Environmental Addendum

February 2014

Sri Lanka: Green Power Development and Energy Efficiency Improvement Investment Program

Prepared by Ceylon Electricity Board, Ministry of Power and Energy, Democratic Socialist Republic of Sri Lanka for the Asian Development Bank.

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ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AP	Affected Persons
asl	Above Sea Level
BOD	Biochemical Oxygen Demand
CBO	Community-Based Organisation
CC	Construction Contractor
CDM	Clean Development Mechanism
CEA	Central Environmental Authority
CEB	Ceylon Electricity Board
CECB	Central Engineering Consultancy Bureau
CPUE	Catch Per Unit Effort
CR	Critically Endangered
DD	Detailed Design
DO	Dissolved Oxygen
DPP	Disaster Preparedness Plan
DWC	Department of Wildlife Conservation
EA	Executing Agency
EIA	Environmental Impact Assessment
EN	Endangered
EMP	Environmental Management Plan
EMoP	Environmental Monitoring Plan
EPL	Environmental Protection License
FD	Forest Department
FS	Feasibility Study
FSL	Full Supply Level
GoSL	Government of Sri Lanka
GRC	Grievance Redress Committee
GRM	Grievance Redress Mechanism
GS&MB	Geological Survey and Mines Bureau
HPP	Hydropower Project
ID	Irrigation Department
IEE	Initial Environmental Examination
IUCN	International Union for Conservation of Nature
LA	Local Authority
LB	Left Bank
MASL	Mahaweli Authority of Sri Lanka
MC	Municipal Council
MDF	Medium-Density Fibreboard
MHPP	Moragolla Hydropower Project
MOL	Minimum Operating Level
NBRO	National Building Research Organisation
NEA	National Environment Act
NIRP	National Involuntary Resettlement Policy
NT	Near Threatened
NTU	Nephelometric Turbidity Units
NWS&DB	National Water Supply and Drainage Board
NZG	National Zoological Gardens
OHSP	Occupational Health & Safety Plan

OSF	Other State Forest
PAA	Project Approving Agency
PD	Project Director
PMO	Project Management Office
PMF	Probable Maximum Flood
PP	Project Proponent
PS	Pradeshiya Sabha
PVC	Poly-Vinyl Chloride
RB	Right Bank
RC	Reinforced Concrete
RDA	Road Development Authority
RoW	Right of Way
RP	Resettlement Plan
SIA	Social Impact Assessment
SPS	Safeguard Policy Statement
TEC	Technical Evaluation Committee
ToR	Terms of Reference
TL	Transmission Line
TSS	Total Suspended Solids
UC	Urban Council
UDA	Urban Development Authority
UNFCCC	United Nations Framework Convention on Climate Change
WMP	Watershed Management Plan

WEIGHTS AND MEASURES

GWh	gigawatt hour
ha	hectare
Hz	hertz
km	kilometre
km^2	square kilometres
kV	kilovolt (1,000 volts)
kW	kilowatt
kWh	kilowatt hour
m	metre
m^2	square metre
m^3	cubic metre
$m^3/km^2/y$	cubic metres per square kilometre per year
m^3/s	cubic metre per second
mm/s	millimetres per second
masl	metre above sea level
MCM	million cubic metre
MW	megawatt
MVA	megavolt ampere
rpm	revolutions per minute

PREFACE

This document is the first of five volumes, which together describe the environmental studies conducted in relation to the Moragolla Hydropower Project (HPP) in Sri Lanka. These studies were conducted between 2009 and 2014 on behalf of the Project Proponent, The Ceylon Electricity Board (CEB). The studies comprise: a) an Local Environmental Impact Assessment (EIA) prepared according to the Sri Lankan National Environment Act (NEA) (1980, amended 1988), which was approved by the Mahaweli Authority of Sri Lanka (MASL) in August 2013; b) Final Reports of 14 Additional Studies conducted in 2013 to provide data to update the Local EIA and allow a re-evaluation of project impacts and mitigation; c) an Environmental Addendum and Environmental Management Plan (EMP) prepared to upgrade the Local EIA to comply with the ADB Safeguard Policy Statement (SPS) (2009); and d) a Resettlement Plan prepared according to Sri Lankan law and the ADB SPS.

The report of these studies comprises five volumes, which are arranged as follows:

Volume 1: Environmental Addendum (2014) - **this document;**
Volume 2: Environmental Management Plan (2014);
Volume 3: Resettlement Plan (2014) (Standalone document, to be disclosed in March 2014);
Volume 4: Additional Environmental Studies (2013);
Volume 5: Local Environmental Impact Assessment (2012).

Volumes 1-2 represent the final assessment of the environmental impacts of the Moragolla HPP, prepared in compliance with national law and ADB policy. These documents incorporate all relevant results and data from the earlier Local EIA and the Additional Environmental Studies; and Volumes 4 and 5 are provided only to allow access to all data relating to the updated environmental impact assessment if needed.

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-	-	OTHER REPORT	Future Climate Change risk assessment for the proposed Moragolla HP	Included New

ALL CROSS REFERANCE TABLES IN ENVIRONMENTAL ADDENDUM (2013)

EXECUTIVE SUMMARY - VOLUME 1 and VOLUME 2

A. Background

1. Moragolla Hydropower Project (MHPP) is one of several hydropower projects identified by the Government of Sri Lanka (GoSL) to reduce the role of fossil-fuelled power generation, which has outstripped hydropower over the past 30 years as readily exploitable locations have been utilised. Returning hydropower to greater prominence would promote sustainable development and reduce greenhouse gas emissions in line with the National Climate Change Policy, and limit exposure to fluctuating international fuel prices. The Executing Agency is the Ministry of Power and Energy (MoPE) and the Implementing Agency is the Ceylon Electricity Board (CEB). Assistance has been requested from the Asian Development Bank (ADB) in funding project construction.

2. The project will be located in the upper reaches of the Mahaweli Ganga in the Central Highlands of Sri Lanka, approximately 22 km south of Kandy City and 130 km north-east of Colombo. The Mahaweli is the largest river system in Sri Lanka, with 24 major tributaries and a length of over 200 km, draining into the Bay of Bengal at Trincomalee on the east coast. It already supports 9 other hydropower and mini-hydro dams, two upstream of Moragolla. The dam site is east of Ulapane village in a narrow high-sided valley, with a catchment of 809 km^2.

3. A Feasibility Study (FS) in 2009 included a Local Environmental Impact Assessment (EIA), approved by the Mahaweli Authority of Sri Lanka (MASL), the Project Approving Agency (PAA) for this Local EIA in August 2013. A study to review the FS and prepare detailed designs and bidding documents in 2012-13 included a component to upgrade the Local EIA to comply with ADB *Safeguard Policy Statement* (2009). Upgrading involved: 15 Additional Studies and Surveys in March - November 2013 (water quality, aquatic ecology, groundwater, river users, socio-economics, etc); a re-assessment of impacts and mitigation; and preparation of other materials to address gaps in the Local EIA. The final study report comprises 5 volumes, and the main components are: Environmental Addendum (Vol 1); Environmental Management Plan (Volume 2); Resettlement Plan (Volume 3).

B. The Project

4. The project involves construction of a 37 m high, 236 m long concrete gravity dam (crest at 550 masl), to create a 38.5 ha, 1.98 MCM reservoir with a Full Supply Level (FSL) at 548 masl. The concrete spillway contains 5 radial gates (13 x 14 m) designed to pass a 10,000 year flood (6,700 m^3/s) with no increase in FSL, or with a 2 m increase if one gate was non-operational and closed. Water will be diverted by an intake just upstream of the dam, into a 2.7 km , 4.7 m Ø underground headrace tunnel, surge tank and penstock on the left bank, to an above-ground powerhouse and 28 m open-channel tailrace outfall, through which water will return to the river. A 500 m transmission line (TL) with two towers will connect the switchyard to an existing TL from the powerhouse of the Kotmale HPP on the right bank.

5. MHPP is designed as a run-of-river scheme, with an installed capacity of 30.2 MW (2 x 15.1 MW); and it will operate as a “peaking” station, generating power in the daily peak demand period (5-9 pm), and at other times if there is sufficient water (mainly in the monsoon season). The dam includes a pipe to discharge a constant “Environmental Flow” (E-flow) of 1.5

m^3/s,Volum 4, E-flow study, which will pass through a micro-hydro plant on the right bank, generating an additional 360 kW.

6. Construction will take 4.5 years (mid-2015 to end-2019), preceded by a 1.5 year pre-construction phase of financial arrangements and tendering. There will be three main construction areas (dam/intake; surge tank/penstock and powerhouse/tailrace) and 13 "ancillary sites" (quarry, spoil disposal, access roads, resettlement site, etc). Together these will cover 55 ha, plus another 52 ha for the reservoir and buffer. Construction will involve a great deal of excavation, tunnelling, spoil disposal, materials transportation and creation of structures mainly from reinforced concrete. The basic statistics of the construction process are as follows:

- Clearance of all vegetation from 55 ha; removal of trees/shrubs from 38 ha (reservoir);
- Earthworks at most sites, some involving deep excavation, tunnelling, drilling, blasting;
- Excavation of 400,000 m^3 of bulk soil/rock and transporting 300,000 m^3 to disposal sites;
- Quarrying 100,000 m^3 of stone, and transporting it to the crusher or dam site;
- Reducing 45,000 m^3 of stone to aggregate in a mechanical crusher and storing on-site;
- Bringing to site around 100,000 m^3 of sand and other constituents of concrete;
- Mixing 150,000 m^3 of concrete and transporting for use mainly at the dam/powerhouse;
- Around 55,000 journeys by dump trucks and concrete mixers, of an average of 2 km;
- 100 large construction vehicles and 20-30 smaller vehicles, on site for up to 4 years;
- A workforce of around 650 (150 skilled, 300 unskilled, 100 operators, 100 supervisors).

7. On completion, CEB will operate the MHPP with a relatively small team of technicians, engineers and managers, because of the high degree of monitoring, control and automation provided by modern hydropower plants. The project cost is estimated at $128 million, of which more than half is for the main civil works (dam, tunnel and other structures) and 20% each for the hydro-mechanical and electromechanical components. Almost $2 million is allocated for environmental mitigation and monitoring through contractor's budget.

C. Analysis of Alternatives

8. The 2009 FS investigated three locations for the dam, with different dam heights and tunnel lengths; and the Local EIA examined the environmental impacts, ease of mitigation and capital costs. Initial screening removed one option as technically infeasible and discounted "no-project" because of the environmental and financial cost of fossil-fuel based alternatives. More detailed analysis showed the proposed scheme as clearly preferred in terms of both cost and environmental impacts (smaller reservoir, less resettlement).

9. The chosen option was then modified to further reduce environmental/social impacts, by: a) decreasing reservoir FSL by 2m to reduce inundation of a road on the right bank and paddy land on the left bank; and b) repositioning the intake and tunnel to allay concerns in Ulapane Industrial Estate regarding vibration from tunnel blasting. Further modifications in the FS review, include: a) relocating the dam 100 m downstream where bedrock is nearer the surface, which reduces excavation near the industrial estate; b) revising proposals to access the site along the populated Ethgala Road on the left bank and accessing from the sparsely inhabited right bank by a river causeway, thus reducing disturbance to residents; and c) redesigning the surface penstock as an underground structure to avoid surface excavation and resulting noise and dust.

D. Baseline Conditions

10. . The Environmental Addendum and EMP deal mainly with the natural environment, plus those impacts on people that do not produce socio-economic changes (air quality, noise, landscape, etc). Existing conditions in each sector are summarised below:

Sector	Existing Conditions
Hydrology	Mahaweli basin has a high mean annual rainfall (3,852 mm/y) and at the project site, average monthly river flow is ca 6-11m^3/s in the dry season (Jan - Apr) and 20-50 m^3/s in the monsoon (May - Nov); and the flow duration curve shows a minimum of 3.6 m^3/s (95% exceedence). There are small confluences with Ulapane Oya just upstream of the dam site (LB) and Atabage Oya 3 km downstream (RB). A larger confluence with Kotmale Oya 3 km upstream (RB) is captured by Kotmale Dam and Reservoir (172.5 MCM) and used for power generation in an underground conveyance and powerhouse on the RB opposite the Moragolla site. Water returns at the Atabage Oya confluence; and Kotmale Dam (built in 1985) provides no E-flow.
Water Quality	Surveys in 2013 showed that river water is well oxygenated and not grossly polluted. Quality is however strongly influenced by the activities of man, with high turbidity and TSS deriving from soil runoff, and high faecal and total coliforms from inputs of plant debris and human and animal waste. An outfall from Crysbro Poultry Factory 2 km downstream of the dam site (LB) is a source of organic pollution and exceeds legal discharge standards for BOD, TSS and faecal coliforms. Comparison with proposed standards shows that river water is not suitable for drinking, bathing or irrigation (because of high turbidity and bacterial content).
Ground Water	The project area is in Sri Lanka's middle peneplain, which features heavily dissected ridges/valleys with steep rocky slopes, through which the Mahaweli flows NNE with incised bends and meanders. The area is in the west of the Highland Complex with high grade meta-sediments and granulitic orthogneisses. With shallow hard bedrock, thin overburden and steep topography, groundwater is present in isolated, small, shallow aquifers. Surveys showed that wells for domestic supply are shallow (1-15 m), with water columns of 0.5-3.5 m, and water that does not meet potable standards for pH, ammonia and faecal/total coliforms.
Land-Use and Landscape	This is a sparsely populated rural area of undulating topography and mixed vegetation, dominated by the river valley. Natural vegetation has been largely removed to provide agricultural land, some of which is now abandoned. The main land-uses are: small-scale agriculture in home gardens (46% of the area); scrub recolonizing unused land (26%); tea plantations (9%); secondary forest (6%); and paddy (3%). The main population centres are the villages of Ethgala, SAARC and Ulapane, over the hillside on the left bank (LB).
Geology, Topography and Natural Hazards	Field studies in 2009 found no evidence of landslides, except for some gully and bank failures. Geological and topographic investigations at the reservoir site in 2013 found suitable bedrock and slope stability on the LB, and gneissosity dipping towards the river on the RB where there are two previous rock slides. These are mainly below Minimum Operating Level (MOL), so there is little risk of landslides during impoundment. Independent studies in 2009 and 2013 concluded that there is no risk of the dam failing. Over 2,500 concrete gravity dams have been built since 1930 in a variety of locations and none has failed.
Air Quality	Monitoring in 2009 found that concentrations of SO_2, NO_2, CO, O_3 and dust (PM_{10} and $PM_{2.5}$) were all below national ambient air quality standards, so as expected in a rural area, air quality is generally good.
Noise and Vibration	Monitoring in 2009 showed low noise and vibration levels, and it was concluded that this is a low-noise environment, and there should be no damage or inconvenience from vibration in normal circumstances.
Aquatic Ecology	Surveys in 2013 revealed a diverse aquatic fauna in the project area, with 40 fish species (21 indigenous, 14 endemic, 5 exotic) including 8 that are nationally threatened (Sri Lanka Red Data List). Seven of these occur fairly widely, but *Labeo fisheri* (green/mountain labeo) is confined to a shorter length of the Mahaweli and tributaries, and is found in low densities. This is a conservation priority, but the project area is not critical habitat for any species as all are distributed more widely, in viable feeding and breeding habitats.
Terrestrial Ecology	There is no original forest left in the project area and the nearest forest conservation areas are 25km away. The remaining degraded habitats provide refuge for a quite diverse terrestrial fauna, including 41 endemic or endangered species, including 16 nationally threatened (mostly butterflies/dragonflies). An analysis by IUCN classified five species as conservation priority: lesser gull butterfly; one-spot grass yellow butterfly; fishing cat; rusty-spotted cat; Sri Lanka pigmy mouse-deer. None of the habitat is critical for these or other species as all occur elsewhere and none are dependent solely on the project area for feeding or breeding.

Physical Cultural Resources	There are four archaeological sites 2-2.5 km from the project site; all are not well-preserved Buddhist buildings from the 14th, 15th and 18th centuries. Field studies in 2009 found no archaeological scatter at the project site because of land clearance for agriculture, and it was concluded there is a low potential for further discoveries. There are some sites of local cultural importance, including roadside shrines.
River Users	River usage by local people is limited because of access difficulties. Currently there are: 4 sites used for washing/bathing in the reservoir area; 2 licensed abstraction points between the dam and tailrace sites (Dunhinda Irrigation Canal 0.28 m^3/s; Crysbro Poultry Factory 220 litres/day); and in the 17 km downstream of the tailrace, 21 sand mining sites (with 63 miners) and 34 bathing sites (used by almost 800 families).

E. Impacts and Mitigation: Pre-Construction and Construction

11. **Hydrology:** Construction will involve substantial work in the river bed to build the dam, tailrace outfall and causeway, with cofferdams and a river diversion to allow construction in the dry. This should not cause major hydrological impacts because the diversion tunnel will pass a flood discharge of 320m^3/s, without interruption and cofferdams will withstand the expected minimal overtopping without structural damage. One concern is at the causeway and tailrace where cofferdams alone will deflect the river away from the sites, which may cause flooding outside the river channel in the monsoon. This will be avoided by conducting this work in the dry season.

12. The presently proposed method of reservoir filling involves total closure of the diversion conduit, and there is no facility to provide downstream flow until water reaches the level of the E-flow outlet, which is expected to take 19 hours. This means that CEB will contravene their agreement with MASL to provide an E-flow of 1.5m^3/s at all times, so an alternative means of filling must be found that will allow the requisite downstream flow throughout this period.

13. **Water Quality:** This is one of the main concerns regarding impacts in the construction phase, because of the size of the areas involved, the fact that most will be cleared of vegetation leaving bare soil, and the proximity of the river, which contains rare species and is used by local people for washing and bathing. The main risks are that during rainfall, silt may wash into the river from site roads, exposed soil, stored or transported sand and soil, or the quarry and spoil disposal sites. This will be addressed through a coordinated programme of action at all sites, involving: collecting all site drainage in ponds and allowing sediment to settle before discharge to the river; reducing erosion by covering cut surfaces where possible; protecting loose material from rain when stored or transported; and managing spoil disposal to minimise erosion, via drainage and slope stability structures, and careful supervision and monitoring throughout.

14. There are also risks that spilled fuel, oil and other polluting materials used and stored on site may wash into the river, affecting ecology and river users. Such materials will therefore be stored in areas with concrete floors and bunds, with drainage treated by oil separators. Sewage pollution will be avoided by providing adequate toilets and washrooms at all sites and accommodation camps and treating effluent to national standards before discharge.

15. **Groundwater:** Concerns that groundwater may drain into the headrace tunnel, depleting aquifers and domestic wells on the left bank, were allayed by a survey in 2013, which found that the aquifers are small and confined and the tunnel is located deep within intact bedrock, so seepage is unlikely. Blasting will be carefully planned and controlled to minimise fissuring outside the tunnel vicinity, which could create drainage routes; and wells will be monitored regularly so that alternative water can be supplied by tanker if well levels were to fall.

16. **Geology and Topography:** Field studies in 2009 and 2013 found no evidence of prior large-scale landslides and concluded that there is no significant risk of landslides during reservoir filling or from the small-scale fluctuations in water level that will occur during MHPP operation. Slopes will be monitored during and after impoundment to detect any small landslips that may trigger larger landslides, so that remedial action can be implemented if necessary.

17. **Air Quality:** This is another area in which there could be significant impacts from construction; and many are the converse of the water quality risks, as sites/activities that release silt during rain may also liberate dust when dry. The river is again sensitive, as dust can increase turbidity loads; and there are also concerns for the health of workers and residents from breathing dust; and the productivity of crops and other vegetation, which is reduced by a coating of dust. These impacts will be addressed by the measures to control silt, plus others aimed specifically at dust, including: avoiding blanket clearance of site vegetation and re-vegetating as soon as feasible; spraying site roads, soil and spoil disposal areas in dry weather; providing workers with dust masks; and monitoring dust on site and in residential areas nearby.

18. There are also air quality risks from the large numbers of vehicles used on site and in transporting materials, which liberate exhaust gases, causing local air pollution and contributing to global loads of greenhouse gases, which the project is reducing by the use of hydropower. Emissions will be reduced by: prohibiting the use of older vehicles; ensuring regular servicing of vehicles and machinery; repairing or replacing any with excessive emissions; and ensuring the use of emissions-reducing fittings on all vehicle exhausts.

19. **Noise and Vibration:** This is also an area of key concern as noise and vibration are produced by most construction, and this project involves major physical changes in a large area over several years, plus activities like blasting and transportation, which increase the potential for these impacts. Risks relate to disturbance of residents and wildlife and reductions in their quality of life; damage to workers' hearing from repeated or excessive exposure; and structural damage to buildings. Impacts will be reduced by a range of measures including: expanding the controls on vehicles to minimise noise/vibration; surveying structural condition of buildings near sites and along transport routes and providing remediation or compensation for any damage; and implementation of an Occupational Health and Safety Plan (OHSP) by contractors as outlined in Volume 2 Appendix 1 upon receiving approval of CEB at later date to reduce exposure to noise and other workplace risks.

20. **Physical Cultural Resources:** An assessment in 2009 found that the project carries no risk to known archaeological sites, which are all >2 km away; and there is also little likelihood of uncovering new material as the area has low potential for such discoveries. The project will however adopt a precautionary approach by establishing a 'chance finds' procedure, which prescribes appropriate action in the event of any discovery. There are some sites of local cultural importance such as roadside shrines, and discussions will be held with the community to determine the locations of such features and agree mitigation, which may include speed limits, relocation if feasible, and compensation for inconvenience or any damage.

21. **Occupational Health and Safety:** All construction carries a degree of risk, and this is heightened in a large and complex project such as this. All contractors will therefore be required to produce and implement an OHSP covering all sites and off-site activities, to protect workers, staff, site visitors and any others who come into contact with the construction activity. OHSPs will include: a) an assessment of all risks associated with each element of the construction work for which the contractor is responsible; b) appropriate steps to prevent accidents, injury or

disease; and c) preventative and protective measures that are consistent with national law and international good practice. Implementation of the OHSP will be closely monitored throughout.

22. **Aquatic Ecology:** Activities that reduce water quality will also affect aquatic animals and plants, eg: increased turbidity may reduce photosynthesis and clog respiratory surfaces; oil and other materials can be toxic; and pressure waves from blasting can kill fish and other animals. These will be addressed by the measures to prevent pollution, and by other action such as using chemical fracturing or hydraulic breakers in the riverbed instead of blasting. Fish are also at risk from poaching by workers and this will be prevented by awareness-raising, sanctions including job-losses, and monitoring. Catch-and-haul will be conducted to protect the priority species *Labeo fisheri* and other large fish, by translocation to undisturbed areas upstream and downstream, and in Kelani River nearby, as recommended by IUCN. This will be preceded by a survey of riverbed pools at the project site to confirm species and numbers, and follow-up surveys in the new habitats to monitor survival. Channels will also be drilled in the riverbed downstream of the dam site to maintain connections during low flows when MHPP is operating.

23. **Terrestrial Ecology:** Construction sites and ancillary areas will be cleared of vegetation, and trees and shrubs will be uprooted and removed from the reservoir. This will affect 93 ha, removing >900 trees (none endangered), 3-4% of the right bank secondary forest and a thin strip of riparian forest. This will reduce the already limited natural habitat and disturb inhabiting animals. To compensate, CEB will re-vegetate a 100 m buffer around the reservoir (70 ha), with planting regimes aimed at sediment retention and providing suitable habitat for the five priority terrestrial species and others. A rescue programme will be conducted to capture and relocate animals prior to site clearing, or to allow them to move naturally. Poaching by workers will be prohibited, with awareness-raising and dismissal if any animals are captured or harmed.

F. Impacts and Mitigation: Operation

24. There are fewer environmental risks in the operational phase, mainly because hydropower does not use finite sources of energy or produce significant emissions. There are still some impacts to be mitigated, as follows.

25. **Hydrology:** When the MHPP is operating, the reservoir will provide a large, new and fairly stable water body upstream of the dam, but river flow will be reduced downstream. Around 50 m^3/s of water is diverted through the conveyance to generate power, and is returned 2.7 km downstream. In the dry season there will be very little overflow from the reservoir, so from the dam to the tailrace, river flow will comprise the E-flow of 1.5 m^3/s (41% of the average minimum natural flow), plus an input from a small local stream. In the monsoon, E-flow is augmented by overspill from the dam, so flow will be higher, but still less than normal.

26. Downstream of the tailrace, river flow will be similar to normal in the monsoon as in the intended 15-19 hour daily generation period, water will discharge from the Moragolla system, and from the tailrace of Kotmale HPP (which also operates as a peaking station). There will also be flood season inputs from Atabage Oya and other tributaries. In the dry season the tailraces will only release water in the 4-6 hour generation period, so for 18-20 hours each day river flow will comprise Moragolla E-flow plus dry season inputs from tributaries. There are only three tributaries in the first 8 km below the tailrace, so flow is likely to be reduced in this area. This may have negative impacts on ecology, water quality and river users, so CEB will examine the feasibility of operating the two stations out-of-phase in the dry season to extend the period in which E-flow is augmented by additional tailrace water.

27. **Water Quality:** High river flow and rapid turnover during the long daily generation period should maintain adequate water quality in the reservoir during the monsoon. In the dry season, increased retention and limited circulation could deoxygenate lower levels, especially if the present vegetation is left to decompose; so trees and shrubs will cleared from the inundation area (at the end of construction to reduce the risk of runoff or dust from the bare soil). Reduced river flow will provide less dilution of pollutants, including the Crysbro effluent, which exceeds national discharge standards. CEB will repair and extend this outfall to discharge downstream of the Moragolla tailrace and will discuss with Crysbro the feasibility of timing their intermittent releases to occur when Moragolla is also discharging, to maximise dilution and dispersion.

28. **River Users:** The only human uses of the river between the dam and tailrace are the Crysbro factory and Dunhinda Irrigation Canal and the E-flow was designed to provide enough water for these operations, so they should continue unaffected. There may be flow changes in the 8 km downstream of the tailrace, so sand miners and people washing/bathing here may experience rapid changes in flow and depth when the Moragolla and Kotmale HPPs resume daily operations, which may increase the risk of these activities. CEB will utilise mass media to raise awareness of the likely changes, and will install sirens between the dam and Kaudupitiya Ela 11.2 km downstream, to warn people when each tailrace is about to begin operations and when the combined discharge will exceed 110 m^3/s.

29. **Dam safety:** A dam safety study in 2013 predicted that dam failure from a 10,000 year flood would raise water levels by 20-22 m in a large area downstream, causing widespread damage, destruction and loss of life. It also concluded that this will not happen because 2,500 concrete gravity dams have been built since 1930 and none has failed. CEB will however produce a Disaster Preparedness Plan (DPP) and set up the necessary structures to ensure that such losses would be reduced as much as possible if such an event did happen. The DPP will address the resources, responsibilities, communications, procedures, etc needed to ensure an effective response; and training will be given to all key individuals and organisations.

30. **Aquatic Ecology:** There is no evidence of significant spawning migrations amongst fish in the project area, but the dam will isolate upstream and downstream populations, which may reduce genetic diversity and population survival. Mitigation will focus on the high and moderate priority (nationally threatened) species, and will include: offset habitat protection upstream at Nawalapitiya (by replanting riparian vegetation, improving land management, etc) to enhance natural aquatic populations; and prohibiting introduction of exotic species to the Moragolla reservoir to avoid competition with native species.

31. **Terrestrial Ecology:** Terrestrial habitat will be enhanced as temporarily-occupied project sites revegetate and the reservoir buffer matures. Further mitigation will focus on maintaining vegetative cover and stable soil conditions in the upper watershed to maintain faunal habitat and reduce sediment inputs to Moragolla reservoir. A Watershed Management Plan will be developed as explained in Volume 4, Aforestation and Watershed Management, to improve management of private land (home gardens) and state land around Nawalapitya. This will include (as relevant): engineered structures (bunds, check dams); planting (ground-cover crops, grass strips); reforestation; home garden improvement; wetland creation; awareness raising; etc; supported by technical assistance and grants.

G. Environmental Management Plan

32. The Environmental Management Plan (EMP) in Volume 2 provides the framework for implementing the environmental mitigation, enhancement and compensation. It is in four parts, comprising EMPs for construction and operation phases, and EMPs for the two special issues (aquatic and terrestrial ecology) where mitigation is more complex and requires action in all phases. Each part deals with each environmental feature in turn, summarises the potential impacts and mitigation to be applied, and assigns responsibility for each action. It provides additional information to assist in implementation, including performance indicators, monitoring requirements, programme, budget and Terms of Reference for any consultancy input. Mitigation in the construction phase is mainly the responsibility of the contractors and action in the operational phase is mainly allocated to CEB; but some action is required of both parties, and the design consultant, in all phases. Construction contracts will require contractors to provide all mitigation and conduct all monitoring assigned to them in the EMP and EMoP.

H. Environmental Monitoring Plan

33. The Environmental Monitoring Plan (EMoP) in Volume 2 provides the mechanism to ensure that: a) all of the actions to provide the mitigation are taken as set out in the EMP; b) the actions mitigate impacts and protect the environment as intended; and c) residual impacts of the project are recorded, so that additional mitigation can be provided if any unexpected impacts occur. The EMoP is in the same four parts as the EMP and includes: physical and chemical monitoring of emissions; biological surveys of fish, planted vegetation and other features; and surveys of river users. In each case the approach to the monitoring is described, including the method, parameters, location, frequency, and responsibility; plus guidance on threshold levels that would trigger corrective action. Emissions monitoring is mainly the responsibility of the contractor, to raise awareness of the impacts of construction activities and the mitigation needed. The remainder of the monitoring is assigned to CEB as the Project Proponent, although this may be outsourced to specialist consultants and contractors if necessary.

I. Stakeholder Consultation and Disclosure

34. CEB has conducted an extensive programme of stakeholder consultation and disclosure throughout the Local EIA and Environmental Addendum studies. This has utilised a variety of methods including: consultation meetings and awareness programmes; meetings with key stakeholder representatives; group discussions with affected communities; correspondence with government agencies; public disclosure of Local EIA documents; and three multi-stakeholder meetings during the Addendum Studies. Draft final documents (Vols 1-3) will be disclosed on CEB and ADB websites and hard copies will be made available for comment in the project area. No comments were received during Local EIA disclosure, and comments at stakeholder meetings focused mainly on Resettlement issues. The few environmental concerns related to the Crysbro discharge, impacts on sand miners and river bathers, and the Dunhinda Irrigation Canal. These and others were taken into account in project planning and the environmental studies. CEB will continue these processes throughout project construction and beyond.

J. Grievance Redress Mechanism

35. CEB will establish a Grievance Redress Mechanism (GRM) to ensure that any concerns, complaints and grievances about the project's environmental performance are received and resolved. This will have two levels: a) initial complaints received by the contractor or client on site will be resolved *in situ* where possible by discussion with the complainant and subsequent agreed action; b) any issues that cannot be resolved locally will be referred to a Grievance

Redress Committee (GRC), comprising senior representatives of local government and the project agencies (client, contractor, supervision consultant), the local community and Affected Persons. A complaints register will be maintained in the client's site office and by the GRC. CEB will inform complainants in writing of decisions made, action to be taken and the programme. Decisions by the GRC will be deemed final, although complainants may take further action through a court of law if they wish.

K. Cost of Environmental Management and Monitoring

36. Environmental mitigation and monitoring that involves good construction practice will be covered by the contractors' work budgets and will not require additional provision as mention in clause B.7. The cost of the remaining environmental measures is estimated at SLR 61,253,732 or US$ 470,000, of which 72% is for the special measures to protect and enhance aquatic and terrestrial ecology.

I. INTRODUCTION

37. With its relatively high rainfall and prevalent ridge and valley topography in the central highlands, Sri Lanka has a good potential for hydropower, which has traditionally supplied a major proportion of the country's energy needs (99.8% of installed capacity in 1990 and 94% in 1995)[1]. However, by the beginning of the 21st century, much of the hydropower potential had already been exploited, and this, along with the severe drought and resulting power crisis of 1996, prompted a rapid growth in fossil fuelled stations, which by 2004 provided over 60% of the installed capacity (5080 GWh). With a predicted annual growth in demand of 6-8%, this trend is expected to continue; and the Generation Expansion Plan of 2007 envisaged a 5430 MW increase in capacity in 2008-22, of which 4480 MW (83%) would be provided by fossil fuels (mainly coal)[1]. This is both expensive (as Sri Lanka has no hydrocarbon reserves) and environmentally damaging (non-renewable; producing greenhouse gases and other pollutants).

38. Because of this, the Sri Lankan Government (GoSL), through its primary electricity generation, transmission and distribution agency the Ceylon Electricity Board (CEB), has begun to re-examine the potential use of indigenous and renewable energy resources. This incorporates previously discounted non-optimal schemes, such as small to medium-sized hydropower plants. The Moragolla HPP is one of the most attractive of these, because of its favourable location (in a steep-sided valley, with stable geology and historically reliable rainfall); economic and financial acceptability; and the anticipated relatively limited environmental impacts, and strong commitment from CEB to avoidance and mitigation.

39. The concept of a hydropower station at Moragolla was first proposed in a survey of the resources of the Mahaweli Ganga in 1962[2]; and the location was highlighted as one of 27 potential hydropower sites in an Electricity Supply Master Planning Study in 1987[3]. Four of these, including Moragolla, were incorporated by CEB into their Long-Term Generation Expansion Plan 2009-2022; and the project was earmarked for implementation in the Government's Mahinda Chinthana 10-year Development Plan.

40. Technical studies for the Moragolla project began with a review of costs in 2006[4], followed by Feasibility Studies funded by the Kuwait Fund for Arab Economic Development in 2009[5]. Nippon Koei Co Ltd was then appointed by CEB in 2012 to conduct a review of the Feasibility Study and prepare detailed designs and bidding documents for the construction process, which is programmed to start in early 2016[6].

[1] CEB (2008): *Long Term Generation Expansion Plan 2009-2022*. Ceylon Electricity Board, Colombo.

[2] Hunting Survey Corporation (1962): *A report on a survey of the resources of the Mahaweli Ganga Basin, Ceylon*. Prepared in co-operation with the Surveyor General of Ceylon. Government Press, Colombo.

[3] GTZ (1987): *Master Plan for the Electricity Supply of Sri Lanka* - Volume A-1. Deutsche Gesellschaft für Technische Zusammenarbeit, Germany.

[4] JICA (2006): *Master Plan Study on the Development of Power Generation and Transmission System in Sri Lanka.* Japan International Cooperation Agency, Tokyo.

[5] CECB/ Al-Habshi (2009): *Moragolla Hydropower Project: Feasibility Study, Final Report (Vols 1-6)*. Central Engineering Consultancy Bureau (Colombo) and Al Habshi Consultants Office (Kuwait).

[6] Nippon Koei (2013): *Moragolla Hydro Power Project, Review of Feasibility Study and Preparation of Detailed Designs and Bidding Documents*; *Final Report*. Nippon Koei Co Ltd, Tokyo.

41. The Feasibility Study included a Local Environmental Impact Assessment (EIA)[7], which was approved by the Mahaweli Authority of Sri Lanka (MASL) in August 2013. The Sri Lankan Government subsequently requested assistance from the Asian Development Bank (ADB) in funding construction, and the contract for the FS Review included a component to review the Local EIA and upgrade it as necessary to fulfil the requirements of the ADB *Safeguard Policy Statement* (SPS, 2009). The present report (Volumes 1, 2, 4) presents the results of the upgrading process, and Volume 5 is the original Local EIA.

[7] CECB/Al-Habshi (2012): *Moragolla Hydropower Project, Feasibility Study, Final Report: Vol 3 Environmental Impact Assessment.* Central Engineering Consultancy Bureau (Colombo) and Al-Habshi Consultants Office (Kuwait).

II. APPROACH AND RATIONALE

42. The environmental studies within the FS Review began in November 2012 with a detailed review of the Local EIA report (in draft at that time) and a comparison with the requirements of the ADB SPS, as specified in SPS Appendices 1 (Environment) and 2 (Involuntary Resettlement). The results were presented in a Gap Analysis, which is shown in Appendix 1 below. The conclusions were that, although not set out strictly according to the SPS, the Moragolla Local EIA largely conforms to ADB requirements and adequately assesses most of the potential impacts of the project and proposes appropriate mitigation.

43. The main deficiencies in the Local EIA report are: a) the absence of an Environmental Management Plan (EMP) and Grievance Redress Mechanism (GRM), which are not required under Sri Lankan EIA legislation; b) no specific account of the stakeholder consultation and disclosure process, for which information is dispersed in the document or lacking; c) no explanation of the rationale for the proposed environmental flow[8] of 1.5 m^3/s ; d) lack of detail on the institutional arrangements for implementing the environmental mitigation; and e) no examination of the impact of the project on groundwater around the headrace tunnel, or aquatic ecology downstream of the tailrace outfall. The Gap Analysis in Appendix 1, also identified a need to collect additional baseline data in certain locations and topics, where coverage or analysis was insufficient in the Local EIA, or where conditions may have changed in the intervening period.

44. These issues were addressed by a series of additional studies and surveys mainly conducted in March - June 2013. These were as follows:

a) Water quality surveys in the immediate project area (reservoir to tailrace outfall) to examine project impacts and the influence of a polluting discharge from a poultry plant;
b) Aquatic ecology surveys in the same area, and downstream of the tailrace outfall where there may also be low river flows in the dry season when the project is operating;
c) Groundwater surveys in the area that could be affected by headrace tunnel construction;
d) Land-use mapping in the immediate project area to update information in the Local EIA;
e) Study of the rationale for the proposed environmental flow and its suitability in this case;
f) An account of the previous and ongoing stakeholder consultation/disclosure process;
g) A study of the institutional arrangements for implementing the project and its EMP, the capacity of the key agencies, and any strengthening needed;
h) Socio-economic surveys (inventories of houses, land ownership, river users, income and employment, infrastructure, etc) to provide data for the Resettlement Plan (RP).

45. The results of these surveys revealed a small number of other issues for which some further study was needed in order to adequately address potential project impacts or to plan and implement appropriate mitigation. Issues included: a) the presence of certain endangered fish and terrestrial animals in the project area; b) lack of data on river water quality in the monsoon and on users of the river downstream of the tailrace; and c) lack of information on the environment of sites proposed for project activities (quarrying, spoil disposal), which are different from locations proposed earlier and investigated by the Local EIA study. These were addressed by seven additional surveys and studies, conducted in September - November 2013. These were:

[8] Water that is discharged downstream of a dam at all times, with the intention of providing sufficient water to maintain a healthy ecosystem and satisfy the needs of human users

i) Survey of water quality in the immediate project area in the monsoon season;
j) Survey of the environmental features of newly-proposed sites for quarrying, spoil disposal and other project activities;
k) Survey of river uses and users downstream of the proposed tailrace outfall;
l) Expert report on the ecology of rare or endangered fish present at the project site, and measures to avoid or mitigate project impacts;
m) Expert report on the ecology of rare or endangered terrestrial animals found at the project site, and measures to avoid or mitigate project impacts;
n) Preparation of an afforestation plan to compensate for trees removed during construction; and a watershed management plan to reduce degradation of land and water in the reservoir catchment by the activities of man
o) Study of slope stability in the reservoir area and the possibility of dam failure.

46. . The results of the remaining 14 additional studies, surveys and expert reports are provided in the final reports from each activity, presented in Volume 4. Most studies included the collection and analysis of new baseline data, an assessment or re-assessment of the potential impacts of the project, and recommendations on the avoidance or mitigation of negative impacts and enhancement of the features where appropriate. All reports were examined in detail, and data, findings and recommendations are incorporated into the text of Volumes 1-2 as appropriate.

47. The objectives of this report are to: a) present the final assessment of the potential environmental impacts of the Moragolla HPP and the actions proposed to avoid, reduce or compensate for all potentially negative impacts; and b) present the environmental assessment in a complete, yet readily accessible form. The information on which the assessment is based comes from the original Local EIA study and the additional studies, and as noted above the final reports are provided in this document (Volumes 4 and 5). The assessment of impacts is presented in Volumes 1-2 (Natural Environment) and this is all a reader needs to refer to in order to understand the complete revised Local EIA. Information from the original Local EIA and the additional studies is incorporated into Volumes 1, 2 and to maintain clarity and brevity, these data are presented as much as possible in summary form. To enable the reader to refer to original data if necessary, the source of the information is identified in each case and can be found in Volumes 4 and 5.

III. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

L. Environmental Protection and Management

48. There are a number of legislative and regulatory instruments in Sri Lanka that address environmental management in both general and specific terms. Among these are the 1978 Constitution of Democratic Socialist Republic of Sri Lanka and a number of acts and regulations. The acts and regulations are of particular relevance to the proposed Moragolla HPP are as follows;

- National Environment Act (NEA) No 47 of 1980 as amended by act No 56 of 1988 and act No 53 of 2000
- EIA regulations gazetted under NEA (Government Gazette Extraordinary No.772/72 dated 24 June 1993 and in several subsequent amendments)
- Environmental Protection License (EPL) regulations gazetted under NEA (Government Gazette Extraordinary No. 1533/16 dated 25 January 2008)
- Environmental Standards stipulated under NEA:
- Wastewater Discharge Standards- Gazette Notification No. 1534/18 dated 01/02/2008;
- National Environmental (Noise Control) Regulations 1996 - Gazette Notification no. 924/12 dated 23.05.1996
- Interim standards on Air Blast Over Pressure and Ground Vibration
- The Land Acquisition Act No 9, 1950 and subsequent amendments
- Sri Lanka Electricity Act, No. 20 of 2009
- Mines and Minerals Act No. 33 of 1992
- Mahaweli Authority of Sri Lanka Act No. 23 of 1979
- Soil Conservation Act No. 25 of 1951 and No. 29 of 1953 and amended by Act No. 24 of 1996
- Irrigation Ordinance No. 32 of 1946, Act No.1 of 1951 and No. 48 of 1968, Law No. 37 of 1973
- Fauna and Flora Protection Ordinance as amended by Act No. 49 of 1993 and subsequent amends.
- The Antiquities Ordinance, No.9 of 1940 (now Act) and the subsequent amendments, particularly the Antiquities (Amendment) Act No. 24 of 1998 is the primary Act.
- National Involuntary Resettlement Policy (NIRP)
- The Urban Development Authority Act No. 41 of 1978
- Local Authorities acts: The Municipal Council (MC) Act No. 19 of 1987 & Urban Council (UC) Act No. 18 of 1987
- The Irrigation Ordinance (Chapter 453)

49. The constitution of the Democratic Socialist Republic of Sri Lanka under chapter VI: Directive Principles of State policy and Fundamental duties in section 27-14 and in section 28-f proclaims “The state shall protect, preserve and improve the environment for the benefit of the community”. “The duty and obligation of every person in Sri Lanka to protect nature and conserve its riches”. These two statements show the commitment of the state and obligations of the citizens.

50. The National Environmental Act No. 47 of 1980 (NEA) is the basic national charter for protection and management of the environment. The NEA has been amended twice to make

improvements and to respond to the needs of the time; National Environmental (Amended) Act No 56 of 1988; and National Environmental (Amended) Act No 53 of 2000.

51. There are two main regulatory provisions in the NEA through which impacts on the environment from the process of development are assessed, mitigated and managed. These are:

a) The Environmental Impact Assessment (EIA) procedure for major development projects. Regulations pertaining to this process are published in Government Gazette Extraordinary No.772/72 dated 24 June 1993 and in several subsequent amendments.
b) The Environmental Protection License (EPL) procedure for the control of pollution. Regulations pertaining to this process are published in Government Gazette Extraordinary No. 1533/16 dated 25 January 2008.

M. Environmental Impact Assessment

52. The provision relating to EIA is contained in Part IV C of the National Environmental Act. The procedure stipulated in the Act for the approval of projects provides for the submission of two types of reports; Initial Environmental Examination (IEE) report and Environmental Impact Assessment (EIA) report. Such reports are required in respect of "prescribed projects" included in a Schedule in an Order published by the Minister of Environment in terms of section 23 Z of the act in the Gazette Extra Ordinary No. 772/22 dated 24th June 1993. Prescribed projects in the Power Generation Sector include "construction of hydroelectric power stations exceeding 50 MW" and "installation of overhead transmission lines of length exceeding 10 km and voltage above 50 kV", neither of which apply to the Moragolla scheme. However, any project or undertaking irrespective of its magnitude, if located partly or wholly within an Environmental Sensitive Area, will become a prescribed project requiring approval under the EIA regulations; hence the requirement for EIA in the case of this project.

53. Any developmental activity of any description whatsoever proposed to be established within one mile of the boundary of any National Reserve (see table below), should receive the prior written approval of the Director of Wildlife Conservation. The Fauna and Flora (Protection) Ordinance mandates that the project proponent should furnish an IEE of EIA report in terms of the National Environmental Act for this purpose.

54. The EIA process is implemented through designated Project Approving Agencies (PAAs). The PAAs are line ministries and agencies that are directly connected with a prescribed project. They are responsible for administration of the EIA process under the NEA. Determination of the appropriate PAA will be based on the following unranked criteria:

- The PAA having jurisdiction over the largest area, or
- Having jurisdiction over diverse or unique ecosystems, or
- Within whose jurisdiction the environmental impacts (resource depletion) are likely to be the greatest,
- The PAA having statutory authority to licence or otherwise approve the prescribed project

55. A given organization cannot act both as the PAA as well as the project proponent. In such cases the CEA will designate an appropriate PAA. Similarly when there are more than one PAA the CEA determine the appropriate PAA.

56. As the Moragolla Hydropower Project is located in an area under the jurisdiction of Mahaweli Authority of Sri Lanka the MASL was designated by CEA as the appropriate PAA for this project.

57. In order for a project to be approved the project proponent should submit either an Initial Environmental Examination (IEE) report or an Environmental Impact Assessment (EIA) report as determined by the PAA. Once an EIA report has been submitted, there is mandatory period of 30 days during which the public can inspect the document and comment on the report.

58. Further, a public hearing may be held to provide an opportunity to any member of the public to voice their concerns. A decision whether to approve the project will be made by the PAA only after public consultation is done and major issues are resolved.

N. Environmental Protection License

59. The Environmental Protection License (EPL) is a regulatory / legal tool under the provisions of the National Environmental Act. The EPL procedure has been introduced to prevent or minimize the release of discharges and emissions into the environment from industrial activities in compliance with national discharge and emission standards , to provide guidance on pollution control for polluting processes and to encourage the use of pollution abatement technology such as cleaner production, waste minimization etc. Here the industries are classified into three lists named A, B and C (in Government Gazette Extraordinary No 1533/16 dated January 25, 2008). List A comprise of 80 potentially high polluting industries, List B comprise of 33 medium polluting industries and List C comprise of 25 low polluting industrial activities. EPL's for List A and List B industries are issued by the relevant Provincial/ District offices of the CEA while EPLs for List C industries are issued by the relevant local authority. The EPL issued for List A industries are valid for a period of one year while List B and List C industries are valid for a period of three years, from the effective day of the issue of license. For List A and List B industries the project proponent must submit a duly filled application (can be obtained from CEA headquarters, provincial and district offices or downloaded from www.cea.lk) for each prescribed activity to provincial or district office of CEA who will evaluate the application and determine the relevancy of issuing an EPL and the adequacy of the details furnished and determine and appropriate inspection fee. Then the project proponent must pay the prescribed fee to CEA headquarters, provincial or district office of CEA and submit the receipt to the relevant provincial or district office of the CEA. Then a team of officers will carry out an inspection and submit a report based on the site visit and the information provided. If the Issue of EPL is recommended the project proponent can obtain the EPL upon payment of license fee.

60. For List C industries issue of EPL is delegated to local authorities (Municipal councils, Urban councils or Pradeshiya Sabha). The procedure to be followed is the same except the Local Authority will appoint a Technical Evaluation Committee (TEC) that will make the final decision regarding the issue of EPL based on the field assessment report and information furnished by the industrialist. For the renewal of an EPL the project proponent shall submitting a renewal application three months prior to the date of expiry to the relevant authority.

61. There are several activities associated with construction of the Moragolla Hydropower Project that come under the provisions of this regulation and the Contractor is responsible for obtaining the Environmental Protection License (EPL) in each case. The prescribed activities are: bulk petroleum liquid or liquefied petroleum gas storage or filling facilities; asphalt processing plants; concrete batching plants; mechanized mining activities; granite crushing

(metal crushing) plants; incinerators; wastewater treatment plants; solid waste dumping yards; and toxic or hazardous waste treatment or disposal facilities.

62. A comprehensive description of EIA/ IEE process and EPL procedure are given in Volume IV Report 7.

63. The national organization that has the mandate to implement the provisions under NEA and to protect and take measures to safeguard the environment is the Central Environmental Authority. It currently operates nine Provincial Offices and nine District Offices thought the country.

64. The following key national agencies with a mandate for environmental management and protections are also relevant to the activities of MHPP; The Forest Department, the Department of Wildlife Conservation, Department of Archeology, Disaster Management Center and Geological Survey and Mines Bureau. They have their regional offices and staff to cater to and monitor the environmental safeguards as per the policies and regulatory provisions governing them. In addition there are several national agencies that are impacting on the environment and adopting environmental safeguards as well. They are Urban Development Authority (UDA), Water Supply and Drainage Board (NWS&DB), Road Development Authority (RDA), Department of Agriculture, Department of Agrarian Services and Irrigation Department (ID).

65. The Local Authorities (LA) are also having provisions under their respective acts to safeguards and provide useful facility and maintain the same for the convenience of the public in their respective areas. The Municipal Council (MC) Act No. 19 of 1987 and Urban Council (UC) Act No. 18 of 1987 provide for the establishment of MCs and UCs with a view to provide greater opportunities for the people to participate effectively in the decision making process relating to administrative and development activities at a local level and it specify the powers, functions and duties of such LAs and provide for matters connected therewith or incidental thereto. These acts cover public health, drainage, latrines, unhealthy buildings, conservancy and scavenging, nuisance etc. As explained in the previous section the LAs are empowered to issue Environmental Protection License (EPL) under NEA for industries carrying out activities of low polluting nature.

O. Multinational Agreements

66. Sri Lanka has acceded or ratified around 40 Multilateral Environmental Agreements (MEA). The MEAs that are relevant to this project are shown in Table 1.

