# CHAPTER 3

# DESCRIPTION OF THE EXISTING ENVIRONMENT

# 3 DESCRIPTION OF THE EXISTING ENVIRONMENT

## 3.1 Project Impact Area

The description of the existing environment is limited to the study area or the Project Impact Area (PIA) of the Basic Option. However where necessary the area has been expanded beyond the PIA. The selection of the PIA is based on two factors.

1. The criteria given by the TOR. This include the following

    - Project Sites Areas directly affected by the project itself and areas indirectly affected (maintenance area etc.)
    - Locations affected by construction activities (quarries, refuse disposal areas, tunnel muck disposal areas, traffic diversions, work camps, temporary access roads etc.)
    - Area beyond the project site where there is potential for environmental impacts.
    - Study the aquatic fauna and flora from 50 meters upstream of dam to 100 meters downstream from the tailrace outlet
    - Fauna and flora in the inundation area:
        - Fauna and flora in the area up to the high flood level
        - Fauna and flora in the 60 meters reservation area from high flood level
    - Fauna and flora along the river reservation:
      Fauna and flora at a distance of 60 meters from the bank along transects at reasonable intervals. Location of line transect were determined according to habitat variation and 100 meter gradient contours.

2. Expert analysis by the Study Team and consultants.

    - The main impact area considered for the EIA study is the 600 meters wide belt along the tunnel trace. This was selected on the basis that the most significant impact – the potential reduction of ground water during tunneling - could extend up to an area twice the maximum depth of the tunnel from the surface which is 300 meters. The area of 600 meter radius encompass other main project components, i.e., powerhouse, tunnel and, surge tank site. However, depending on other environmental and social data generated during the study this zone will be adjusted but will not be reduced.
    - Locations affected by construction activities, e.g., crew camp sites, quarry sites, tunnel muck dumping sites, access roads etc. The exact impact area around these sites will vary based on the impacts but not less than 100 meters.
    - The areas up to 50 meters upstream of the entire length of the Victoria Dam and a 20-meter wide area on either side of the Mahaweli river for 100 meters from the tailrace of the Basic Option.

### 3.1.1 Physical Environment

The physical environment of an area is its abiotic component, consisting of land, water, and air. The main characteristics of land are the topography, geology, soil, and land surface characteristics in the form of land use or land cover types. Water or hydrology is made up of the groundwater and surface water resources of an area, including its quality and quantity. The drainage network and the major water bodies constitute the surface water bodies. The rainfall characteristics will be covered under hydrometeorology of the area. Air quality and noise levels are extremely important parameters for humans as well as the wildlife in the VRR Sanctuary. A discussion of the existing environmental problems will also be included in this section.

### 3.1.2 Topography

The project area is a rugged terrain with an elevation ranging from about 240m above msl to about 800m (Figure 3-1). This gives the relief of the area to be over 500m. The elevation rises steeply in many sections towards west from the Mahaweli river bed which runs in a northwest-southeast direction. The lowest elevation is marked by the bottom of the Mahaweli River which flowed in a deep valley before the construction of the Victoria Reservoir at the Victoria Falls. Now the flow in the reach from Victoria Dam to the Victoria Powerhouse is limited to local drainage and contributions from small tributaries from the left and right bank areas to the Mahaweli River. The flow derived from the upper catchment is directed through the Victoria tunnel for power generation. The proposed project utilizes the same quantum of water and therefore does not affect the current flow regime of the Mahweli River up to the Victoria Powerhouse.

A number of small tributaries that traverse the area flow in an easterly and northeasterly direction to join the Mahaweli River. The terrain is highly dissected by these streams creating a ridge and valley topography. The river valleys are covered with boulders fallen from the steep valley-side slopes. This can be attributed to past landslides. The stream frequency increases in a downstream direction. As can be seen from Figure 3-1, elevation increases from the east to west. The tunnel trace cuts through this ridge and valley terrain at least 100m below the surface.

The percentage land area above various elevation levels is given in Figure 3-2. The curve shows that over 50% of the area has an elevation above 400m. This mountainous terrain is cut by numerous perennial and seasonal streams. The low elevations are found close to the Mahaweli River as a narrow belt.

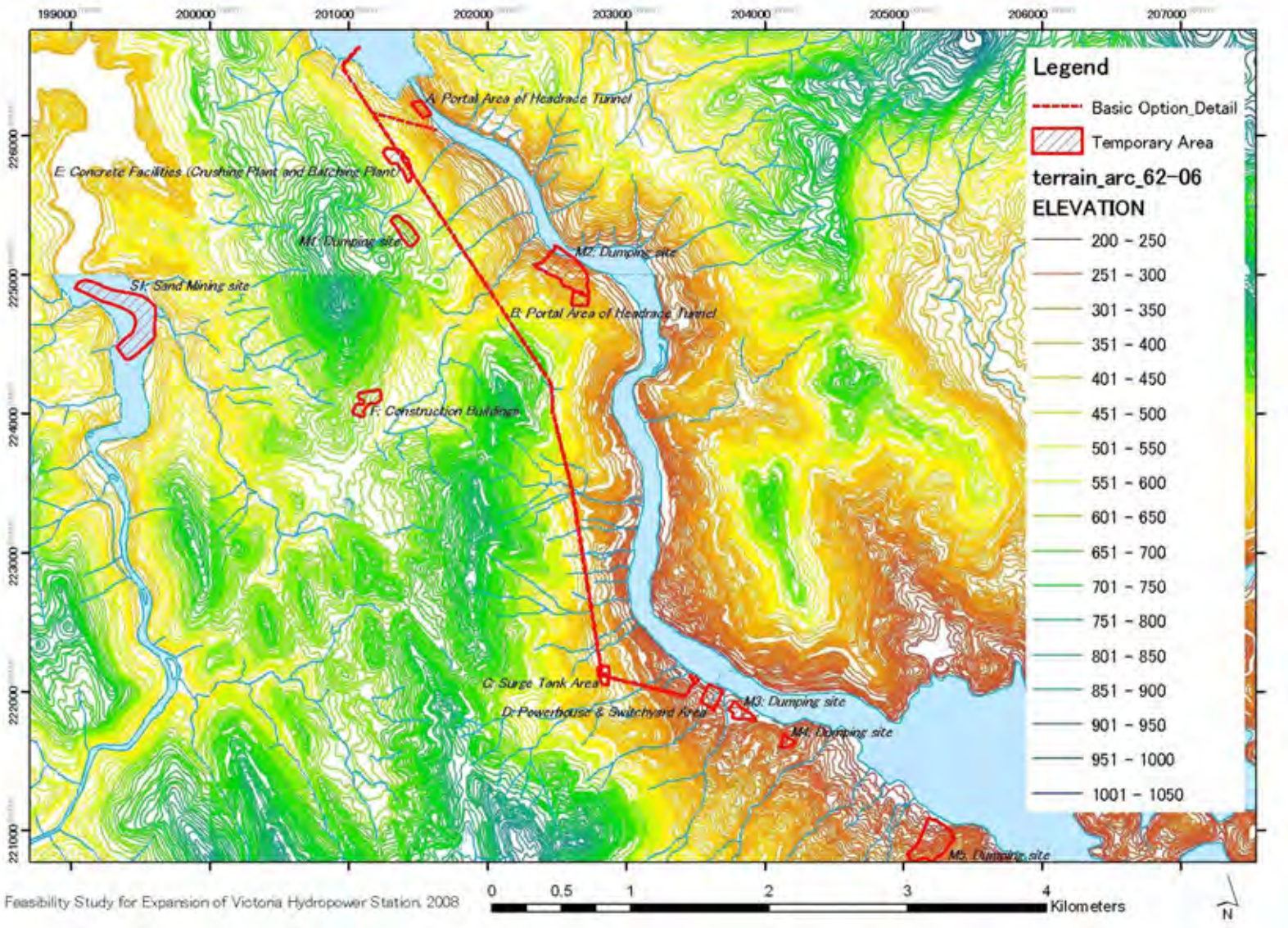



**Figure 3-1 Contour map of the PIA**

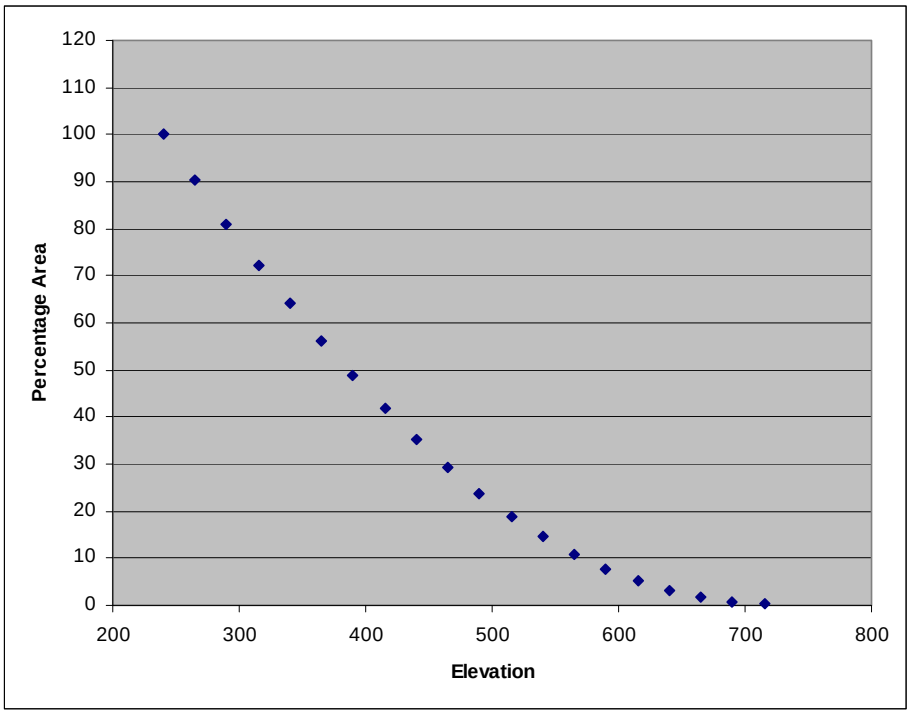



**Figure 3-2 Area Altitude Curve of the Project Impact Area (Basic Option)**

**Slope**

The slopes in the study area range from almost flat to extremely steep slopes. The slope categories are a simplified version of the NRMC classification prepared for agricultural lands. Four slope classes identified are listed in Table 3-1 with the recommended uses. The distribution of slope categories in the PIA is given in Figure 3-3.

**Table 3-1 Slope Categories and Recommended Land Use Types**

| % Slope | Description | Use |
|---|---|---|
| 0-20 | Flat | SuiTable for seasonal crops with minimum soil conservation needs |
| 20-40 | Moderate Slope | Seasonal crops with soil conservation |
| 40-60 | Moderate to very Steep | Pasture/Forestry, perennial crops |
| >60 | Extremely Steep | Pasture and forestry only |

The steepest slopes are found close to the river valley and the mid-slope areas. At present the area close to the valley bottom is under natural or semi-natural vegetation. However, some of the steep mid-slopes are under chena cultivation in some areas.

The final stretch of the Alternative runs through a very steep terrain with slope gradients exceeding $40^{o}$. This area belongs to the Galauda North and Hilpenkandura GN Divisions. The tunnel crosses part of this terrain (Figure 3-3).

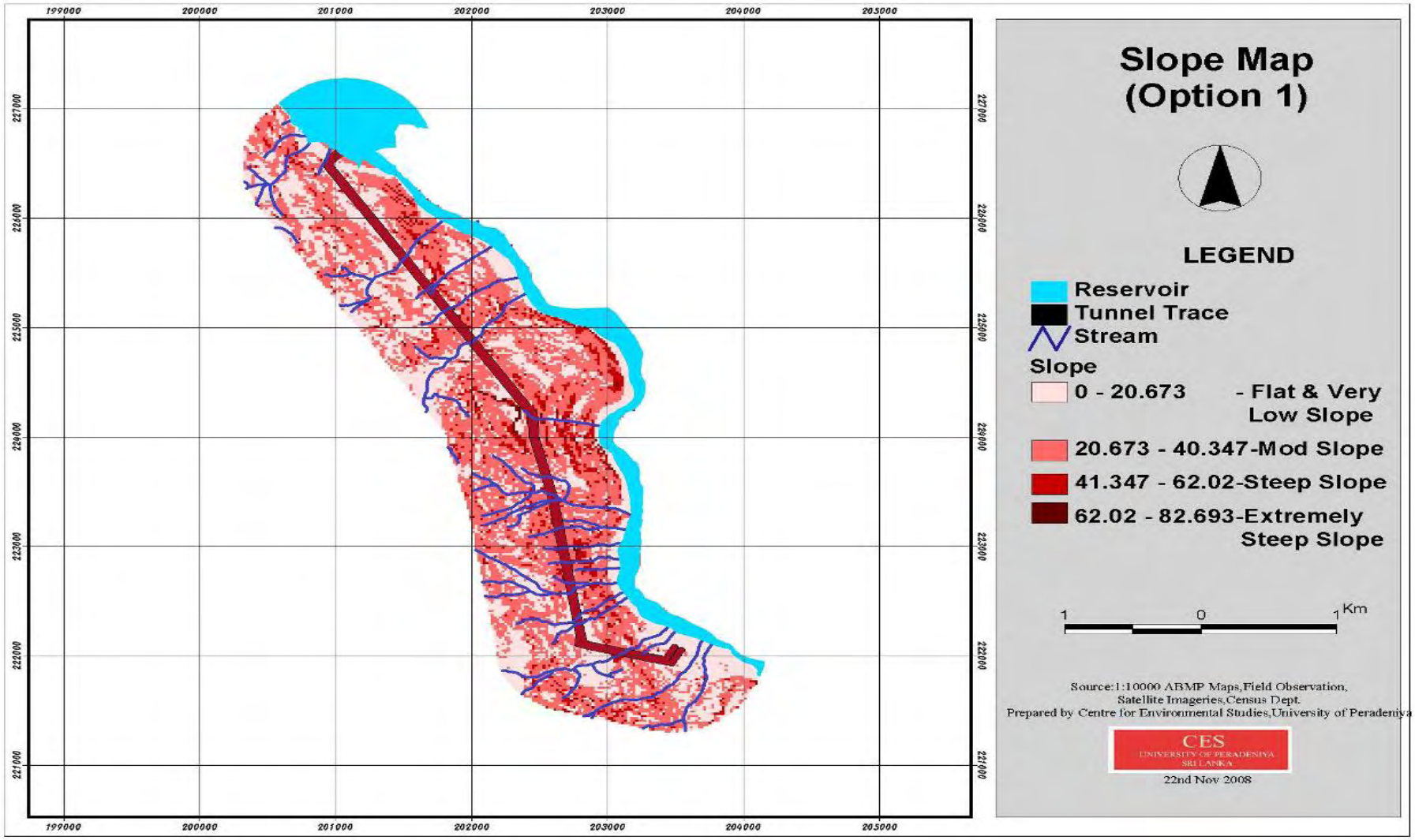



**Figure 3-3 The Slope Map of the Project Impact Area**

### 3.1.3 Geology & Soil

#### 3.1.3.1 Underlying geology

The Project area is composed of Precambrian metamorphic rocks, such as Gneisses (Garnetiferous Quartz Gneiss, Quartz Biotite Gneiss, Biotite Gneiss), Granulite, Quartzite, and Crystalline Limestone (Marble). Generally, these rocks lie alternately with some folding, as bands nearly parallel to the Mahaweli River (Figure 3-4), and sometimes occur as lens-like shapes or as displaced blocks of rocks. The thickness of each layer of Gneisses, Granulite, and Quartzite varies from several cm to tens of metres.

The bed rock consists of,

(i) Gneisses, namely Garnetiferous Quartz Gneiss (GQGn), Quartz Biotite Gneiss (QBGn), Biotite Gneiss (BGn)

(ii) Granulite

(iii) Quartzite

(iv) Crystalline Limestone –Marble

The controls of stability of this type of rock are,

(i) Solution cavities

(ii) Foliation

(iii) Joints

(iv) Faults

Bed rock condition in the powerhouse foundation is not considered as the foundation has already been laid

The strike of the foliation in these metamorphic rocks varies from NW-SE to NNW-SSE from the dam area to the powerhouse area, nearly parallel to the Mahaweli River. The river in this reach lies in a syncline (Huluganga Synform). Hence, the foliation dips downward to the riverbed on both banks. The dip varies 15° near the river bed to 40° at the upper slope. The irregular dip variations occur due to the minor folding and the presence of displaced blocks of rocks. The fresh rock is overlain by the weathered zone which in turn is covered by an overburden of talus deposits. Gneisses are exposed broadly along the riverbed, so only a little river deposit occurs on the riverbed.

Since no critical weak zone was encountered in the existing facilities with the revised tunnel alignment, the geotechnical condition should be almost good within the Basic Option area. However, one could expect to encounter some problems. Gneisses tend to break along the foliation plane or biotite layers when they are weathered, so the open excavation in the weathered zone needs to be alert to the instability of isolated blocks. Because Quartzite was often seen with continuous layers of biotite mica, they are sometimes associated with the instability of the tunnel roof. Granulite was seen as a good rock. However, each layer is not distributed widely. Crystalline Limestone was also seen as a good rock, but it essentially has a high solubility, so the tunnel excavation needs to be alert to the existence of cavities. However, these problems are not critical and could be minimized by effective countermeasures. For example, the instabilities can be prevented by adequate supports, and the cavities detected in advance by probe drillings during construction.

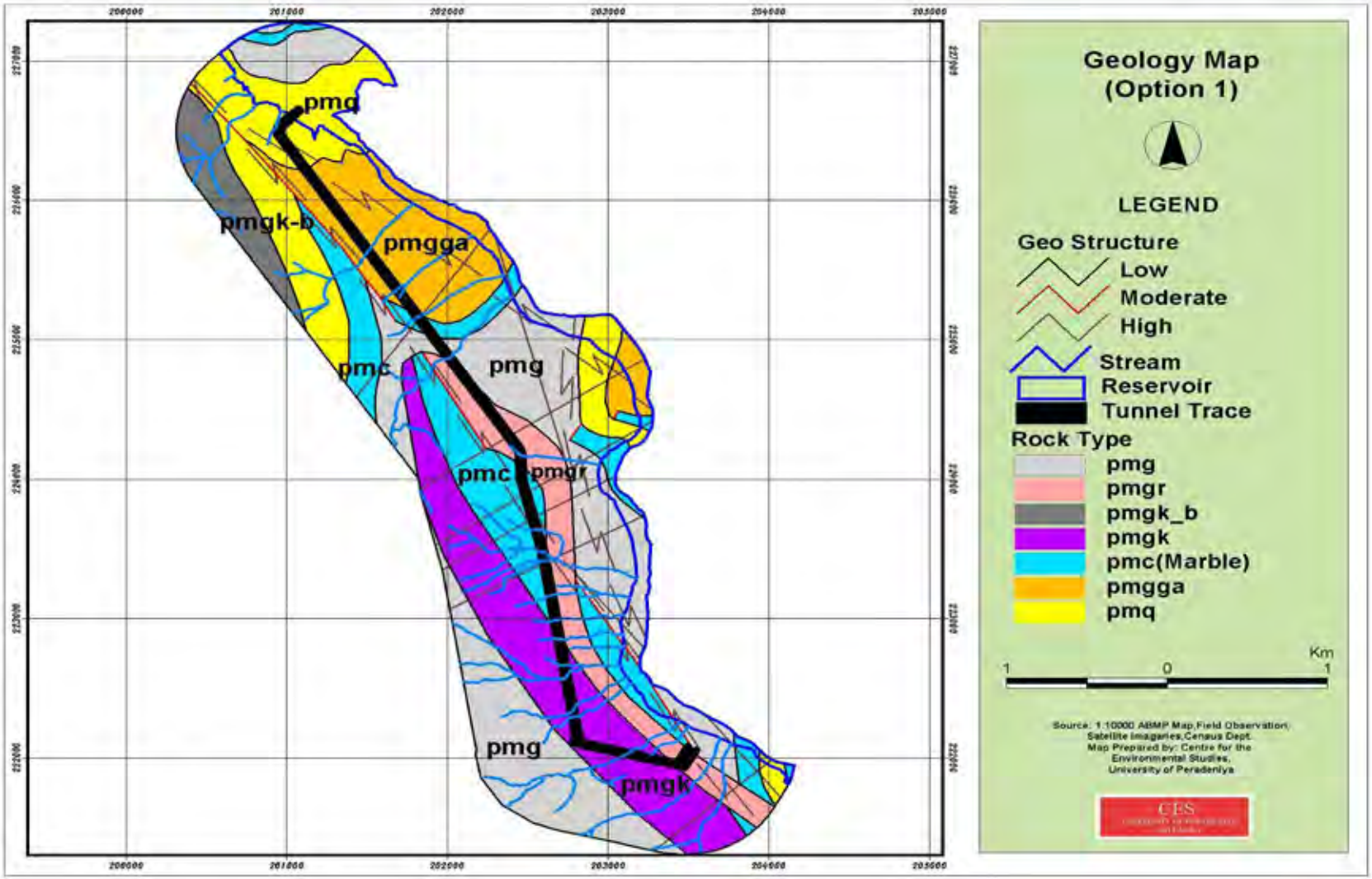



**Figure 3-4 Geology of PIA**

The bed rock in the penstock traverse consists of garnetiferous quartz gneiss (GQGn) and quartz biotite gneiss (QBGn). The penstock will be laid on these rocks. The rocks are competent to provide sufficient anchorage for the penstock. The rock beds show a dip of 40° which is marginal for sliding. Therefore, the possibility of rock slides has to be ascertained by a geotechnical analytical method. If they are found to be unstable, the exposed rock should be stabilized by rock bolting.

