport and loading equipment will be a source of water contaminants as the spillage of fuel and lubricants and tire wear will pollute the water. The equipment exhaust gases too which can dissolve in tunnel waste water.

Vehicle parking and maintenance yards
See Section 4.2.8

4.2.11 Ground water Table along the tunnel route at present expected draw down during construction and after construction (Significant)

Underground tunneling will cause seepage of groundwater into the tunnel and thereby lower the water Table. This change in ground water Table will however be temporary and will revert to normal with the lining of the tunnel sealing the seepage paths. Looking at the effects observed during the first phase of constructions the effects were significant in the villages of Hakurutale and Welikada and also to a lesser degree in other surrounding villages. As the village wells tap the subsurface flows the recovery of water levels during rainy seasons will be ineviTable. However, seepage into the tunnel will cause dropping of water levels at faster rates with longdry spells. Figure 4.7 illustrates the possible impact area and the serious impact area in relation to ground water depletion. 10 wells are in the possible impact area and 4 of 10 wells are in the serious impact area.

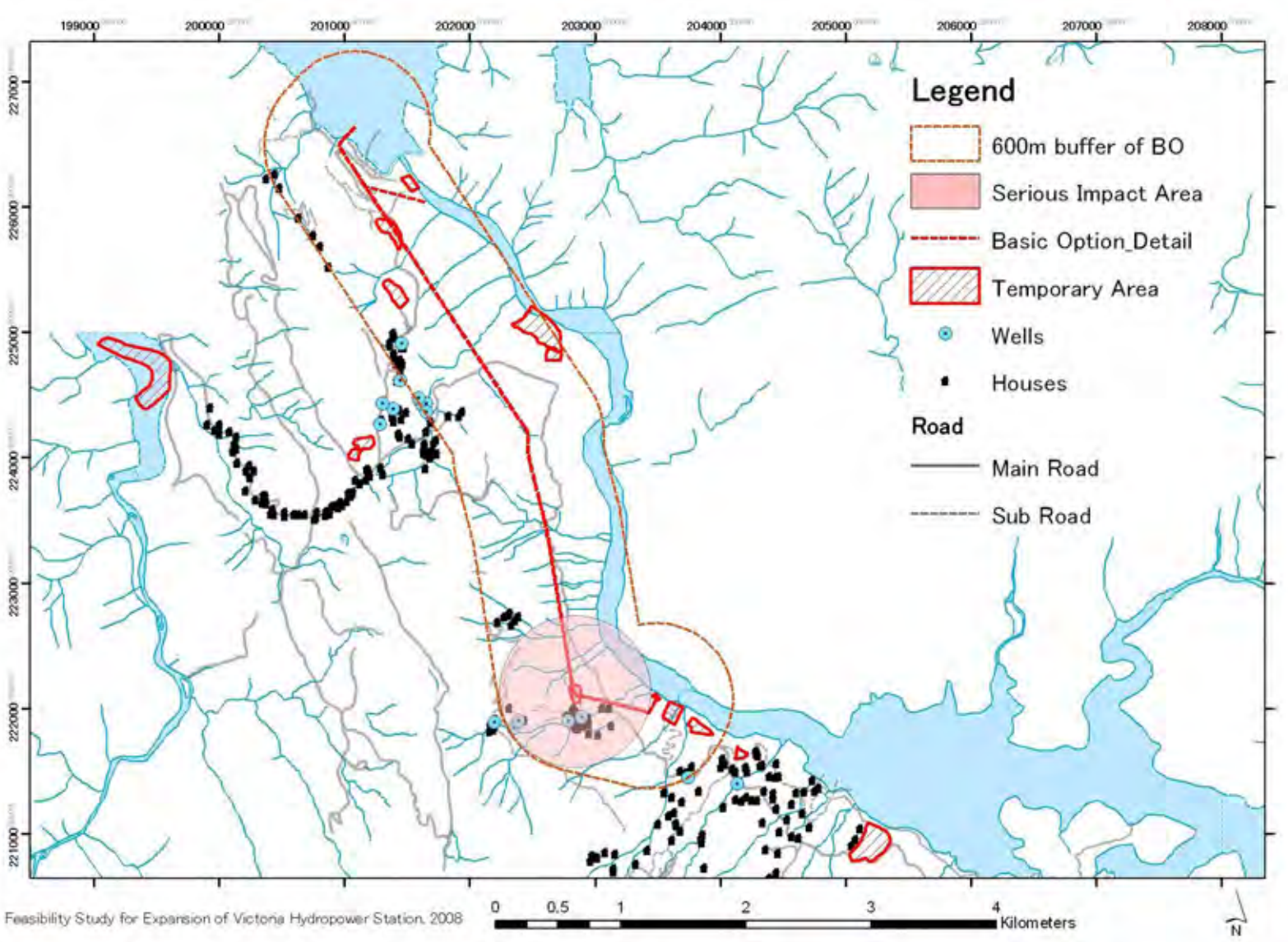

Figure 4-7 Location of the wells in the impact area

4.3 Ecological Impacts

4.3.1 Impacts on terrestrial fauna and flora (noise)

The proposed new tunnel runs at an average depth of 300m below the surface. The present Victoria Tunnel also runs parallel to the proposed new tunnel. As there is no impact to the ground level fauna and flora from the exiting tunnel, it is unlikely that the proposed tunnel would lead to any negative impacts to the fauna and flora in the project area. However, the increased noise during the construction period could have a nuisance effect and some disturbance to all fauna. While this is an irreversible impact, its severity could be minimized by the use of low noise generating equipment.

4.3.2 Impacts on aquatic fauna and flora with special reference to migration of fish species and environmental flow requirement of the down stream of the dam

Migration of fish and other aquatic species has been disturbed (completely disturbed) due to the construction of the Victoria dam. No provision has been made to maintain the environmental flow during the construction of the Victoria dam. The situation will remain the same during the construction of the proposed project as the control over the release of water from the Victoria reservoir is solely vested with MASL.

4.3.3 Impacts on wildlife and forest reserves (if any)

During the construction of the tunnel a large quantity of tunnel muck will be generated and these will have to be dumped in the project area. The contractor has identified six sites for tunnel muck dumping. The ecology team has investigated these sites and has prepared a report on the ecological status of these sites. The report is attached to this document as Annex 5 and 6.

4.3.4 Impacts on elephant migratory routes (Significant)

It has been estimated that the water level of the Mahaweli river downstream of the powerhouse can go as high as 2 meters maximum during the time of peak operation when both the existing and new power house are generating and the water level of the Rangenigla reservoir is at the practical Minimum Operational Level (MOL) of elevation at.209 m (see Annex 3.4). This could most probably prevent the elephants from crossing the river within that stretch. On very rare occasions, it is also possible that the rise of water and the high velocity of flow could cause injury to elephants who are already in the channel. However, according to locally available evidence, the popular migration route of elephants is the shallow areas of Randeniagala reservoir located downstream of this stream (which will not be affected due to the increased flow of the project).See figure 4-8.

Elephant movements in the Kohaombagana area may also get disturbed once Tunnel Muck dumping is started at this site.

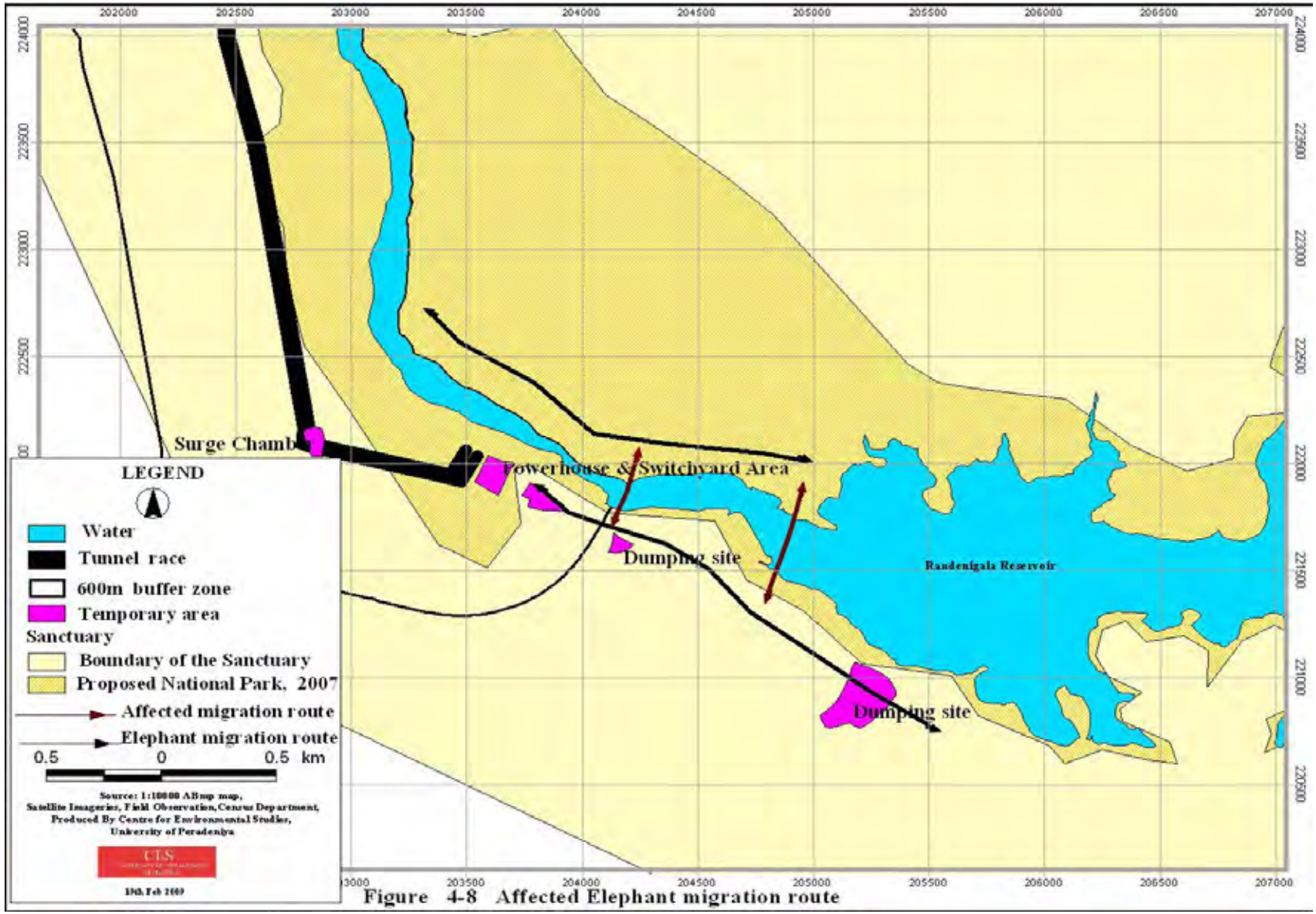

Figure 4-8 Affected Elephant migration route

Figure 4-8 Affected Elephant migration route

4.3.5 Impacts due to changing habitats of the area

Major change in habitats would occur in tunnel muck dumping sites. During the period of construction these sites will be filled with rubbles. Heavy machinery will operate in these sites day and night. Hence, animals will avoid these habitats completey during the construction period. However, these sites will be rehabilitated through restoring the vegetation cover soon after the completion of the constructions. This will eventually promote the colonization of the sites by faunal groups.

4.3.6 Impacts due to changing of feeding areas / migratory routes of animals

The feeding areas of animals will not be significantly affected as most of the faunal groups range in a fairly large area within the sanctuary. Elephants are the only animal that range in the largest area. Some elephants move to forested areas in Kohombagana at the base of the Victoria reservoir along the dry river bed passing the Power Station. Movements of these elephants could be disturbed during the time of construction.

4.3.7 Loss / disturbance of forest (Significant)

In the Basic Option, only an extension to the existing power house will be made while the present switchyard will also be used. Hence, there is no loss of forest due to construction of the power house and no new transmission lines are required. However, some vegetation cover will be lost due to the construction of workers quarters and vehicle parking / maintenance sites. (Figure 4-9) Most of the faunal groups (especially the higher vertebrates such as birds and large mammals) would avoid the construction areas completely.

Table 4-6 Estimated loss of vegetation by temporally facility area (ha)

Temporally facilities		Forest	Scrub	Paddy/ seasonal	Homestead	No vegetation	Total
A	Portal Area of Headrace Tunnel	0.22	0.65	0.00	0.00	0.00	0.87
B	Portal Area of Headrace Tunnel	0.94	0.07	0.00	0.00	0.00	1.01
C	Surge Tank Area	0.00	0.96	0.00	0.00	0.00	0.96
D	Powerhouse & Switchyard Area	0.00	0.00	0.00	0.00	1.61	1.61
E	Concrete Facilities (Crushing Plant and Batching Plant)	0.00	0.31	0.00	0.00	1.86	2.17
M1	Dumping site	0.00	0.00	0.00	0.00	2.06	2.06
M2	Dumping site	0.23	5.71	0.00	0.00	0.00	5.94
M3	Dumping site	1.33	0.00	0.00	0.00	0.00	1.33
M4	Dumping site	0.54	0.00	0.00	0.00	0.00	0.54
M5	Dumping site	5.07	0.00	0.00	0.72	0.00	5.79
Total		8.33	7.70	0.00	0.72	5.53	22.28

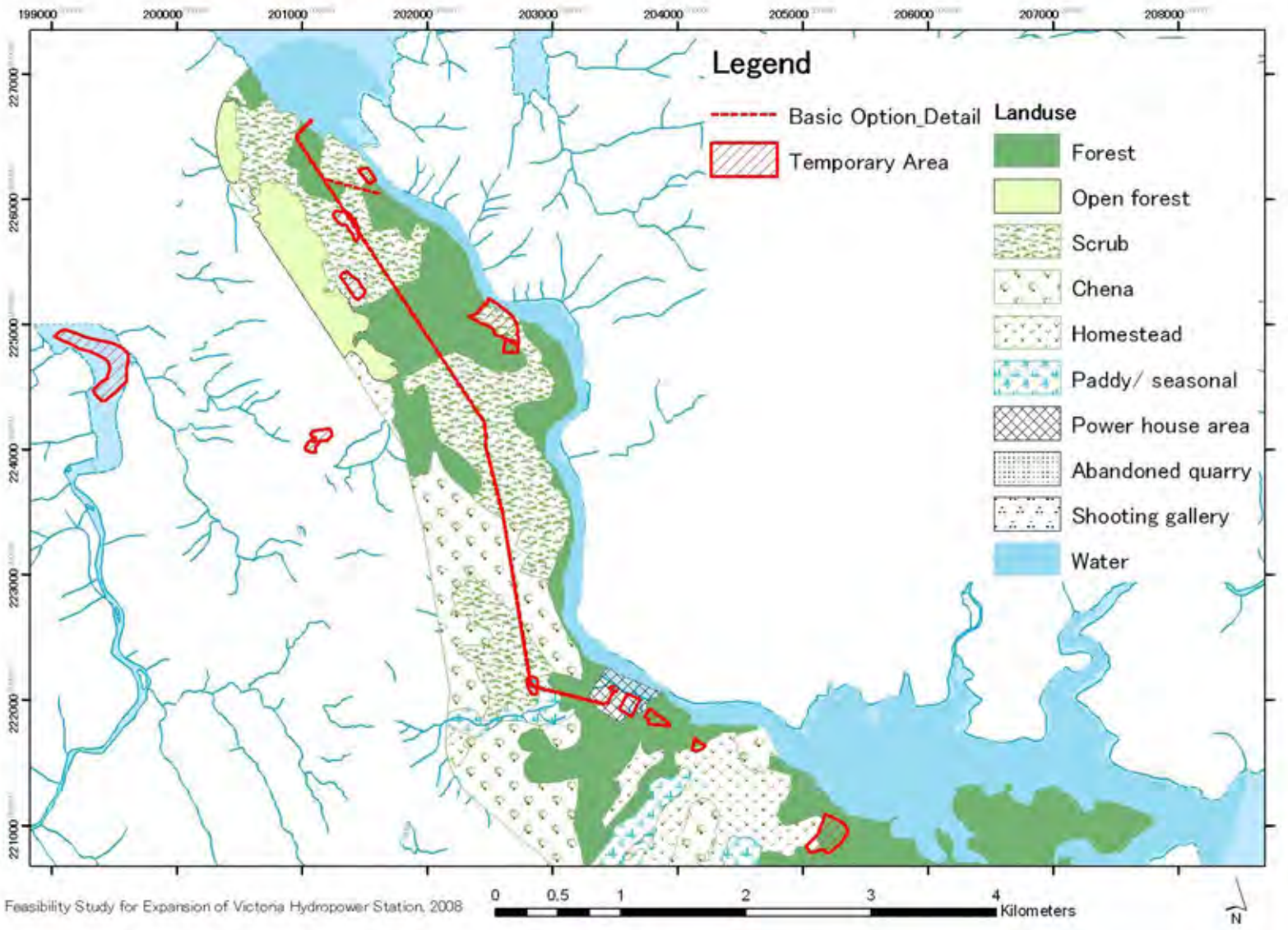

Figure 4-9 Loss of forest by temporary facility area

4.3.8 Impacts on wildlife reserves / interference with wildlife migration

Since the proposed development project is taking place in a wildlife sanctuary, its impact will be felt by the fauna and flora inhabiting the sanctuary. Migration of elephants in the area will be disturbed due to the construction work and tunnel muck dumping activities in some areas such as Kohombagna proposed dumping site where elephants move frequently. See Section 4.3.4 for the impact on elephant migration.

4.3.9 Flooding of habitats

No habitats will be flooded due this project activity. The increase in water level in the Mahaweli below the proposed power house during the peak hours will not be significant as this area anyway gets flooded when Randenigala reservoir fills up. If at all the additional increase in the water is likely to positively impact on the riverine habitats.

4.3.10 Changes in water quality and quantity associated with changes in habitat environment

During construction no major change in habitat is anticipated as the extent of disturbance on the ground surface area is at a minimum. Therefore, any water quantity or quality change due to any habitat environment change is not expected. However, if the wildlife tend not to move around the area due to construction activities, there will be minor surface water quality improvements as less contamination from animal droppings, etc. can be expected.

4.3.11 Fragmentation of habitats

Habitat fragmentation could occur due to the construction of Penstocks. However, this could happen only if Ooptions 2 or 3 are considered. Access roads to adits will also fragment the habitats.

4.3.12 Impacts on wetlands due to changes in water balance

No wetlands are associated with the project area.

4.3.13 Introduction of invasive species due to hydrological alternatives

Invasive shrub *Mimosa pigra* (Ginat Memosa) has already been established along the Mahaweli River bank and adjacent lands in the project area. This species has a great potential to colonize opened up areas in the project sites.

4.3.14 Impacts on rare / endemic species

Type locality of the rare endemic fish species *Labeo fisheri* (Mountain Labeo) has already been lost due to the construction of the Victoria Dam. The project is unlikely to have a devastating impact on any of the following endemic species as they are found in abundance in areas outside the PIA and the habitats that they live in are not significantly affected or destroyed by the Project.