Table 1: Project-relevant international agreements to which Sri Lanka is a party

Agreement	Ratification Date	Objectives
Atmosphere		
Vienna Convention for the Protection of the Ozone Layer (1985)	15 December 1989	Protection of the Ozone Layer through international cooperation in the areas of scientific research, monitoring and of information exchange
Montreal Protocol on Substances That Deplete the Ozone Layer (1987)	12 December 1989	Reduction and the eventual elimination of the consumption and production of Un-anthropogenic Ozone Depleting Substances
United Nations Framework Convention on Climate Change (UNFCCC-1992)	23 November 1993	Stabilization of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climatic systems

Kyoto Protocol (1997)	3 October 2002	The Annex 1 parties (Developed Countries) to reduce their collective emissions of greenhouse gases by at least 5% of the 1990 level by the period 2008 –2012.
Biodiversity		
International Plant Protection Convention (1951)	12 February 1952	To maintain and increase international co-operation in controlling pests and diseases of plants and plant products, and in preventing their introduction and spread across national boundaries
Plant Protection Agreement for Asia and Pacific Region (1956)	27 February 1956	To prevent the introduction into and spread within the region of destructive plants
CITES - Convention on International Trade in Endangered Species of Wild Fauna & Flora (1973)	4 May 1979	To protect certain endangered species from being over-exploited by adopting a system of import/export permits, for regarding the procedure.
Convention on the conservation of Migratory Species (CMS-1979)	6 June 1990	To protect those species of wild animals which migrate across or outside national boundaries
Convention on Biological Diversity (CBD-1992)	23 March 1994	Conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including appropriate access to genetic resources and by appropriate transfer of relevant technologies and appropriate funding
Cartagena Protocol on Bio Safety (2000)	28 April 2004	To contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specially focusing on transboundary movements.
Land		
United Nations Convention to Combat Desertification (UNCCD- 1994)		To combat desertification and to mitigate the effects of drought in countries experiencing serious droughts and/ or desertification with the final aim being to prevent land degradation in the hyper arid, arid, and semi arid, dry sub humid areas in the countries that are parties of the Convention
Chemicals		
Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and Their Disposal (1989)	28 August 1992	To reduce transboundary movements of hazardous waste; to dispose of hazardous and other waste as close as possible to the source; to minimize the generation of hazardous waste; to prohibit shipments of hazardous waste to countries lacking the legal, administrative and technical capacity to manage & dispose of them in an environmentally sound manner; to assist developing countries in environmentally sound management of the hazardous waste they generate
Rotterdam Convention (1998)	19 January 2006	To promote shared responsibility and cooperative efforts in the international trade of certain hazardous chemicals, to protect human health and the environment; to contribute to the environmentally sound use of those hazardous chemicals by facilitating information exchange, providing for a national decision-making process on their import/export
Stockholm Convention on Persistent Organic Pollutants (POPs -2001)	22 December 2005	To protect human health and the environment from persistent organic pollutants (POPs).

IV. DESCRIPTION OF THE PROJECT

67. The Local EIA report attached as Volume 5, provides a great deal of information on the project, including the site context (location, land ownership, access routes, etc), a list of the main technical features of each component (dam and intake, spillway, reservoir, tunnel, etc), and descriptions of the reservoir inundation area and the sites of activities and facilities associated with construction (alternative quarry sites, spoil disposal areas, access roads, labour camp, contractors' and engineer's site offices, residential camp, etc). Site preparation activities, construction methods and the likely workforce are also described. This information can be found in Section 2.2 of of this report, so it is not duplicated below. Instead the following chapter provides an updated description of the project and its various components, incorporating the changes that occurred in the design stage; and an explanation of the main construction activities. This provides sufficient information to enable the subsequent assessment of impacts to be understood without reference to the material in the Local EIA.

A. Project Location and Overall Design

68. The proposed site of the Moragolla Hydropower Project is located on the upper reaches of the Mahaweli Ganga in the Central Highlands of Sri Lanka, approximately 22 km south of Kandy City and about 130 km north-east of Colombo (see Fig 1). The dam site is at 7°06' north latitude and 80°34' east longitude, in a hill area with an altitude of 470 to 650 m above sea level (masl). The catchment area above the dam site is 809 km^2 (including the Kothmale Oya basin). The upper and lower reaches of the Mahaweli river system support other hydropower and irrigation projects, and those near the Moragolla site are shown in Fig 1. The closest is the Kothmale Dam, located about 6 km upstream on the Kothmale Oya, which joins the Mahaweli Ganga about 3 km upstream of the proposed Moragolla dam. The tailrace of the Kothmale Hydropower Station (commissioned in 1985) is located just upstream of the confluence of the Atabage Oya and the Mahaweli Ganga, almost directly opposite the proposed site for the tailrace of the Moragolla project (see Figs 1 and 2).

69. The project will involve a daily peak generation power station with an installed capacity of 30.2 MW (2 x 15.1 MW), produced from a rated head of 69 m. The concrete gravity intake dam will be 37 m high, with five radial gates on a 77 m wide overflow spillway. The top elevation of the dam will be at 550 masl and the spillway crest will be at 534 masl. This will create a 38.5 ha, 1.98 Million Cubic Meters (MCM) reservoir, with a Full Supply Level (FSL) at 548 m. Water will be diverted through an intake into a 2.7 km underground headrace tunnel, surge shaft and penstock on the left bank of the river, to a power house and tailrace outfall located opposite the confluence with the Atabage Oya (Fig 2). The dam includes a small sluice and tunnel to purge sediment from around the intake if necessary, plus an intake to a micro-hydro plant, to generate an additional 360 kW from the constant environmental flow of 1.5 m^3/s.

B. Project Components

70. The main project components are: the dam, spillway and intake; headrace tunnel; surge tank; penstock; powerhouse; tailrace; switchyard; the permanent access roads; and the reservoir. The proposed locations of these are shown in Fig 2; and Figs 3 - 6 provide detailed drawings of the major structures. The main features of each component are described below, and Table 2 shows the changes that have occurred since the FS.

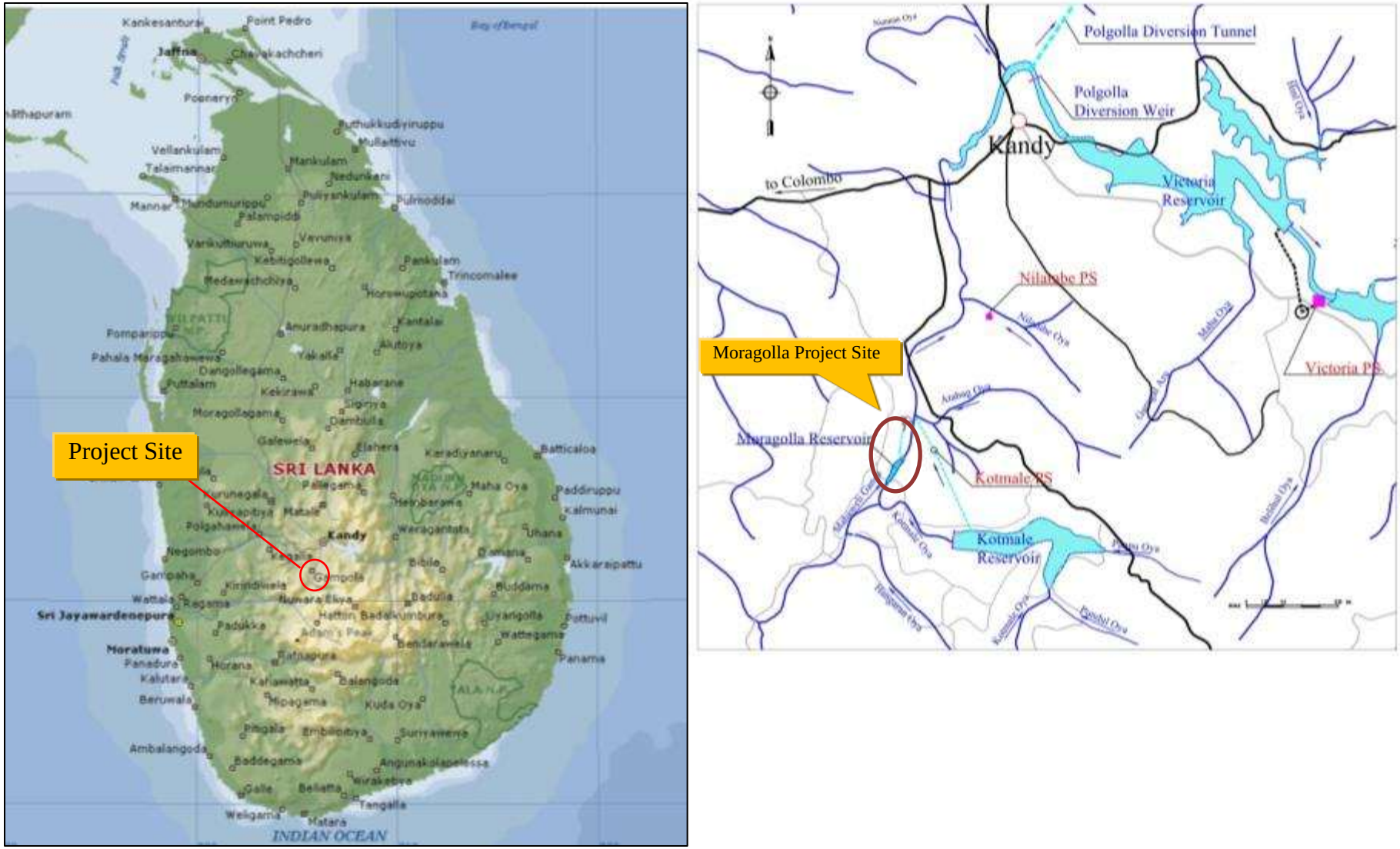

Figure 1: Location of the proposed Moragolla Hydropower Project, and other existing dams and HP stations in the vicinity

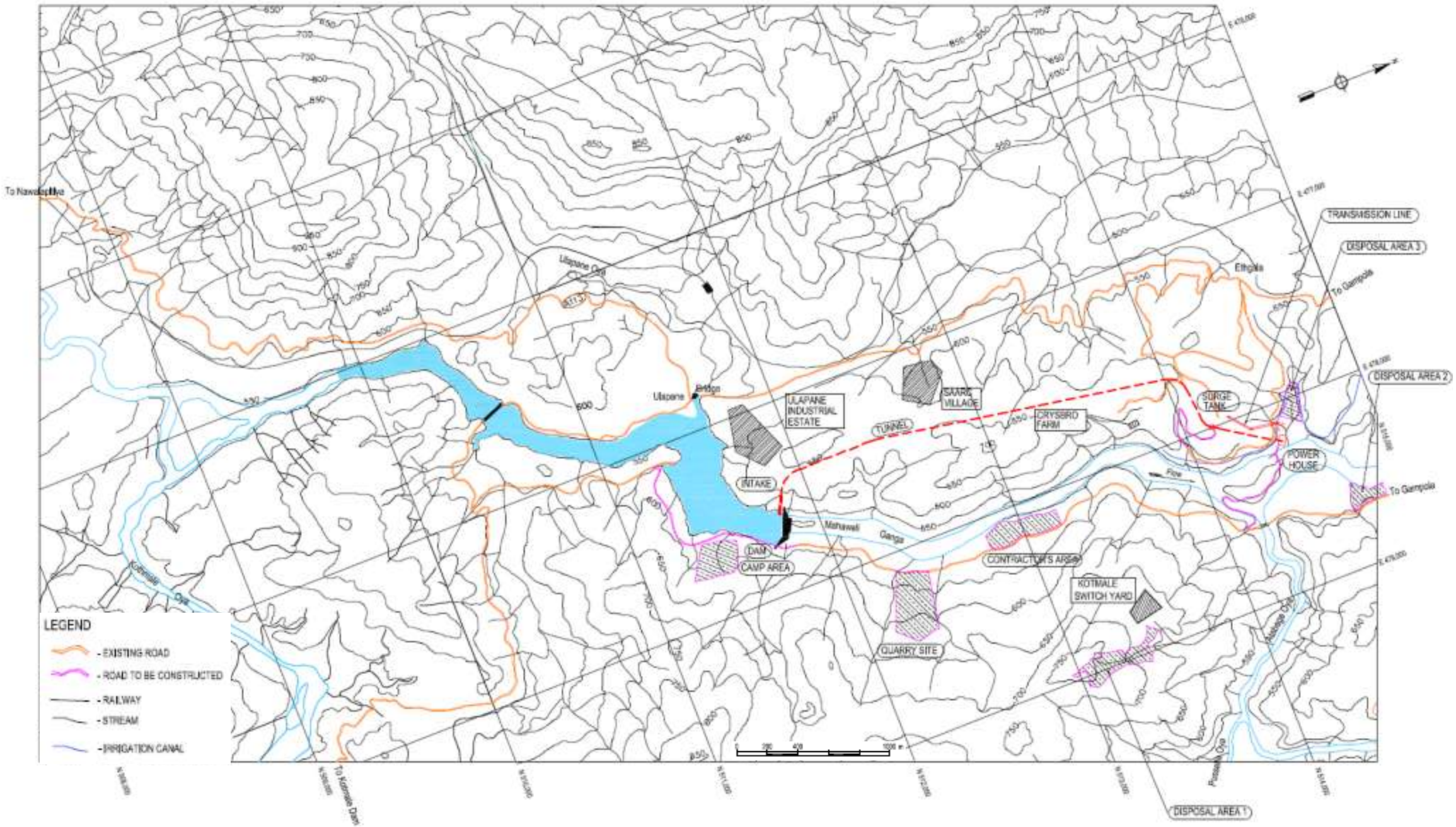

Figure 2: Location of the project components and other construction and disposal areas

71. **Concrete Gravity Dam:** The dam is of a concrete gravity type with a height of 37 m and a length of 236 m at the crest level of 550 masl (Figs 3 and 4). The dam will be constructed of mass concrete, and there will be an inspection gallery in the dam body, containing pressure relief wells, gauges and other instruments. The location of the dam is the main change in the project from the Feasibility Study, as the axis has been moved approximately 100 m downstream (where solid rock is exposed on the right bank of the river), to reduce the excavation and associated intrusion into the Ulapane Industrial Estate required to reach a suitable rock foundation at the former location.

72. **Intake and Micro-hydro Plant:** The intake will be located just upstream of the dam on the right bank (Fig 3). The entrance sill is at 535 masl, 1 m above the spillway crest. A small sediment flushway is provided to remove sediment periodically if it accumulates in front of the intake (predicted to take 50 years to reach this level, see below). If needed, sand will be washed downstream through a steel-lined conduit in the dam body. The micro-hydro plant will be located immediately downstream of the dam, on the right bank alongside the spillway (Fig 3) and will comprise a 15 x 10 m building housing a horizontal shaft turbine and generator, producing 360 kW from the constant environmental flow. The design incorporates a bypass pipe with a jet flow gate to release the guaranteed flow when the generating equipment is undergoing maintenance or repair.

73. **Spillway:** The concrete spillway will be equipped with 5 radial gates, 13 m wide and 15 m high on the overflow crest at 534 masl (Fig 4). The spillway design provides the capacity to pass a 10,000-year flood and a 1,000-year flood under the following conditions:

a) 10,000 year flood (6,700m^3/s) at FSL 548 masl, with all gates fully opened;
b) 10,000 year flood at 550 masl, with one gate non-operational and closed;
c) 1,000 year flood (4,100m^3/s) at FSL with one gate non-operational and closed.

(b) and (c) are CEB requirements, and (b) is required to avoid inundation of the banks of the Ulapane Oya (upstream of the dam on the left bank, Fig 2) above 550 masl and the reservoir periphery above 551 masl. One spillway will be equipped with a flap gate, to release surplus water and floating debris from the reservoir.

74. **Headrace Tunnel:** The headrace tunnel will be 2,727 m in length from the intake to the surge tank, and will be excavated beneath the hillside on the left bank (Figs 2 and 5). It will be created in a standard horseshoe cross section, with rock supports provided where necessary. Concrete lining with steel-bar reinforcing will be placed around the inside to form a 4.7 m diameter circular section. The left bank is covered with comparatively thick, weathered rock, extending to 40-60 m from the ground surface, so the tunnel route is laid where the ground elevation is above 600 m to ensure sufficient rock cover to maintain ground stability and avoid significant groundwater incursion from above.

75. **Surge Tank:** The surge tank (Fig 5) is designed as a restricted orifice type with an inner diameter of 12.5 m to absorb excess pressure as a result of power fluctuations and in the event of turbine trips.

76. **Penstock:** The penstock is the other component in which the design has been changed compared to the FS, as the surface penstock proposed at that time would have required major excavation to reach suitable foundation rock, plus extensive slope protection works, and there would also have been a risk of collapse. Instead, the penstock will now be entirely underground,

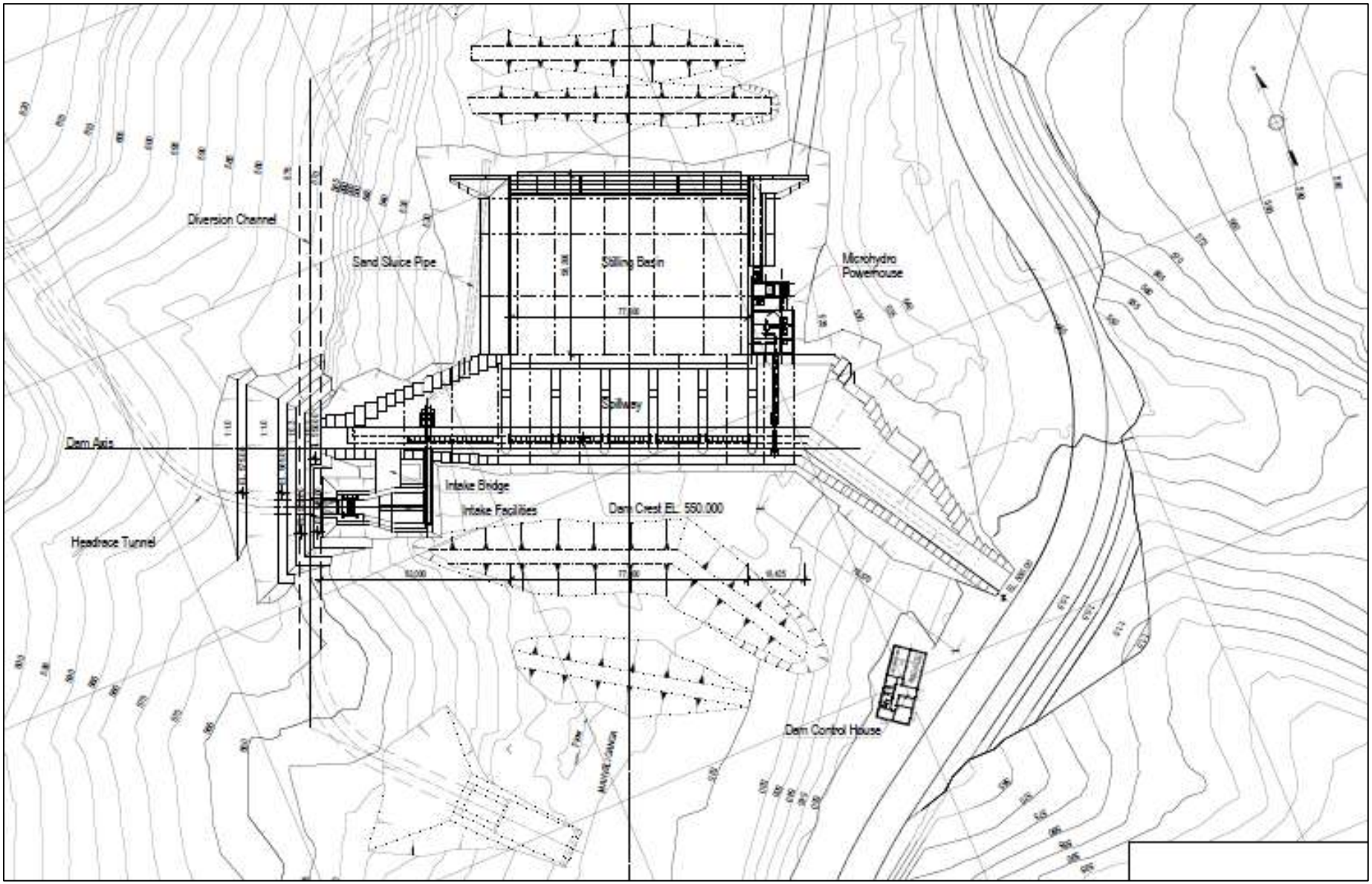

Figure 3: Plan view of the proposed dam, spillway, headrace tunnel intake and micro-hydro station

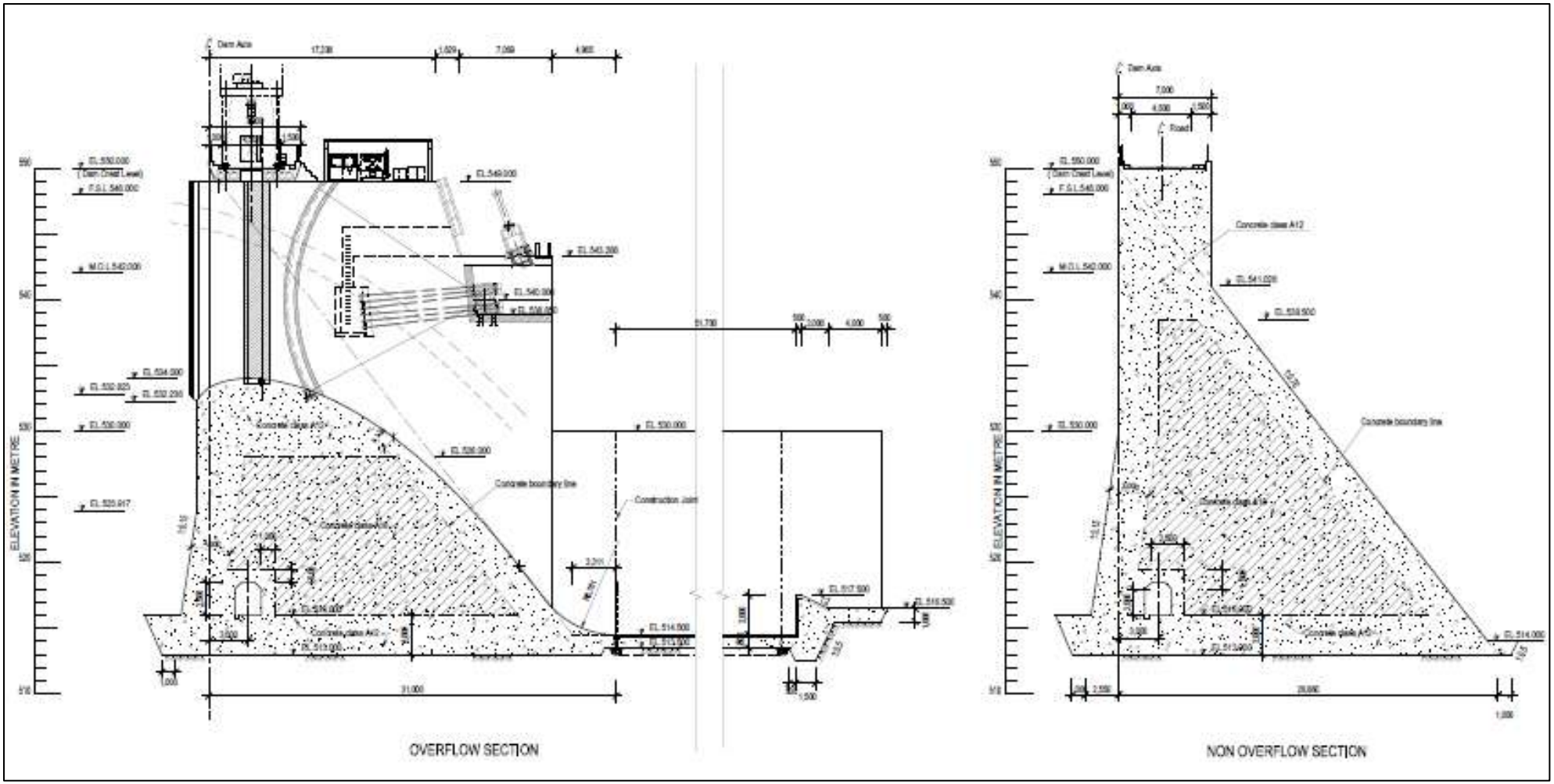

Figure 4: Cross sectional view through the dam

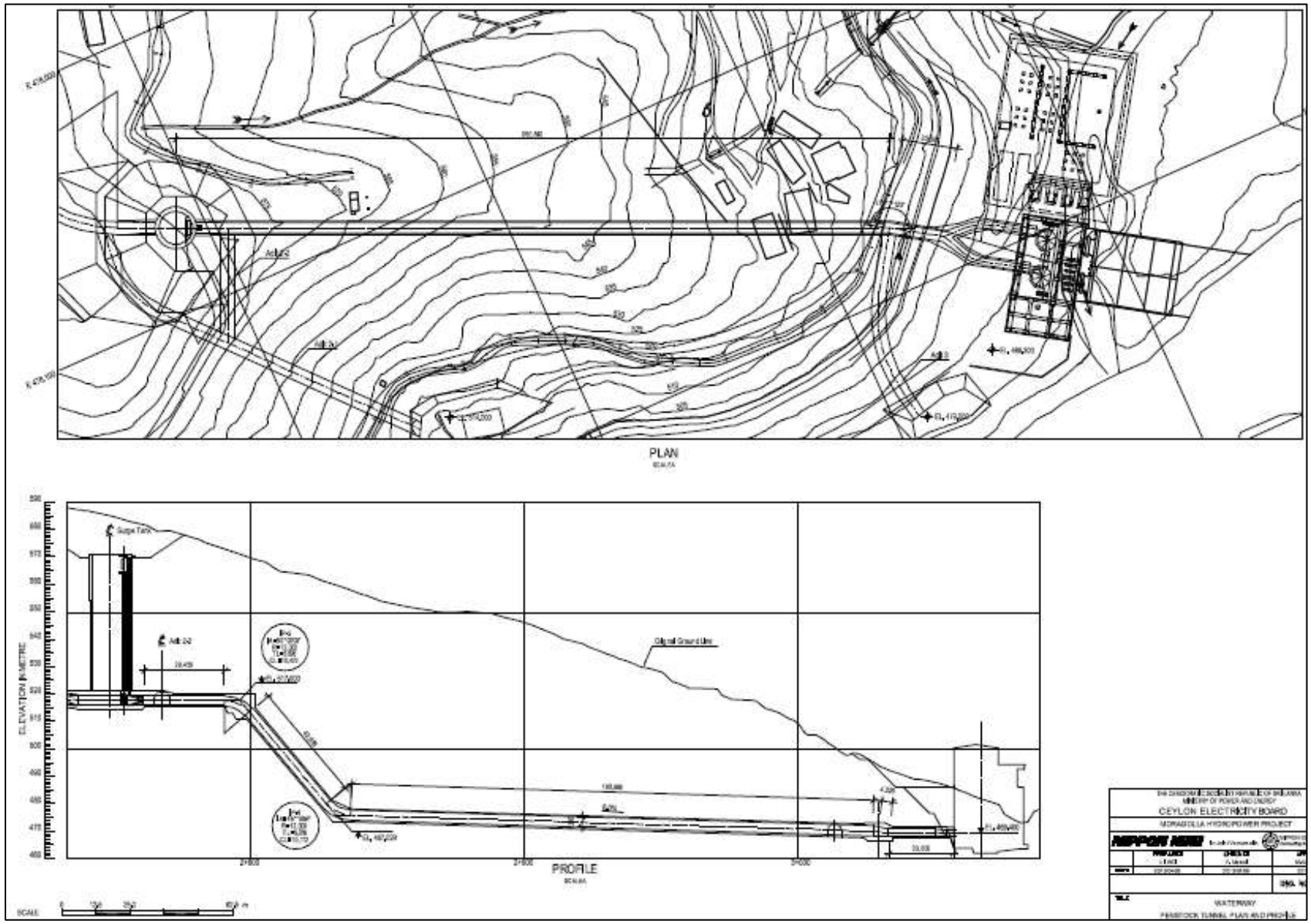

Figure 5: Plan and profile of the headrace tunnel (downstream), surge tank, penstock and tailrace outfall

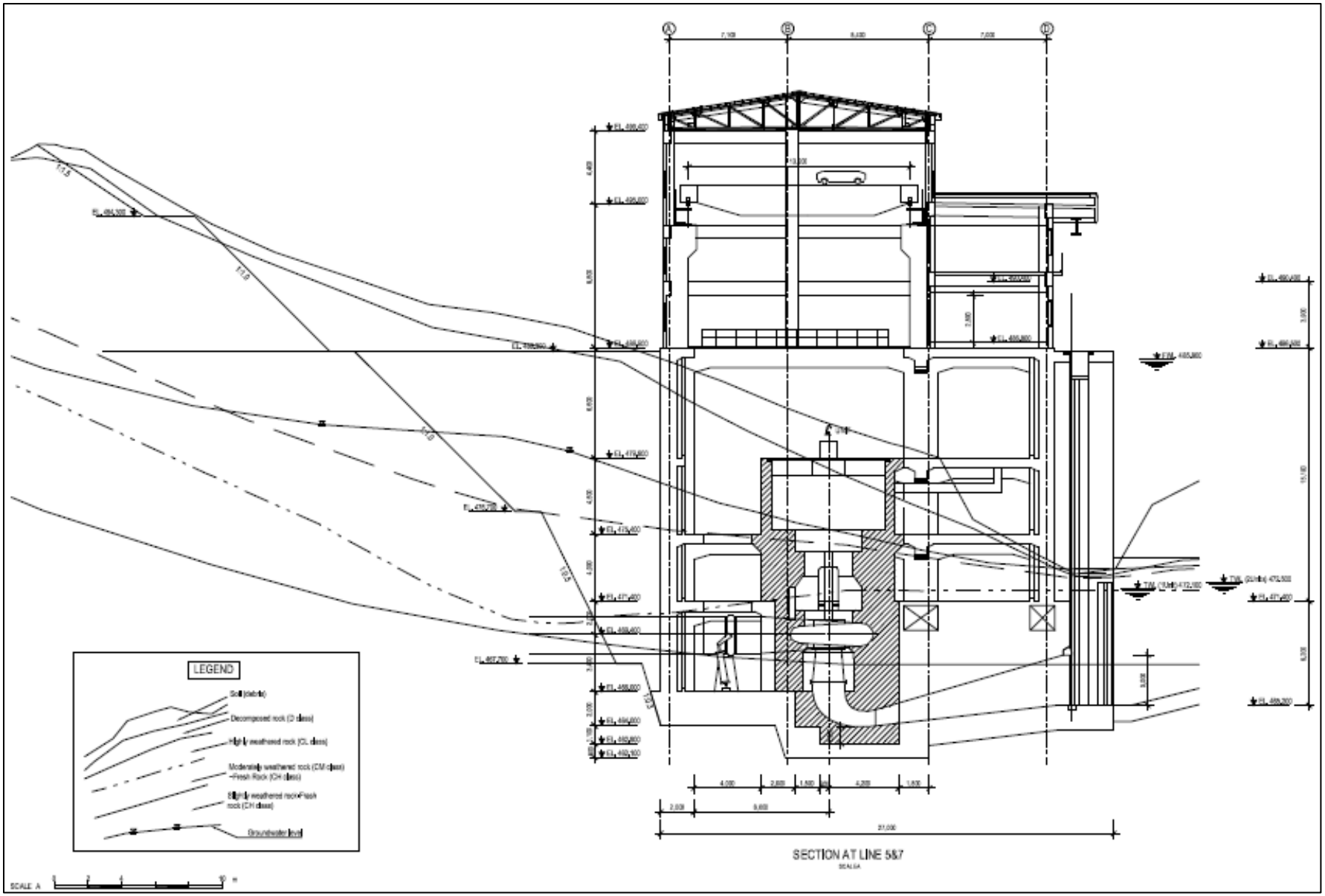

Figure 6: Section through the power house

Table 2: The main features of the project at Feasibility Study and Detailed Design Stage

Feature	Local EIA (2012)	Environmental Addendum (2013)	Remarks
River Hydrology			
Catchment area (Total)	809 km^2	809 km^2	No Change
Catchment (unregulated)	247 km^2	247 km^2	No Change
Mean annual basin rainfall	4,000 mm	3,852 mm	Decreased due to making flow duration curve using series method
Mean annual inflow	21.95 m^3/s; 690 MCM	22.4 m^3/s	Increased due to making flow duration curve using series method
Sediment yield	< 250 $m^3/km^2/y$	265 $m^3/km^2/y$	Increased based on NEDECO formula derived for Mahaweli Basin
10,000 year flood	6,000 m^3/s	6,700 m^3/s	Increased due to reducing lag time of peak floods for Nawalapitiya basin and Kotmale basin.
1,000 year flood	3,973 m^3/s	4,100 m^3/s	Increased due to reducing lag time of peak floods for Nawalapitiya basin and Kotmale basin
25 year flood	1,058 m^3/s	1,150 m^3/s	Increased due to reducing lag time of peak floods for Nawalapitiya basin
Reservoir			
Full Supply Level	548 masl	548 masl	No Change
Minimum Operating Level	542 masl	542 masl	No Change
Capacity at FSL	4.23 MCM	4.66 MCM	Increased due to shifting the dam axis by 100m toward downstream
Effective storage	1.87 MCM	1.98 MCM	Increased due to shifting the dam axis by 100m toward downstream
Surface area at FSL	36.5 ha	38.47 ha	Increased due to shifting the dam axis by 100m toward downstream
Dam and Intake			
Dam type	Concrete Gravity	Concrete Gravity	No Change
Dam height	35 m	37 m	Increased due to shifting the dam axis by 100m toward downstream
Crest length	214.5 m	236 m	Increased due to shifting the dam axis by 100m toward downstream
Design flood (10,000 year)	Q 10,000: 6,000 m^3/s	Q 10,000: 6,7000 m^3/s	Increased due to reducing lag time of peak floods for Nawalapitiya basin and Kotmale basin.
Spillway crest elevation	534 masl	534 masl	No Change
No of spillway gates	5	5	No Change
Type of gates	Radial; one top-flap gate	Radial and counterweight; 1 top-flap gate	Changed to have more safer operation
Gate dimensions (w x h)	15 x 15 m	13 x 15 m	Reduced due to accurate analysis
Size of intake gate	4 x 6 m	4.7 x 4.7 m	Reduced due to accurate analysis
Conveyance			
Design Discharge	45 m^3/s	50 m^3/s	Increased due to increasing power

Feature	Local EIA (2012)	Environmental Addendum (2013)	Remarks
			output
Headrace tunnel			
Type	Concrete-lined	Concrete-lined	No Change
Shape: excavated	Horseshoe	Horseshoe	No Change
Shape: lined	Circular cross section	Circular cross section	No Change
Length	2,980 m	2,727 m	Reduced due to change of intake and power house location
Internal diameter	4.5 m	4.7 m	Increased due to excavation economic analysis
Inlet sill elevation	530 masl	532.5 masl	Reduced due to layout optimization
Surge shaft			
Type	Restricted orifice	Restricted orifice	No Change
Shape	Circular cross section	Circular cross section	No Change
Diameter	13.5 m	12.5 m	Reduced due to layout optimization
Up surge water level	566.92 masl	564.5 masl	Reduced due to layout optimization
Down surge water level	526.67 masl	524.9 masl	Increased due to layout optimization
Surge tank gate	None	3.8 x 3.8 m	Introduced to ease maintenance of pressure conduit
Penstock			
Length	Tunnel 145 m; Surface 185 m	Tunnel 318 m	Decreased due to underground penstock
Excavation diameter	T 3.3 m; S 2.7 - 1.5 m	5 m	Increased to installed underground penstock
Pipe diameter	3.3 m	3.8 m	Increased due to increasing power output
Powerhouse and tailrace			
Type	Surface	Surface	No Change
Length	29 m	44 m	Increased due to layout optimization
Width	18 m	24 m	Increased due to layout optimization
Normal tailwater level	473 masl	472.5 masl	decreased due to layout optimization
Maximum tailwater level	486.5 masl	485.8 masl	decreased due to layout optimization
Tailrace channel	Open; 25 m long	Open; 28 m long	Increased due to layout optimization
Power Generation: Turbines			
Type	Vertical-shaft Francis	Vertical-shaft Francis	No Change
Speed	500 rpm	375 rpm	decreased due to layout optimization
Rated output	13.25 MW x 2 units	15.55 MW x 2 units	Increased due to layout optimization
Rated head	69.38 m	69.0 m	decreased due to layout optimization
Generators			
Rated voltage	11 kV	11 kV	No Change
Rated output	17.2 MVA x 2 units	17.8 MVA x 2 units	Increased due to layout optimization
Rated frequency	50 Hz	50 Hz	No Change
OHT crane capacity	None	60 ton	Not considered

Feature	Local EIA (2012)	Environmental Addendum (2013)	Remarks
Transformers			
Type	3 phase; oil-immersed	single phase; oil-immersed	Changed to enhanced reliability
Rated voltage	132 kV/ 11 kV	132 kV/ 11 kV	No Change
Rated Output	17.2 MVA x 2 units	36 MVA x 1 unit	Changed to enhanced reliability
Switchyard			
Location	Outdoor	Outdoor	No Change
Rating	None	132 kV	Not considered
Transmission Line			
Rating	132 kV	132 kV	No Change
Location	Moragolla switchyard to existing TL between Kotmale and Polpitiya PS	Moragolla switchyard to existing TL between Kotmale and Polpitiya PS	No Change
Type	Overhead, double circuit	Overhead, double circuit	No Change
Length	500 m	500 m	No Change
Energy Production			
Generation (mean annual)	81.65 GWh	97.6 GWh	Increased due to layout optimization
Generation (on-peak)	15.53 GWh	29.5 GWh	Increased due to layout optimization
Generation (off-peak)	66.12 GWh	68.1 GWh	Increased due to layout optimization
Mini-hydro (mean annual)		2.9 GWh	Not considered in Local EIA

in a tunnel 318 m in length and 3.8 m in diameter (Fig 5).

77. **Power House:** The above-ground power house will be 44 x 24 m and 39 m high, with a floor level at 486.5 masl and the turbine centre at 469.4 masl, determined by the rating curve at the tailrace (Fig 6). The nearby switchyard area of 900 m^2 proposed in the FS was found to be too small to accommodate the necessary equipment, so this has been increased to 3,000 m^2 and the platform at 486.5 masl will be formed by cutting and filling.

78. **Tailrace Outfall:** The tailrace outfall will be a reinforced concrete open channel, 28 m in length, through which diverted water will be returned to the Mahaweli Ganga almost directly opposite the confluence with the Atabage Oya.

79. **Access Roads:** The FS proposed to improve the existing road from the power house to Ethgala and widen the carriageway from 3 to over 5.5 m to allow delivery of equipment and materials. This was found to be impracticable because of the proximity to the road of houses

80. **Reservoir:** The reservoir will have a Full Supply Level (FSL) of 548 masl and a Minimum Operating Level (MOL) of 542 masl, with a total capacity of 4.66 MCM at FSL, and a surface area of 38.5 ha (Fig 2). The reservoir will extend approximately 3 km upstream from the dam, to a point around 500m downstream of the confluence with the Kothmale Oya. The river valley is generally quite steep at this location, so the reservoir will remain quite narrow, with a surface area of only around twice the present wet season extent, with the maximum increase being across lower ground on the right bank opposite Ulapane (see Fig 2).

81. **Transmission Line:** The transmission line (TL) from the Moragolla switchyard will run to the nearest existing TL, which runs between the Polpitiya hydropower station and the Kothmale switchyard on the right bank of the Mahaweli Ganga (Fig 2). This crosses the river in a north-westerly direction, and runs close to the proposed Moragolla surge tank. The grid connection will require nearly 500 m long transmission line consisting of only two transmission towers.

C. Design Changes

82. The descriptions of the project components in Section B above, and the comparison of the features of the project during the FS and final design (Table 2) show that the main changes in the project are as follows:

a) The dam axis is relocated approximately 100 m downstream, where solid bedrock is exposed on the right bank and closer to the surface on the left bank, thus reducing excavation volume and associated intrusion into Ulapane Industrial Estate.
b) Dam relocation reduces the length of the headrace tunnel by 107 m, and produces a slightly larger reservoir, at the same surface elevation (FSL 548 masl).
c) As instructed by CEB, a micro-hydro power plant has been incorporated into the dam to generate an installed capacity of 360 kW from the environmental flow of 1.5 m^3/s.
d) The FS proposed a 185 m surface penstock with a 145 m tunnel, and this has been relocated underground, to avoid the deep excavation and extensive slope protection needed, and associated landslide risk;
e) The 900 m^2 switchyard has been increased to 3000 m^2 to accommodate equipment;
f) The proposed usage of Ethgala Road to transport equipment and materials has been abandoned because of the impracticability of widening the carriageway; and a causeway will be built across the river instead, for access from Gampola Road on the right bank.

83. There were also some changes in the hydrological calculations and resulting design assumptions, based on analysis of additional meteorological data, recalculated stream flows and other factors (explained in the Final Design Report[6]). As a result the detailed design is based on a reduced estimate of mean annual rainfall, an increased mean inflow, and higher sediment input than adopted in the FS (see Table 2). These changes produced an increase in the capacity of the design flood (6,000m^3/s to 6,700m^3/s for the 10,000 year flood event) and necessitated modifications in the size of the spillway gates and other features. The design discharge of the water conveyance also increased (45m^3/s to 50m^3/s), which required an increase in the diameter of the headrace tunnel (4.5m to 4.7m) and associated changes in the downstream components. The power generation capacity of this plant was recalculated, that has increased from 26.5MW to 30.2MW of the installed capacity and average annual energy production has also increased from 81.65GWh to 97.6 GWh by the final project layout.

D. Project Cost

84. Table 3 shows the estimated cost of constructing the project, according to the final report of the design study. This shows that the total cost is US$ 128 million, of which around 30% is expected to be expended on inputs from within Sri Lanka, and 70% from outside the country. The total construction cost is $105 million, of which more than half is the cost of the main civil works (dam, tunnel and other structures) and around 20% each is for the hydromechanical and electromechanical works (power generation). Almost $2 million is allocated for the environmental mitigation measures not covered within the contractors' normal construction

costs, and these costs are discussed further in the EMP (Volume 2). The overall cost of $128 million compares with the estimate of $85 million given in the Feasibility Study in 2009.

Table 3: Estimated cost of construction of the Moragolla HPP (US$1,000)

Item	Description	Amount		Total
		Local	Foreign	
Lot 1	Preparatory Works	4,881	1,941	6,822
Lot 2	Main Civil Works	21,545	33,089	54,634
Lot 3	Hydromechanical Works	1,836	16,526	18,362
Lot 4	Electromechanical Works	1,334	24,020	25,354
Lot 5	Transmission Line Works	60	140	200
	Total Construction Cost	**29,595**	**75,576**	**105,171**
	Engineering and Administration*	3,786	8,834	12,620
	Environmental Mitigation**	737	1,106	1,843
	Project Cost (without Physical Contingency)	34,119	85,517	119,636
	Physical Contingency***	2,801	5,530	8,331
	Project Cost (with Physical Contingency)	**36,920**	**91,047**	**127,967**

* 12% of the construction cost, split into 30% local and 70% foreign
** 3% of preparatory works and main civil works, split into 40% local and 60% foreign
*** 10% of preparatory works and main civil works and 5% of hydromechanical, electromechanical and TL works

E. The Construction Process

1. General Features

85. The Moragolla Project is a run-of-river hydropower scheme. These traditionally involve little or no water storage, and if there is a dam, it is smaller than those involved in conventional hydropower schemes as its function is to divert water through a waterway to turbines, rather than storing water for power generation by regulated flow. run-of-river schemes normally operate as peaking stations, generating power intermittently, mainly during high demand periods, rather than continuously to satisfy base load requirements.

86. Moragolla is therefore smaller than most regulated-flow hydropower plants, with a smaller dam, reservoir and power generation apparatus, and a much shorter transmission line. Nevertheless, with a concrete dam that is 37 m high, 30 m wide at the base and 236 m along the crest; a 2.7 km long, 4.7 m diameter headrace tunnel to be drilled through bedrock; an underground surge shaft and penstock; plus a powerhouse, switchyard and array of power generation equipment (turbines, generators, transformers), this is clearly a major project, in which there will be substantial physical changes and a high potential for environmental disturbance and damage. Figure 7 shows that it also involves a long construction period, estimated at 4.5 years (2015-19), proceeded by 1.5 years of preconstruction activities (securing finance and tendering).

87. Figure 8 shows the location and actual footprint (to scale) of all sites that will be directly affected by the construction process, and Table 4 shows the size of each area and the main work activities that will be conducted at each. This shows that there are three main construction areas (dam and intake; surge tank and penstock; and power house and tailrace) at which most of the major construction will take place. There are also 13 other "ancillary sites", where activities associated with and arising from the main construction will be conducted (quarrying; spoil disposal; access roads; provision of housing for project personnel and resettled families; etc).

Additional Table 4(a) for Addendum: Additional project sites

Location (letters are those used in Fig 3)	Area (ha)	Local EIA (2012)	Environmental Addendum (2013)
a) Dam and Intake	15.27	✓	✓
d) Surge Tank and Penstock	0.49	✓	✓
b) Powerhouse and Tailrace	3.45	✓	✓
m) Contractors' Work Area	4.00		✓*
k) Disposal Area 1	4.58	✓	✓
l) Disposal Area 2	1.51	✓	✓
n) Disposal Area 3	1.89		✓**
j) Quarry	7.81		✓***
i) Personnel Camp	3.85	✓	✓
p) Resettlement Site	9.16	✓	✓
f) Diversion Road	0.70	✓	✓
g) Access Road 1	0.65	✓	✓
h) Access Road 2	0.45		✓
o) Road to Powerhouse	0.50	✓	✓
e) Transmission Line	0.92	✓	✓
c) Reservoir and Buffer	51.75	✓	✓
q) Ulapane Buffer Area	5.96	✓	✓

* Has not identified in Local EIA (2012)
** Added due to insufficient capacity of disposal area
*** Added due to unsuitability of the quarry sites selected by Local EIA (2012)

88. Table 4 shows the main construction works that will occur at each site, which indicates that there are eleven basic activities. Some of these commonly occur at most construction sites (eg land clearance, excavation, creation of structures), although they vary considerably in scale and complexity. Others are quite specialised and tend to be associated mainly with larger projects (eg tunnelling and blasting). Together these are the processes that may affect the environment directly or indirectly during the construction period, so they need to be understood in order to assess the nature and extent of their potential impacts. Each process is described below.

2. Construction Activities

89. **Site clearance:** Site clearance is normally the first physical activity conducted at construction sites, and is preceded only by some basic surveying to determine levels, topography, and the presence of any features that may influence the approach to construction (rock outcrops, drainage channels, etc); and an exercise to locate and mark the boundaries of the site. Clearance involves the cutting or uprooting of trees, shrubs and other vegetation, and the demolition of buildings, and the disposal of the resulting debris. Trees may be cut by hand using chain saws, or may be pushed over and uprooted by bulldozer; and in this project both methods will probably be used, depending on topography. Shrubs and remaining ground

Table 4: The categories of construction sites and the main activities involved at each

Location (letters are those used in Fig 3)	Area (ha)	Site clearance	Earth works	Blasting	Excavation - General	Excavation - Tunnelling	Crusher; Concrete Plant	Spoil Disposal	Soil covering; planting	Concrete Structures	House Building	Road Construction
a) Dam and Intake	15.27	✓	✓	✓	✓	✓				✓		
d) Surge Tank and Penstock	0.49	✓		✓		✓				✓		
b) Powerhouse and Tailrace	3.45	✓	✓	✓	✓	✓				✓		
m) Contractors' Work Area	4.00	✓	✓				✓					
k) Disposal Area 1	4.58	✓	✓					✓	✓			
l) Disposal Area 2	1.51	✓	✓					✓	✓			
n) Disposal Area 3	1.89	✓	✓					✓	✓			
j) Quarry	7.81	✓	✓	✓	✓							
i) Personnel Camp	3.85	✓	✓		✓						✓	✓
p) Resettlement Site	9.16	✓	✓		✓						✓	✓
f) Diversion Road	0.70	✓	✓									✓
g) Access Road 1	0.65	✓	✓									✓
h) Access Road 2	0.45	✓	✓									✓
o) Road to Powerhouse	0.50											✓
e) Transmission Line	0.92	✓			✓					✓		
c) Reservoir and Buffer	51.75	✓							✓			
q) Ulapane Buffer Area	5.96											

vegetation are then scraped by the blade of a bulldozer, or chopped by hand at ground level by machete. The resulting debris is sometimes burned on site, or more often is loaded onto dump trucks and taken for disposal. Trees may also be prepared for sale or donation to the local community by removal of branches and cutting into smaller lengths.