The bed rock in the headrace is variable. A vertical section showing the new headrace with the geological formation along the trace is given in Figure 3-5. The records of the existing tunnel construction show that the bed rock in this region has posed stability problems during tunnel excavation. The designers have used a rock classification system to decide on rock competency and hence to select a rock support method.

Information in Figure 3-5 and Table 3-9 show that the bed rock is unstable only at a few locations along the tunnel. However, in general, the rock is in good condition for tunnel dredging.

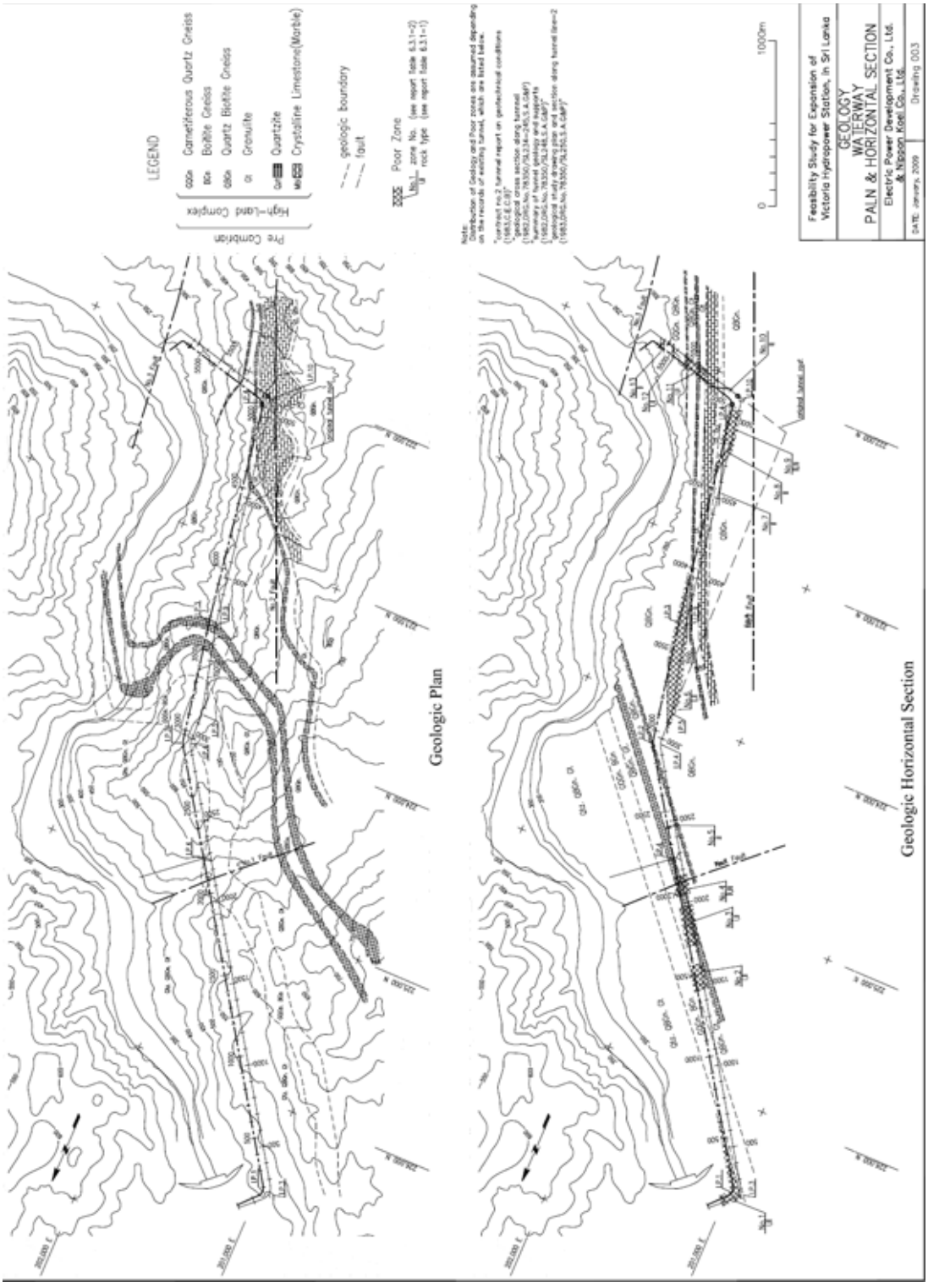



**Figure 3-5 Map of Geology of Project Area**

### 3.1.3.2 Regional and local geological structure, presence of active linear faults

Five major faults are found in the PIA as shown on Figure 3-5. Four of these five faults can be found in construction reports of the existing Victoria Power project. They are located at the Victoria dam site, the powerhouse basement, near the adit, and near the surge tank. The fault near the surge tank is the biggest and the most troublesome. During the construction of

the first Victoria tunnel, a collapse of 300m$^3$ of fractured rock and 800 ℓ/sec flow of groundwater occurred into the tunnel. This led to a relocation of the tunnel alignment in order to avoid this fault. It is noted that the basic option selected out of the three options will not encounter this fault as mentioned in 2.1.3.4. A large amount of deposits was identified by the site reconnaissance carried out by the Study Team of the feasibility study. However, the deposits are located downstream of the powerhouse site and out of the project structure areas.

### 3.1.3.3 Rock mass strength

The rock mass classification system used in the design of the existing tunnel is used in this feasibility study. This four class rock mass classification system is described below:

Class I
Geology: The rock is fresh or slightly altered, joints are generally widely spaced and rough.
Profile: The profile is generally very good with little or no overbreak. More than 70% of half barrels are left. No instability except isolated blocks bounded by unfavourable joints.

Class II
Geology: The rock is fresh or slightly altered and well jointed, with a small proportion of clay-filled or slicken sided joints. Isolated shear zones of the order of 0.5m width may occur. This condition would be typical of isolated zones of poorer rock within otherwise high quality rock, or may be associated with the margins of faulted zones below.
Profile: The profile becomes irregular and controlled by joints. Between 20% to 80% of half barrels are left. Limited raveling of blocks and loosening of the rock around the tunnel occurs.

Class III
Geology: The majority of the rock is moderately altered and well jointed with slicken sided and clay-filled joints. There are multiple zones of sheared and altered material of the order of 0.5m in width. This condition would be typical of minor faults and the peripheral parts of major faults.
Profile: The profile becomes very irregular with overbreak controlled by joints. Less than 20% of half barrels are left. Considerable raveling occurs, leading to substantial collapses if unsupported.

Class IV
Geology: The rock is predominantly highly altered, and/or there is a high incidence of joint infilling. All rock is closely jointed or sheared. This condition would be typical of the central part of a major fault.
Profile: The profile is very irregular and unsTable. Immediate support is required to prevent a major collapse.

Table 3-2 and Table 3-2 show critical zones that might be encountered along the new tunnel giving the rock and draw down conditions. Data for this Table was derived from the final report of the feasibility study.

## Table 3-2 Poor Zone Encountered along Existing Tunnel (1/2)

| Zone no. | General condition | | | | | | | Details of the weak rock parts | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ch. (m) existing | Width(m) | Rock Type (%) I | Rock Type (%) II | Rock Type (%) III | Geology | Assumed orientation | Ch. (m) | Width(m) | Rock Type | Trouble | Geological condition | Support installed |
| 1 | 85 - 208 | 123 | 32.5 | 67.5 | 0.0 | Granulite /Quartzite | pararell to the foliation | 85 - 111 | 26 | II | N/A | A jointed rock zone associated with smooth beddings, and minor cavitated zones. | 3m pattern bolts |
| | | | | | | | | 151 - 208 | 57 | II | N/A | A jointed rock zone associated with smooth beddings. | 3m pattern bolts |
| 2 | 1,470 - 1,622 | 152 | 16.4 | 83.6 | 0.0 | Granulite | perpendicular to the foliation | 1,470 - 1,555 | 85 | II | N/A | A jointed rock zone associated with slickensided steep joints, and some smooth beddings. | 3m pattern bolts<br>50mm shotcrete |
| | | | | | | | | 1,580 - 1,622 | 42 | I-II | N/A | A jointed rock zone associated with minor faults. | 3m pattern bolts<br>50mm shotcrete |
| 3 | 1,741 - 1,977 | 236 | 60.6 | 39.4 | 0.0 | Quartzite | perpendicular to the foliation | 1,741 - 1,748 | 7 | I-II | N/A | A jointed rock zone associated with a minor fault. | 3m spot bolts |
| | | | | | | | | 1,822 - 1,832 | 10 | I-II | N/A | A jointed rock zone associated with a minor fault and slickensided steep joints. | 3m pattern bolts |
| | | | | | | | | 1,861 - 1,875 | 14 | I-II | N/A | A jointed rock zone associated with minor faults. | 3m pattern bolts |
| | | | | | | | | 1,915 - 1,945 | 30 | II | N/A | Series of minor faults associated with minor fructured zones. | 3m pattern bolts |
| | | | | | | | | 1,945 - 1,977 | 32 | I-II | N/A | A jointed rock zone associated with some slickensided steep joints. | 3m pattern bolts |
| 4 | 2,050 - 2,164 | 114 | 0.0 | 88.6 | 11.4 | Gneiss | perpendicular to the foliation | 2,050 - 2,134 | 84 | II | rock fall (sliding on a bedded plane) | A jointed rock zone associated with a series of minor faults and slickensided steep joints.<br>A rock fall occurred at tunnel crown Ch.2,071-2,083m. | 3m pattern bolts<br>partly 50mm shotcrete<br>partly 1m spacing ribs and backfilled concrete |
| | | | | | | | | 2,134 - 2,147 | 13 | III | N/A | A jointed rock zone associated with a fault(2-3m width) and sheared and broken materials.<br>Groundwater inflow of 100 L/m was recorded. | 3m pattern bolts<br>2m long tensioned rock bolts<br>100mm shotcrete with weld mesh |
| | | | | | | | | 2,147 - 2,164 | 17 | II | N/A | A jointed rock zone associated with a series of minor faults and slickensided steep joints. | 3m pattern bolts |
| 5 | 2,465 - 2,475 | 10 | 0.0 | 100.0 | 0.0 | Gneiss | perpendicular to the foliation | 2,465 - 2,475 | 10 | II | N/A | A jointed rock zone associated with smooth beddings and steep joints. | 3m pattern bolts |
| 6 | 3,098 - 3,760 | 662 | 76.6 | 19.3 | 4.1 | Gneiss | pararell to the foliation | 3,098 - 3,125 | 27 | III | Unstable rock (sliding along a minor fault) | An unstable zone associated with a fault(0.5m width ) consisted of sheared and broken rock fragments. | 100mm shotcrete with weld mesh<br>4m pattern bolts<br>supports were installed immediately |
| | | | | | | | | 3,125 - 3,190 | 65 | II | N/A | A jointed rock zone associated with shuttered rock. | 3m spot bolts |
| | | | | | | | | 3,535 - 3,588 | 53 | II | N/A | A jointed rock zone associated with shattered rock and a sheared bedding. | 3m pattern bolts<br>50mm shotcrete |
| | | | | | | | | 3,730 - 3,750 | 20 | I | N/A | A thin band of moderately weathered micaceous Crystalline Limestone. | 3m pattern bolts<br>50mm shotcrete |
| | | | | | | | | 3,750 - 3,760 | 10 | II | N/A | A thin band of moderately weathered micaceous Crystalline Limestone lying behind the tunnel crown. | 3m pattern bolts<br>50mm shotcrete |
| 7 | 4,580 - 4,590 | 10 | 0.0 | 100.0 | 0.0 | Gneiss | pararell to the foliation | 4,580 - 4,590 | 10 | II | N/A | A jointed rock zone associated with a minor fault. | 3m pattern bolts |

## Table 3-3 Poor Zone Encountered along Existing Tunnel (2/2)

| Zone no. | General condition | | | | | | | Details of the weak rock parts | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ch. (m) existing | Width(m) | Rock Type (%) I | Rock Type (%) II | Rock Type (%) III | Geology | Assumed orientation | Ch. (m) | Width(m) | Rock Type | Trouble | Geological condition | Support installed |
| 8 | 4,760 - 4,838 | 78 | 0.0 | 100.0 | 0.0 | Gneiss | diagonally across the foliation | 4,760 - 4,838 | 78 | II | N/A | A jointed rock zone associated with minor faults, steep slickensided joints and smooth beddings. | 3m pattern bolts<br>4m long tensioned rock bolts<br>100mm shotcrete with weld mesh |
| 9 | 4,838 - 5,046 | 208 | 0.0 | 41.3 | 58.7 | Gneiss | perpendicular to the foliation | 4,838 - 4,960 | 122 | III | rock fall (sliding alog minor faults) | A shattered zone associated with a series of minor faults.<br>A rock fall of 25m$^3$ occurred around Ch.4,923m from the west shoulder of the tunnnel. | 4m pattern bolts<br>50-100mm shotcrete |
| | | | | | | | | 4,960 - 5,020 | 60 | II | N/A | A jointed rock zone associated with shattered rock. | 3m pattern bolts |
| | | | | | | | | 5,020 - 5,046 | 26 | II | N/A | A jointed rock zone associated with a minor fault and steep slickensided joints. | 3m pattern bolts |
| 10 | 5,215 - 5,222 | 7 | 0.0 | 100.0 | 0.0 | Gneiss | perpendicular to the foliation | 5,215 - 5,222 | 7 | I-II | N/A | There is a minor fault | 3m pattern bolts |
| 11 | 5,388 - 5,550 | 162 | 25.9 | 74.1 | 0.0 | Granulite Quartzite | pararell to the foliation | 5,388 - 5,418 | 30 | I-II | N/A | A jointed rock zone | 3m pattern bolts |
| | | | | | | | | 5,418 - 5,438 | 20 | II | N/A | A jointed rock zone associated with a minor sheared zone and a micacious Crystalline Limestone layer. | 3m pattern bolts<br>50mm shotcrete with weld mesh |
| | | | | | | | | 5,438 - 5,468 | 30 | I-II | N/A | A jointed rock zone associated with a micacious Crystalline Limestone layer. | 3m pattern bolts |
| | | | | | | | | 5,500 - 5,530 | 30 | I-II | N/A | A jointed rock zone | 3m pattern bolts |
| | | | | | | | | 5,530 - 5,540 | 10 | II | N/A | There is a thick micacious Crystalline Limestone layer. | 3m pattern bolts |
| | | | | | | | | 5,540 - 5,550 | 10 | I | Major ground water inflow (fissure) | A ground water inflow of 50-100L/m and back pressure 0.25-0.45MPa(2.5-4.5bar) was recorded in the probe hohes.<br>15tons of cement were injected. | 3m pattern bolts |
| 12 | 5,625 - 5,635 | 10 | 100.0 | 0.0 | 0.0 | Gneiss | pararell to the foliation | 5,625 - 5,635 | 10 | I | rock fall (sliding along a sheared zone), Major ground water inflow | There is a broken and sheared zone (<1m width) associated with clay, which contributed to the formation of weadges and blocks.<br>A groundwater inflow of 50-60 L/m was recorded at this zone. | 3m pattern bolts<br>4m long tensioned rock bolts<br>50mm shotcrete with weld mesh ribs |
| 13 | 5,655 - 5,664 | 9 | 0.0 | 100.0 | 0.0 | Gneiss | pararell to the slope | 5,655 - 5,664 | 9 | II | Unstable rock (sliding on bedded planes) | A weathered and jointed rock zone associated with smooth beddings and slickensided steep joints. | 3m pattern bolts<br>50mm shotcrete<br>ribs |

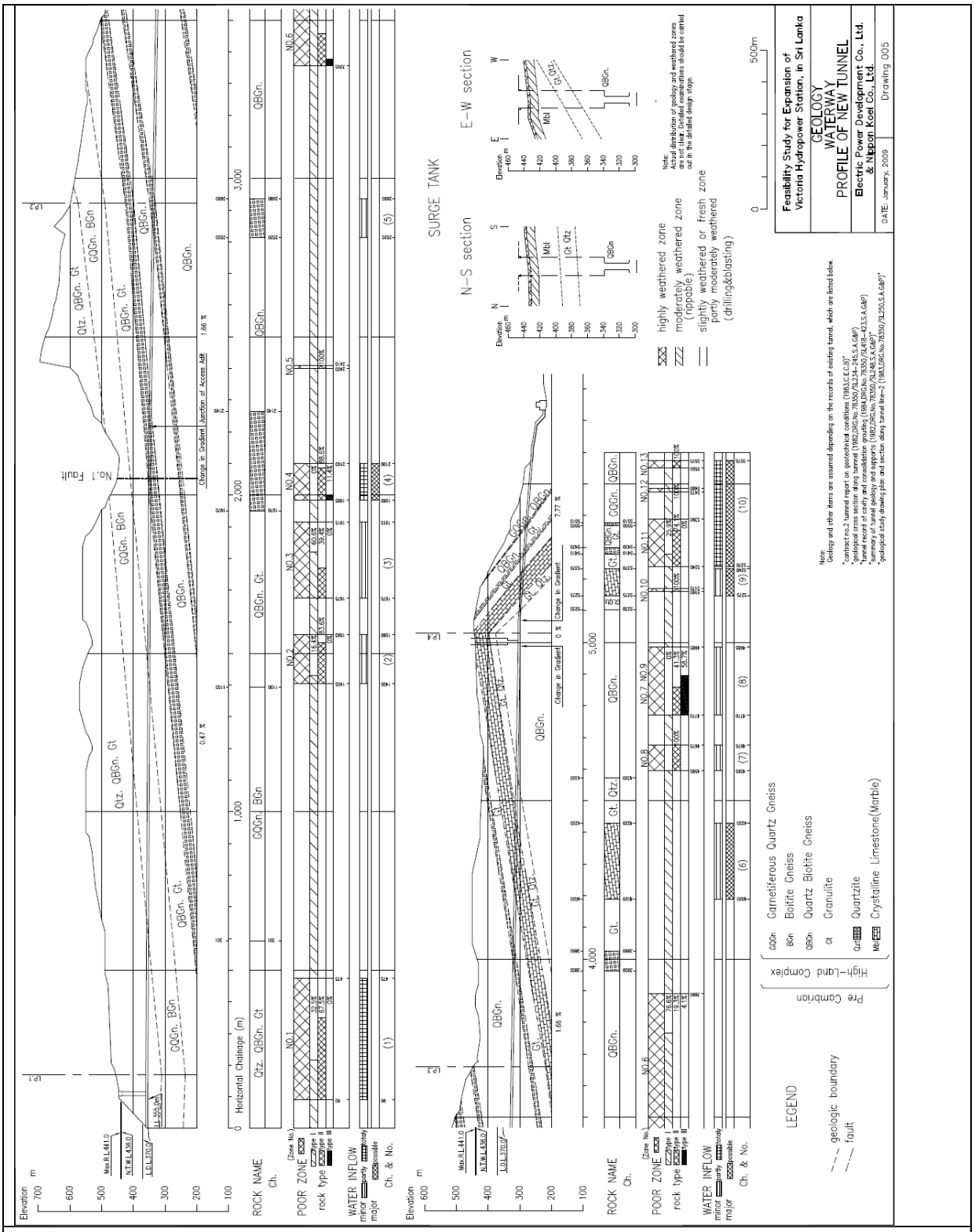



**Figure 3-6 Vertical section showing new tunnel and geology Ch 00+00 to 05+750**

#### 3.1.3.4 Soil types, distribution and thickness

The reconnaissance soil map of the PIA depicts only one soil series which is the Ulhitiya Series (Mapping Unit 39, Mapa, Dassanayake and Nayakakorale (2005:115-116). According to the local soil classification this series belongs to the Reddish Brown Earths Great Group. The soil is well drained and moderately deep to deep with abundant rock outcrops and isolated boulders. The parent material is derived from the weathering products, alluvium in stream valleys and colluvial material. The thickness of the top soil (A horizon) varies with topographic position. The soil reaction is medium to slightly acidic (pH 6-6.5) and base saturation of subsurface soil is greater than 35%. The surface soil is poor in organic carbon due to rapid decomposition and erosional loss. The surface soil has a sandy clay loam texture and the clay content increases with depth. Accelerated soil erosion is in evidence everywhere due to chena cultivation

#### 3.1.3.5 Leakage conditions

No unique leakage conditions in soil is found in the area except normal percolation in the soil horizon.

#### 3.1.3.6 Soil characteristics in relation to salinity, acidity, iron toxicity, ground water recharge and land use capabilities

(These aspects of soil are hardly relevant to the proposed project. The impact area is not to be used for cultivation.)

#### 3.1.3.7 Land slide potentials of the area

See section 3.1.5.18.