Table 4-7 Endemic species

Items	Name	Common name	Category[10]	Hone Gardens	Chena	Grasslands	Scrub Forest	Secondary Forest	Stream Bank Vegetation	Impact
Flora	*Ziziphus lucida*	Eraminiya(S)	CR	+	+	+	+	+	+	+
	Argyreia populifolia	Giri-tilla(S)	Endemic	+	+	+	+	+	+	+
	Wendlandia bicuspidate	Rawan-idala(S)	Endemic	+	+	+	+	+	+	+
	Syzygium assimile	Damba(S)	Endemic	+	+	+	+	+	+	+
	Micromelum minutum	Wal-karapincha(S)	Endemic	+	+	+	+	+	+	+
	Derris parviflora	Kalawel(S)	Endemic	+	+	+	+	+	+	+
	Strychnos trichocalyx	Kaduru (S)	Endemic	+	+	+	+	+	+	+
Butterflies	*Troides darsius*	Common Birdwing	NT	+	-	-	-	+	+	+
Land snails	*Cyclophorus ceylanicus*	Common Snail	NT	-	-	-	-	-	+	-
Amphibians	*Duttaphrynus melanostictus*	Common house toad	Endemic	+	-	-	+	-	-	+
	Lankanectes corrugatus	Corrugated water frog	Endemic	-	-	-	-	-	+	-
	Fejervarya kirtisinghei	Montain paddy field frog	Endemic	-	-	-	-	-	+	-
Reptiles	*Chrysopelea taprobanica*	Sri Lankan Flying Snake	VU	-	-	-	+	-	-	+
	Bungarus ceylonicus	Sri Lankan Krait	NT	+	-	-	+	-	-	+
	Chrysopelea taprobanica	Green Pit-Viper	VU	-	+	-	-	+	-	+
Birds	*Ocyceros gigalensis*	Sri Lanka Grey Hornbill	Endemic	+	-	-	-	+	+	+
	Gallus lafayettii	Sri Lanka Jungle fowl	Endemic	+	-	-	+	+	+	+
	Loriculus beryllinus	Sri Lanka Hanging Parrot	Endemic	+	-	-	+	+	-	+
	*Pellorneum fuscocapillum**	Brown-capped Babbler	NT	-	-	-	-	+	-	+
Mammals	*Macaca sinica*	Toque monkey	NT	+	-	-	+	+	+	+
	Semnopithecus priam	Grey Langur	NT	+	-	-	+	+	+	+
	Manis crassicaidata	Indian Pangolins	NT	-	-	+	-	-	-	-

4.3.15 Impacts on biological diversity

The overall loss of biological diversity would be minimal in option 1. Temporary loss of habitats during the construction phase will be restored at the end of the project. No species will be lost from their respective habitats as no site-specific species have been recorded from the project area.

4.3.16 Possible impact on the fauna and flora of the river terrain k.m from the dam to the Power Station if the existing provision for the Mini Hydro facility is utilized as a part of the Capacity Expansion Project.

The river terrain from the Victoria dam to the power house remains a dry bed with exposed rocks (Figure 3.21) from the time of the construction of Victoria dam. Before the construction of the Victoria dam, this rocky areas of the Mashaweli River supported rare, endemic and endangered fish species namely *Labeo fisheri* (Mountain labeo). Mountain labeo showed a very restricted distribution within the Mahaweli River (ie. From Polgolla to Minipe anicut). Construction of Mahaweli reservoirs such as Polgolla, Victoria, Randenigala and Rantambe has resulted in displacing this rare species from its original habitat, and threatening it with extinction.

However, we have found a single specimen of this fish during our field sampling in a rock pool in the spray zone of the Victoria power station, an indication that there are a few isolated populations of this species still in the area.

[10] NT-Near Threatened / VU-Vulnerable / EN-Endangered / CR-Critically Endangered

The proposed project will not change the water management system, including the release of the environmental flow that is already being practiced by the MASL.

4.4 Impacts on Agricultural Fields

There will be temporary impacts on agricultural production due to the lowering of the ground water level as a result of this project. The impacts on paddy and chena cultivation, home gardens and other cash crops are discussed below.

4.4.1 Paddy cultivation (Significant)

According to the social survey, most of the farmers are of the view that tunneling could affect their paddy production. During Victoria stage 1, for example, the water springs in Hakurutale had dried up causing 20 families to be evacuated. This past experience is often cited to suggest that similar impacts can be caused by the proposed project. Thus the area around these water springs is defined as a serious impact area as given in Figure 4.7.

Due to lowering of the ground water level, paddy output will be reduced, though temporarily. The output reduction is calculated by using the total acreage (14.8 ha), average yield (60 bushels per acre), cost of cultivation per acre (Rs. 25,000) and the current market price of paddy (Rs. 28.00) during the *maha* season. Thus the economic loss from paddy production will be Rs. 1,503,182.72. This reduced output will persist during the construction period.

Table 4-8 Estimated economic loss of paddy cultivation

Land use	Impact Area	
	The Serious impact area	Project impact area
Paddy/ seasonal (ha)	14.5	14.8
Average yield (bushels/ha)	148	148
Price (Rs/bushel)	588	588
Cost of cultivation (Rs/ha)	61,774	61,774
Economic loss from paddy production (Rs./year)	366,125	373,700

This economic loss will transform into a social loss at the level of individual families. Paddy cultivation provides a substantial amount of rice for family consumption and therefore food security. Thus, the cash compensation will not necessarily meet the social value. When a cash compensation is given to a family, the possibility exists that it may be misused (e.g., the family may spend that money to buy luxury goods or the husbands may spend it on alcohol). This may lead to worsening economic conditions of a family causing women to seek extra employment.

4.4.2 Chena lands (vegeTable)

Chena is the main agricultural land use in the impact area during *maha* season in terms of extent especially in Hakurutale, Welikada and Ambewela GN divisions which mainly cultivate upcountry vegeTables. The estimated loss of production from the project is given in Table 4.9. Although Chena agriculture is primarily rainfed (except in Hakurutale where they grow vegeTables in the paddy fields during *yala* using stream water) and thus would not be

directly affected by any possible draw down of the ground water Table, the EIA team took a conservative approach by including chena also as an affected agricultural land use.

Table 4-9 Estimated economic loss of chena cultivation

Land use	Impact Area	
	The Serious impact area	**Project impact area**
Chena (ha)	39.7	113.8
Net Income (Rs/ha)	49000	49000
Economic loss from chena (Rs./year)	1,945,300	5,576,200

4.4.3 Home Gardens (Significant)

Homesteads account for about 10.6 ha in the impact area. Home gardens are located at the tail end of the project area towards the Randenigala reservoir in the village of Hakurutale and in Welikada. Home gardens are likely to be affected due to lowering of ground water level.

Table 4-10 Estimated economic loss of home gardens

Land use	Impact Area	
	Serious impact area	**Project impact area**
Homestead (ha)	12.2	10.6
Net Income (Rs/ha)	49,000	49,000
Economic loss from home gardens	597,800.00	1,272,530

4.4.4 Other cash crops: Wetland during *Yala* season (VegeTable) (Significant)

VegeTable cultivation in the paddy fields is the main agricultural activity in the *yala* season and is the main source of household income. Generally, the project will not impact upon these vegeTable cultivations. However, vegeTable cultivation in Hakurutale near the water spring may be negatively affected as a result of the lowering of the ground water level. Calculation of the loss of vegeTable cultivation is rather complex due to multiple varieties cultivated and their variable market price. Therefore, only an approximate calculation of the loss is given based on the information provided by the households. The total acreage that will be affected is 39.72 acres and the average income from an acre of vegeTables is Rs. 50,000.00. Thus, the total loss from vegeTable cultivation in the impact area will be about Rs. 9,64,000.00. The cost of cultivation is not deducted from this. This loss of vegeTable production will be there during the construction phase of the project.

4.5 Air Pollution

4.5.1 Exhaust gas from vehicular traffic

Impacts due to air stressors such as small particulate matters (dust) are expected to be most severe during the construction period. A secondary source of emissions may include exhaust from the diesel engines of transportation equipment, tunneling machinery and earth moving equipment. If construction machinery running with fuels such as diesel is used, harmful

gases such as SO_2, NO_2 and CO would cause air pollution. The degree of air pollution from construction equipment will greatly depend on the age and condition of the machinery and the operator of the equipment.

Change in air quality due to dust and exhaust fumes, dust due to exposed surfaces, rock blasting and increased traffic is possible. During the combustion of diesel or petrol, if the combustion is complete and if adequate oxygen is present the product should be carbon dioxide. However, in practice these conditions are not achieved resulting in partial combustion producing carbon monoxide, oxides of nitrogen and sulfur soot will pollute the environment. Dust due to earth works in construction activities and increased traffic on unpaved roads will be significant throughout the construction period.

4.5.2 Dust from construction

Dust is generated from construction and decommissioning activities, transportation activities and from tunnel construction and tunnel muck dumping activities.

Construction and decommissioning: these activities may generate emission of fugitive dust caused by a combination of on-site excavation and movement of earth materials, contact of construction machinery with bare soil, and exposure of bare soil and soil piles to wind. As mitigation measures, water needs to be sprayed regularly on construction sites and the bare soil surfaces must be paved or compacted.

Transportation activities: to mitigate dust problems from traffic in the project area, water must be sprayed on access roads and on construction sites. If not the access roads could be paved. During the operational phase, there will be no immediate sources of air pollution from the hydropower plant itself. However, the level of increase in air pollutants could be quite insignificant but it will need to be monitored closely.

Tunnel construction: dust during construction of the tunnel is the primary air pollutant from the project. Drilling and blasting techniques produce large quantities of fine particulates, which can create a temporary nuisance and health effect. The greatest risk to nearby residents / travellers will be during the initial stages of the portal constructions at the bottom of the proposed tunnel route; at other times dust management can be contained to the tunnel portal. Activities should be managed so that dust does not migrate to a significant extent beyond the vicinity of the work platform, and does not affect any dwelling. Dust management details should be contained in the Construction Environment Management Plan, and should be mentioned in the complaints procedures.

The aggregates crushing plant may also produce dust at levels which become a nuisance or health effect. Aggregates should be kept damp. The sitting of the plant should be as far as possible from dwellings to reduce the potential for dust deposition.

Materials handling procedures should be such that spoil handling is kept to a minimum to reduce the potential for creating dust. Materials should be kept damp.

Muck disposal; tunnel muck must be maintained damped before transportation as it can minimize dust during transportation. However, once muck is unloaded, activities at the dumping sites can cause significant dust pollution. Therefore the dumping site should be sprayed with water and the bare areas well-compacted..

4.6 Noise / Vibration (Significant)

In many instances, the impacts due to noise and vibrations during the construction period can be significant. During construction, noise and vibration will be generated from vehicular movements, sand and aggregate processing, concrete mixing, excavation machinery, construction noise, and blasting (Figure 4-10) . However the degree of concern greatly depends on many factors such as the construction process, type and condition of equipment used, and layout of the construction site, etc. Many of the factors of concern are traditionally left to the contractor's discretion, which makes it difficult to accurately estimate levels of construction noise. Hence, in this study the expected noise and vibration levels during the construction stage are compared against the standard values reported at similar construction sites elsewhere to obtain an idea about the noise and vibration impact of the related activities.

It is common that most construction sites today are heavily dependent on a variety of modern construction equipment. Thus the overall construction noise levels in a particular site are governed primarily by the noisiest pieces of equipment. For most construction equipment, the engine, which is usually diesel, is the dominant noise source. Table 4-11 illustrates the noise levels at a location 15 m and 30 m of the noise generating construction equipment associated with the various stages of construction. Typical maximum noise emission levels (L_{max}) and equivalent continues A-weighted sound pressure determine over a eight hour time interval ($L_{ACq\,8}$) levels at a location 15 m away are summarized; based on construction equipment operating at full power. Although the noise levels given in Table 4-11 represent typical values, based on (a) the condition of the equipment (e.g., age, presence of mufflers and engine cowlings); and (b) the technique of use by the operator (aggressive vs. conservative), there can be wide fluctuations in the noise emissions of similar equipment.

Table 4-11 Typical values of noise produced by common vehicles and equipment used in construction activities

Equipment	L_{max} at 15 m /dB(A)	$L_{ACq\,8}$ at 15 m /dB(A)	$L_{ACq\,8}$ at 30 m /dB(A)
Auger/drill rigs	85	82	76
Telescoping boom bucket trucks	81	71	65
Front Loader	80	75	69
Dump Truck	71	63	57
Concrete truck	82	79	73
Vibratory hammer	85	82	76
Diesel construction train	77	58	52
Generator (nighttime lighting)	82	70	64
Pneumatic drill (in concrete)	85	80	74
Utility truck (with crane)	81	76	70
Flat bed truck	78	68	62
Compactor	81	75	69
Dozer	85	82	77
Hammer to drive rods (small vibrator)	86	80	74
Backhoe	80	75	69
Wood saw to construct forms	88	82	76
Forklift	80	74	69
Large crane	85	82	76

According to the proposed noise standards, the construction area shall not produce noise exceeding 75 dB during day time (06.00 – 21.00 hrs) and 50 dB during night time (21.00 – 06.00).

The main potential impact of high noise levels and vibration will be on the construction workers since tunneling activities are not expected to generate impacts to villages located near the construction sites. However, if any noise or vibration occurs, these noises / vibrations may be disruptive to daily village life, particularly against current low ambient noise levels, although they at the same time are integral to construction practices. Thus noise and vibration mitigation and control measures should be documented in detail in the Construction Environment Management Plan that allows contractors to complete the works while providing the community with an expectation that disruptions will be kept to a practicable minimum.

Noise Levels during Machinery Operation

The Figure 4-10 shows the area that is expected to experience noise levels exceeding 70dB during the operation of construction machinery and the movement of construction vehicles. The impact areas shown include houses mainly along the roads where construction vehicles will travel. The anticipated instantaneous sound level along these roads during vehicle travel exceeds the stipulated standards available for 8 hour average (but the 8 hour average sound levels anticipated is much lower as the expected frequency of construction vehicle movement is low). However, a few houses (about 8 units) close to other project sites will experience sound levels exceeding the stipulated standards. Therefore, the expected sound levels from this project are not expected to cause significant impacts on the community and the environment. However, operations during night time should be restricted as the standard is 50dB.

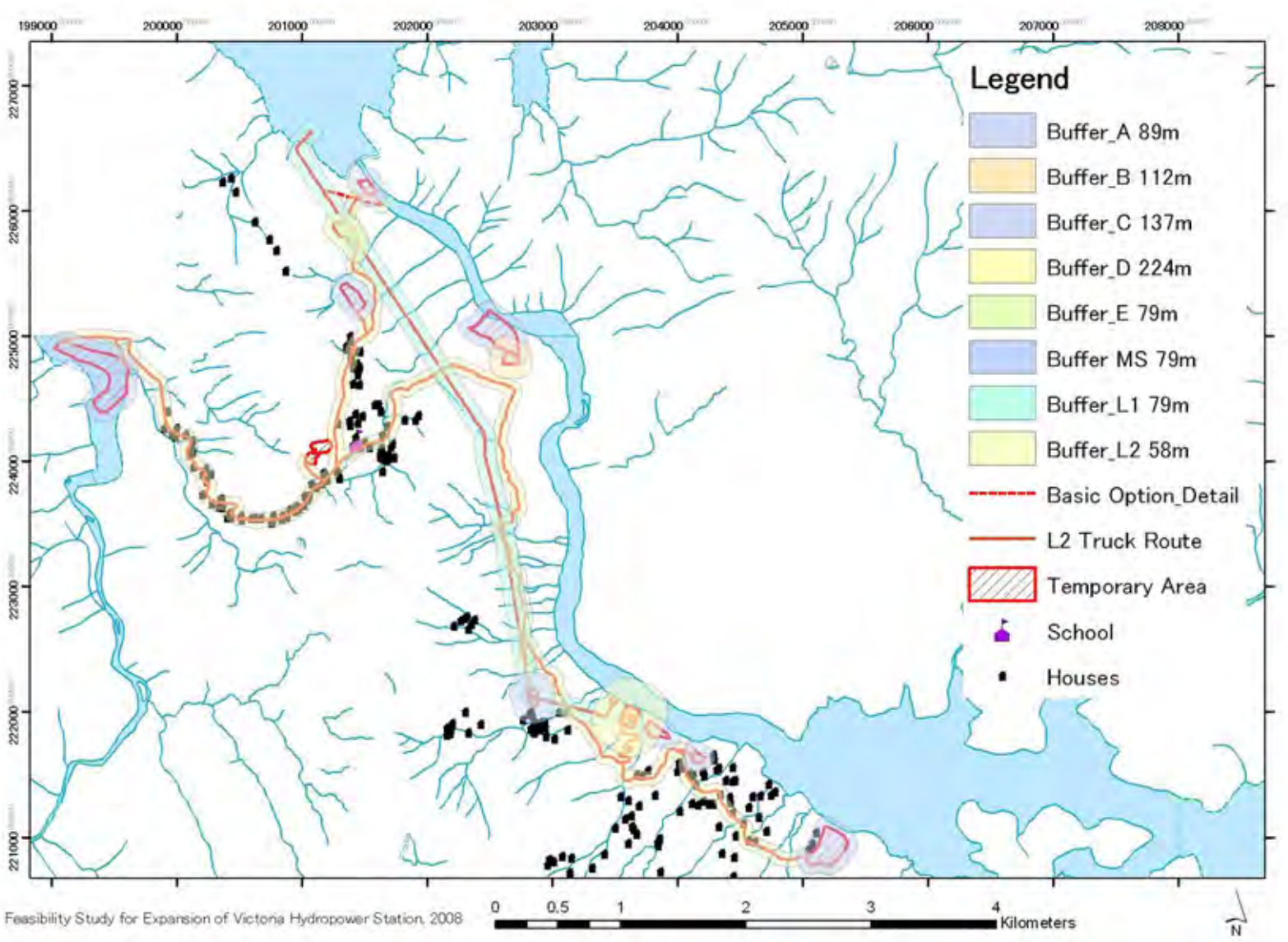

Figure 4-10 Noise Impact Area

4.7 Sociological / Cultural Impacts

4.7.1 Change / disruption of lifestyle

As a result of the inflow of outside workers into the area, there might be disturbances to social cohesion in these predominantly rural settlements. The inhabitants expect positive benefits which will change their lifestyles. For example, the small vendors and boutiques in the impact area will positively benefit by the inflow of outside workers. Especially during the construction period, the project will have a positive impact on the economy thus changing their life styles.

4.7.2 Conflicts between resident people (Significant)

The project will not induce any conflicting situations among members of the resident population. It is evident from the stage 1 that while residents were divided into two groups, pro and against the project, the division did not escalate to the level of a conflict. As the area is ethnically homogenous, the divisions among the residents are not significant.

4.7.3 Relocation of the income generation activities

The project will not have any direct impact on the relocation of income generation activities. (See section 4.7.18 and Figure 4-11)

4.7.4 Change in the economic infrastructure

Roads and electricity are the main economic infrastructures available in the impact area. The road section of Rajamawatha within the impact area may have negative impacts due to the transportation of muck. The road may also experience traffic congestion during the construction period.