Package No.	Activities	Unit	Quantity
Preconstruction Activities			
Financial Arrangement and Selection of Consultant		lot	1
PQ, Tender, Evaluation and Contracts Award, Lot 1		lot	1
PQ, Tender, Evaluation and Contracts Award, Lot 2, 3. 4, 5		lot	1
Lot 1	Preparatory Works (ICB)		
Construction power supply (33 kV line), repair & relocation of irrigation canal and implementation of catchment management plan, fundation of existing bridge improvement		-	LS
Construction of camp for Employer and Engineer and resettlement area		-	LS
Construction of access roads		-	LS
Lot 2	Civil Works (ICB)		
	Mobilization	-	LS
	Temporary facilities & construction roads	-	LS
River Diversion	River diversion works	-	LS
Dam and Spillway	Excavation, common & rock, dam	m3	237,000
	Foundation treatment	lot	1
	Mass & structural concrete, dam & spillway	m3	108,800
Intake	Excavation, common & rock, Intake	m3	13,500
	Concrete	m3	2,500
H. tunnel	Adit No.1, 2 & 3	m	450
	Excavation, tunnel	m3	77,000
	Concrete, invert & tunnel lining	m3	21,000
	Grouting (backfill & consolidation)	lot	1
	Plug concrete	lot	1
	Water fillling	lot	1
Surge tank	Excavation, commmon	m3	26,000
	Shaft excavation	m3	9,500
	Concrete	m3	2,800
	Grouting (consolidation)	Lot	1
Penstock	Excavation, tunnel	m3	8,300
	Concrete	m3	3,500
P.house	Exca. common & rock , P. house, S. yard & tailrace	m3	47,000
	Concrete	m3	10,400
	Roofing & other architectutral & finishing	lot	1
Switchyard	Excavation, Fill and concete	lot	1
Tailrace	Excavation and concete	lot	1
Lot 3	Hydro-Mechanical Works (ICB)		
Hydr-mechanical	Design, manufacturing & transportation	lot	1
	Install, spillway gates, stoplogs and gantry crane	lot	1
	Install. power intake gates and trashrack	lot	1
	Surge tank gate	lot	1
	Steel liner installation & concreting	lot	1
	Draft tube gates	lot	1
	Test and commissioning	-	LS
Lot 4	Electro-Mechanical Works (ICB)		
Electro-mechanical	Design, manufacturing & transportation	lot	1
	Installation of overhead travelling crane	lot	1
	Installation of draft tube	lot	1
	Unit 1 insatallation of E&M equipment	lot	1
	Unit 2 insatallation of E&M equipment	lot	1
	Switchgear installation	lot	1
	Test and commissioning	-	LS
	Transmission line	-	LS

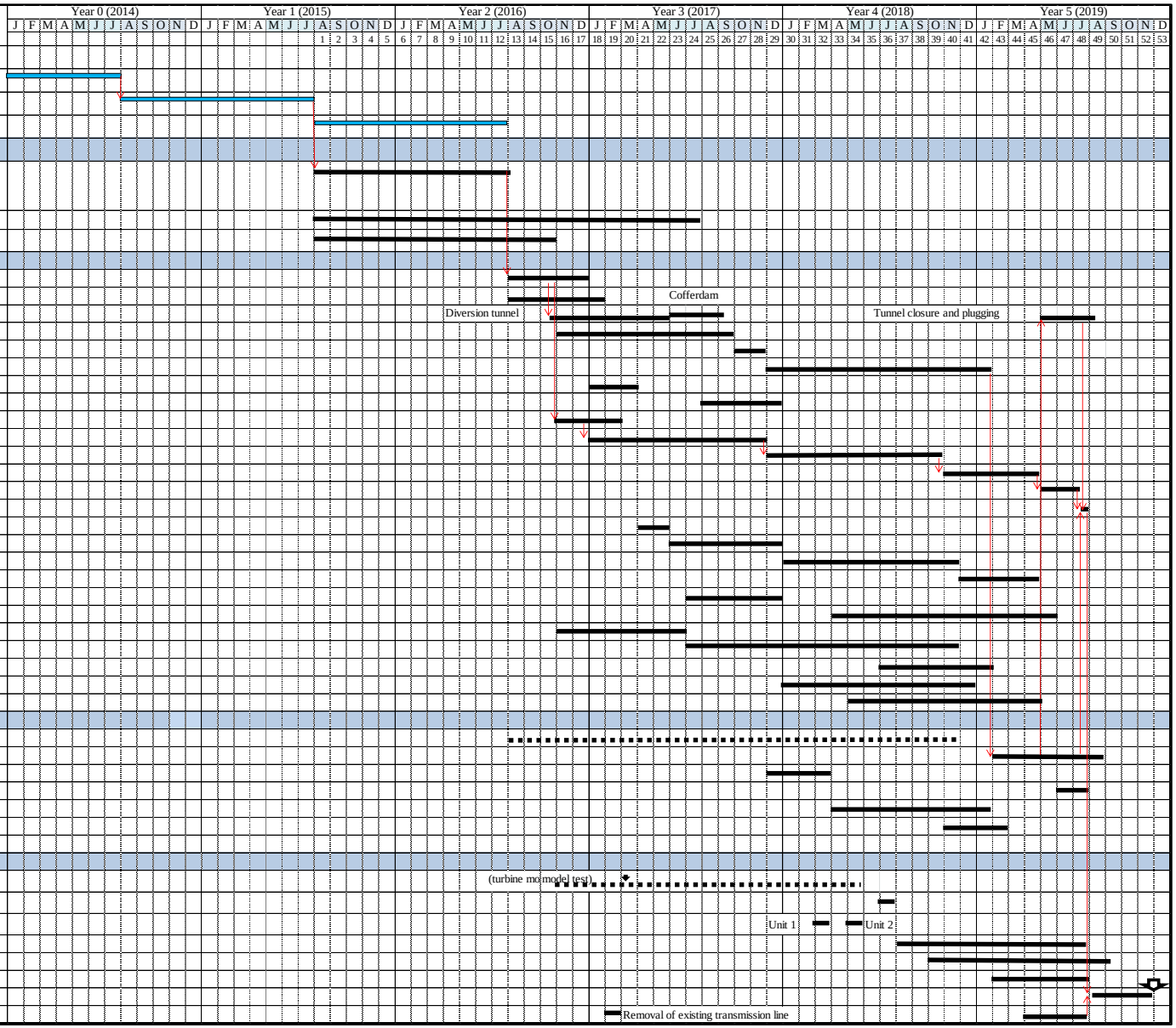

Figure 7: Proposed construction programme

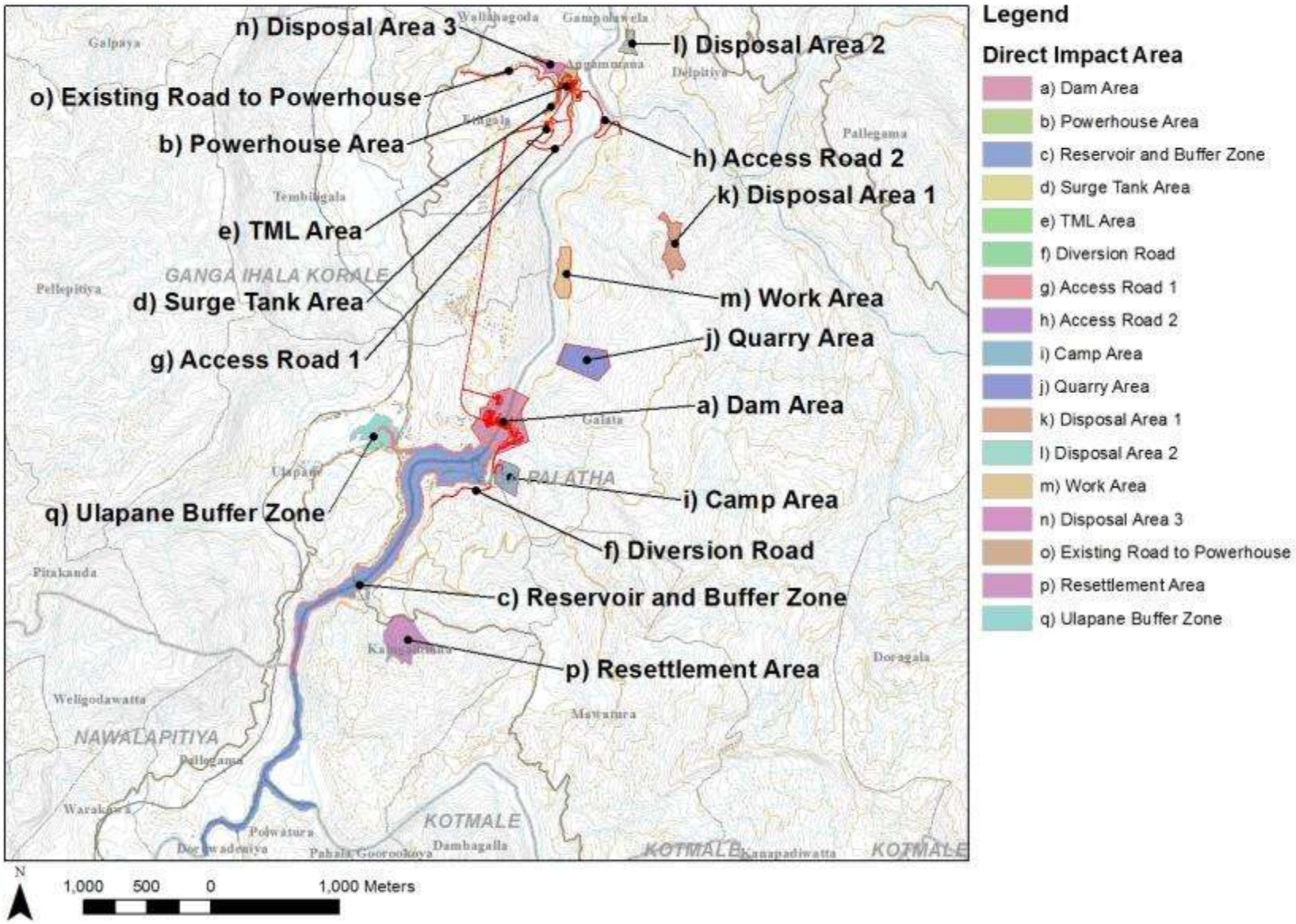

Figure 8: Locations of construction sites and related activities

90. **Earthworks:** Earthwork involves the moving or removal of topsoil, subsoil and/or unconsolidated rock, and is normally done to flatten a patch of ground, or to achieve a required slope, or to bring the ground to the level specified in the design, upon which structures (buildings, roads, etc) are to be constructed. Earthworks can involve excavating to a lower level or filling with material dug from elsewhere to raise the surface; and slopes exposed by earthworks may need to be protected by other engineering work (terracing, rock protection, etc) to avoid erosion and landslips. In this project, earthworks will be required at most of the construction sites, most notably at the dam and intake, and the powerhouse and tailrace area, but also at the sites where excess excavated material will be deposited, as the level and profile will need to be monitored and adjusted to promote long-term stability. There will also be some more limited earthworks at the sites where buildings and roads will be constructed, eg access roads, resettlement area, etc. Most of this work will be done by bulldozers and backhoes (Photo 1), in conjunction with backhoe excavators and dump trucks (Photo 2) to move the material; and the work will continue for several months in the early construction stage.

91. **Blasting:** Blasting is the use of explosives (or other methods including gas pressure) to break down rock, so that it can be removed during excavation. Blasting has been used in mining and construction for many years, and has achieved a high level of sophistication, arising from the need to maintain control and safety. In this project, blasting will mainly be used to excavate rock from the hillsides and valley floor at the dam site, and to assist in the removal of underground rock to form the route of the headrace tunnel and for the surge chamber and penstock. Blasting will also be used at the quarry to dislodge and break down rock into sizes suitable for direct use, or further processing by the crusher (see below). In most cases, blast holes will be drilled into the rock, by pneumatic hammer drill attached to a backhoe digger, after which the explosive charge is installed and connected to detonators ready for firing. In applications such as this, which require the removal of large amounts of rock, blasting can involve several charges laid in drill holes along a fault line or arranged in a grid across a rock surface, which are then detonated simultaneously. After blasting, the collapsed rubble and other debris is loaded into dump trucks and taken for disposal or crushing if it is suitable for use.

92. **General Excavation:** General excavation refers to all of the smaller-scale earth removal and moving activities that go on at construction sites once the larger earthworks have been completed. It includes creation of trenches for utility pipelines and drains, footings/foundations for buildings, cavities for installation of underground tanks and other structures, etc. This work is normally done by single backhoe excavators, again working with dump trucks, onto which material is loaded for transport to storage sites (topsoil and useable aggregates) or disposal areas. In this project there will be a need for smaller-scale excavation at most sites, in particular where buildings or other structures are constructed, and to create concrete foundations for the two transmission towers.

93. **Tunnelling:** In this project the use of a tunnel-boring machine has been ruied out on grounds of cost-efficiency, so the 2.7 km headrace tunnel and the underground locations for the surge chamber and penstock will be created by tunnel excavation, assisted by rock blasting as outlined above. The normal technique is to tunnel into the main route from side-tunnels or adits, which begin at a slightly lower elevation to allow water to drain out and fresh air to enter. In this project there will be three adits, one about 200 m downstream of the dam, one at the surge tank, and one at the penstock tunnel (see Fig 8). The adits and the main tunnel will be excavated mainly by drilling and blasting, and excavated material will again be loaded into dump trucks. Once the adits reach the main route they will continue uphill and downhill, eventually meeting tunnels excavated from the intake and powerhouse. The main tunnel will be excavated

in a horseshoe section below and lined with reinforced concrete (RC) at the top, to form a circular cross section. Where necessary, metal rock-supports will be installed before the RC to strengthen the roof and prevent any collapse.

94. **Crusher and Concrete Plant:** A crusher is a machine designed to reduce large rocks by mechanical means into smaller-sized rocks or aggregate (required for construction purposes, eg concrete, stone protection, base materials, etc). It normally consists of a hopper or delivery chute, into which the rock is tipped from a dump truck and/or pushed by a small bulldozer or excavator. It then enters the crushing device, in which mechanical pressure is applied in some form to break the rock into smaller particles, which fall onto screens of different sized mesh, from where they are carried away to stockpiles by band conveyors (Photo 3). A concrete plant

Photo 1: A typical picture of a Power shovel

Photo 2: A typical picture of a Backhoe excavator loading a dump truck in a quarry

Photo 3: A typical picture of a Crusher Plant

Photo 4: A typical picture of a Concrete batching plant

comprises the various elements required to create concrete in large quantities (Photo 4). This normally includes metal bins for the storage and delivery of sand, aggregate, potash and cement; and a piped water supply, all of which feed into a mixing chamber. Such devices are now electronically controlled and highly automated, with such features as chillers and heaters to provide accurate temperature control, and computer controlled delivery to ensure accurate mix compositions for different applications. Both plants will be established in the Contractors' work area, located alongside the river on the right bank (Fig 8).

95. **Spoil disposal:** Spoil is soil, rock and other excavated material that is not suitable for re-use in the construction project and must therefore be disposed of. In this project it is estimated that there will be about 300,000 m^3 of unusable spoil, approximately two-thirds originating in the dam area and one-third from the powerhouse site, of which around 50,000 m^3 in total will come from the tunnel excavation. This will be loaded into dump trucks and transported for disposal at three locations shown in Fig 8. These were chosen for a variety of reasons, including stable geology and suitable profile to accept the required volume of spoil, proximity to the spoil sources, unlikely to be subject to flooding, owned by the government, and not located close to major inhabitation. After deposition, the material will be repositioned and profiled by bulldozer.

96. **Soil covering and planting:** Once the disposal areas are full and have reached the design level and profile for final closure, a layer of topsoil (retained from excavation elsewhere in the construction area), will be applied from trucks and spread evenly by a light excavator to cover the deposited spoil to a depth of at least 30 cm. A range of native trees, shrubs, grasses and other vegetation will then be planted, in order to restore each area to a natural appearance, and to stabilise the ground, retaining the soil to prevent erosion by rainfall. The other major area to be planted is the 100 m wide buffer zone around the reservoir perimeter above FSL, which CEB committed in the Local EIA report to plant with native trees and other vegetation to compensate for the trees that will be felled at the construction sites and the reservoir. There will also be some smaller scale planting and landscaping at the areas in which new housing will be provided (resettlement area, personnel camp). Planting schemes will be designed and implemented by appropriate specialists employed by CEB, who will maintain all vegetation until it is established.

97. **Concrete structures:** In addition to the large-scale excavation and tunnelling, the other major construction activity in this project is the creation of a variety of concrete structures. The most significant of these are the dam and the tunnel, plus the downstream facilities - surge tank, penstock, power house and tailrace outfall. With the exception of the dam, all of the other large structures will be constructed from reinforced concrete (RC), where steel reinforcing rods and bars are placed and attached by hand to create an interior skeleton for the walls, columns and other structural components (Photo 5), and heavy-duty metal and timber/plywood formwork is bolted around the outside to create a mould into which pre-mixed concrete is poured (Photo 6). Once the concrete has set, the formwork is removed, and the concrete surface is finished by masons by hand if necessary. The process is repeated in the next adjacent part of the structure, which is gradually created in this way. A similar technique will be used to create the walls of the tunnel, although shotcrete (pressure-sprayed concrete) may also be used in places.

98. Construction of the dam will be preceded by creation of two coffer dams in the river bed to divert the flow through an excavated tunnel on the left bank, to allow dam construction in the dry (see Fig 3). The diversion tunnel will be around 300 m in length, with a shallow gradient and a diameter sufficient to allow passage of the 10-year dry season flood (320m^3/s) without

overtopping the cofferdam. The dam will then be built from mass concrete, whereby concrete is poured into portions of the dam structure delimited by formwork, but without the use of metal reinforcing. On completion of the structure, grouting is applied to maintain watertight conditions.

Photo 5: A typical picture of a steel reinforcing for building foundations and small structural columns

Photo 6: A typical picture of a steel and plywood formwork

99. Most of the other components incorporated into the concrete structures (spillway gates and operating apparatus; turbines; generators; transformers; electrical switchgear and other equipment; etc) will be brought to site ready-made, or as individual components for assembly on site (eg transmission towers). These components and materials will be delivered on trucks and offloaded and positioned by crane, and connected up *in situ*.

100. **House building:** House building will be a relatively small element of the project, and will be conducted at two main sites: a) in the area where CEB will re-house the 17 families whose present accommodation lies within the inundation area of the reservoir (as agreed in the Resettlement Plan); and b) at the accommodation camp near the dam site (Fig 8), which will house the site staff of the supervision consultant, contractors and client during the construction stage, and the CEB site staff when the scheme is operating. In total, around 50 houses will be built, and this will be done, mainly by hand, using standard techniques. Footings and trenches for utility pipes and other services will first be excavated by backhoe; and concrete and stone will be poured in to create the foundations of each house. Bricks and mortar are then applied by masons by hand to create the walls, and plaster is applied to finish the internal surfaces. Wooden joists are fixed in place, followed by tiles or other roofing materials. Finally the interior fixtures and fittings are put in place and connected up by plumbers, electricians, carpenters, etc.

101. **Road construction:** This is also a relatively minor component, as the total length of new road to be provided is only around 3 km. Roads will be built: a) to provide access to the power house and surge tank from Atabage-Mawathura Road on the opposite bank; b) to replace a 0.5 km length of the same road upstream of the dam that will be inundated by the reservoir (Fig 8); and c) within the two areas of new housing mentioned above. Some minor upgrading of the existing road from Ethgala to the power house will also be conducted, to allow access by personnel when the causeway across the river is inundated in the monsoon. Road construction normally begins with land clearance along the Right of Way (RoW) and earthworks to achieve the design levels and profiles, and these activities will be conducted as described above. There may be a need for excavation in places and possibly some creation of embankments, but this is likely to be quite small in scale, as most of the new roadways are near the river, where the topography is relatively flat. Once the ground profile has been achieved, pavement material (normally gravel/aggregate of different particle sizes) is then added in layers, with each layer being compacted by heavy roller. Finally a layer of asphalt (bitumen) mixed with aggregate is poured on to form the top surface.

102. **Vehicles, machinery and workforce:** The approach to the construction process will be determined by the contractors, so the details are not known at the time of writing. However estimates of the numbers and types of vehicles and workers are made in the design stage for the purposes of estimating budgets. These suggest that the construction process will involve approximately 10 bulldozers, 12 backhoe excavators, 10 power shovels, 50 dump trucks, 5 concrete pumps, 10 mixer trucks, 5 truck cranes, 2 crawler cranes, 1 tower crane, 1 crusher and 1 concrete batching plant. In broad terms the earth-moving plant will be involved in the early stages of construction and the concreting equipment in the middle and later stages. The workforce is estimated at around 650 persons, comprising approximately 150 skilled and 300 unskilled workers, 100 operators/drivers, and 100 foremen/supervisors. Actual numbers will vary throughout the construction period, but earth moving and concreting are both quite labour-intensive activities, so numbers of workers would be expected to be near the maximum for much on the early and middle period of construction (say the first 2-3 years).

F. Operation of the Completed Scheme

1. General Features

103. In major projects such as this, all elements of the scheme are subject to a complex testing and validation regime throughout the construction period, and especially once each individual component has been built. These checks are specified in design manuals and project technical specifications, and are conducted by properly accredited and experienced experts in each respective field. There is then a commissioning period, in which the individual components and the scheme as a whole are subject to further checks to ensure correct operation. This occurs in the "defects and liability" period of the contract, in which the contractor remains on site and is liable to make good any defects or malfunctions to the satisfaction of the supervising consultant and the client. This period normally lasts for one year, at the end of which the project is handed over to the client, who then assumes responsibility for operation of the scheme.

104. Despite their size and complexity, hydropower schemes are normally operated by a relatively small workforce, because of the high degree of performance monitoring and control provided by modern automated systems. Central control rooms contain complex arrays of meters, gauges, and other devices, which show the real-time performance of all components of the scheme in great detail, and which automatically alert operators to any deviations or areas of concern, and recommended remedial actions when needed. Such systems are all automated and computerised, to ensure the requisite high degree of performance and safety, and reduce the possibility of errors and malfunctions. Control rooms are operated by a small number of highly qualified and trained technicians, supervised by one or two senior managers, and an overall head of operations or site manager, who will be a highly experienced CEB senior technical expert.

105. There is also a small maintenance team, which is responsible for conducting routine maintenance of the various scheme components as specified in the operation manuals, and for implementing any repairs or replacement of components as may be necessary. This team will contain highly trained technicians, specialised in hydromechanical and electromechanical engineering, plus other fields, plus a small number of semi-skilled persons, and unskilled labourers. The work of this team will be planned and organised by a senior engineering manager, who reports to the site manager. Other site employees will include small numbers of catering staff, cleaners and security operatives.

2. Operational Characteristics

106. Like the nearby Kothmale HPP, the Moragolla scheme is intended as a peaking station, primarily aimed at the daily peak electricity demand period. It will therefore operate from around 5 pm to 9 pm each day, and at other times (contributing to the base load electricity supply), depending on water availability. Figure 9 shows the expected average daily operation for each month throughout the year. This shows that during the monsoon period (June to November in this part of the country) there is expected to be sufficient water to allow power generation for 15 -18 hours per day. However during the dry season (January to April) power will only be generated for around 4 - 7 hours per day, and in February and March, during the four-hour peak demand period only.

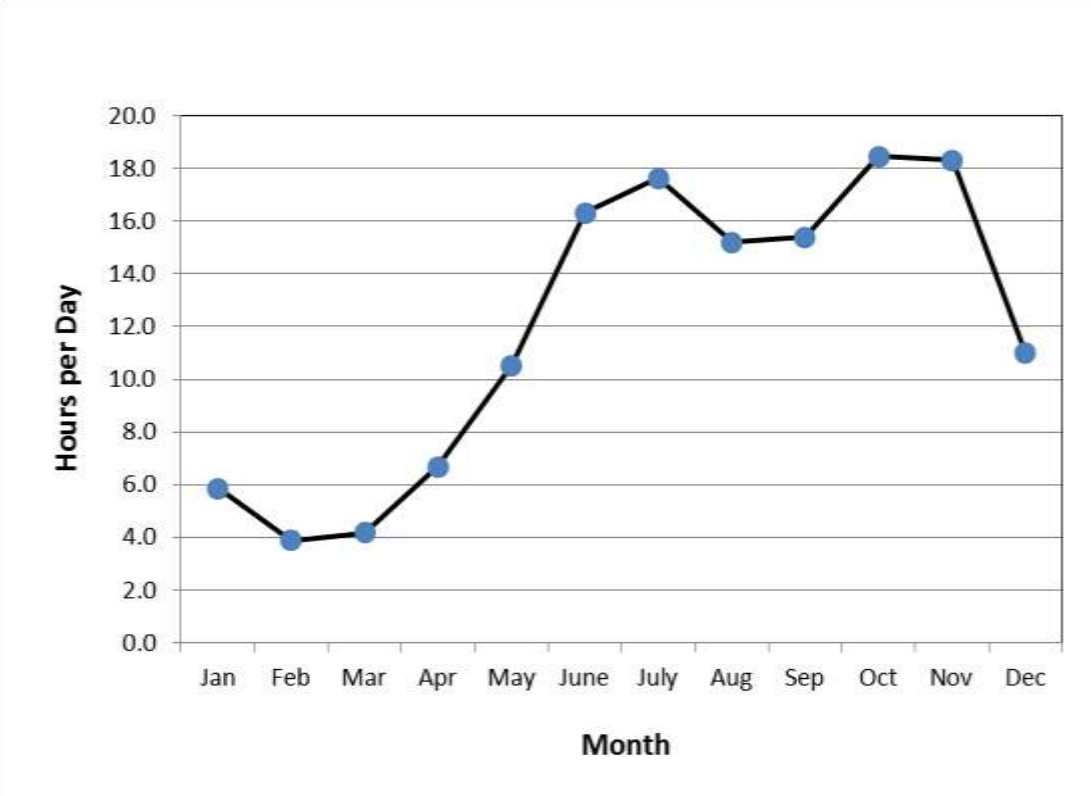

Figure 9: Estimated average operating hours per day for the Moragolla HPP

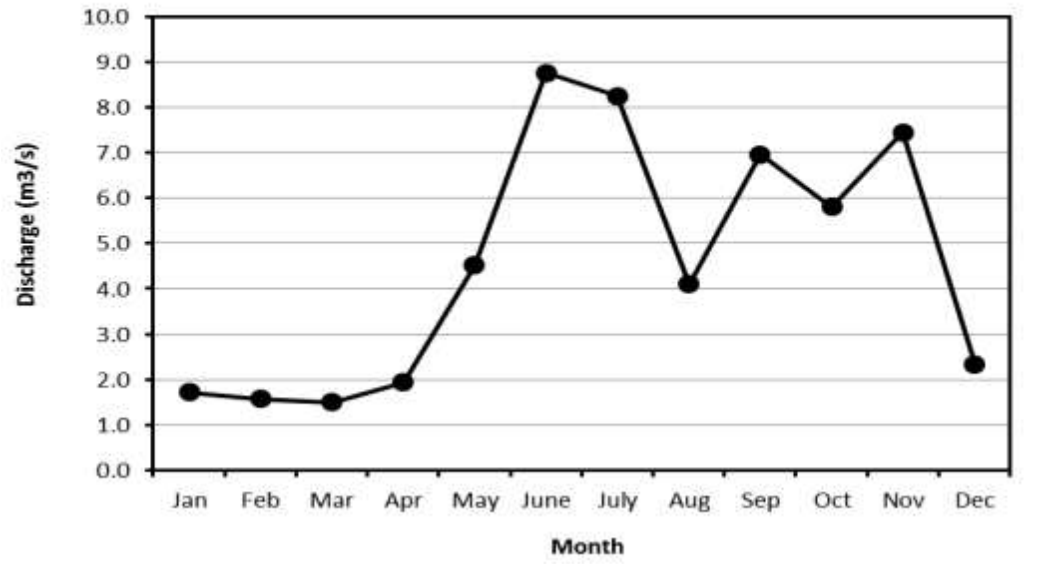

Figure 10: Predicted monthly water release from Moragolla dam (including E-flow)

107. Whenever power is generated, water will pass through the headrace tunnel and powerhouse and be returned to the river through the tailrace outfall 2.7 km downstream. The

guaranteed E-flow of 1.5m^3/s will be discharged from the dam at all times, and water will also overflow the spillway crest when there is an excess (mainly during the monsoon period). Figure 10 shows the calculated monthly release of water from the dam, which shows that in the dry season, discharge will mainly be limited to the E-flow, and in the wet season, dam flow will average at between 4 and 9 m^3/s.

108. Figure 11 shows the likely average monthly flow from both the Moragolla and Kothmale tailraces, which shows that the combined flow (ie downstream of the Atabage Oya) will fluctuate between 20 and 30 m^3/s in the dry season and 60 and 70 m^3/s in the wet season. Figure 12 shows how the average water level in the reservoir will vary throughout the year by 0.4 m maximum whereas the daily changes will also be quite small and is in the range <2 m.

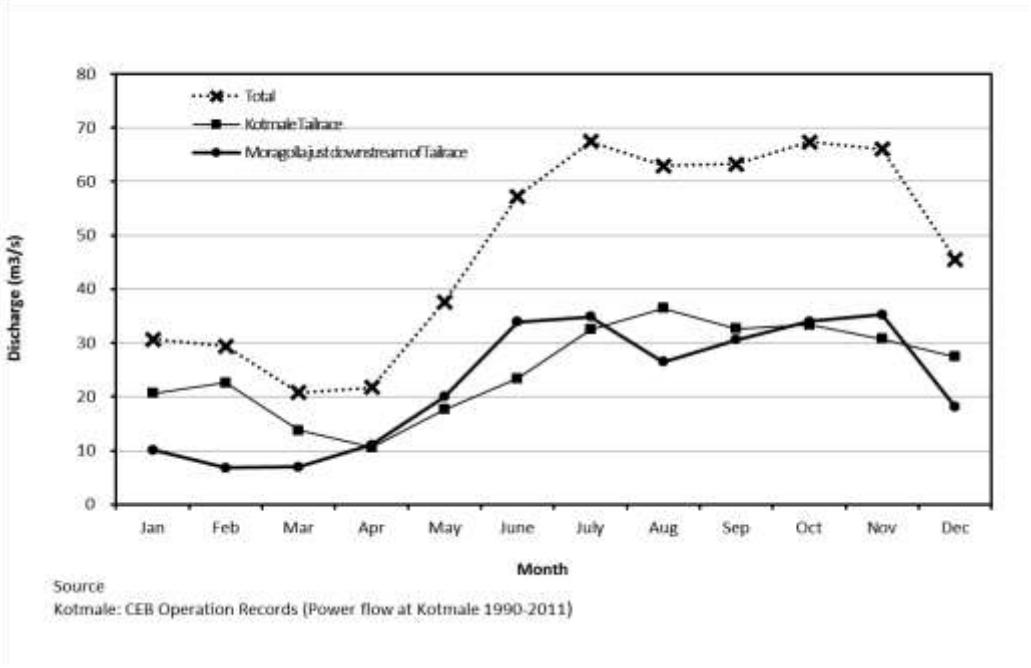

Figure 11: Average monthly flow from the Kotmale tailrace and immediately downstream of the Moragolla tailrace

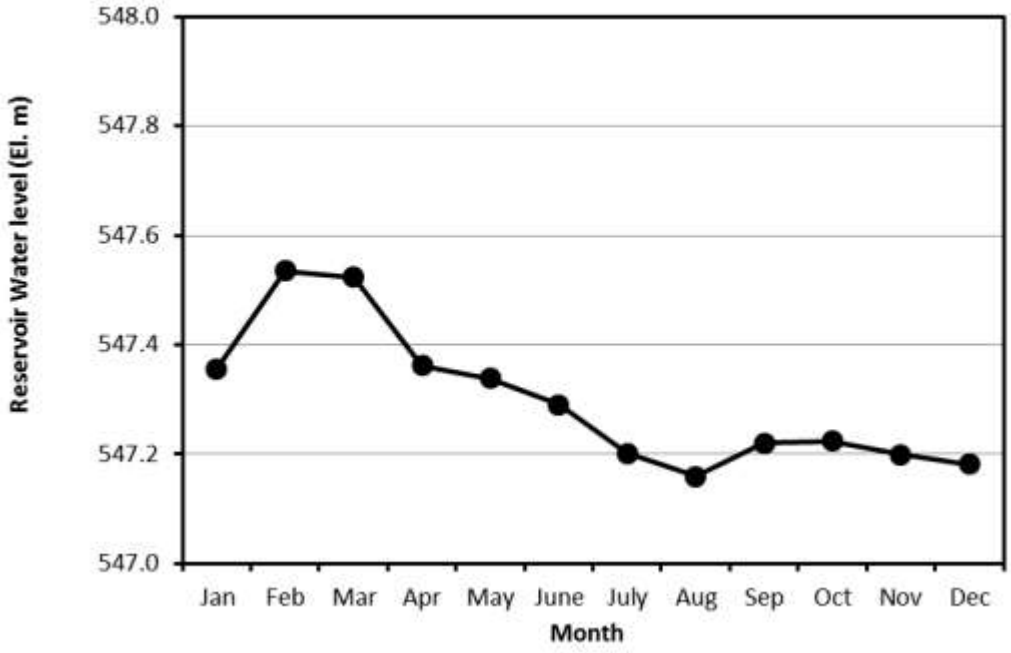

Figure 12: Predicted average water level in the Moragolla reservoir

V. ANALYSIS OF ALTERNATIVES

109. Section 1.1 of the Local EIA report describes the process through which the Moragolla site was identified as suitable for hydropower generation, and the subsequent studies through which the project was developed over several decades. The Feasibility Study investigated three alternative locations for the dam, which also involved different dam heights, lengths of headrace tunnel, and other scheme variations. Section 2.1 of the Local EIA report considers the main environmental impacts of each alternative and the No Project Option, the ease of mitigation of impacts and other aspects, including capital costs. This comparison is summarised in Table 5 overleaf.

Additional Table 6(a) for Addendum: Alternatives

Description	Local EIA (2012)	Environmental Addendum (2013)
Baseline data	• Sect. 2.1 Four alternatives & Alternative 2 preferred	• No change • CEB Selected the preferred option 2 using Multi Criteria Decision Analysis (MCDA)
Impacts	• Sect. 2.1 inundation of Ulapane valley • Sect. 2.1 Blasting risk to Industrial Estate • Sect. 2.1 Slope protection risk	• CEB Restudy and Simulated reservoir flood levels for deciding of buffer zone. • CEB carried out additional Geological investigations • CEB carried out aditional Geological investigations & field observation
Mitigation	• Sect. 2.1.3 Full supply level restrict to 548m • Sect. 2.1.3 repositioning of intake location • Sect. 5.4.1 Slope protection	• No change • CEB shifted dam axis by 100m further downstream • No change

110. The initial screening identified Alternatives 1 (High Dam, Short Tunnel) and 2 (Moderate Dam, Longer Tunnel) as potentially feasible, and the Local EIA study then compared the technical, economic, and environmental implications of each. This is shown in Table 6, which clearly identifies Alternative 2 as the Preferred Option, on grounds of cost as well as potential environmental impacts.

Table 6: Comparison of Feasible Options (from Local EIA Report Section 2.1)

	Item	Alternative 1	Alternative 2	Preferred
Technical & Economic	1. Dam height (m)	49	32	2
	2. Tunnel length (km)	1.8	3.1	1
	3. Effective head (m)	70.5	69	NSD
	Gross head (m)	75	75	NSD
	Head loss (m)	4.5	6	NSD
	4. Annual Energy (GWh)	83	82	NSD
	5. Topographic conditions	Favourable	Favourable	NSD
	6. Geological conditions	Favourable	Favourable	NSD
	7. Project cost (USD$ million - dam and tunnel)	42	35	2
Environmental	1. Affected area	High	Low	2
	2. Inundation of existing roads (km)	3.5	0.4	2
	3. Inundation of cultivated and other lands	High	Low	2
	4. Resettlement impacts	High	Low	2
	5. Sanitation problems and health hazards	Same	Same	NSD
	6. Impacts on livelihoods of Affected Persons	High	Low	2
	7. Environmental Mitigation Costs	High	Low	2

Notes:

a) Comparison based on outline design information as available at Local EIA (2012).

b) Potential impacts were not quantified at the time of this analysis. A Low/High ranking was used to compare alternatives; this was for comparison only and is not based on any absolute value

c) NSD = No Significant Difference between the options for this factor

Table 5: Preliminary Screening of Project Alternatives (from Local EIA Report Section 2.1)

Alternative	Main Features	Option-specific Impacts	Cost considerations	Conclusion
1. High dam; short headrace tunnel	49 m dam parallel with Crysbro Farm (Fig 2) and a 1.8 km tunnel	The reservoir would submerge 3.5 km of the Mawathura-Galatha road and a large area of paddy land on the banks of the Ulapane Oya and create a pool alongside Ulapane village, causing sanitary issues and increased mosquito breeding	The extra cost of high dam would be offset by the reduced length and cost of the tunnel. There would be higher resettlement costs than other alternatives	Alternative 3 is difficult technically and highly expensive and was discounted. Alternatives 1 and 2 are similar in terms of technical feasibility Alternative 2 is slightly cheaper
2. Moderate dam; longer tunnel	32 m dam at Weliganga; 3.1 km tunnel	The reservoir would submerge paddy land on the Ulapane Oya, but only 400 m of the Mawathura-Galatha road, so loss of infrastructure would be less than Alternative 1	The capital cost of this option is roughly the same as for Alternative 1, but the reservoir inundates less infrastructure, so there would be lower resettlement costs than Alternative 1	
3. Low dam, open channel headrace tunnel	15 m dam just downstream of Ulapane bridge; 1.2 km pressure conduit to 3.1 km tunnel	This approach avoids submergence of the Ulapane Oya paddy fields and Mawathura Galatha road. However the Ulapane Oya prevents construction of a tunnel over the upper part of the route, so a pressure conduit is the only feasible solution.	The high extra cost of the pressure conduit makes this alternative impracticable	
4. No project	No hydropower scheme	This alternative involves no engineering works so there would be no environmental impacts at the site. However the Government would still have to fulfil the country's energy needs, and would generate power by an alternative method, most likely a 13 MW diesel-fired plant and a 14 MW gas turbine. This would generate an estimated 72,000 tonnes of CO_2/year, thus contributing significantly to global warming (figures from Final FS Review report[6])	The fossil-fuel-based alternatives would cost an estimated US$ 11 million per annum (FS Report Volume 5, Appendix K) and be vulnerable to fuel price fluctuations	Alternative 4 is significantly more costly in the long-term compared to hydropower options. It would also contribute significantly to global warming, which GoSL is committed[9] to reduce through increased use of clean and renewable energy generation via less carbon-intensive fuels. This alternative was therefore not considered further

[9] Government of Sri Lanka (2012): *National Climate Change Policy*. Government House, Colombo.

111. The preferred option was then subject to certain modifications in order to avoid or reduce specific environmental impacts identified during the options evaluation process. The main actions were:

a) Reduction in the reservoir FSL from 550 to 548 masl to reduce inundation of the Mawathura - Galatha road on the right bank and the Ulapane Oya valley on the left bank (see Fig 2) and avoid ponding behind Ulapane Village, which could encourage mosquito breeding and cause sanitation issues.
b) Repositioning the intake and aligning the headrace tunnel closer to the river to allay the concerns of businesses in Ulapane Industrial Estate (Fig 2) regarding the potential impacts of blasting in the tunnel.
c) Retaining the originally proposed location of the powerhouse and tailrace outfall to avoid increases in spoil transportation and dumping (and associated environmental impacts) and impeding operation of the Dunhinda irrigation canal, which would occur if proposed alternative locations were adopted.

112. Further modifications were introduced in the FS Review and DD study, to reduce other potential impacts, to address certain technical issues and reduce construction costs. These were:

a) Relocating the dam axis approximately 100 m downstream to a location requiring less excavation to reach suitable bedrock, thus reducing excavation in the vicinity of the industrial estate, and reducing the length of the headrace tunnel and the associated blasting and spoil dumping.
b) Modifying the proposal to use the existing Ethgala Road as the access route to the power house, and instead constructing a causeway across the river and new access roads from the less-inhabited right bank, thus reducing disturbance to residents in the Ethgala area.
c) Redesigning the proposed surface penstock as an underground structure, to avoid the surface excavation and slope stabilisation measures, which will also reduce disturbance by noise, dust and visual intrusion in this area.

VI. BASELINE CONDITIONS, ENVIRONMENTAL IMPACTS AND MITIGATION

A. Approach

113. The review of the Local EIA report conducted in November 2012 (see Gap Analysis, Appendix 1) concluded that the description of the existing environment of the project area was appropriate and based on current data; and that the assessment of the potential impacts of construction and operation of the project was based on a robust analysis and recommended suitable mitigation. Certain issues were identified where some further study was needed and these were addressed by the additional studies, the final reports of which are provided in Volume 4 of this report. The fields in which additional work was conducted were as follows

Physical:	water quality; groundwater; environmental flow; land-use; slope stability; dam failure;
Biological:	aquatic ecology; terrestrial ecology; newly-proposed quarry and spoil disposal sites; afforestation and watershed management plans;
Human:	socio-economics; downstream river users; consultation and disclosure; institutional arrangements.

Additional Table 7(a) for Addendum: Baseline conditions and enviromental impacts

Description	Local EIA (2012)	Environmental Addendum (2013)
Baseline data	• Chapter 3, Annexures 1-4 and Appendices Cand D	• Volume 4 Collection of updated data by studies of Aquatic ecology; Ground water distribution; Terestial ecology, River water quality, etc. •
Impacts	• Sect. 2.1 Inundation of Ulapane valley • Sect. 2.1 Blasting risk to Industrial Estate • Sect. 2.1 Slope protection risk	• CEB Restudied and Simulated reservoir flood levels for establishing of buffer zone. • CEB Executed additional geological investigations and ground mapping. • CEB Conducted aditional geological investigations & field observation

114. Consultation and disclosure is described in Chapter VII below; and the institutional arrangements for project implementation are explained in the Environmental Management Plan (Volume 2). The additional work on the other topics is presented and discussed in detail in the following chapter below. This includes summaries of the existing conditions, impacts and mitigation in the main environmental sectors (physical, biological and human) as described in the Local EIA report, in order to present the complete assessment of impacts.

115. The re-assessment of impacts was aided by the development and application of two primary assessment tools, which are shown in Tables 7 and 8. The first is a Summary Matrix of Environmental Impacts (Table 7), which was used to screen each aspect of the project and each constituent activity for all potential interactions with the environment. The matrix shows all of the project activities in each phase down the left hand side and each component of the

natural environment across the top; and in each case indicates by means of a simple coding system how the two will interact. This identifies the sources of impact and their broad nature (positive/negative; significant/not significant).

116. The nature and scale of the impacts is then determined in more detail from Table 8, which summarises the type of impacts likely to be associated with each activity in this project, in a simple series of bullet points. This considers the impacts first in terms of the project activities, and then in terms of the main baseline parameters (both as listed in the Summary Matrix), which can be cross-referenced to ensure that all potential impacts are captured. The information in the bullet points then forms the basis for the discussion of impacts throughout the following chapter.

117. These are simple assessment tools, which have been used on a variety of projects elsewhere, in each case tailored to the specific project and location. Tools like these normally prove especially useful in complex projects such as this, because they provide a logical framework within which to identify sources of impact and the outcomes, and detailed checklists, which ensure that nothing is overlooked.

Table 7: Summary matrix of environmental impacts

Project: **Moragolla Hydropower**	Country: **Sri Lanka**	Location: **Mahaweli Ganga**	Proponent: **CEB**
DESCRIPTION OF CODES			
0	**+**	**-**	**X**
No significant negative impact (transient, or high recovery potential, or small ratio loss) and there is no significant public concern.	Significant positive impact	Negative impact that can be mitigated to acceptable levels (moderate or minor).	Significant Negative Impact that cannot be mitigated (major)

MATRIX OF IMPACTS

	PHYSICAL/CHEMICAL							**BIOLOGICAL**						
Project Activities	**Slope/ Sediment Stability**	**Climate**	**Air Quality**	**Noise Levels & Vibration**	**Hydrology**	**Groundwater**	**Surface Water Quality**	**Biodiversity**	**Protected Areas**	**Vegetative Cover/ Diversity**	**Forest Resources**	**Wildlife, Terrestrial, Avian**	**Aquatic Habitats**	**Fish Stocks/ Migration**
Pre-Construction														
Land acquisition: temporary	0	0	0	0	0	0	0	-	0	-	-	-	0	0
Land acquisition: permanent	0	0	0	0	0	0	0	-	0	-	-	-	0	0
Land clearing and cuts (work sites and access roads)	-	0	-	-	0	0	-	-	0	-	-	-	-	0
Influx of workers (worker camps)	0	0	0	-	0	0	-	0	0	0	0	-	0	-
Construction equipment mobilized	0	0	-	-	0	0	0	0	0	0	0	-	0	0
Fuel storage	0	0	0	0	0	-	-	0	0	0	0	0	-	-
Construction														
Influx of more workers (worker camps)	0	0	0	-	0	0	-	0	0	0	0	-	0	-
More construction equipment	0	0	-	-	0	0	0	0	0	0	0	-	0	0
More fuel storage	0	0	0	0	0	-	-	0	0	0	0	0	-	-
Blasting	-	0	0	-	0	-	0	0	0	0	0	-	-	-
Quarry operation	-	0	-	-	0	0	-	0	0	-	0	-	-	0
Crusher plant operation	0	0	-	-	0	0	-	0	0	0	0	-	0	0
Muck generation and disposal	-	0	-	-	0	0	-	0	0	0	0	-	-	0
River diversion (cofferdam)	0	0	0	0	-	0	-	0	0	0	0	0	-	-
Transmission line tower installation (land clearing)	-	0	0	0	0	0	0	0	0	0	0	0	0	0
Operation														
Reduced worker numbers (just permanent staff)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reservoir operation (flooded area)	-	0	0	0	-	0	-	0	0	-	-	-	+	+
Water intake to headrace	0	0	0	0	-	0	0	0	0	0	0	0	0	-
Diversion dam operation	0	0	0	0	-	0	-	0	0	0	0	0	-	-
Maintenance of minimum environmental flow	0	0	0	0	-	0	-	0	0	0	0	0	-	-
Occasional sediment purging	0	0	0	0	0	0	-	0	0	0	0	0	-	-
Risk of dam burst	-	0	0	0	-	0	-	0	0	0	0	0	-	-
Maintaining cleared right-of-way for transmission line	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8: Summary of impacts associated with each project activity and physical/chemical or biological parameter

Summary Analysis of Impacts by Project Activity	
Project Activities	**Possible Impacts (on all baseline parameters)**
Pre-Construction	
1. Land acquisition: temporary	Impacts are due to loss of access and clearing vegetation, leading to: • Reduced use of farm land and loss of any associated income during construction period (then access again). • Reduction in visual aesthetics of current lands (converted to roads, construction sites; and used by trucks and other vehicles). • Temporary loss of habitat and associated biodiversity, due to vegetation clearing, tree clearing (to be compensated); possible temporary disturbance of terrestrial wildlife during pre-construction activities. • Then, all temporary land acquisition areas will revert to rehabilitated or wild state after construction.
2. Land acquisition: permanent	As above (#1). So impacts are due to loss of access and clearing vegetation, leading to: • Some houses being demolished and permanent reduced use of farm land, with associated loss of income and assets: compensated. • Reduction in visual aesthetics of current lands (less appealing visuals, due to creation of staff quarters, facilities, and project buildings). • Limited permanent loss of habitat and associated biodiversity, due to vegetation clearing; tree clearing (to be compensated); areas no longer accessible or attractive to terrestrial wildlife. • In summary, permanently acquired land will be converted to staff quarters, facilities, and project buildings, rather than wild state, but with tree and shrub planting to mitigate.
3. Land clearing and cuts (work sites and access roads)	As in #1 and #2 above, land clearing is the requisite activity after acquisition. Impacts in #1 and #2 above apply; in addition the main concern is sediment mobilization and erosion, possibly leading to: • Slope instability and sediments entering forested areas and creeks and the river (causing reduced water quality due to turbidity and possible occlusion of aquatic habitat, until sediments are flushed naturally). • Generation of dust (transient). • Associated noise (transient). • Health and safety issues associated with construction, as well as risks to local communities using the access roads. • When land clearing is complete, access roads are finished, and facilities are in place, all of the above impacts and risks are neutralized. Furthermore, the construction activity and access roads will increase local business and improve transportation services (mostly in the northern end of the project area, where there are more people).
4. Influx of workers (worker camps)	• Risk of social instability (with first wave of workers), poaching of fish and wildlife near work sites, and generation of waste (risk of reduced water quality from sewage), and noise. • Health and safety issues associated with construction work. • On the other hand, there will be increased business opportunities associated with worker consumption.
5. Construction equipment mobilized	• Mostly a concern with noise, emissions, and dust and their effects on workers, local residents and wildlife; all transient and in sporadic occurrence, although centred on work sites. • Health and safety issues associated with construction equipment (accidents). • Poor aesthetics of vehicles and equipment in a well-vegetated natural environment. • Equipment and construction activities may inhibit wildlife movements.
6. Fuel storage	• Risk of spills, if not properly controlled and bunded; risk of contamination of groundwater and surface water (aquatic habitat compromised; possible impact on various fish species; impact on water supplies and users). • Explosion risk.
Construction	
7. Influx of more workers (camps)	• As in #4 above, except that numbers increase and risks increase accordingly.
8. More construction equipment used	More equipment used for the dam, tunnels, powerhouse, etc • As in #5 above, except that more equipment is used over a longer period, so risks increase accordingly.
9. More fuel storage	• As in #6 above, except that the risk of a spill increases (higher volumes in more locations).
10. Blasting	• Generally, this can be managed with few or no impacts if carefully planned and implemented with proper safety protocols and local awareness-raising; but there is a residual concern for “knock-on” effects, such as slope instability, noise and risk of wildlife disturbance, possible fracturing of bedrock and alteration of

Summary Analysis of Impacts by Project Activity	
Project Activities	**Possible Impacts (on all baseline parameters)**
	existing aquifer dynamics (groundwater). • Concern for fish exposed to pressure wave of blasting (has occurred in other locations downstream). • Associated health and safety risk.
11. Quarry operation	• As in #3 and #5 above; mostly a concern with noise and dust; truck traffic on public roads. • Risk of localized land slips; some vegetation clearing may be necessary; risk of disturbance of wildlife. • Possible sediment run-off to local creeks and streams (turbidity and reduced quality of aquatic habitat). • Loss of public access to adjacent land. • Reduced visual aesthetics in adjacent areas. • Health and safety issues for quarry workers.
12. Crusher plant operation	• Concern for noise and dust; truck traffic, although localized. • Risk of sediment mobilization to local creeks and streams, and possibly the river (causing turbidity and reduced quality of aquatic habitat). • Reduced visual aesthetics in adjacent areas. • As with other work sites, health and safety issues for workers. • Disturbance of terrestrial wildlife in immediate area.
13. Tunnel muck generation and disposal	• Concern is for slope stability and proper containment of deposited muck (it is more significant for this activity than any of the others); so disposal sites will require preparation and containment structures (retaining walls) beforehand; • Risk of sediment entry to local creeks and the river (restricted hydrology and turbidity plumes leading to negative effects on aquatic habitat, albeit transient). • Dust and noise will be generated (mostly by trucks and dumping). • More difficult access to areas adjacent to muck disposal sites. • The muck disposal sites present very poor visual aesthetics until such time as they are terraced and re-vegetated. • Health and safety issues (especially truck drivers and dozer operators). • Temporary disturbance of terrestrial wildlife and loss of plants and slow-moving animals if submerged by dumped material.
14. River diversion (cofferdam)	• Very temporary disturbance of the river (during finalization of the cofferdam). • The river will be channelled to the diversion tunnel for most of the duration of the main dam construction, which will maintain downstream discharge and regular seasonal variations. • There will likely be some turbidity pulses in the river during cofferdam construction (which will be flushed quickly); transient impacts on aquatic habitat quality and possibly disturbance of fish.
15. Transmission line tower installation (land clearing)	• Minimal concern, as there will only be modification to an existing tower; some vegetation will be cleared (only a few trees evident), with a risk of some very localized slope instability. • No impact on wildlife expected, given that a tower already exists on the proposed site.
Operation	
16. Reduced worker numbers (just permanent staff)	• Diminishing local supplier business and reduced demand for informal businesses near construction sites and the local roads. • Reduced risk of friction between immigrant workers and local communities; increased social/cultural stability.
17. Reservoir operation (flooded area)	• Permanent flooding of the margin of the Mahaweli Ganga for a distance of about 3 km (mostly steep slope vegetation, some trees and scrub); only a very small percentage of similar adjacent habitat on both sides of the river will be inundated. • Alteration of upstream hydrology (from fast-flowing to more quiescent); this could present an opportunity for aquatic habitat diversity, which may suit some species in this section of the river; option for recreation and interpretation facilities; a positive for visual aesthetics (water body in this hill area, with a vegetated 100-m buffer all around); risk of safety issues, if there is increased public access to reservoir/river area. • Upstream areas (watershed) will need to be maintained to ensure good water quality.
18. Water intake to headrace	• Risk of fish intake, due to accelerated velocity near intake; but a sequential screen apparatus can preclude this risk.
19. Diversion dam operation	• Localized fish movement will be disrupted (no upstream movement, and just downstream movement through the spillway, with minimum environmental flow; however, no long-distance migrants use this part of the river. • Reduced downstream discharge, potential alteration of downstream surface water quality. • The dam itself and the reduced river flow will present a negative visual aesthetic.
20. Maintenance of minimum	• Related to the above (#19), reduced downstream discharge, especially in the lean season (December-March).