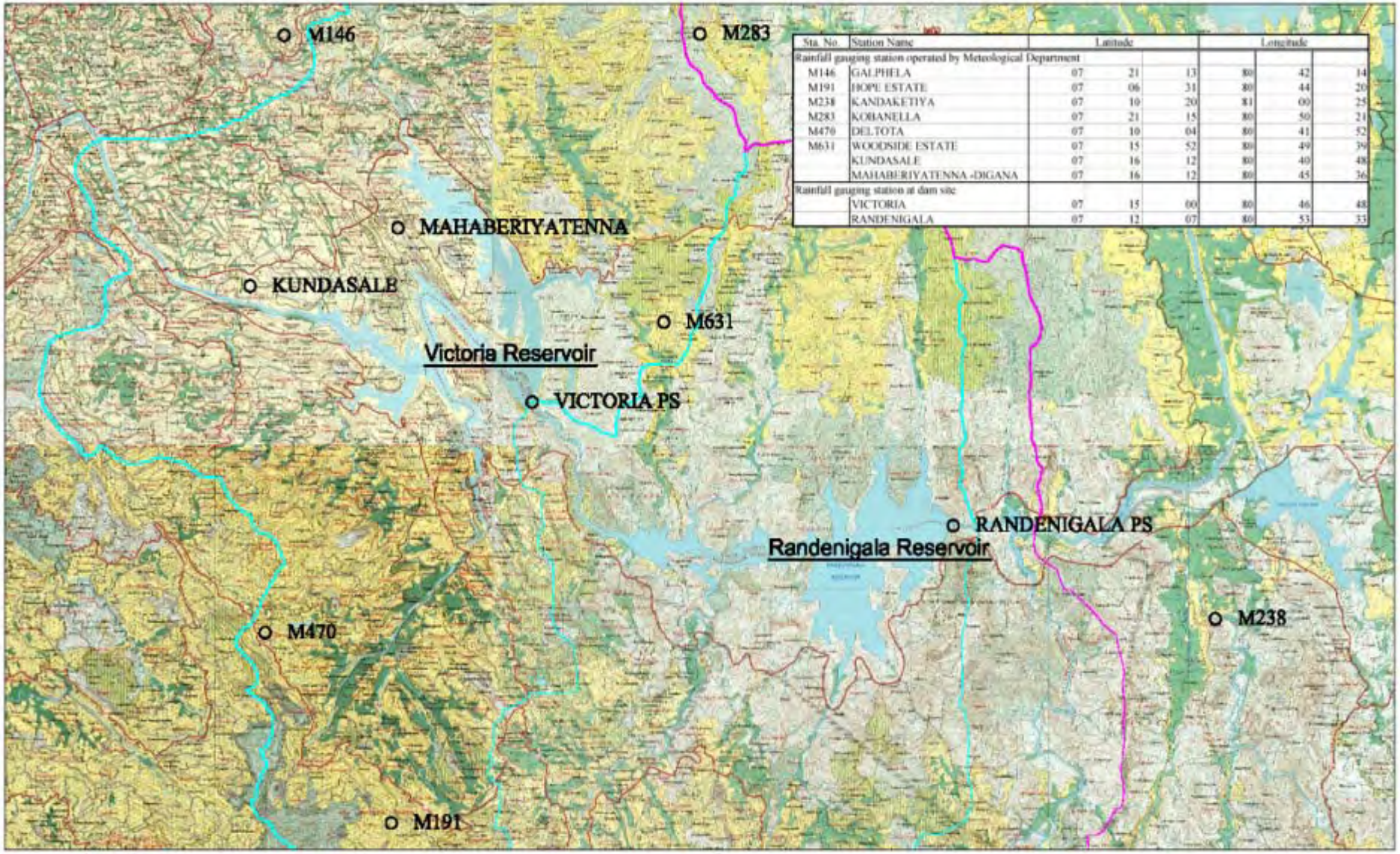
#### 3.1.3.8 Mineral resources

No mineral survey has been conducted in the area and nowhere is mining reported. Since the PIA is within the Sanctuary, mining activities are not permitted even if mineral resources are in existence. The proposed project does not in any way affect the future exploitation of such resources.

### 3.1.4 Meteorology

#### 3.1.4.1 Rainfall pattern

The wide spatial variation of the rainfall around the study area is clearly seen in the average rainfall distributions observed at the gauging stations closest to the area in Figure 3-8. The locations of the meteorological stations are shown in Figure 3-7. The closest rain gauging station to construction is the Victoria Dam. Here the rain is high from October to January and low in the other months. The rains during the inter-monsoons in April are responsible for the somewhat high rain during that month. Other months, especially June, July and August are drier.




| Sta. No. | Station Name | Latitude | | | Longitude | | |
|---|---|---|---|---|---|---|---|
| Rainfall gauging station operated by Meteological Department | | | | | | | |
| M146 | GALPHELA | 07 | 21 | 13 | 80 | 42 | 14 |
| M191 | HOPE ESTATE | 07 | 06 | 31 | 80 | 44 | 20 |
| M238 | KANDAKETIYA | 07 | 10 | 20 | 81 | 00 | 25 |
| M283 | KOBANELLA | 07 | 21 | 15 | 80 | 50 | 21 |
| M470 | DELTOTA | 07 | 10 | 04 | 80 | 41 | 52 |
| M631 | WOODSIDE ESTATE | 07 | 15 | 52 | 80 | 49 | 39 |
| | KUNDASALE | 07 | 16 | 12 | 80 | 40 | 48 |
| | MAHABERIYATENNA -DIGANA | 07 | 16 | 12 | 80 | 45 | 36 |
| Rainfall gauging station at dam site | | | | | | | |
| | VICTORIA | 07 | 15 | 00 | 80 | 46 | 48 |
| | RANDENIGALA | 07 | 12 | 07 | 80 | 53 | 33 |

**Figure 3-7 The locations of the gauging stations**

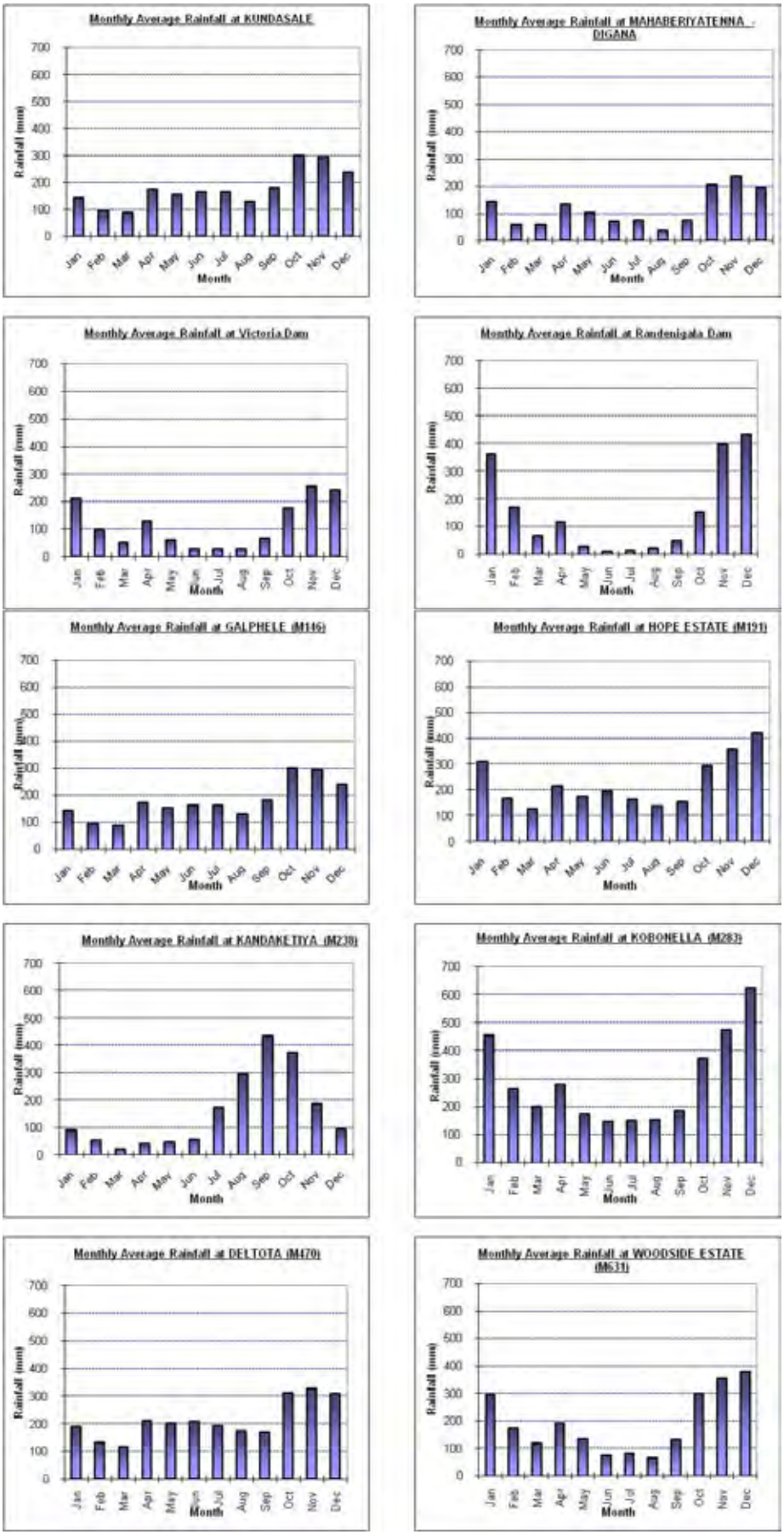



**Figure 3-8 Rain fall pattern (2)**

#### 3.1.4.2 Wind

There is no wind measuring station close to the study area. The closest is located at Katugastota about 10 km from the head waters of the Victoria reservoir. However, the Victoria Dam and the study area are located on the leeward side of the mountains for the southwest winds. During this period (June, July) the windward slopes of the central hills receive rainfall and there are dry winds in the leeward slopes. These are very high-speed winds. This phenomenon causes the wind close to the Victoria Dam and the study area to be very different from the winds at Katugastota. Therefore the wind data of Katugastota will not be used in this report. During other months low winds are generally observed in the area.

### 3.1.5 Hydrology

#### 3.1.5.1 General description of the catchment areas of water bodies

The catchment upstream of the Randenigala Reservoir is entirely located in the central hills of Sri Lanka. The location of hills at the centre with the surrounding flat low lying plains of the country takes the advantage of rains during both monsoons and inter-monsoons. Therefore the Mahaweli Catchments receive rains throughout the year.

The uppermost catchments are a national forest reserve that continuously feeds the river with its retained runoff. The area below the forest reserve is planted with tea mottled with forests on the mountain tops, steep slopes and river banks. The next lower elevation where the Victoria Reservoir is located is predominantly home gardens. VegeTable and paddy cultivation are also widespread in the catchments and are greatly responsible for the sediments in the river system.

#### 3.1.5.2 Flow regimes during dry season

The river reach of the study area distinctively belongs to two different river regimes. They are:

- Reach from the dam to powerhouse
- Reach from powerhouse to headwaters of Randenigala Reservoir

The reach from the Victoria Dam to powerhouse has different characteristics as there is no river flow especially during dry periods. Only the seepage waters and water from the creeks are collected in this part of the river. Only during an event where the dam bottom outlet is opened or when a spill discharge occurs does this river reach come alive with river flow. The reach below the power plant carries the combined flow coming from the above reach and the power discharge.

#### 3.1.5.3 Surface drainage pattern

See Section 3.1.5.9

#### 3.1.5.4 Occurrence of flooding and return period

Flooding at the proposed power station site is not an issue as the release of water from Victoria is only through the existing tunnel and takes place according to the MASL directives with the only exception being occasional spilling. In any case the existing power house is designed with the maximum spilling taken into account. Please also see sections 3.1.5.10-17.

### 3.1.5.5 Existing water use pattern of the area

The water use in the surrounding neighborhood to the study area is mainly for paddy and vegeTable cultivations. The cultivation relies on the rain water and a few ad-hoc diversions from creeks flowing through the area. Paddy is cultivated during the Northeast monsoon period with higher rainfall and vegeTables in the seasons immediately following. No cultivations are done during the drier period from June to August. As the cultivations use the rainwater and subsurface flow it is difficult to quantify the amount used by the farmers. However, it is clear that the livelihood of the farming community depends on the water flow in the creeks.

### 3.1.5.6 Surface water quality of the river regime

In order to describe the existing state of the surface water quality of the area, field investigations were carried out at selected locations. The study locations encompass the Mahaweli River both upstream and downstream of the proposed power station and other creeks and tributaries of the river stretch involved. Historically no extensive studies have been conducted for surface water quality of this area. Hence data from the investigations carried out during this study is used to describe the surface water quality of the area.

Samples were collected from six sites in total with two locations in the Mahaweli River, three locations from the surrounding creeks and one sample from the tributary where sand mining for the project is proposed. Location of these sampling points is shown in Figure 3-9. All these samples were analyzed for a range of general parameters, nutrients, cations, anions and trace metals.

Then main target of these investigations was to assess the impact on water quality of human activities associated with settlements and agriculture. This is because there are no industrial activities in the project area. The water quality was assessed during November-December 2008. The obtained water quality parameters are shown in Table 3-4 below. During this investigation samples were taken both during dry conditions and during wet conditions with three samplings taken during dry weather and five samples during wet weather conditions.

**Table 3-4 Surface water quality (Ref. Figure 3-9Figure 3-9 for locations)**

| Location | 22 (Creek 1) | | 20 (Creek 2) | | 21 Creek 3 (dry) | 23 (River)* (wet) | 24 (River)* (wet) | 25 (Stream) (wet) |
|---|---|---|---|---|---|---|---|---|
| | Dry | Wet | Dry | Wet | | | | |
| Temperature $^0$C | 25.0 | 24.2 | 25.0 | 24.4 | 24.6 | 24.9 | 25.1 | 24.6 |
| pH | 7.6 | 7.8 | 7.4 | 7.9 | 7.2 | 7.6 | 7.2 | 7.4 |
| Conductivity (µS/cm) | 455 | 456 | 645 | 790 | 498 | 326 | 102 | 164 |
| Dissolved Oxygen (mg/l) | 8.03 | 8.05 | 5.51 | 5.54 | 3.03 | 6.10 | 7.87 | 8.93 |
| Alkalinity total (mg/l as $CaCO_3$) | 190 | 170 | 240 | 130 | 210 | 140 | 40 | 50 |
| Nitrogen ($NO_3^-$ -N) mg/l | 1.1 | 0.4 | 0.2 | <0.1 | 0.5 | 0.1 | 0.3 | 0.3 |
| Phosphorous ($PO_4^{3-}$-P) mg/l | 0.05 | 0.05 | 0.03 | 0.19 | 0.10 | 0.11 | 0.08 | 0.10 |
| Total Hardness (as $CaCO_3$) mg/l | 190 | 186 | 240 | 260 | 210 | 110 | 35 | 53 |
| $BOD_5$ (mg/l) | 1.4 | 1.13 | 2.2 | 1.11 | 21 | 1.67 | 1.33 | 1.0 |
| TSS (mg/l) | 20 | 14 | 202 | 240 | 76 | 16 | 90 | 152 |
| TDS (mg/l) | 292 | 364 | 238 | 260 | 688 | 96 | 136 | 20 |

| Location | 22 (Creek 1) | | 20 (Creek 2) | | 21 Creek 3 (dry) | 23 (River)* (wet) | 24 (River)* (wet) | 25 (Stream) (wet) |
|---|---|---|---|---|---|---|---|---|
| | Dry | Wet | Dry | Wet | | | | |
| Iron (mg/l) | 0.01 | 0.01 | 0.22 | <0.01 | 0.37 | 0.06 | 0.20 | 0.29 |
| Turbidity (NTU) | 0.43 | 0.4 | 2.5 | 0.26 | 8.2 | 0.7 | 4.2 | 5.8 |
| Color (PtCo APHA units) | 40 | 20 | 19 | 12 | 27 | 9 | 35 | 34 |
| Total Coliform (pfu/100ml) | 0 | 42 | 0 | 200 | 0 | 260 | 140 | 30 |
| Fecal Coliform (pfu/100ml) | 0 | 0 | 0 | 60 | 0 | 12 | 06 | 22 |

* sampling of Mahaweli water quality just upstream of the proposed power plant and just down stream the proposed power plant.

The following sections detail the existing surface water quality of the project areas including the location proposed for sand mining based on the field and laboratory investigation carried out during this study.

3.1.5.6.1 Physical parameters: temperature varied from 24.2°C to 25.1°C. Except in one location (creek 3) the water was well saturated with oxygen. pH in all locations was almost neutral with slightly alkaline (7.2–7.9). The water was moderately soft with conductivity values of 102 to 790 microsiemens per centimeter (µS/cm), total alkalinity of 40 to 240 mg/l and total hardness values of 35 to 260 mg/l as $CaCO_2$. Turbidity was very low during the sampling days with values less than 8.2 NTU turbidity units. Results indicated that the concentration of suspended solid matter and dissolved solid matter are moderate. In some creeks (creek 2) suspended solids content was fairly high during both dry and wet condition showing less soil erosion during the wet season. Except in creek 2, suspended solids content in other locations in the study impact area were less than 90 mg/l. These values indicate low erosion activity. However, compared to suspended solids content, dissolved solids content in creeks show higher values with the highest being 688 mg/l in creek 3. As there was no previous monitoring data available, these values could not be compared for any seasonal or long term quality variations.

3.1.5.6.2 Biochemical parameters: high concentrations of phosphorus (0.03 to 0.19 mg/l as $PO_4^3$-P) shown in creeks and river water indicate eutrophic conditions. NO3- -Nitrogen was less than 1.1 mg/l. High nutrient values ($PO_4^3$ - P and $NO_3$- - N) point out that they can be linked with human activity. However the 5-day biochemical oxidation demand (BOD5) show low figures less than 2.2 mg/l except in creek 3 where BOD5 is 21 mg/l. The reason for the low DO (dissolved oxygen) level observed in creek 3 is associated with this high organic content as organic matter is oxidized aerobically consuming the DO in water.

Iron concentration in all surface waters show low levels. However the total hardness in surface water show moderate values with 260 mg/l being the highest observed at creek 2. Relatively high hardness concentrations are normal with the lime stone formations available in the catchment.

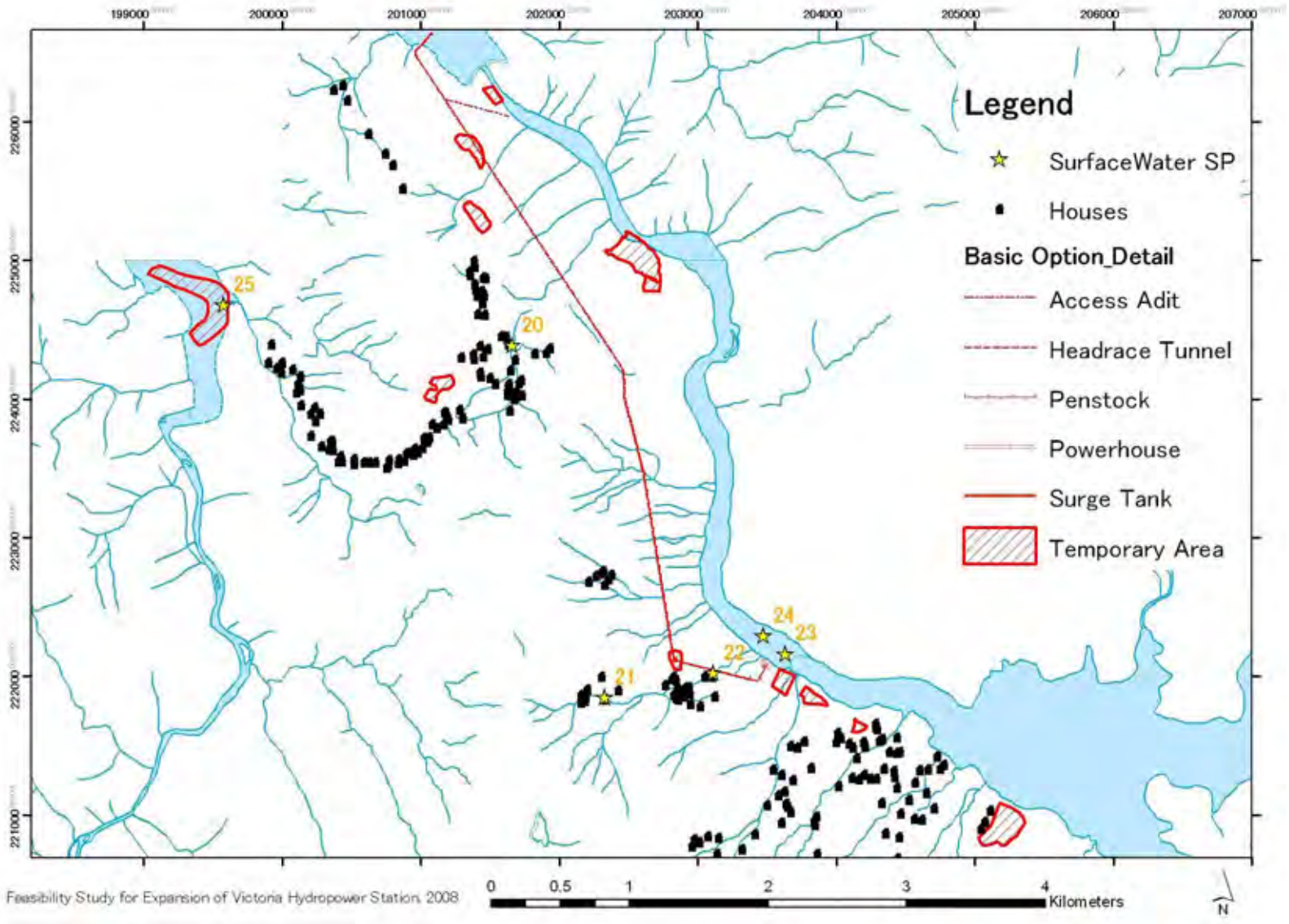



**Figure 3-9 Locations of Surface water samplings**

Total coliforms were detected from all locations during the wet season. No coliforms were detected during the dry period. The highest level was observed in the main river with 260 pfu/100ml at upstream of the existing power house. Also high total coliform values of 200 pfu/100ml in creek 2 and 140 pfu/100ml main river downstream of power plant was also observed. Fecal coliform too was observed in creek 2 and in the main river. Highest level of 60 pfu/100ml is observed in creek 2. The result obtained show high coliform contamination during wet season indicating that the main source is surface runoff. Observed coliform and nutrient levels in streams link the pollution mainly to human activities especially from the release of domestic wastes and improper agriculture practices. Fecal coliform during wet season indicate a problem with toilet waste disposal systems.