4.7.5 Change in land use pattern

As discussed under the project details much of the project works will be confined to the underground; only the surge tank and the powerhouse will be constructed on the surface. In addition, dumping sites will be opened on the ground. Therefore, direct impacts on land use will be limited to those land use categories.

Table 4-12 Impacts on Land use

Land use	Significant change
Chena	0.00 ha
Forest	8.40 ha
Homesteads	0.72 ha
Scrubs	7.70 ha
Shooting gallery	1.86 ha
Power house area	2.06 ha
Paddy seasonal crops	0.00 ha
Quarry	2.06 ha

- the existing quarry will be used for dumping tunnel muck and the shooting gallery will be used as a concrete mixing facility. This is the only shooting ground available in the Kandy area as mentioned by the Chief Officer attached to the Victoria camp.

- Paddy mainly grows in the *maha* cultivation season in the area using available rain and creek water. A main water source in the impact area is the Hakuruthale spring under which 39 acres of land are used for paddy cultivation during the *maha* season and for vegeTable cultivation in the *yala* season. This cultivation was obstructed during Victoria phase I due to the drying up of the spring. It might happen this time too and the problem will continue until the lining of the tunnel with concrete. Therefore, it is a short term impact though it is significant as 20 families entirely depend on it. In Victoria phase I those people were evacuated although they returned later.
- Though the quarry site will be filled with muck, it will not have any significant socio-economic consequences.

4.7.6 Impact on property values

The value of properties such as land and houses will not change significantly as there is no rural development component within the project. However, due to the powerhouse construction property values at Hakuruthale will slightly increase.

Table 4-13 Estimated impact area (ha)

Temporally facilities		Forest	Scrub	Paddy/ seasonal	Homestead	Total
M5	Dumping site	5.07	0.00	0.00	0.72	5.79

4.7.7 Effect on Education

Two primary schools located close to the tunnel are already closed due to inadequate registration of students. There are no other schools with in the impact area. The Victoria School located in Welikada, just outside the PIA, may experience a slightly increased noise generated from the increased movement of heavy vehicles. But this is unlikely to be significant.

4.7.8 Effects on Health

Water-borne diseases, dust related diseases, and accidents are common in many projects carried out in Sri Lanka in the past. The water related diseases such as malaria will be irrelevant here as pooling of water will not take place. However, dust could be a problem at the Khombagana dumping site where about 20 houses are located on its western perimeter. In addition to them accidents are common when workers are working underground with machines. During the social survey, we came across three persons from the area who suffered from accidents from the Victoria Phase I project. However, adherence to proper safety procedures could minimize such incidents.

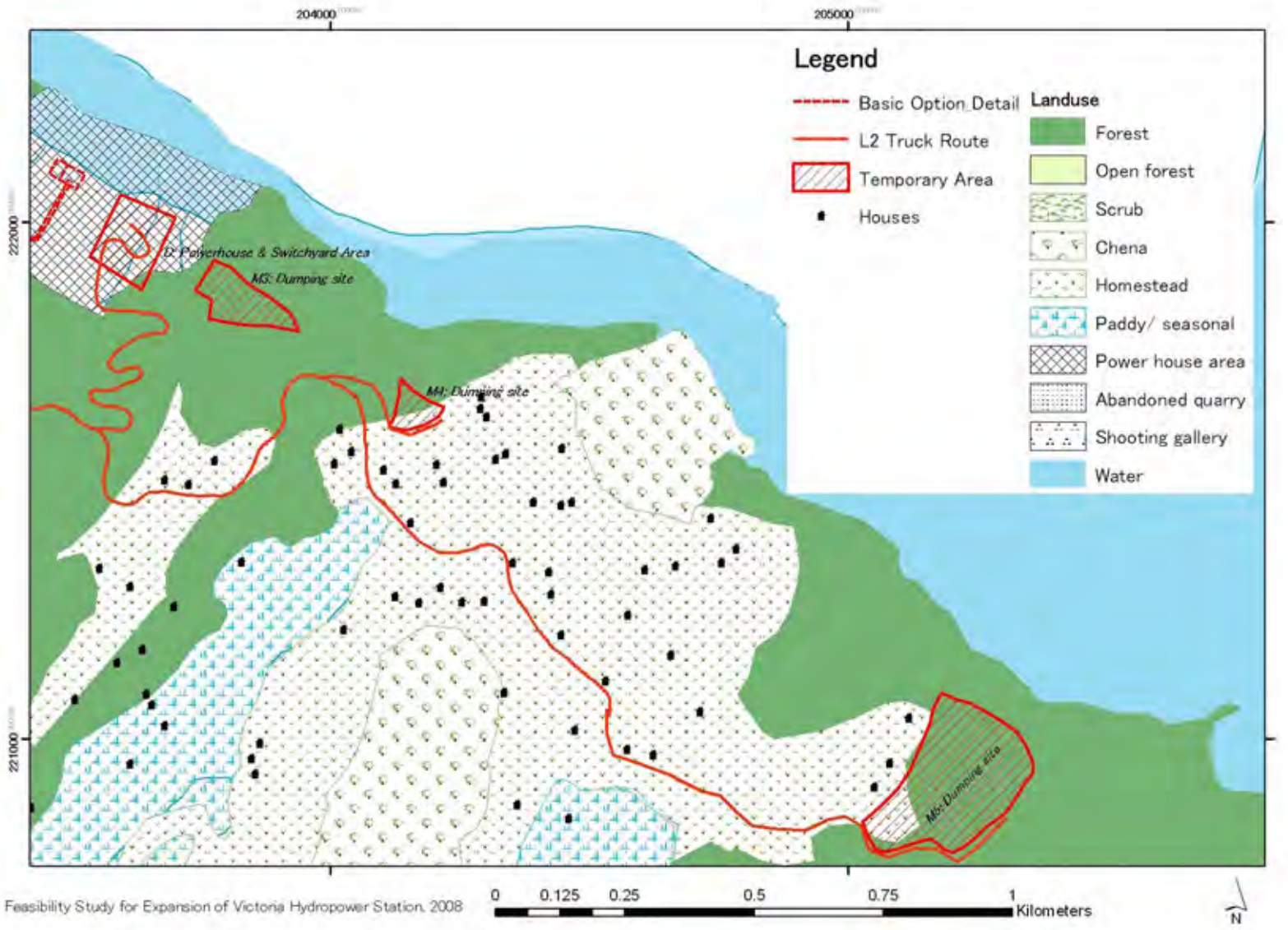

Figure 4-11 Loss of private land at tunnel muck dumping site in Kohombagana

4.7.9 Impact on quality of life

The economic aspect of life of many people will grow at least during a period of 5 years. Thereafter this will decline. However more than 80 people will have better economic conditions with the start of the operation of the powerhouse. Beneficiaries will be the employees of the power house, and shop and boutique owners. This is a positive long term impact of the project.

4.7.10 Employment generation during construction & operation (Significant)

The project will generate regional employment opportunities directly and indirectly. Direct employment will be generated through direct recruitment to project work as the project will prefer to hire local inhabitants for two major reasons. First, local labor will be cheaper than outside labor. Second, the labor supply will be more reliable as the workers are resident in the same area, thus involving no transport cost to the workers.

The project may generate indirect employment as the local inhabitants may even start new boutiques and food stalls targeting workers in the project. Also, the inhabitants in the surrounding area may employ themselves as agents providing certain building materials to the project.

4.7.11 Impact on sites and monuments of historical, cultural and religious significance

The temple Siri Dalanda Viharaya is located on the boundary of the PIA. At present, a *stupa* is being built on a large rock located inside the PIA. The chief incumbent of the temple has expressed concern over possible impacts of vibration. However the technology used in drilling the tunnel will not have any impact on the rock which in located over 200 meters vertically and 250 meters horizontally away from the proposed tunnel trace.

As mentioned in 2.2.4.9.5, any blasting work for tunnel excavation has limitations with a maximum on blasting vibrations against the existing tunnel which is located 36m away from the new tunnel. As also shown in the Table, places which are located more than 200 m from the blasting point will not be affected due to blasting.

4.7.12 An existing transportation system

The new tunnel is dug parallel to the existing tunnel and it crosses the road at two places. As it is dug deep in the ground the tunneling will not have an effect on transportation. However, the transportation of tunnel muck along this road to the dumping sites will have a negative impact on the smooth flow of traffic at present. 18 km of existing roads will be affected for 4 years.(Figure 4-12)

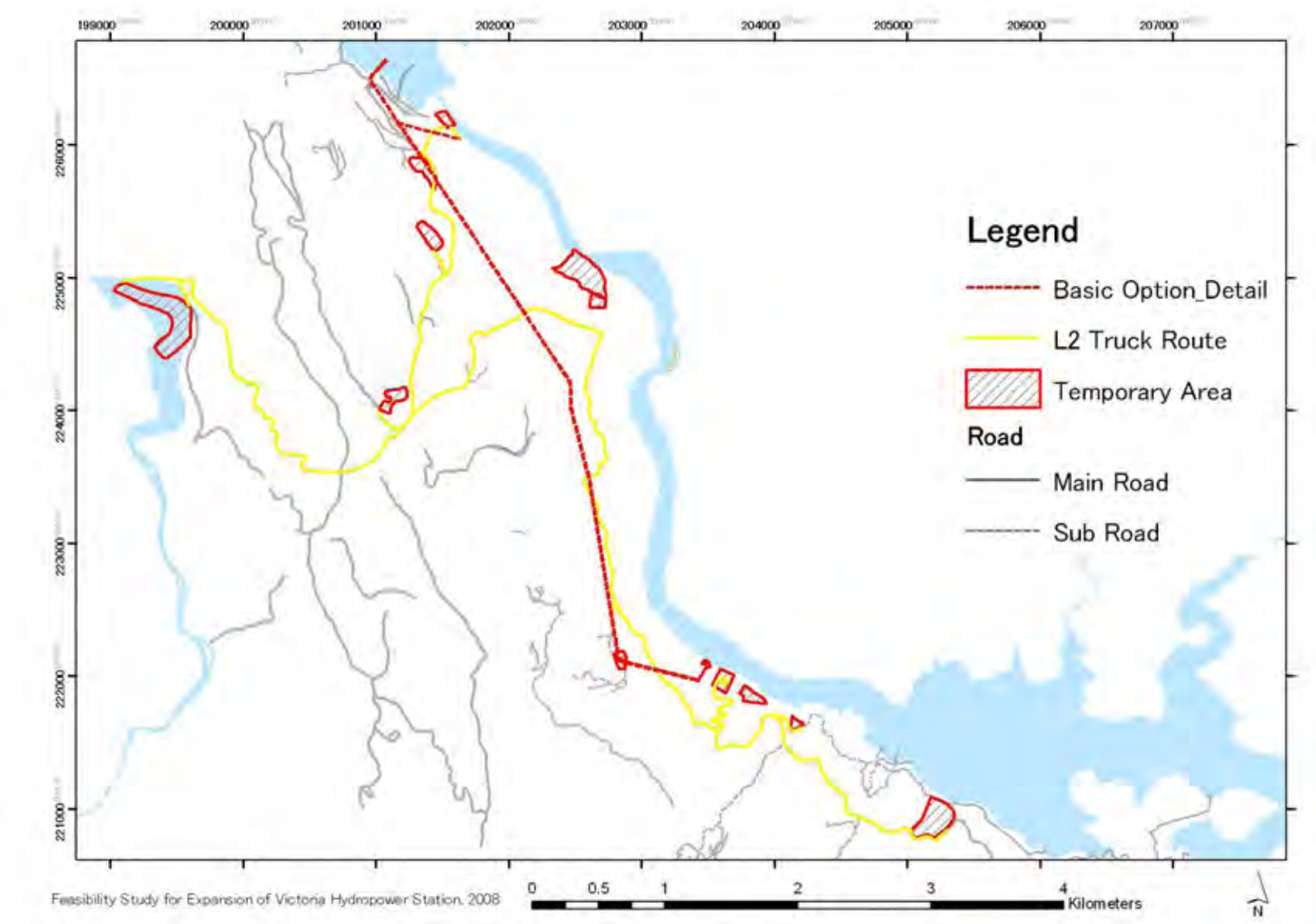

Figure 4-12 Heavy trucks routes

4.7.13 Impact on existing water extraction/ irrigation schemes and downstream area (Significant)

There are no major or minor irrigation schemes above the tunnel. However, during the survey it was noticed that some families were taking water from small pipes fixed to streams. But there are two major irrigation schemes in the lower area, Victoria and Randenigala. Water level of Victoria and Randenigala will not change in the long term due to the proposed intervention. But, as mentioned previously, water extraction by villagers from pipes will experience significant negative impacts in two ways during the construction period.

(a) Possible drying up of some springs
(b) Pollution of water sources due to releasing of impurities with water from tunnel and camp sites.

Problems with water during Victoria stage 1 was reported by the villagers in all GN divisions. Therefore, it is wise to keep on eye on these villages during the construction period. The situation however may be more serious at Hakuruthale GN Division causing difficulties to 20 houses (this is discussed in detail under paddy cultivation).

The pollution of water source occurs at streams close to the releasing points of waste water from the tunnel. This can happen due to the release of oily, greasy (liquid waste) and other small particles with iron and rock (solid waste). This is a significant negative impact happening during the construction period.

There is no significant downstream impact from this development

4.7.14 Impact on existing water extraction for drinking purposes (Significant)

As discussed under existing environment half of the households in each village use water from either streams or springs for drinking purposes. The drawdown of ground water due to tunneling operation will reduce the ground water availability for the villagers. The most affected villages are Hakurutale and Welikada. Table 4.15 and Figure 4-13 shows the number of houses affected.
The extent of the impact on drinking water is classified into two: significant impact area and possible impact area.

Table 4-14 Number of houses affected by underground water deterioration

GN Division	Number of households		
	Significant impact area	Possible impact area	Total
Hinguruladuwa	0	0	0
Ambewela	0	6	6
Welikada	0	19	19
Bogahalanda	0	0	0
Hakurutale	22	7	29
Hilpenkandura	0	3	3
Total	22	38	57

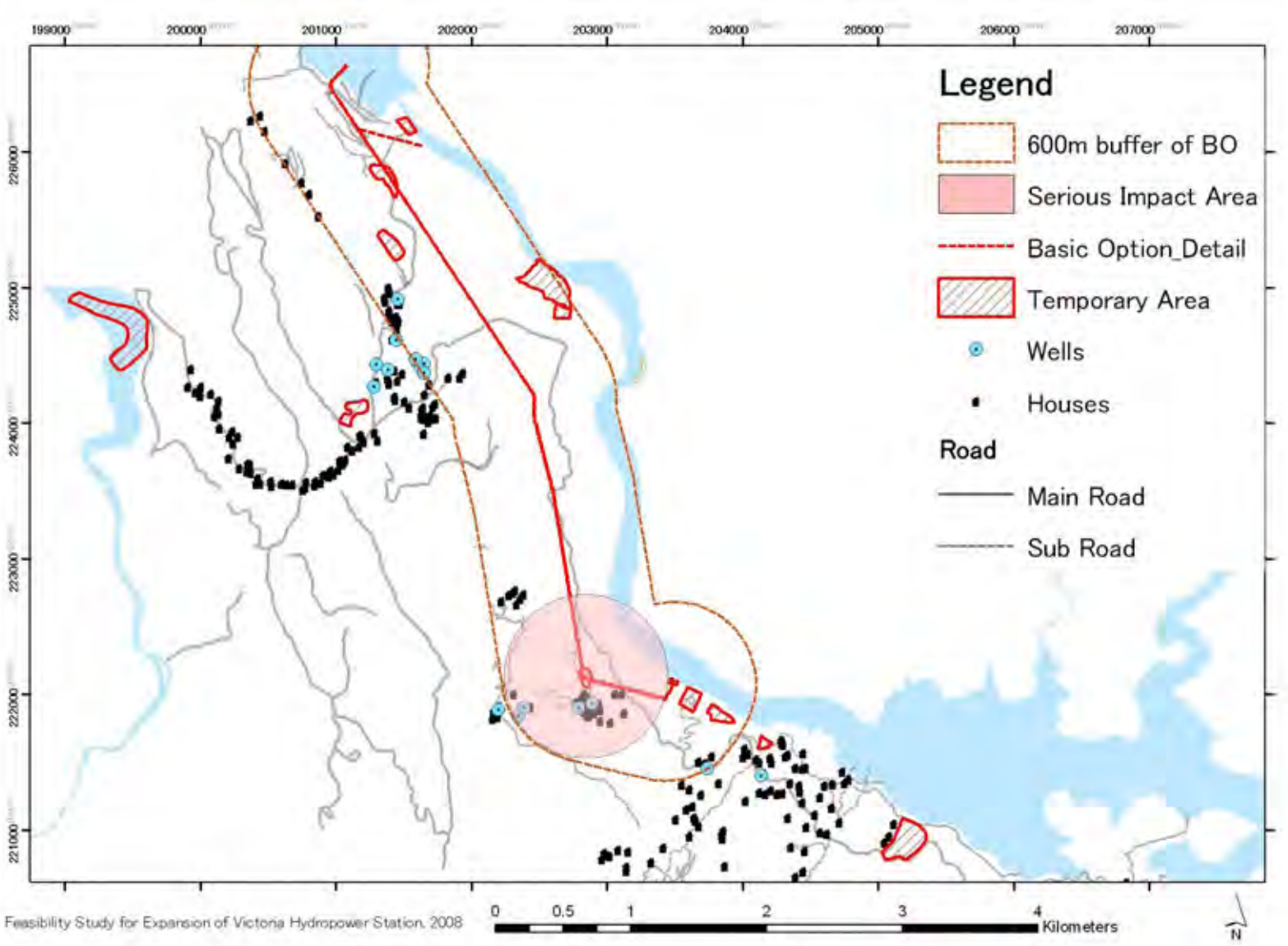

Figure 4-13 Temporary lowering of ground water affecting domestic uses

4.7.15 Impact as flood protection

As the proposed project will not cause any flooding, flood related impacts are not expected.

4.7.16 Impacts due to material and machinery transportation (Significant)

Muck transportation will generate dust which will impact on residents, shopss boutiques, vegeTable vendors settled on both sides of the road, and children commuting to school. (Figure 4-14) But as the roads are surfaced, the likelihood of dust becoming an unbearable problem is less. However, the frequent movement of heavy trucks could damage the road surface.

4.7.17 Migration of the people into area

The nature of this project is such that it will not develop any services, such as new roads, towns, public spaces, etc., which will induce the migration of people into the area. Therefore this is not considered as a significant impact. However the area close to the powerhouse may be more attractive, therefore a small number of people at least from surrounding area may settle in the area if the Wild Life Department does not keep vigilant (According to the current rules and regulations pertaining to Sanctuaries new developments inside of the Sanctuaries are illegal). During the social survey, it was seen despite regulations new houses and shops were coming up.

4.7.18 Relocation of People – Payment of Compensation for the loss of private lands (Significant)

The proposed project will not relocate people.