Summary Analysis of Impacts by Project Activity	
Project Activities	**Possible Impacts (on all baseline parameters)**
environmental flow	• Alteration of river width available as habitat (narrower); increasingly, discharge will be made up, downstream, by tributaries; monsoon flows will still be substantial; habitat for fish will still be maintained up to the diversion dam, but reduced in area, volume and quality. • Reduced visual aesthetics of the downstream Mahaweli (smaller river), for about 3 km until it reaches the combined tailraces and discharge of the Atabage Oya.
21. Occasional sediment purging	• Purging of sediments from the reservoir, if they accumulate to the height of the intake, may be required after 15-20 years; this may result in a turbidity pulse in downstream parts of the river, depending on how this process is undertaken; this will be a very transient effect, that can be mitigated by undertaking this during the monsoon, when turbidity in the river is at a maximum, in any case. • Temporary degradation of aquatic habitat and impacts on fish will be minimal, if undertaken at a time when the river has high suspended sediment loads (June-September); sediments will be flushed quickly, into the downstream sections of the river.
22. Risk of dam burst	• This is a very low probability event, which can be monitored, if there are signs of pending dam failure; the concern is for human safety, given that there are many communities within the flash flood zone downstream. • A warning system can nevertheless be installed to notify of a pending dam failure. • Any resulting flash flood would cause scour along the river banks and a huge turbidity plume, clogged with scrub vegetation and trees; it would also damage the existing downstream aquatic habitat and flush fish into downstream areas down to the Polgolla dam; recovery from a flash flood would take a few years, but it would occur.
23. Maintaining cleared right-of-way for transmission line	• Regular clearing of the vegetation within the right-of-way, especially near the tower foundation; this is a very small project footprint and is therefore inconsequential. • Local communities would most likely use the right-of-way for farming. • Negative visual aesthetics of the transmission line will persist, with regular clearing of the right-of-way.

Summary Analysis of Impacts by Baseline Parameter	
Parameter	**Accumulated Impacts From all Project Activities**
Physical	
Slope/ Sediment Stability	• The main concern is with road cuts (for the access roads), and disposal of tunnel muck; these operations will require slope stabilization prior to and during work; therefore, the risk of sediments going down slope, knocking down trees and entering watercourses can be managed. Most of these works will be less than 500 meters from the river so there is an associated risk of silt entering the river and increasing turbidity. • There are smaller risks of slope failure from blasting and the quarry operation. • All new sediment slopes will eventually re-vegetate; this can be accelerated by planting appropriate steep slope vegetation as soon as possible after the slope has been created, and terracing as much as possible.
Climate	• The project will not impact climate *per se*; future climate variation may have an impact on annual rainfall amounts and seasonal patterns, which may affect the project power production modelling. • There will be a significant offset of carbon dioxide emissions that would otherwise be produced, if coal or oil were used to produce the equivalent amount of electricity.
Air Quality	• Air quality impacts relate mainly to the generation of dust during excavation, blasting and earth-moving, operation of vehicles on unmade site roads, and vehicle exhaust emissions. • All air quality impacts will be localized and transient during pre-construction and construction; these can all be mitigated with exhaust and dust controls. Local communities will not be immediately adjacent to work sites. Workers can wear masks to reduce health impacts of dust.
Noise Levels, Vibration	• The main sources of noise will be from excavation, earth-moving, blasting (short-duration and infrequent), site vehicles, and certain activities and equipment such as stone-crushing. • Noise increases will also be localized and transient during pre-construction and construction; noise increases can be managed with exhaust controls and workers wearing ear protection. Local communities will not be immediately adjacent to work sites.
Hydrology	• The main impact is a reduction in downstream river discharge, as a result of the diversion dam; a minimum environmental flow of 1.5 m^3/s, with some downstream tributary increments, will compensate. • The “knock-on” effects of reduced downstream discharge include reduced river width below the dam, altered aquatic habitat, and less volume of habitat for fish. • A dam burst would create a sudden change in downstream hydrology (flash flood, with rapid dissipation downstream), although such an event is unprecedented.

Summary Analysis of Impacts by Baseline Parameter	
Parameter	**Accumulated Impacts From all Project Activities**
Groundwater	• Linkages between the project and groundwater are expected to be minimal; a fuel spill could possibly contaminate groundwater, and blasting could create a localized shift in aquifer characteristics that might affect percolation and recharge. • Creation of the headrace tunnel is unlikely to cause a preferential drainage channel and depletion of groundwater wells in the vicinity as all wells exploit discrete aquifers confined by bedrock above the tunnel route
Surface Water Quality	• Transient reductions in surface water quality, caused by pre-construction and construction activities (would most likely be sediment intrusions into the river), should be of little concern, as they will very quickly be flushed downstream during most months (April-November); turbidity plumes created in the lean season will take longer to flush out. Work site management, and sediment controls in particular, will reduce most risks of this nature. • Bunded fuel storage, sewage treatment on-site or off-site, and proper management of worker camps should minimize the risk of contamination of surface water by organic and hazardous materials. • Operation of the dam will create a flooded area, which, while constantly circulating and exchanging (due to inflow to the headrace), could lead to some risk of reduced water quality, especially in lower levels of the reservoir; upper watershed management will be encouraged. • Occasional sediment purging from the reservoir (perhaps only after about 20 years) could cause some turbidity plumes downstream, but this will likely be done during the high discharge monsoon season, when the river is already carrying a higher sediment load, and discharge volumes are quite high, which will accelerate flushing. • Reduced discharges in the lean season (with minimum environmental flow) create a higher risk of reduced water quality in downstream areas as there will be less dilution of any pollutants and less natural aeration because of reduced water flow.
Biological	
Biodiversity	• Land acquisition and related clearing (mostly in secondary forest or scrub vegetation areas), for the dam and powerhouse components, and the worker camps) will reduce available habitat (vegetation) and may therefore reduce available area for wildlife. However, none of these project sites are critical or unique in terms of biodiversity, and no vulnerable or endangered terrestrial species are likely to be affected. • No net loss of species, or incremental pressure on specific species, is likely to occur. It is therefore expected that no measureable change in local biodiversity will occur as a result of the project. However, see comments regarding fish below.
Protected Areas/ Biological Corridors	• There are no protected areas in the zone of influence of the Moragolla project and no known biological corridors through which significant numbers of animals migrate.
Vegetative Cover/ Diversity	• All land clearing will occur in areas which have been altered or degrading over the last >100 years (for tea plantations and home gardens); no unique habitats or protected/ vulnerable species will be cleared. • While some cleared areas will remain permanently converted to project sites, they will be enhanced with plantings, and all temporarily cleared areas will be allowed to revert to natural vegetative cover, or will be planted with specific species.
Forest Resources	• As noted above, approximately 900 trees have been identified for cutting, but this includes no vulnerable or protected tree species. • All trees that will be cut will be compensated for, by replanting appropriate species to create suitable habitat for wildlife at a ratio of at least 2 new trees for every one lost.
Wildlife, Terrestrial, Avian	• No specific unique wildlife habitats will be affected by the project, and the project will not create any large barriers to wildlife and bird movements; any disruption of wildlife behaviour will be temporary (just during pre-construction and construction), and animals (including birds) will be able to move around or over construction sites. • Wildlife are at risk from poaching (construction workers), but this potential activity will be disseminated as an illegal activity and monitored.
Aquatic Habitats	• Aquatic habitat is at risk from sediment and hazardous material inputs, if work site management and mitigation measures are not properly designed and implemented; the most pervasive risk is sediments entering the watercourses. • Fortunately, the Mahaweli is fast-flowing (in most months), and any sediment inputs will likely flush out quite quickly (in most months, except during the lean season); any intrusion or contamination of aquatic habitat during the pre-construction and construction phases would be transient. • Formation of the reservoir above the diversion dam could be a positive feature (diversity of aquatic habitats, more lentic conditions suitable for some native fish currently in the river system), whereas reduction in discharge below the diversion dam (minimum environmental flow) will reduce the volume and quality of river habitat, and possibly cause dis-connections between the various deeper pools downstream to the tailrace site (about 3 km); the discharge from the Atabage Oya, and the Moragolla and Kothmale tailraces will maintain a large discharge in the Mahaweli throughout the rest of the

Summary Analysis of Impacts by Baseline Parameter	
Parameter	**Accumulated Impacts From all Project Activities**
	downstream sections. • During project operation, there could be occasional turbidity pulses in the river, due to sediment flushing or cleaning in the reservoir (but only after about 20 years); this would likely occur during the monsoon, when river discharge is high and suspended sediment levels are at their annual peak, in any case. • A dam burst would cause a rapid scouring effect in the downstream of the Mahaweli, which would create a significant alteration of existing aquatic habitat; this would be an unprecedented event and would require several years for recovery.
Fish Stocks/ Migration	• During pre-construction and construction, fish will continue to have access to all sections of the Mahaweli Ganga, with largely unrestricted movements (through the diversion tunnel and the openings in the temporary causeway). • Fish may be at risk from poaching and from sediment and hazardous material spills into the river. • During project operation, fish may continue to make movements downstream (through the sluice gates when operating and the intake for environmental flow; they will be screened from the headrace intake); they will not be able to move upstream past the diversion dam. Most fish found in the river occur above and below the dam site at present and will continue to exist and breed as such; the mountain Labeo, in this area, only occurs below the dam site, and therefore does not appear to need the upper reaches of the Mahaweli Ganga for feeding or breeding (they are possibly blocked by the waterfalls and cascades at and above the dam site). • Nevertheless, various mitigation measures for fish are proposed.

B. Recommendations of Local EIA study: Physical Environment

Additional Table 9(a) for Addendum: Physical Environment

Description	Local EIA (2012)	Environmental Addendum (2013)
Baseline data	• Chapter 4, Annexures 1,5,7and Appendices A, D, F	• Volume 4 ;Collection of data to redefine existing condition through aquatic ecology; groundwater; river water quality, etc. •
Impacts	• Sect.4.1 soil erosion and siltation • Sect.4.2 water quality impact • Sect.4.3 ecological impact • Sect.4.4 impact due to reduction of river discharge capacity • Sect.4.5 impact on bedrock stability •	• Volume 2 Sect 2 • Volume 2 Sect 2 • Volume 2 Sect 2 • Volume 2 Sect 2 • Volume 2 Sect 2 •
Mitigation	• Sect. 5.4 measures to address impact on physical environment. • Sect. 5.5 measures to address impact on biological environment. •	• Volume 2 Sect 2 . • Volume 2 Sect 2 • .

118. The Local EIA report described existing conditions in nine elements of the physical environment (topography; geology; land-use; drainage; hydrology; water quality; air quality; noise; and vibration) and then identified potential impacts and mitigation in each field. This is

summarised in Table 9, which shows that the main expected physical impacts during the construction period are:

- Tunnel excavation could temporarily lower ground water levels, reducing the availability of water in wells and in streams used to irrigate paddy fields in the vicinity;
- 489 mature trees will be removed from the reservoir and other construction sites, adversely affecting the local landscape (and ecology - see Section VI.K below);
- Soil could erode from construction sites and spoil dumping areas during heavy rainfall;
- Labour camps could be a source of additional pollution if they are not adequately managed and provided with suitable sanitary facilities;
- Noise and vibration from construction activities could disturb people and wildlife;
- Blasting and ground vibration could injure workers and cause damage to property.

119. The mitigation proposed in the Local EIA report in order to address these impacts is as follows:

- Provide alternative drinking water from tankers if water levels are reduced in wells; and pay compensation to farmers if yields are reduced in paddy fields;
- Plant trees and other vegetation in a 100 m wide buffer zone around the reservoir perimeter above FSL to compensate for trees felled during construction;
- Implement a Soil Conservation Plan to reduce soil erosion at all construction sites; and build dykes at spoil disposal sites to provide suitable drainage;
- Provide appropriate sanitary and sewerage facilities at worker accommodation camps;
- Ensure construction work adheres to appropriate legal standards for noise and vibration;
- Ensure that tunnel construction and blasting are conducted according to the appropriate legal and technical standards and that all work is subject to an appropriate Occupational Health and Safety Plan (OHSP).

Table 9: Summary of existing conditions, potential impacts and mitigation in the physical environment, as presented in the 2012 Local EIA study

Existing Physical Conditions	Potential Impacts	Proposed Mitigation
Topography: The project area is in the middle peneplain of Sri Lanka where the topography comprises ridge and valley systems with steep slopes. Ridges are heavily dissected by 1st and 2nd order streams, which flow in a dendrical pattern and join the Mahaweli River, which flows NNE. In the project area the river valley is narrow, with a 30-35° slope on the left bank and around 18° on the right. The project is located between the confluences with the Kothmale Oya and Atabage Oya, the two main tributaries in the upper Mahaweli Ganga basin. The left bank comprises low hills (to 950 masl) separating the Mahaweli Ganga from the Maha Oya basin. The right bank rises to 850 masl and separates Kothmale Oya and Atabage Oya sub-basins. The river bed drops from 551 masl at the confluence with the Kothmale Oya to 473 masl at the confluence with the Atabage Oya, providing a gross head of 78 m. Above and below the site, bed levels are less steep. Ulapane Oya, a minor left bank tributary with a wide valley, joins the Mahaweli Ganga immediately upstream of the dam site. Kothmale dam lies upstream on the Kothmale Oya and the headrace tunnel, underground powerhouse and tailrace tunnel lie within the hill on the right bank, so the Moragolla structures will be on the left bank.	Water level fluctuations could cause landslides along the reservoir banks	Provide upslope drainage, retaining structures and toe protection along reservoir banks where needed to prevent failure of slopes
Geology: The project area falls within the Highland complex of pre-Cambrian crystalline rocks, close to the western boundary with the Kadugannawa complex. The geological structure is simple, although the regional structure is of NW plunging synforms and antiforms. The strike trend is N-S with slight deviations to the NW and NE; dip direction is W with moderate to gentle angles (10-40°). The NW trending Kotmale Shear Zone crosses the area in the middle of the tunnel route. Garnetiferous/Charnockitic gneiss and Quartzite are the dominant rock types and underlie most of the project area. Bedrock outcrops are common along the river bed, bank and on slopes. Overburden consists mainly of soils, talus deposits and colluviums (transported soil). Soils comprise slity-sand, clayey silty-sand and clayey-sand, with high moisture and plasticity, specific gravity of 2.4-2.6 and 35-40% fines. Engineering geological investigations at the sites of project components are discussed in the Local EIA (Volume 4).	Tunnel excavation could temporarily lower ground water levels, reducing the availability of water in wells and in streams used to irrigate paddy fields	Provide drinking water from tankers if wells are affected during construction; and pay compensation to farmers of paddy lands if cultivation is reduced
Land-use: Undulating topography with mixed vegetation is the dominant landscape; and tea plantations (abandoned and active), homesteads and shrubs are the main land-uses; Ulapane industrial area is on the hill west of the dam. *Reservoir:* 90% of the inundation area comprises steeply-sloping river valley, which is unsuitable for agriculture or other uses. The flora includes various trees, such as mahogany, magnolia etc. The remaining inundation area includes a 410 m length of road on the right bank, some residential land and areas planted with mixed crops. *Tunnel:* The land above the tunnel route is 35-40% bare and the rest is cultivated with mixed crops (pepper, coffee, cardamom, fruit trees, etc) and small patches of tea and paddy lands. Ulapane Industrial Estate and small settlements (Denmark Watta, Ethgala Watta and Ulapane Village) are nearby. *Surge Shaft, Penstock, Powerhouse:* abandoned land, no agriculture, two houses near the surge shaft. *Transmission Line:* 80% home gardens; 20% abandoned land.	Creation of the reservoir will inundate 400 m of the Mawathura-Galatha road. 489 trees of DBH >20 cm will be removed from the reservoir and other project sites	Build a new diversion road to replace the inundated length. Plant trees and other vegetation in a 100 m wide buffer of green belt around reservoir high flood level

Existing Physical Conditions	Potential Impacts	Proposed Mitigation
Residential Camp: Mainly cultivated with mixed crops and fruit trees, and with some trees of timber value.		
Drainage: Mahaweli Ganga originates at 1300 m around Hatton. At 5km above the dam site it is joined by Kotmale Oya, one of the largest tributaries in the basin. Two smaller tributaries (Ulapane Oya and Atabage Oya) join the Mahaweli upstream and downstream of the dam site on the left and right banks; and all other streams are quite short. Kotmale dam and reservoir (172.5 MCM) retain all water in Kotmale Oya except for large flood flows; and after passing through the Kotmale conveyance, water returns to the Mahaweli upstream of Atabage Oya. Thus most of the discharge from Kotmale Oya is unavailable to the Moragolla scheme.	Soil could erode from construction and spoil dumping sites during heavy rainfall	Implement a Soil Conservation Plan to reduce soil erosion at all sites; build dykes at spoil disposal sites to provide suitable drainage
Hydrology: The mean annual natural flow of the river at the dam site is 21.95 m^3/s, with a range of 13.8 to 34.6 m^3/s over a 40-year period (1968-2007). The average minimum flow in February and March is 6.38 and 6.83 m^3/s and the average maximum (June) is 39.79 m^3/s. In contrast the flow duration curve shows a minimum of 3.0 m^3/s (100% occurrence) and a maximum of over 75 m^3/s (<5%). There are no reliable records of the highest flood levels, but this was estimated at 526 masl from flood marks, deposition levels and infrastructure locations. Floods can be caused by the annual monsoon and especially by tropical cyclones but the latter are rare. Kotmale reservoir regulates 562 km^2 of the total 809 km^2 Moragolla catchment (ca 70%), which lowers the risk of flooding from short-recurrence events, but not those with higher return periods as the reservoir would also be full at that time.	Low flows in the 400 m of river downstream of the dam could affect aquatic species Reduced river flow will provide less dilution so concentration of pollutants will increase. There could be additional pollution from labour camps	Release the proposed environmental flow of 1.5 m^3/s from the reservoir at all times. Relocate the Crysbro outfall to discharge downstream of the tailrace outfall. Provide proper sanitary & sewerage facilities at labour camps
Water Quality: Surveys showed that water quality was generally normal in the project area, except for high counts of coliform bacteria, which suggests faecal pollution. Subsequent tests suggested the outfall from the Crysbro Broiler Processing Industry and nearby housing as potential sources of this pollution, and river water in this area is unsuitable for contact recreation (eg bathing) or drinking without proper treatment (at least boiling).		
Air Quality: Levels of dust (PM_{10} and $PM_{2.5}$) and common atmospheric pollutants from traffic and industry (SO_2, NO_2, CO and O_3) were measured at 5 locations in March 2009 and all values were well within legal limits, giving no indication of air pollution in the project area.	Hydropower causes less gaseous emissions and less impact on climate change than hydrocarbon fuelled power generation	Positive Impact. CEB will investigate the possibility of obtaining Carbon Credits
Noise: Noise levels (day time and night time L_{eq}) were measured in March 2009 at 10 locations, including the proposed project locations and residential areas in the vicinity. Levels were all within acceptable limits (daytime 40-56 dB(A); night time 41-49 dB(A)), which indicates that the project area is a low-noise environment, mainly because of its rural location.	Construction noise and vibration could disturb people and wildlife	Construction must adhere to legal standards for noise and vibration; restrict night-time working
Vibration: Ambient levels of vibration were measured in March 2009 at 9 locations, including proposed project locations and residential and industrial areas in the vicinity. Vibration levels were all below the allowable level of 0.5 mm/s in residential or sensitive areas due to construction activities, so there should be no structural damage or inconvenience of people from vibration under normal circumstances.	Blasting and ground vibration could cause Injury to workers and damage to property	Tunnelling and blasting must be done to legal & technical standards. Health & Safety Plan must be followed.

120. These mitigation measures, and others identified by this re-assessment of impacts, are incorporated into the Environmental Management Plan (EMP) for the project, which is provided in Volume 2 of this report. The remainder of this section describes the additional investigations in the physical environment conducted in 2013, re-evaluates the potential impacts of the project in relation to these issues, and proposes additional mitigation where necessary.

C. Hydrology and Environmental Flow

121. The impacts of the project on hydrology in the Mahaweli Ganga and the adequacy of the proposed environmental flow of 1.5 m^3/s were investigated in 2013 on the basis of additional data and analyses generated by other elements of the FS Review and DD Study and a separate evaluation of the rationale and suitability of the proposed E-flow, the final report of which is provided in Volume 4. Results from both sources are incorporated into the discussion below.

Additional Table 10(a) for Addendum: Hydrology and Environmental Flow

Description	Local EIA (2012)	Environmental Addendum (2013)
1- Baseline data	• Sect. 3.14 Hydrology and drainage	• CEB Restudied hydrology in the project area and recalculate river discharge based on more accurate methodologies, models and criterias.
2,3- Impacts	• Sect.4.45 River diversion could cause localised flooding outside the main river channel • Sect 4.49 Releasing of river maintenance flow.	• No change • No change
4- Mitigation	• Sect.4.4.5.1 River diversion using coffer dams • Sect 4.49 Releasing of E-flow of 1.5m^3/s.	• Instead of using coffer dams diversion tunnel would be used by CEB for river diversion. • No change • Further discussed in Sect VI.C.4

1. Existing Conditions

122. The Mahaweli Ganga is the largest river system in Sri Lanka, with 24 tributaries that contribute to the combined discharge that drains into the Bay of Bengal at Trincomalee (Fig 13). The river originates in the high peaks in south central Sri Lanka, and is fed by a high mean annual basin rainfall, estimated at 3,852 mm/yr. In the southwest of the Mahaweli watershed, in which the Moragolla project is located, most of the rain falls from April to November (monsoon); and in contrast, the northeast part of the watershed does not exhibit much seasonality in rainfall.

123. Data from 40 years of daily observations presented in the Local EIA study (Volume 5 - Table 3.9, Annex 3) shows a mean annual natural flow in the river at the dam site of 21.95m^3/s,

with a minimum average monthly flow of 6.38 m^3/s in February and a maximum of 39.79m^3/s in June. Figure 14 shows this data as plotted in the Local EIA report (Appendix D), compared with data from the pre-feasibility study (labelled MAHW 263), which was based on monthly time-series. Both graphs show a similar variability associated with seasonal differences in rainfall, with average flows fluctuating around 10m^3/s between December and April and rising to 30-50 m^3/s in June to October, depending on the method of analysis.

124. Table 10 shows the flow duration curve at the dam site, as estimated by hydrological investigations during the FS Review study. This is similar to data in the Local EIA report and shows a calculated minimum flow of 3.6m^3/s (exceeded 95% of the time) and a maximum of > 66 m^3/s.

Table 10: Estimated flow duration curve for Mahwaeli Ganga at the proposed dam site

Percent Exceedence	Flow Rate (m^3/s)
95	3.60
90	4.46
85	5.34
80	6.28
75	7.33
70	8.99
65	10.34
60	11.91
55	13.31
50	14.80
45	14.49
40	18.76
35	21.12
30	23.74
25	27.19
20	31.99
15	38.47
10	47.97
5	66.07

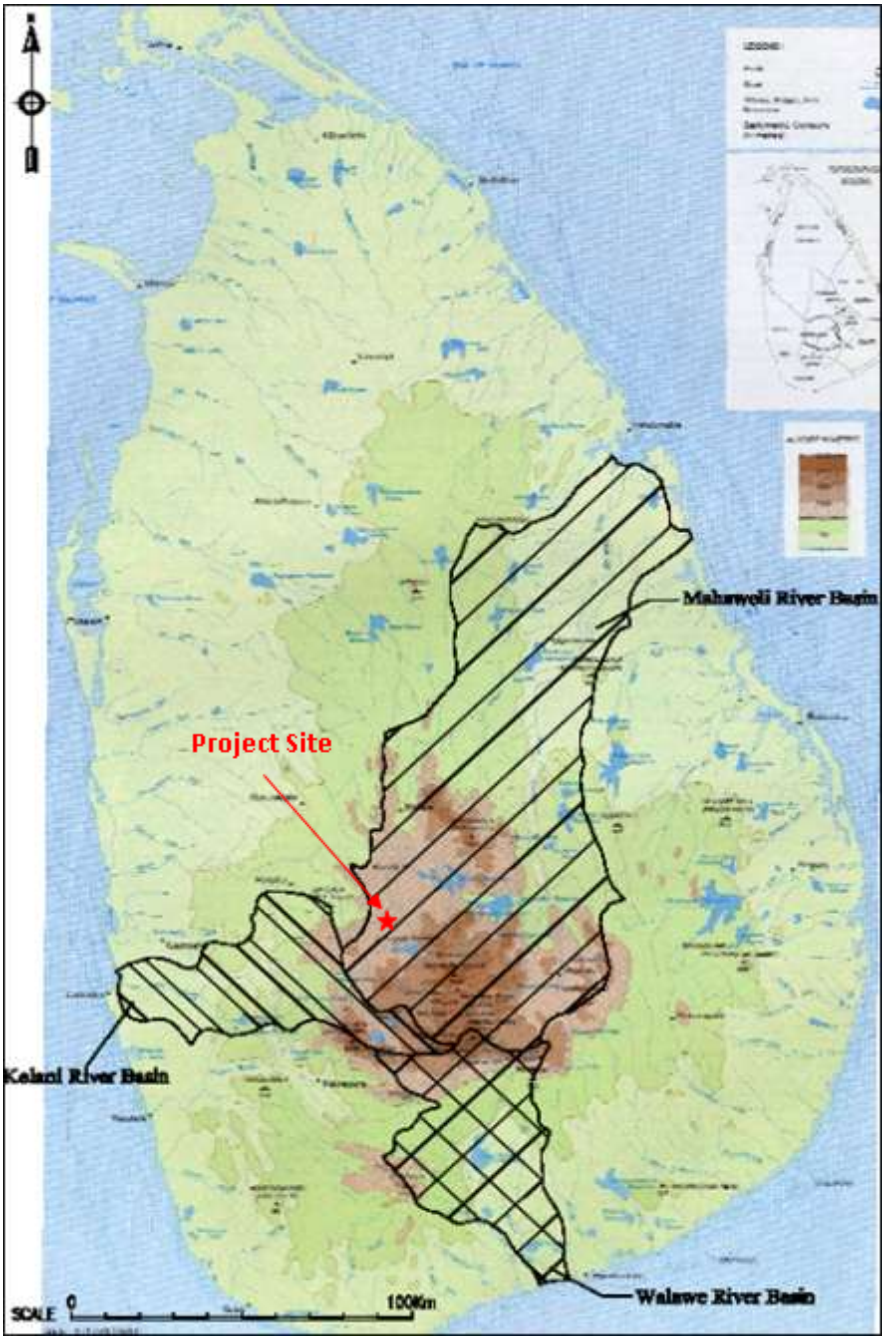

Figure 13: The major river basins in Sri Lanka

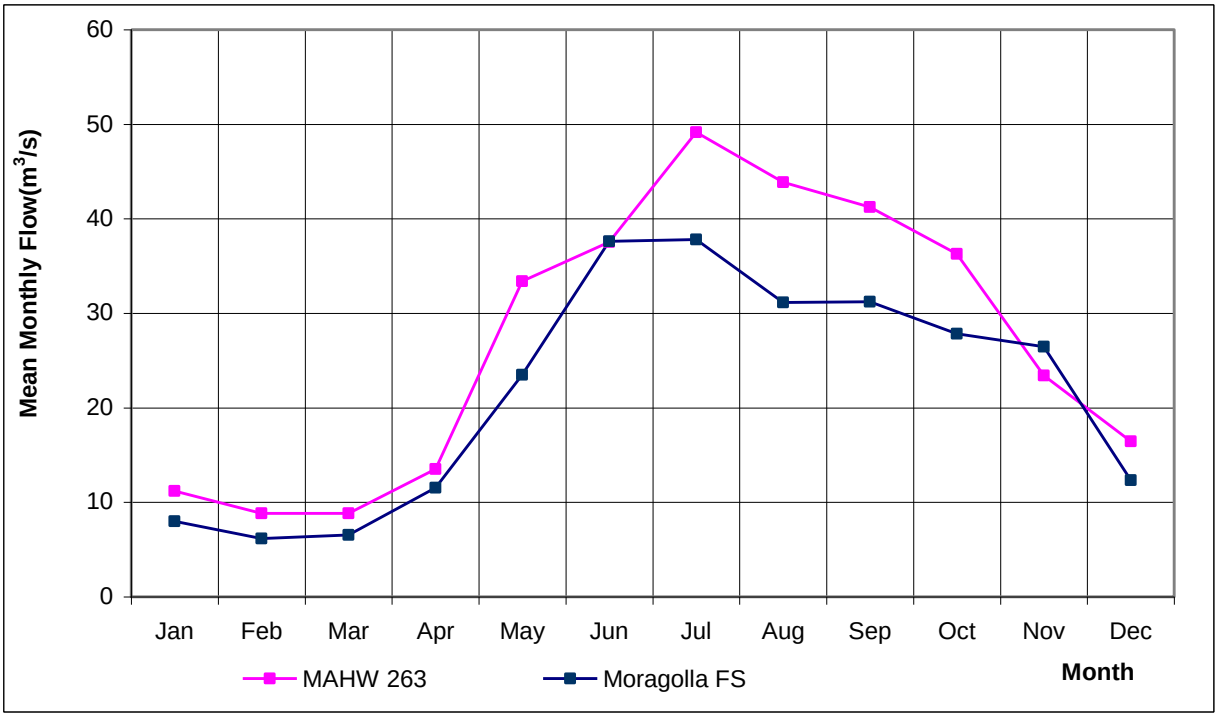

Figure 14: Average monthly flow in the Mahaweli Ganga (MAHW = pre-feasibility study, averages of monthly data 1950-1985; Moragolla FS = Feasibility Study, averages of daily data 1968-2007**)** - see Fig 11 for data from the FS Review Study

125. The other notable hydrological feature in the project area is Kotmale Oya, which joins the Mahaweli Ganga 3 km upstream of the proposed Moragolla Dam (Fig 2). This is one of the largest tributaries in the Mahaweli Basin, but its discharge is almost entirely captured by the Kotmale Dam and Reservoir (172.5 MCM) and used for power generation in a conveyance system beneath the hillside on the right bank opposite the Moragolla site. Water is returned to the Mahaweli near Atabage Oya (3 km downstream of the proposed dam) and only the unregulated peak monsoon flows will be available to the Moragolla scheme as Kothmale Dam (commissioned in 1985) provides no E-flow. The other tributaries in the study area are the Ulapane Oya immediately upstream of the dam and the Atabage Oya downstream, which are both much smaller than Kotmale Oya. There are some other small streams in the study area, but these are all short, and low in volume.

2. Pre-construction and construction phase impacts

126. The Impact Matrix in Table 7 shows that the main activities of the pre-construction phase will be land-acquisition and clearance, and initial mobilisation of the main contractors, who will establish their site offices and other facilities, and bring some construction equipment and a small workforce to site to conduct the initial set-up procedures. None of these activities will affect river flows, so there should be no impacts on hydrology during this stage.

127. Once construction begins, the main activity in which there could be effects on hydrology is construction of the dam, for which the river will be diverted to allow work to be conducted in the dry. This will involve prior excavation of a diversion tunnel (approximately 300 m in length) through the hillside on the left bank, followed by creation of rock and soil coffer dams to

gradually deflect water into the tunnel (see Fig 3). The diversion tunnel is designed to carry floodwaters of a 1 in 10 year dry season flood (320m^3/s), so in most circumstances water will pass through the tunnel without interruption. Cofferdams may be overtopped occasionally during the monsoon, but there will be no risk of failure as the cofferdams are constructed of cemented sand and gravel, and have been shown in extensive previous usage to withstand overtopping without substantial damage. There should therefore be no significant impacts on hydrology, as river flow will continue through the tunnel largely unimpeded throughout the year.

128. Two other activities that also involve construction in the river are creation of the tailrace outfall (the lower 25% of which will project into the river) and the causeway to allow vehicle access from the right bank. Both activities will require small-scale diversion of the river channel to enable construction to be done in the dry, but in both cases the river will continue in the existing channel and diversion tunnels or pipes will not be needed. To ensure that the diversion does not cause any localised flooding outside the river channel, both activities should be conducted in the dry season (December to April) when river flow is near the seasonal minimum.

129. The design of the dam includes a diversion conduit near the base, through which river water is allowed to pass temporarily, once dam construction is completed. At this time the coffer dams are gradually removed, and simultaneously, similar material is tipped at the intake to the diversion tunnel, to close the entrance. The diversion tunnel is then allowed to drain, after which the centre portion is sealed with a thick plug of concrete. After the various commissioning tests have been completed, the gated entrance to the diversion conduit (located at the base of the dam on the upstream side) will be closed to allow the reservoir to fill. At present it is planned that this will be done at the end of the dry season in April, and it is calculated that the water level will take approximately 19 hours to reach the height of the E-flow discharge, located around halfway up the dam face (just below the Minimum Operating Level of 542 masl). During the filling period there will be no downstream flow, so CEB will be in contravention of its obligation to provide a flow of at least 1.5m^3/s at all times. It will be necessary therefore to devise some means of allowing the requisite downstream flow during the filling operation.

3. Operation phase impacts

130. The hydrology of the river will begin to change whilst the reservoir is filling, as the natural flow cycle is replaced by a cycle determined by the needs of power generation. The most obvious changes will be the creation of a large lake upstream of the dam; and a reduction in flow in the river, especially between the dam and tailrace, which will only receive flows above the environmental discharge when there is an excess of water in the reservoir (mainly during the monsoon season). The other change will be the diversion of water from the reservoir through the headrace tunnel during the power generation cycle, when the water will be returned to the river through the tailrace 2.7 km downstream.

131. The main longer-term effects on the surrounding environment are related to operation of the reservoir and the resulting variable discharge from the tailrace (on a daily and monthly basis). The Moragolla scheme will have a “co-influence” with the Kotmale power station, which has been releasing its discharge to the Mahaweli Ganga at the confluence with the Atabage Oya for the last 28 years. As a result the Kotmale Oya upstream from the proposed Moragolla dam has been deprived of its normal discharge since 1985.

132. Figure 12 (in Chapter IV above) shows the expected fluctuation in the 35 ha Moragolla reservoir (which generally has steep slopes). Average monthly water levels will be highest in

February and March (at about 547.5 masl) and lowest in August-December (at about 547.2 masl), and will vary by only about 0.4 m throughout the year. Daily variations will be greater, but still only around 1-2 m, so this new water body will be relatively stable.

133. Water will be released from the dam (as environmental flow and occasional spill releases) and through the tailrace outfall. Figure 10 shows the predicted monthly variability in these combined environmental flow and spill releases (based on the expected daily power generation cycle). As noted above, this indicates the minimum expected flow in the dry season (when accumulating storage in the reservoir is required) at 1.5m^3/s in February-March, and a maximum discharge of about 9 m^3/s in the early monsoon (June-July). This combined flow, as well as that of a few other small local tributaries, will constitute the new discharge regime in the 3 km between the dam and the tailrace.

134. The combined effects of the Moragolla tailrace discharge, the environmental flow and spill releases, and the Kotmale tailrace discharge will create variability in both the discharge rates and the water levels in the downstream section of the Mahaweli Ganga. However, when monthly discharge data is examined, the variation in rate of flow is not so different from the current annual variability, which shows a one order-of-magnitude fluctuation in discharge rates between dry and wet years (from 4 to about 66m^3/s, Table 10), and the influence of the monsoon within a year (seasonal variation 8 to 40 m^3/s, Figure 14). Hourly discharge patterns will change significantly when the project is operating, but there should not be major differences in the daily, monthly or annual rates of discharge.

135. Figure 15 suggests that there should also be no great difference in downstream water depth between the environmental flow of 1.5m^3/s and the previous (natural) low flow condition (95% exceedance discharge of 3.6m^3/s). Assuming inflows from major tributaries are proportional to their catchment areas, Fig 15 suggests that low flow water levels in the Mahaweli Ganga will provide a water depth of around 1.5 m (with deeper water in the pools in the river bed that are present in this area). It should be noted however that the lowest discharge rates and therefore the shallowest water will occur between the Moragolla Dam and tailrace.

136. Together, the Moragolla and Kotmale tailrace discharges will produce a minimum flow of about 20 m^3/s downstream of the tailraces (in March and April) and a maximum of 70 m^3/s in July (monthly averages: Fig 11). Figures 16 and 17 show that the most frequent combined discharge (about 50m^3/s, in seven months of the year) will maintain water levels of at least 1 to 3 metres above the river bed downstream of the tailraces. An increase of 3 - 4 times this discharge rate (up to 200m^3/s) adds only 1.5 - 2 m to the water level (Fig 16), which reflects the wider cross-section of the river in the downstream stretch (Fig 17) compared to above the dam.

137. An account of hydrology also needs to examine short-term variations, throughout the day, because Moragolla and Kotmale hydropower schemes will operate as peaking stations, so they will not generate power continuously. Indeed, Fig 9 shows that the Moragolla scheme will generate for only 4-6 hours per day throughout the dry season (January-April), and it is possible that the Kotmale station may be operated on the same cycle. If this was the case it could mean that for 20 hours per day throughout this four-month period, the only river flow downstream of the Moragolla dam and the two tailraces would be the Moragolla environmental flow plus small inputs from downstream tributaries. This would not maintain the flow rates and depths discussed above, so it would be advisable for CEB to examine and implement a strategy to keep the tailrace discharges out-of-phase (not dry at the same time) to avoid greater downstream impacts.

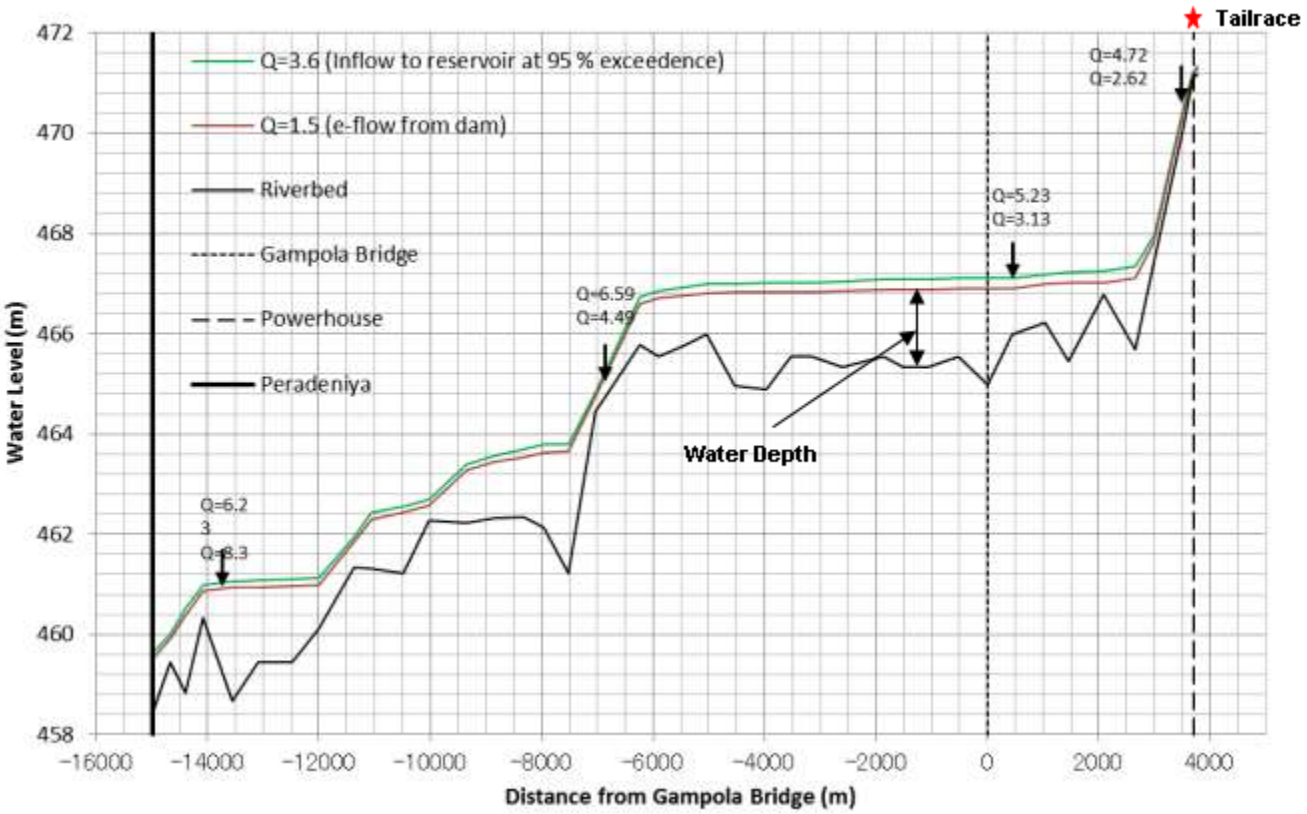

Figure 15: Water depth in the Mahaweli Ganga under existing minimum flow (green) and proposed E-flow (red)

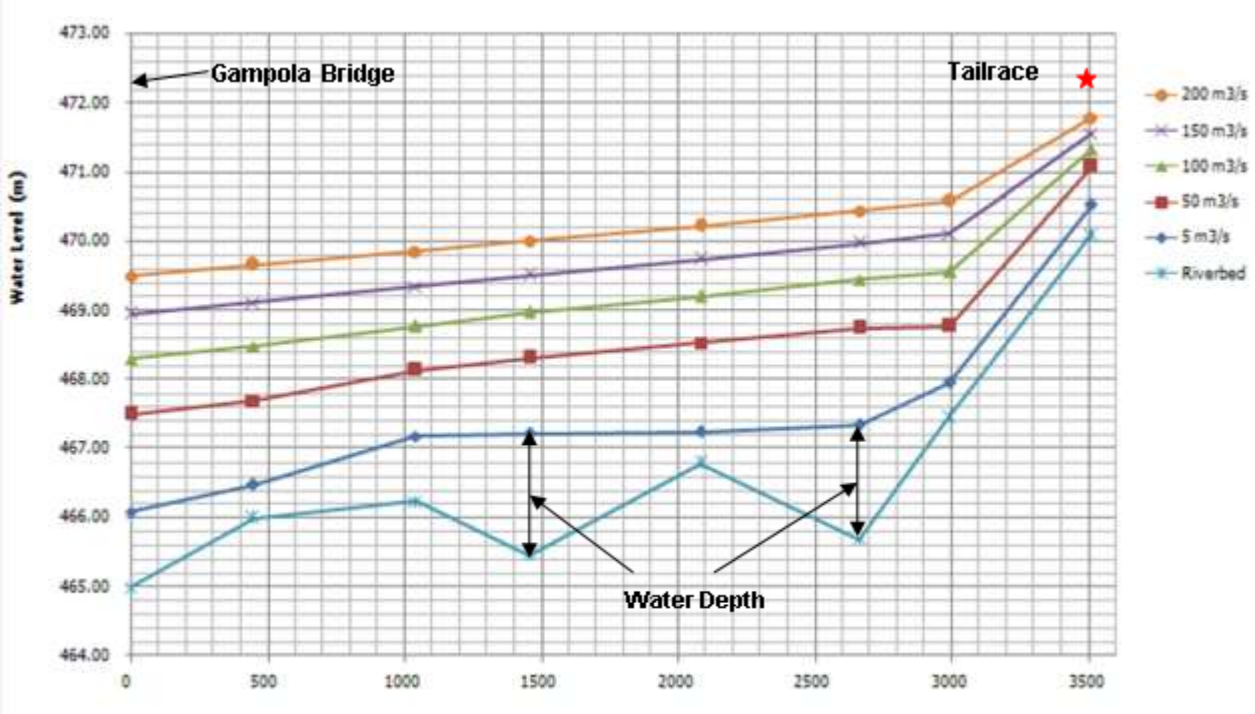

Figure 16: Predicted variability in water levels downstream of the Moragolla tailrace under different discharge regimes

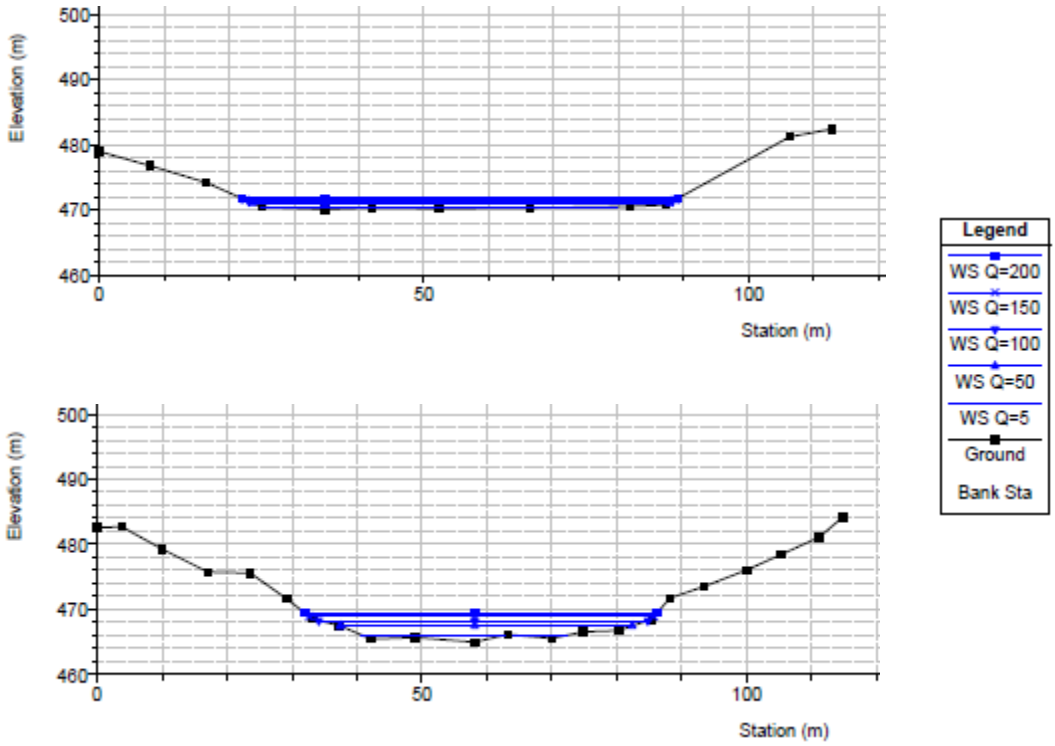

Figure 17: Variability of water levels downstream of the Moragolla tailrace under different discharge regimes: a) 200 m downstream (top); b) Gampolla bridge 3.7 km downstream

4. Proposed mitigation

138. **Pre-construction and Construction phases:** The assessment above indicates that normal good practice in dam construction includes sufficient precautions to avoid most hydrological impacts without the need for further intervention. Construction involves several works on the river bed (creation of the dam, downstream causeway and the outer part of the tailrace tunnel), for which the river will be diverted to allow construction in the dry. The main hydrological concern is that river flows could be impeded (especially in the monsoon), causing localised flooding and risks to the safety of workers and local people. However, safety is a major concern in a large project such as this, and is addressed in both the design and construction practice. The tunnel through which the river is diverted at the dam site is designed to allow passage of a 1-in-10-year dry season flood (320 m^3/s); and coffer dams that direct water into the tunnel are designed to be fully watertight and to remain structurally sound during any overtopping, which will only occur rarely, if at all. All such structures will also be regularly monitored to detect and address any water seepage.

139. One precaution that was suggested above is for the smaller-scale in-river works (tailrace outfall and causeway), to be conducted in the dry season, to avoid the risk of localised flooding outside the main river channel that could arise from the usage of only coffer dams to deflect water away from these areas. These works will be quite short in duration so it should not be difficult to programme them in the low flow season as suggested.

140. A concern regarding the period in which the reservoir is filled, is that CEB would be in default of their obligation to provide an environmental flow of 1.5 m^3/s at all times, if filling is conducted as presently planned, without allowing any downstream flow during the estimated 19 hour filling period. If it is not practicable to partially close the gate to the diversion conduit to allow downstream flow whilst the reservoir is filling, then some other way must be found of providing the agreed E-flow during the filling period.