### 3.1.5.7 Ground water levels, including ground water level along the tunnel route

The survey carried out identified ground water levels at several locations where existing wells are in operation (see Table 3-5). These locations are confined to two major clusters, one in Welikada and the other in Hakurutale where human settlements are found. Except these two clusters, the tunnel traces go through uninhabited area where no wells exist. While the majority of the people in the Hakurutale cluster indicated that the water level in their wells decreased during the construction of the tunnel in Victoria Phase I, the response from people in Welikada was mixed.

**Table 3-5 Water Level (meters below ground surface Ref. Figure 3-10 for locations)**

| Well Location | 1 | 2 | 3 | 5 | 7 | 12 | 14 |
|---|---|---|---|---|---|---|---|
| Groundwater level (m) | 0.90 | 0.50 | 0.40 | 1.20 | 0.30 | 0.50 | 1.45 |

### 3.1.5.8 Ground water quality

To evaluate the state of groundwater quality of the area, field investigations were carried out at selected locations. The investigation focused only on shallow groundwater quality as there was no access to deep groundwater. Selected study locations included wells in the impact area where they are used both for drinking as well as for other purposes. The selected sample locations are shown in Figure 3-10. As with surface water, no extensive studies have been conducted for groundwater quality of this area and hence data from the investigations was used to describe the existing groundwater quality of the project area.

Samples were collected from seven different locations with only one location sampled both in dry and wet weather conditions. All other locations were investigated during the dry weather conditions. The samples were analyzed for a range of general parameters, nutrients, cations, anions and trace metals.

**Table 3-6 Current groundwater quality of the area (ref. Figure 3-10 for locations)**

| Well Location Number | 1 | 2 | 3 | | 5 | 7 | 12 | 14 |
|---|---|---|---|---|---|---|---|---|
| | | | Dry | Wet | | | | |
| Temperature $^0$C | 25.8 | 26.3 | 25.9 | 24.2 | 24.6 | 26.3 | 26.4 | 23.4 |
| pH | 7.3 | 7.4 | 8.6 | 7.5 | 7.6 | 7.5 | 7.3 | 7.2 |
| Conductivity (µS) | 683 | 504 | 556 | 553 | 722 | 877 | 719 | 540 |
| Dissolved Oxygen (mg/l) | 7.06 | 5.46 | 7.26 | 6.92 | 5.93 | 7.16 | 5.19 | 5.75 |
| Alkalinity (mg/l) | 260 | 200 | 200 | 200 | 260 | 300 | 320 | 219 |

| Well Location Number | 1 | 2 | 3 | | 5 | 7 | 12 | 14 |
|---|---|---|---|---|---|---|---|---|
| | | | Dry | Wet | | | | |
| Nitrogen ($NO_3^-$ -N) mg/l | 0.2 | >0.1 | 2.0 | 1.2 | 0.3 | 0.3 | 0.9 | 0.6 |
| Phosphorous ($PO_4^{3-}$-P) mg/l | 0.05 | 0.03 | 0.03 | 0.11 | 0.05 | 0.04 | 0.03 | 0.12 |
| Total Hardness (as $CaCO_3$) mg/l | 260 | 210 | 213 | 210 | 280 | 326 | 360 | 230 |
| $BOD_5$ (mg/l) | 1.19 | 1.53 | 1.62 | 1.33 | 1.50 | 1.53 | 1.42 | 1.88 |
| TSS (mg/l) | 78 | 172 | 266 | 144 | 142 | 188 | 316 | 88 |
| TDS (mg/l) | 386 | 158 | 34 | 130 | 344 | 362 | 202 | 74 |
| Iron (mg/l) | 0.03 | 0.01 | 0.04 | 0.01 | 0.03 | 0.01 | <0.01 | 0.08 |
| Turbidity (NTU) | 0.9 | 0.3 | 0.45 | 0.35 | 0.6 | 0.45 | 0.44 | 0.97 |
| Color (PtCo APHA units) | 11 | 40 | 34 | 35 | 32 | 6 | 12 | 7 |
| Total Coliform (pfu/100ml) | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 |
| Fecal Coliform (pfu/100ml) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The impact on water quality from area geology and human activities associated with settlements and agriculture practices was assessed during November - December 2008 at the said seven locations. The obtained results are shown in Table 3-6.

3.1.5.8.1 Physical parameters: The temperature varied from 24.2°C to 26.4°C. Except in a few locations where the dissolved oxygen content was less than 6 mg/l, most well water was acceptably saturated with oxygen. pH in all locations was almost neutral but with a slightly alkaline condition (7.2–8.6). The water was moderately soft with conductivity values ranging from 504 to 877. The micro-siemens per centimeter (µS/cm), however, was understandably higher than that of the surface water quality of the area. The total alkalinity of 200 to 320 mg/l and total hardness values of 210 to 360 mg/l further confirms this fact. Turbidity was very low during the sampling days and showed values less than 1 NTU turbidity units. Results indicated that the concentration of suspended solid matter and dissolved solid matter are moderate to low. The maximum observed total suspended solids (TSS) and total dissolved solids (TDS) levels were 316 mg/l and 382 mg/l respectively. As there was no previous monitoring data available, these values could not be compared for any seasonal and long term quality variations.

3.1.5.8.2 Biochemical parameters: fairly high concentrations of phosphorus (0.03 to 0.12 mg/l as PO43--P) shown in wells indicate eutrophic conditions. The well at location 1 show higher phosphorous concentrations during wet weather condition than in dry conditions. Observed NO3- Nitrogen was less than 2.0 mg/l. Higher nutrient values ($PO_4^3$ - P and $NO_3$-N) indicate that they can be linked with anthropogenic activities. However, the 5-day biochemical oxidation demand (BOD5) show low figures (less than 1.63 mg/l), thus indicating that the nutrient source may be from agriculture activities rather than from domestic wastewater.

Iron concentration shows low levels. However, total hardness in groundwater show moderate values in all wells with 210 mg/l and 360 mg/l being the lowest and highest observed. Relatively high hardness concentrations in groundwater are normal in catchments with limestone formations.

No fecal coliform is observed in any of the locations in both wet and dry seasons. However, total coliform was observed in the well sample that was taken during the wet weather period. A fairly high value of 25 pfu/100ml is observed. As with surface water, the observed nutrient levels in the wells might be more related to agriculture activities than domestic activities.

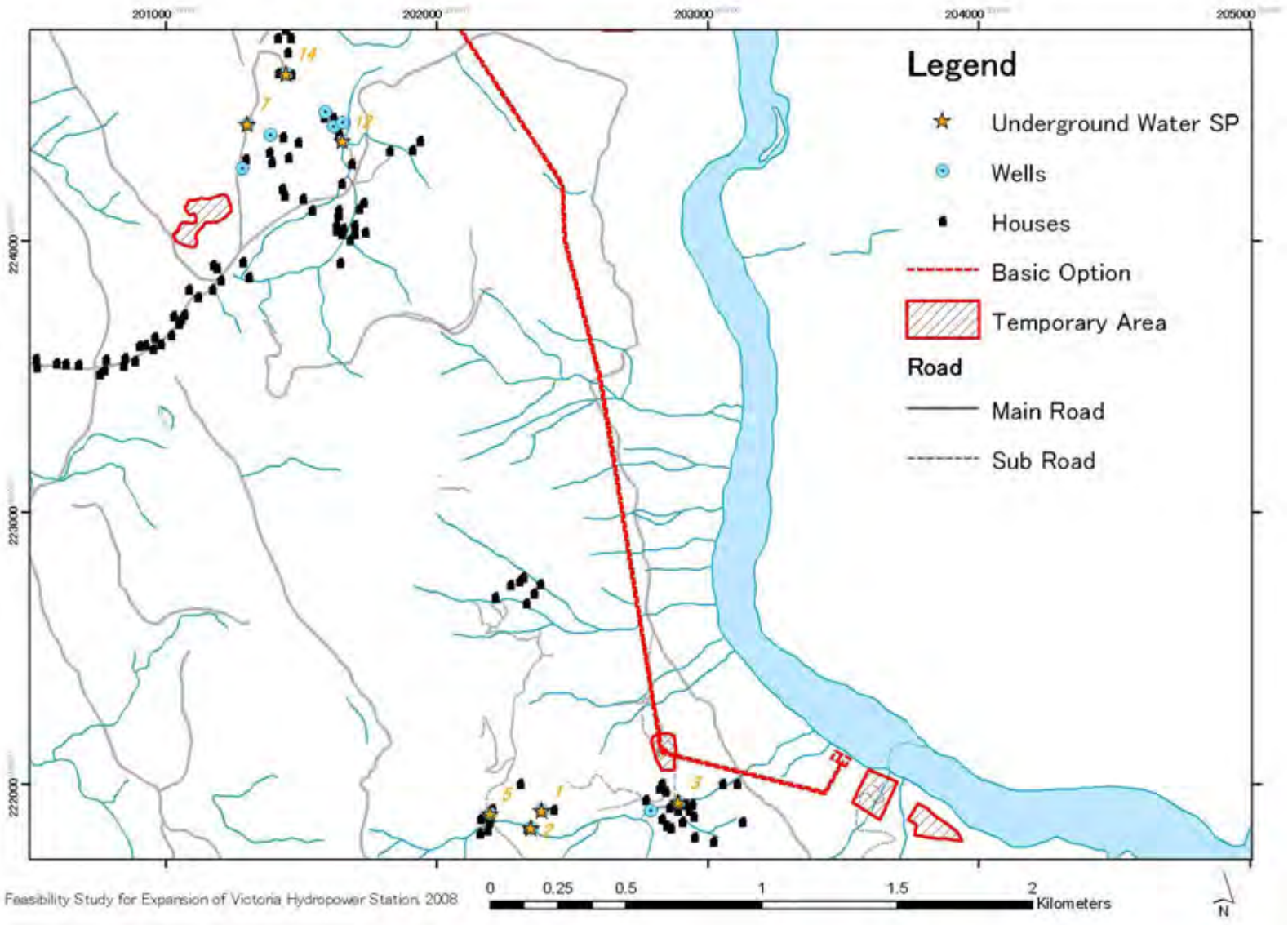



**Figure 3-10 Locations of Groundwater sampling**

### 3.1.5.9 Drainage pattern of the study area

The major stream in the project area is the Mahaweli River. The reach from the Victoria Dam to the Victoria Power Station now carries only the local drainage and contribution from the small tributaries draining the valley side slopes on either side of the Mahaweli. Much of the flow from the Victoria Reservoir is diverted through the Victoria headrace tunnel and is discharged back into the Mahaweli River at the outlet of the Power House. The tunnel trace crosses 15 tributaries. In the northern part, the tributaries run in a northeasterly direction and join the Mahaweli River. In the southern half, the tributaries flow in a southeasterly to northeasterly direction. There are numerous dry valleys in the region which become activated during the rainy seasons. The blue line shown on the 1:10,000 maps are the perennial streams. People of the area use the perennial and seasonal streams for irrigation of paddy as well as vegeTable cultivations. Even some of the perennial streams are reduced to a trickle during the dry season as observed at the beginning of the field survey before the start of the Intermonsoon and NE monsoon rains. The observed flow pattern in the streams crossing the Mahaweli Rajamawatha in the PIA is illustrated in Figure 3-11.

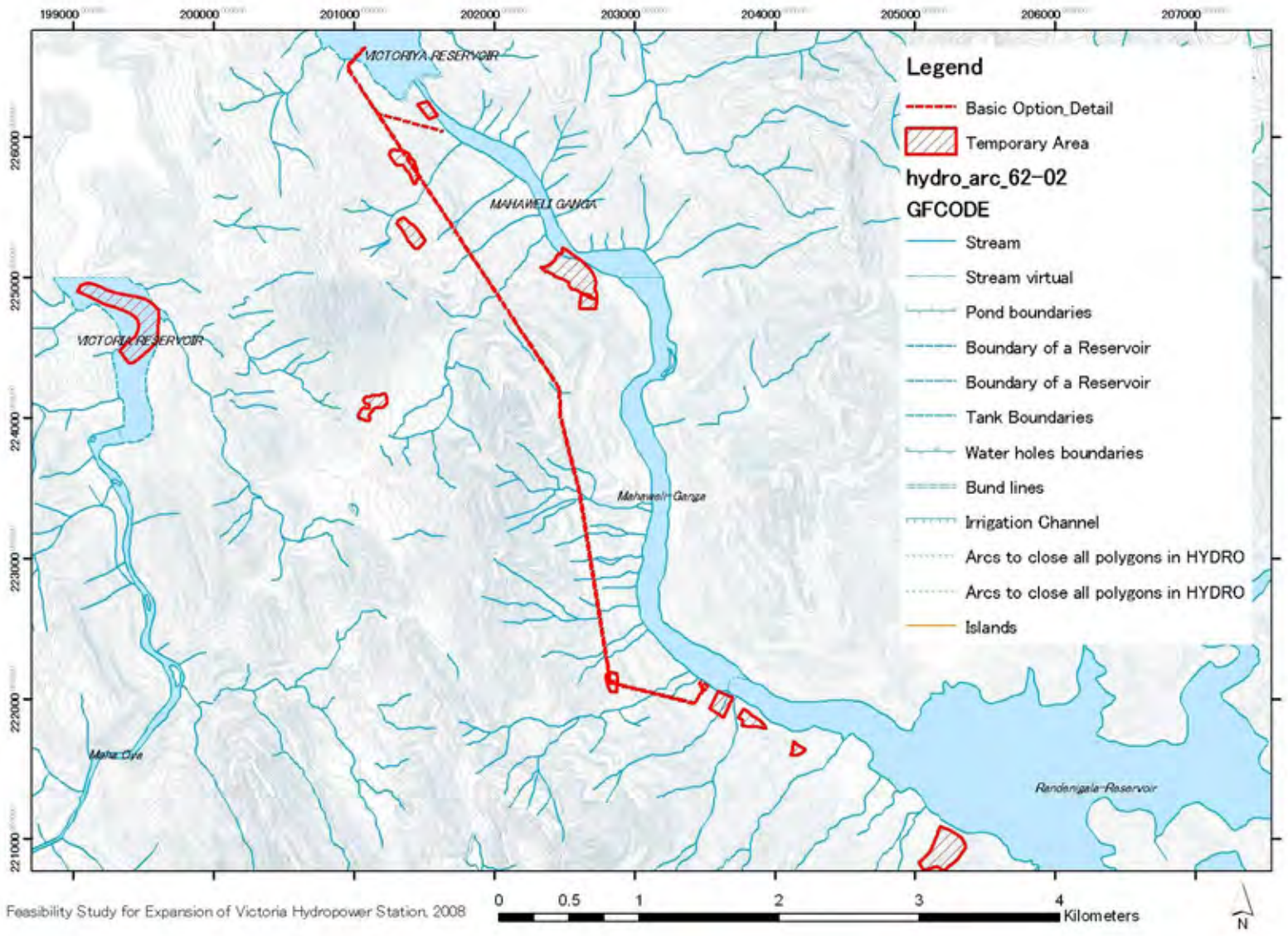



**Figure 3-11 Drainage Pattern**

### 3.1.5.10 Mean annual flow of the river

As the Mahaweli water flow between the Victoria and Randenigala reservoirs occurs only through the existing tunnel (except during spilling) and since in any case it is controlled by Mahaweli Authority and CEB, this is not relevant.

The average annual inflow to the Victoria reservoir is 1, 532 million cubic meters which is equal to 48.6 $m^3/s$, according to data recorded by MASL from 1985 to 2006.

### 3.1.5.11 Mean monthly discharges for a period of 100 years

As the Mahaweli water flow between the Victoria and Randenigala reservoirs occurs only through the existing tunnel (except during spilling) and in any case it is controlled by Mahaweli Authority and CEB, this is not relevant.

There is no recorded data for a 100 year period. Details on inflow data mentioned in 3.1.5.10 are described in 3.1.5.17.

### 3.1.5.12 Indicate the approximate level of the highest flood experienced at the site

As the Mahaweli water flow between the Victoria and Randenigala reservoirs occurs only through the existing tunnel (except during spilling) and in any case it is controlled by Mahaweli Authority and CEB, this is not relevant. The limited catchment area above the existing powerhouse does not receive sufficient water to cause a flood and any increase in the water in the catchment will be easily conveyed along the existing dry bed channel of the Mahaweli.

### 3.1.5.13 Drainage Management Plan

No separate drainage management plan is needed for the project. The water used by the powerhouse will be released back to the Mahaweli River at the same site as the existing powerhouse.

### 3.1.5.14 Flood frequency analysis giving the flood peaks corresponding to the following return period of 2,5,10,50,100

As the Mahaweli water flow between the Victoria and Randenigala reservoirs occurs only through the existing tunnel (except during spilling) and since in any case it is controlled by the Mahaweli Authority and CEB, this is not relevant. The limited catchment area above the existing powerhouse does not receive sufficient water to cause a flood and any increase in the water in the catchment will be easily conveyed along the existing dry bed channel of the Mahaweli.

Because the dam is an existing facility of for the proposed project, analysis of flood frequency is out of the scope of the present project study. Floods with return periods in the existing study are described in 3.1.5.4.

### 3.1.5.15 The discharge corresponding to the bank full discharge

As the Mahaweli water flow between the Victoria and Randenigala reservoirs occurs only through the existing tunnel (except during spilling) and since in any case it is controlled by

the Mahaweli Authority and CEB, this is not relevant. The limited catchment area above the existing powerhouse does not receive sufficient water to cause a flood and any increase in the water in the catchment will be easily conveyed along the existing dry bed channel of the Mahaweli River.

### 3.1.5.16 The minimum dry season flow, base flow

As the Mahaweli water flow between the Victoria and Randenigala reservoirs occurs only through the existing tunnel (except during spilling) and since in any case it is controlled by the Mahaweli Authority and CEB, this is not relevant. The base flow will be the same as that maintained by MASL.

### 3.1.5.17 Flow details including the mean natural flow average flow and the annual variation of the flow

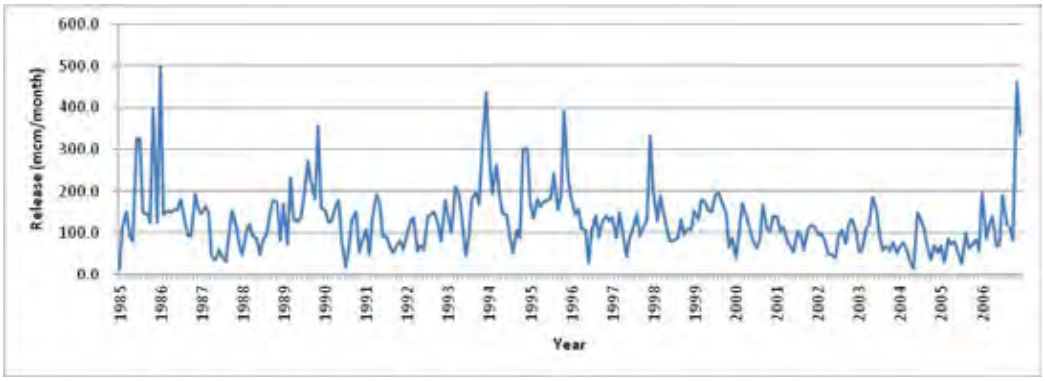
As revealed in Table 3-7, there is a definite seasonal fluctuation in the flow of the Mahaweli River with two clear high flow and low flow periods. (Source: MASL)
Figure 3-12 indicates that during the last 20 years the flow of Mahaweli has not changed significantly although there are fluctuations. However, the operation of the proposed project is not dependent on the Mahawli flow but on the operational rules of the MASL,

**Table 3-7 Monthly Variation of Flow**

(unit: MCM)

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum | 498.8 | 195.1 | 263.7 | 198.1 | 184.2 | 326.0 | 325.4 | 272.4 | 221.2 | 185.5 | 460.6 | 436.0 |
| Minimum | 11.7 | 26.6 | 54.9 | 28.0 | 14.5 | 26.1 | 16.9 | 28.3 | 52.0 | 34.1 | 54.2 | 50.3 |
| Average | 143.4 | 107.2 | 148.4 | 119.4 | 105.4 | 102.7 | 118.1 | 121.0 | 117.3 | 116.6 | 178.6 | 153.8 |

(Source: MASL)




*(Source: MASL)*

**Figure 3-12 The annual variation of the flow**

### 3.1.5.18 Is the project area prone / subject to natural disasters such as landslides and earth slips?

Some parts of the PIA have been identified as having a high landslide hazard potential (Figure 3-14 . Lanslide Zonation Map), but no serious landslides have been reported from the area in the past. Though there were widespread landslides in 2007, they did not affect this

area very much except for a few slips at road cuttings[5]. The local residents also indicated that they did not experience any landslides during the construction of the existing Victoria tunnel.

However, during the field survey it was found that most of the houses in Hakuruthale, a village to the east of the surge tank, have large cracks in the walls (See Annex 10). The floors are also cracked and they are gradually widening. These houses are located on almost flat land bordering the Rajamawatha and the cracks may either be due to subsidence or swelling clays in the soil (Plate 3, x). Cavities in crystalline limestone are a probable cause of the subsidence, not external factors. Some houses which have developed cracks are newly built. This problem is unlikely to be aggravated by the tunnel blasting activities. No evidence of movement of debris on slopes is found in other areas.

In order to assess the present status of structural problems in the houses, a survey of the PIA should be done prior to starting tunneling operations. Such a survey will provide a baseline for future compensation claims.

The National Building Research Organization (NBRO) has prepared landslide zonation maps of the area at 1:50,000 scale (Figure 3-13). According to these maps, the landslide potential is divided into four classes with progressively increasing hazard levels as follows:

i. Zone 1: Landslides not likely to occur

ii. Zone 2: Landlsides can be expected

iii. Zone 3: Modest level of landslide hazard

iv. Zone 4: Landslides are most likely to occur.