The tunnel muck dumping site at Kohombagana contains private lands. (Figure 4-11) The maximum amount of private land that might be used for this purpose is 6.2 ha. These lands, although privately owned and was used for sedentary agriculture including chena practices, have been left fallow for over a decade largely due to the continuing disturbances of wild elephants. The lands were now overgrown with vegetation and appears as a secondary forest. As these lands fall inside the core area of the VRR Sanctuary people cannot practice agriculture anymore. Because of both these facts, there is no market for these lands and thus during consultations, the people agreed to part with the ownership of these lands for a reasonable compensation around Rs. 100,000.00 per acre.

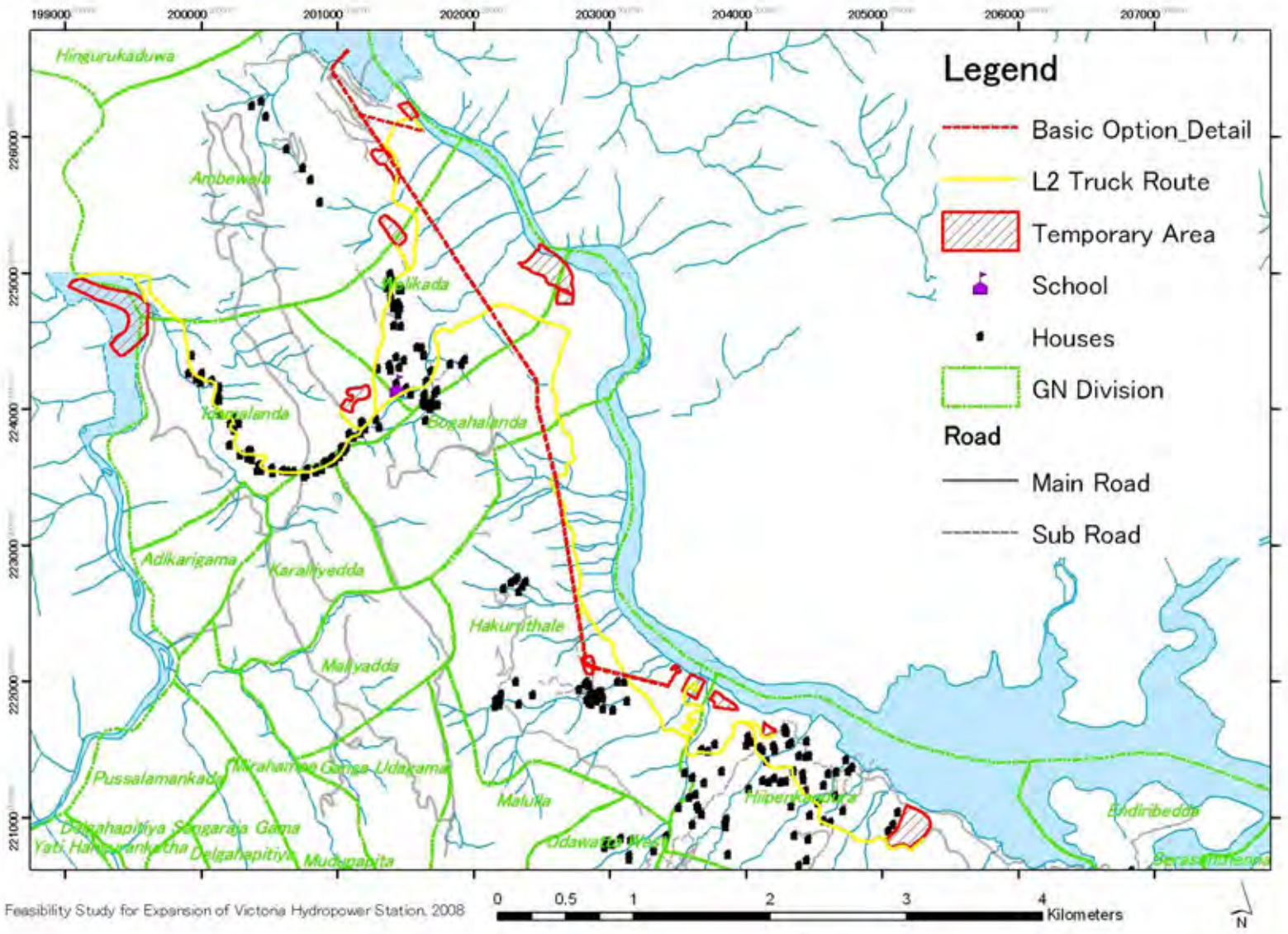

Figure 4-14 Location of houses and heavy trucks route

4.8 Impact during construction work

4.8.1 Construction hazards

Major construction hazards taken into account in project construction planning are as follows:

(a) Impact on blasting against the existing structures
(b) Selection of temporary facilities areas and spoil banks (muck damping areas)
(c) Precautions and measures against accidents during construction works.

Because the existing structures such as the dam, its abutments, intake, tunnel, and powerhouse are located near new structures, control blasting methods will be adopted as mentioned in 2.2.4.9 and in other relevant sub-clauses required by TOR.

Since the project area is located in the VRR sanctuary, temporary facilities areas and spoil banks are selected from the areas previously used for construction or owned by CEB/other organizations.

With regard to item (c), traffic accidents caused by vehicles for the works, fire disasters in the tunnel due to incorrect handling of explosives, human accidents due to lack of oxygen caused by malfunction of tunnel ventilation, accidents due to heavy leakage water in the tunnel, those due to muck scattered by blasting are considered significant during the construction period. As precautions, it is proposed that correct handling of explosives by qualified workers, installation of ventilation systems with enough capacity and continuous maintenance, providing escape routes for evacuees at the time of heavy water leakage in the tunnel, installation of safety nets to prevent muck from scattering will be undertaken by the contractor. Such precautions will minimize the damages.

With regard to concerns other than those mentioned above, measures taken in similar projects will be adopted as stated in the relevant sub-clauses in this report.

4.8.2 Impact of the blasting works (Significant)

To prevent impacts of blasting on existing structures such as the dam, its abutments, intake, tunnel, and powerhouse blasting should be controlled by the use of appropriate specific charges in the blasting rounds to limit peak particle velocity below 2cm/sec against the nearest structure. Entrance to the stub should be barricaded to avoid accidents in the last 15m before holing. All sockets left in the old blasting should be pumped and free of any remnant explosives. Protection against the installed gate is also necessary at this stage. Impact on the existing tunnel and the surge tank is discussed under impacts on bed rock stability due to tunnel construction. Figure 4.15 shows the location of new tunnel relative to the existing tunnel. Very special care is needed in the choice of blasting pattern and explosives charges to prevent any blasting damage to the existing tunnel.

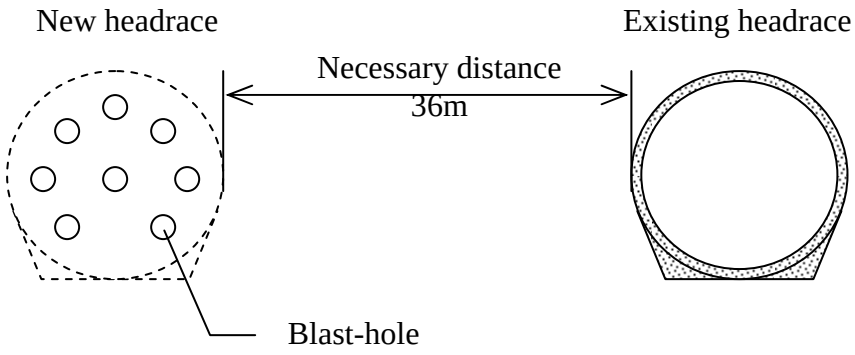

Figure 4-15 Distance between New headrace tunnel and Existing headrace tunnel

4.8.3 Impacts of water issues for D/S irrigation

The operation of the Victoria reservoir will not change with the new extension. The only change is that the water releases will be done only during the peak hours of power requirement. The total water quantity of generation and releases will be the same as at present. In this case the bulk water issues will be decided at the water management meeting conducted by MASL. Based on these bulk issues and present climatic conditions the weekly release will be decided using system simulations. CEB will then decide on the daily releases to total up the weekly allocations based on their generation and distribution system optimizations. There will be no change in this system of water management and there will be no change in bulk quantity allocation which in turn implies that the releases from Victoria and Randenigala reservoirs will not change.

The construction will occur only in the downstream of the reservoir. All the intake structures from the reservoir were completed during phase 1. Therefore, no construction is required at the reservoir which needs lowering of the water level. The bulk heads are used to close the existing portion of the proposed tunnel which is about 20m in length and completed. As all construction can be performed without any interference to the existing reservoir, the reservoir operations are not affected during the construction or commissioning of the project.

Table 4-15 Agriculture area estimated as affected by lowering underground water (ha)

Land use	Impact Area	
	Significant impact area	Possible impact area
Chena	39.7	113.8
Homestead	0.0	10.6
Paddy/ seasonal	14.5	14.8
Total	54.2	139.2

See Figure 4-16 for details.

4.9 Impact by tunneling change (Significant)

Tunneling will definitely intercept some aquifers as encountered in the existing tunnel. However, past experiences can be used to meet conditions in advance. The lowering of ground water Table can be minimized by drilling under grout cover at locations of high ingress of water. Table 2-5 gives the locations of high ground water flow.

4.10 Impact on water operation

4.10.1 Impact on water management operations of the Reservoirs

The normal water management of the Victoria and Randenigala reservoirs are based on the operating rules of each reservoir and decisions taken at the biannual water management meeting conducted by MASL. It is true that the discharge capacities of the Victoria reservoir is increased during this extension, but as the reservoir operation is only based on the inflows to the reservoir and the existing available water quantity the total discharge from the reservoir cannot be changed. The purpose of the extension is to generate only during the peak power demand period of the day instead of throughout the day. This is achieved with shorter generation hours with higher discharge rates but totaling to same power release as before.

4.10.2 Effect or impact of future operation rules of Victoria and Randenigala Reservoirs

Victoria reservoir

Operation rules of the Victoria reservoir is proposed to be revised in the feasibility study along lines that the requirement of irrigation should be released through the tunnels and that operation of the spillway gates and the bottom outlet by MASL should be kept closed.

Randenigala reservoir

It is true that the discharge capacities of the Victoria reservoir is increased during this extension, but as the reservoir operation is only based on the inflows to the reservoir and the existing available water quantity the total discharge from the reservoir cannot be changed. The purpose of the extension is to generate only during the peak power demand period of the day instead of throughout the day. This is achieved with shorter generation hours with higher discharge rates but totaling to same power release as before.

In addition, as mentioned in the next clause, 4.10.3, with full operation of the existing and expansion units, the rates of the drawdown of water level in the Victoria reservoir is estimated to be small, hence the impact on water level fluctuation is negligibly small.

It is considered that the present operation rules of the Randenigla reservoir will not be affected due to the expansion project.

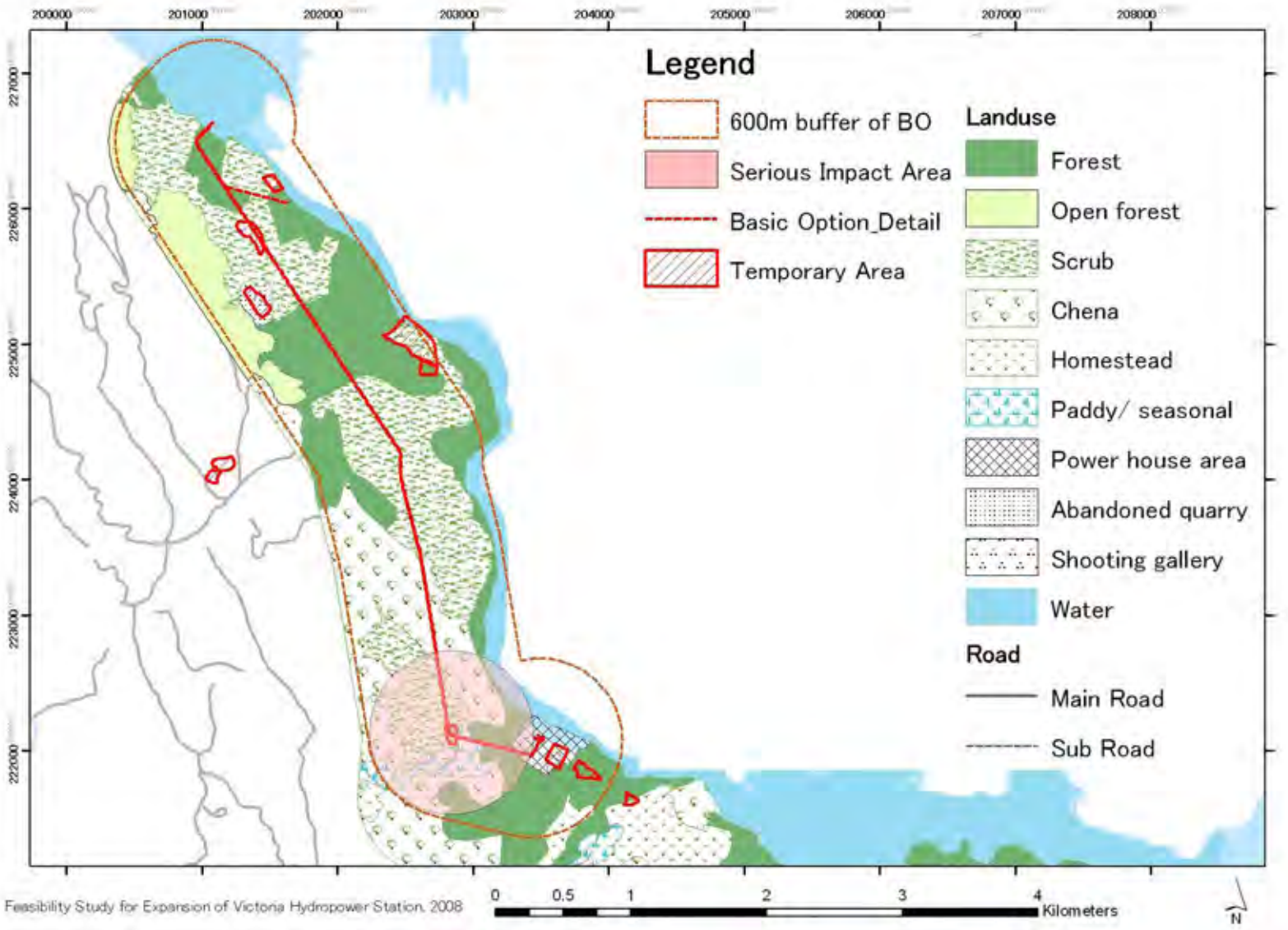

Figure 4-16 Temporary reduction in agricultural production to lowering of ground water

4.10.3 Impacts due to daily fluctuation / variation of the water level in Victoria, Randenigala and Rantambe reservoirs

The proposed enhancement of power production by the new project does not involve releasing additional water from the Victoria Reservoir. According to the agreement with Mahaweli Authority, it has been proposed to enhance power production using the same quantum of water. Therefore, the total daily amount of water use for the hydropower generation will not be changed after the expansion of the hydropower plant. The daily fluctuation of the water level in the Randenigala and Rantambe reservoir will thus be the same as before.

With full operation of the existing and expansion units, the rates of the drawdown of water level in the Victoria reservoir is estimated as;

- Minimum Operational Level (MOL) : 36.5 cm/hour
- Full Supply Level (FSL) : 4.6 cm/hour

The above rates are based on the assumption that no inflow into the Victoria reservoir is accounted. Therefore, the actual rate of drawdown will be smaller than the above figures. Consequently, the rate of the drawdown is small and the impact on water level fluctuation will remain negligibly small. Hence, the daily outflow from the Victoria Reservoir and inflow into the Randenigala and Rantambe Reservoirs will remain at about the same level.

4.10.4 Impacts of daily water level changes on behavior of Victoria Dam

As mentioned in the section 4.10.3, no significant change in the Victoria reservoir is anticipated by the very small reduction of the water level. Therefore, no significant change in the Victoria dam behavior is anticipated either.

4.11 Impacts of the tunnel muck dumping (Significant)

Tunneling muck will be an environmental concern. One concern is the ecological impact. The second is the stability of the dumps. The third is the possible washing of fines to the streams.

On Surface and Ground water quality: As the method of tunnel muck disposal is open dumping, it will cause release of certain wastes, especially suspended solids, into the surface water sources with rainfall runoff. If tunnel muck contains unused basting materials, chemicals, other wastes, etc., those too will be released to both ground and surface water sources along with the rainfall runoff.

4.12 Impacts on bedrock stability

- Penstock installation

Penstock installation can be carried out on exposed bed rock. The bed rock here consists mainly of Garnetiferous Biotite Gneiss which is weather resistant. The bed rock is competent to support and anchor the penstock. Sliding along the planes dipping at 15 ° will be marginal. However support is necessary against block failure that can be caused by the near vertical joint system at the site.

- Power house construction

The power house foundation has already been constructed. There is no danger of bed rock sliding on the powerhouse. The slope excavation near the powerhouse site will need support against block failure similar to the site of penstock installation.

- Tunnel construction

The bedrock stability will be a concern during tunnel excavation and construction. The existing tunnel runs through good rock mostly but some weak zones have been identified in Table 2-5 in Section II. The existing tunnel has been appropriately supported by roof bolting, spiling and steel arching depending on the severity of instability of bed rock. A similar supporting method can be applied in the proposed tunnel. The difficult zones can be anticipated in advance. At three locations along the tunnel the influx of water has been severe. These horizons consist of limestone and quartzite. It is possible to minimize the influx of water into the tunnel by providing a grout cover in advance of mining of such weak zones.

Regarding blasting work to prevent the existing tunnel and structures from damaging, proposed measures are mentioned in 2.2.4.9 and other sections required in TOR. Necessary tunnel support should be installed to maintain stability of the surrounding rock. Grouting in the tunnel in advance at weak sections should be carried out to minimize seepage and roof collapse.

- Surge Tank Excavation

The surge tank is offset horizontally about 40 m away from the existing surge tank. Since the position of the existing surge tank was shifted to avoid a heavy influx of water the new tunnel is unlikely to encounter similar flow conditions.

The total depth of this surge tank is about 150 m. The diameter of the vertical excavation for the surge tank is 22 m. The most appropriate excavation would be to widen to the required diameter an excavation made by raise climbing or by raise boring. Due to the large diameter and due to the verticality of the excavation it is easy to control direction. Therefore there is no possibility of holing into the existing tank.

However, blasting to widen the opening to the final diameter can affect the integrity of the existing surge tank. The blasting vibration levels should be limited to acceptable levels as calculated by the relationship given in section 2.2.4.9. This means the reduction of the specific charges, limiting the drill hole length, and maintaining good direction control by survey precision. The alignment of the existing tunnel can be checked from post-tunneling survey records (correlation surveys).