141. **Operation phase:** Hydrological changes are amongst the most significant impacts of the operation of hydropower stations, as the regime post-impoundment is normally quite different from that prevailing naturally. By proposing to build a hydropower project at a particular site, the government (or private developer) inherently accepts that hydrological changes will occur. The EIA process then determines the extent of the changes and the importance of any features or activities that depend on the river flow, and devises methods to reduce hydrological impacts if necessary. This normally involves the provision of an environmental flow, plus other actions.

142. The importance and habitat requirements of animals and plants that inhabit the river and its environs are assessed in Section VI J below. In this section above, the long-term hydrological regime was considered *per se* and it was found that the combined discharge from the tailraces of the Moragolla and Kotmale stations, together with the E-flow from the Moragolla dam will create variability in flow that is not greatly different from the present natural fluctuations between years or seasonal fluctuations within a year. Downstream of the tailraces, water depths are expected to be 1-3 m above the river bed for seven months of the year, and around 1.5 m in the low-flow season.

143. The E-flow of 1.5m^3/s was proposed by CEB as the rate of discharge that could be accommodated without affecting the financial viability of the project. The analysis conducted for this study in 2013 (see Volume 4) showed that when expressed as a percentage of the natural minimum flow, the Moragolla E-flow (41%) was the highest of 16 HP stations in South Asia for which information was available. Calculations via methods commonly used to formulate E-flows elsewhere were also generally favourable, with the CEMAGREF[10] formula suggesting that 1.44 m^3/s would be needed to maintain downstream ecology; and the Montana/Tennant[11] method suggesting that 2.44 m^3/s would allow the short-term survival of fish (without taking into account the deeper pools present at the Moragolla site).

144. There is therefore no suggestion from these studies that an increase in E-flow is needed. The hydrological analysis presented above concludes that there will be significant flow reductions between the Moragolla Dam and tailrace outfall, but that downstream of the tailrace the hydrological regime will not be greatly different from what prevails at present. This assumes discharges from both tailraces. If however the Kotmale and Moragolla stations were operated on an identical peak generation cycle, then there would be periods (possibly up to 20 hours per day throughout the four-month dry season) when there is no discharge from either tailrace. This could cause more significant changes in river flow and depth downstream, so it is recommended that CEB investigates the feasibility of operating the two stations out of phase in the dry season to avoid long periods when both tailraces are dry. This is the only mitigation needed to address hydrological impacts in the operational phase.

[10] Centre National du Machinisme Agricole, du Genie Rural, des Eaux et des Forets, France

[11] Tennant D L (1976): *In stream flow regimens for fish, wildlife, recreation and related environmental resources.* Fisheries 1(4): 6-10.

D. Water Quality

145. Water quality in the immediate project area (from upstream of the proposed reservoir to downstream of the tailrace outfall site) was investigated by a survey in March 2009 for the Local EIA study, and again in March, May and September 2013 for the present study. Data from 2009 is provided in the Local EIA report (Volume 5: Table 3.7, Annex 4) and data from the 2013 surveys are presented and discussed in the two water quality reports in Volume 4 and in the account below.

Additional Table 11(a) for Addendum: Water Quality

Description	Local EIA(2012)	Environmental Addendum(2013)
1- Baseline data	• Sect. 3.1.4.4 water quality of river regime	• Volume 4 ; Restudy river water quality in dry and wet sesons • Volume 4; Additional study on river water quality in monsoons.
2,3- Impacts	• Sect.4.2.3 formation of algae due to eutrophication • Sect 4.2.3 dilusion of Crysbro waste water	• No change • No change
4- Mitigation	• Sect.5.4.2 mitigatory measures to avoid water quality deterioration • Extension of waste discharge line of Crysbro upto the proposed tailrace	• Volume 2 Sect IV table 4. Further discussed in Sect VI.D.4 • No change

1. Existing Conditions

146. Table 11 shows the results from the four stations that were sampled on all three occasions in 2013. This suggests that water quality in this part of the Mahaweli Ganga is quite mixed, with certain parameters that are indicative of good water quality (neutral pH, high Dissolved Oxygen (DO)and low Biochemical Oxygen Demand (BOD), but some parameters that are characteristic of poorer water quality (high Turbidity, Total Suspended Solids (TSS) and Coliform bacteria).

147. The data show quite a lot of evidence of ongoing impacts from the activities of man, as the high levels of turbidity and TSS probably originate from the runoff of cultivated soil during rainfall, and the slightly elevated levels of Ammonia, Nitrate and Total Phosphorus, whilst not exceeding the proposed water quality standards, probably arise from runoff of fertilizers. The high concentrations of total coliforms probably come from soil and plant debris, and the high levels of faecal coliforms suggest pollution by human sewage and/or animal droppings, which are probably also washed into the river by rain.

148. Most parameters were present in lower concentrations in March than at other times of the year, which is almost certainly related to the limited rainfall (and runoff) at this time. Dissolved Oxygen was highest at all stations in September, probably because of increased

turbulence at the height of the monsoon. Most other parameters were recorded at their highest levels in May, presumably when initial rainfall increases the input of materials from on land, but river flow is not yet sufficient to dilute the concentrations significantly. There are no consistent spatial patterns evident in the differences between stations, and in general the results for individual parameters are broadly similar throughout the project area at any one time, which is to be expected within a relatively small site.

149. The outfall from the Crysbro Poultry Processing Industry, on the left bank, 2 km downstream of the dam site, was investigated in detail in July 2013, to check reports in the Local EIA that it was a potential source of pollution. The data are included in Table 11, which shows that the effluent is high in BOD, suspended solids and faecal coliforms and exceeds the legal limits for these parameters. The effluent is however quite low in volume and is discharged intermittently, and the data show no evidence of any influence from these discharges outside the immediate vicinity of the outfall.

Table 11: Seasonal variations in water quality in the project area in 2013 (Average of two samples. KO = Kotmale Oya above confluence with Mahaweli Ganga; MG = Mahaweli Ganga above confluence with Kotmale Oya; D = dam site; TO = tailrace outfall

Location	pH	Temp °C	Turbidity NTU	DO mg/l	BOD_5 mg/l	Ammonia mg/l	Nitrate mg/l	Total P mg/l	TSS mg/l	Faecal Coliform	Total Coliform
KO - Mar	7.1	27.2	4.0	7.2	<1	0	0.288	0.097	2.4	200	1,000
KO - May	6.6	21.8	14.4	8.2	1	0.14	0.803	0.084	4.8	158	5,550
KO - Sep	7.0	20.8	18.5	8.2	1	0.05	1.134	0.134	5.5	274	6,000
MG - Mar	7.1	25.3	20.6	6.9	<1	0.03	0.330	0.040	12.7	850	11,700
MG - May	7.1	23.7	25.8	7.4	<1	0.37	0.637	0.020	32.2	1,200	205,000
MG - Sep	8.3	20.5	54.3	7.8	1.4	0	0.521	0.142	26.1	1,000	8,900
D - Mar	7.3	26.0	33.9	7.2	<1	0.04	0.326	0.039	15.9	900	14,100
D - May	6.5	21.5	30.5	8.2	1.3	0.17	0.463	0.106	32.7	5,000	110,000
D - Sep	7.2	20.3	70.9	8.2	<1	0.01	0.550	0.120	24.1	2,050	13,600
TO - Mar	7.0	25.1	3.7	7.4	<1	0.03	0.270	0.106	2.7	540	9,000
TO - May	7.0	21.5	118.5	6.1	<1	0.16	0.411	0.138	58.5	350	105,000
TO - Sep	6.1	19.3	15.3	7.5	1.2	0.03	1.195	0.131	8.0	550	8,300
Proposed Ambient Water Quality Standards[a]											
Drinking ST	6-8.5	-	5 max	6 min	3 max	-	5 max	0.23 max	-	600 max	5,000
Bathing	6-9	-	-	5 min	4 max	-	5 max	0.23 max	-	50 max	1,000
Aquatic life	6-8.5	-	-	3 min	3 min	0.94 max	5 max	0.23 max	-	-	20,000
Drinking CT	6-9	-	-	4 min	4 min	-	5 max	0.23 max	-	-	5,000
Irrigation	6-8.5	-	-	3 min	3 min	-	5 max	0.23 max	-	-	1,000
Crysbro - Jul	6.8	26.8	158	<1	790	8.4	0.456	3.55	75	274	23,000
Tolerance Limits for Discharge of Industrial Waste to Inland Surface Waters											
Limit	6-8.5	<40	-	-	30	50	-	5	50	40	-

ST = Simple Treatment (boiling); CT = Conventional Treatment (filtering and chlorination)

Faecal coliform: E coli/100 ml; Total coliform: Coliform organisms/100 ml

Shading shows non-compliance with proposed ambient water quality standards for Drinking Water (simple treatment) (top); and exceedence of tolerance limits for the discharge of industrial waste to inland surface waters (bottom)

a: International Development Association/World Bank (2000): *Environmental Standards Report, Version 2*. Technical Assistance Consultancy: DHV Institutional and Policy Development, Environmental Action 1 Project, EA1P R98009.

151. Overall the results indicate that the water in the project area is quite strongly influenced by runoff of material from on land, in particular soil, plant debris, and human and/or animal waste, and that concentrations tend to be higher early in the rainy season and diluted at the height of the monsoon. The Crysbro outfall is a source of organic pollution and exceeds legal discharge limits for BOD, TSS and faecal coliforms, but its influence in the river is small and localised. Comparing the data with proposed water quality standards for specific uses suggests that water in this part of the Mahaweli Ganga is not suitable for drinking (after simple or conventional treatment), or for bathing or irrigation, primarily because of its high turbidity and bacterial content.

2. Pre-construction and construction phase impacts

152. The Impact Matrix (Table 7) identifies water quality in the river as one of the major areas of concern throughout the project, as there are several activities in all three phases that could have negative impacts. This is the main reason why this topic was studied in more detail in 2013. Table 7 shows that in the pre-construction and construction stages, the principal risks are from: land clearance; worker accommodation camps; fuel storage; quarrying; operation of the crusher plant; tunnelling and the disposal of spoil; and the usage of coffer dams to divert the river. Some of these risks were also identified by the Local EIA study, which highlighted concerns that: a) soil could erode from construction sites and spoil dumping areas during heavy rainfall; and b) labour camps could be a source of additional pollution if they are not adequately managed and provided with suitable sanitary facilities (Table 9).

153. **Common risks at all sites:** The summary of the impacts associated with each project activity (Table 8) shows that many of the potential impacts on water quality are associated with the risk of exposed soil washing into the river during rainfall. This risk will arise as soon as vegetation is cleared in the pre-construction period, and will remain as long as there are areas of uncovered soil and unmade roads at each site. This applies to all of the main construction sites (dam; headrace tunnel; powerhouse, switchyard and tailrace outfall) and also to most of the ancillary sites (access roads; camp site; resettlement site; quarry; and spoil disposal sites). Risks will be greatest: a) where the larger areas of soil are exposed, and for the longest duration (eg dam site); b) where activities are conducted in or near the river (construction of dam, tailrace outfall and causeway; crusher operation; road and causeway construction); and c) at sites where soil is handled and processed in large quantities (tunnel, dam, quarry and spoil disposal sites).

154. This project involves the clearance of vegetation from 54.73 ha of land (data from Table 4), and the partial clearance of a further 51.75 ha (removal of trees and shrubs from the reservoir). There will be further earthworks at the majority of sites (Table 4), which will produce around 300,000 m^3 of waste spoil, approximately 80% from the dam site and 20% from the powerhouse (including tunnel muck). This will be taken by truck to the three disposal sites shown in Figs 2 and 8. A further 100,000 m^3 of stone, sand and aggregate will be excavated from the quarry, of which around half will be be taken to the dam site and used to build cofferdams; and half will be processed (and stored) at the crusher site, and subsequently taken to the various construction locations. There will therefore be a very great deal of exposed soil, and additional large-scale handling, processing and storage of soil, sand and other particulates.

155. Clearly there are major risks that sediment will wash from these sites and these activities into the river, especially as many of the sites and activities are close to the river and some will be conducted on the river bed. The description of existing water quality (Section VI.D.1 above) shows that the Mahaweli Ganga in this area is already adversely affected by sediment and other materials washing into the river with rainfall, mainly as a result of farming practices with little regard to drainage or soil conservation, and the extensive removal of natural vegetative cover. Photo 7 shows the present high turbidity in the river during the monsoon in 2013. Section VI.J below shows that there are important aquatic resources in the river, including rare species of fish, which could be directly affected by increased turbidity irritating their gills and impeding respiration, and indirectly affected if suspended sediment makes it difficult to capture food, or smothers food organisms when settling on the river bed. Section VI.N discusses the human uses of the river downstream, and CEB will also want to avoid creating a negative public view of the project by inhibiting these activities.

Photo 7: Turbulent and turbid flow in the Mahaweli Ganga upstream of the tailrace outfall site in September 2013

156. **Additional risks at earthworks sites:** The sites of major excavation (such as the dam and powerhouse) may leave soil exposed for lengthy periods, while excavation continues in order to reach lower levels. This could increase the risk of erosion of cut slopes by rainfall, leading to slope failure and landslips, which as well as compromising safety, also release additional fine material that may wash into the river with rain. Such risks are heightened in areas such as this, with a steep topography, where all natural surface drainage runs into the river.

157. There are further risks associated with the tunnelling operation, both with the removal and transportation of spoil and with the management of drainage. Transporting large quantities of spoil by truck in the monsoon season carries a risk that rainfall may wash fine material from the loads if soil is carried uncovered; and if the excavated tunnel material is “muck” (ie semi-liquid because of high water content), this could also wash from the trucks during transportation.

158. The groundwater study (Section V1.E below) suggests that the tunnel will not form a major conduit for drainage of groundwater, because of the extent of the largely impervious bedrock above and the fact that most aquifers in this area are confined and discrete. There will however be some entry of water from fissures in the bedrock, and this will tend to drain out towards the river along the sloping adits, and it will also be pumped out once tunnelling is on the down-gradient. The drainage water will inevitably be high in turbidity, so it could add to the sediment load in the river if precautions are not taken to intercept and reduce the sediment content.

159. **Quarrying:** The main additional risk associated with the quarrying, is of slope failure liberating fine material, because slopes in this area will not be designed to maintain stability in the way that they are for the constructed earthworks at the project sites, and collapse of slopes is an essential component of quarrying activity. There is therefore a somewhat heightened risk

of the production of turbid runoff from the quarry site, especially as the entrance is alongside the Gampola road, only about 50 m from the river (Fig 2).

160. **Crusher plant:** The crusher plant will be located in the Contractors' work area, which is even closer to the river on the west of the Gampola Road. There are therefore additional risks to water quality from this site, because of its proximity to the river, and because processed material is likely to be stored here prior to transportation for use at the various construction sites. There could therefore be runoff from the site itself and from the stockpiled material, especially if the particle size is small.

161. **Spoil disposal:** Aside from the major earthworks, spoil disposal is probably the other activity with which there is the greatest risk of the mobilisation of fine sediment, and drainage into the river during rainfall. Spoil is material that cannot be used in the construction, so it is treated as waste, and is sometimes discarded without the same kinds of control and supervision as is routinely applied at construction sites. There may therefore be a heightened risk of slope failure and rain-fed erosion, because of inappropriate deposition, lack of compaction and covering of surfaces, and uncontrolled and unconfined drainage. Two of the sites proposed for spoil disposal for this project are very close to the river, so there will need to be strict controls on the disposal operation, and adequate engineering of the deposited material.

162. **River diversion:** Coffer dams are sometimes made from steel and inserted into the ground by pile-driving, and they can also be much more informal structures, created from tipped stone and soil. In this case the cofferdams will be properly designed and constructed solid structures, made from cemented sand and gravel, so there is no risk of fine material being washed out by contact with river water. The cofferdams are designed to withstand a flow of 320 m^3/s, so there is unlikely to be frequent overtopping. In the event of water levels rising substantially in the monsoon season, working areas at the damsite would be evacuated, so there should also be no risk of water pollution from floodwaters inundating vehicles, machinery or construction materials.

163. The two remaining activities that could adversely affect water quality in the river are fuel storage and the operation of accommodation camps. Here the risks are not related to soil erosion or increasing turbidity, but to other forms of water pollution.

164. **Fuel storage:** It was estimated in Section IV.E above that the construction process would involve over 100 large construction vehicles (bulldozers, backhoe excavators, dump trucks, etc) plus a variety of smaller vehicles for transporting personnel and other purposes. Contractors will therefore need to refuel vehicles on site, and they may also establish a workshop where vehicles can be routinely serviced and repaired when necessary. Hydrocarbon derivatives are toxic to most aquatic organisms (and to man), so measures will be needed to avoid spillage of these materials, to contain and carefully dispose of any spills that do occur, and to prevent any spilled material entering the river. Measures will also be needed to ensure safe storage of fuels in bulk, as the accidental rupture of a storage tank and spillage of a large quantity of fuel into the river, could have major consequences by killing aquatic organisms over a large area locally and downstream.

165. **Accommodation camps:** The main civil contractor will be required to provide housing for professional staff of the contractors, consultant and client in a designated camp upstream of the dam on the right bank (Fig 2). Such housing will be properly designed and constructed, and

provided with suitable services, including waste collection and treatment, so there should be no risk of water pollution from this location.

166. Contractors will probably employ some of their workforce from the local communities in the vicinity of the project, and will provide daily transport to and from the normal place of residence. They may also bring into the area workers from elsewhere, for whom they will have to provide accommodation. Some workers may be accommodated in the local community, but contractors may also choose to provide a camp facility on site. If this is the case, it will be essential that the workers' camp is provided with adequate sanitation and sewage treatment in the same way as the camp for professional staff. This will ensure that untreated sewage does not enter the river, to contribute to the high load of faecal pollution, which is already present, as shown by the recent survey (Table 11). Contractors should also be required to provide adequate toilets and washing facilities at all construction sites and to ensure that waste from these is adequately treated.

3. Operation phase impacts

167. Table 7 shows that there are also concerns regarding water quality, both upstream and downstream of the dam, once the hydropower scheme is operating. Table 8 shows that upstream the main issue relates to the maintenance of water quality in the reservoir, where the water will be slow-moving and confined and therefore not exposed to the natural aeration of normal turbulent river flow. Downstream the main concern is the reduced quantity of water and low rates of flow, especially in the dry season, and the resulting reduced dilution of pollutants.

168. **Water quality in the reservoir:** Water quality in the reservoir should not be a problem in the monsoon season, as turbulence in the fast-moving upland streams should ensure good aeration of the inflow; and power will be generated for 15-18 hours per day at this time (Fig 9), so there will be a rapid turnover of the impounded water. Inflowing water will also be cooler than the water in the reservoir, so it will tend to sink below the surface, promoting vertical mixing which should replenish oxygen in the lower levels.

169. In the dry season, water will be retained for longer periods and will be discharged through the tailrace for only 4 - 6 hours per day, so there will be less circulation in the reservoir. The water could therefore become deoxygenated at lower levels, especially if there is a large quantity of organic material on the reservoir bed that is gradually decomposing (a process that uses oxygen). For this reason it will be essential to remove trees and shrubs from the reservoir area before impoundment, to prevent the creation of anoxic conditions at lower water depths. CEB should also implement measures to improve agricultural practices and land management in the wider catchment of the Moragolla Reservoir (to the extent that they are able) to reduce the inputs of pollutants and especially organic materials, which deoxygenate water as they decompose.

170. **Downstream water quality:** There is one aspect of downstream water quality that will be improved significantly by the presence of the dam and reservoir, which is turbidity. Sediment contained in the inflowing water will tend to settle out in the slow-moving waters of the reservoir, so it is very likely that the water flowing downstream will be less turbid than at present. With an annual sediment yield of 265$m^3/km^2/y$, a catchment area of 247 km^2 and a trapping efficiency of 40%, calculations in the FS Review and Detailed Design (DD) Final Report estimate that after 50 years around 30% of the reservoir volume will be filled with sediment. The dam and reservoir will therefore act as a large sediment trap, and along with improved land management in the

watershed, this should improve the general quality of the water flowing downstream. Further improvements may arise from the retention of pollutants (such as nitrate and phosphate) that are adsorbed onto the fine sediment particles, and from the natural decay of coliform bacteria in the retained water.

171. The reservoir includes a sluice to periodically clear sediment from around the intake by washing downstream, but this is unlikely to be needed for the next several decades and would be small in scale and done during the monsoon, so there would be no noticeable impact on turbidity. The generation system will remain fully operational regardless of the sediment retained in the reservoir, so there are no plans to purge sediment from the wider area and no structures in the dam to enable this to be done. If sediment were pumped downstream at any time it should be done gradually, throughout a monsoon season, to achieve maximum natural dilution.

172. The remaining concern is the reduced quantity of water discharged from the dam, and the reduced dilution it will afford to pollutants contained in the discharged water and entering downstream. The Crysbro effluent is a particular concern, as it discharges into the area between the Moragolla dam and tailrace in which water flow will be the most limited, especially during the dry season. CEB has offered to extend the Crysbro outfall so that it discharges downstream of the Moragolla tailrace, although this will require more extensive works than previously anticipated as the recent surveys showed that the discharge pipe is broken and the effluent now flows in unconfined channels down the hillside. A better option would be treatment of the effluent at source by the company (as required by law) to meet the legal standards. The other pollutants in the water (coliforms, ammonia, fertilizers, etc) also need to be diluted, to the extent that is feasible within the anticipated discharge regime. This further supports the suggestion made above of operating the Moragolla and Kotmale stations out of phase in the dry season, in this case to dilute the pollutants in the water for a longer period each day.

4. Proposed mitigation measures

173. **Pre-construction and construction phases:** The major risk to water quality from pre-construction activities and especially in the construction stage, is that exposed soil could wash into the river during rainfall, causing significant increases in turbidity in an already highly turbid aquatic environment. This could have deleterious impacts on animals and plants inhabiting the river and the activities of people who use the river for washing, bathing and other purposes. This risk is common to most of the construction sites and begins when the area is cleared of vegetation and continues for as long as bare soil or unpaved roads are present. The risk is increased at sites where there are significant earthworks and deep excavation (dam and powerhouse), with attendant risks of slope failure, which would liberate more fine material. The risk is also greater at sites that are close to the river (crusher), where construction work is conducted in the river (dam, tailrace), or where soil is handled or processed in large quantities (quarry and disposal sites).

174. Reducing this impact, and avoiding it as much as possible, will require concerted effort at all construction sites to establish the necessary precautions, and constant vigilance in implementation and monitoring to ensure that the measures function adequately at all times. The most important measure will be to plan the topography and surface drainage at all sites, to ensure that all runoff is collected in adequately-sized ponds in which drainage is allowed to remain for sufficient time to allow significant settlement of sediment, before water at the surface is drained off into the river. These measures will need to be carefully designed, constructed and maintained; and periodically re-designed and re-constructed at those sites at which the

topography changes in the course of the construction work. Settlement ponds should be constructed in duplicate so that the system remains functioning while filled ponds dry out to enable removal and disposal of sediment. There should also to be frequent regular monitoring of the silt content of discharged water to ensure that it does not exceed prescribed values.

175. There will need to be a range of additional measures targeted at specific additional risks and sites and these will include the following:

Deep cuts and steep slopes	- Engineered slopes with gradients to assure stability; - Erosion protection via stone facing, gabions, etc where needed; - Covering or vegetating final surfaces as soon as possible; - Incorporation of designed and constructed drainage culverts; - Regular monitoring during construction and after completion;
Spoil transport	- Covering all loads with secure tarpaulins during rainy season; - Allowing wet material to dry and de-liquefy before transportation;
Material storage	- Covered storage of loose material to prevent contact with rainfall; - Collection and sedimentation of all drainage from storage areas;
Spoil disposal	- Engineering planning of disposal sites and disposal operations; - Specification of slope gradients, compaction methods drainage, etc; - Ensure drainage collection, sediment traps and controlled discharge; - Incorporation of check bunds and other slope stabilisation features; - Specification of final profiles & vegetation cover to maintain stability; - Close regular supervision and monitoring of the disposal operation;

176. Other potential impacts on water quality relate to possible sources of other pollutants, in particular fuel and lubricants from storage and refuelling sites and maintenance workshops and sewage pollution from accommodation camps and work sites. These should be mitigated by various other methods including:

Fuel storage	- Storage & refuelling in secure, properly managed, designated areas; - Storage in areas with watertight concrete floors and bunds; - Storage area drainage passed into oil separator before discharge;
Maintenance workshop	- Concrete floors; drainage passed into oil separator; - Waste oil collected in secure containers and taken for safe disposal
Accommodation camps	- Adequate toilets and bathrooms for all residents; - Sanitary facilities cleaned and sanitary materials replenished daily; - Sewage removed or treated on site to national disposal standards;
Work sites	- Adequate toilets/washrooms for the numbers of personnel on site; - Toilets and washrooms cleaned and materials replenished daily; - Sewage removed or treated on site to national disposal standards.

177. **Operation phase:** Once the scheme is operating, water quality in the reservoir should be relatively normal in the monsoon because turbulence upstream will maintain oxygen exchange, cooler inflowing water will sink below warmer impounded water so lower levels will remain aerated, and power generation for 15-18 hours a day will allow a rapid turnover of water.

In the dry season, water will be retained longer and there will be less circulation, so water could become deoxygenated, especially if there is a large quantity of decomposing organic matter on the bed. This could adversely affect fish and other organisms in the reservoir and downstream when the water is discharged. This will need to be addressed by a combination of measures, including:

- Removal (uprooting) of all trees and shrubs from the reservoir area before inundation;
- Promotion of improved land management to reduce pollutant inputs in the watershed;
- Planting a buffer zone around the reservoir with soil-retaining trees and other vegetation;
- Building sediment traps at the edge of the reservoir, with regular silt removal/disposal;
- Regular monitoring of the quality of water throughout the reservoir, so that additional action can be taken if necessary.

178. The quality of the water flowing downstream is expected to be improved in some respects by the dam and reservoir, which will trap sediment and any adsorbed pollutants, and reduce the content of coliform bacteria by natural decay. There are no plans to purge sediment from the reservoir as this will not affect scheme operation, but if sediment was pumped downstream at any time, it should be done gradually throughout a monsoon season to maximise dilution.

179. The main concern downstream is the reduction in flow in the dry season, when there will be much less water to dilute pollutants than at present. CEB is proposing to extend the Crysbro outfall to downstream of the tailrace, but with the tailrace only operating for four hours per day this will not provide a complete solution. Since Crysbro effluent is released only after retention for 24 hours in settling ponds, a mechanism could be introduced to discharge the effluent when the Moragolla scheme is in operation. A better solution would be treatment of the Crysbro effluent at source to meet the requisite legal standards and operation of the Kotmale and Moragolla stations out of phase in the dry season to release water to supplement the E-flow and provide better dilution over a longer period.

E. Groundwater

180. Potential impacts of the tunnel excavation on the quality and distribution of groundwater were not discussed in detail in the Local EIA study, so it was the subject of an additional investigation in 2013. The final report of that study is included in Volume 4 and the results are incorporated into the following account.

Additional Table 12(a) for Addendum: Groundwater

Description	Local EIA (2012)	Environmental Addendum (2013)
1- Baseline data	• Has not established	• Volume 4; Collection of data and preparation of description of existing condition on ground water.
2,3- Impacts	• Sect 4.4.7 Effect of project activities including tunnelling on waterways and groundwater table, possible helth hazards and effectd on the vegetative cover.	• No change

4- Mitigation	• Sect 5.4.2.2 Mitigatory measures to avoid ground water quality deterioration	• No change Further discussed in Sect VI.E.4

1. Existing Conditions

181. The project area lies in the middle peneplain[12] of Sri Lanka and is characterised by heavily dissected ridges and valleys with steep rocky slopes, through which the Mahaweli flows NNE with incised bends and meanders. The tunnel will be excavated within the isolated N-S orientated ridge on the left bank, which reaches an elevation of 700 m. Geologically the area is in the western part of the Highland Complex, which consists of high grade meta-sediments[13] and granulitic orthogneisses[14]. The tunnel route is underlain by garnet sillimanite biotite gneiss[15] with quartzite[16] bands, but due to the low dip angle, the tunnel will not run through quartzite.

182. The topography and geology of the area and field observations during the survey work suggest that groundwater is unlikely to be present in large and continuous accumulations, mainly because of the presence of shallow hard bedrock and relatively thin overburden, and the steep topography. The porous and weathered overburden favours the development of isolated and discontinuous small shallow aquifers. Recharge potential is very poor since the percolation of rainwater into deeper aquifers is hindered by tight joints in the bedrock.

183. Table 12 shows the survey results for 15 existing wells located within 250 m of the headrace tunnel route. Twelve wells were dug vertically into local aquifers and three were fed by springs. Wells were monitored in March 2013 towards the end of the dry season and in May 2013 after the first monsoon rains.

184. Column 2 shows the depth of the water level in metres below the ground and Column 3 shows the height of the water column in the well; so adding the two figures gives the depth of the well. This shows that the wells are all quite short, ranging from 1 m to 14.6 m, which confirms the shallow nature of the aquifers. The level of water varies quite considerably across the area, depending on geology and topography, and some shallow wells had water available at the surface, whereas in some of the deeper wells there was only a relatively small amount at the bottom. All wells contained some water in both monitoring periods, and individual water columns varied between 0.5 and 3.5 m in height.

185. There was no great variation in water quantity in individual wells between the two sampling periods, presumably because the initial monsoon rain is not sufficient to cause major changes. The same is true of water quality, which was marginal in most wells during both surveys. Several of the wells did not meet national standards for the quality of potable water in terms of pH and ammonia, and most of the wells exceeded the levels of faecal and/or total

[12] A nearly flat surface produced by a long period of sub-aerial erosion; almost a plain

[13] Sediment or sedimentary rock that shows evidence of having been subject to metamorphism (solid state re-crystallization of pre-existing rocks due to changes in heat and/or pressure and/or introduction of fluids (without melting))

[14] Metamorphic rocks formed by the metamorphism of igneous rocks

[15] Metamorphic rock composed chiefly of garnet, sillimanite and biotite minerals

[16] Metamorphosed sandstone consisting of an interlocking mosaic of quartz crystals

coliform bacteria; and in fact only one well complied with the bacterial standards during both analyses. These results suggest contamination of the water by human and/or animal waste, most probably entering with rainfall runoff. These results are typical for a rural setting, and indicate that groundwater in this area should not be consumed raw, but would be suitable for drinking after simple treatment by boiling.

2. Pre-construction and construction phase impacts

186. The Impact Matrix (Table 7) and the Summary of Impacts by Baseline Parameter (Table 8) suggest that the main risks for groundwater during pre-construction and construction are: a) pollution from the spillage of fuel; and b) blasting along the tunnel route, which could allow water to drain from the surface aquifers into the tunnel void. In reality both risks are likely to be quite small. The mitigation measures recommended in Section VI.D.4 above will greatly reduce the

Table 12: Water quantity and quality in wells in the vicinity of the proposed tunnel route

Well/ Spring	Water Level	Water Depth	pH	Temp °C	Cond µS/cm	DO mg/l	BOD_5 mg/l	Amm mg/l	Nitrate mg/l	Iron mg/l	PO_4 mg/l	TSS mg/l	Faecal Coliform	Total Coliform
1S D	0	0.5	7.4	24.6	42	6.9	<1	0.05	0.29	0.1	0.205	1.6	12	15
1S R	0	0.5	6.5	24.1	24	6.9	<1	0.16	0.10	0.3	0.132	2.9	9	13
2W D	0.5	0.5	7.7	23.2	58	5.6	<1	<0.02	0.04	<0.1	0.070	<1	0	2
2W R	0.5	0.5	5.7	23.8	62	4.3	<1	0.07	0.02	0.1	0.261	<1	26	141
4W D	3.1	3.0	8.3	23.2	157	5.2	1.8	0.07	2.12	<0.1	0.174	3.0	0	8
4W R	3.5	2.6	5.9	23.1	134	5.9	<1	0.08	2.08	0.1	0.327	<1	1	29
5W D	2.9	1.2	6.2	23.7	11	4.3	<1	0.02	0.06	0.2	0.386	<1	3	80
5W R	2.9	1.2	6.9	22.8	14	4.6	>1	<0.02	0.01	0.1	0.33	<1	5	42
7S D	0	2.5	6.4	23.5	182	2.7	1.3	0.1	1.84	<0.1	0.220	1.0	3	45
7S R	0	2.5	6.5	23.9	22	3.2	<1	<0.02	0.17	0.1	0.33	<1	1	22
9W D	0.5	1.2	6.0	23.1	46	3.9	1.8	0.19	0.99	0.1	0.226	4.8	5	12
9W R	0	1.7	6.9	23.4	149	4.7	<1	<0.02	0.35	0.1	0.204	<1	1	41
10S D	0	0.5	6.2	24.6	35	5.6	<1	0.04	0.05	0.1	0.205	<1	12	70
10S R	0	0.5	6.4	24.7	14	5.6	<1	<0.02	0.12	0.1	0.273	<1	0	41
11W D	13.6	1.0	6.5	24.3	168	2.1	1.97	0.03	<0.01	0.3	0.128	2.5	41	60
11W R	12.8	1.8	5.8	23.2	44	4.6	<1	0.07	0.19	0.3	0.216	3.8	11	20
12W D	6.8	1.2	5.8	24.3	36	5.4	<1	<0.02	0.06	0	0.156	1	0	11
12W R	6.6	1.4	5.2	23.2	47	4.1	<1	0.14	1.28	0.1	0.264	2.7	8	9
13W D	10.3	1.5	6.2	24.3	34	5.2	1.17	0.05	0.03	0.1	0.272	2.5	5	76
13W R	8.3	3.5	6.3	23.0	21	6.0	<1	<0.02	0.03	0.1	0.159	8.4	0	0
14W D	1.2	1.5	6.1	24.2	37	3.9	1.24	0.01	0.02	0.1	0.064	12	0	9
14W R	1.5	1.2	6.2	23.4	5	4.1	<1	<0.02	0.92	0.1	0.333	2.4	0	4
16W D	5.2	1.5	6.1	23.5	58	6.3	1.12	0.02	0.72	0	0.39	3.8	0	80
16W R	3.4	3.3	6.4	24.1	47	5.1	<1	0.05	0.07	0.1	0.3	1.3	10	80
17W D	5.9	0.7	6.5	23.1	69	1.5	1.04	0.47	0.04	0.1	0.315	1.8	3	11
17W R	4.4	2.2	6.5	23.1	28	5.1	<1	0.14	0.04	0.1	0.072	3.6	0	0
18W D	2.5	2.2	6.1	23.3	34	3.9	1.45	0.05	0.54	0.1	0.052	<1	2	13
18W R	3.2	1.5	6.5	23.5	38	3.2	<1	0.14	0.08	0.1	0.273	1.3	14	19
National Standard for Potable Water[a]														
Desir	-	-	7-8.5	-	750	-	-	-	-	0.3	-	-	0	10
Max Permis	-	-	6.5-9	-	3500	-	-	0.06	10	1	2	-	-	

Data from 15 sampled wells (12 Dug wells, 3 Springs) that are within 250 m horizontally of the proposed tunnel centre

D = Dry season (March 2013); R = after initial Rains (May 2013)

Water Level (m) measured from the ground; Water Depth (m) measured from the bottom of the well

Faecal coliform: E coli/100 ml; Total coliform: Coliform organisms/100 ml

Shading shows non-compliance with national standards for potable water (maximum permissible levels)

a) Sri Lanka Standard 614: 1983 - Specification for Potable Water; Part 1 Physical and Chemical Requirements; Part 2 Bacteriological Requirements

risk of fuel spills and ensure that any spillage that does occur has no risk of percolating into groundwater (storage in secure areas with concrete floors and bunds, from which drainage is collected and treated in an oil separator).The groundwater study concluded that there is also very little risk of loss of water from the shallow aquifers during tunnel excavation, because the tunnel route is located deep within intact bedrock so seepage is very unlikely.

187. Blasting to create the tunnel could however induce fracturing of the wider bedrock, which could create connections with some of the discrete aquifers, from which water might then drain. It will be very important therefore that charges are calculated very carefully throughout the blasting operation in order to confine the fracturing to the excavation area as far as possible.

3. Operation phase impacts

188. Operation of a hydropower station poses little or no risk to groundwater as there is no storage of fuel or other potential toxins on site and very little usage of lubricants etc during maintenance activities. The headrace tunnel will be formed from a thick layer of reinforced concrete, so there is no risk of any leakage from or drainage into the structure. The improved watershed management proposed in Section V.K below may improve the quality of groundwater in wells in the reservoir catchment. The reservoir itself or the reductions in downstream flows between the dam and the tailrace are unlikely to have any effect on the availability of water in the area as the aquifers are small and confined, and probably therefore without hydrological connections to the river.

4. Proposed mitigation measures

189. The requirement to protect groundwater from potential sources of pollution reinforces the need for the mitigation to avoid spillage of fuels, oils and other toxic materials proposed in Section VI.D.4 above. The one additional measure specifically related to groundwater is for blasting to be very carefully planned and implemented to avoid damaging bedrock outside the immediate vicinity of the tunnel, to prevent fissuring creating drainage paths from the surface aquifers. This should be combined with a programme of regular monitoring of all wells on the left bank between the dam and headrace so that reductions in water would be detected if they were to occur. The location of all wells in this area is shown in Annex 4 of the Additional Study Report on Groundwater (Volume 4) and geo-references are provided in Annex 5. Well monitoring should continue throughout the tunnel construction; and alternative supplies of potable water should be provided by tanker if necessary (as proposed in the Local EIA study, Table 8).

F. Land Use and Landscape

190. A study of land use in the project area was conducted in 2013, to update information and maps presented in the Local EIA to reflect any changes in the intervening period. The 2013 study involved reference to current satellite photographs and new on-site surveys to ground-truth the various land-use categories and to check specific classifications in any areas of doubt. The satellite image is shown in Figure 18 and the updated land-use map is Figure 19.

Additional Table 12(b) for Addendum: Land Use and Landscape

Description	Local EIA (2012)	Environmental Addendum (2013)
1- Baseline data	• Sect. 3.1.3 Land use within the study area	• Volume 4; Restudy and update information and maps to reflect any changes in intervening period.
2,3- Impacts	• Sect.4.6,2 Impact on land use patterns	• Change due to optimization of project components such as new quarry site, new dumping area, underground penstock, shifting of dam axis, etc. (Impact on land use patterns will be discussed further in the standalone document Vol.3 Resettlement Plan)
4- Mitigation	• Compensatory action and resettlement plan	• Introduced entitlement policy matrix (Mitigation will be discussed further in the standalone document Vol.3 Resettlement Plan)

1. Existing Conditions

191. The Local EIA study did not provide information on the area of land devoted to each activity (see Figure 19 for 2013 data), so it is not possible to evaluate and quantify changes in land use in detail. Comparing the new land use map with those from 2009 (Local EIA Figs 3.4 and 3.7 -Volume 5) does not reveal any major changes in the four years between the two studies. Today the area is still dominated by small-scale agriculture conducted in home-gardens in and around the inhabited areas: Ethgala, SAARC Village and Ulapane from north to south on the left bank and Delpitiya and Weliganga on the right bank; and this activity is more prevalent on the left bank, where there is more inhabitation. Much of the rest of the area comprises abandoned plantations (mainly tea), which are in various stages of re-colonisation by natural vegetation and are therefore categorised as scrub-land. There are also some small active tea plantations - on the right bank near Ulapane Bridge and on the left bank downstream of the dam.

192. There is some secondary forest[17] on the right bank near Kotmale power house and at the south-west corner of the study area opposite the confluence with the Kotmale Oya. These areas and the re-growing scrub on abandoned lands are the only areas of semi-natural terrestrial vegetation. There are two areas of paddy fields on the left bank, around the Ulapane Oya and west of the Ethgala to Ulapane road, and some smaller areas around Weliganga on the right bank. There is a light industrial area at Ulapane immediately west of the dam site and an army camp at the confluence with the Atabage Oya; and Kotmale powerhouse is on the right bank, with the conveyance tunnel buried in the hillside.

193. The study area comprises 2133 ha in total; and the table given in Fig 19 shows that home gardens cover almost half of the land (1015 ha, 48%); scrub covers 565 ha (26%); tea plantations 195 ha (9%); forest 133 ha (6%); and paddy 64 ha (3%). The landscape remains as

[17] Forest that has re-grown after clearance at some time in the past; not primary or primeval forest

described in the Local EIA: undulating topography with mixed vegetation, dominated by home-garden agriculture and abandoned tea plantations in various stages of re-growth. The Mahaweli valley dominates the topography, and the relief changes from 470 m at the river bed to a maximum of 700 m on the left bank north of the dam site. This is a rural area that is lowly populated, especially in the areas in which the project structures will be located. The main population centres are the three villages of Ethgala, SAARC and Ulapane, over the hillside on the left bank.

2. Pre-construction and construction phase impacts

194. Table 4 shows that the construction areas will cover 55.23 ha, which is 2.6% of the total land shown in Fig 19. The appearance of almost all of these areas will alter quite dramatically in the pre-construction period or shortly thereafter, as vegetation is removed and construction vehicles, equipment and personnel occupy each site. There will then be further quite profound changes as the construction activities begin and the new concrete structures start to form. The greatest changes will occur at the larger sites, which are the dam, powerhouse, quarry, spoil disposal sites and contractors' area. The overall site is not a location that has any special landscape beauty or renowned features; and the low inhabitation means that there will be very few people in the area to notice the impacts on land-use and landscape. The changes that occur during the construction stage will therefore be of little or no significance and there is no need for any screening or other action to reduce visual impacts.

195. The dam is located partly on the river bed. Fig 19 shows that the on-land part of dam and all other main project sites are located in an abandoned scrub-land area. The clearance of vegetation and creation of the project structures will therefore require no changes in land-use and there will therefore be no adverse impacts on this feature.

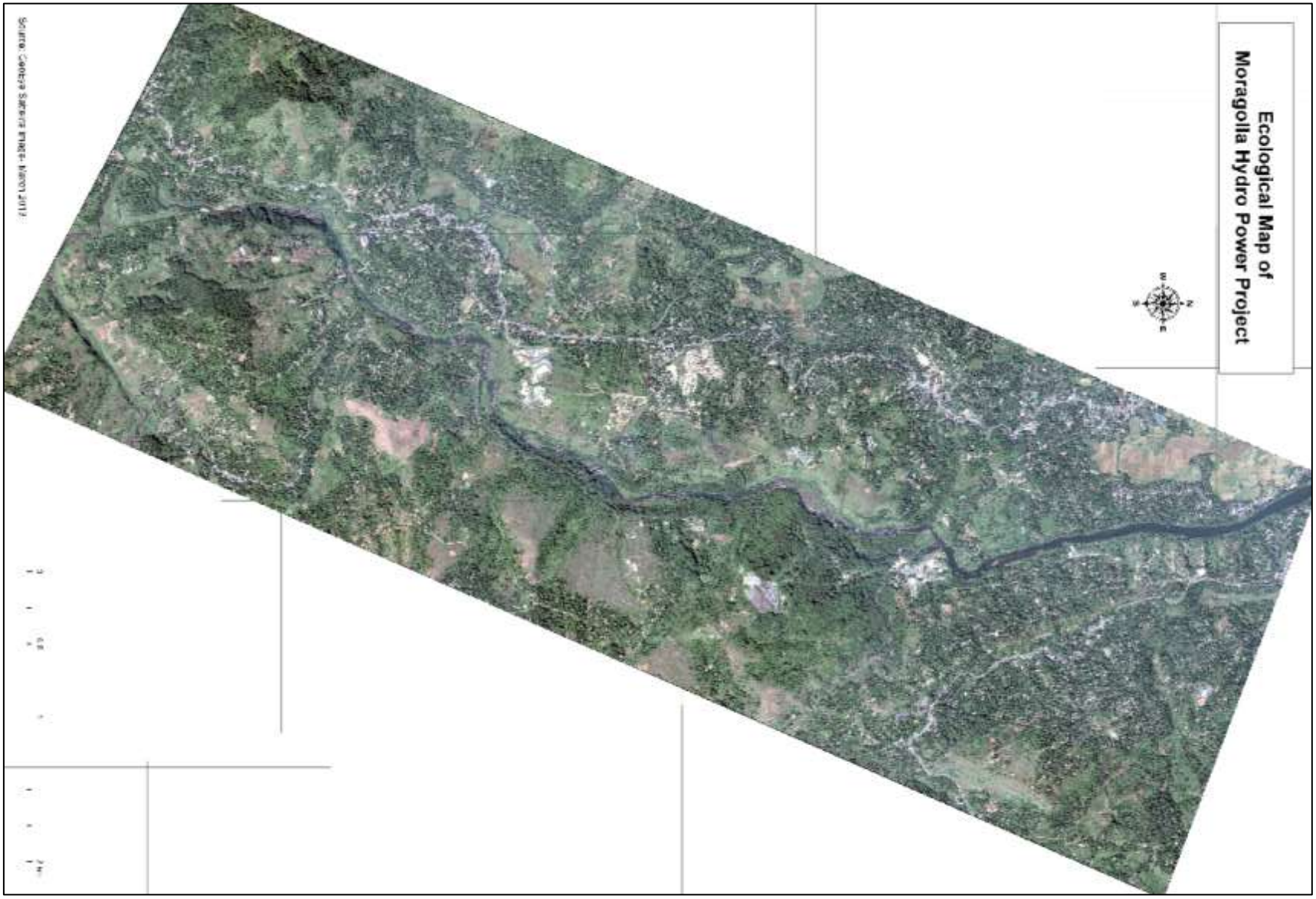

Figure 18: Satellite image of the immediate project area (March 2013)

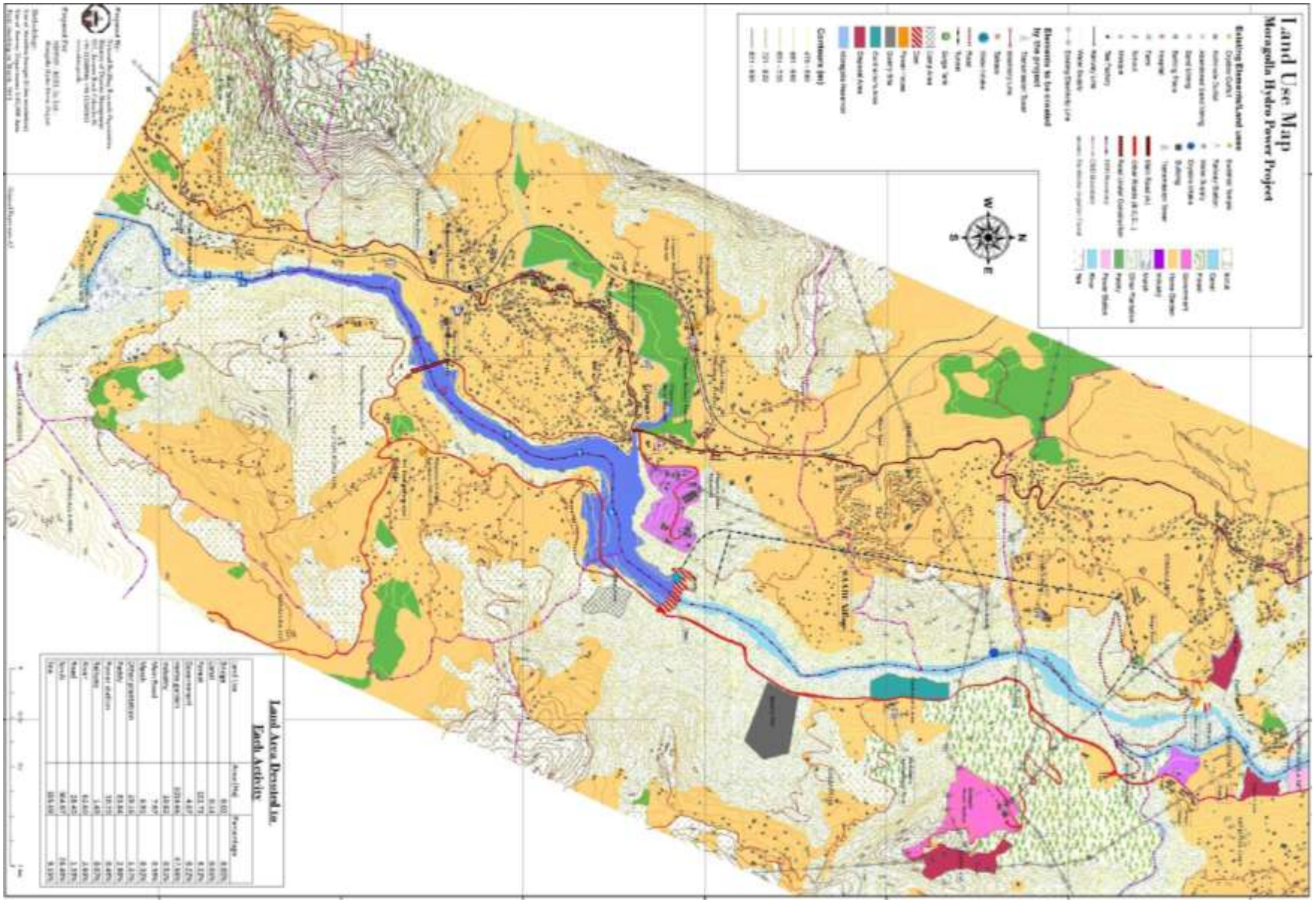

Figure 19: Land-use in the immediate project area in 2013 (including location of proposed Moragolla HPP elements)

3. Operation phase impacts

196. The above-ground concrete structures will be quite visible in the landscape once they are completed, but as they are only likely to be seen by relatively few people, they do not need to be screened. Indeed dams are impressive feats of engineering that are normally considered attractive landscape features in their own right, so they do not need to be hidden from view. Similarly reservoirs are almost always considered as enhancements, especially in a landscape like this that is otherwise dominated by narrow, steep valleys and foliage.

197. Creation of the reservoir should also not have major impacts on land-use, because as explained in the Local EIA report, approximately 90% of the area to be inundated is not suitable for use in agriculture or other purposes because of its steep topography. There will however be significant impacts in the remaining 10% of the inundation area, which contains a small number of houses and other buildings, owned and inhabited by 17 families, and some other land that is used for economic purposes (primarily farming). These locations are mainly in the lower-lying area immediately upstream of the dam on the right bank, where part of the Gampola road will also be inundated, requiring re-routing to a higher level. These include relocation of the affected households and provision of new housing, land and other assets to replace what will be lost when the reservoir is created. These measures have all been agreed between CEB and the affected persons and comply with national law[18] and ADB policy on Involuntary Resettlement[19] and no further action is needed.