Most of the PIA fall within low to moderate hazard levels (Figure 3-14). The landslide free area is confined to a small area (11% of PIA area) and located in the Welikada GN Division. This area has moderate slopes. The area designated as Other is waterbodies which are non-landslide prone areas. Four areas have been identified as having a high risk of landslides. The largest of them is located in Bogahalanda GN Division. The other is located above the surge tank at Hakurutale.

[5] One such slip occurred a year ago blocking the main road at Hakurutale near the powerhouse.

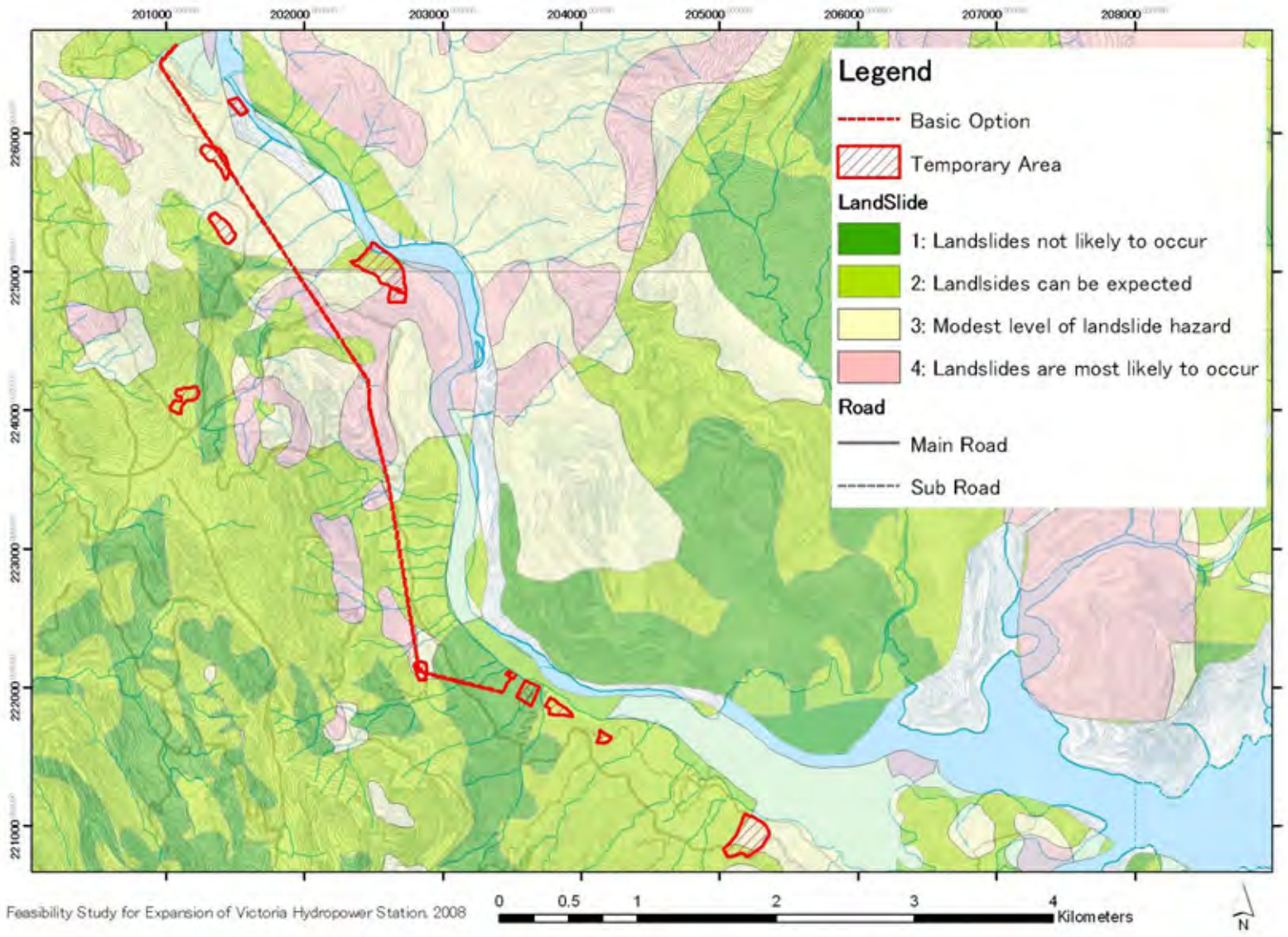



**Figure 3-13 Landslide Zonation map**

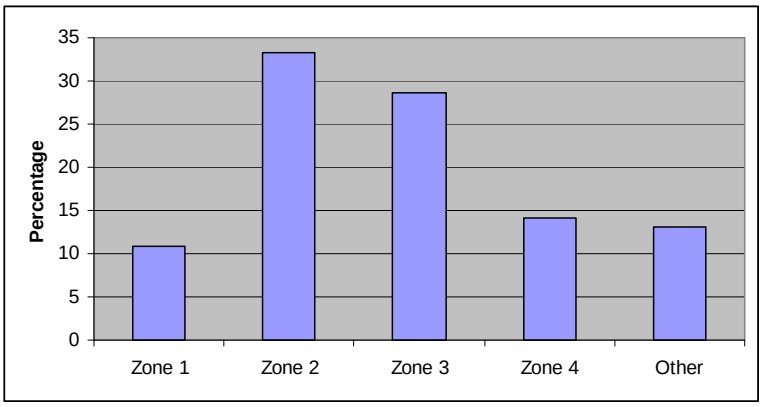



**Figure 3-14 Percentage of land Subject to Various Hazard Levels**

The rest of the area can be described as landslide prone area. However, the area highly prone to landslides is confined to 14% of the total area. The largest area (33%) belongs to the low landslide hazard zone (Zone 2). The tunnel trace runs through major landslide hazard areas (Zone 4) belonging to Welikada and Bogahalanda GN Divisions and Hakuruthale division at the end of the tunnel. The Welikada division has 19 households, whereas Bogahalanda is devoid of any dwelling houses. The elevation of this section varies from 500m to 600m. The tunnel is at a depth of 150-250m from the surface. It is therefore unlikely that vibration from blasting at this depth would induce landslides in this area. The people in the Welikada GN Division did not report any past landslides either, particularly during the construction of Victoria Phase I tunnel.

The second problem area is Hakuruthale, where there is evidence of subsidence in the crystalline limestone terrain. There were many houses with large cracks in walls as well as the cement floor of the houses. Cracks are found even in recently constructed houses indicating that the problem is instability in the area. No landslides were reported by the people of the area during the construction of the Victoria reservoir and the tunnel. The cracks in the buildings may be attributed to possible cavities in the crystalline limestone rock or expansive soil layers or both.

The remaining areas also have moderate hazard levels (Zone 3), but there are no dwelling houses in this area. These are either forests or chena lands. It is recommended that a survey is done in the populated areas to determine the present condition of houses and structural failures in order to prevent false compensation claims. It is also necessary to monitor the area to determine the risk levels during the construction period.

### 3.1.6 Land Use

#### 3.1.6.1 Existing land use pattern in the area with details of extent and types

Human settlements in this area date back to historical times but, until the construction of the Mahaweli Rajamawatha, the whole area remained inaccessible to the outside world. The main mode of transport of goods was by caravan (i.e., *thavalama*). The traditional livelihood of the people was subsistence agriculture. The construction of Mahaweli Rajamawatha under the Accelerated Mahaweli Project in the early 1980s opened up the region to the outside world and the subsistence economy of the traditional villages became closely integrated with the rest of the country. The two major factors that affected land use pattern in the area are the construction of the Rajamawatha and the establishment of the VRR Sanctuary. The former

brought about major change in the local economy by introducing commercial farming into the traditional subsistence economy.

Today, even the traditional chena cultivation is somewhat commercialized and at least a part of the production is sent to markets outside the area. Market gardening has become a major form of farming in chenas and home gardens. Establishment of the VRR Sanctuary in 1987 has restricted human land use to a certain extent. Cultivation of traditional agricultural lands is allowed within the VRR Sanctuary but cultivation of new lands or cutting trees even on private lands is not allowed. The establishment of the VRR Sanctuary, however, put breaks to this transformation in the area which is located within the limits of the sanctuary. Although people are permitted to cultivate land to which they have customary user rights, the traditional practice of chena cultivation in government land is not allowed. Farmers also face the threat of wildlife attacks on farmlands within the sanctuary.

Several types of agricultural land use can be found in the area. The land use classification used in mapping is an adaptation of that of the Survey Department (Agricultural Base Mapping Project – ABMP 1:10,000 Series). Ten categories of land use were identified in the area (Table 3-8). These land use categories can be grouped into three major categories, as agricultural land use, natural and semi-natural areas, and miscellaneous land use. Under agricultural land use, three categories can be identified. They are home gardens, chena lands, and paddy/vegeTable/tobacco lands. Both perennial and seasonal crops are grown in the area. The perennial crops found in home gardens are a mixture of trees and shrubs interspersed with vegeTable plots. The seasonal crops are again divided into paddy and highland crops. Paddy cultivation is done in more permanent fields. Because of the specific requirements of hydrological conditions, methods of water management and land preparation, the extent and location of paddy fields do not change from year to year. But there is a crop rotation in most paddy fields in this area. The highland crops are mostly cultivated in chenas and in home gardens. The chena lands are mostly found on steep slopes at higher elevations. It is safe to say that most chena lands are traditional village forests used for this form of agriculture. This land is owned by the villagers individually (with title deeds in their name) or through customary ownership, that is, the land used by them for cultivation for generations. In this study, only those areas that were cultivated within the last 5-6 years was mapped as chena lands. The abandoned chena lands under fallow may have been mapped as scrub and grassland land.

The extent of land use in the PIA is given in Table 3-8. As can be seen from the Table, agricultural land use consists of chena cultivation, homegardens and paddy lands with a crop rotation between *yala* and *maha.*

**Table 3-8 Land Use in the Project Impact Area**

| Agricultural Land Use | Natural Semi-Natural Areas | Other |
|---|---|---|
| Home Gardens | Closed Canopy Forest | Victoria Power House Property |
| Chena (Shifting Cultivation) | Secondary Forest | SL Army's Shooting Gallery |
| Paddy/Seasonal Crops | Scrub and grassland | Surface Water |
| | | Abandoned Quarry |

The extent of land use in the area can be considered separately under the three project options.

The distribution of land under the different land use types in the impact area for Basic Option is illustrated in Figure 3-16. Most of the PIA of the Basic Option are covered with natural or

semi-natural vegetation belonging to the land cover types of secondary forests and grasslands and mapped as closed canopy forest, secondary forest, and scrub and grassland, and Grasslands (499 ha or 59%). The total extent of agricultural lands and settlements is 201ha or 24%. The remaining area is covered by waterbodies, the properties of the Victoria Powerhouse and the SL Army's Shooting Gallery. The total area under different land use categories is shown in Figure 3-15.

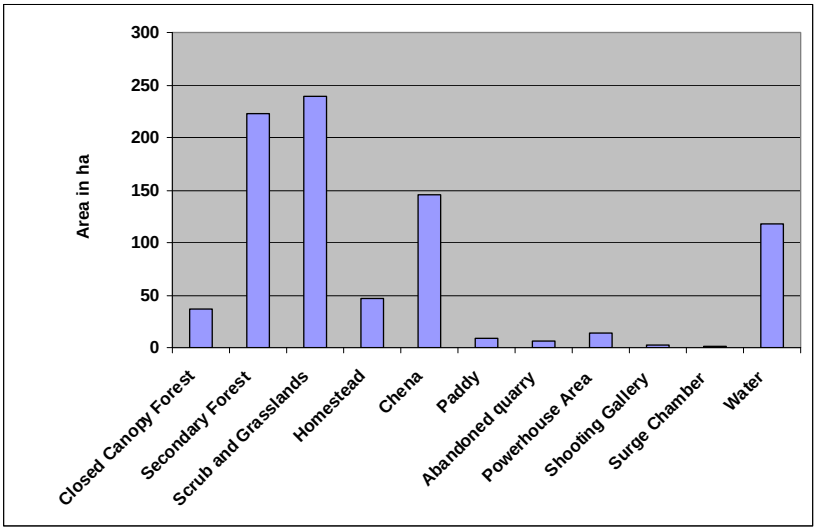



**Figure 3-15 Land Use in the Impact Area of the Basic Option**

**Table 3-9 Land Use in the Impact Area of the Basic Option by GN Division**

| GN name | Closed Canopy Forest | Secondary Forest | Scrub and grassland & Grasslnds | Chena | HG | Paddy/ Vege | SLArmy Shoot. Gallery | Water | Powerhouse Surge Tank | Quarry |
|---|---|---|---|---|---|---|---|---|---|---|
| Ambewela | 16.2 | 15.3 | 54.7 | 32.7 | 12.9 | - | 2 | 23.1 | - | - |
| Bogahalanda | 18 | 17.1 | 58.9 | 18.9 | 0.2 | - | - | 9.8 | - | - |
| Hakurutale | 0.4 | 105.7 | 79.4 | 71.2 | 1.8 | 8.9 | - | 14.9 | 13.5 | - |
| Hilpankadura | - | 19.5 | 2.2 | 0.4 | 0.02 | - | - | 1.2 | 1.6 | - |
| Hingurukaduwa | 2.4 | - | - | 0.8 | 0.3 | - | - | 12.8 | - | - |
| Malulla | - | 0.02 | - | 3.4 | 0.1 | - | - | - | - | - |
| Walikada | - | 64.8 | 44.3 | 18.5 | 31.1 | - | - | 7.7 | - | 6.1 |
| **Total** | **37** | **205.62** | **239.5** | **145.9** | **46.1** | **8.9** | **2** | **69.5** | **15.1** | **6.1** |
| % | 4.7 | 26.0 | 30.3 | 18.4 | 5.8 | 1.1 | 0.3 | 8.8 | 1.9 | 0.8 |

Distribution of land use types by GN Divisions (Table 3-9 Figure 3-16) shows that most of the homesteads are confined to Ambewela, Hilpenkandura and Welikada. The remaining Divisions either have no homesteads at all or the extent is insignificant. However, the Divisions that have negligible extents of homesteads are the main chena cultivation areas. The characteristics of the main agricultural and residential land use types are as follows:

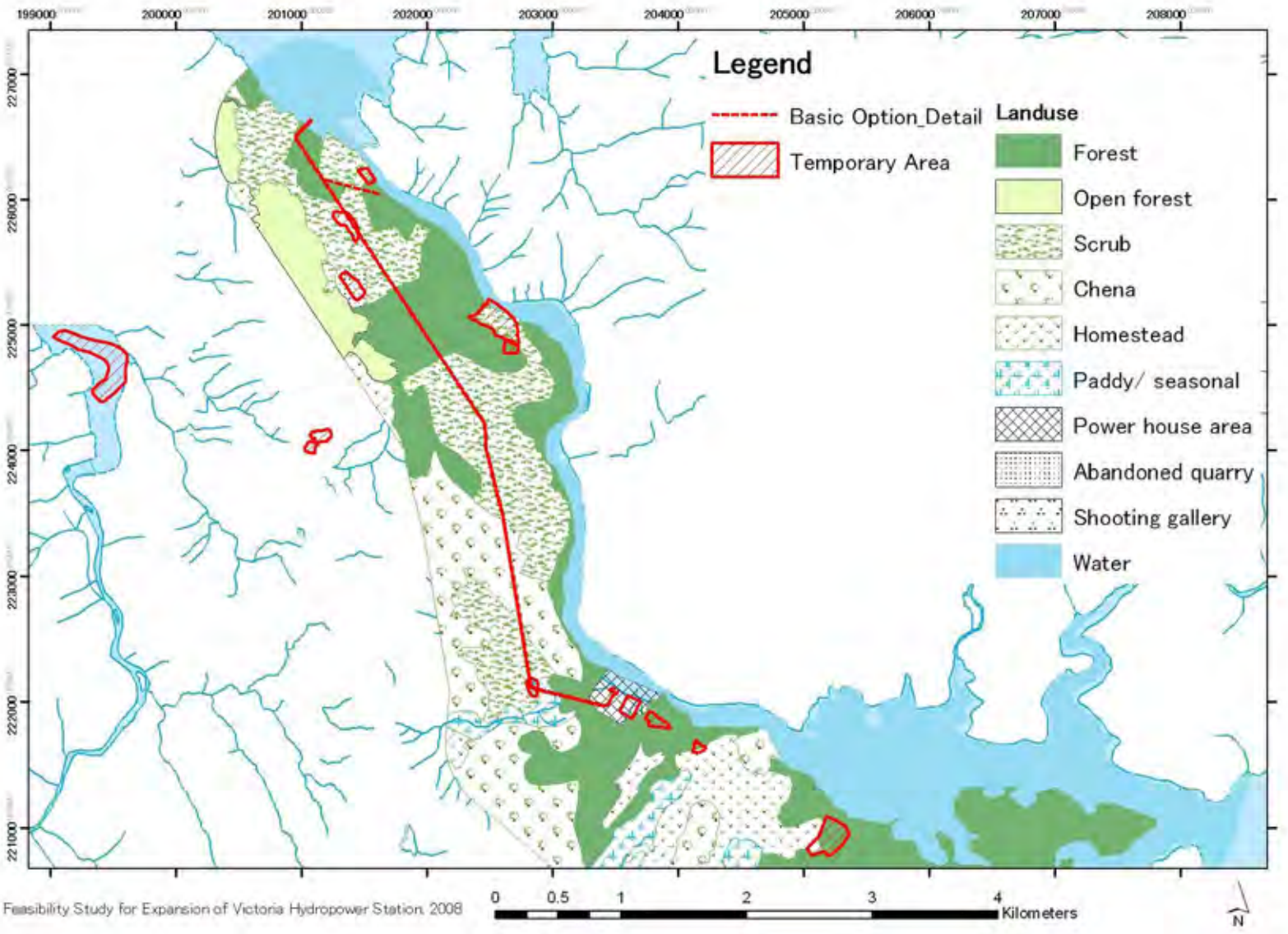



**Figure 3-16 Land Use Map**

#### 3.1.6.1.1 Paddy/ VegeTable

Paddy is found only in the Hakurutale GN Division. The paddy is found in flat lands as well as on sloping lands. The latter is terraced for retaining water. In the lower parts paddy cultivation is done using ground water, whereas in the upper parts the local streams are used for irrigation. Paddy lands in the area are subjected to a crop rotation. The main paddy season is the *maha* season during which a high rainfall is received from the northeast monsoon and the intermonsoons. During the relatively dry *yala* season, paddy cultivation is restricted to areas with assured water resources such as springs and streams because of the low rainfall. Hybrid varieties of paddy are usually cultivated in the area. In other paddy lands, vegeTable and tobacco are cultivated during the *yala s*eason. The paddy fields are used for vegeTable cultivation during the *yala* season and also when the *maha* rainfall is not enough for paddy cultivation.

#### 3.1.6.1.2 Chena (Slash and Burn) Cultivation

Herath (1997) claims that there is a 5-6 year rotation of at least 9 types of crops in chenas. These crops are highland paddy, finger millet, sesame, , green gram chilly, cowpea, pumpkin, gingely and various types of vegeTables. Chena lands are extremely variable over time and space. The distribution and extent of chena lands can vary from one year to the next. Chena cultivation is dependent entirely on rainfall and is carried out during the *maha* season. Highland crops, grown in the chenas, include grains, vegeTable, tobacco, etc. The most common vegeTables cultivated are brinjal, tomato, radish, bean and chili. Cultivation of vegeTable on a commercial scale occurs in chena lands. In addition, vegeTable cultivation is also practiced in home gardens. These plots are too small to be mapped as a separate category.

#### 3.1.6.1.3 Home Gardens

This is found in and around the settlements, and therefore is confined to populated areas of the PIA. The main GN Divisions which have sizable areas of home gardens are Welikada, Hilpenkandura and Ambewela (Table 3-9). They are located on high ground away from the Mahavali River valley. Although home gardens are generally considered to be excellent forms of land cover if managed properly, they do not provide sufficient income to the households. As a result, many traditional homegardens have now been converted to

cultivation of cash crops. Thus the traditional characteristics of the home gardens are rapidly changing making them more like chena areas.

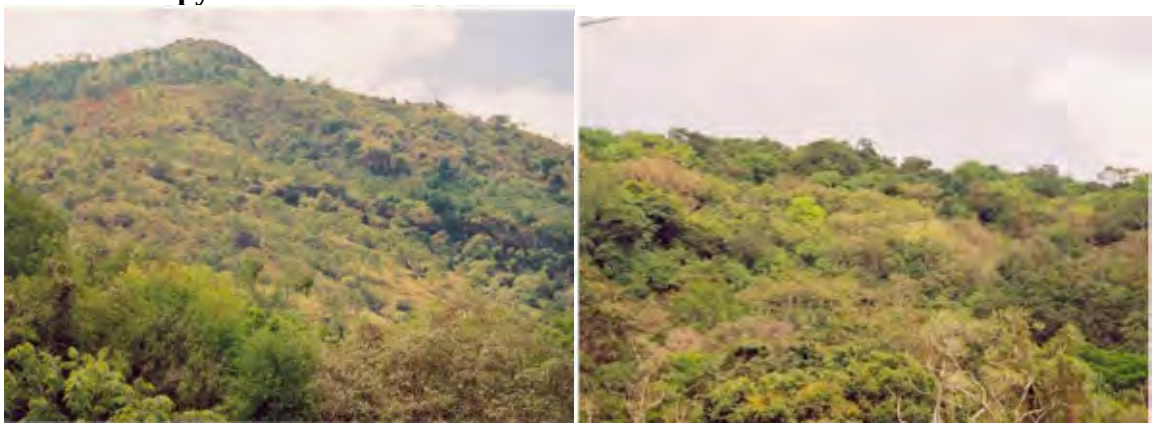
#### 3.1.6.1.4 Waterbodies

A large area within the PIA is covered with waterbodies in the area. The area under water is high in the Divisions which are adjacent to the Victoria and Randenigala Reservoirs. No other Divisions with sizable waterbodies are found within the PIA. The streams are too small to be considered waterbodies.