4.13 Impacts of the existing and the planned project activities

There are no planned development projects in the area, except the DWLC Management plan (see Annex VI for the Executive Summary of the DWLC Management Plan). As the PIA comes under the VRR Sanctuary, the project during construction and the operation phases should conform to the management plan of the DWLC for the VRR Sanctuary (see section 1.7 for the details of how the project conforms to the management plan of the DWLC).

4.14 Impacts of blasting operations (Significant)

Existing Structures

The maximum allowable vibration limit is determined to prevent the existing structures from damaging due to the blasting for the construction works for the proposed project (see 2.2.4.9). The following empirical equation is used to estimate the vibration of a structure due to blasting with assumed explosive volume at planning construction works for the waterway. It provides the vibration levels depending the distance from the blasting point to the observation point on the structure. It has been confirmed by using the equation that vibrations of the existing structures such as the tunnel do not exceed the maximum allowable vibration limit (see 2.2.4.9.6).

Houses

According to available Japanese literature, when vibration velocity is less than 0.2 kine (cm/s) no damage on houses is generated but when it is 0.2 to 0.5 cm/s slight damages on houses may occur. As for individuals, vibration levels less than 55 dB will not disturb sleep and at 60 to 65 dB vibration only light sleep will be disturbed, and at levels higer than 69 dB even heavy sleep will be disturbed. The vibration levels that are predicted at the nearest houses are also well within the standards published by the Central Environmental Authority of Sri Lanka.

It is clear that the shortest distance to the surface above the proposed tunnel trace where the blasting will take place is 120 meters at a point 2250 meters from the tunnel intake. However this area is uninhabited. The shortest distance to the houses located on the surface in Welikada above the tunnel trace is over 200 meters. Thus it is clear that blasting along the tunnel will have no impact on the structures or the people.

However, at the Surge Tank site where some surface level blasting will take place, the shortest distance to the nearest house is 105 meters and only 3 houses fall within 150 meters (105 meters, 123 meters, 136 meters respectively). Of the three, only the closest house falls inside the threshold vibration and noise levels that will have some impact on the structures or the individuals (see Figure 4-18).

Velocity of vibration is estimated by following empirical equation.
$V = K \cdot W^{2/3} \cdot D^{-2}$
V: Velocity of vibration (cm/s)
K: Coefficient related to blasting conditions (Center-cut: 750, Side hole blasting: 350)
W: Loading of explosive per 1 rotation (kg) (Center-cut: 9.0 kg, Side hole blasting: 15.5 kg)
D: Distance from the center of blasting
Velocity of vibration is converted to vibration level by following empirical equation.
$VL = 20 \log V + 83$
VL: Vibration level (reference acceleration of vibration 10^{-5} m/s^2)
Relation between D and V, VL is shown in Table 4-16.

Table 4-16 Relation between D and V, VL

D (m)		50	100	150	200
V (cm/s)	Center cut	1.29	0.32	0.14	0.08
	Side hole blasting	0.87	0.22	0.10	0.05
VL (dB)	Center cut	85.2	73.2	66.2	61.2
	Side hole blasting	81.8	69.8	62.7	57.7

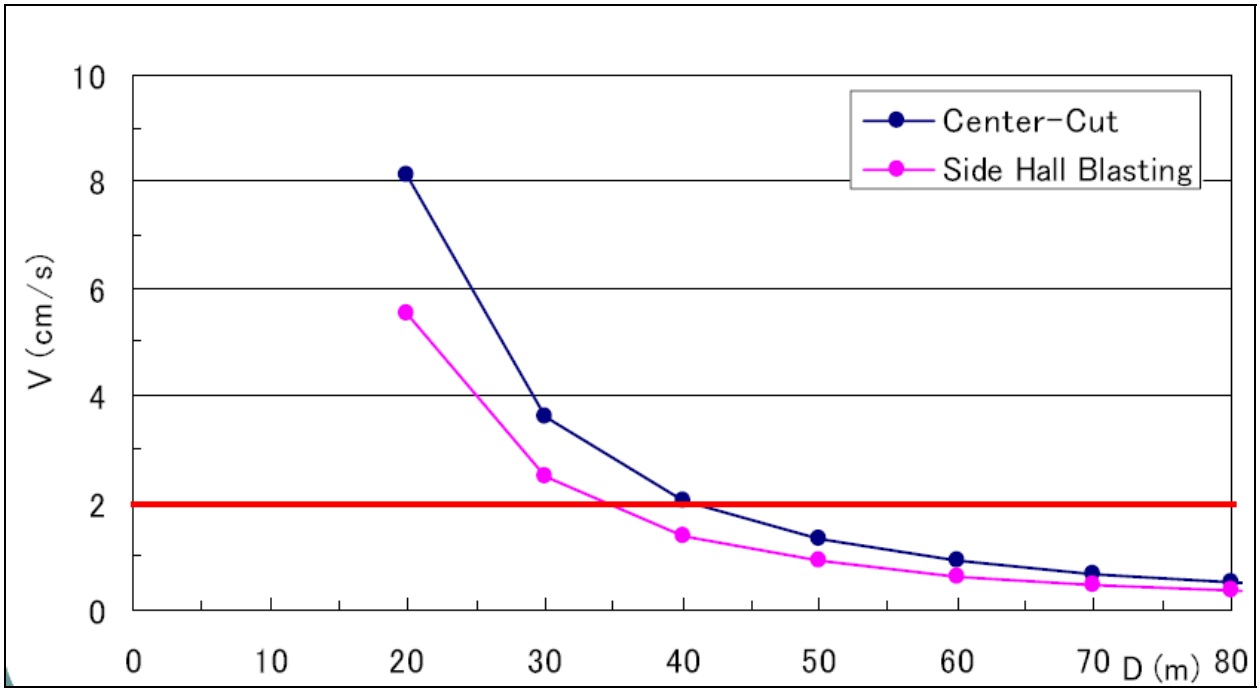

Figure 4-17 Velocity curve by distance from the tunnel

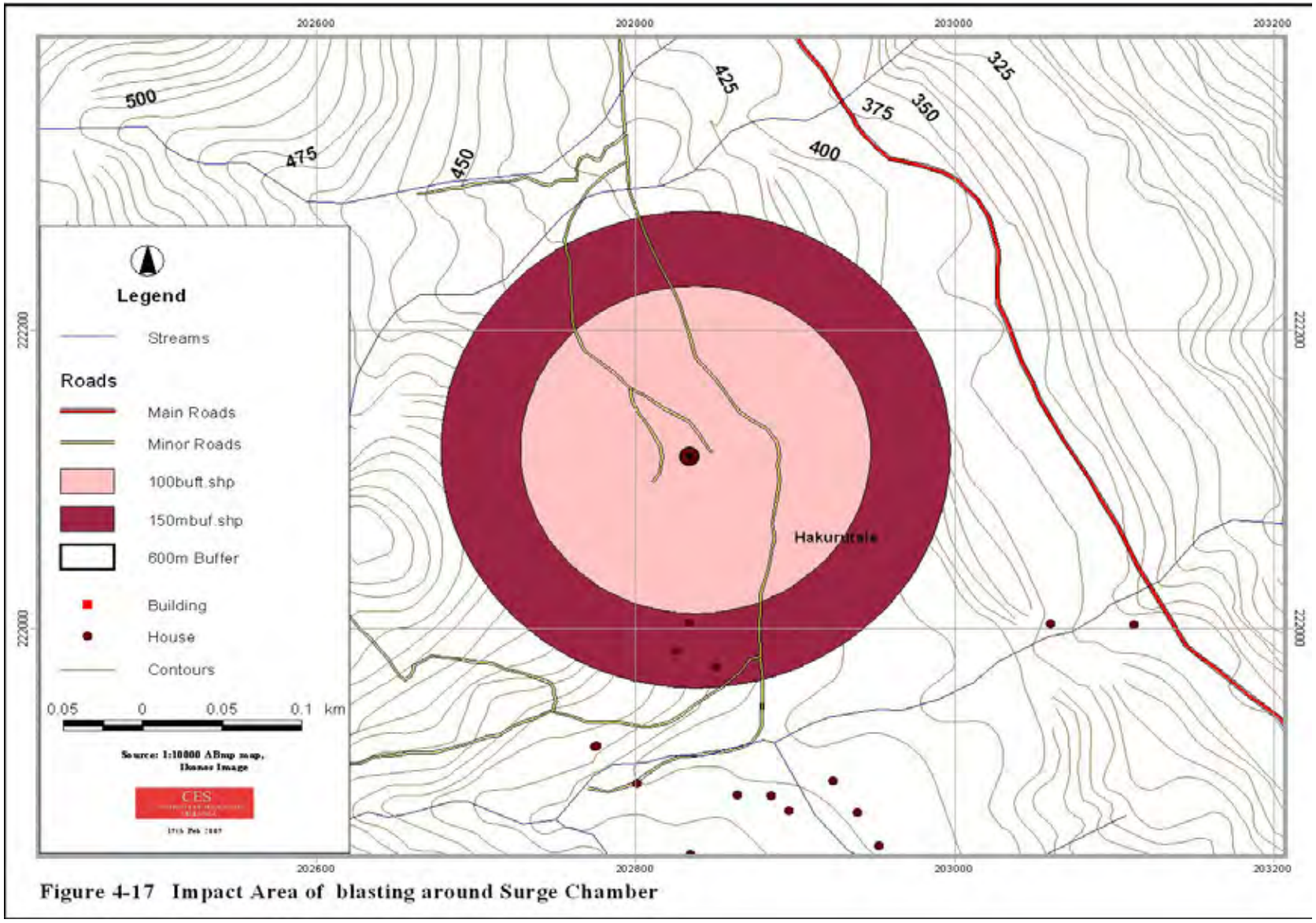

Figure 4-17 Impact Area of blasting around Surge Chamber

Figure 4-18 Impact Area of blasting around surge tank

4.15 The present rights of the MASL to operate the spillway gates

It should be noted that the present rights of the MASL to operate the spillway gates and the Low Level Outlet Gates will not be altered by this project. However, the CEB in consultation with the MASL will develop a program to generate using the water that is likely to spill during heavy rainy periods.

4.16 Positive Impacts

4.16.1 Reduction of Carbon and Savings in Foreign Exchange (Significant)

The total power generation will be the same as now, even after the proposed project is constructed due to the MASL conditions on the use of Victoria water. However, the CEB would still have to use fossil fuel to meet the peak hour demand if the proposed project is not constructed. Similarly, in future, the proposed project would allow the spill waters of Victoria, although not a frequent occurrence, to be used for power generation. In both cases, the proposed hydropower project will offset a significant carbon emission. 15,169.40 ton of CO_2 will be saved by this project.

Table 4-17 Generation Energy per year (GWh)

	Diesel	Coal	Total
With the project	468	248	716
Without the project	230	475	705
Covered by other sources	238	-227	11

Table 4-18 Estimated additional CO_2 for cover by other projects

	Generation Energy per year (GWh)	Adjustment factor	Energy produced per year (GWh)	Unit Fuel Amount (Kg/kWh)	Total Fuel needed (t)	Ratio of CO2 to weight of fuel (t-CO2 / t-fuel)	Total CO2 (t)
Gas	238	1.02312	243.5	0.27081	65,943	2.92	192,241.36
Coal	-227	1.08207	-245.6	0.36402	-89,414	1.98	-177,071.97

4.16.2 Injection of Capital to the Local Economy (Significant)

As in the case of most major development projects, the proposed project will also inject capital to the local economy in a number of ways. These include such direct methods as payment for local labour which is estimated to be about 10% of the manual labour requirement of the project, and purchasing local produce by the labour force coming into the project which is estimated to be 5% of the local labour wages. In addition, there are a number of indirect ways of money flow into the local economy by way of increases in sales in the local shops, house rents, supporting services, etc.

4.16.3 Increase in Regional Employment Opportunities (Significant)

As happens normally in such situations, some of the manual labour requirements of the project will be met by locally available human resources. It is conservatively estimated that 10% of the manual labour would be sought from the Hanguranketa Division. In fact one of the benefits the people in the PIA expect from the project is also the employment opportunities during the construction and operational period as it has been the case with Victoria Phase I.

4.16.4 Creation of a positive impression on the Project (Significant)

On most occasions, the project proponents take the community and society where the projects are implemented for granted and pay no attention to the problems and issues (real and imagined) created by the project. This leaves a very negative attitude towards the project and the project proponents and it could, as has happened with respect to some development projects in the country, lead to protests eventually leading to costly delays. As the people have already formed an opinion that the tunneling will lead to a reduction of ground water level thus affecting their domestic and agricultural use, the project should from the beginning engage in a determined proactive program to build an amicable relationship with the community and provide direct and indirect help and support to the local communities. The belief that Victoria Phase I negatively affected their ground water (wells) and the declaration of the VRRS which has imposed restriction on traditional landuses have left some negative views among the people about both the MASL and DWLC. However, the people have a positive attitude towards the CEB and the Victoria Power House as it provides some employment opportunities to the local people. The proposed Victoria project should therefore work closely with the community to ensure that people will be positively disposed towards the project. The project can employ a Public Relations or Community Liaisons Officer full time at the project site to liaise between the Project and the community.

CHAPTER 5

PROPOSED MITIGATORY MEASURES

5 PROPOSED MITIGATORY MEASURES

This chapter should set out the proposed measures to minimize the significant impacts identified in Chapter 4. The EIA team was in constant contact with the feasibility study team, who is also in charge of the basic design, feeding the latter with the potential impacts so that mitigation measures can be integrated into the designing of the project. The principle of mitigation by planning and design has been adopted firstly to prevent the impacts from occurring in the first place and secondly to avoid costly post-impact mitigation. The selection of the Basic Option as the preferred alternative is the most effective environmentally significant mitigation measure as it reduces both the magnitude and the severity of the impacts on both the natural and social environment as discussed in section 2.1.

However, some impacts cannot be mitigated by planning and design thus requiring post-impact mitigation. The following Table summarizes the mitigations proposed for the significant impacts identified in Chapter 4.

Table 5-1 The mitigations proposed for the significant impacts

IMPACT		Assessed Impact	Mitigation Measure
NEGATIVE			
1	Temporary lowering of ground water affecting domestic uses	57 households will be affected.	Provision of mobile water supply to the affected families (➔ 5.1, p5-2)
2	Temporary reduction in agricultural production (paddy) due to lowering of ground water	139.2 ha (Rice field and vegeTable field)	Cash compensation for the loss (➔5.2, p5-2)
3	Impact on the integrity of the existing tunnel and other structure and houses	Blasting is controlled by the use of appropriate specific charges in the blasting rounds to limit peak particle velocity not exceeding 2cm/sec for existing civil structures.	Use modern and safe technology(➔ 0, p5-3
4	Pollution of surface water from tunnel discharge	10 locations are estimated as possible impact area. But no houses will be affected.	Control spillage/Treating the tunnel discharge through oil traps (➔ 5.4, p5-3)
5	Increase in work related accidents	Traffic accidents, tunnel accidents, fire, etc.	Follow strict safety measures(➔ 5.5, p5-3)
6	Reduction of forest cover at dumping sites	Reduction in forest cover is 8.14 ha	Implement a environnemental restoration program (➔ 5.6, p5-4)
7	Disturbance to some species due to noise and other activities	During construction some species who live near the sites will be affected.	Use low noise machinery/ some noise is not mitigable (➔ 5.7, p5-4)
8	Soil erosion due to tunnel muck dumping and access road construction	Length of the rubble is 1253 meter	Use appropriate soil conservation methods during construction (parallel with impact 6) (➔ 5.8, p5-4)
9	Ground Water Pollution		Treating the waste water before discharging into the ground (integrated with impact 4) (➔ 5.9, p5-4)
10	Disturbances to the community		Awareness programs for the workers (➔

IMPACT		Assessed Impact	Mitigation Measure
	from the workers		5.10, p5-4)
11	Damages to Road due to increase in heavy traffic	Affected road is 18 km, 4 years.	Immediate repairing of the damaged roads (➔ 5.11, p5-5)
12	Obstruction to the migratory movement of elephants	Migration routes from Power Station to Randenigala Reservoir will be affected during operation.	Installing 8CCTVs to monitor elephants on the bed. And flash lights at 8points (cross sections) along right bank of the channel from the powerhouse (➔ 5.12, p5-5)
13	Loss of private land at tunnel muck dumping site in Kohombagana	5.79 ha would be affected by temporary facilities in Kohombagana.	Payment of compensation for the loss of land at Rs. 100,000 per acre (➔5.13, p5-1)

IMPACT		Nature of Impact	Enhancement Measure
POSITIVE			
1	Reduce carbon fuel/foreign exchange savings	Beneficial	Initiate carbon-credit benefits (➔ 5.13, p5-5)
2	Injection of capital to the local economy	Enhanceable	Buy local raw material/employ local people (➔ 5.14, p5-5)
3	Increase in regional employment opportunities	Enhanceable	Give preference to locals in hiring for all jobs (➔5.15 , p5-6)
4	Building a positive impression of the project	Enhanceable	Open an office to public (➔5.16 , p5-6)
			Contribute to community development programs (➔5.17 , p5-6)

5.1 Provision of mobile water supply to the affected families for the loss of ground water.

Lowering of ground water in four villages, namely, Ambewela, Hakurutale, Hilpenkandura and Welikada has been identified as a possible impact during the construction period (see section 4.7.14). 57 houses, 241 people in the impact area would possibly be in a target for water supply. Since there is no natural water source to establish a piped-water system in these two villages this impact has to be mitigated by supplying water with water tank trucks as required. The water supply is only during construction, because the drawing down period is estimated as only during construction. The daily requirement of water in the rural sector has been estimated at 100 liters per person (NWSDB, 2006). Thus the total volume of water that would have to be supplied annually is 8,796.5 m^3 if all the wells dry up and no rain water is available in the area during the construction period. This would require roughly 8 water tank trucks (with a 3 m^3 in capacity) a day. However, there will be some water remaining in the wells and there will be rainwater particularly during the *maha* season each year.

5.2 Cash compensation for the loss of agricultural production

19 families from Welikada, 6 families in Ambewela, 3 families in Hilpenkandura and 29 families in Hakurutale live within the PIA and thus their primary livelihood – agriculture - will be affected by the potential lowering of the ground water Table during construction. They grow highland crops during the dry seasons and paddy during the wetter season of the

year. Cash compensation for the loss of agricultural production due either to the potential lowering of ground water and or the loss of water in wells is based on the section 4.4 "Impacts on Agricultural Fields". The total value of the cash compensation for the loss of agricultural produce is Rs. 28,889,720**.** (see Table 2).

Table 5-2 Estimated compensation cost for the loss of agricultural production

Chena	5,576,200	4	22,304,800
Homestead	1,272,530	4	5,090,120
Paddy/ seasonal	373,700	4	1,494,800
Total			28,889,720

5.3 Use modern and safe technology to minimize vibration impacts

The construction of the project carries out underground and open-air works near the existing Victoria dam, intake for expansion, existing waterway and powerhouse. The maximum vibration limit was set for blasting work for the construction works (See 2.2.4.9). The amount of explosive must be controlled in order to keep under the accepTable value. The contractor should carry out several times of trial blasting, each time loading different amount of explosives, in the new access adit to confirm appropriate blasting method with the maximum allowable blasting vibration, and measure the velocity of vibration with vibrographs at the intake gate shaft and/or in the dam inspection galleries. The contractors should strictly watch the blasting method, amount of explosives, etc., with the trial blasting. Vibration due to the blasting during construction period should be measured on the existing structures and/or rock surfaces with the vibrographs to confirm safety of the existing structures.