G. Geology, Topography and Natural Hazards

198. The Local EIA report covers the issue of disaster management for the completed hydropower scheme in some detail. The risk of the major physical hazards is considered, in particular landslides (Local EIA Report: Section 3.1.4.10, based on an investigation by the National Building Research Organisation, NBRO - Local EIA Appendix D) and the possibility of dam failure, leading to sudden catastrophic downstream flooding (Local EIA Report: Section 2.2.12). Both issues were re-investigated in 2013, so that additional precautions could be incorporated into the designs or scheme management if necessary to assure the highest order of safety for the scheme and the surrounding population. The expert report on these issues is included in Volume 4.

[18] Government of the Socialist Democratic Republic of Sri Lanka (2001): *National Involuntary Resettlement Policy* Government of Ceylon (1950): *Land Acquisition Act* (and subsequent amendments)

[19] Asian Development Bank (2009): *Safeguard Policy Statement*. Appendix 2 Safeguard Requirements - Involuntary Resettlement

Additional Table 12(c) for Addendum: Geology, Topography and Natural Hazards

Description	Local EIA (2012)	Environmental Addendum (2013)
1- Baseline data	• Sect. 3.1.3 Land use within the study area	• Volume 4; Restudy and update information and maps to reflect changes incoporated by optimization of project components. CEB conducted Topographic analysis and ground mapping
2,3- Impacts	• Sect.4.1 Soil erosion and siltation	• No change
4- Mitigation	• Sect 5.4 Mitigation measures to address impact on the physical environment	• No change • Further precautions described in Sect VI.D.4

1. Slope Stability

199. The expert study in 2009 included site reconnaissance and review of existing geological and topographic data. NBRO found no evidence of previous landslides in the project area except for some gully and bank failures, and concluded that the completed project was unlikely to provoke landslides, providing suitable preventative actions were taken during construction. Recommendations included:

- Prevention of soil erosion in the area surrounding the reservoir;
- Evacuation of several houses on steep soil slopes on the right bank, the toes of which would be inundated;
- Protection of an unstable rock mass approximately 500 m upstream of the dam site;
- Ensuring adequate supervision during the construction stage;
- Minimising heavy blasting and deep excavations and installing suitable rock protection;
- Minimising removal of vegetation to promote erosion control.

200. These and other measures to minimise erosion and landslips during construction are included in the mitigation measures proposed in Section VI.D.4 above. The NBRO study did not evaluate slope stability in the reservoir area in detail: some unstable rock masses were identified but no information on their location, sizes and condition was provided. This area was therefore re-examined in September 2013 via topographic analysis (presence and location of: landslide scars; talus; terrace; plain and cliff) and ground mapping (geological components; outcrops; rock condition; weathering; structure of strata, joints, fracture zones; distribution of unconsolidated deposits; and location and water flow of springs and tributaries).

201. This investigation revealed no evidence of large-scale landslides in the reservoir area and found that the structure of bedrock provides suitable slope stability on the left bank, where gneissosity dips towards the hillside. On the right bank, gneissosity dips towards the river and there are two locations of previous rock slides, approximately 1 km and 1.35 km upstream of the

dam site (Photos 8 and 9). However in each case the majority of the unstable rock mass is below Minimum Operating Level (MOL: 542 m), so even if the rock slides into the reservoir, the physical impact will be limited to short-lived wave action. Erosion at the edge of the reservoir caused by fluctuation of the water level should also not be significant, because bedrock outcrops at the toes of steep slopes on both banks, and where there are more gentle slopes there is a thick protective cover of vegetation.

202. The report concludes that landslides are unlikely to have a significant impact on the dam or reservoir; and the only mitigation needed is to monitor the reservoir slopes during impoundment in order to detect any small scale landslides, which cannot be identified, and which could trigger larger landslides.

2. Dam Failure

203. The Local EIA report examines the likelihood of the dam failing in the manner in which such events have occurred in the past, which are from: a) overturning due to the strength of the applied forces; b) sliding along the foundation or weaker planes in the foundation material; and c) failure of the foundations due to excessive loading. The main factor considered was the ability to safely pass the probable maximum flood (PMF), because overtopping can damage the dam structure and scour foundation material from areas critical to the stability of the dam, leading to a sudden and complete failure from sliding, or overturning from undermining and loss of toe support. Failure from seepage was also examined because, even though the Moragolla Dam will be constructed of impervious concrete and founded on sound rock through which there is almost no seepage, foundations can fail from seepage through weak zones despite sealing by curtain grouting, causing the dam to disintegrate and collapse.

Additional Table 12(d) for Addendum: Dam Failure

Description	Local EIA(2012)	Environmental Addendum(2013)
1- Baseline data	• Sect. 2.2.11 Arrangements for discharge of forecasted probable maximum flood • Sect 2.2.12 Details required to check the adequacy of the proposed dam and associated structures considering probable failure condition.	• CEB Restudied and updated information to reflect changes incoporated by optimization of project components. • CEB conducted topographic analysis and ground mapping • Volume 4; River downstream water user information was collected over an extended area up to Peradeniya Bridge, 17 km away • CEB conducted additional geological investigations • CEB conducted inundation mapping
2,3- Impacts	• Endanger downstream property and human life	• No change
4- Mitigation	• Sect 2.2.13 Proposal for emergency action plan along with arrangements for early warning systems and details required to ensure the dam safety aspects. • Sect 5.4.9 Disaster management plan	• No change Further discussed in sect VI.N.4 • No change

204. The Local EIA found that the dam has been designed to adequately resist overturning and sliding with acceptable margins of safety (factors of 2 and 1.5 respectively) and that the spillway has a maximum discharge capacity of 7,750m^3/s, whereas the PMF is estimated as 6,000 m^3/s. There is therefore no risk of overtopping. Even with one gate non-operational and closed the PMF could be passed safely without undue increase of the water level in the reservoir above FSL.

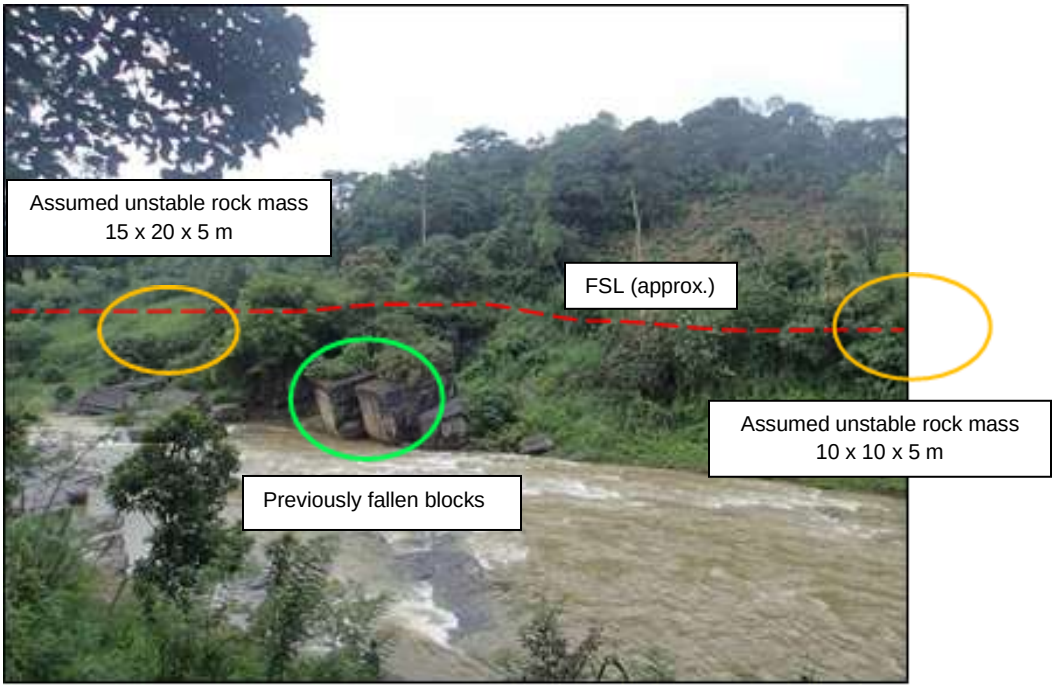

Photo 8: Unstable rock masses on right bank 1 km upstream of dam site

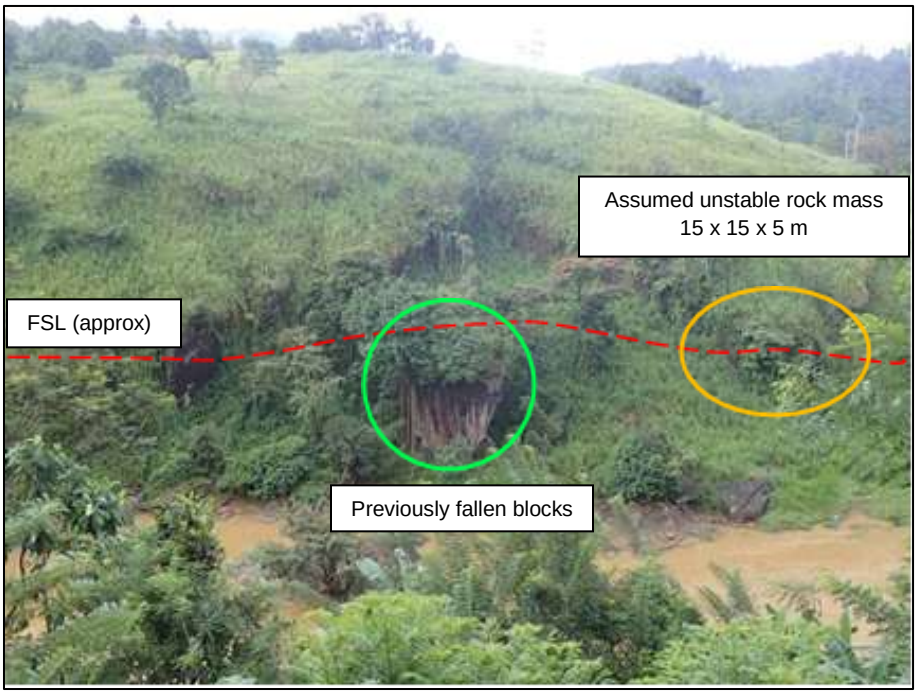

Photo 9: Unstable rock mass on right bank 1.35 km upstream of dam site

205. The issue of dam safety was re-examined in 2013 to take into account the changes in design and the results of additional engineering studies conducted during the FS Review and Detailed Design. This analysis is presented in the additional study report on slope stability and dam failure. The analysis points out that Moragolla is a concrete gravity dam and such dams are designed so that the weight of the dam, pulled downwards by the earth's gravity, far exceeds the lateral force of the retained water, avoiding any risk of the dam overturning or sliding.

206. In most cases of dam failure in the past, the main cause has been the quality of the foundations or the occurrence of unusually large floods that the dam was unable to pass safely. At the Moragolla site the foundation rocks are garnetiferous gneiss and charnockitic gneiss, which are fresh and sound. The foundation has a safety factor of more than 4 against shear force, even in the cases of the 1-in-10,000 year flood and the maximum credible earthquake with a seismic coefficient of 0.10. The dam is designed to meet all safety requirements in accordance with modern technical standards; and the possibility that the dam will fail due to foundation failure is remote.

207. The Moragolla spillway has the capacity to pass the peak discharge of a 10,000 year flood (6,700 m^3/s) with the reservoir level at FSL (548 masl), 2 m below the top of the dam. Even if one gate is completely blocked, the spillway will be able to release the peak discharge of the 10,000 year flood at a reservoir level of 550 masl, the top level of the dam. The possibility of the dam being overtopped is remote. Even if the dam were to be overtopped, it is able to withstand the resulting water pressure because of the massive concrete body on the solid rock foundation.

208. The independent technical analyses conducted in 2009 and 2013 reached the same conclusion, which is that there is no possibility that Moragolla Dam will be subject to catastrophic failure. This is further supported by historical precedence, which shows that, although 1% of concrete gravity dams built before 1930 failed, none of the 2,500 built more recently have failed[20].

209. Notwithstanding the strength of this conclusion, hydrological studies were conducted in 2009 to predict the area that would be flooded if the dam were to fail. In the absolute worst case, of the dam disappearing instantaneously when the 10,000 year flood reaches its peak, it is estimated that a flood of 13,300m^3/s would flow downstream. This would raise water levels to 488 masl at Gampola and 482 masl at Peradeniya as shown in Figure 20 below. The potential impacts of such an event and related disaster management procedures are discussed in Section VI.N below.

H. Air Quality

210. Air quality in the project area was described in the Local EIA report using data from a survey conducted in 2009, which included analyses of the levels of the main air quality constituents. In a rural area such as this it is unlikely that conditions would have changed significantly in the intervening four years, so no additional survey work was conducted in 2013. The Local EIA did not discuss potential impacts of the project on air quality, or propose any mitigation, so these issues are examined in the following section (using the baseline data from 2009) so that recommendations can be made for the mitigation of impacts, if necessary.

[20] ICOLD (2000): *The Gravity Dam: a dam for the future. Review and Recommendations.* International Commission on Large Dams, Bulletin 117.

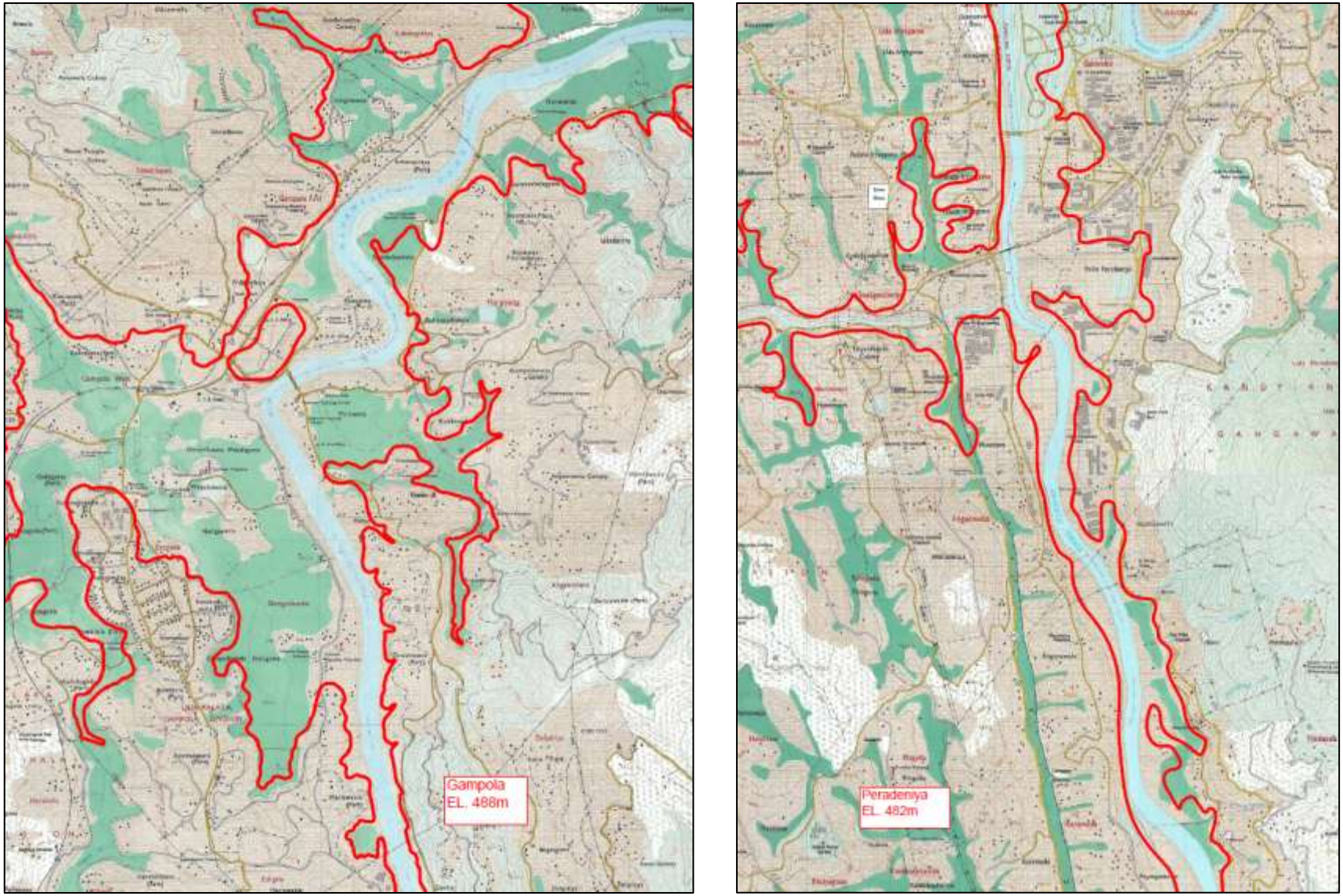

Figure 20: Predicted flood level at Gampola (left) and Peradeniya (right) for dam failure in a 10,000 year flood

Additional Table 13(a) for Addendum: Air Quality

Description	Local EIA (2012)	Environmental Addendum (2013)
1- Baseline data	• Sect. 3.1.5 Ambient air quantity in the project area.	• No change
2,3- Impacts	• Sect 4.6.4 Impact due to material transportation • Sect 4.6.5 Noise, Vibration and Air pollution due to dust.	• No change
4- Mitigation	• Sect 5.4.3 Mitigation measures to address air quality deterioration	• No change Further discussed in Sect VI.H.4

1. Existing Conditions

211. Table 13 shows the results of surveys on air quality, noise and vibration, conducted for the Local EIA study in March 2009. Data are compared with the most relevant legal standard or proposed standard in each case.

Table 13: Background levels of noise, vibration and air quality in the study area in 2009[21]

Location	Noise L_{eq} dB(A)		Vibration	Air Quality mg/m^3				Particulates mg/m^3	
	Day	Night	mm/s	SO_2	NO_2	CO	O_3	PM_{10}	$PM_{2.5}$
Tailrace	46	43	<0.5	0.007	0.009	1.5	0.001	0.008	0.003
Residence - Power House	54	58	<0.5	-	-	-	-	-	-
SAARC Village	54	48	<0.5	-	-	-	-	-	-
Ulapane Industrial Estate	56	49	<0.5	0.019	0.028	3.5	0.003	0.013	0.005
Dam Left Bank	52	46	<0.5	0.013	0.011	1.8	0.001	0.008	0.002
Dam Right Bank	54	48	<0.5	-	-	-	-	-	-
Residence, Left Bank	54	48	<0.5	-	-	-	-	-	-
Residence Right Bank	53	49	<0.5	0.012	0.010	2.5	0.002	0.011	0.050
Quarry Site	40	45	<0.5	0.018	0.015	2.8	0.003	0.016	0.007
Mahaweli Maha Saya	44	41	<0.5	-	-	-	-	-	-
National Standards	55[a]	45	0.5[b]	0.120[c]	0.150	10	0.200	0.100	0.050

a) CEA: National Environment (Noise Control) Regulations No 1, 1996, Annex II (Gazette Extraordinary No 924/12). Maximum permissible noise level at the boundary of land containing a noise source; in a low noise area.

b) CEA: Proposed Air-Blast Over Pressure and Ground Vibration Standards for Sri Lanka.
Interim Standards for vibration of the operation of machinery, construction activities and vehicle traffic movements.
For Type 4 Buildings (Structures that are declared as archaeologically preserved)

c) CEA: Ambient Air Quality Standards, 2008 (Gazette Extraordinary No 156/22).

Shading shows non-compliance with the relevant standards

[21] Local EIA Report (see Volume 5), Tables 3.10, 3.11 and 3.12 (Annex 4)

212. Air quality was monitored at five sites spread throughout the project area, and covered the four most common gaseous pollutants (Sulphur dioxide, Nitrous oxide, Carbon monoxide and Ozone) and the two main particulate components (<2.5 microns and <10 microns). All parameters were well below the levels specified in the national ambient air quality standards so the Local EIA concluded that there is no evidence of air pollution in the project area. This is as would be expected in a rural location that is sparsely populated, and with only light industry present.

2. Pre-construction and construction phase impacts

213. Table 7 (Summary Impact Matrix) shows that many of the activities conducted during the pre-construction and construction phases of the project carry some risk of adversely affecting air quality. The main risks are from land clearing and the major earth-moving and processing operations (quarry; crusher plant; and spoil disposal); and there are also risks from the operation of construction equipment, which are therefore common to most sites.

214. **Dust at construction sites:** Table 7 shows that the activities and sites at which there could be impacts on air quality are mainly those where there are also risks to water quality. This commonality relates to the creation, presence and usage of areas of bare soil, which could liberate dust when dry, as well as producing silt-laden runoff during rainfall. As with water quality, the risk of dust arises as soon as an area is cleared of vegetation, and persists as long as bare soil or unpaved roads remain. Risks are again greatest where the larger areas of soil are exposed and for the longest time (eg dam site); and where there are large earthworks and soil handling and disposal activities (excavation for the dam; tunnelling; quarry; and spoil disposal sites). Risks are also greatest during the dry season, especially if there is windy weather.

215. Dust consists of particles in the atmosphere; and at construction sites it comprises mainly fine particles of dry soil, which are blown into the air by wind, disturbed by vehicles, or generated when soil is handled (eg during excavation, transportation and disposal). Dust is normally assessed according to the quantity of material of different particle sizes present in the air, and the 2.5 and 10 micron fractions recorded in the 2009 surveys are the most commonly measured parameters.

216. Like water quality, the severity of dust impacts depends on the nature and sensitivity of the receptors in the vicinity, and the river is again an important feature, as the project must not add significantly to existing high turbidity loads by allowing large quantities of dust to blow across and into the river or its tributaries. Vegetation is also sensitive, as a covering of dust on leaves reduces photosynthesis and plant productivity. Dust should therefore not be allowed to blow across land containing crops, or onto vegetation around construction sites, as trees and shrubs coloured orange from construction dust creates a poor impression of site management.

217. For air quality impacts, human habitation is one of the most important factors as dust inhalation can cause respiratory difficulties and create or exacerbate associated health problems; and the nuisance-effect of dust entering people's houses and gardens can quickly generate public opposition to a project. Although the Moragolla site is not heavily inhabited, dust will still need to be strictly controlled at all sites, and especially where there are houses or workplaces nearby (even in small numbers), including the dam, powerhouse, quarry, contractors' area and Disposal Areas 2 and 3 (see Figs 8 and 19). Dust will also need to be controlled to protect the health of workers, site staff and visitors.

218. **Emissions from vehicles:** Vehicles generate other forms of air pollution, primarily from the burning of hydrocarbon fuels. As a result, vehicle exhausts release varying amounts of particulate matter (soot and metals), nitrogen oxides, carbon monoxide, carbon dioxide, sulphur dioxide (especially from diesel fuel) and other toxic components (benzene, acetaldehyde, etc). These contribute to air pollution locally, especially where topographic and meteorological conditions limit dispersion; and globally (carbon dioxide and nitrous oxide are amongst the major greenhouse gases and contributors to global warming).

219. It was estimated in Section IV.E.2 above that over 100 specialised vehicles will be involved in the construction process for this project (including 50 dump trucks, 12 backhoe excavators, 10 bulldozers, 10 power shovels and 10 concrete mixer trucks), plus possibly 20-30 smaller vehicles for transporting personnel and other general activities. Most of the construction vehicles are large and fuelled by diesel, and many of them will be in almost daily operation throughout much of the construction period (Fig 7).

220. The project area is quite sparsely populated, especially in the vicinity of the main construction activities (dam and powerhouse) and construction-related activities (quarry and disposal sites), see Fig 19. Localised air pollution and its impacts on residents (which can include respiratory illness, nausea and other physiological problems) should therefore not be major issues. However, the valley topography and the fact that some local roads and project sites are enclosed by tall vegetation, suggests that this is not an area from which atmospheric pollutants will be quickly dispersed. CEB will also not want to negate the benefits gained by avoiding power generation by fossil-fuelled stations, by the excessive use of petrol and diesel fuelled vehicles and plant in the construction process. Reduction of vehicle usage is discussed with other mitigation measures below.

221. **Transportation:** Transportation of materials presents a particular issue with respect to air quality, as it widens the potential exposure area to include roads and their environs; and increases the pollution sources to include: road dust; materials spilled or blown from trucks; and emissions from vehicle exhausts. These can all affect people living alongside the haulage routes, and any sensitive buildings, habitats, land-uses, etc nearby. Transportation is a major issue for this project because of the amount of material involved and the numbers of vehicle movements, in an area in which there is little traffic normally.

222. It was explained above that an estimated 300,000 m^3 of waste spoil will be produced, around 250,000 m^3 at the dam site and 50,000 m^3 at the powerhouse. Figure 21 shows the anticipated flow of this material to the three disposal sites. All of the material from the powerhouse will be dumped at Disposal Site 3 nearby (see Fig 8), via the purpose-built access road (see Fig 19). The material from the Dam site will be taken across the dry river bed and via Atabage-Mawathura Road on the right bank to Disposal Area 1 (120,000 m^3), Disposal Area 2 (10,000 m^3) and via the causeway to Disposal Area 3 (113,000 m^3). This will be carried on dump trucks with an estimated capacity of around 20 m^3 so transportation will take around 30,000 truck movements (one journey loaded and a return journey empty).

223. Figure 21 shows that there will also be additional transportation of material in the opposite direction: 45,000 m^3 from the quarry to the crusher at the contractors' area; and 55,000 m^3 from the quarry to the dam site to create cofferdams. A further 150,000 m^3 of concrete will be carried from the contractors' area, to the dam (115,000 m^3) and powerhouse (33,000 m^3). This will require an additional 25,000 journeys.

224. Transportation of materials will therefore take an estimated 55,000 journeys of mostly large dump trucks (Photo 2) and concrete mixer-trucks (Photo 4). With an average journey of around 2 km, over 100,000 km will be travelled in an area of roughly 4 x 2 km (between the dam and disposal sites 2 and 3). There will be a great many other vehicle movements: bringing workers and staff to site daily and returning to their accommodation at night; delivering equipment, components and other materials to site; carrying personnel and equipment between sites; and many other movements of heavy and light vehicles and equipment within and between sites. Figure 7 shows that transportation of materials will take place mainly in years 2, 3 and 4 of the construction programme. Assuming a six-day working week and a 50-week working year, there will be around 60 truck movements each day between construction sites and disposal areas, quarry or batching plant.

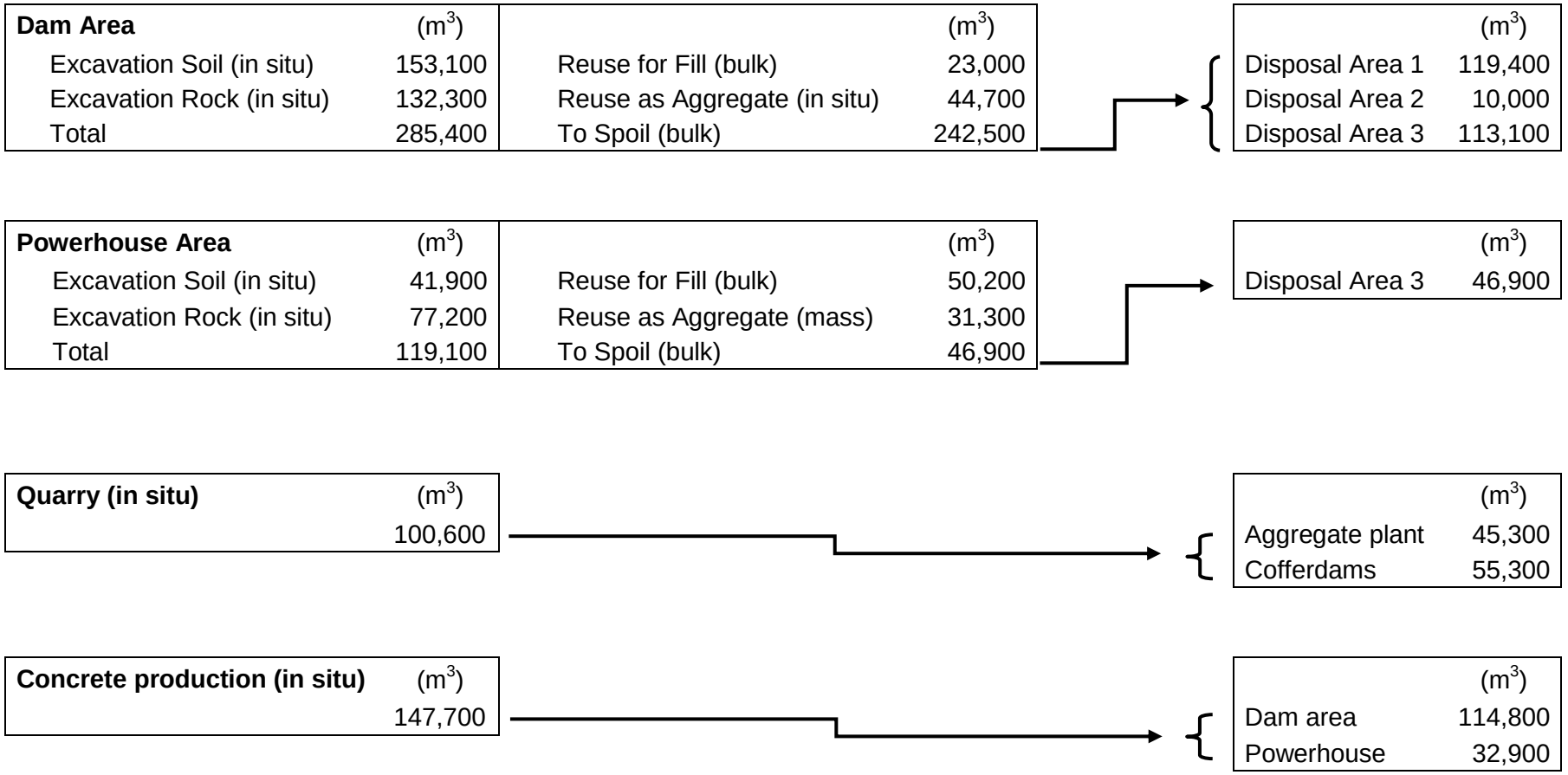

Figure 21: Flow of material during the construction process

225. Many potential impacts can be avoided or significantly reduced by careful site selection and receptive project planning and design, and that is the case for this scheme. All vehicle journeys create some exhaust emissions and these are greater with heavier (and older) vehicles. Trucks carrying loose material from unpaved construction sites will inevitably generate some dust (from the tyres and chassis) even if no materials are spilled or blown from the loads. However the choice of this site and the locations of the main project components means that air quality impacts associated with this operation will be less significant than might be otherwise expected, because of the limited sensitive receptors.

226. Around one third of the (two-way) journeys carrying spoil for dumping will be between the dam site and Disposal Area 1, and two-thirds of the journeys carrying concrete will be in the opposite direction. Along this route there are only two residential properties and one business, opposite the Contractors' area (Fig 19). Extending this route to Disposal Area 2 only passes one more inhabited area, the army camp near Atabage Oya. There are therefore very few houses and people in the vicinity of about 50% of the journeys carrying material (spoil for disposal; or stone, aggregate or concrete for use in construction), so any air quality impacts relating to this activity should not be of major significance, especially with the adoption of some straightforward safeguards as discussed below.

3. Operation phase impacts

227. There will be no impacts on air quality once the completed Moragolla scheme is in operation, and as noted above, reducing contributions to the global production of greenhouse gases by avoiding power generation via fossil fuels is one of the principal benefits of the use of hydropower. This is emphasised in the Local EIA study, which also estimates that by adopting hydropower as the generation mode instead of a fossil-fuelled power station, the government will save foreign exchange expenditure on fuel costs of around US$ 11 million annually.

228. CEB intends to submit the Moragolla HPP to the United Nations Framework Convention on Climate Change (UNFCCC) for consideration as a candidate project under the Clean Development Mechanism (CDM). CDM was established under the UN Kyoto Protocol in 2005 and is the mechanism through which developed nations purchase Certified Emission Reductions (carbon credits) from developing countries, obtained by implementing projects that reduce carbon emissions. This supports sustainability in the developing countries, assists the developed countries in meeting their emissions reduction targets, and reduces greenhouse gas emissions and global warming.

229. The FS Review and Detailed Design Study includes a CDM element, which is aimed at assisting CEB apply for CDM registration. At the time of writing this is at an early stage in which draft "prior consideration" documents have been prepared for submission to UNFCCC as notification of the intention to seek CDM status. The process will be continued in the forthcoming months, with the aim of securing CDM registration prior to commencement of MHPP operations. If this is successful the project will achieve the major long-term environmental benefits of contributing to worldwide reductions in greenhouse gas emissions and global warming and generating revenue for the Sri Lankan government for investment in further sustainable development in the future. The CDM study estimates that the CO_2 emissions avoided by operation of the Moragolla project amount to 71,736 tonnes of CO_2 per year[6].

4. Proposed mitigation measures

230. **Pre-construction and construction phases:** the main concerns regarding impacts of the project on air quality relate to the production of dust and the release of polluting gases by vehicle exhausts. These can be issues at most construction sites and alongside roads used to transport material (for disposal and for use on site), and exhaust emissions also contribute to the increasing global loads of greenhouse gases. The project area is not especially sensitive to these factors because it is quite sparsely inhabited, but site personnel will need to be protected, along with other receptors, including the river, cultivated land, vegetation and inhabited areas, near construction sites and alongside transportation routes.

231. Dust is the main issue, as it is a risk at all construction sites and most ancillary sites for as long as there is bare soil exposed; and the risk increases in the dry season, especially in windy conditions, and where there are major earth-moving operations (dam, powerhouse, tunnel, quarry and spoil disposal sites) and/or significant vehicle traffic on unmade roads. The correlation between impacts on air quality from dust and water quality from soil erosion was noted above. It is not surprising therefore that many of the mitigation measures already proposed to reduce soil erosion during rainfall, will also help to reduce dust production in dry weather. This therefore reinforces the need for these measures, which include the following:

Deep cuts and steep slopes	- Protection via stone facing, gabions, etc where needed; - Covering or vegetating final surfaces as soon as possible; - Monitoring (slope stability and dust production) during construction;
Spoil transport	- Covering all loads with tarpaulins (to reduce dust and rain wash-off);
Material storage	- Covered storage of loose material to prevent contact with rain/wind;
Spoil disposal	- Engineering planning of disposal sites and disposal operations; - Specification of slope gradients, compaction methods, drainage, etc; - Incorporation of check bunds and other slope stabilisation features; - Specification of final profiles & vegetation cover to maintain stability; - Close regular supervision and monitoring of the disposal operation;

232. There are also some additional measures, aimed specifically at dust reduction, which should be applied at all sites. These are:

- Planning a staged vegetation clearance operation to avoid blanket clearance of all sites at the start of construction and instead clear individual land parcels only when needed;
- Linking this to an accelerated re-vegetation programme so that any planned landscaping and planting of completed site areas is done as soon as feasible;
- Spraying all site roads and significant areas of bare soil with water three times per day in the dry season, and during dry conditions at other times if needed to damp down dust;
- Periodic light spraying of exposed soil at quarry and spoil disposal sites if feasible;
- Provision of workers with dust-preventing face-masks and training in their usage;
- Operation of wheel washes at all site exits to reduce vehicle dust on local roads;
- Regular frequent monitoring of dust at sensitive sites throughout the construction period, including Ulapane Industrial Estate; and residences along Gampola Road and near the dam, power house, quarry and disposal areas;

233. Emissions from vehicles will be reduced to an extent by the normal economics of construction, whereby contractors will streamline the construction process and avoid wastage and duplication of effort where feasible, in order to minimise costs and maximise profit. Fuel and vehicle hire are significant costs in a project of this nature, so contractors should seek efficiency savings in these areas, which will automatically minimise exhaust emissions. Experienced contractors (which will be needed for a project of this size and complexity) will seek these efficiencies without the need for a great deal of external stimulus, so no specific mitigation in this area is proposed.

234. There are additional actions that can also contribute significantly to emissions reductions, so these should be applied. These include:

- Avoiding the increased emissions associated with older vehicles by prohibiting the usage of vehicles on site that are older than say 10 years from first registration;
- Requiring contractors to routinely service and maintain all vehicles and machinery according to manufacturers' specifications;
- Requiring contractors to repair any vehicles that are showing excessive visible exhaust emissions, and to replace any that are repeatedly deficient;
- Ensuring that all site vehicles and machinery are fitted with the appropriate equipment to reduce exhaust gas emissions, including catalytic converters where applicable.

235. **Operational Phase:** There will be no adverse impacts on air quality once the MHPP is operating, so no mitigation is needed. As explained above, the operating project will provide significant air quality benefits by reducing greenhouse gas emissions, estimated as equivalent to 72,000 tonnes of CO_2 per year. The completed project will therefore provide significant environmental benefits on a global scale, which could also yield economic benefits for the government if the proposed application for CDM registration is accepted.

I. Noise and Vibration

236. Noise and vibration are the only major elements of the physical environment that have not yet been mentioned in any detail in this Environmental Addendum. Existing conditions in both of these aspects were adequately described in the Local EIA on the basis of surveys conducted in 2009, and the absence of major changes in land use in the intervening four years (see Section VI.F) indicates that conditions will not have changed significantly. No additional survey work was therefore conducted in these fields in 2013. The Local EIA was however somewhat deficient with respect to the assessment of impacts on these topics and in proposing mitigation, so these issues are examined in more detail below.

Additional Table 13(b) for Addendum: Noise and Vibration

Description	Local EIA (2012)	Environmental Addendum (2013)
1- Baseline data	• Sect. 3.1.6, 3.1.7 Ambient noise level, vibration level in the project area.	• No change
2,3- Impacts	• Sect 4.6.5 Noise, Vibration and Air pollution due to dust.	• No change
4- Mitigation	• Sect 5.4.4 Mitigation measures to address impact due to noise/ vibration	• No change Further discussed in sect VI.I.4

1. Existing Conditions

237. The results of the 2009 surveys are shown in Table 13 above, together with the most relevant national standards, from the Local EIA report. The noise standards are not directly applicable to the survey data as they prescribe the level of noise at the boundary of a noise-emitting operation, and are used here for reference only because there are no ambient noise standards in Sri Lanka. For this reason results are not shown as exceeding these standards, even though some values are above the quoted level. The vibration standards are applicable even though they are not yet legally prescribed. However it should be noted that the limit quoted in the Local EIA applies to sensitive preserved structures declared by the Department of Archaeology, and that standards that are more applicable to the buildings in the study area (Type 3 - single and two-storey houses and buildings made of light construction from bricks, cement blocks, etc) allow a greater level of vibration (2-8 mm/s intermittent).

238. On the basis of these results the Local EIA concluded that:

- The project area is a low-noise environment, mainly because of its rural location; and
- Vibration levels are well below those prescribed for sensitive areas, so there should be no structural damage or inconvenience of people from vibration in normal circumstances.

2. Pre-construction and construction phase impacts

239. At various places in this document it has been calculated that the construction process will involve the following:

- Excavating 400,000 m^3 of soil and rock at the dam, powerhouse and from the tunnel;
- Transporting 300,000 m^3 of waste spoil to disposal sites up to 4 km away;
- Quarrying 100,000 m^3 of stone and transporting it 1 km to the crusher or dam site;
- Reducing 45,000 m^3 of stone to aggregate in a mechanical crushing machine;
- Bringing to site around 100,000 m^3 of sand and other constituents of concrete;
- Mixing 150,000 m^3 of concrete at the batching plant and transporting it for use at the dam and powerhouse;
- Around 55,000 journeys by dump trucks and concrete mixers, of an average of 2 km over a 3-4 year period;
- 100, mostly large, specialised construction vehicles plus 20-30 smaller utility vehicles, operating on-site for most of the four-year construction period;
- Excavating a 2.7 km long, 4.7 m diameter tunnel through bedrock, via mainly pneumatic drilling and blasting, with further blasting at other sites, especially the dam.

240. Most of these activities and vehicles emit noise towards the higher end of the range to which people are exposed under normal circumstances, and some of the activities (such as pneumatic drilling and blasting) would be above this range. Some of the activities will be conducted more-or-less constantly when they are in progress (excavation, transportation of materials), whereas others will be short-lived and intermittent (blasting). The semi-enclosed nature of the valley environment, and the relatively short distances involved (the valley width is <1 km in most places) means that sound will transmit quite easily.

241. Noise and vibration are inextricably linked, as sound waves are produced by vibrating structures or surfaces. Activities that emit audible noise therefore frequently also generate detectable vibration, and that is often the case in construction work. In this project the main potential sources of vibration are likely to be the major physical activities: a) heavy site vehicles and deep excavation; b) transportation of materials (heavy vehicles driving along small rural roads); and blasting (pressure waves caused by the explosive charge).

242. For both noise and vibration the main sensitive receptors are people and wildlife. These can both be irritated and disturbed by exposure to various kinds of extraneous noise, in particular loud noises (constant or intermittent) or even softer noises, when constant or semi-constant. Repeated or long-term exposure can cause psychological stress and altered mood and behaviour and have quite severe impacts on quality of life (in humans and animals). Exposure in the workplace can cause these impacts and can also reduce safety by affecting concentration and reducing the effect of warning noises.

243. Vibration causes similar problems, and when significant noise and vibration occur together they generally exacerbate both psychological and physiological effects. Vibration may cause other impacts in its own right, including damage to buildings and other structures, for which the risk is generally greater in rural locations in developed countries, where buildings are generally not designed and constructed to withstand such forces.

244. In general, the limited inhabitation and natural habitat in the project area means that this is not a location in which there are large numbers of receptors that are highly sensitive to these factors. However, as with air quality, some of the locations (those listed above, and others with houses and other buildings nearby) will be sensitive, so mitigation will be needed; and the workforce will also need to be adequately protected at all sites.

3. Operation phase impacts

245. There will be some noise and vibration from the MHPP when it is operating, mainly from the water cascading down the spillway and through the tailrace outfall when power is generated; and possibly in the powerhouse area from operation of the turbines and other mechanical components.

246. Noise and vibration from water flowing down the spillway and tailrace outfall will be similar to the natural effect of water flowing in the river during the monsoon season, and will be experienced intermittently, so these should not be significant sources of disturbance of people or wildlife. Similarly, noise and vibration from the powerhouse will also be intermittent, and will be dampened by the design of the building, much of which is below the natural ground level (Fig 6). This includes the turbine room, which is the main potential source of noise and vibration.

4. Proposed mitigation measures

247. **Pre-construction and construction phases:** Noise and vibration will be produced by most of the physical activities conducted in the pre-construction and construction phases and the main concerns are the larger-scale activities, conducted using larger equipment, especially when implemented for long periods. This is not a location that is especially sensitive to these factors because of the low inhabitation and very limited natural habitat, but mitigation will be needed to reduce noise and vibration at locations where there is inhabitation nearby; and some actions will be needed at all sites, to protect workers and other site personnel.

248. Some of the mitigation that has been proposed to reduce impacts on other elements of the environment will also reduce noise and vibration (especially those related to air quality), so this strengthens the need for these measures. This includes:

- Prohibiting usage of older vehicles on site, eg no more than 10 years from registration;
- Requiring contractors to routinely service and maintain all vehicles and machinery according to manufacturers' specifications.

249. Some of the other measures proposed above will also reduce noise and vibration, if modified slightly. These are as follows, with additions included:

- Requiring contractors to repair any vehicles that are producing excessive exhaust emissions or significant noise, and replace any that are repeatedly deficient;
- Ensuring that all site vehicles and machinery are fitted with the appropriate equipment to reduce exhaust gas emissions and noise, including catalytic converters and noise-reducing exhaust fitments.

250. Construction sites that are expected to be the most sensitive to noise and vibration are: the dam (with Ulapane Industrial Estate in the vicinity); the powerhouse, tailrace and disposal area 3 (with several houses nearby); and the routes for the transportation of materials (because of the frequency and duration of the operation). If there is significant disturbance at these sites it might be necessary to erect noise barriers, but given the expense and visual impact of such structures, it is not proposed to recommend this measure immediately, but instead to monitor noise and vibration in the inhabited areas nearby, and to install barriers if noise is excessive, and if required by local residents. The structure of properties in these areas should also be surveyed before and during the construction period to record existing damage and any subsequent changes that may be attributable to the construction process so that CEB can arrange suitable repair or compensation. This is sometimes known as a "crack survey".

251. Finally measures to reduce exposure to noise and vibration for workers and other site staff should be developed and included in the Occupational Health and Safety Plans (OHSP), which all contractors will be required to prepare and implement (see Volume 2 Environmental Management Plan). As a minimum these should include the following:

- Provision of ear protectors that are effective to international noise-reduction standards and relevant to the type of exposure for different activities;
- Making the use of ear protectors mandatory for all personnel when in specified circumstances;
- Provision of training in the dangers of exposure to repeated and excessive noise and vibration, and the means of avoidance and reduction;
- Limiting exposure hours to those required by Sri Lankan law or recommended by international best practice (whichever provides greater protection).

252. The Local EIA study identified the main potential impacts from noise and vibration as: a) construction noise and vibration could disturb people and wildlife; and b) blasting and ground vibration could cause injury to workers and damage to property (Table 9). To combat these impacts the study recommended that:

- Construction works must be carried out in adherence to environmental standards specified for noise and vibration;
- Construction work should be restricted at night-time where necessary;

- The tunnelling operation should be carefully planned and executed in accordance with blasting methodology investigation reports;
- Tunnelling should incorporate appropriate supporting and dewatering systems;
- An OHSP should be followed;
- Appropriate material handling techniques should be adopted.

253. Any of these measures that have not already been highlighted in the account above will be incorporated in to the EMP in Volume 2.

254. **Operational Phase:** Noise and vibration from the operating scheme will be produced by water flowing down the spillway and through the tailrace outfall, but this is expected to be similar to the effect of the river flowing under natural conditions, so there should be no additional impacts. There may also be some noise and vibration in and around the powerhouse, but this will be dampened by the surrounding hillside and is therefore not expected to be noticeable outside the immediate vicinity of the powerhouse structure. No mitigation should therefore be required, except for powerhouse workers to be provided with ear defenders if found to be necessary.

J. Aquatic Ecology

1. Baseline Conditions and Vulnerabilities

255. The Mahaweli Ganga (above and below the project site) was surveyed during the original Local EIA work undertaken between 2009 and 2012 and twice again in 2013 (the additional studies, see Volume 4), so that seasonal variability in the physical conditions, the nature of the aquatic habitat, and the presence and diversity of aquatic fauna can be properly understood and possible project impacts anticipated. The baseline description below incorporates data from these studies and also refers to the descriptions in earlier sections of this report on the physical nature and water quality of the project site and the wider Mahaweli catchment, where relevant to the discussion of the distribution of vulnerable aquatic fauna (with a focus on fish).

Additional Table 14(a) for Addendum: Aquatic Ecology

Description	Local EIA (2012)	Environmental Addendum (2013)
1- Baseline data	• No clear baseline data on river ecology downstream of the proposed dam site.	• Volume 4; Collection of data and preparation of existing conditions in aquatic ecology and river water quality
2,3- Impacts	• Sect 4.3.2 Impact on aquatic fauna and flora with special reference to migration of fish species and environment flow downstream of the dam	• Sect VI.J.2 Pre-construction and construction phase impacts and Sect VI.J.3 Operation Phase Impacts
4- Mitigation	• Sect 5.5.2 Mitigation measures for drying of the river downstream of the dam site.	• Sect VI.J.4 Proposed mitigation measures

a. Overview of the Mahaweli Ganga System

256. The Mahaweli Ganga forms the largest river system in Sri Lanka, and is fed by a high mean annual basin rainfall, estimated at 3,852 mm/yr. The annual mean discharge of the Mahaweli Ganga, at the dam site, is 22.4m^3/s (discharge within the year can range between about 8 and 40 m^3/s, as noted previously in Section VI.C.1). A main tributary of the Mahaweli Ganga in the upper reaches is the Kothmale Oya (which now supports two hydropower dams, see Fig 1). From the project site downstream, the Mahaweli Ganga continues to receive flow from other tributaries.

257. A key feature of the whole Mahaweli Ganga system is its confinement to the central mountains and hills which, due to severe geological scoring, north-south ridges, deep valleys, and a slight topographic "tilt", has its discharge directed eastwards, through the Victoria Falls (now the dam), to the plains on the eastern side of Sri Lanka. It is suggested that the Victoria Falls in the past (over thousands of years) would have prevented upstream migration of fish, which could partially account for the high degree of endemism of fish in the Mahaweli Ganga (the Victoria dam now maintains that barrier to upstream movement of fish). There is a drop of about 145 m between the Victoria Dam and next reservoir (5 km away), most of this drop occurring where the falls used to be, immediately below the current dam (see Fig 22 and Photo 10).