#### 3.1.6.1.5 Natural and Semi-Natural Vegetation

The existence of over 60 % of natural/semi-natural vegetation cover in the area is a direct result of the restrictions imposed by the VRR Santurary on the clearing of forests. The area is relatively intensely policed by the Wildlife Department. This has dissuaded the local people from encroaching on forest lands belonging to the sanctuary for cultivation and settlement. However, the area mapped as scrub and grassland and grasslands is former chena lands and they are cultivated from time to time. It is difficult to identify chena land under fallow in the field or from satellite imageries. These are highly disturbed areas and if left intact will gradually return to forests. More densely forested areas with open spaces were mapped as Secondary Forest. The Closed Canopy Forest areas completely cover the land surface. Quite a large area is covered by Closed Canopy Forest.

**Closed Canopy Forest**



#### 3.1.6.1.6 Status of the Land

Current land use practices in the area are contributing to accelerated soil erosion. Most slopes covered with a thin layer of soil and stony surfaces are a very common sight on chena lands (Plate 3.1). Chena cultivation and small vegeTable plots are the main causes of soil erosion. It has been found that soil erosion on sloping lands under vegeTable and tobacco is extremely high everywhere in the highlands of Sri Lanka (Wickramagamage, 1990). In contrast, soil erosion under homegardens and paddy cultivation (including terraced paddy) is usually negligible. The same can be said about the PIA too. But where home gardens are used for cultivation practices that are similar to chena cultivation and vegeTable cultivation, the soil is highly degraded due to erosion.

There is some degree of awareness among the people about the problem of soil erosion on sloping lands. Although this has not prevented them from cultivating steep slopes, some soil conservation efforts are in evidence. The main conservation method practiced in the area is construction of check dams across slopes to arrest soil erosion. As can be seen from the Plates 3.1a-d, soil erosion is rampant on steep slopes that are used for chena cultivation.

### 3.1.6.2 Land use potential of the site

As the PIA is located within the VRR Sanctuary with elephants frequenting the area, the only sustainable landuse practice in the area is to allow the natural vegetation to regenerate as it is visible already. DWLC in any case does not allow any landuse that destroys the existing vegetation cover.

### 3.1.6.3 Zoning Plan of VRR Sanctuary

Since the entire PIA lies within the VRR Sanctuary, it comes under the management plan of the Sanctuary (DWLC, 1999). This management plan has divided the Sanctuary into two zones, Core Area Zone and the Buffer Zone (Figure 3-17). The Core Area Zone is the immediate upper catchment area of the Randenigala and Rantambe Reservoirs and has the best Intermediate Zone forest vegetation. It has been recommended that this zone have minimum human intervention and "allow critical ecological processes to continue unhindered and unaltered" (DWLC, 1999:62). In order to achieve this objective, it has been proposed that the Core Area Zone be declared a National Park. This will involve resettlement of existing villagers within this zone.

The Buffer Zone is the area between densely populated villages and the Core Area. This area is highly disturbed and comes under heavy pressure from surrounding villages as well as villages located within this area. The rotational grazing arrangement of domestic animals in a sustainable way will be allowed in the Buffer Zone, but consumptive uses will be prohibited (DWLC, 1999:78-72).

Normally, traditional villages exist within sanctuaries in Sri Lanka but the VRR Sanctuary Management Plan envisages removing all human settlers from the Core Area and to restrict village settlements to the periphery.

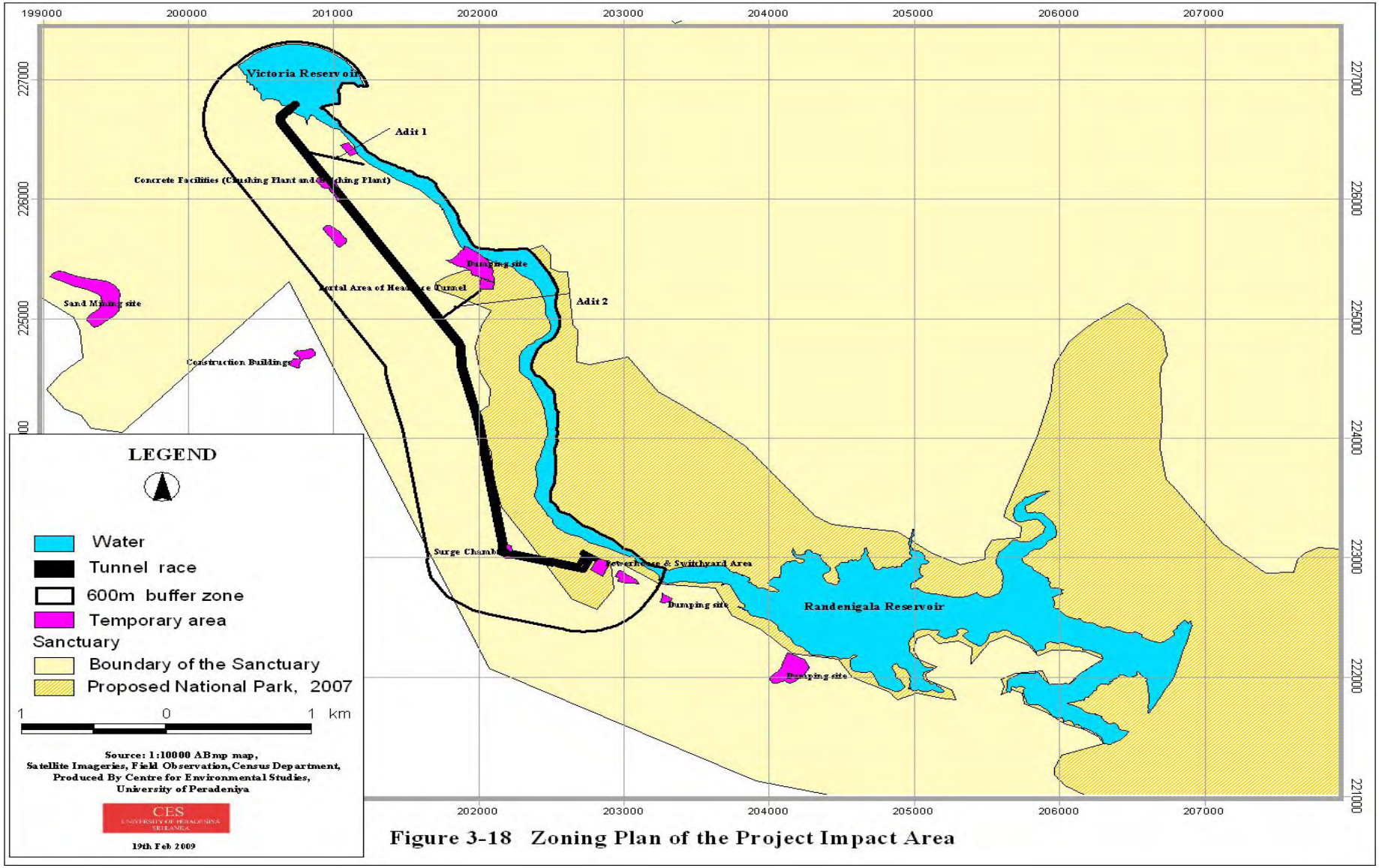



Figure 3-18 Zoning Plan of the Project Impact Area

**Figure 3-17 Zoning Plan of the PIA**

### 3.1.7 Air Quality & Noise

#### 3.1.7.1 Air quality

There is no air quality monitoring stations in the project impact area as well as in the surrounding regions. Therefore, to evaluate the current air quality of the impact area, site specific monitoring was conducted in December 2008. This investigation was carried out at four locations close to the proposed tunneling area and close to the proposed penstock and powerhouse construction areas. Also a roadside sampling was taken. The obtained monitoring results are presented in Table 3-10. The results indicate that the air quality in the project area was good during the evaluation period with no concerns shown. The main reasons could be the low traffic flow and no industrial pollution sources in the project area.

**Table 3-10 Observed air quality of the impact area (refer Figure 3-18 for sampling locations)**

| Location | CO ppm | $CO_2$ ppm | $NO_x$ ppm | SO2 ppm | Particulate matter ($\mu g/m^3$) |
|---|---|---|---|---|---|
| Road side - Victoria Tunnel Office (26) | < 0.1 | < 0.1 | < 0.1 | < 0.1 | 95 |
| Summer Hut - Victoria Tunnel Office (27) | < 0.1 | < 0.1 | < 0.1 | < 0.1 | 14 |
| Near the Power Station Transformers (28) | < 0.1 | < 0.1 | < 0.1 | < 0.1 | 35 |
| Near the Proposed Tunnel Outlet (29) | < 0.1 | < 0.1 | < 0.1 | < 0.1 | 15 |

#### 3.1.7.2 Noise

The proposed project is located surrounding rural areas and sanctuary areas that belong to the Low Noise Region, categorized in Noise and Vibration Standards of Pollution Control Division, Central Environmental Authority. The existing noise levels taken from the standards stipulated in the Gazette of the Democratic Socialist Republic of Sri Lanka, No. 924/12 – May 23, 1996, under sections 23P, 23Q and 23R of the National Environmental Act, No. 47 of 1980, is given in Table 3-11 and 3.12.

## Table 3-11 Existing Standards of Noise Levels (SCHEDULE I)

Maximum Permissible Noise Levels in dB at Boundaries (as $L_{ACq\,T}$ - A-weighted sound pressure determine over a T hour time interval) under Noise Control Regulation

| Area | Area definition | Day time (06.00 – 18.00 hrs) | | Night time (18.00 – 06.00 hrs) | |
|---|---|---|---|---|---|
| | | Sri Lanka | International [a] | Sri Lanka | International [a] |
| Silent Zone | Area covered by a distance of 100 m from the boundary of a courthouse, hospital, public library, school, zoo, sacred areas, and areas set apart for recreation and environmental purposes | 50 | - | 45 | - |
| Low Noise | An area located within any Pradeshiya Sabha | 55 | 55 | 45 | 45 |
| Medium Noise | An area located within any Municipal or Urban council area | 63 [b] | 55 | 50 | 45 |
| High Noise | Export processing zones established by the BOI or industrial estate approved under part IV C of NEA | N/A | 70 | 60 | 70 |

a - World Bank Guidelines

b - Provided that the noise level does not exceed 60 dB (A) inside existing houses, during day time

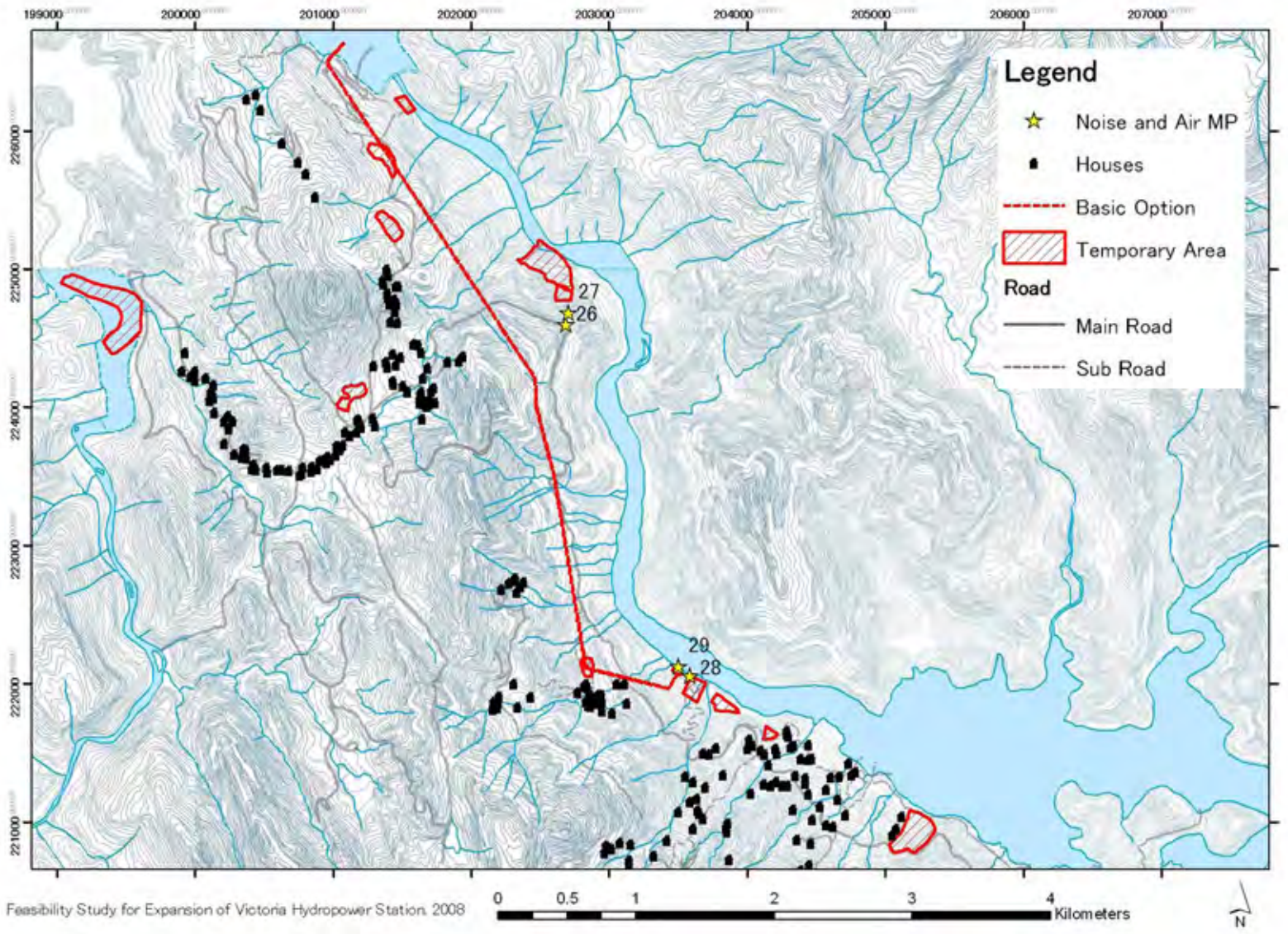



**Figure 3-18 Air quality and Sound level measurement locations**

The measurements made on the existing noise levels show that the existing values at most times are well within the standards for low noise areas. But as the Kandy-Randenigala highway runs through the project area, the roadside noise levels during vehicle movement exceed the 55dB limit. However these are maximum sound levels and not the weighted average values as stipulated in the standards. The 20 min average noise levels are however within the standards required. The 8 hour noise levels could be much lower than these.

**Table 3-12 Existing noise levels (refer Figure 3-18 for sampling locations)**

| Location | Sound level (dB) | | |
|---|---|---|---|
| | Traffic | No traffic | Average (20 min) |
| Road side - Victoria Tunnel Office (26) | 60.1-84.5 | 41-44 | 49 |
| Summer Hut - Victoria Tunnel Office (27) | 35-42 | 30-37 | 38 |
| Near the Power Station Transformers (28) | - | 48-55 | 50 |
| Near the Proposed Tunnel Outlet (29) | - | 50-54 | 52 |

* During no power generation

## 3.2 Biological Environment

### 3.2.1 Fauna and Flora

#### 3.2.1.1 Proximity to wildlife reserves, sanctuaries, elephant corridors, wetlands and forest reserves

The proposed project activities will be carried out in the Victoria–Randenigala-Rantambe (VRR) sanctuary (Please see Figure 2-19). VRR sanctuary is the largest sanctuary in Sri Lanka and a major part of it is located in the Intermediate Climatic zone (Figure 3-20 for Habitat map ).

#### 3.2.1.2 Fauna and Flora in the river

Fish fauna in the Victoria Reservoir from 50m meters upstream of the dam (Figure 3-20) was sampled using cast nets. Eleven fish species were recorded from the site during sampling. Fish fauna in the sample were dominated by *Devario malabaricus* and *Etroplus suratensis* (Table 3-13).

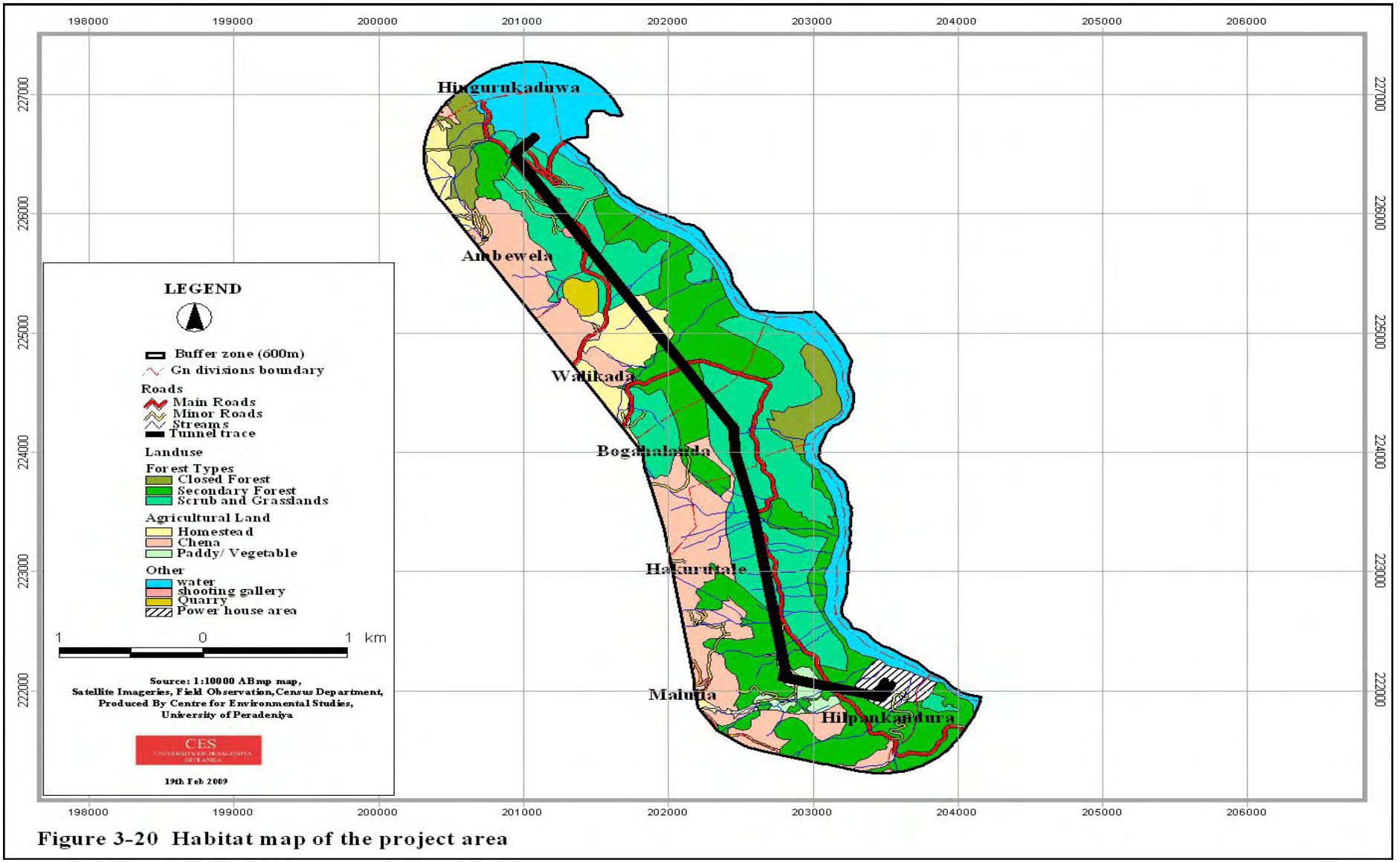



**Figure 3-19 Habitat map of the project area**


**Figure 3-20 Sampling site upstream Victoria Dam**

**Table 3-13 Fish fauna recorded in the Victoria Reservoir (50 m upstream from the Dam)**

| **Family** | **Scientific name** | **Common name** | Abundance |
|---|---|---|---|
| Cyprinidae | *Cyprinus carpio* | Common Carp | + |
| Cyprinidae | *Devario malabaricus* | Giant Danio | ++ |
| Cyprinidae | *Hypothalmichthys molitrix* | Silver Carp | + |
| Cyprinidae | *Puntius sarana* | Olive barb | + |
| Cyprinidae | *Puntius singhala** [6] | Filamented barb | + |
| Cyprinidae | *Tor khudree* | Mahseer | + |
| Cyprinidae | *Rasbora daniconius* | Striped Rasbora | + |
| Cichlidae | *Oreochromis niloticus* | Tilapia | + |
| Cichlidae | *Etroplus suratensis* | Green Chromide | ++ |
| Cichlidae | *Oreochromis mossambicus* | Tilapia | + |
| Gobiidae | *Sicyopterus griseus* | Stone Goby | + |

Abundance: + ( 1 – 10 individuals); ++ (11 – 20 individuals) , Sampling effort 10 cast net samplings.

The downstream stretch of the Mahaweli River between the Victoria dam and the water discharge outlet of the Victoria Power House remain a dry reviver bed with exposed rocks (Figure 3-21) from the time of construction of the Victoria Dam. Some water is collected in rock pools during the rainy season.

Field sampling was not allowed along the river reservation due to security reasons as these areas fall under the high security zone of the Victoria dam and the Powerhouse.

[6] *: Endemic species

**Figure 3-21 Dry bed of Mahaweli River downstream from the Victoria Dam**

### 3.2.1.3 Fauna and flora in the inundation area:

There is no inundation area in the project.