As mentioned in 4.14 the impact on the houses would be small if the amount of the explosive of the blasting does not affect the existing structures. The excavation of the surge tank in the Hakurutare GN division will be done only in daytime (around 10 hours) in order to prevent the villagers from receiving the serious noise and vibration impact of blasting on the villagers during night time.

5.4 Control spillage/Treating the tunnel discharge through oil traps to treat waste water

Tunnel discharge will contain high amounts of suspended particles. In addition it could also contain nitrates from explosive materials, oil and grease from machinery, and other impurities based on the mineral composition of the excavated materials. All tunnel waste water must be treated for suspended solid removal, oil and grease removal, nitrogen compound removal and any other substance that is in excess of the prevailing discharge standards. The use of a grease trap followed by a settling/ lagooning tank should be adequate to treat this waste water up to the required levels.

5.5 Follow strict safety measures to prevent work accidents

The local workers should be educated and trained to follow safety measures. Proper safety equipment should be made available to the construction crew and visitors. Notices displaying the safety warnings and precautions must be placed at all work fronts. The workforce and the

visitors should be compelled to follow the safety guidelines and regulations strictly. A stock of basic first aid medicine with trained personnel should be available around the clock. An ambulance also should be made available. The Project Proponent should maintain comprehensive daily records on the safety of its workers at all construction sites.

5.6 Implementation of an environmental restoration program to prevent soil erosion

The rehabilitation of forest cover at the dumping sites consists of three components—soil conservation, rehabilitation and replanting, and maintenance. The proposed soil conservation measure is given in section 5.22. Forest cover has to be re-established in the dumping sites identified by the project. The total area of the dumping sites is estimated as 15.66 ha. Altogether there are seven dumping sites varying from 0.54 ha to 5.94 ha (see section 4.3.7). Due to the nature of the tunnel muck it is impossible to directly plant any trees. These sites have to be leveled, and soil conservation measures applied and refilled with top soil before any replanting are to take place (see section 5.22 for more details on soil conservation). The re-establishment has to be monitored and maintained until the plants are fully established.

5.7 Use low noise machinery to mitigate noise impacts

The PP should request the contractor not to use old machinery and to maintain them in excellent working condition so that they generate only the minimum noise. This is especially applicable to the heavy vehicles transporting sand and muck.

5.8 Use appropriate soil conservation methods during construction (parallel with impact 6) to mitigate soil erosion

See Section 5.6, 5.19 and 5.22

5.9 Treating the waste water before discharging it into the ground (integrated with impact 4) to mitigate ground water pollution

All wastewaters must be properly treated (to comply with the existing discharge standards) before releasing it into the surrounding. In addition all toilet waste disposals must be guaranteed as safe for area groundwater. All toilet wastewater from camp and construction sites must be separated and treated on sites by using conventional septic tank systems. Hazardous wastes such as vehicle maintenance waste should not be dumped on open ground and they must be collected separately and disposed of in an appropriate manner.

5.10 Awareness programs for the workers to address the potential conflicts

A general awareness program for the workers should be conducted by professionally qualified experts on socially communicable diseases on a regular basis during the construction period and also on the need to respect the social-cultural environment of the local communities.

5.11 Immediate repairing of the damaged road to mitigate damages to the roads

The total length of the existing road that will be used during construction is estimated at 18 km. On average, a 10 ton damp truck will make 115,500 trips during the construction period estimated to last 52 months. However, it has not been estimated how much damage that could cause taking into consideration the weight of the vehicle and number of trips. Therefore, the RDA cost estimation for patching damaged roads were used in calculating the mitigation cost. Either the Project itself can repair the roads or enter into an agreement with the RDA to effectively repair the road on a continuous basis.

5.12 Installing Flash Lights and CCTVs to monitor the migration of elephants

To ensure that impacts on elephant migration are mitigated, the first requirement is to build a sufficient database on the actual migration pattern of elephants across the stream downstream of the proposed powerhouse. For this purpose, as a preliminary measure, eight CCTVs will be installed at an early stage of the construction, if possible one year before the commencement of the construction works, at reasonable intervals on the right bank of the channel to observe the presence of elephants on the stretch of the river bed concerned. The ecological specialists including those of DWLC will be appointed for elephant survey and analysis. If the elephant presence is confirmed during the observation in the pre-construction period, it is suggested to control the blasting time in consideration of the activity time and area of the elephants during the construction period. And installation of flash lights is suggested in the operation stage. The flash lights will be installed in the river bed and flash 15 minute before the operation to warn the elephants. Eight lamps will be installed at 8 defined cross sections downstream of the powerhouse. The mitigation measures for the elephants will be continually revised based on the survey and analysis results.

5.13 Payment of compensation for the loss of land at Rs. 100,000 per acre for the private lands at the dumping sites at Kohombagana

About 6.2 ha of land at the Kohombagana muck dumping site is owned privately but the land is now abandoned and is overgrown with vegetation. Although there is no market for land in this area due to the declaration of the VRR sanctuary, it is important that the rightful owners receive cash compensation for the land. After several discussions with the villagers and officials, it is proposed that they will be compensated with a hypothetical value of Rs. 100,000.00 per acre.

5.14 Injection of capital to the local economy

Once this project starts, a large amount of capital will be injected into the local economy in three main ways. First, the project will employ the villages from the surrounding area as casual labor in its construction activities which would directly lead to an increase in incomes among the villages. Second, the project must buy local raw material such as sand, rock aggregates, rubble and bricks from the local suppliers living in the area. Third, the project workers must be encouraged to purchase their daily food items such as rice and vegeTables from the local boutiques.

5.15 Increase in regional employment opportunities

The project will generate regional employment opportunities directly and indirectly. Direct employment will be generated through direct recruitment to the project as it will prefer to hire local inhabitants for two major reasons. First, local labor will be cheaper than outside labor. Second, the former will be more reliable as they reside in the same area thus eliminating transport costs to the workers. The project will provide employment in the form of casual labor, drivers, guards, clerks, etc., and design a recruitment plan to give preference to the local inhabitants.

The project may generate indirect employment as the local inhabitants may even start new boutiques and food stalls targeting the workers in the project. Also, the inhabitants in the surrounding area may employ themselves as suppliers to provide certain building materials to the project.

5.16 Open an office to public to improve the positive impression of the project

There is already a Visitor Center at the Tunnel Office of CEB. The Center has a beautifully landscaped area with interpretive boards explaining the existing Victoria Project and the Mahaweli river development projects. A vista point offering a panoramic view of the Victoria Dam is also situated at this site along with a conference room that can accommodate up to 50 people. The Center is open to the public free of charge and it is occasionally visited by school children and a few members of the public. There is no publicity given to the Visitor Center and thus the Visitor Center remains mostly under-used.

The existing center can be developed into a fully developed visitor center with state of the art audio-visual equipment to become information diffusion and education center explaining the Mahaweli River development projects and the VRR sanctuary as well as the proposed project. The monitoring office of the proposed project can also be located at the center and a public relations office linking the project with the people of the PIA.

5.17 Contribution to community development programs to improve the positive impact of the Project.

The proposed project can contribute to community development in the area substantially in the following ways.

- Build community development halls in the two villages of Hakurutale and Welikada
- Repair a motorable access road to Hakurutale – Bodigolla by extending the existing road to the Surge Tank.
- Construct a building for a Dispensary (a small-scale medical center) at Adikarigama. The nearest hospital located in Hanguraketa is 8.5 km away.

These activities could lead to the creation of a positive impression of the project among the people of the PIA and the vicinity.

5.18 Environment Management Program

See Section 1.9 for a description of how the proposed project may complement the DWLC master plan and the Environmental Management Program envisaged. As the PIA lies almost entirely within the Sanctuary, CEB cannot implement a management plan of its own aimed at protecting the catchment area. The MASL, DWLC and CEB should work in close coordination to realize these objectives.

An environmental management mitigation plan is proposed to address the impacts at the 5 tunnel muck dumping sites. One of the dumping sites is a quarry used during Phase I of the Victoria project. Although it can be further expanded, concrete aggregates will not be extracted for the proposed project in order to avoid noise impact. Except for one, all other sites were previously used as tunnel muck dumping sites. The new site at Kohombagana will be used only if the other sites are inadequate. At Kohombagana the mitigation measures described in Section 5.6 will be strictly adhered to.

The sand mining site is located in the lower part of the Ma Oya valley, which is within the inundation area of the Victoria Reservoir. The bed load of the Ma Oya is deposited at this site when the reservoir level is high. Removal of sand from this site is unlikely to have an adverse impact on the environment because the river will deposit its bed load again at this site in the same way as has been happening in the past.

Safe disposal of waste water evacuated from the tunnel will be treated before being discharged into the environment.

Where new road construction or expansion of new roads is undertaken, the newly exposed banks and waste soil dumps will have to be landscaped and stabilized.

5.19 Soil Conservation Management Plan

A separate soil conservation management plan is not required in addition to what has been proposed in Section 5.6 and 5.22 as the potential for soil erosion is concentrated primarily at the tunnel muck dumping sites. Sensible soil erosion prevention methods have to be followed at all stages of construction.

5.20 Resettlement Plan

The project does not lead to a displacement of people. Thus, either temporary or permanent resettlement of people is not required. However, compensation for the reduction or loss of water in the wells within the impact area and any consequent reduction in or loss of agricultural production and the loss of lands for the dumping sites will be based on the following entitlement matrix. A more detailed household survey on resettlement impacts with an Inventory of Losses (IOL) will be carried out within the impact area prior to the commencement of the construction.

Table 5-3 Compensation for the reduction in or loss of water in the wells and loss of lands for dumping sites

No	Impact or Loss	Entitlement
1	Loss of water in the wells for domestic use	Provision of water through bowsers to all affected families from the time of first detection of loss of water in the well until the water yield in the wells reach accepTable levels
2	Loss of agricultural production dependent on wells	Providing of cash compensation for the loss from the time of first detection until the water yield in the wells reach accepTable levels. This will initially cover 8 seasons during the construction period and will be extended as identified by monitoring
3	Loss of land for the dumping site at Kohombagana	Pay compensation at a rate not less than Rs. 100,000.00 per acre or Rs. 250,000.00 per ha.

5.21 Noise and vibration control measures

5.21.1 Blasting control measures

Blasting noise will not be a factor affecting the environment except at the surge tank and that too is only for a short time when the blasting takes place at the surface.

Blasting vibration emanating from the full face tunnel excavation could be a concern for the existing tunnel. However, this will be controlled by adjusting the amount of explosives used for the excavation. As mentioned earlier, the integrity of the existing tunnel located only 36 meters away from the proposed tunnel should be the primary consideration in the tunnel excavation.

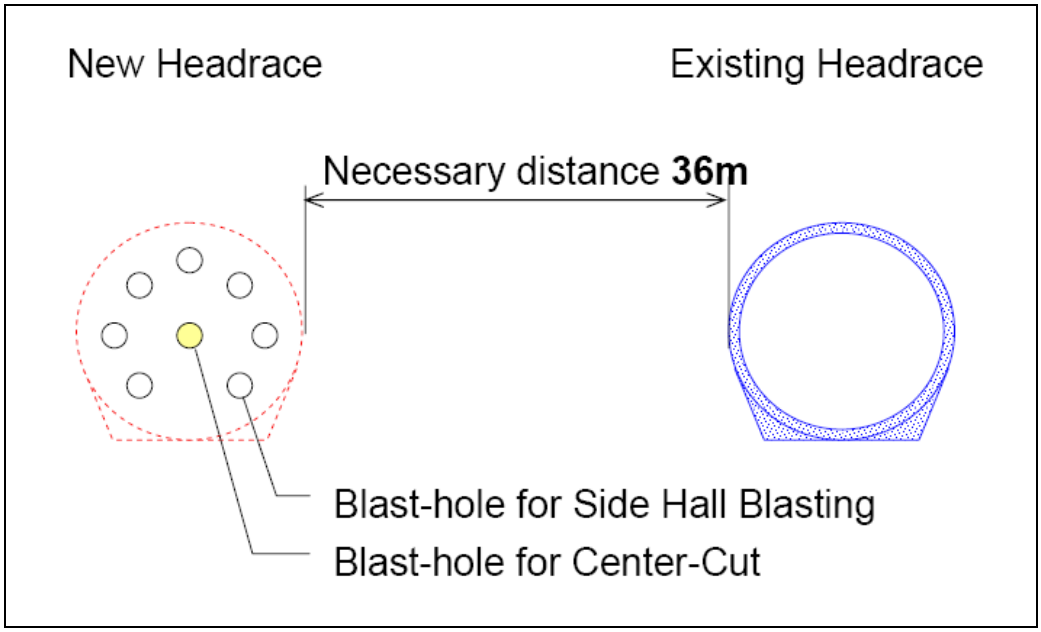

Figure 5-1 Tunnel excavation in heading and benching

Blasting vibration and noise at the surge tank site reach should be controlled by adjusting the explosives to maintain the desired levels. Also blasting at fixed declared times are very essential at this site partly to inform the people living in the nearby houses and partly people

who might be travelling along the adjacent road. It is also important that the blasting for the surge tank shaft be conducted only during daytime.

Mitigation measures for noise impacts on construction workers will include standard occupational health and safety practices such as ear protection and enforcement of exposure duration restrictions.

During operations, noise will mainly be generated in the power station but it will have no impact on people as there are no houses in the vicinity. Mitigation measures for noise impacts on workers at the power plant will include standard occupational health and safety practices such as ear protection.

5.21.2 Noise and vibration control measures for construction machines and vehicles

For this project, noise will be a concern only during construction. Operational noise will not change from the current levels. Noise and vibration sources during construction relate to roading, tunnelling, quarrying, spoil management and other earthworks, from rock blasting, and heavy machinery use. These noises / vibrations may be disruptive to daily village life, particularly against current low ambient noise levels, although they are integral to construction practices. Noise and vibration mitigation and control measures should be documented in detail in the Construction Environment Management Plan that allow contractors to complete the works while providing the community with an expectation that disruptions will be kept to a practicable minimum. Minimum requirements are considered as follows:

- The contractor should operate in accordance with relevant international/local standards for construction noise
- People should be educated about blasting practices, warned when blasting will occur and be able to keep clear of blasting when it occurs
- Blasting and other noisy operations close to dwellings and public meeting places should be restricted to suiTable working hours and days, and agreed to with the community. This may include restrictions on working on Sundays
- A complaints register should be maintained during construction which documents noise issues and measures to resolve the issues
- Machinery shall be maintained to the manufacturers' specifications to ensure that noise emissions are no greater than reasonably expected from heavy machinery
- No dwellings or public meeting places should be at risk from debris from blasting operations.

5.22 Debris waste, tunnel muck disposal facilities method and location

All tunnel waste should be dumped in selected and approved locations. The waste dumps should be sTable, safe and environmentally pleasing. Re-vegetation should be facilitated. Therefore, the dumping should be behind a rock dyke formed with waste rock. It should leave a berm of 1 to 1.5 every 4m height. It should maintain a slope of 1 in 1.5 for the exposed side of the dyke and provide a filter at the tow of the dyke to prevent loss of fines. Figure 5-2 gives an illustration of a rock dump. The actual dimensions of the rock dumps will vary based on the site conditions such as the slope and the terrain.

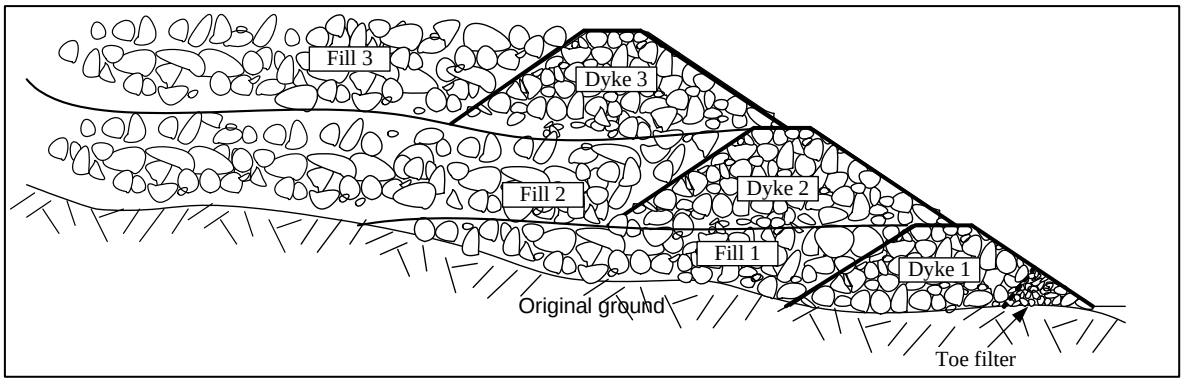

Figure 5-2 Illustration of a rock dump

Tunnel blasting uses a large amount of ammonium-nitrate. If concrete (particularly shotcrete) is used for tunnel tightening, the runoff becomes very alkaline and reacts with ammonium to create free ammonia, which is very toxic for fish and other aquatic animals. Therefore, runoff from tunnels and spoil rock deposits can cause fish kills during periods with low flow. Runoff from the tunnel must be monitored and passed through a sedimentation basin where neutralization could be performed if extremely high pH values are observed.

5.23 Restructuring of the surrounding environment

Since the greatest impact areas of the project include muck dumping sites, a mitigation plan to restore the vegetation cover (and loss of habitat) is proposed in Chapter 6. A tree planting program could be initiated in all the other exposed areas (sites used for workers quarters, vehicle maintenance sites, etc.)

5.24 Public health measures to control vector and water-borne diseases

One of the impacts on public health is the release of air-borne dust. Dust suppression at the source and during transportation of waste rock will be necessary.

Toilet water should not be allowed to be discharged into the river, as it could cause health hazards for those living downstream. Black water (toilet water) will be collected and treated with the necessary infiltration capacity. Gray water (washing and kitchen water) will be filtered at the site before being discharged it into the river.

5.25 Disaster Management

The project is not likely to lead to any disasters affecting the people in the impact area and thus a separate disaster management plan is not required. Industry best practices and safety procedures will be strictly adhered to in order to prevent accidents at work sites during the construction period. An ambulance will be on standby at the project site for any emergency.

5.26 Reestablishment and restoration of infrastructure

The only infrastructure that requires restoration due to the impacts of the project is the 13.7 kms of the main highway (Rajamawatha). The project will enter into an agreement with the

RDA and provide compensation for RDA for the damages caused for RDA to repair the damages to the highway. Restoration of the muck dumping sites will be carried out by the project itself through the mitigation measures proposed and it will be closely monitored.

5.27 Facilitation of the environmental flow requirement downstream of the Dam

The proposed project will not cause any change to the total volume of the flow between the existing dam and the power station. In any case, the environmental flow of Mahaweli river is under the control of MASL and the CEB has no jurisdiction over it.