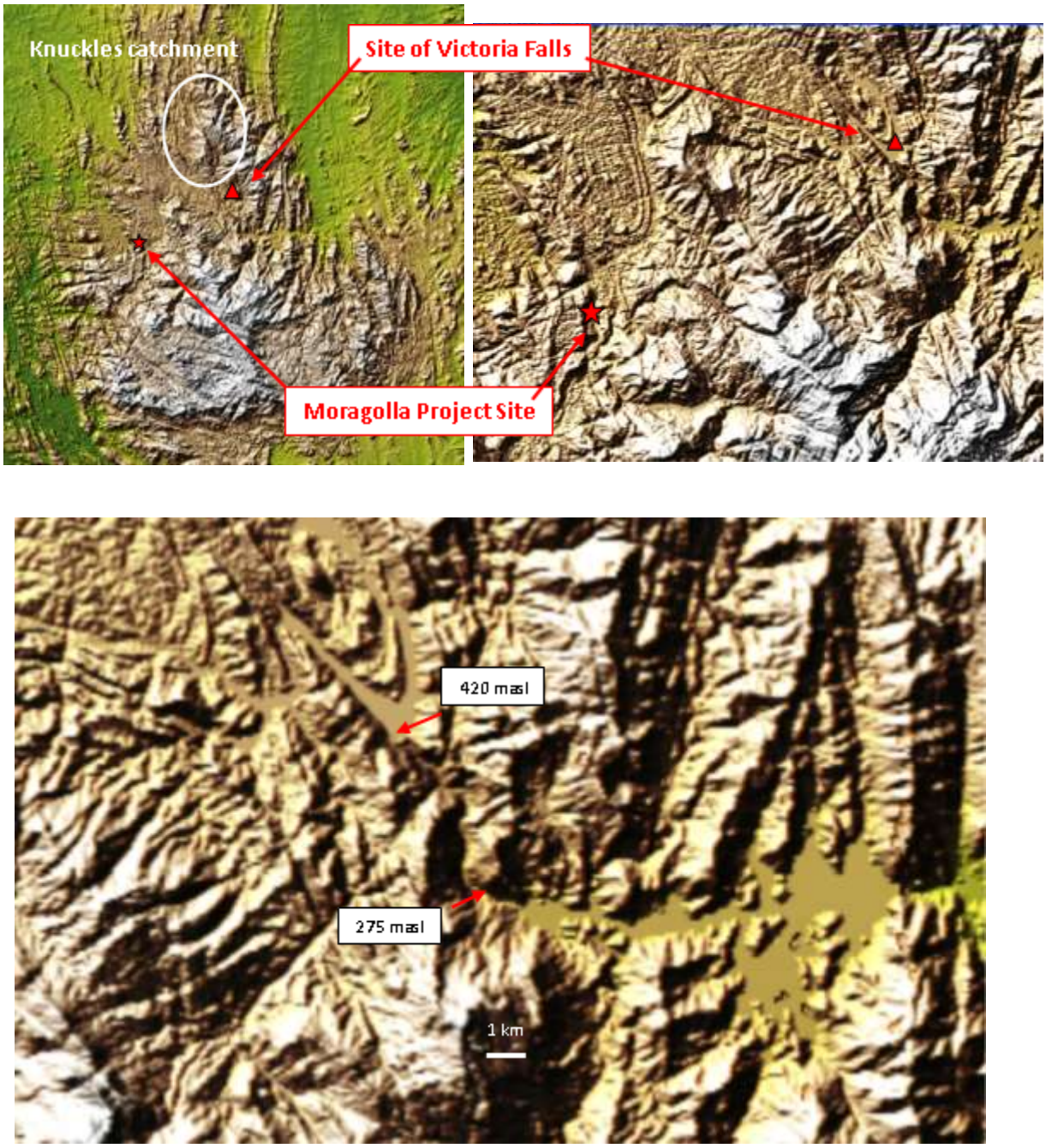

Figure 22: Location of the main natural barrier to upstream movement of fish in the Mahaweli Ganga (site of Victoria Falls, now a dam; highest elevations are shown in white, grading to brown, yellow, and green as elevations reduce); the Knuckles catchment, an area of high fish endemism, is indicated .

Photo 10: Tailrace at the Victoria Dam (slope trending lines have been inserted).

258. The Mahaweli Ganga flows through a diversity of physical conditions, from narrow upstream stretches (above about 500 m asl) dominated by rapids, cascades, and small waterfalls (at and above the project site) to wider, slower flowing stretches, starting after the confluence with the Atabage Oya. Most of the natural vegetation along the river banks was removed many years ago to provide land for tea plantations and other types of farming, and as a result there are almost no pristine river habitats left in the system, at least from the project site down to the Victoria dam, and there are constant inputs of sediments and contaminants to the river. Annual sediment yield is estimated at 265 m^3/km^2 [22] (this supports a pervasive sand mining industry all along the river). With lower elevations and a wider river downstream from the project site, the density of human settlements increases significantly, with the Kandy area being the most affected.

b. River Habitat Features

259. The diversity of river habitat types within the project zone of influence was examined in early 2013. The nature of habitat types is summarized in Table 14, which covers locations above the confluence of the Mahaweli Ganga and the Kothmale Oya down to the river stretch just downstream from the confluence of the Mahaweli Ganga and the Atabage Oya. The main habitat classifications (bed-forms, of significance to fauna) are shown below[23].

[22] Nippon Koei (2013). Technical Design Report for Moragolla Hydropower Project.
[23] NBRO Aquatic Survey (May 2013) - see Volume 4.

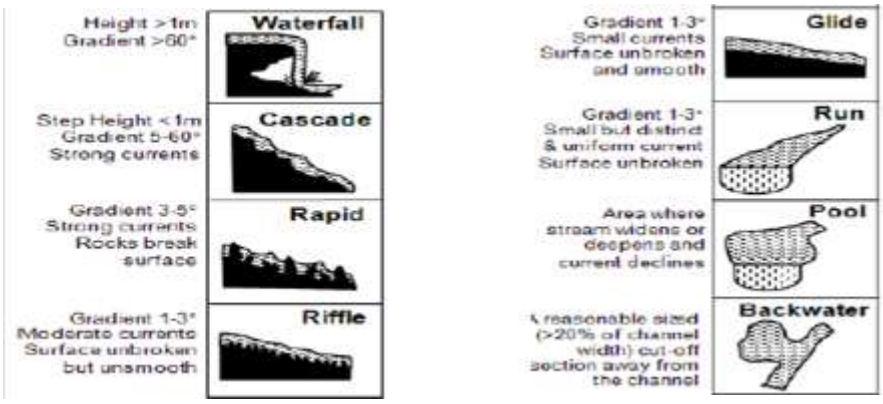

Table 14: Summary of river habitat features within the zone of influence of the Moragolla project

Criteria	Location						
	Kothmale Oya (KO)	**Mahaweli upstream**	**Mahaweli confluence KO**	**Reservoir area**	**Near dam site**	**tailrace location**	**Mahaweli downstream**
Valley shape	Shallow	broad	broad	broad, shallow asymmetrical floodplain	gorge	shallow	Shallow
Floodplain features	Remnant channels	Remnant channels	Remnant channels	Splays	Floodplain scours	Floodplain scours	Flood channels
Riparian zone composition	Trees >10m 25% Trees <10m 40% Shrubs 10% Grass/ferns/ sedges 25%	Trees >10m 20% Trees <10m 25% Shrubs 15% Grass/ferns/s edges 40%	Trees >10m 25% Trees <10m 35% Shrubs 30% Grass/ferns/s edges 10%	Trees >10m 45% Trees <10m 30% Shrubs 10% Grass/ferns/ sedges 15%	Trees >10m 45% Trees <10m 20% Shrubs 30% Grass/ferns/ sedges 5%	Trees >10m 30% Trees <10m 40% Shrubs 20% Grass/ferns/ sedges 10%	Trees >10m 25% Trees <10m 40% Shrubs 20% Grass/ferns/ sedges 15%
Shading of channel	5-25%	5-25%	5-25%	50-75%	>75%	5-25%	5-25%
Extent of trailing bank vegetation	Slight	Slight	slight	moderate	moderate	Slight	slight
Native and exoticriparian vegetation	Native 55% Exotic 45%	Native 60% Exotic 40%	Native 65% Exotic 35%	Native 95% Exotic 5%	Native 60% Exotic 40%	Native 75% Exotic 25%	Native 65% Exotic 35%
Longitudinal extent of riparianvegeta tion	Occasional clumps L Isolated/scatt ered R	Semi continuous L Isolated/scatt ered R	Semi continuous L Occasional clumps R	Semi continuous L Semicontinu ous R	Occasional clumps L SemicontinuousR	Semi continuousL Semi continuous R	Occasional clumps L Isolated/ scattered R
Overall vegetation disturbance rating	High disturbance	High disturbance	High disturbance	Moderate disturbance	Low disturbance	Moderate disturbance	High disturbance
Physical barriers tolocal fish passage	B Moderately restricted L Partly restricted H Good	B Moderately restricted L Partly restricted H Good	B Partly restricted L Good H Good	B Very restricted L Moderately restricted H Moderately restricted	B Very restricted L Very restricted H Moderately restricted	B Good L Partly restricted H Good	B Good L Partly restricted H Unrestricted
Type of bars	Mid channel bar vegetated	Mid channel bar	Side/pointed bar vegetated	Mid channel bar	Side/pointed bar vegetated	Mid channel bar un-	Side/pointed bar

Criteria	Location						
	Kothmale Oya (KO)	**Mahaweli upstream**	**Mahaweli confluence KO**	**Reservoir area**	**Near dam site**	**tailrace location**	**Mahaweli downstream**
		vegetated		vegetated		vegetated	vegetated
Dominant particlesize on bars	Boulder and Silt/clay	Cobble and Silt/clay	Cobble and Gravel	Boulder, Pebble Cobble	Boulder	Boulder and Cobble	Boulder and Cobble
Channel modifications	Re-sectioned	Re-sectioned	Re-sectioned	Re-sectioned	Re-sectioned	Dam and diversion (Dunhida irrigation canal)	Dam and diversion (Polgolla)
Extent of bed-formfeatures	Pool 85 % Backwaters 15%	Glide90% Backwaters 10%	Riffle 65% Run 25% Backwaters 10%	Rapid 30% Glide 40% Run 20% Pool 10%	Waterfall 5% Cascade 20% Rapid 20% Riffle 5% Pool 40%	Riffle 30 % Glide 30% Run 30% Pool 10%	Glide 60% Run 40%
Bed compaction	Tightly packed armored	Low compaction	Moderate compaction	Tightly packed armored	Tightly packed armored	Moderate compaction	Moderate compaction
Sediment matrix	Framework dilated	Framework dilated	Framework dilated	Framework dilated	Bedrock	Open framework	Open framework
Sediment angularity	Well rounded	Well rounded	Well rounded	Well rounded	Well rounded	Well rounded	Well rounded
River substrate composition	Bedrock 60% Boulder 20% Cobble 5% Pebble3% Gravel 4% Sand 3% Fines 5%	Bedrock 5% Boulder 15% Cobble 30% Pebble 20% Gravel 10% Sand 5% Fines 15%	Bedrock 10% Boulder 8% Cobble 50% Pebble 12% Gravel 5% Sand 10% Fines 5%	Bedrock 35% Boulder 18% Cobble 10% Pebble 20% Gravel 5% Sand 12%	Bedrock 95% Boulder 5%	Bedrock 15% Boulder 25% Cobble35% Sand 15% Fines 5%	Bedrock 5% Boulder 10% Cobble25% Pebble 5% Gravel 10% Sand 45%
Bed stability rating	Moderate erosion	Moderate erosion	Moderate erosion	Moderate erosion	Bed stable	Moderate erosion	Moderate erosion
Bank shape	Concave	Concave	Concave	Stepped	Wide low bench	Concave	Concave
Bank slope	Flat	Flat	Low	Moderate	Steep	Flat	Low
Bank material	Bedrock 10% Boulder5% Cobble 5% Pebble 5% Gravel 5% Sand 20% Fines 50%	Bedrock 10% Boulder 40% Cobble 10% Pebble 5% Gravel 5% Sand 10% Fines 20%	Bedrock 15% Boulder 5% Cobble 15% Pebble 5% Gravel 25% Sand 25% Fines 10%	Bedrock 20% Boulder20% Cobble 15% Pebble 10% Gravel 10% Sand 15% Fines 10%	Bedrock 80% Boulder 10% Sand 5% Fines 5%	Bedrock 20% Boulder10% Gravel50% Sand 15% Fines 5%	Bedrock 5% Pebble 35% Gravel 10% Sand 30% Fines 20%
Macrophyte cover in bank	Native 60% Exotic 40%	Native 40% Exotic 60%	Native 30% Exotic 70%	Native 20% Exotic 80%	Native 10% Exotic 90%	Native 15% Exotic 85%	Native 5% Exotic 95%

261. Table 14 reflects the variability evident in the Mahaweli Ganga system in the project area. A significant factor is the operation of the Kothmale dam (in operation for almost 30 years), which has depleted flows in the Kothmale Oya and therefore the Mahaweli Ganga between the confluence with the Kothmale Oya and the confluence of the Mahaweli Ganga and the Atabage Oya (a distance of about 6 km). The residual physical aquatic habitat reflects that influence, with remnant flood channels evident in the upstream parts of the survey area, and floodplain scours and flood channels demarking the Mahaweli Ganga from the dam site downstream. Bedrock, boulders and cobble (moderate to tightly packed) dominate all sections of the river that were surveyed, which reflects the underlying geology of the project area, and the prevailing hydrology of the river system over the last few thousand years. Bedrock dominates the riverbed at the dam site, which reflects the gorge river profile in this area, and

predominant accelerated river flow velocities as a result. As a consequence of river discharge, profile, and riverbed type, there are some patterns evident in bed-from types, with:

- pools evident in the mouth of the Kothmale Oya and near the dam site;
- glides (smooth, unbroken river flow at low gradients) dominating in the upstream and downstream sections of the Mahaweli Ganga (where a wide run then dominates, below the confluence with the Atabage Oya);
- riffles and rapids dominate the reservoir area and slightly upstream from that; and,
- waterfalls, cascades, rapids, and riffles (reflecting a rough riverbed and increasing river gradient) dominate in the area of the proposed dam and downstream to the confluence with the Atabage Oya; potential fish movement is most restricted in the area of the proposed dam, due to waterfalls and cascades (so there is difficulty getting upstream from this point).

262. Shading of the river channel by overhanging vegetation is most pronounced in the reservoir area and at the dam site, which reflects the higher density of trees immediately adjacent to the river, which in turn reflects the steeper slopes in these areas, inhibiting human access (and cutting of trees for development of cultivated areas). The various river habitat types are shown in Photo 11. Figure 23 shows aerial views of different sections of the river from Ulapane Bailey bridge (reservoir area) to the dam site and the confluence of the Mahaweli Ganga and Atabage Oya, indicating riverine vegetation and degree of overhang.

Photo 11: Diversity of river habitat types in the immediate project area (left to right; top to bottom; dried section of Kothmale Oya near Mahaweli; small pools in the Kothmale Oya; pool in Mahaweli Ganga in reservoir area; waterfall/cascade in reservoir area – about 3 m high; confluence of Atabage Oya; downstream stretch of the Mahaweli Ganga upstream from Peradeniya; river flow direction is indicated).

Figure 23: Aerial views of sections of the Mahaweli Ganga (left to right; the bridge in the proposed reservoir area; the dam site; and the confluence of the Mahaweli Ganga and the Atabage Oya; river flow direction is indicated).

263. The river habitat conditions in the project area have consequences for all plants and animals associated with the Mahaweli Ganga (especially fish). The main influences on the distribution of aquatic fauna are discharge rates, water depth, riverbed type, incidence of aquatic vegetation, and degree of shading (this is discussed later). Water quality (described in Section VI.D.1 above) also has a pervasive effect on all aquatic plants and animals.

c. Biological Features

264. The distribution of flora and fauna (biota) in the Mahaweli Ganga, within the zone of influence of the Moragolla project, is greatly influenced by the physical and chemical attributes of the river system (described above), which in turn are dominated by human uses of adjacent land areas, as well as human activities, such as sand mining, in the river itself. Distribution of biota also reflects the relative degrees of connection to (or isolation from) other upstream and downstream sections in the overall Mahaweli Ganga system (also described previously). Historically, the natural barriers were the waterfalls which occur at various points in the system, with Victoria Falls probably being the main natural barrier between the higher and lower elevation sections of the overall Mahaweli Ganga system. For aquatic plants, and most aquatic invertebrates, given their quite short lifecycles and high reproductive outputs, widespread distribution of species is evident in the project area (and, for some, throughout most parts of Sri Lanka). The same is true of most smaller vertebrates (amphibians and reptiles). Fish species have more specific requirements, and require more detailed analysis. Distribution and vulnerabilities of aquatic biota are described below, with due attention to those species which are categorized as especially vulnerable or endangered.

265. Given the diversity of river habitats from above the project site down to the Polgolla dam (about 30 km downstream), the aquatic ecology surveys for this project showed that there is:

- quite high diversity of aquatic plants (17 flowering aquatic plants, 7 of which are endemic; the latter are confined to the downstream reaches of the river below the project site, at Gampola);
- many invertebrates (including 7 endemic dragonflies and damselflies, and one crab, all occurring through the whole river stretch and elsewhere in Sri Lanka);
- a relatively high diversity of freshwater fish (47 species recorded, 14 of which are Sri Lanka endemics; discussed below);
- 3 indigenous aquatic reptiles (one, the flap-shell turtle is endangered, but only occurs upstream of the project site);

- 12 aquatic bird species (none vulnerable or endangered); and,
- several small mammals which are associated with riverine habitat (fishing cat, rusty-spotted cat, and the otter, which are endangered or vulnerable, but occurring throughout the project area and elsewhere in Sri Lanka as well).

266. These biota are all well-documented in the various field study reports undertaken in 2013 (they are included as Local EIA appendices, along with specific references and citations). Key details for fish are summarized below, since they are at most risk from the altered hydrology expected with the Moragolla project. Apart from the details provided above, aquatic vegetation and aquatic invertebrates are not further discussed here. While they may be affected by the more restricted aquatic habitat between the dam and the tailrace (less water volume and therefore patchier distribution of sustained aquatic habitat), they are distributed elsewhere in the Mahaweli Ganga and have resiliency due to their short life cycles and high reproductive potential.

267. Surveys in 2013 indicated that the fish diversity in the project area is relatively high. Forty-seven fish species have been recorded in the whole Mahaweli Ganga system (of 91 recorded overall for Sri Lanka); and 40 of the 47 fish species in the river system were observed in the project area. These species belong to 17 families, representing 14 endemic species, 21 indigenous and 5 exotics. Of these, eight species are nationally threatened[24]according to the current Red Data List of Sri Lanka. These include: *Channa ara* (Giant Snakehead); *Labeo fisheri* (Green or Mountain Labeo); *Channa orientalis* (Smooth-breasted Snakehead); *Garra ceylonensis* (Ceylon Stone-sucker); *Pethia melanomaculata* (Fire fin barb); *Pethia reval* (Red fin barb); *Pethia nigrofasciata* (Black ruby barb);and *Wallago attu* (Shark catfish). Further, the catadromous migrating eels *Anguilla bicolor* (Level finned eel) and *A. nebulosa* (Long finned eel) have been recorded in the area, despite the presence of several dams between the project site and the sea; they appear to be quite resilient, as they occur in rivers throughout Sri Lanka. *Tor khudree* (Black Mahseer), which swims upstream to spawn, has also been recorded in the project area (and is caught by fishers, who also target tilapia). Figure 24 shows the relative abundance of the endemic fish that were caught during the surveys in the project area (depicted as relative catch-per-unit-effort; CPUE). *Dawkinsia singhala* (Sinhala filamented barb) was the most abundant endemic fish species (5.75 CPUE) in the project area whereas all other endemic fish species encountered, including *Belontia signata* and *Clarias brachysoma*, occurred at comparatively low densities (<1.5 CPUE).The occurrence of the endemic and nationally threatened fish species in the project area needs to be considered in the context of their wider distribution in Sri Lanka. This is discussed below.

268. The degree of endemism seen in fish species reflects the characteristics of the overall Mahaweli Ganga system (discussed above; Victoria Falls representing a natural barrier at the downstream end of the mid-altitude system) and specific sub-catchments. Five of the endemic fish species in Sri Lanka are confined to the Mahaweli Ganga Basin; these include *Labeo fisheri* (Green or mountain labeo), *Dawkinsia srilankensis*[25] (Sri Lanka blotched filamented barb), *Systomus martenstyni* (Sri Lanka Martenstyn's barb), *Laubuca insularis* (Sri Lanka Knuckles laubuca); and, *Devario* cf. *aequipinnatus* (Sri Lanka Knuckles danio). Furthermore, all these species, apart from *Labeo fisheri*, are restricted to the Knuckles sub-catchment (see Figure 22)

[24]Nationally Threatened encompasses the three most at-risk conservation categories of Vulnerable, Endangered and Critically Endangered used in the IUCN Red List of Threatened Species

[25]Formerly considered to belong to the Genus *Puntius.*

of Mahaweli Ganga. Due to the significance of the fish distribution pattern and endemism, the Mahaweli Ganga basin is considered to be a discrete ichthyological province within Sri Lanka[26].

269. In addition to these fish species, four other endemic freshwater fish species, *Pethia nigrofasciata* (Sri Lanka black ruby barb), *Pethia reval* (Sri Lanka red-finned barb), *Rasboroides vaterifloris* (Sri Lanka golden rasbora), and *Puntius titteya* (Sri Lanka cherry barb), which were restricted to the southwestern ichthyological province, were introduced to the Mahaweli Gangabasin near Ginigathhena, which is located upstream of the Moragolla site, by Senanayake and Moyle in 1982. These introductions were made in an effort to conserve these species. Of these four introductions, only *Pethia nigrofasciata* and *Pethia reval* occur in the project area, suggesting that they have dispersed downstream from their entry point, and obviously have survived the translocation (however, their impacts on locally occurring fish species are unknown).

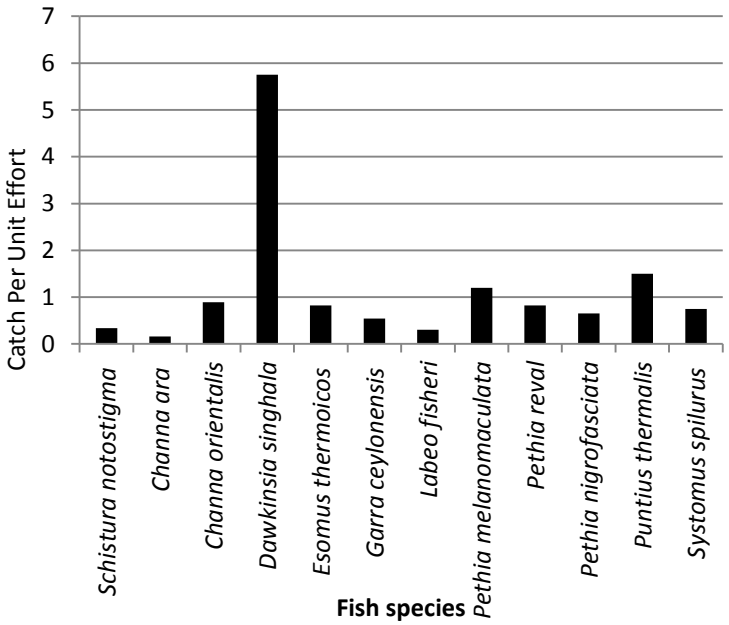

Figure 24: Relative density (relative CPUE) of endemic fish species caught in March 2013 in the project area.

270. Table 15 summarizes the classifications for the fish recorded in the project area that have conservation status in Sri Lanka. Table 16 lists all native fish species recorded in the project area, and their ranking which reflects vulnerability, based on specific criteria, including their overall distribution, project overlap with specific habitat requirements, whether or not they are generalists (for habitat and food requirements), conservation status, and ability to be bred in captivity. This is used to isolate the fish species of most concern in the project area (which can then be singled out for mitigation measures). The rankings are biased to the conservation status of each fish species, which in turn mostly reflects the distribution of the fish within Sri Lanka (and the world).

[26] Senanayake, R. (1980) The biogeography and ecology of the inland fishes of Sri Lanka. PhD dissertation (unpublished), University of California. 421pp.

Table 15: Conservation status of fish recorded from the project area (endemic species are indicated *; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; DD – Data Deficient; NT – Near Threatened)

No.	Family	Species	Common name	Conservation Status (MoE, 2012)
1	Balitoridae	*Schistura notostigma**	Banded mountain loach	NT
2	Belontiidae	*Belontia signata**	Comb-tail	NT
3	Channidae	*Channa ara**	Giant snakehead	EN
4		*Channa orientalis**	Smooth-breasted snakehead	VU
5	Clariidae	*Clarias brachysoma**	Marble catfish	NT
6	Cyprinidae	*Garra ceylonensis**	Ceylon stone-sucker	VU
7		*Labeo fisheri**	Mountain/ Green labeo	CR
8		*Pethia melanomaculata**	Fire fin barb	VU
9		*Pethia reval**	Red fin barb (translocated)	EN
10		*Pethia nigrofasciata**	Black ruby barb (translocated)	EN
11		*Systomus spilurus**	Sri Lanka olive barb	DD
12		*Tor khudree*	Mahseer	NT
13	Siluridae	*Wallago attu*	Shark catfish	EN

Table 16. Ranking of native fish species recorded in the project area (fish introduced from outside Sri Lanka – exotics – have been excluded); criteria are explained at the bottom of the table; see the IUCN report in the Local EIA appendix for specific rationale

Species	Points Allocated for Each Criterion						Total	Priority
	Species Status	Dist'n	Potential Project Impact	Consv'n Status	Generalist or Specialist	Success of Captive Breeding		
Labeo fisheri	+2	+2	+5	+6	+1	+2	+18	High
Pethia reval	0	+1	+3	+4	+1	0	+9	Mod.
Channa ara	+2	0	0	+4	+1	+1	+8	Mod.
Garra ceylonensis	+2	0	+3	+2	+1	+1	+8	Mod.
Schistura notostigma	+2	0	+3	+1	+1	+1	+8	Mod.
Channa orientalis	+2	0	+3	+2	+1	0	+8	Mod.
Belontia signata	+2	0	+3	+1	+1	0	+7	Mod.
Pethia melanomaculata	+2	0	+3	+1	0	0	+6	Mod.
Pethia nigrofasciata	0	+1	0	+4	+1	0	+6	Mod.
Tor khudree	+1	0	+3	+1	0	+1	+6	Mod.
Anguilla bicolour	+1	0	+3	0	+1	0	+5	Low
Anguilla nebulosa	+1	0	+3	0	+1	0	+5	Low
Clarias brachysoma	+2	0	0	+1	0	0	+3	Low
Puntius thermalis	+2	0	0	0	0	0	+2	Low
Anabas testudineus	+1	0	0	0	0	0	+1	Low
Mystus seengi	+1	0	0	0	0	0	+1	Low
Mystus vittatus	+1	0	0	0	0	0	+1	Low
Channa gachua	+1	0	0	0	0	0	+1	Low
Channa punctata	+1	0	0	0	0	0	+1	Low
Channa striata	+1	0	0	0	0	0	+1	Low

Species	Points Allocated for Each Criterion						Total	Priority
	Species Status	Dist'n	Potential Project Impact	Consv'n Status	Generalist or Specialist	Success of Captive Breeding		
Lepidocephalichthys thermalis	+1	0	0	0	0	0	+1	Low
Amblypharyngodon melettinus	+1	0	0	0	0	0	+1	Low
Dawkinsia singhala	+2	0	-1	0	0	0	+1	Low
Esomus thermoicos	+2	0	-1	0	0	0	+1	Low
Puntius bimaculatus	+1	0	0	0	0	0	+1	Low
Puntius dorsalis	+1	0	0	0	0	0	+1	Low
Puntius vittatus	+1	0	0	0	0	0	+1	Low
Rasbora dandia	+1	0	0	0	0	0	+1	Low
Awaous melanocephalus	+1	0	0	0	0	0	+1	Low
Glossogobius giuris	+1	0	0	0	0	0	+1	Low
Heteropneustes fossilis	+1	0	0	0	0	0	+1	Low
Mastacembelus armatus	+1	0	0	0	0	0	+1	Low
Ompok bimaculatus	+1	0	0	0	0	0	+1	Low
Aplocheilus parvus	+1	0	-1	0	0	0	0	Low
Etroplus maculates	+1	0	-1	0	0	0	0	Low
Etroplus suratensis	+1	0	-1	0	0	0	0	Low
Devario malabaricus	+1	0	-1	0	0	0	0	Low

1. **Status of the species**: native but recent introduction to area (0), Indigenous (+1), Endemic (+2);
2. **Distribution**: Island wide (0), Mahaweli basin and Dry Zone (+1), Mahaweli basin and Wet Zone (+2), Mahaweli basin only (+3);
3. **Impact to species due to the proposed reservoir/dam:** Positive (-3), Low negative (+3), High negative (+5); no impact (0);
4. **Conservation status (based on the National Red List 2012 of Sri Lanka):** LC (0), NT (+1), DD (+2), VU (+2), EN (+4), CR (+6);
5. **Generalist or specialist** with respect to reproduction, habitat and feeding habits: generalist (0), specialist (+1); and;
6. **Captive breeding**: successfully bred species (0), hard to breed (+1), captive breeding not successful (+2).

271. Only one species, *Labeo fisheri* (mountain or green labeo), was identified as a high priority species, mainly due to its quite restricted distribution in the Mahaweli Ganga system, and its requirement for clear, relatively deep, and fast-flowing river conditions (discussed further below). Nine species: *Schistura notostigma* (Sri Lanka banded mountain loach); *Belontia signata* (Sri Lanka combtail); *Channa ara* (Sri Lanka giant snakehead); *Channa orientalis* (Smooth-breasted snakehead); *Garra ceylonensis* (Sri Lanka stone sucker); *Pethia reval* (Sri Lanka red-finned barb); *Pethia nigrofasciata* (Sri Lanka black ruby barb); *Systomus spilurus* (Sri Lanka olive barb); and, *Wallago attu* (Shark catfish) were identified as moderate priority species. They all have a slightly wider distribution than *Labeo fisheri* and less specific habitat requirements. The remaining 30 species in the ranking (Table 16) are considered as low priority species as they have wider distributions than the higher-ranked fish species. Based on this analysis, *Labeo fisheri* (mountain or green labeo; see Photo 12) is the only fish species that can be considered at risk from the Moragolla hydropower project. Its specific distribution (Figure 25) and habitat requirements (Table 17) are discussed below.

Photo 12: *Labeo fisheri* (specimen caught near confluence of Mahaweli Ganga and Atabage Oya in May 2013); approximately 35 cm long.

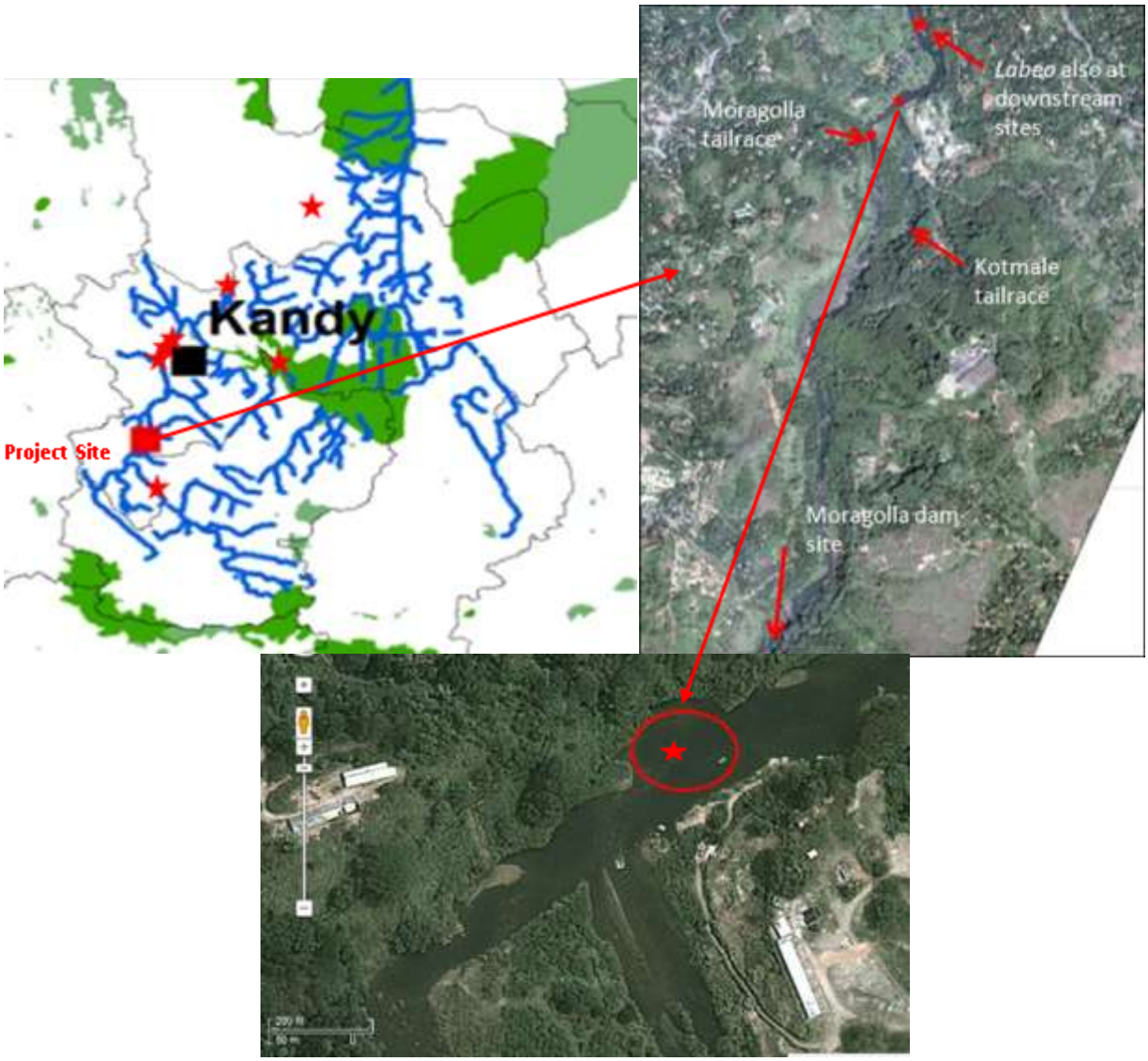

Figure 25: Known distribution of *Labeo fisheri* (★) in Sri Lanka, and the two specific known locations in the project area.

Table 17: Summary of known information about *Labeo fisheri* (IUCN, 2013 with additions; see appendix for citations and references).

Scientific name	*Labeo fisheri*
Common names	Green labeo, Mountain labeo, Kalu gadeya, Gadeya
Synonyms	*Labeo gadeya*, *Morulius gadeya*
Conservation status	Endangered (Global Red List, 2009), Critically Endangered (National Red List, 2012).
Distribution within Sri Lanka	Endemic to Sri Lanka and restricted to the Mahaweli Ganga basin.
Distribution within the Mahaweli Ganga system	The known distribution of *Labeo fisheri* is restricted to the upper and middle reaches of the Mahaweli River basin, including tributaries that originate from the Knuckles mountain area. *Labeo fisheri* was a common edible fish species in middle reaches of the Mahaweli Ganga until the late 1970s (strong possibility that it has been over-fished).
Feeding, habitat preference, life cycle, and population density	Pethiyagoda (1991) reports that the juveniles of *Labeo fisheri* feed on algae that grows on rocky surfaces. The external morphology of the fish also indicates bottom dwelling and grazing feeding habits. The preferred habitat of this fish is deep, shaded, clear, fast-flowing water, and rocky mountainous pools in the main river system (Pethiyagoda, 1991; Shirantha, 2012). It moves fast through the water, staying close to the bottom.Breeding has not been recorded, but Shirantha (2012) suggests an upstream movement for spawning (like other cyprinids, eggs would drift downstream). In 1990, Wickramanayake reported the possible extinction of this fish (now known to be incorrect). Pethiyagoda (1991) recorded this species from a few locations within the Mahaweli basin (near Kandy and Knuckles area). A recent study on the distribution of *L. fisheri* shows that the population density of this species in the middle reaches of the Mahaweli River (Knuckles area) is 1 per 0.5 km^2 (Shirantha, 2012). Several specimens have been found near Kandy in the last two years, and a single specimen was caught by a fisherman (in 2011) in the small river that flows into the Kothmale reservoir (the latter indicates an isolated population above the Kothmale dam, which is to be verified). Several were caught in the Mahaweli Ganga near the confluence with the Atabage Oya, and at some downstream sites, in 2013 (the survey for the Moragolla project).
Reproduction	Not recorded (Pethiyagoda, 1991; Shirantha, 2012).
Captive breeding and *ex situ* conservation	According to the available data, this is one of the most difficult fish to breed in captivity. Pethiyagoda (1991) stated that there is no record of aquarium kept *L. fisheri*. Further, Shirantha (2012) reported that all efforts to keep this species in captivity were unsuccessful. It can, therefore, be concluded that the likelihood of successfully breeding this species in captivity is extremely low.
Critical habitats	The project area (only at and below the confluence of the Mahaweli Ganga and the Atabage Oya) can be considered as a habitat area for adult *Labeo fisheri*. The historical distribution of this species ranges from the project area to the Victoria–Randenigala area, and the Kalu Ganga sub-catchment in the Knuckles area. Recent observations have confirmed the presence of *Labeo fisheri* in its original range, as well as above the Kothmale reservoir. Whereas there has been much speculation about the pending extinction of this species, it is usually found when fish surveys are focused on finding it. It appears to have some resilience (especially if not fished) within its very limited range, despite the presence of dams and human inputs to the river system. Given that more than 80% of observations of *Labeo fisheri* have been made in the original distribution area of the fish downstream from the project site, it is concluded that the project site, above the proposed tailrace is not critical habitat for this fish.

272. There is no doubt that the green or mountain labeo (*Labeo fisheri*) has a restricted range, which, along with over-fishing, is perhaps the main factor in its relative rarity in Sri Lanka. Nevertheless, when fish surveys are undertaken, it is found within its original range (and now also apparently in the upper reaches of the Kothmale Oya, in 2011). Validation of recent observations of *Labeo fisheri* (Figure 19) confirms that 90% of observations and scientific catches of this fish occur in the traditional habitat range of this species, which is at least from the confluence of the Mahaweli Ganga and Atabage Oya down to the Victoria Reservoir, and in

the Knuckles area tributaries that enter the Mahaweli Ganga. It appears that the *Labeo fisheri* favours the wider, shaded, faster flowing sections of the river and deeper pools, as the fish survey for the Moragolla project did not indicate any catches of *Labeo fisheri* in the stretches of the Mahaweli Ganga above the area near the confluence with the Atabage Oya, an area that is characterized by rapids, riffles, cascades, and waterfalls, and a lower discharge rate than below the confluence with the Atabage Oya. While *Labeo fisheri* may have been in the upper reaches of the Mahaweli Ganga at some point, with the operation of the Kothmale dam, the discharge in the Mahaweli Ganga, from the confluence with the Kothmale Oya, has been significantly reduced, whereas the discharge from the confluence of the Atabage Oya and the Kothmale tailrace has maintained relatively high discharge in the downstream sections of the Mahaweli Ganga, apparently contributing to the habitat requirements of *Labeo fisheri*, as these fish continue to be found there, but not in the upstream sections of the Mahaweli Ganga. This current distribution of *Labeo fisheri* has implications for assessment of impacts and development of appropriate mitigation measures.

2. Pre-construction and construction phase impacts

273. The potential impacts of the Moragolla Project, related to the aquatic environment, were defined from the overall environmental impact matrix (Table 7 above), and the summary of impacts associated with each project activity and environmental parameter (Table 8). All possible impacts and required mitigation measures are then discussed in detail below.

274. Impacts during the pre-construction and construction phases, are clustered according to how they affect the receiving environment (hydrology, water quality, habitats, and aquatic biota in sequence). Note that the possible environmental impacts are described first, then followed by a discussion of the most appropriate and practical mitigation measures.

275. **Sediment inputs to watercourses:** Land clearing and construction activity at all project work sites (quarry, dam site, access roads, adits, crusher plant, muck disposal sites) will mobilize sediments and may create slope instability, causing sediments to enter adjacent creeks and the river. This may lead to transient reduced water quality, due to suspended sediments (turbidity), which could occlude aquatic habitat in some areas. This depends very much on the time of year; for example, if sediments are mobilized and enter the Mahaweli Ganga during the eight months of high discharge, the sediments will tend to stay suspended and will be flushed quite quickly, moving downstream until they reach low flow velocity areas where they will eventually settle out (possibly in the Polgolla upstream area, retained by the dam). Flushing of construction-related sediments in the Mahaweli Ganga will be accelerated by the discharge contributions from the Kothmale tailrace and the Atabage Oya, so the section at most risk is from the dam site down to the Atabage Oya (about 3 km); this possible impact is mitigated naturally by the high velocity flow in this area, due to rapids, riffles, cascades, and some waterfalls, especially during the monsoon. It can be concluded that any accidental sediment inputs to the Mahaweli Ganga will be transient events, quickly flushed, especially during the monsoon. The Mahaweli Ganga is naturally turbid during the monsoon, and already suffers from many sections being sand mined, which creates large clouds of suspended sediments throughout the sand mining areas. To some extent, aquatic biota in the river system have adapted to the natural turbidity associated with the monsoon, and are somehow acclimating to or avoiding the sand mining areas. Regardless, all construction activities can be managed with sediment control measures to prevent sediment inputs to the watercourses in the project area; the construction of the causeway near the powerhouse site and the diversion tunnel and cofferdam at the dam site will be the most challenging since these works will occur directly in

the course of the Mahaweli Ganga, and will likely be undertaken during the lowest flow conditions (to enable work), which means that at this time sediments will be disturbed and enter the river in high concentrations during low flow periods.

276. **Other contaminants in watercourses:** There is always the risk of entry of contaminants into watercourses during the construction phase, due to poor work site management. This can include sewage from poorly constructed latrines, lubricants and other chemicals, and fuel. Whereas sewage is not a great concern, since there are already significant inputs of such waste from surrounding communities and farm animals (see the water quality section above), construction-related chemicals and fuel are much more toxic, and can lead to fish kills. Rapid dispersion in the relatively high flow velocities in the Mahaweli Ganga would help mitigate such contaminants, but the best approach is to avoid the risk of accidental spills altogether by locating fuel storage away from the area (bunded) and to keep other chemicals properly sealed and stored, also away from the river.

277. **Temporary disruption of flow due to the cofferdam:** The current plan is to create a tunnel diversion for the Mahaweli Ganga (on the left bank, about 300 m long, with a very shallow gradient, about a one meter drop over that distance), to allow continuous downstream discharge of the Mahaweli Ganga for the duration of construction of the main diversion dam. Several cofferdams above and below the dam site would be constructed to isolate the main diversion dam work site. Assuming a sufficiently large aperture, under most conditions the flow through the diversion tunnel should allow fish to move both upstream and downstream (this assumes no significant velocity increases, or at least sufficient periods of relatively low velocity that it does not completely inhibit upstream movement of fish; and there will be no drop at the downstream end of the diversion tunnel). The main fish of concern, *Labeo fisheri*, does not appear to occur in the river stretch above the area of confluence with the Atabage Oya, so it would not likely use the diversion tunnel. All fish above the diversion tunnel would be able to pass downstream through the diversion at all times, as the gradient, noted above, will be low and the outlet of the diversion tunnel will go back into the Mahaweli Ganga without a drop.

278. **Effects of blasting:** The main concern related to blasting is that fish could be exposed to pressure waves from blasting; they are particularly vulnerable because of their swim bladder, which can be damaged by blast pressure waves in water. Rock blasting at the site of mini-hydro in Gatambe (near Kandy) resulted in fish deaths several years ago (including a specimen of *Labeo fisheri*), so this issue has some profile[27].It is anticipated that blasting will take place along the dam axis, as well as near the tailrace location (other sites further away from the river are not as great a concern). It will be a significant benefit that work at the dam site will occur in the dry (between the cofferdams, described above), such that direct transference of blast shock waves to water will be greatly reduced. The same may also be the case at the tailrace site, as it will be somewhat recessed from the riverbank, at least where it exits from the tailrace tunnel. As noted elsewhere, the main concern is for *Labeo fisheri*, which is present near the proposed tailrace location, but not at the dam site. Management of construction works at the tailrace location will need to include consideration of non-explosive rock breaking and displacement techniques (such as dexpan or hydraulic breakers).

279. **Poaching of fish:** There is a risk that construction workers will attempt to catch fish illegally (poaching); this has been an issue at other construction sites adjacent to rivers,

[27] Kumudini Hettiarachchi and Shalomi Daniel (May, 2012). Now vital aquatic plants face similar fate as fish. www.sundaytimes.lk/110807/News/nws_18.

especially as some construction workers have easy access to explosives. The main species that have been encountered in local fisher catches in the project area are mahseers and tilapia, and these would also be reflected in catches from illegal fishing. These species are not a particular concern, as they occur in other parts of the river system (tilapia are especially common). The main concern is the mountain labeo (*Labeo fisheri*), as noted several times above. The risk of fish poaching will have to be addressed through a system of information dissemination and sanctions, backed up with vigilance and community monitoring.

3. Operation Phase Impacts

280. The project will create a marked permanent change in the hydrology of the Mahaweli Ganga (discharge rates, river breadth, and water depth) from the reservoir down to the location below the confluence of the Atabage Oya and the Mahaweli Ganga, where the tailraces from the Kothmale and Moragolla powerhouses will enter the river and "temper" these hydrological changes. The total length of river that will revert to either a relatively stable reservoir or a depleted river will be about 6 km; the 3 km length below the dam being the most affected (reduced discharge most of the time, compared to now; reduced width of river, and shallower water).

281. **Reservoir operation and downstream flows:** Section VI.C.3 provided a summary of the altered hydrology of the Mahaweli Ganga as a result of operation of the reservoir. Those details are repeated here as they pertain to possible impacts on aquatic ecology. The minimum environmental flow of 1.5 m^3/s, in terms of impact on water levels in the immediate downstream section of the Mahaweli Ganga, will not differ significantly from the existing low flow conditions (the 95% exceedance discharge of 3.6 m^3/s), although the presence and operation of the dam will mean that low flow conditions will prevail over a longer period. Even ignoring contributions of water flow from the Kothmale and the Atabage Oya (and other downstream tributaries), the project data indicate that low flow water levels in the Mahaweli Ganga will be maintained at about 1.5 m depth (it would still be deeper in the pools, wherever they are located). Obviously the lowest discharge rates and the shallowest water will occur in the area between the dam and the Moragolla tailrace (over 3 km), where "average" water depth will likely be quite shallow, but with the scattered pools still retaining relatively large quantities of water.

282. The combined effect of the Moragolla and Kothmale tailrace discharges will produce a minimum of about 20m^3/s in the immediate downstream section of the Mahaweli Ganga and a maximum of about 70m^3/s (monthly averages). Throughout the downstream section of the Mahaweli Ganga (below the tailraces), the most frequent combined discharge (about 50 m^3/s, in eight months of the year) will maintain water levels of at least 1 to 3 meters above the river bed. A variability of 3-4 times this discharge rate (up to 200m^3/s) may add 1.5-2 m to the water level. Thus water depths in the Mahaweli Ganga should range between 1 and 5 meters in the downstream sections (below the Moragolla tailrace). A serious concern relates to the possibility of both the Moragolla and Kothmale dams operating with the same generating cycles in the dry season (December-April), which could result in both tailraces being dry for up to 20 hours per day. If this were to occur, the only residual discharge in the Mahaweli Ganga below the two tailraces would be the minimum environmental flow and the contributions from the Atabage Oya and other tributaries further downstream. This situation can be avoided by adjusting the power generation cycles of both plants so that one or the other tailrace is discharging water at all times.

283. These data indicate that the area between the dam and the tailrace will still retain some water during the lowest discharge periods (December to April). This will reflect 1.5 m^3/s spread over the riverbed and channels totalling about 15-20 m in width; perhaps about 10 cm in average water depth, if such a number could be defined in an extremely variable riverbed. Given this low flow, connectivity of pools may be limited, which would make this 3 km section, at this time of year, less attractive to larger fish. At all other times of the year, this section will receive higher discharges and will probably have more connectivity of pools (with 30-40 cm average water depth contributed from the dam (based on the same analysis above, with 3-4 times the discharge, from spill-over and the environmental flow). For fish which tend to move at the beginning of the monsoon, as river discharge starts to increase, there will still be some scope to move into the river section below the dam (but obviously not able to get past the dam; discussed below); fish will not likely move into this river section during the lean season. On the other hand, the Atabage Oya will still be flowing, and the rest of the downstream section of the Mahaweli Ganga (90% of the river section downstream from the Moragolla dam and above the Polgolla dam) will be "fish swimmable" at all times of the year, as indicated above with the consideration of water depth.

284. Small fish (requiring less water) will not be so affected by the changed hydrology, whereas larger fish would probably forego the lean season access to the 3 km stretch below the dam. The particular concern is *Labeo fisheri*, but this fish is already confined to the area near the confluence of the Mahaweli Ganga and Atabage Oya and downstream from there. They do not frequent the rougher, more turbulent parts of the river up to the dam site. Therefore, one can conclude that this aquatic habitat, which will further diminished, is already sub-optimal and not important to *Labeo fisheri*.

285. The reduced volume of water in the 3 km section downstream from the dam will mean that contaminant concentrations (for example, coliform, ammonia, fertilizers, organic compounds, etc.) will increase in concentration in the lean season, if such inputs still exist. The main concern is the small volume of intermittent discharge from the Crysbro poultry farm on the left bank of the Mahaweli Ganga (below the dam site, but above the tailrace location). Wastewater from the poultry farm would therefore need to be treated (the preferred option, and required by law), or its ultimate outfall discharge location moved to an area below the Moragolla tailrace, where dilution would probably be sufficient to minimize any negative effects.

286. Operation of the reservoir will alter the Mahaweli Ganga upstream hydrology, inducing a change in the 3 km above the dam, going from fast-flowing to a more quiescent water body. For some fish species currently in the river system, this induced aquatic habitat diversity could suit some expansion of the population, by providing deeper water and relatively stable and quiescent shoreline, further enhanced by the expected 100-meter vegetated buffer all around (increasing the shade in the shoreline area, which suits many fish). However, given the negative experience in other parts of Sri Lanka, with exotic lake-type fish species being introduced and competing against native fish species, stocking of the reservoir is not recommended.

287. Given the likelihood of increased sediment accumulation in the reservoir area (at an estimated rate of 265m^3/km^2 [28]), it will be important to encourage and enhance effective watershed management in the areas upstream from the reservoir (the proposed vegetated buffer around all of the reservoir will help in this regard). This "sediment trap" effect of the

[28] Nippon Koei (2013). Technical Design Report for Moragolla Hydropower Project.

reservoir may provide some benefit to fish in the downstream areas, as suspended sediment loads (turbidity) may be reduced, which also suits many fish species (however, sediments will continue to come into the system from the Atabage Oya and other tributaries and land-based activities downstream from the Moragolla tailrace. Degraded water quality in the reservoir should not be a significant issue, as there will be fairly frequent turnover of water as it gets directed to the headrace. Inputs of cooler water from upstream will also promote circulation by sinking below the generally warmer water already held in the reservoir. However, as proposed in Section VI.D.4 above, all vegetation in the reservoir area will need to be completely cleared before inundation to prevent subsequent organic breakdown, low dissolved oxygen, and high nutrient levels in the deeper water of the reservoir.