### 3.2.1.4 Fauna and flora along the river reservation

Field sampling was not allowed along the river reservation due to security reasons as these areas fall under the high security zone of the Victoria Dam and the Powerhouse.

### 3.2.1.5 Fauna and flora in the spray zones

The stretch of Mahaweli River facing the water discharge outlet of the Victoria power station is treated as the spray zone in this study. The left bank of the Mahaweli River facing the discharge outlet of the powerhouse was sampled (Figure 3-22). The spray zone sampled consisted of 24 tree species (including one endemic species), 16 shrub species and six liana species. Plant species such as *Flueggea leucopyrus* (Heen katu pila), *Glycosmis angustifolia* (Bolpana) *Dimorphocalyx glabellus* (Weliwanna), *Croton laccifer* (Keppetiya) dominate the riverine vegetation of the spray zone (Appendix I).

**Figure 3-22 Riverine vegetation (opposite Victoria Power station)**

The sampling of fish fauna of the Mahweli River in the Spray Zone of the Victoria Powerhouse has resulted in the recording of 11 species of fish including three endemics. Tilapia species, mainly *Oreochromis niloticus*, dominate the fish fauna in the rock pools of the spray zone (Table 3-14). It should be noted that the rock pools in the spray zone support a small population of rare and nationally threatened fish *Labeo fisheri*. Considering the conservation importance of this species, the rock pools in the spray zone should not be filled or drained disturbing this rare species of fish even during the construction phase of the second powerhouse.

**Table 3-14 Fish species recorded from the spray zone of the Victoria Powerhouse**

| Family | *Scientific name* | Common name | Abundance |
|---|---|---|---|
| Cyprinidae | *Devario malabaricus* | Giant Danio | ++ |
| Cyprinidae | *Garra ceylonensis** | Stone Sucker | ++ |
| Cyprinidae | *Labeo fisheri** | Mountain Labeo | + |
| Cyprinidae | *Puntius sarana* | Olive barb | ++ |
| Cyprinidae | *Puntius singhala** | Filamented barb | + |
| Cyprinidae | *Tor khudree* | Mahseer | ++ |
| Cyprinidae | *Rasbora daniconius* | Striped Rasbora | + |
| Cichlidae | *Oreochromis niloticus* | Tilapia | +++ |
| Cichlidae | *Oreochromis mossambicus* | Tilapia | + |
| Cichlidae | *Etroplus suratensis* | Green Chromide | ++ |
| Heteropneustidae | *Heteropneustes fossilis* | Stinging Catfish | + |

Abundance: + (<20 individuals); ++ (21 – 50 individuals); +++ (> 50 individuals)
Sampling effort (10 cast net samplings)

### 3.2.1.6 Fauna and flora of the tunnel location and Transmission Line Path

The tunnel line runs underneath six habitat types which are found in the area. The habitat types include homegardens, chena lands, grasslands, scrub and grasslands, and secondary forests, and rivereine forests (stream bank vegetation). A summary of the floral composition along the tunnel trace is given in Table 3-15. The tunnel runs under these habitats at an average depth of 300m.

**Table 3-15 Summary of the floral composition of tunnel trace**

| Habitat | Families | Species | Trees | Shrubs | Liana |
|---|---|---|---|---|---|
| Home gardens | 34 | 77 | 51 | 16 | 10 |
| Chena | 13 | 14 | 12 | 2 | - |
| Grassland | 14 | 21 | 4 | 5 | 12 |
| Scrub and grasslands | 36 | 83 | 52 | 18 | 13 |
| Secondary forests | 17 | 38 | 27 | 7 | 4 |
| Stream bank vegetation | 32 | 74 | 42 | 11 | 21 |

### 3.2.1.7 Vegetation Study

**Paddy fields**

Paddy cultivation is practiced using rain water in the *maha* season (October - April) only. The extent of the area under paddy cultivation is small. When there is not enough rainfall, farmers cultivate vegeTables in their paddy fields. Types of vegeTables cultivated in the paddy fields are given in Table 3-16.

**Figure 3-23 Paddyfields**

**Table 3-16 VegeTable crops cultivated in paddyfields**

| Family | Species | Common name | Life form |
|---|---|---|---|
| Apiaceae | *Daucus carota* | Carrot | Herb |
| Caricaceae | *Carica papaya* | Papaya | Tree |
| Chenopodiaceae | *Beta vulgaris* | Beetroot | Herb |
| Convolvulaceae | *Ipomoea batatas* | Sweet Potato | Climber |
| Euphorbiaceae | *Manihot esculenta* | Manioc | Shrub |
| Fabaceae | *Phaseolus lunatus* | Curry Bean | Climber |
| Fabaceae | *Psophocarpus tetragonolo* | Wing Bean | Climber |
| Solanaceae | *Lycopersicon esculentum* | Tomatoes | Climber |
| Solanaceae | *Solanum macrocarpon* | Brinjole | Shrub |
| Solanaceae | *Solanum melongena* | Ela Batu | Shrub |
| Solanaceae | *Capsicum annuum* | Red pepper | Herb |
| Solanaceae | *Capsicum frutescens* | Bird pepper | Herb |

During the sampling period, the area was dry and very few bird species were recorded from the sites (Table 3-17).

**Table 3-17 Bird species recorded in paddy fields**

| Family | Species | Common name | HG | Chena | GL | SF | SeF | SB |
|---|---|---|---|---|---|---|---|---|
| Alcedinidae | *halcyon smyrnensis* | White-throated kingfisher | + | - | - | + | + | + |
| Columbidae | *Streptopelia chinensis* | Spotted Dove | + | + | - | + | + | + |
| Estrildidae | *Lonchura malacca* | Blackheaded Munia | + | + | - | + | - | + |
| Estrildidae | *Lonchura punctulata* | Scaly Breasted Munia | - | - | - | + | - | - |
| Sylviidae | *Orthotomus sutorius* | Common Tailorbird | + | + | - | + | - | - |

**Homegardens**

Homegardens contain a variety of plants of which most are planted (Appendix II). This includes cash crop species such as Coconut, Jack Fruit and Kaju (*Anacardium occidentale*). Some other tree species have been planted as hedge species such as Ginisiriya (*Gliricidia sepium*), Gansooriya (*Thespesia populnea*), and Wata endaru (*Jatropha curcas*) (Figure 3-24). Home gardens are cultivated extensively during the rainy season. The ground cover of the homegardens is removed and the land is prepared for vegeTable cultivation with the commencement of rains in early November (Figure 3-25).

**Figure 3-24 A Home garden**

**Figure 3-25 Land preparation in home gardens**

**Chena**

Chena cultivation is mainly done in private lands bordering the homesteads. These lands generally support some planted tree species such as *Artocarpus heterophyllus* (Kos) and *Mangifera indica* (Amba). Some valuable timber species such as *Chloroxylon swietenia* naturally occur in the chena lands (Appendix III). Chena lands generally remain as dry scrub and grasslands dominated by Panicum (30%) and Lantana (20%) cover during the April to October dry season. Before the commencement of *maha* rains (in November) villagers set fire to the grasslands and prepare the land for chena cultivation mainly forvegeTable crops (Figure 3-26 & Figure 3-27). Cultivations continue up to March in the following year. The cultivation depends entirely on rain water. After harvesting the land becomes fallow.

**Figure 3-26 Land preparation for chena cultivation**

**Figure 3-27 Chena land**

**Grasslands**

Grasslands are found in slopes that have not been used for chena cultivation for sometime. Grasslands are subjected to frequent fires during the dry season (Figure 3-28). Tree species diversity is low in grasslands (Appendix IV). This may be mainly due to the frequent fires occurring in the grasslands. However, commercially important tree species such as *Chloroxylon swietenia* (Burutha) and typical dry zone tree species such as *Drypetes sepiaria* (Weera) are found in the grasslands. *Panicum maximum* (60%) and *Lantana camara* (20%) dominate the ground cover in grasslands.

**Figure 3-28 Grasslands**

**Scrub and grasslandlands**

Scrub and grasslandlands occur in areas where chena cultivations have been abandoned sometimes back due to the suspension of this activity by the Department of Wildlife Conservation. These are state lands that people in the areas used for chena cultivations before the establishment of Victoria-Rndenigala-Rantambe (VRR) sanctuary. Under the sanctuary regulations, villagers are not allowed to practice chena cultivation in lands other than those owned by them. Due to the abandonment of chena cultivation, fast growing shrubs like *Lantana* have rapidly colonized these lands (Figure 3-29). Scrub and grasslands are at early stages of succession and hence they support the highest number of plant species (83 species in 36 families) among all the habitats sampled (Table 3-15). Species like *Flueggea leucopyrus* (heen katupila), *Croton laccifer* (Keppetiya) and *Toddalia asiatica* (kudumiris) dominate the scrub and grasslandlands (Appendix V). The majority of the sampling area is under this category.

**Figure 3-29 Scrub and grasslands**

**Secondary forests**

Secondary forests occur in VRR sanctuary lands where disturbances such as chena cultivations have been suspended soon after the establishment of the sanctuary. Natural tree cover has been re-established over the scrub and grassland vegetation in these areas (Figure 3-30). Species such as *Gliricidia sepium* (Giniceria) planted along the hedges of early chena lands can still be seen in these sites. The ground layer in these sites are Lantana dominant (20% cover). Planted species such as *Mangifera indica* (Amba) and *Artocarpus heterophyllus* (Kos) are also to be found (Appendix VI).

**Figure 3-30 Secondary forests**

**Stream bank vegetation**

In addition to the riverine vegetation sampled in the spray zone of the Victoria Powerhouse, several other stream bank vegetation in the study area were also sampled. Most of these streams carry water during the rainy season and a few months of the early dry season. The streams run dry during the drought period (July – October) (Figure 3-31). Since the streams carry water during most part of the year, vegetation along the stream banks are well established. The stream bank vegetation sampled included 10 species of liana, ten species of shrubs and 31 tree species. Among all habitats sampled, the maximum number of endemic plants (six species) has been recorded from the stream bank vegetation. Unlike a characteristic stream bank vegetation (riverine vegetation), the stream sides sampled did not support characteristic water loving plants such as *Terminalia arjuna*, which was a characteristic species among spray zone vegetation. The non-availability of water during some parts of the year may be promoting hardier species (such as *Pterospermum suberifolium* – Welan) to colonize along the stream banks (Appendix VII).

**Figure 3-31 Stream bank vegetation**

### 3.2.1.8 Faunal Study

Faunal sampling was also carried out in the six habitat types mentioned in Table 3-18. The time period during which this field study was conducted (October to early November, 2008) was not a period suiTable for faunal sampling. Since this period is toward the end of severe drought, most samples showed characteristically dried up ground vegetation cover. During this period the farmers prepare lands for chena cultivation to coincide with the commencements of rain in late November. Due to land preparation, the ground level vegetation (grass and shrubs) have been removed (Figure 3-33) and farmers set fire to the dry vegetation. Fauna in the area are heavily disturbed due to these activities. This is an annual event in the sampling area.

Field sampling carried out recorded six groups of animals, namely, Butterflies, Land Snails, Amphibians, Reptiles, Birds and Mammals. Considering the poor habitat conditions, only the presence of a particular species in a habitat is recorded during sampling. Except for butterflies and birds, all other groups are under represented in the area due to the prevailing habitat conditions. Amphibians were rarely encountered in the sampling plots (Table 3-18). Only a few endemics were found among the species encountered.

Of the six habitats sampled, home gardens, scrub and grasslands, secondary forests and stream banks supported a comparatively higher number of fauna that the other two sites, namely, the chena and grasslands. A list of fauna recorded during sampling is given in Appendix VIII.

Most of the water bodies had dried up in the sampling area and hence fish samples could not be obtained.

**Figure 3-32 Extensive land clearings for vegeTable cultivation**

**Table 3-18 Summary of fauna observed during sampling**

| Habitat | Group | Families | Species | Endemics |
|---|---|---|---|---|
| Home gardens | Butterflies | 6 | 30 | - |
| | Land snails | 2 | 2 | - |
| | Amphibians | 1 | 1 | - |
| | Reptiles | 7 | 11 | - |
| | Birds | 22 | 30 | 3 |
| | Mammals | 6 | 12 | 1 |
| Chena | Butterflies | 5 | 25 | - |
| | Land snails | 3 | 3 | - |
| | Amphibians | - | - | - |
| | Reptiles | 5 | 11 | 1 |
| | Birds | 11 | 15 | - |
| | Mammals | 4 | 7 | - |
| Grasslands | Butterflies | 5 | 16 | - |
| | Land snails | - | - | - |
| | Amphibians | - | - | - |
| | Reptiles | 2 | 2 | - |
| | Birds | 3 | 5 | - |
| | Mammals | 4 | 4 | - |
| Scrub and grasslands | Butterflies | 6 | 28 | - |
| | Land snails | 2 | 2 | - |
| | Amphibians | 1 | 1 | - |
| | Reptiles | 8 | 11 | - |
| | Birds | 19 | 34 | 2 |
| | Mammals | 8 | 11 | 1 |

| Habitat | Group | Families | Species | Endemics |
|---|---|---|---|---|
| Secondary forests | Butterflies | 5 | 26 | - |
| | Land snails | - | - | - |
| | Amphibians | 1 | 1 | 1 |
| | Reptiles | 6 | 9 | 1 |
| | Birds | 21 | 27 | 4 |
| | Mammals | 11 | 11 | 1 |
| Stream banks | Butterflies | 5 | 26 | - |
| | Land snails | 1 | 1 | - |
| | Amphibians | 1 | 1 | - |
| | Reptiles | 4 | 6 | - |
| | Birds | 20 | 30 | 2 |
| | Mammals | 8 | 10 | 1 |

### 3.2.1.9 Endemic species

22 endemic species were found during the ecological survey which was conducted between Sep. 15, 2008 to Dec. 20, 2008. It is possible however that some endemic species may not have been recorded in the survey.

**Table 3-19 List of endemic species**

| Items | Name | Common name | Category[7] | Hone Gardens | Chena | Grasslands | Scrub Fores | Secondary Forest | Stream Bank Vegetation |
|---|---|---|---|---|---|---|---|---|---|
| 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 | - | - | + | - | - | - |

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

#### 3.2.1.10 Elephant

About 100 wild elephants live in the VVR sanctuary. They move on both sides of the Mahaweli River (See Figure 3-34).

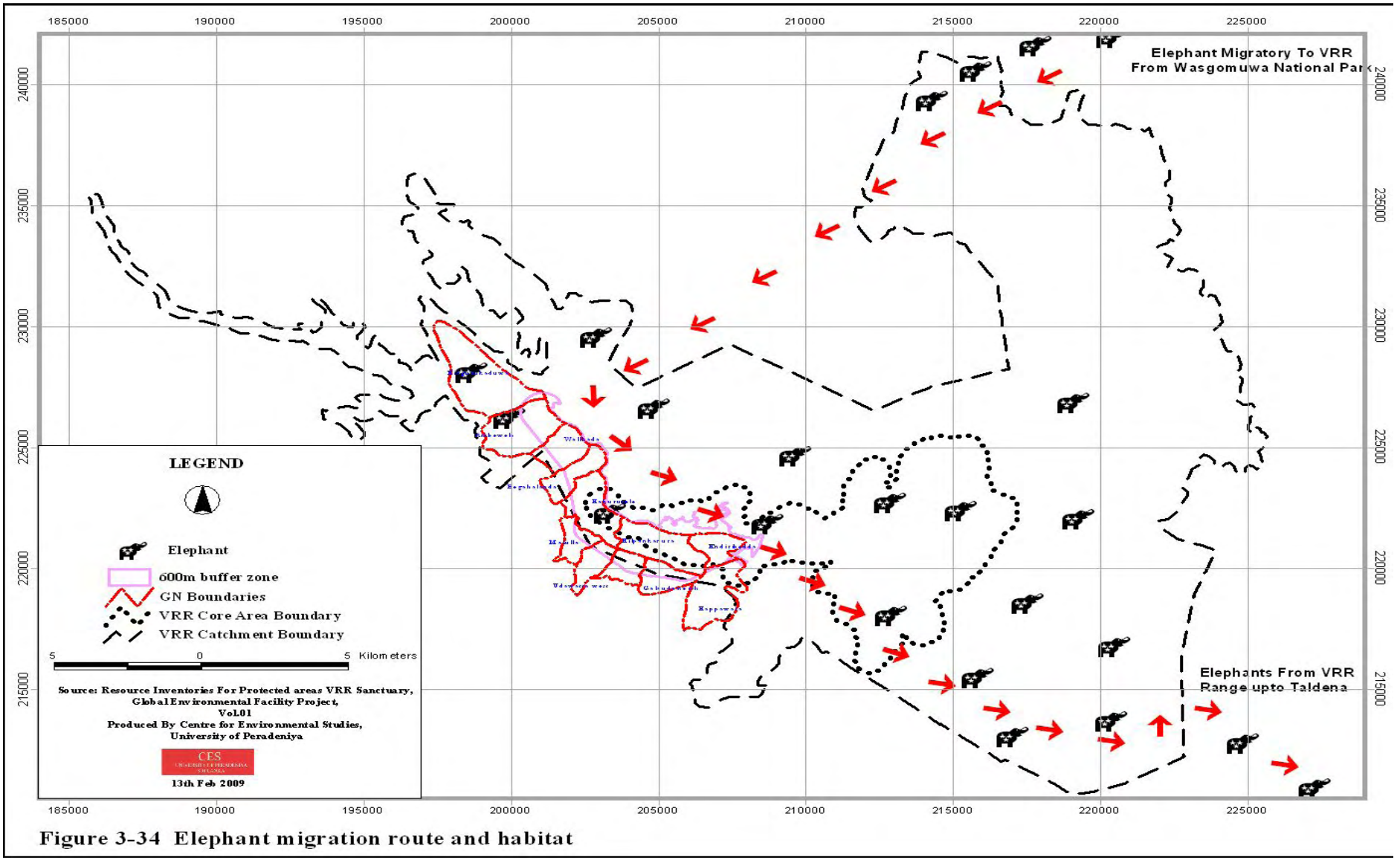



Figure 3-34 Elephant migration route and habitat

**Figure 3-33 Elephant migration route and habitat**

### 3.2.2 Number of trees

he average tree density of the forest is 300 per hectare and the average tree density of the scrub and grassland is 500 per hectare. Based on these averages, the number of trees estimated is at 9,310. However, it is important to note that the terminology used as "trees" and "shrubs" refer to a broad biological classification. According to this classification a "tree" could vary from a height of few feet to over 100 feet. The 9310 trees would include this entire range.

**Table 3-20 Estimated loss of vegetation by temporally facility area (ha)**

| Temporary facilities | | Area (ha) | | Density (No/ha) | | Number of Tree (No) | | Total (No) |
|---|---|---|---|---|---|---|---|---|
| | | Forest | Scrub and grassland | Forest | Scrub and grassland | Forest | Scrub and grassland | |
| A | Portal Area of Headrace Tunnel | 0.22 | 0.65 | 300 | 500 | 66 | 325 | 391 |
| B | Portal Area of Headrace Tunnel | 0.94 | 0.07 | 300 | 500 | 282 | 35 | 317 |
| C | Surge Tank Area | 0.00 | 0.74 | 300 | 500 | 0 | 370 | 370 |
| D | Powerhouse & Switchyard Area | 0.06 | 0.00 | 300 | 500 | 18 | 0 | 18 |
| E | Concrete Facilities (Crushing Plant and Batching Plant) | 0.00 | 0.31 | 300 | 500 | 0 | 155 | 155 |
| M1 | Dumping site | 0.00 | 0.00 | 300 | 500 | 0 | 0 | 0 |
| M2 | Dumping site | 0.23 | 5.71 | 300 | 500 | 69 | 2855 | 2924 |
| M3 | Dumping site | 1.33 | 0.00 | 300 | 500 | 399 | 0 | 399 |
| M4 | Dumping site | 0.27 | 0.00 | 300 | 500 | 81 | 0 | 81 |
| M5 | Dumping site | 3.05 | 7.48 | 300 | 500 | 915 | 3,740 | 4,655 |
| Total | | 6.10 | 14.96 | | | 1,830 | 7,480 | 9,310 |

## 3.3 Social Environment

### 3.3.1 Population characteristics, settlements in the study area

The Proposed Victoria Hydropower Station Capacity Expansion Project is located within the Hanguranketha Secretarial Division in the Nuwara Eliya District of the Central Province. The division has 15% of the total population in the Nuwara Eliya district (see Figure 3-34).

The Hanguranketha Division is 231 sq km in size and consists of 131 Grama Niladari divisions. It is located 27 km away from the second largest city in Sri Lanka, Kandy. Victoria and Randenigala reservoirs are located on the eastern boundary of the division. The total population of the division is 103797 with a density of 449 per sq km. The Sinhalese and Tamils are the two major ethnic groups in this division, respectively with 85.6% and 14.2% of the total population. Muslims account for only 0.2% of the total population.

The division is predominantly rural accounting for 84.2% of the total population. The estate population is 14.5% and the urban population is only 1.4% of the total population. The major settlement types are given in Table 3-21 and Figure 3-36.

**Table 3-21 Population by settlement types in Hanguranketha Division**

| Settlement type | Total population | % of total population |
|---|---|---|
| Rural | 87415 | 84.2% |
| Estate | 14980 | 14.4% |
| Urban | 1402 | 1.4% |

*Source: Grama Niladari Census, 2007*

7 Grama Niladari divisions of the Hanguranketha Division fall within the identified impact area but only 4 of them have settlements within the main impact area. They are Ambewela, Welikada, Hakurutale and Heelpenkandura with a total of 57 potentially affected households. The social survey was conducted in these four divisions. The area and the total population of these six divisions are given in Table 3-22 (see Figure 3-34). The sand mining site and the tunnel muck dumping site in Kohombagana are located away from the main impact area. While there are no houses located within the 100 meter perimeter of the sand mining site, there are some private houses beyond the perimeter of the Kohombagana tunnel muck dumping site. Some of the lands that have been identified for this tunnel muck dumping site are also privately owned.