5.28 Measures to salvage / relocate archeological / cultural monuments

No archaeological or cultural monuments were located in the PIA.

5.29 Measures to salvage / rehabilitate wild life reserves

Since the project sites are located within the VRR sanctuary, the Department of Wildlife Conservation, which has management authority of the land, has prepared a management plan for better management of the sanctuary land (Executive Summary of the VRR management plan is given in Annex VI, No. 6). The proposed project will complement this plan in a number of ways as described in Section 1.9 in Chapter 1.

5.30 Landslide stabilization measures to prevent landslides as well as for the expected failures during and after the construction works

No major project-induced landslides are expected as most of the construction activities entail underground tunneling and the vibrations from explosives will be strictly controlled as described in Section 5.21.1. No large earthwork is required for the powerhouse as the site has already been prepared during Victoria Phase 1.

5.31 Measures to improve habitats

See Section 5.29.

5.32 Restoration of land in construction area

Tunneling will not affect the land surface except at the waste dump and access roads to dumps. Maintenance of the rock dump and re-vegetation of the roads are necessary. See Section 5.22 for further details.

5.33 Measures to ensure the existing riparian rights of the area

Access to riparian zone near powerhouse and switch yards is strictly prohibited as these areas are designated as high security zones. However, the existing fishing rights of the villagers in the border villages of the reservoir will not be affected.

5.34 Measures to control vector and water-borne diseases

Toilet water should not be allowed to be discharged into the river, as it could cause health hazards for those living downstream. Black water (toilet water) will be collected and treated with the necessary infiltration capacity. Gray water (washing and kitchen water) will be filtered at the site before being discharged into the river.

Water that gets collected in rock pools in the dry river bed between the Victoria dam and the Victoria Power Station could serve as breeding grounds of mosquitoes which transmit malaria and dengue to humans. However, this condition cannot be rectified now since it is an outcome of the original Victoria Project. During the construction of Victoria dam, provision was not made to maintain an environmental flow in order to maintain a minimum water level in the river.

However, the following measures could be taken to minimize the impacts on water: Raw sewage or partially treated sewage should not be discharged into the river or into the streams as it could cause health hazards for downstream communities or pollute the Randenigala reservoir. Black water (toilet water) should be collected and treated with the necessary infiltration capacity. Gray water (washing and kitchen water) should be filtered at the site before being discharged into the river.

5.35 Measures to Dam failure

The activities of the proposed project will not have any impact on the existing dam. Please refer to section 5.36

5.36 Measures to minimize the impacts on blasting on the dam structure

The Victoria Dam is designed to withstand a maximum vibration or earth quake force of 0.1g. (Ref Article 1:12, specification, Volume III, Hydraulic equipment contract No 4). The contractor should keep the explosives volume as prescribed in section 5.22.1. At those rates, the vibration velocity of the dam due to blasting is estimated at less than 0.4 kine (cm/s) which will have no impact on the Dam. In case blasting is conducted in the tunnel near the dam and in the new access adit, velocity meters should be installed on strategic points on the Dam to measure the vibration levels. As the existing tunnel will be operational during the construction of the proposed project, vibration at the tunnel should be estimated with results of the trial blasting to be carried out prior to the commencement of tunnel blasting.

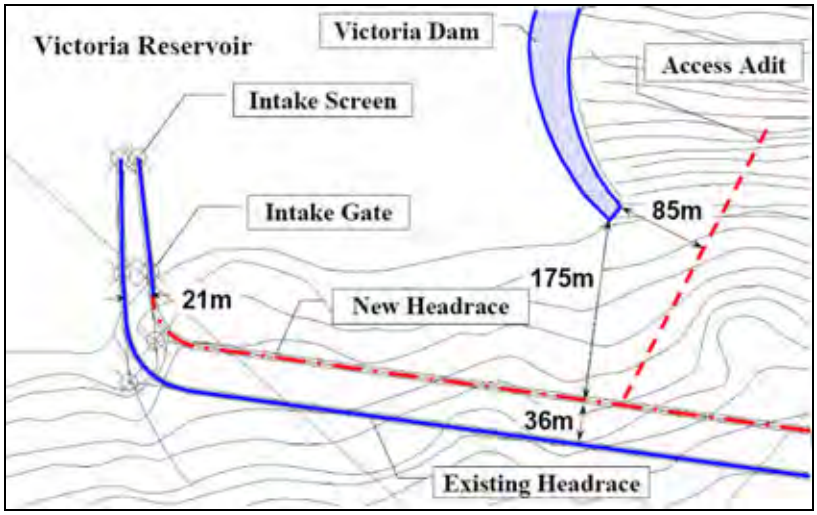

Figure 5-3 Distance between existing structures and blasting lines

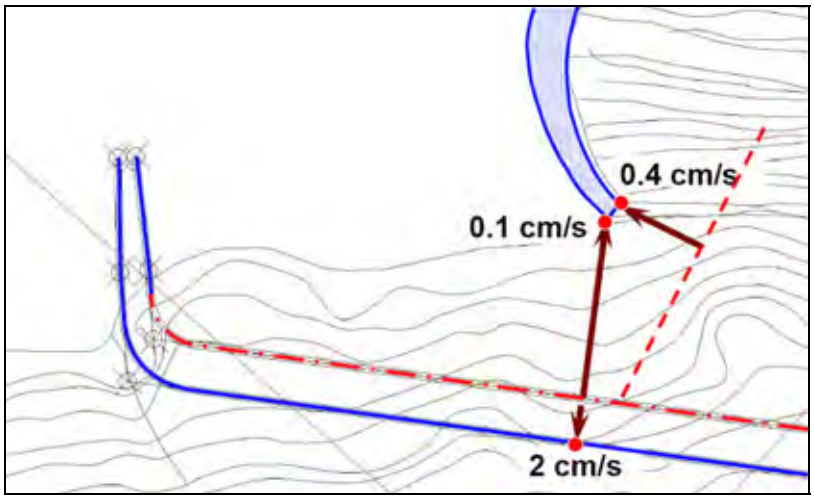

Figure 5-4 Estimated vibration velocity of the dam and existing tunnel

5.37 Measures to minimize the impacts of the transmission line

No new transmission line will be installed as existing lines have enough capacity.

5.38 Drainage Management Plan

No separate drainage management plan is required but sensible practices will be followed at construction sites and tunnel muck dumping sites.

5.39 Precaution to keep the ground water level as at present to avoid any effects to surface cultivation

It is not possible to totally prevent the ground water from seeping into the tunnel workings. But there is one course of action available to minimize the temporary draw down of the

ground water level. That is to identify the zones of ground water inflow in the tunnel trace and to grout the zone in advance of tunneling.

5.40 Excavation Methodology for new tunnel and proposed precaution to avoid any collapse or failure on existing tunnel

As mentioned in Section 5.22.1, full-face excavation of tunnel excavation will be carried out with carefully defined explosive volumes to limit the impacts of blasting.

The shaft excavation for the surge tank will be carried out in two steps: pilot hole excavation and enlargement excavation. The pilot hole will be excavated with a raise climber upward from the headrace tunnel or with a raise borer downward from the ground to the headrace tunnel, widening then with a reaming bit upward from the headrace tunnel. After completion of the pilot hole, the enlargement excavation will be executed with the drill and blasting method downward from the ground. The mucks will be dropped to the headrace tunnel through the pilot hole and then hauled outside with dump trucks through the penstock tunnel.

The condition of the rock layers of the tunnel is estimated to be favorable. Location of weak zones and their potential for water leakage has been estimated in the final report of the feasibility study by using geological records taken during the previous construction. In such locations probe drilling should be conducted.

5.41 Socio-economic Mitigation Measures

See Table 5-1 and sections 5.1, 5.2, 5.5, 5.10 and 5.11.

CHAPTER 6

COST BENEFIT ANALYSIS

6 COST BENEFIT ANALYSIS

6.1 Cost for Mitigation and Monitoring of Environmental Impacts and Mitigation

The significant impacts of the projects were identified through a rigorous matrix ranking method by the experts. The identified impacts and the mitigation methods are given respectively in Chapter 4 and 5. The impacts and mitigation were then costed following detailed discussions with experts in the relevant areas and using custom rates. The estimated mitigation costs are given in Table 6-1. Total mitigation and monitoring cost is Rs. 307,688,859.68**.**

1) Provision of mobile water for the loss of domestic water

There will be 29 families from Hakuruthale and 19 families from Welikada, 3 from Hipenkandura and 6 from Ambewela affected from the depletion of groundwater during the four year construction period. The water requirement is estimated as 8,796.5 m^3/year. If all the water has to be provided, the total cost of supplying water using bowsers will be Rs. 79,168,500.00**.**

2) Cash compensation for the loss of agriculture production

In calculating the loss of paddy, the yield, cost of production and price of paddy was assumed as 1200kg/ac, Rs. 25,000 and Rs. 28/kg respectively. Thus, the total value of the paddy loss due to reduction in groundwater is calculated as Rs. 1,503,182.72. The net profit from vegeTable crops is assumed as Rs 20,000/ac and therefore the loss of vegeTables is Rs 22,486,880.00. The loss incurred by home gardens is Rs. 2,094,560.00. Thus the total cash compensation of the crop loss due to lowering of water Table is calculated as Rs. 28,889,720.00**.**

3) Impact on the integrity of the existing tunnel

Internalized

4) Pollution of surface water from tunnel discharge

Internalized

5) Increase in work related accidents

Internalized

6) Re-establishment of forest cover on the dumping sites

The rehabilitation of forest cover on the dumping sites consists of three components—soil conservation, rehabilitation and replanting, and maintenance. The top soil layer will be set aside before tunnel muck dumping and will be replaced later. The cost is included in the civil works.

Generally 500 forest plants (*Bulu, cone, burutha, welang, mee, pihimbiya*) can be grown per hectare. Usually the wholesale price of a plant is Rs. 30 and the cost of plants is Rs. 0.36 million. Generally a person can do 50 plants per day at a daily wage rate of Rs. 500. Therefore the planting cost is Rs. 0.12 million. This is also included in the civil cost. After

the establishment of plants, they have to be maintained for at least 3 years until the plants are fully established. The maintenance includes replacing the dying plants and watering when it is necessary. This can be approximated as Rs. 50,000.00 per hectare per year and the total maintenance cost is around RS. 2,349,000.00 for 3 years. Of this, the first year maintenance is included in the civil cost and thus only three years maintenance cost is considered in calculating the mitigation cost.

7) Disturbance some species due to noise and other activities

Internalized through the use of low noise equipment

8) Soil conservation

The total area of the dumping site is 15.66 ha. If a square of 15.66 ha one length of a side is assumed to be 395.73 and the length of the compacted soil structure needed as proposed for soil conservation is 1474.58 m (491*3), and if the variation on the ground is factored in, the total length would be 1253m. If we factor in the variation on ground the total length would be 1253 meters. If a 5% average slope in the dumping area is assumed, there will be an average height of 9.89 m. Thus the cost of the compaction needed for soil conservation is going to be Rs. 4,710,027.00 if Rs. 3000 for a dozer hour is assumed.

9) Ground Water Pollution

Internalized into the civil works

10) Training of the workers

As a mitigatory measure, training programs for the workers should be carried out during the construction period. It is assumed that a total of 16 such programs is needed, each costing Rs. 20,000. Thus the total mitigation cost is going to be Rs. 320,000.00.

11) Deterioration of roads due to increase of heavy traffic

The distance used in the main road is 4 km (Adit 1 to Quarry is 1.5 km and Surge Tank to Dumping site 3 is 2.5 km). RDA rates for patching pot holes are used in calculating the cost needed for keeping the road without destructing. The estimated value is around Rs. 161,718,439.68.

12) Disturbance to Elephant migration (Setting up flood lights and CCTVs)

It has been suggested that there should be a corridor for elephants to cross the Mahaweli River to allow them free migrations during the peak operational time. The suggested compensation measure is to erect 8 flood lamps, if necessity is confirmed, to warn the elephants and 8 CCTV to monitor their movements. The total cost for construction and maintenance of the system is Rs. 4,420,000.00.

13) Compensation for private lands in Kohombagana.

It was estimated that 6.2 ha of privately owned land will have to be acquired for the Kohombagana tunnel muck dumping site if needed. At the rate of Rs. 100,000 per acre the total compensation cost is estimated at Rs. 1,550,000.00.

14) Building a positive impression on the project.

Building a positive impression of the projects depends on direct contribution of the project to the community. What is proposed is to construct two community development halls and a

building for a rural dispensary/medical center. The total cost estimated for this activity is Rs. **4,500,000.00**

15) Monitoring Cost

The cost of monitoring includes the following:

Item	Rate	Duration	Unit	Cost
Institutional Fee of the Monitoring Institution	150,000.00	54	Months	8,100,000.00
Full time field monitor	45,000.00	54	months	2,430,000.00
Experts in specific fields	20,000.00	54		1,080,000.00
6 Members of the monitoring Team	1,000.00	54	sittings	54,000.00
Vehicle	100,000.00	54	months	5,400,000.00
Computer/Printer	200,000.00	2	Unit	400,000.00
Consumables	1,500.00	54	months	81,000.00
Laboratory	50,000.00	60		3,000,000.00
Total				**20,545,000.00**

16) The total mitigation and monitoring cost

The total mitigation and monitoring cost is given in Table 6.1.

Table 6-1 Mitigation Cost

Costs	Impact	Cost (Rs)
1	Mobile water supply	**79,168,500.00**
2	Cash compensation for crop loss	**28,889,720.00**
3	Impact on the integrity of the existing tunnel	**Internalized**
4	Pollution of surface water from tunnel discharge	**Internalized**
5	Increase in work-related accidents	**Internalized**
6	Re-establishment and rehabilitation of forest cover	**2,349,000.00**
7	Disturbance to some species due to noise and other activities	**Internalized**
8	Soil conservation at dumping sites	**4,228,200.00**
9	Ground Water Pollution	**Internalized**
10	Training of working staff	**320,000.00**
11	Immediate repairing of roads	**161,718,439.68**
12	Flash lights and CCTVs at 8 points along downstream from reservoir	**4,420,000.00**
13	Compensation for private lands	**1,550,000.00**
14	Cost of building a positive impression of the project	**4,500,000.00**
15	Monitoring cost	**20,545,000.00**
	Total Mitigation and Monitoring Cost	**307,688,859.68**

The above total mitigation and monitoring cost in Sri Lankan Rupees is converted as US$ 2,154,099 by using the exchange rate as of the end of October 2008 for the benefit and cost analysis.

6.2 Benefit Cost Analysis

6.2.1 Methodology

6.2.1.1 Methodology

Economic evaluation aims at measuring the "economic" impact brought about to a country by implementing a project from the viewpoint of the national economy. Here, a comparison of costs and benefits expressed in terms of economic prices will be made by applying the Discount Cash Flow Method, which is widely adopted for such purposes.
The basic approach for this method is as follows. First, the cash outflow (costs) and inflow (benefits) are developed on an annual basis over the project life. Secondly the amount generated during different years will be discounted to the start year of the project and expressed as an accumulated present value at the same standard year. Then a comparison will be made between the costs and benefits. Evaluation indices to be obtained will be the Net Present Value, the Benefit/Cost Ratio, and the Economic Internal Rate of Return (EIRR). The EIRR is a discount rate at which the present values of the two cash flows become equal. This rate shows the return to be expected from the project. EIRR is expressed in the following equation:

$$\sum_{t=0}^{n} C_t / (1+r)^t - \sum_{t=0}^{n} B_t / (1+r)^t = 0$$

Where,

Ct	:	Cost
Bt	:	Benefit
t	:	Year
n	:	Project life (year)
r	:	Discount rate (= EIRR)

6.2.1.2 Basic Conditions

According to the discussions with CEB, as well as in line with the existing reports for other projects in Sri Lanka, the following basic conditions were adopted:

- Opportunity cost of capital
  Opportunity cost of capital refers to an interest rate at which the appropriateness of investment can be justified. A rate of 10% was used in view of the rates used for other projects in Sri Lanka.
- Discount rate
  A discount rate of 10% will be used. This rate of 10% is also used commonly in other projects. 8% and 12% were also used for sensitivity analysis.
- Conversion factor
  Standard conversion factor of 0.9, used commonly in other projects, was used. This is a coefficient to calculate the economic price from the construction costs estimated at the market price. It is applied to the domestic currency portion.
- Economic life
  Economic life of each facility, according to the experience of the Consultant, was determined as follows:
  - 50 years for civil works
  - 35 years for hydro-mechanical and electro-mechanical equipment

- Project life (Calculation period)
  Calculation period for evaluation is 55 years: 50 years of service life for civil facilities and 5 years for construction works. It is assumed that the power plant will become commercially operational in January.
- Evaluation Point
  Evaluation was made at the entrance of the Substation to which the transmission line from Victoria Hydropower Project is connected. Therefore, a transmission loss is considered.
- Cost Estimate
  Estimation of cost was based on the price level of October 2008. Those works already completed as a part of the existing project are considered as a sunk cost; therefore, such cost was not included in this Project.
- Escalation
  No escalation was considered; therefore, a constant price will be used.
- Tax
  Taxes including VAT are excluded from the calculation, being a transfer item.

6.2.2 Economic Costs of the Project

The economic costs of the Project were calculated from the market price as presented in Chapter 10 (The cost includes environmental cost). Construction cost, as well as Operation and Maintenance cost and replacement cost, was included in the cost stream. The method of economic pricing is as follows:

Foreign currency portion

- Exclusion of transfer items such as taxes (import tax, value added tax) and subsidies

Local currency portion

- Exclusion of transfer items such as taxes (VAT) and subsidies
- Conversion of market prices to economic price, applying standard conversion factor

6.2.2.1 Initial Investment Costs (at Economic Price)

Initial investment costs by facility are shown in Table 6-2.

Table 6-2 Initial Investment Cost (at Economic Price)

(Unit : US$1000)

Description	1st Year		2nd Year		3rd Year		4th Year		5th Year		Total
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	
I Direct Construction Cost											
Preparatory Works	431	2,480	0	0	0	0	0	0	0	0	2,911
Civil Works	10,767	4,519	15,818	8,782	8,952	11,815	4,864	5,895	0	0	71,411
Hydro-Mechanical Equipment	4,393	0	1,700	594	3,696	1,278	5,735	1,949	2,197	0	21,542
Electro-Mechanical Equipment	10,185	0	8,738	2,097	29,742	7,138	12,445	2,987	6,790	0	80,122
Total Direct Construction Cost	25,776	7,000	26,256	11,473	42,390	20,230	23,044	10,831	8,987	0	175,985
II Environmental Cost	0	485	0	485	0	485	0	485	0	0	1,939
III Administration and Engineering Fee	2,578	700	2,626	1,147	4,239	2,023	2,304	1,083	899	0	17,599
IV Contingency	2,835	818	2,888	1,310	4,663	2,274	2,535	1,240	989	0	19,552
Grand Total (I to IV)	31,189	9,003	31,769	14,415	51,291	25,012	27,883	13,639	10,874	0	215,075
TOTAL (FC+LC)	40,192		46,184		76,303		41,522		10,874		215,075

Conversion Factor: 0.9

Source: JICA Study Team Calculation

The annual investment amount for major items, including the Engineering and Administration Cost as well as Contingency, is summarized in Table 6-3.