**Table 3-22 Area, Total population and population density of the impact area**

| GN Division | Total Population of GN Division[8] | Area falling within the Project Impact Area | | | | |
|---|---|---|---|---|---|---|
| | | Area (ha) | Total no of households | Total population | Population density person/ha | % of total population of the division |
| Hingurukaduwa | 630 | 18.0 | 0 | 0 | - | 0 |
| Ambewela | 694 | 165.7 | 6 | 30 | 0.18 | 4.3% |
| Welikada | 770 | 144.7 | 19 | 77 | 0.53 | 10.0% |
| Bogahalanda | 760 | 92.6 | 0 | 0 | - | 0 |
| Hakurutale | 191 | 271.3 | 29 | 119 | 0.44 | 62.3% |
| Hilpenkandura | 413 | 11.9 | 3 | 15 | 1.26 | 3.6% |
| Total | 3,458 | 704.2 | 57 | 241 | 2.91 | 6.9% |

*Source: Social survey*

The impact area has 57 households within four GN divisions with a total population of 241 according to the social survey. The population density is very low in the whole impact area. The impact area is homogenous in terms of the ethnic, religious and linguistic composition of the population, that is, Sinhalase and Buddhists speaking the Sinhala language.

The impact area consists primarily of rural settlements engaging in paddy and chena cultivation. There are no estate or urban settlements within the impact area. Settlements are clustered into two main localities, one in Welikada and the other in Hakurutale.

[8] There is a discrepancy in the total population data given by the Grama Niladri and the Samurdhi Niladari. The figures given here are taken from Samurdhi Niladari.

### 3.3.2 Socio-economic and demographic status of the impact area

The male population of the impact area is higher than the female population, 52.3% to 47.7% respectively. Table 3-23 below gives details.

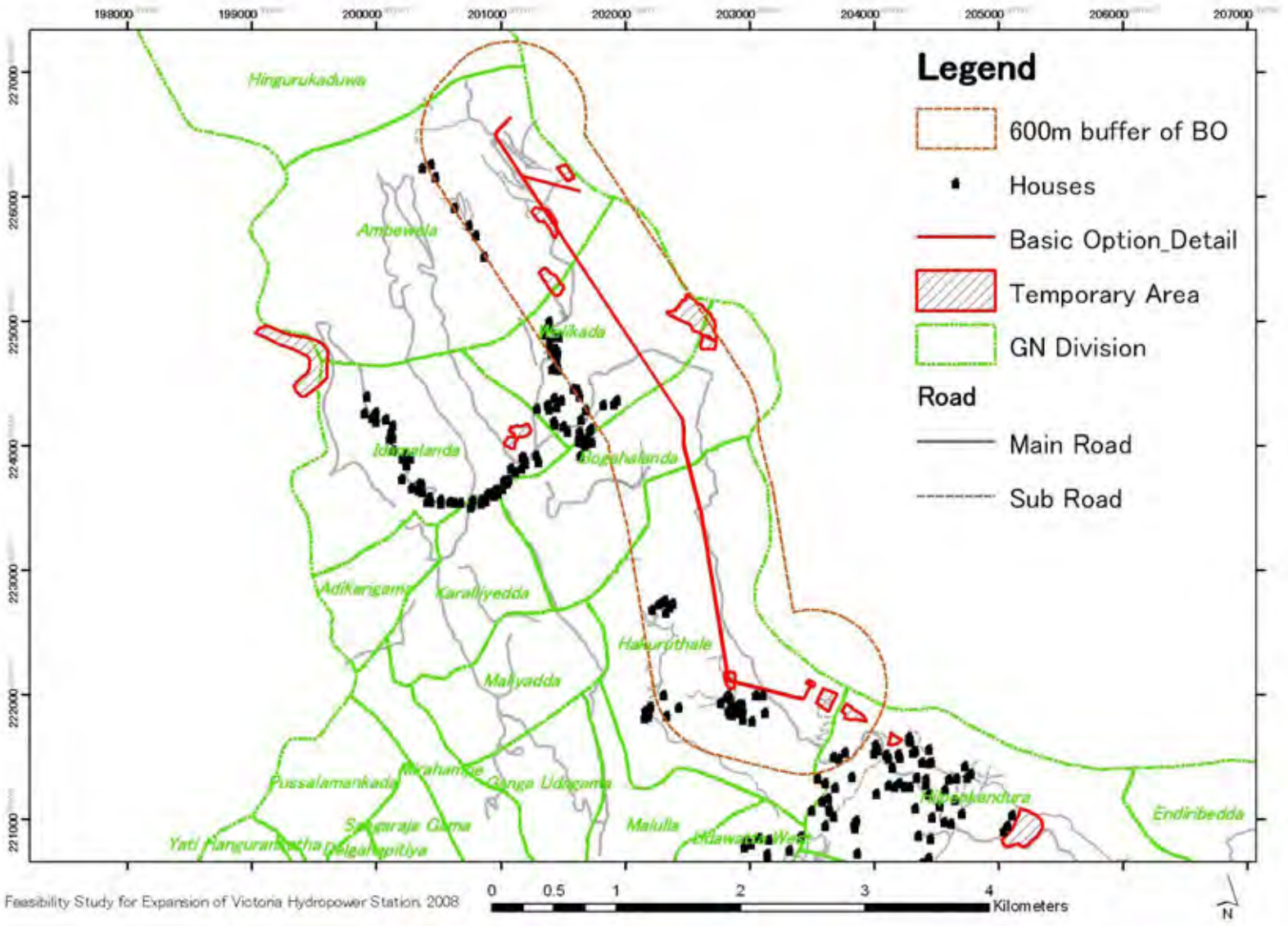



**Figure 3-34 GN divisions in the project area**

**Table 3-23 Male, female population of the impact area**

| GN Division | Male | Female | Total | Male % | Female% |
|---|---|---|---|---|---|
| Welikada | 33 | 44 | 77 | 43.0 | 57.0 |
| Hakuruthale | 65 | 54 | 119 | 54.6 | 45.4 |
| Hilpenkandura | 7 | 8 | 15 | 46.6 | 53.4 |
| Ambewela | 13 | 17 | 30 | 43.3 | 56.7 |
| Total | 118 | 103 | 241 | 48.9 | 51.1 |

*Source: Social Survey (Question No 1.4)*

About 60% of the total population of the impact area is in the age group of 19-60 while 31% of total population is under 18 and 8% over 61. This age profile shows a higher percentage of the population in the economically active group with lower numbers in the dependent category Table 3-24 below gives details.

**Table 3-24 Population by age group**

| GN Division | 0-18 | 19-60 | 60 plus |
|---|---|---|---|
| Welikada | 27 | 46 | 4 |
| Hakuruthale | 38 | 67 | 14 |
| Hilpenkandura | 5 | 8 | 2 |
| Ambewela | 10 | 14 | 6 |
| Total impact area | 80 | 135 | 26 |

*Source: Social survey*

In terms of educational levels, 36% of the total population have passed the GCE Ordinary Level examination while 10.5% have passed the GCE Advanced Level examination. About 41% of the population have completed up to eighth grade while 11% has had no schooling at all. The fact that 88% of the total population have attended school shows a higher rate of literacy among people in the impact area.

The study area is a relatively poor agricultural area. The average income per household is Rs. 12314.95 per month while the per capita income is Rs. 2969.79. The area can be considered as a poor area as most of the families are Samurdhi recipients.

Twenty five people (3% of the total population) from the impact area have gone to the Middle East for employment.

**Table 3-25 Economic profile of the impact area (income and Samurdhi)**

| GN Division | Total no of households | Average Income per HH (Rs.) | Per Capita income (Rs.) | % of Samurdhi receipients of total households |
|---|---|---|---|---|
| Hakurutale | 29 | 11,308.62 | 2755.88 | 11 (37.4%) |
| Heelpenkandura | 3 | 10,124.36 | 2024.82 | 3(100%) |
| Welikada | 19 | 10,763.16 | 2655.84 | 6 (31.6%) |
| Ambewela | 6 | 12006.47 | 2401.29 | 3 (50%) |
| Total impact area | 57 | 11137.93 | 2634.82 | 40.3 |

*Source: Social survey*

According to the social survey, 60% of the total households receive Samurdhi aid which is indicative of the high poverty level in the area. Among the divisions, Hilpenkandura is the poorest with 100 % of the total households receiving Samurdhi. Hakurutale and Welikada have a relatively lower number of Samurdhi recipients.

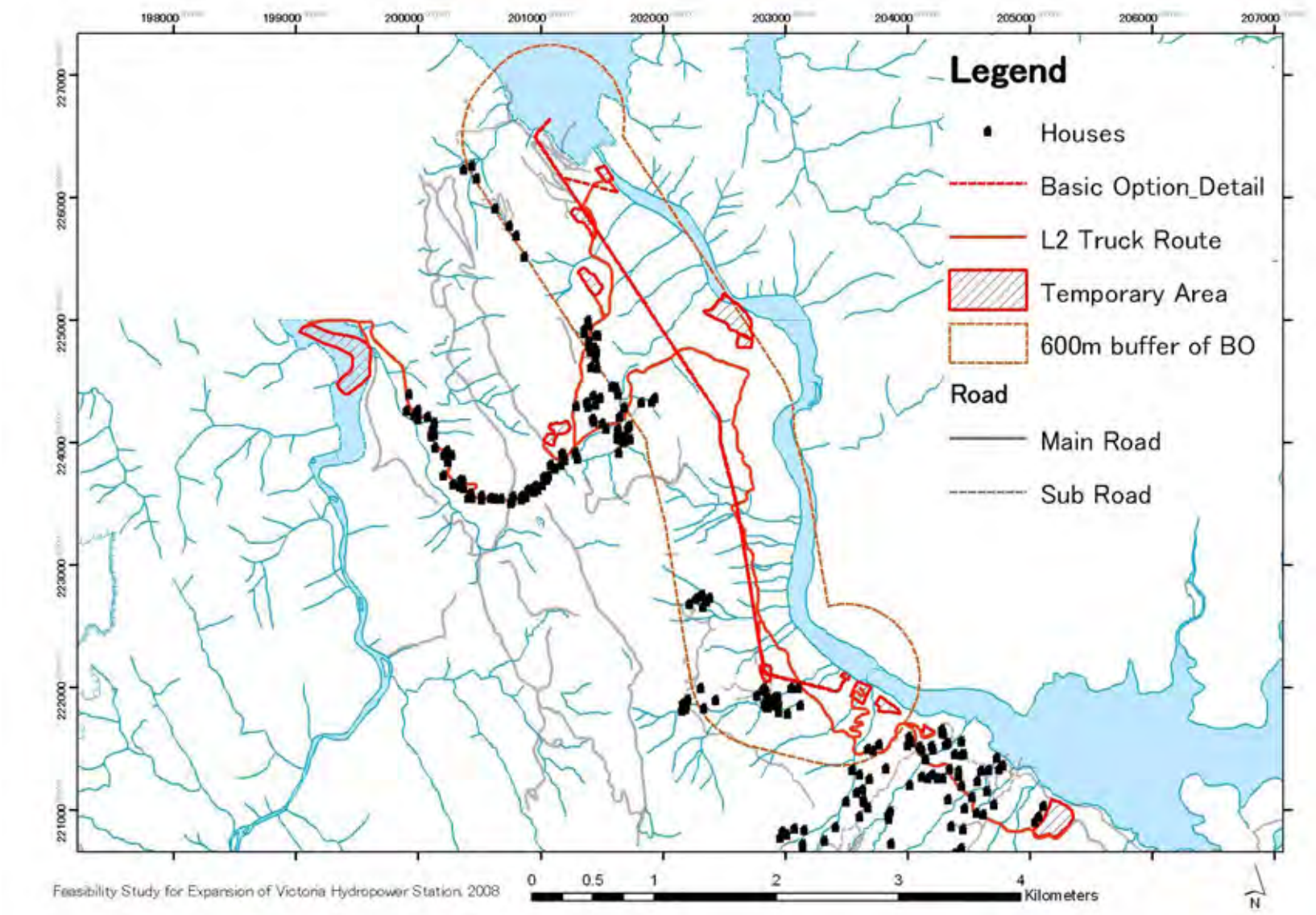



**Figure 3-35 Settlement near the project site**

**Table 3-26 Number of samurdhi recipient / households by coupon value**

| GN division | Samurdhi recipients | No.of recipients by coupon value in Rs. | | | | | |
|---|---|---|---|---|---|---|---|
| | | 900 | 525 | 415 | 375 | 210 | No |
| Hakuruthale | 11 | 5 | 0 | 1 | 4 | 1 | 11 |
| Hilpenkandura | 3 | 1 | | 2 | | | 3 |
| Welikada | 6 | 1 | 0 | 0 | 2 | 3 | 6 |
| Ambewela | 3 | | 1 | 2 | | | 3 |
| Total | 109 | 29 | 8 | 23 | 33 | 20 | 70 |

### 3.3.3 River users

The inhabitants in the divisions above the powerhouse do not use the river much, but those who are in the lower areas use the river primarily for bathing and washing purposes. They do not use the river water for agriculture or any other economic purposes. However, they use the reservoir for fishing on a very small scale.

### 3.3.4 Income generation sources and patterns

The major source of income for the impact area is agriculture. This is about 60% of the total number of employed people. Paddy cultivation is the main source of livelihood, while vegeTable cultivation is also undertaken simultaneously. Tobacco is grown as a cash crop in the Hilpenkandura division. The second category of income generation is casual labor which is about 27% of the total employed population. According to the Census 2001, about 25 people have gone abroad as Middle East employees.

**Table 3-27 Major employment types of the impact area**

| | Farmers | Labors | Soldiers | Teachers | Others |
|---|---|---|---|---|---|
| Welikada | 14 | 10 | 4 | 1 | 0 |
| Hakuruthle | 24 | 15 | 3 | 0 | 3 |
| Hilpenkandura | 6 | 2 | 0 | | 2 |
| Ambewela | 8 | 4 | 1 | 0 | 2 |
| Total | 52 | 31 | 8 | 1 | 7 |

Source: Social survey

### 3.3.5 Existing environmental considerations, problems or issues prevailing in the area

The inhabitants of 115 households of the 184 households (63%) in the impact area have lived in the same place of residence during Stage 1 of the Victoria Hydro Power Station project. They are more aware of the potential impacts of this project than those who have settled after Stage I.

Seventy five (75) families out of the 184 acknowledge that there are environmental problems related to stage 1 while 59 either said they were not aware of or did not mention any such problems. They identify the decreasing ground water Table as the most prominent environmental issue that directly affects them. Changing rainfall patterns and biodiversity rank second and third. Soil degradation and the mixing of limestone into drinking water are other problems that the people have pointed out.

A majority of the people in the area consider the VRR sanctuary to be a problem. Many point out threats from the elephants and other wild animals such as monkeys and wild pigs to their agriculture.

Observation reports indicate that there is a potential for landslides in the Udawatta west division. Generally, observation reports mention the difficulty of obtaining water because the springs and wells tend to dry out in the dry season. Obtaining water for their crops is a major problem mentioned by most of the inhabitants in the area.

### 3.3.6 Cultural, historical, protected reserves and archeological aspects / considerations

There are no cultural and historical protected reserves and sites of archaeological significance within the impact area. 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 on the *stupa*.

### 3.3.7 Existing infrastructure facilities, transportation, communications, power supply and sanitation, healthcare, hospital, water supply etc.

The main highway from Kandy-Mahiyangana, the Raja Mawatha, which was built during stage 1 runs through the GN divisions in the impact area. However, Welikada is the only division served by the highway as it is close to the highway. Major settlement in Hakurutale are located away from the highway. Observation reports of the research assistants indicate that the Hakurutale primary school was closed due to the difficulty of transportation for the teachers. Certain minor road projects are being carried out at the moment under national "Maga Neguma" road development program (for instance, in the Hilpenkandura division). Overall, the lack of accessibility due to not having sufficient roads is frequently quoted as a major infrastructural problem.

All GN divisions, have electricity.

The Victoria National School is located near the existing turn off to the Dam site from the main road. The school is located just outside the main impact area of the proposed project but all the children living in the impact area come to this school for education..

### 3.3.8 Present water supply and water uses

The main source of water supply in the area is spring-based wells. Most of the wells are common dug-wells on the springs near the streams, while some are private home-based wells. (Figure 3-37) Table 3.28 gives the rank order for each source of water supply for domestic use including bathing for each GN division. Wells built on springs or the springs themselves are the main source of water for domestic use. Some villages have a central spring as the main source of water supply for the inhabitants (for e.g., the *diya bubula* in Hakurutale).

In all the divisions, rain water is predominantly used for the purpose of irrigating agriculture, except for occasional use of common wells to supply water for vegeTable cultivation.

**Table 3-28 Rank order of water sources for domestic use**

| Water source | Ambewela | Hakurutale | Hilpenkandura | Welikada |
|---|---|---|---|---|
| Taps | 1 | - | 3 | 2 |
| Spring/common wells/home wells | 2 | 1 | 2 | 1 |
| Water projects | 3 | - | - | |
| Reservoir | 4 | - | - | |
| Streams | 5 | 2 | 1 | 1 |
| Wells | 6 | - | - | 6 |

### 3.3.9 List any social cultural sensitive areas

There are no socially or culturally sensitive areas identifiable within the impact area. However, there are two temples in the Welikada and Hilpenkandura divisions.

## 3.4 Details of existing and planned projects in the area

There are no planned development projects in the area, except the DWLC Management Plan (see Annex VII-8 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 1.9 for details on how the project conforms to the management plan of the DWLC).

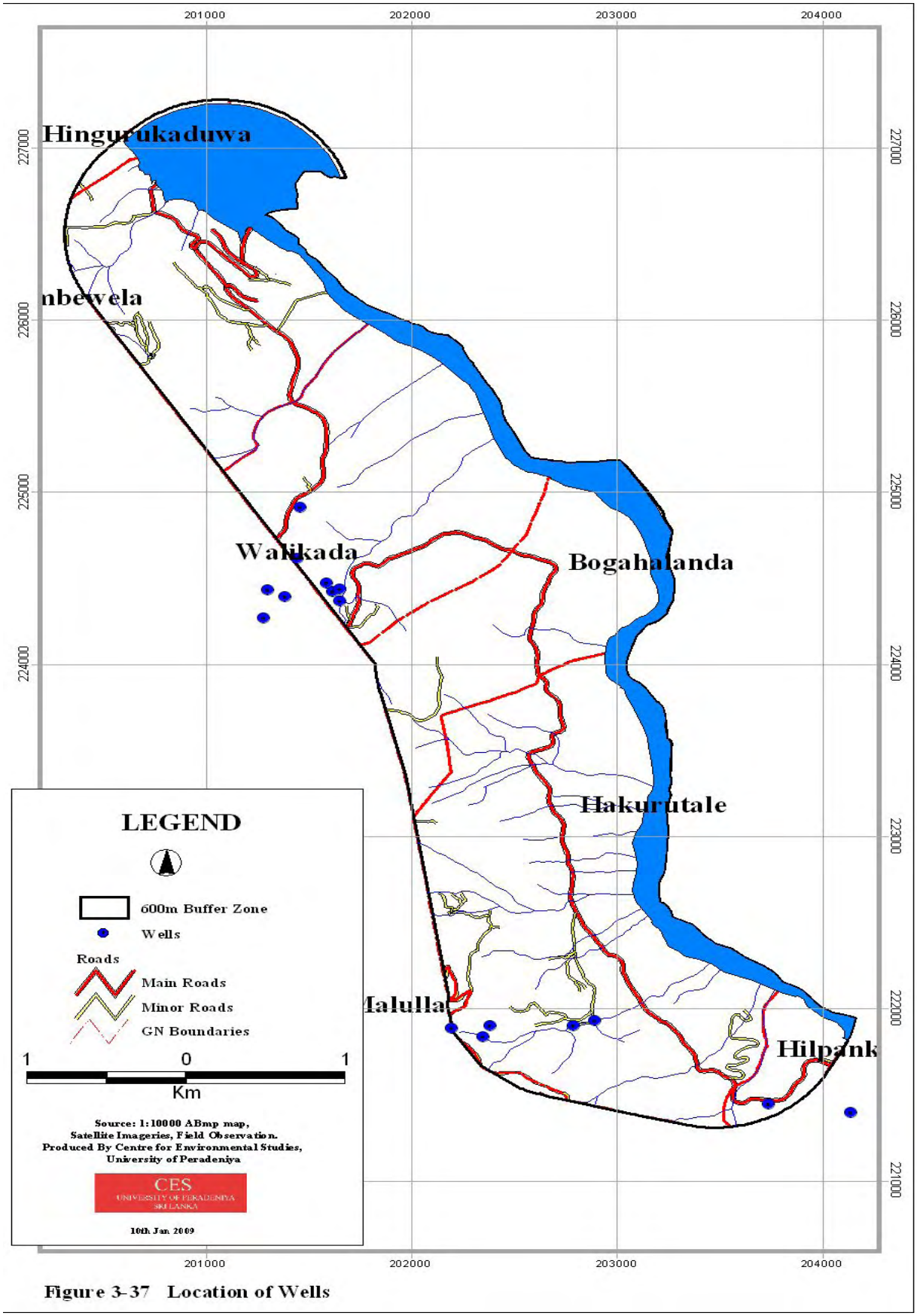



Figure 3-37 Location of Wells

**Figure 3-36 Location of wells**