Table 6-3 Initial Investment Cost by Item (at Economic Price)

(unit: US$1000)

	Civil works	Hydraulic/Electro-mechanical equipment	Others	Total
1st year	15,287	14,578	10,327	40,192
2nd year	24,599	13,129	8,456	46,184
3rd year	20,766	41,854	13,683	76,303
4th year	10,759	23,116	7,647	41,522
5th year	0	8,987	1,887	10,874
Total	71,411	101,664	42,000	215,075

Source: JICA Study Team Calculation

6.2.2.2 Operation and Maintenance Cost (at Economic Price)

The Operation and Maintenance Cost is shown in Table 6-4. The cost was calculated by multiplying the construction cost of each work item (including a 10% contingency) by a certain rate. This rate was determined according to the Consultant's experiences with similar projects.

Table 6-4 O&M Cost (at Economic Price)

(unit: US$1000)

Item	Construction cost	Factor	Amount
Civil Works	78,552	0.5%	393
Hydraulic/Electro-mechanical Equipment	111,830	1.5%	1,677
Total	---	---	2,070

Source: JICA Study Team Calculation

Replacement cost of equipment after fulfilling the service life will be separately considered, referring to the initial investment cost.

6.2.3 Economic Benefit of the Project

For the purpose of this study, an incremental benefit between the two cases, that is, "with project" and "without project", is considered as the economic benefit for the project.
Economic benefit of a hydropower project consists of capacity benefit (kW value) and energy benefit (kWh value). Generally, the capacity benefit is obtained from incremental dependable power capacity and a capacity value assumed as a construction cost of an alternative thermal power plant, as well as fixed O&M cost; while the energy benefit is obtained from the incremental energy and energy value assumed as the variable operation cost of an alternative thermal power plant (fuel cost, etc.)
After completion of the expansion works, the Victoria Hydropower Project is to be operated as a 3-hour peak load power station, changing the actual operational function to cope with both peak and off-peak load power when water is available for generation. Therefore, considering the generation characteristics for both cases, "with" and "without" the project, two alternative thermal power plants have been selected: a gas turbine plant for peak load power and a coal-fired thermal power plant for off-peak load power. Power benefit and energy benefit for each alternative thermal power plant are estimated according to the following classification as shown in Table 6-5:

Table 6-5 Alternative Thermal Power Plant

Item	Purpose	Power Benefit	Energy Benefit
Gas Turbine	Peak load	Construction cost Fixed O&M cost	Variable O&M cost
Coal-fired Thermal	Off-peak load	---	Variable O&M cost

Source: JICA Study Team Calculation

The Economic Benefit of the Project is shown in Table 6-6, the Economic Value of Gas Turbine in Table 6-8 and the Economic Value of the Coal-fired Thermal Power Plant in Table 6-9. Explanation for each item follows.

Table 6-6 Economic Benefit of the Project

No.	Description	Unit	With Project	W/out Project	Net
1.	Annual Energy	GWh	715.9	705.0	11
2.	Firm Energy	GWh	468.2	230.0	238
3.	Secondary Energy	GWh	247.7	475.0	-227
4.	Dependable Peak Capacity	MW	393.0	210.0	183
5	Power to be Generated (Gas)	MW	464.7	248.3	
6	Power to be Generated (Coal)	MW	--	--	
7.	Energy to be Generaged (Gas)	GWh/yr	479.03	235.32	
8.	Energy to be Generaged (Coal)	GWh/yr	268.03	513.98	
9.	kWh-Value (Gas)	US$/MWh	282.43	282.43	
10.	kWh-Value (Coal)	US$/MWh	63.98	63.98	
11.	kW-Value (Gas)	US$/kW	80.86	80.86	
12.	Annual Benefit (Gas)	US$1000/yr	167,069	83,441	83,627
13.	Annual Benefit (Coal)	US$1000/yr	17,149	32,885	-15,736
14.	Total Annual Benefit	US$1000/yr	184,217	116,326	**67,891**

Source: JICA Study Team Calculation

6.2.3.1 Adjustment Factor

In order to estimate the economic benefit in terms of alternative thermal power plant, firstly an adjustment factor was used to adjust the difference of loss rate between the hydropower plant and the thermal power plant. With such an adjustment factor, basic characteristics of alternative thermal power plant will be obtained. Then the economic benefit will be calculated using such basic characteristics. Adjustment Factor is shown in Table 6-7.

Table 6-7 Adjustment Factor

Item	Gas Turbine	Coal-fired Plant
kW Adjustment factor	1.18247	1.22017
kWh Adjustment factor	1.02312	1.08207

Source: JICA Study Team Calculation

6.2.3.2 Basic Characteristics of Alternative Thermal Power Plant

Basis characteristics of alternative thermal power plant are shown in Table 6-8. Detail of calculation is shown in Table 6-6.

Table 6-8 Basic Features of Alternative Thermal Power Plant

Item	Unit	Gas Turbine		Coal-fired Plant	
	Project	with	w/out	with	w/out
Installed capacity	MW	464.7	248.3	---	---
Energy generation	GWh	479.0	235.3	268.0	514.0
Plant Life	Years	20		30	

Source: JICA Study Team Calculation

(1) Construction cost

Construction cost of alternative thermal power plant (at economic price without IDC) is shown in Table 6-9.

Table 6-9 Construction Cost of Alternative Thermal Power Plant

(unit: US$/kW)

	Gas Turbine (75MW)	Coal-fired (300MW)
FC Portion	460.8	889.6
LC Portion	77.6 × 0.9	347.7 × 0.9
Total	530.6	1,202.5

Source: Data from CEB (as of January 2008)

(2) O&M cost

Annual Operation and Maintenance cost (at economic price) of the alternative thermal power plant is shown in Table 6-10. As for the Gas Turbine, foreign portion occupies 80% of the total cost, and 20% for local portion.

Table 6-10 O&M Cost for Alternative Thermal Power Plant

Item	Gas Turbine (75MW)	Coal-fired (300MW)
1. Fixed O&M cost	US$/kW/month	US$/kW/month
FC Portion	0.412	0.513
LC Portion	0.103 × 0.9	0.146 × 0.9
Total	0.505	0.644
2. Variable O&M cost	US cent/kWh	US cent/kWh
FC Portion	0.328	0.201
LC Portion	0.082 × 0.9	0.057 × 0.9
Total	0.402	0.252

Source: Data from CEB (as of January 2008)

(3) Fuel cost

Fuel cost for alternative thermal power plant is shown in Table 6-11.

Table 6-11 Fuel Cost of Alternative Thermal Power Plant

Item	CIF Price	Fuel Cost
Auto Diesel	US$134.2/bbl	US cent 9,521/GCal
Coal WC	US$155.5/MT	US cent 2,468/GCal

Source: Data from CEB (Average of January 2008)

6.2.4 Economic Evaluation

The total present value of the economic cost during the initial year of the project amounts to US$182,321,000 (with a discount rate of 10%; the same will be applied to the following calculations). The total present value of the economic benefit is US$417,959,000. The net present value (B-C) is calculated as US$235,639,000, and the benefit cost ratio (B/C) is 2.29. The economic internal rate of return (EIRR) was calculated as 19.8%. In calculating the annualized cost, the same procedure was followed that was used in annualizing the construction costs (section 6.1). The results of the analysis are given in Table 6-12. The calculated benefit cost ratio is 2.29 and it is concluded that the project is feasible.

Evaluation indices like the Net Present Value (B-C) and Benefit Cost Ratio (B/C) at various discount rates, as well as EIRR are summarized below:

Table 6-12 Result of Economic Evaluation

	Evaluation Index	Evaluation Criteria	Discount Rate
NPV	US$235,639,000	> 0	10%
B/C	2.29	> 1	10%
EIRR	19.8%	> Opportunity cost of capital	10%*

Note: The discount rate is used to obtain annual cost of alternative thermal.*

As a result, NPV result in positive (over zero) and EIRR exceeds 10% as opportunity cost of capital. Therefore the Project is judged as economically feasible.

6.2.5 Sensitivity Analysis

The sensitivity of economic evaluation indices was analyzed for cases with decrease in fuel cost. A discount rate of 10% was used for this analysis. The following assumptions were made using alternative thermal cost as benefit:

Case 1 30% decrease in fuel cost

Case 2 50% decrease in fuel cost

The result of the sensitivity analysis is shown in Table 6-13.

Table 6-13 Results of Sensitivity Analysis

Item	NPV (US$)	B/C	EIRR (%)
Case 1	138,192,000	1.76	16.2
Case 2	73,226,000	1.40	13.5

The indices exceed the evaluation criteria for the Cases 1 and 2, and it is confirmed that even in the worse cases the Project is economically feasible. The level of fuel price used for evaluation remains relatively high, EIRR continues to exceed 10% even with the 72% reduction of the fuel price (i.e. US$38/bbl for diesel and US$44/MT for coal) for the base case.

CHAPTER 7

ENVIRONMENTAL MONITORING PROGRAM

7 ENVIRONMENTAL MONITORING PROGRAM

7.1 Monitoring Committee

The monitoring program proposed is based on both internal and external monitoring. All construction related impacts, i.e., safe issues, noise and vibration, integrity of the existing tunnel will be monitored internally by the project proponent with the consultant and the contractors. The impacts on the physical, biotic and social environment will be monitored externally by a monitoring committee headed by an independent environmental consultancy firm/organization (e.g., the Center for Environmental Studies).
The monitoring committee consists of the following

- A representative of the project proponent (CEB)
- A representative of the consultant employed by CEB for project implementation
- A representative of each contractor
- Grama Niladari of the Welikada and Hakurutale divisions
- A representative of the MASL/MSO
- A representative of the DWLC
- An environmental and social impact assessment specialist stationed at the project site during the entire construction period.
- A reputed scientific organization specializing in environmental research, assessment and monitoring (e.g., Center for Environmental Studies)

The Monitoring Committee shall meet once a month during the construction period and inspect and review the monitoring program and suggest any changes or modification necessary. The Monitoring Committee should submit monthly progress review reports. The monitoring committee shall have access to all construction sites and the contractor shall provide all necessary information. The Monitoring Committee will function during the entire construction period and an additional six months. At this point, the monitoring responsibility will be transferred to the Project Proponent.

The Project Proponent will provide funds required for the functioning of the monitoring program.

7.2 Monitoring Program

The Monitoring Committee will be primarily responsible for implementing the Monitoring Program given below (see Table 7.1). The monitoring program is designed primarily to ensure the effective implementation of the mitigation of the significant impacts.

Table 7-1 Mitigation and Monitoring (Negative impact)

Impact	Nature of Impact	Mitigation Measure	Monitoring					
			Parameter	Locations	Method	Frequency	Duration	Responsibility
NEGATIVE								
(1) Temporary lowering of ground water affecting domestic uses	57 house holds will be affected.	Provision of mobile water supply to the affected families	The number of affected houses getting the supply	Houses	Enumeration of changing ground water level	Weekly	One year in pre-construction stage if possible, construction period and additional one year	Monitoring committee/ Preconstruction ground and surface water levels and quality survey is recommended.
(2) Temporary reduction in agricultural production (paddy, home garden) to lowering of ground water	139.2 ha (Rice field and vegeTable field)	Cash compensation for the loss	The affected agricultural plots	Plots	Enumeration	Every four months	Construction period and additional six months	Monitoring Committee
(3) Impact on the integrity of the existing tunnel and other structures	Blasting is controlled by the use of appropriate specific charges in the blasting rounds to limit peak particle velocity not exceeding 2cm/sec.	Use of modern and safe technology Recording actual status of the existing structures in the pre-construction stage is recommended.	Blasting vibration	Dam/Power House/Other affected places and houses (Tunnel will not be directly monitored as it is in operation)	Continuous monitoring using vibrometers and spot checks	Continuous/ when required	Construction period	MASL and CEB

Impact	Nature of Impact	Mitigation Measure	Monitoring					
			Parameter	**Locations**	**Method**	**Frequency**	**Duration**	**Responsibility**
(3b) Impact on the integrity of the existing houses	Blasting is controlled by the use of appropriate specific charges in the blasting mentioned in (3) above.	Use of modern and safe technology Pre-construction structural distress survey (crack survey) is recommended	Use of machines and methods	Sites of Operations	Observation	Monthly	Construction period	Monitoring Committee
(4) Pollution of surface water from tunnel discharge and at tunnel muck sites	10 locations are estimated as possible impact area. But no houses will be affected.	Control spillage/Treating the tunnel discharge through oil traps	Water Quality parameters and the proper functioning of the treatment	Discharge sites	Inspection and measure	Fortnightly	Construction period	Monitoring Committee
(5) Increase in work related accidents	Traffic accidents, tunnel accidents, fire, etc.	Follow strict safety measures	Use of safety methods and equipments	Workplaces	Observation	Daily	Construction period and additional six months	Monitoring Committee
(6) Reduction of forest cover at dumping sites	Reduction of forest cover is 8.14 ha	Implement a environnemental restoration program	Regrowth Establishment and regeneration	Dumping sites	Observation measure and count	Twice a year for flora/Monthly for Fauna	Construction period and additional three years	Monitoring Committee with an ecologist
(7) Disturbance of some species due to noise and other activities	During construction some species will be affected.	Use low noise machinery/ some noise is not mitigable	Sound levels	Sites of Operations	Measure sound levels	spot checks	Construction period	Monitoring Committee
(8) Soil erosion due to tunnel muck dumping and access road construction	Length of the rubble is 1253 meter	Use appropriate soil conservation methods during construction (parallel with impact 6)	Methods	Dumping sites and access roads	Observation	Monthly	Construction period and additional six months	Monitoring Committee

Impact	Nature of Impact	Mitigation Measure	Monitoring					
			Parameter	**Locations**	**Method**	**Frequency**	**Duration**	**Responsibility**
(9) Ground Water Pollution from Tunnel discharge	Partially mitigable	Treating the waste water before discharging into the ground	Ground Water Quality parameters	Selected wells in the PIA	Measure	Once in two months	Construction period	Monitoring Committee
(10) Disturbances to the community from the workers	Partially mitigable	Awareness programs for the workers	Complaints from villagers	Villages	Enumeration	When required	Construction period and additional six months	Monitoring Committee
(11) Damages to Road due to increase in heavy traffic	Affected road is 18 km, 4 years.	Immediate repairing of the damaged roads	Road damages	Along the roads	Inspection and observation	Weekly	Construction period and decommissioning period.	Monitoring Committee
(12) Disturbance to the migration patterns of elephants	Migration routes from Power station to Randenigala Reservoir will be affected during operation.	Installing 8CCTVs to monitor elephants on the bed. And flash lights at 8points (cross sections) along right bank of the channel from the powerhouse	The presence of elephants on the river bed	Location where lights and CCTVs are installed.	Observation and monthly review	Automatic recording and monthly review	During construction and continue only if there is a need. Flash light will be used only if necessity is confirmed.	Monitoring Committee with the DWLC. The information will be useful for DWLC.
(13) Loss of private land at tunnel muck dumping site in Kohombagana	5.79 ha would be affected by temporary facilities in Kohombagana.	Payment of compensation for the loss of land at Rs. 100,000 per acre	Amount paid	Village	Check and verification	Twice	At the time of valuation and paying compensation	Monitoring Committee

Table 7-2 Enhancement measures and monitoring (positive impact)

Impact	Nature of Impact	Enhancement Measure	Monitoring					
			Parameter	Locations	Method	Frequency	Duration	Responsibility
POSITIVE								
Reduce carbon fuel/foreign exchange savings	Beneficial	CEB to explore the possibility of getting carbon credit benefits						No monitoring required
Injection of capital to the local economy	Enhanceable	Buy local raw material/employ local people	The amount of local produce bought/ The number of locals hired	Project Area and adjoining villages	Rapid Survey	Every Six months	Construction period and decommissioning period.	Monitoring Committee
Increase in regional employment opportunities	Enhanceable	Give preference to locals in hiring for all jobs	The number of locals hired	Project Area and adjoining villages	Rapid Survey	Every Six months	Construction period and decommissioning period.	Monitoring Committee
Building a positive impression of the project	Enhanceable	Open an office to public/ Contribute to community development programs	Functioning state of the art audio visual equipments at the visitor center	Visitor Center and villages	Observation	Every Six months	Construction period and additional six months	Monitoring Committee

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

8 CONCLUSION AND RECOMMENDATIONS

The primary objective of the EIAR is to provide a scientific assessment of the potential environmental impacts of the proposed Expansion of Victoria Hydropower Project and to make recommendations to make the project environmentally sustainable.

This was achieved by several methods:

- Selecting the least damaging alternative. It became amply clear that of the three site alternatives and the no-action alternative, the Basic Option is the most desirable environmentally.
- Identifying the environmental impacts and screening them to define the most significant impacts. Complex methods were employed for this purpose and the findings were fed to the design team in order to integrate mitigation into the planning and designing of the project.
- The use of the latest technologies in tunneling and in the construction of the hydropower station of the project that will either avoid or minimize construction-related environmental impacts such as excessive noise and vibration, work-related accidents, waste, and accidental discharge of oil, chemicals and other waste material into the environment.
- The identification by the EIA team, independently of the TOR entries, 13 negative impacts and 4 positive impacts
- Integrating some of the significant impacts into the planning and design of the projects
- Proposing mitigation measures for those impacts that were not integrated into the project planning and design
- Advocating the exercise of extreme care to ensure that the existing tunnel, which is only 36 meters away, will in no way be affected in the blasting of the new tunnel
- Developing a Monitoring Program to ensure the effective implementation of mitigation measures
- Proposing a Monitoring Committee comprising the Project Proponent, PAA, other stakeholders and an independent institution to supervise and implement the monitoring program.

The following pre-construction surveys are recommended to collect the baseline information that will be required for implementing mitigation measures.

1. Crack survey of all structures within the PIA
2. Groundwater/well survey within the PIA
3. Comprehensive land ownership survey at Kohombagana site
4. Survey of elephant movements using CCTVs

The proposed expansion of Victoria is a national need, especially to meet the peak hour electricity demand in the country which is growing rapidly. Alternative sources of energy, i.e., coal and diesel, is both expensive and cause harmful environmental pollution. On the other hand, the environmental impacts of the proposed project are relatively less and they can be successfully mitigated. The example and lessons learnt from the first Victoria Project clearly demonstrate that in the long term, the proposed project will also complement the

objectives of the Management Plan of the VRR Sanctuary. Thus, the proposed project in addition to being a power generation project will also contribute to the conservation of the environment in which the project is located.

The extended benefit-cost analysis also concludes that the proposed project is economically viable even after environmental and social impact costs and mitigation costs are considered.

Taking all these factors into consideration, the EIA team highly recommends the project subject to the effective implementation of the mitigation and monitoring plan.