288. There will be some risk of entrainment of fish in the headrace intake, which can be mitigated somewhat by using a sequence of screens of variable mesh, to keep them from going into the headrace. However, this arrangement also needs to suit the proper operation of the intake, without the screens getting clogged (trash racks near the surface would be cleaned regularly). For example, a relatively small mesh net, submerged about 2 meters below the surface (to avoid trapping floating debris), could be placed across the width of the reservoir, about 100-200 meters upstream from the dam. Fish which do enter the headrace and go through the turbine will inevitably suffer fairly high mortality rates. Many fish, when encountering a gradient in flow, will orientate against the flow, and try to swim "upstream", or away from the headrace intake entrainment flow; this may be effective for larger fish, especially if this effect can occur at the small mesh net, rather than closer to the headrace intake. Alternatively, the increasing experience with electronic fish barriers (mostly in North America), which seem to keep fish from entering the entrainment area, can be examined for effectiveness in the Moragolla case, and then installed, if feasible.

289. In the event of a dam burst, there would obviously be radical and immediate change in hydrology, in both the reservoir (drained) and the downstream sections of the river (experiencing a high suspended sediment load flash flood, which would scour and erode the riverbanks). This catastrophic event, in addition to being a risk to human safety, would essentially scour away the existing aquatic habitat, which would then take several years to re-establish. It should be stressed however that failure of a concrete gravity dam is extremely rare, with only two such dams having failed since 1950 (see Section VI.G.2 above).

290. **Obstruction of fish movement (the dam):** The diversion dam will prevent fish moving upstream, which means all fish in the river section below the dam will be restricted to that area and downstream sections (as far as the Polgolla dam at least). The fish surveys indicate that there are no long distance migrators in this part of the river, so critical movements for spawning may not be occurring. Fish may be making localized upstream movements for spawning purposes (mostly at the beginning of the monsoon), going into tributaries to spawn. Fish above the dam would still undertake these local migrations, going into the upper reaches of the Mahaweli Ganga and tributaries, and similarly fish below the dam site will have access to tributaries between the Atabage Oya and the Polgolla dam. Floating fish eggs and larvae in all sections of the river may continue to drift downstream and help with fish recruitment in the lower reaches of the river (for example, fertilized cyprinid eggs tend to drift downstream once they are

released; larvae and fingerlings then inhabit a section of the river about 20-25 km below the spawning sites[29]).

291. Almost all fish surveyed in 2013 occur both above and below the proposed dam site, and would therefore continue to populate the river, although with the population discontinuity caused by the dam. The only fish of major concern, *Labeo fisheri*, has not been observed in the Mahaweli Ganga above the dam site; it therefore appears that it has a viable population between the Atabage Oya and the Polgolla dam that should not be affected by the dam (more than 90% of *Labeo fisheri* sightings/catches occur in this area). One specimen of *Labeo fisheri* was apparently caught by a fisherman above the Kothmale dam. This may reflect an isolated population in the upper tributaries of the Mahaweli Ganga, which is hard to explain (possibly a relict of an historical *Labeo* distribution, or it may be a mis-identification). There is no possibility that *Labeo fisheri* is getting upstream past the Kothmale dam; and further studies would be required to verify the presence of *Labeo fisheri* in an area upstream of the dam, which provides very marginal habitat for this fish.

292. Larger fish species, such as *Wallago attu* (Shark catfish) and *Channa ara* (Giant Snakehead), may require a larger section of the river to maintain minimum viable populations (although they occur now in the river system, despite several dams).The concern is that ongoing fragmentation of such populations may affect the genetic diversity of these large and territorial fish species adversely (this is essentially what is happening anyhow in this part of Sri Lanka, with the endemic fish in the middle Mahaweli Ganga system being cut off from the lower reaches historically because of the Victoria Falls; therefore trapped in a section of the river system). Perhaps the only exception to this isolation/endemism effect is noted with the eels (*Anguilla bicolor* and *A. nebulosa*), which do migrate to the sea to spawn, and somehow occur above at least 5 dams along the Mahaweli Ganga (eels are capable of slithering over damp soil, rocks, and grass, usually at night, in order to move up and into rivers, even if watercourses are not available to them for upstream migration[30]).

4. Proposed mitigation measures

293. The assessment of impacts described above has been used to determine the required mitigation measures. Especially for the protection and conservation of fish, which are expected to be at most risk from the Moragolla project, the full range of mitigation options was examined, before selecting the most realistic and practical combination for the specific concerns in the zone of influence of the project. These are discussed below, for each phase of the project. Note that construction best practices, which include effective management of all sediment removal and placement to avoid entry to watercourses (especially at the dam site, and at the proposed causeway), as well as proper storage and labeling of hazardous materials, will be expected as part of the construction contracts, and should address concerns about degradation of water quality. Also, the wastewater discharge from the poultry farm will be moved to the tailrace location (to preclude contamination of the river section below the dam site).

[29] Patel, A.G., K. Glassner-Shwayder, and T. Eder (2010). Halting the Invasion: Maintaining the Health of the Great Lakes and Mississippi River Basins by Preventing Further Exchange of Aquatic Invasive Species. Environmental Practice 12 (4): 342-356.

[30] Prosek, J. (2009). Eels: An Exploration, From New Zealand to the Sargasso, of the World's Most Mysterious Fish. Simon & Schuster.

294. The focus of the mitigation measures during both construction and project operation is maintenance of fish populations in the river, especially the priority species, *Labeo fisheri* (other fish species in the project area have wider distribution and are at less risk, compared to *Labeo fisheri*; see the IUCN 2013 report in Volume 4).

a. Pre-Construction and Construction Phase

295. The main concern during project construction is the risk of poaching of fish by construction workers, and the loss of habitat and actual mortality of *Labeo fisheri* (especially blasting in the area of the tailrace, where *Labeo fisheri* has been seen). To reduce the risk of poaching, all construction workers will be told about the risk to the fish and notified of sanctions if they are caught fishing (for any species). Their activities will be monitored and sanctions strictly applied, if any workers are caught fishing (by any method).

296. With regard to blasting at the tailrace site, as noted previously, alternatives to use of explosives can be considered, including the use of dexpan (drilling and chemical fracturing of rock) and hydraulic breakers (mechanical fracturing of rock). The contractors can be instructed to examine the feasibility of either or both techniques, in order to avoid any disturbance to fish at the tailrace area.

297. It is recommended that a fish survey of all the pools above and below the dam site (down to the confluence of the Mahaweli Ganga and the Atabage Oya) be undertaken in the pre-construction phase, in order to determine the presence and distribution of larger fish (such as *Labeo fisheri*) in the river section that is most likely to be affected by the project. This survey can be undertaken with an inflatable raft and a Garmin-type fish finder, which can establish the depth of the riverbed, the presence of fish (numbers and depth), and specific locations (GPS coordinates). If this survey indicates the presence of larger fish (possibly including *Labeo fisheri*), then a pre-emptive catch-and-haul program can be implemented, before substantial project construction starts (this would involve a small mesh net being used to fish the deeper pools). Any fish caught in this manner would be identified, catalogued, and then safely moved to selected locations further upstream, and/or to an adjacent watershed (see discussion of the proposed translocation below). Some specimens of each species caught would be left in the river (but placed further downstream, away from project construction sites), in order not to deplete the local fish population. In this manner, vulnerable fish near project construction sites can be saved, and their distribution in the river system maintained. This is described in more detail below.

298. Catch-and-haul (translocation) activities have not been documented or reported as a mitigation measure for dam construction in Sri Lanka in the past, with the exception of fish rescue operations implemented jointly by IUCN and the Mahaweli Authority of Sri Lanka (for the Moragahakanda and Kalu Ganga multi-purpose dam projects[31]). This translocation program yielded positive results, with the rescue of several fish sub-populations that inhabit the inundation and downstream areas of the respective dam sites. As part of this translocation work, it was possible to translocate several critical fish species, including *Systomus martenstyni* (Martenstyn's barb), *Dawkinsia srilankensis* (Blotched filamented barb) and *Labeo lanke* (Sri Lanka orange-finned labeo) to the upper catchment of the Amban Ganga and Kalu Ganga sub-basins during the construction period. Based on IUCN's experience with this program, it is recommended that a similar program be implemented to rescue and translocate less mobile and

[31] IUCN (2013). Additional Studies: Fish Mitigation Report - Volume 4.

cryptic fish species encountered at the Moragolla proposed dam site. This would be undertaken in the pre-construction and early construction phase of the project. All translocation activities would be carried out in accordance with the Guidelines for Reintroductions and Other Conservation Translocations (IUCN/SSC, 2013).

299. *Labeo fisheri* (mountain or green labeo) is the only conservation-critical fish species that is present in the Moragolla project area (therefore, identified as a high priority fish species according to the points-based analysis carried out by IUCN). *Labeo fisheri* is restricted to the middle part of the Mahaweli River, including the Amban Ganga and Kalu Ganga sub-catchments of the Mahaweli basin; there is also the one observation of *Labeo fisheri* above the Kothmale dam. Given the existing pressures on this fish (restricted movements, loss of habitat, turbidity, historical over-fishing), translocation of this species to another river basin (the Kelani River basin is proposed[32]) is recommended. However, this trans-river basin translocation should only be carried out after thorough assessments of the existing population of *Labeo fisheri* in the project area (the fish survey proposed above), and the habitat conditions and species composition at the destination site (Kelani River; see Figure 26). Other fish encountered during the catch-and-haul program (during the first two years of project operation) would also be included in the program, as noted in Table 18. A technical committee, including representatives from the Ceylon Electricity Board (CEB), the Department of Wildlife Conservation (DWC), the Forest Department (FD), the National Zoological Gardens (NZG), IUCN and other experts, would be established in order to oversee and evaluate the implementation of the proposed catch-and-haul program.

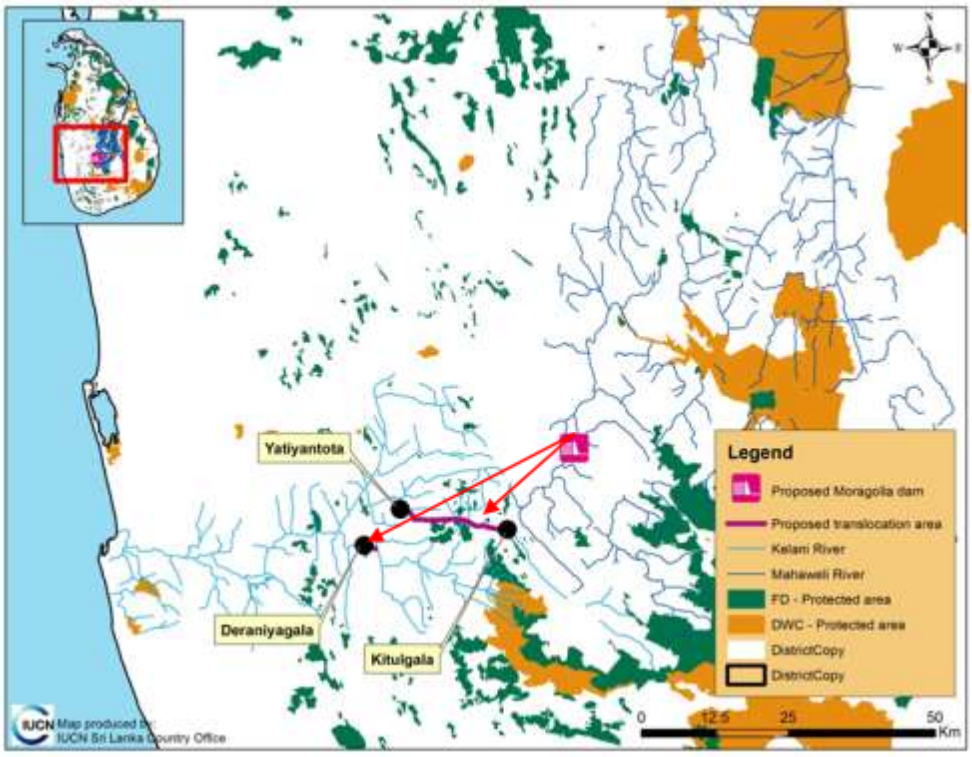

Figure 26: Proposed sites for translocation of *Labeo fisheri*.

[32] IUCN recommends this river basin, as it is adjacent to the Mahaweli and has some similar habitat.

Table 18: Proposed fish catch-and-haul program (translocation).

Species Name	Common Name	Proposed Area for Collection	Proposed Translocation Destination Site*
Labeo fisheri	Mountain (green) labeo	Inundation area (if there) and downstream areas to the tailrace.	Suitable from Kitulgala to Yatiyanthota in the Kelani River or Sitawake River.
Belontia signata	Combtail	Inundation area.	Atabage Oya and Ulapone Oya.
Schistura notostigma	Banded mountain loach	Inundation area.	Atabage Oya and Ulapone Oya.
Species of the Family Bagridae		Inundation area.	Atabage Oya and Ulapone Oya.
Tor khudree	Mahseer	Downstream areas to the tailrace.	Atabage Oya or the upper catchment of Mahaweli up to Nawalapitiya.
Channa ara	Giant snakehead	Downstream areas to the tailrace.	The upper catchment of the Mahaweli up to Nawalapitiya.
Channa orientalis	Smooth-breasted snakehead	Inundation area and downstream areas to the tailrace.	Atabage Oya and Ulapone Oya.
Wallago attu	Shark catfish	Downstream areas to the tailrace.	The upper catchment of the Mahaweli up to Nawalapitiya.
Ompoc bimaculatus	Butter catfish	Downstream areas to the tailrace.	The upper catchment of the Mahaweli up to Nawalapitiya.

* IUCN has determined these destinations, based on a match between the fish habitat requirements and availability in these streams and rivers.

300. After the proposed fish survey, sometime during the lean season when river discharge is at a minimum, it is proposed to undertake a "pool connection" analysis from the dam site to the tailrace, the purpose of which will be to identify how to maintain a connection between all of the larger deeper pools in the section of the river that will receive only the minimum environmental flow (1.5 m^3/s). Once the survey is completed, and the most practical channel connections between the individual pools are identified, and fish have been surveyed and moved, connector channels can be created with hydraulic drills (either deepening current channels or making new ones, as unobtrusively as possible). This might actually be undertaken in the first year of project operation, when the required channel connections between pools can be properly verified under the lowest flow conditions. The overall intention is to establish connections between pools that will maintain some water exchange during lean season via the minimum environmental flow, allowing fish to move between the dam and tailrace at all times, and helping to maintain appropriate water quality.

b. Operation Phase

301. The main concern in the operation phase is maintaining current fish populations above and below the dam site in a viable state (effectively continuing to breed within the newly confined sections, above and below the dam). Various possible mitigation measures were examined (in one of the additional studies undertaken by IUCN, see Volume 4). These are reviewed below, in order to select the most appropriate and practical mitigation measures for the project circumstances and location.

302. **Fish pass or ladder:** Although fish passes and ladders are suitable to facilitate the migration and local movement of fish species in general, their need and effectiveness are very much dependent on the specific features of the project, the river (existence of other barriers to

fish movement), and the local fish populations. A fish pass or ladder cannot be considered as a viable option for the Moragolla project, as there are already four major dams between the project site and the mouth of the Mahaweli Ganga, and several more in the upper river reaches above the project site. None of these dams have fish passes or ladders, yet viable fish populations are still present in individual sections of the river between the dams (and despite the dams). It therefore does not seem sensible to construct a fish pass or ladder at the Moragolla dam. Furthermore, the fish species of main concern (*Labeo fisheri*) does not occur in the Mahaweli Ganga above the area of confluence of the river with the Atabage Oya.

303. **Hatchery:** Although captive breeding of selected fish species, coupled with reintroduction, is a popular conservation action with respect to protecting threatened fish species (by boosting their population size), it is not recommended for the Moragolla project. The project area is not considered to be a critical habitat for the majority of fish species found in the area. The only exception is the high priority species, *Labeo fisheri*, which actually only occurs in the downstream river section in the project area. There is no experience indicating that *Labeo fisheri* can be bred in captivity, and initiatives to establish a hatchery and attempt this cannot be justified (it would have to fit within an overall national hatchery plan, including consideration of other threatened fish species, as well). All other populations of moderate priority species (*Schistura notostigma*, Banded mountain loach; *Belontia signata*, Combtail; *Channa ara*, Giant snakehead; *Channa orientals*, Smooth-breasted snakehead; *Garra ceylonensis*, Stone sucker; *Pethia reval*, Red-fin barb; *Pethia nigrofasciata*, Sri Lanka black ruby barb; *Systomus spilurus*, Sri Lanka olive barb; and, *Wallago attu*, Shark catfish) are not likely to be measurably impacted by the project, due to their wider distribution; therefore, hatchery development for these species is also not warranted.

304. **Offset habitat protection:** The Mahaweli River upper catchment (upstream from the Moragolla reservoir) is identified as a key area for aquatic habitat protection[33], to enhance the conservation of moderate priority fish in the project area (their distribution was described previously), as well as to maintain vegetation and reduce soil loss, to prevent negative impacts on aquatic habitats. Given that the upper catchment of the Kothmale Oya, up to the Kothmale dam, remains relatively dry (except at spillage time), only the Mahaweli Ganga itself up to Nawalapitiya (location shown in Fig 8) will continue to provide suitable habitats for species such as *Wallago attu* (Shark catfish), *Channa ara* (Giant snakehead), *Tor khudree* (Mahseer), and possibly *Labeo fisheri* (although it has not been reliably recorded in the Mahaweli Ganga above the confluence area with the Atabage Oya). Until now, the removal of river bank vegetation up to Nawalapitiya and the depletion of the upper catchment due to encroachment have been observed; the offset habitat protection program is proposed to arrest those practices and improve the water quality and shoreline conditions (providing more shading) along the river section above the reservoir. This program would be associated with most of the initiatives in the terrestrial ecology mitigation program (planting vegetation around the reservoir perimeter, and upper watershed soil management (see Section K below). Table 19 summarizes the main actions within the proposed program.

305. **Prohibition of the introduction of competitive exotic species to the Moragolla reservoir:** Reservoirs tend to be attractive to the fisheries industry. However, given that there are no natural lakes in Sri Lanka, large reservoir conditions are not suitable for the majority of native fish species. As a result, many exotic species have been introduced to the reservoirs of Sri Lanka, with variable results. Some of these exotic species are similar to native species, and

[33] See IUCN (2013). Additional Studies. Fish Mitigation Report.

Table 19: Proposed offset habitat protection program (see details of implementation in Volume 2: EMP).

Action	Resources Required	Potential Implementing Agency	Output/ Outcome	Monitoring
Identification of critical areas for fish in order to facilitate natural movement and relocation; this action is linked with the translocation plan described previously.	GIS expert and aquatic fauna expert.	Technical experts with relevant experience.	Map of the critical and suitable areas in the Mahaweli Ganga system for natural upstream relocation and facilitation of natural upstream movement of fish.	A period of six months is necessary for monitoring and mapping; this action is linked with the translocation plan presented previously.
Identification of on-land areas in the upper catchment and preparation of suitable habitat improvement plans.	GIS expert and terrestrial flora expert.	Forest Department and technical experts with relevant experience.	Map of the upper catchment up to Nawalapitiya prepared, along with habitat improvement plans.	
Implementing an afforestation program in the identified locations. This action can be linked with the afforestation and watershed management plans associated with terrestrial ecology.	Forestry expert and laborers.	Forest Department.	Suitable areas in the upper watershed are replanted with native sediment-retaining tree, shrub and ground-cover species.	Monitoring of the progress of growth.
Community awareness program; this action can be linked with other awareness programs related to the mitigation of impacts on terrestrial fauna, and the afforestation and watershed management plan.	Community mobilizers and environmental communicators.	Forest Department and technical experts with relevant experience.	Communities are educated about the importance of upper watershed management for soil conservation and the protection of the native fish of the area.	Re-visiting relevant sites to evaluate the impacts of the awareness programs.

as such, compete with the indigenous species for resources. For instance, the introduced species *Labeo rohu* is considered a direct competitor of the threatened native species *Labeo lankae*, and various tilapia species have become dominant in some reservoirs.Therefore, a ban on the introduction of competitive fish species, such as *Labeo rohu*, to the Moragolla reservoir is recommended. The larger question of whether or not fishing should be allowed in the Moragolla reservoir at all needs further consideration, as sometimes the intensive fishing efforts for exotic species result in over-fishing of native species. In any case, fishing for *Labeo fisheri* should continue to be banned, and riverine fishing carefully monitored for this species specifically.

K. Terrestrial Ecology

1. Baseline Conditions and Vulnerabilities

306. The zone of influence of the Moragolla project was surveyed during the original Local EIA work undertaken between 2009 and 2012 and several times in 2013 (the additional studies for land use, new project sites, and afforestation measures), so that the overall land use, habitat type and condition, and distribution of flora and fauna that might be at risk from the project could be accurately determined. The baseline description below incorporates data from all of these studies. It includes an overview of the topography and land use at the project site, forest cover and other kinds of vegetation, their quality and degree of disturbance, the identification of any critical habitat conditions for animals, and the distribution of vulnerable plants and animals.

Additional Table 20(a) for Addendum: Terrestrial Ecology

Description	Local EIA (2012)	Environmental Addendum (2013)
1- Baseline data	• Sect. 3.1 Physical environment • Sect. 3.2 Biological environment	• Volume 4; Additional survey for collection of data and preparation of existing conditions in new project sites such as contractor's office area, quary site and disposal area 3.
2,3- Impacts	• Sect 4.3 Ecological impact	• Sect VI.K.2 Pre-construction and construction phase impacts and Sect VI.K.3 Operation Phase Impacts
4- Mitigation	• Sect 5.4 Mitigation measures to address impact on the physical environment. • Sect 5.4.7 Restructuring of the surrounding environment including landscaping of the construction area. • Sect 5.5 Mitigation measures to address impact on the biological environment. • Sect 5.5.1 Mitigation on terrestrial fauna and flora	• Sect VI.K.4 Proposed mitigation measures

a. Topography, Land Types, and Land Use

307. The topography of the project area is mountainous and hilly, with a striking landscape of a deep river valley running between high slopes and escarpments (the left bank of the Mahaweli Ganga tends to have steeper slopes than the right bank, at least in the project area). The elevations in the immediate project area range from about 450 to 800 m asl. This area has supported tea plantations from about the 1850s, and most of the higher catchment area of the Moragolla project is still covered by tea plantations. However, as a result, the natural forest cover of the Mahaweli watershed has decreased gradually over the last two centuries. Forest cover is now confined to a few isolated patches on steeper slopes or higher ground (most of the forested areas are designated as forest reserves, well outside the project area), reflecting the

demand for land for agriculture, development activities, and human settlements. In the project area, which is predominantly rural in character, the majority of the population lives in small communities, engaged in the tea estates or in cultivation of other crops. Vegetables are grown extensively on the steep slopes of the Mahaweli catchment, but without consideration of proper land management practices. Much of the agriculturally active land is exposed to severe soil erosion and landslides, in addition to rapid deforestation. Figures 18, 19, 22 and Photo 13 show the landscape, land types, and land use in the project area. The table in Figure 19 shows the ratios of land types and uses in the project area.

308. As discussed in Section VI.F above, the immediate project area (within 2 km of the Mahaweli Ganga and project components) is dominated by home gardens (almost 48% of the land area), followed by scrub vegetation (mostly grass, bush, and small tree re-growth over previously cultivated land; 26.5% of the land area). Tea plantations comprise about 9% of the project area. Thickly vegetated areas (mostly the secondary forest adjacent to the Kothmale powerplant) and a patchy thin strip of riverine trees make up about 6% of the project area (administratively, the forest area belongs to the category of Other State Forest (OSF), and falls under the jurisdiction of the Mahaweli Authority of Sri Lanka). It is clear from the satellite images (Figure 18) and the groundtruthing that at least 94-95% of the project area can be characterized as disturbed or altered vegetative habitat; dense vegetative cover of value to animals is confined to about 6% of the project area, mainly in two isolated patches of higher ground in the north-east (right bank) and south-west (left bank) of the project area (Fig 27). Photo 13 shows the visual characteristics of the main land types in the project area

Photo 13: Characteristics of main land types in the project area (left to right, top to bottom: riverine forest strip; secondary forest on the riverine slope – right bank; secondary forest in previously cultivated areas – left bank; scrub/grass vegetation – right bank; home gardens; right bank).

b. Forest Cover and Other Vegetation (Habitats)

309. As noted above, forest cover is not at all dominant in the project area. It is worthwhile to examine the forest types in the project area in the context of forest distribution throughout the Mahaweli Basin and the distribution and status of forest protected areas. Figure 27 shows the distribution of forests within the whole Mahaweli Basin and in the project area. Most of the forest cover is restricted to the right bank of the Mahaweli Ganga, which has less steep slopes, compared to the left bank. The secondary forest on the right bank is mostly confined to the area between the river and the Kotmale powerplant, and the pine plantations are mostly in the southern part of the project area, also on the right bank. As noted previously, there is a thin strip of riverine forest, although patchy, along most of the length of the Mahaweli Ganga. None of these small patches of forest are protected. Figure 28 shows the locations of the protected forest areas, all of which are located quite far away from the project site (existing forest reserves are at least 25 km away; other proposed forest reserves are closer).

310. The Moragolla project area falls within the wet climatic zone. The original forest type in the area was lowland rainforest or lowland wet evergreen forests (at elevations <1000 m)[34]. Generally, almost all the forest patches in the Moragolla project area at present are degraded secondary forests of the original lowland rainforest type.

[34] IUCN (2013). Additional Studies. Afforestation and Watershed Management Plan - Volume 4

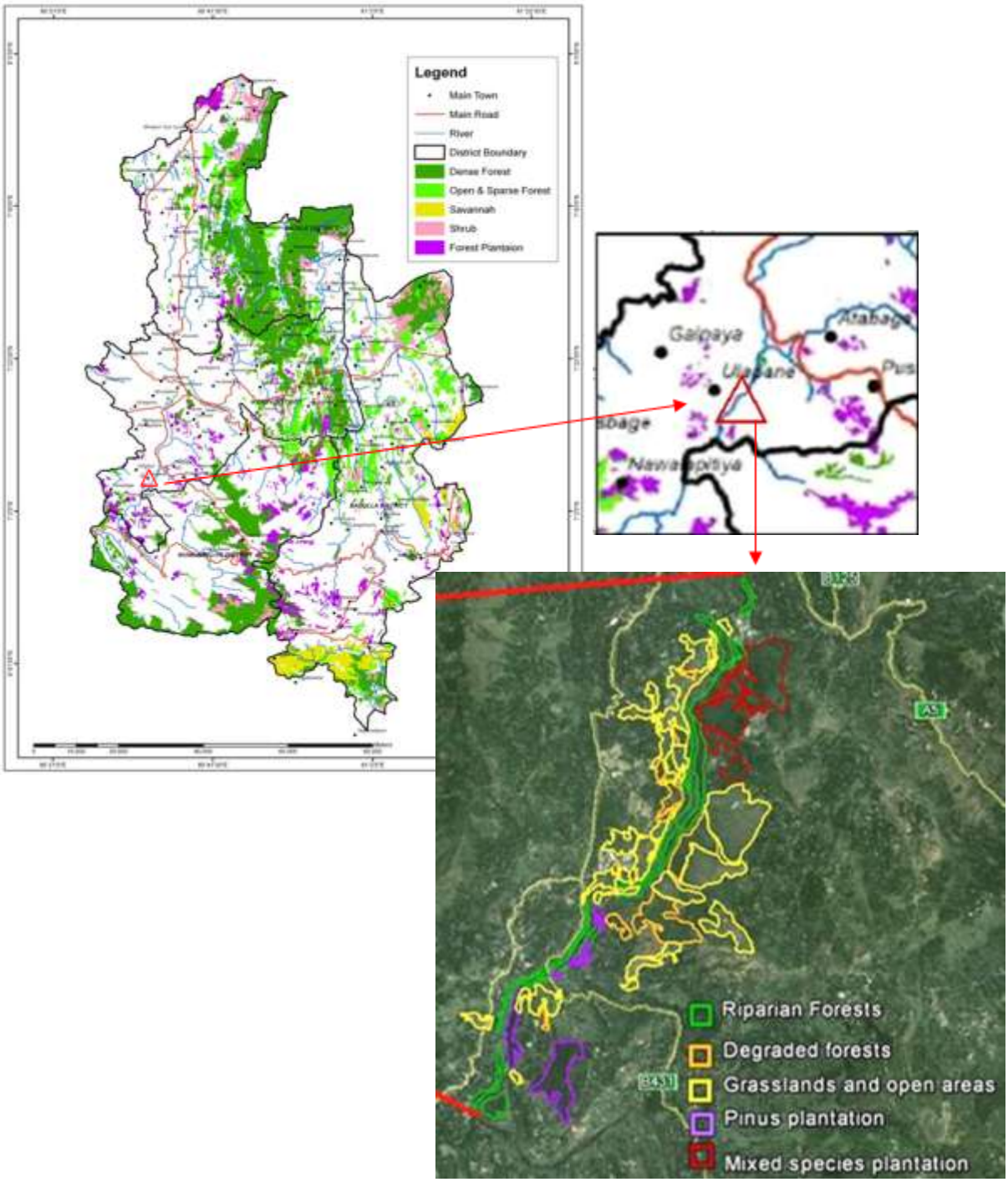

Figure 27: Forest cover and types in the Mahaweli upper catchment, and in the project area.

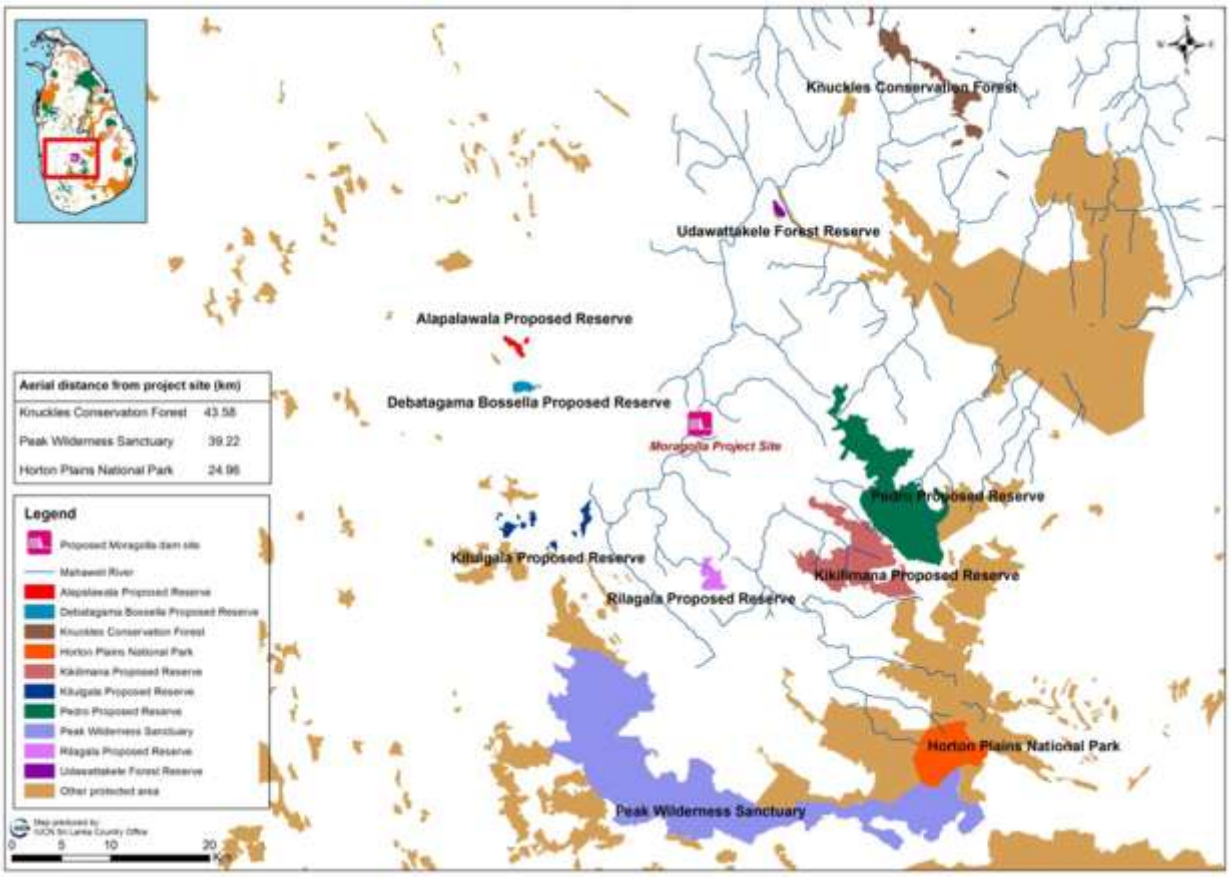

Figure 28: Protected forest areas in central Sri Lanka.

311. According to the findings of the Local EIA, the most prominent tree species in the forested areas near the project site are *Albizia* spp. (Albizia), *Swietenia macrophylla* (Broadleaf Mahogany), and *Artocarpus heterophyllus* (Jak). Composition of vegetation was determined at all project component sites (inundation area; dam site; powerhouse; transmission line; access roads; muck disposal sites; project camps; quarry) in 2009 and 2013 by the studies noted above. Table 20 shows the distribution of the main trees, shrubs, and grasses observed at each of the specific project sites. Details are provided below.

312. The most widely distributed vegetation in the specific project component sites comprises *Macaranga peltata* (kenda tree), *Panicum maximum* (Guinea grass), *Trema orientalis* (Gedumba tree), *Alstonia macrophylla* (Hawari nuga tree), *Acacia mangium* (Acacia tree), and *Ficus* spp. (Nuga tree). These occur at most of the sites. The kenda tree occurs at all sites, expcept the small footprint of the transmission line (where there are few trees, mostly just grass and shrubs). The kenda tree is considered an early colonizer of disturbed sites, reflecting the fact that most of the project area has been cultivated at some point in the past (about 60% is still under active cultivation).

313. The vegetation in the inundation area is dominated by grass and shrubs, with a few scattered trees.The vegetation found at the proposed dam site and surrounding area is highly disturbed as a result of human activities, with grasses, shrubs and pioneer tree species

Table 20: Distribution of main types of vegetation at the specific project sites (R = reservoir area; D = dam site; PH = powerhouse; TL = transmission line; AR = access roads; Q = quarry; C = camps; DS = disposal sites); ranked by breadth of distribution; Q, C, and DS data only for larger trees.

Species	Local name	Nature of Vegetation	Location
Macaranga peltata	Kenda	Tree	R, D, PH, AR, Q, C, DS
Panicum maximum	Rata tana or Guinea grass	Grass	R, D, PH, TL, AR
Trema orientalis	Gedumba	Tree	R, D, PH, AR, DS
Alstonia macrophylla	Hawari nuga	Tree	R, PH, AR, C, DS
Acacia mangium	Acacia	Tree	R, D, Q, C
Ficus spp.	Nuga	Tree	R, Q, C, DS
Lantana camara	Gandapana	Shrub	PH, TL, AR
Mimosa pigra	Giant (*Yoda*) nidikumba	Shrub	R, D, PH
Eupatorium odoratum	Podisinnomaran	Tree	D, PH, TL
Albizia falcataria	Mara	Tree	R, C, DS
Mallotus tetracoccus	Bu-kenda	Tree	R, C, DS
Artocarpus nobilis	Wal Del	Tree	R, C, DS
Gliricidia sepium	Weta mara	Tree	PH, C, DS
Mangifera indica	Amba	Tree	AR, C, DS
Michelia champaca	Sapu	Tree	AR, C, DS
Dicranopteris linearis	Kekilla	Shrub	TL, AR
Symplocos cochinchinensis	Bombu	Tree	R, D
Albizia lebbeck	Albezia	Tree	Q, C
Artocarpus heterophyllus	Kos	Tree	AR, DS
Persea Americana	Ali pera	Tree	AR, DS
Switenia macrophylla	Mahogany	Tree	AR, DS
Spathodea campanulata	Spathodia	Tree	C, DS
Delonix regia	Mi Mara	Tree	Q, C
Grewia damine	Daminiya	Tree	C, DS
Cymbopogon nardus	Pangirimana	Grass	AR
Arundo donax	Giant cane	Shrub	R
Stachylarpheta jamaicensis	Balu nkuta	Shrub	PH
Ageratum conyzoides	Hulan tala	Shrub	TL
Macaranga indica	Kenda	Tree	R
Cipadessa baccifera	Hal bambiya	Tree	R
Syzygium caryophyllatum	Dan	Tree	R
Alstonia scholaris	Rukattana	Tree	Q
Syzygium jambos	Seeni Jambu	Tree	R
Madhuca nerifolia	Gam mi	Tree	R
Homonoia riparia		Tree	R
Aporusa lanceolata	Heen kebella	Tree	R

Species	Local name	Nature of Vegetation	Location
Clusia rosea	Gal goraka	Tree	R
Actinodaphne elegans		Tree	R
Ficus racemosa	Attikka	Tree	R
Makania cordata	Watu palu	Tree	PH
Ipomoea cairiea		Tree	PH
Hyptis suaveolens	Maduruthala	Tree	PH
Blechnus orientais	Pattara werella	Tree	TL
Crotalaria spp		Tree	TL
Cocos nucifera	Pol	Tree	AR
Areca catechu	Puwak	Tree	AR
Syzygium aromaticum	Karabu	Tree	AR
Melastoma malabathricum	Maha bovitiya	Tree	AR
Spandias mombin	Ambalanga	Tree	Q
Homalanthus populifolius	Ginikanda	Tree	Q
Careya arborea	Kahata	Tree	Q
Bridelia retusa	Ketakala	Tree	Q
Terminalia catappa	Bulu	Tree	C
Terminalia arjuna	Kumbuk	Tree	C
Petrospermum suberifolium	Welan	Tree	C
Vitex altissima	Milla	Tree	C
Anacardium occidentale	Kaju	Tree	DS
Hevea brasiliensis	Rubber	Tree	DS
Erythrina sabumbrans	Eramudu	Tree	DS
Neolitsea cassia	Kududawula	Tree	DS
Cinnamomum capparu	Kurundu	Tree	DS
Filicium decipiens	Pihimbiya	Tree	DS
Pterocarpus marsupium	Indian kino tree	Tree	C

dominating. The powerhouse site would be situated on an abandoned land near the river. The vegetation in this area is dominated by grasses and shrubs, with a few scattered trees. About 80% of the length of the transmission line traverses home gardens, while the rest passes over abandoned lands. The abandoned lands are covered mostly by a secondary growth dominated by pioneering herbaceous and shrub species (as noted above). Homegardens, abandoned lands, and tea lands are the main land use types affected by the proposed access road and road expansion areas. At the quarry site, most of the vegetation is made up of grasses and shrubs, with the occasional trees dominated by acacia (*Acacia mangium*), albezia (*Albizia lebbeck*), and delonix (*Delonix regia*). The proposed project camp site is mostly secondary forest, dominated by *Macaranga peltata, Alstonia macrophylla, Acacia mangium*, and *Albizia falcataria*. At the main muck disposal site (near the powerhouse), the trees are dominated by *Macaranga peltata* (kenda), *Gliricidia sepium* (weta mara tree), and *Swietenia mahagoni* (mahogany). This area used to be a Kandyan forest garden, mostly for black pepper cultivation.

314. Results from the detailed tree survey undertaken for the original Local EIA (trees to be cut at project sites) were tabulated to show conservation classification (see Table 21). It can be seen that no trees are classified as critically endangered or endangered. Four are listed as vulnerable, including: *Delonix regia* (flame tree), *Pterocarpus marsupium* (Indian kino tree), *Swietenia macrophylla* (Big-leaf mahogany), and *Artocarpus nobilis* (jackfruit). All these trees occur elsewhere throughout the project area (and Sri Lanka).

Table 21: Detailed tree survey and conservation classifications for trees to be cut.

Family	Species	Common Name	BG	D	R	P	PH	C	NR	R1	R2	DS	TL	CS
Anacardiaceae	*Anacardiumoccidentale*	Cashew	I							1			1	NE
	Lanneacoromandelica		N					1						NE
	Mangiferaindica	Mango	I		10			1	9	6	1			DD
Apocynaceae	*Alstonia macrophylla*	Hard milk wood	I		12				3	8	3	2	4	LC
	Alstonia scholaris	Milkwood pine	N		2								1	LC
Arecaceae	*Areca catechu*	Betel palm	N										2	NE
	Caryota urens	Jaggery palm	N		6			2						NE
	Cocos nucifera	Coconut palm	N		7					6	1			NE
Bignoniaceae	*Spathodeacampanulata*	Fountain tree	I						3	2	7			NE
	Tabebuiarosea	Savannah oak	I		4				1					NE
Malvaceae	*Bombaxceiba*	Cotton tree	N											NE
	Ceibapentandra	Java cotton	I							1	2			NE
	Duriozibethinus	Durian	I		1									NE
Combretaceae	*Terminaliaarjuna*	Arjun tree	N		4									NE
Tetramelaceae	*Tetramelesnudiflora*		N		1									LC
Elaeocarpaceae	*Elaeocarpus serratus*	Ceylon olive	N						2	1				NE
Euphorbiaceae	*Hevea brasiliensis*	Rubber	I							2	1			NE
	Macarangapeltata	Kenda	N	1	4	2				3	9	4	8	NE
	Mallotustetracoccus		N		2							3		NE
Fabaceae	*Acacia mangium*	Black wattle	I	3	14			3	1				4	NE
	Acacia melanoxylon	Hickory	I		3									
	Albizia falcataria	Silk tree	I		34			1	7		1	5		NE
	Albizia odoratissima		N						1	2	1		5	NE
	Cassia (Senna) spectabilis		I							1				LC
	Delonixregia	Flame tree	I		5					1				VU
	Gliricidia sepium	Gliricidia	I				2							NE
	Peltophorumpterocarpum	Yellow flame tree	N		23			1	1					NE
	Pterocarpusmarsupium	Indian kino tree	N					1						VU
Lauraceae	*Neolitsea cassia*	Sri Lanka laurel	N		1	2		1		2	4			NE
Magnoliaceae	*Michelia (Magnolia) champaca*	Magnolia	N		5	1		1	10		1			NE
Meliaceae	*Meliaazedarach*	Indian lilac	N								1			NE
	Swietenia macrophylla	Big-leaf mahogany	I		5					42	11		2	VU
	Toona sp.	Mahogany	I					1	2					
Moraceae	*Artocarpus heterophyllus*	Jackfruit	I		13			5	32	14	12	1		NE
	Artocarpusnobilis		E		3						2			VU
	Ficusexasperate	Fig tree	N							1	2			NE

Family	Species	Common Name	BG	D	R	P	PH	C	NR	R1	R2	DS	TL	CS
	Ficusracemosa	Cluster fig tree	N		6									NE
	Ficus sp.	Fig	N		6									
Myrtaceae	*Eucalyptus (Corymbia) torelliana*	Eucalyptus	I		3									NE
	Eucalyptus sp.	Eucalyptus	I						1	1				
Protaceae	*Grevillearobusta*	Silky oak	I						1					NE
Rhizophoraceae	*Caralliabrachiata*	Corkwood	N							3				NE
Sapindaceae	*Nepheliumlappaceum*	Rambutan	I		1									LC
Malvaceae	*Grewiadamine*		N										1	NE
Cannabaceae	*Tremaorientalis*	Indian charcoal	N	3	4	2	2		1					NE
		Sub Total		7	179	7	4	18	75	97	59	15	28	
		Total		489										

Key: **BG** = Biogeographic status: E = Endemic; N = Native; I = Introduced
D = Dam Site; **R** = Reservoir; **P** = Penstock; **PH** = Powerhouse; **C** = Camp; **NR** = New Road; **R1, R2** = Expansion Roads; **DS** = Dumping Sites; **TL** = Transmission Line
CS = IUCN Conservation Status: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; NE = Not Evaluated (from: http://www.iucnredlist.org/)
Source: CECB, 2012, Environmental Impact Assessment, Moragolla Hydropower Feasibility Study

315. Trees also occur in the home gardens (which make up the majority of the project area). These are shown in Table 22.

Table 22: Trees observed in home gardens in the Moragolla project area.

Species	Local name
Macaranga peltata	Kenda
Alstonia macrophylla	Hawari nuga
Mangifera indica	Amba (Mango)
Artocarpus heterophyllus	Kos (Jak)
Persea Americana	Ali pera
Michelia champaca	Sapu
Switenia macrophylla	Mahogany
Cocos nucifera	Pol (Coconut)
Areca catechu	Puwak
Syzygium aromaticum	Karabu
Nephelium lappaceum	Rambutan
Albizia falcataria	Mara

316. The most important vegetated areas, in terms of provision of habitat for terrestrial fauna (insects, amphibians, reptiles, birds, and mammals) are the thin strips of riparian forest (especially for animals which require refuge and access to the river to feed, such as the fishing cat) and the secondary forest between the Kotmale powerhouse and the river, as this area has the densest forest canopy. These habitats are discussed in more detail below.

c. Terrestrial Fauna

317. Details on faunal incidence and vulnerability are discussed below, based on the three detailed surveys that were undertaken, These comprise: the 2012 Local EIA; the 2013 Aquatic Ecology Survey in Volume 4; and the September 2013 survey of the project camp site, quarry site, and the main muck disposal site on the left bank of the Mahaweli Ganga in Volume 4; the latter are very representative of all habitat types in the project area, although heavy rainfall suppressed the sightings of birds and insects. The relationship between the vegetative habitats and the incidence of terrestrial fauna, as well as the conservation status of fauna, were considered in the development of afforestation plans for the reservoir perimeter.

318. Based on direct and indirect observations (evidence such as scats and tracks) for the 2012 Local EIA, a total of 173 species of terrestrial fauna have been recorded in the areas that may be affected by the project (106 were observed at three project sites in Volume 4 September 2013, during heavy monsoon rains; most having been observed in earlier surveys). From the broader 2012 survey, 23 of the species encountered are endemic to Sri Lanka, while 16 are listed as threatened and 12 are listed as Near Threatened (NT) species (10 of the 23 endemic species are listed as threatened or Near Threatened; see Table 23). For the purpose of evaluation of faunal vulnerability to project impacts and appropriateness for habitat enhancement efforts, 41 species that have been recorded in the project area were considered as "critical" species (see the IUCN report on habitat enhancement; in the appendices). Other faunal species were not given as much attention, as they have a wide distribution in Sri Lanka, as well as outside Sri Lanka, and therefore the proportions of their populations that might be impacted by the project are considered to be insignificant (however, see the IUCN and NBRO reports in Volume 4, which list all species found at all locations).

Table 23: Overview of the terrestrial faunal diversity recorded within the project area
(Local EIA, 2012, at all sites, and the September 2013 survey, at three project sites); CR = critically endangered; EN = endangered; VU = vulnerable; NT = near threatened.

Taxon	Survey Year	Number of Species							
		Total	Species Status			National Conservation Status			
						Nationally Threatened*			NT
			Endemic	Exotic	Migrant	CR	EN	VU	
Butterflies	2012	32	3	0	0	1	0	2	2
	2013	21	1	0	0	1	1	1	0
Dragonflies	2012	23	6	0	0	0	4	4	4
	2013	10	1	0	0	0	0	0	0
Land Molluscs	2012	0	0	0	0	0	0	0	0
	2013	8	4	0	0	0	0	1	2
Amphibians	2012	7	3	0	0	0	0	1	1
	2013	9	7	0	0	0	2	0	2
Reptiles	2012	10	2	0	0	0	0	0	0
	2013	14	5	0	0	0	0	1	1
Birds	2012	88	7	0	11	0	0	0	5
	2013	32	5	0	0	0	0	1	2
Mammals	2012	14	2	1	0	0	2	2	0
	2013	11	2	0	0	0	1	1	1
Total	**2012**	**173**	**23**	**1**	**11**	**1**	**6**	**9**	**12**
	2013	**106**	**25**	**0**	**0**	**1**	**4**	**5**	**8**

* IUCN 2012 National Red List.

319. Observations of amphibians, reptiles, and mammals at the project sites were fairly consistent between 2012 and 2013, whereas flying insects (butterflies and dragonflies) and birds were under-represented in the 2013 survey (discussed above; weather effect related to seasonality), and land molluscs were not recorded in the 2012 surveys (perhaps reflecting sampling methods and individual bias). An aquatic survey in March-May 2013 by IUCN in Volume 4 also recorded fauna with conservation status in Sri Lanka, although only those with some direct association to the river. Nevertheless, some of these fauna occur in the riparian forest, and warrant attention for habitat enhancement.

320. All survey results were examined to determine the presence and distribution of faunal species which have conservation status in Sri Lanka, and their wider distribution beyond the project area. These are noted in Table 24.

Table 24: Occurrence, conservation status, and distribution of fauna (mostly terrestrial) in the project area.

Organism	National Conservation Status	Occurrence in Project Area	Wider Distribution*
Cepora nadina (lesser gullbutterfly)	Critically Endangered	2012 at powerhouse site (scrub vegetation)	Occurs north and south of the project site at higher elevations; other locations throughout Asia.
Phalanta alcippe (small leopard butterfly)	Critically Endangered	Sept 2013 at quarry site (scrub vegetation)	Elsewhere in southeast Sri Lanka; and elsewhere in Asia.
Lethe daretis (Ceylon treebrown butterfly)	Endangered	Sept 2013 at project camp site and main spoil disposal site (secondary forest)	In high elevation bamboo areas (endemic).
Libellago greeni (Green's gem dragonfly)	Endangered	2012 and 2013 all along the river (riparian grass)	Occurs throughout central and south Sri Lanka (endemic).
Paragomphus henryi (Brook hooktail dragonfly)	Endangered	2013 along the river (riparian grass)	Occurs through central and south SriLanka (endemic).
Orthetrum triangulare (triangle skimmer dragonfly)	Endangered	2012 throughout the project area and 2013 along river (riparian grass)	Occurs just in south-central Sri Lanka; also throughout Asia.
Sympetrum fonscolombii(red-veined darter dragonfly)	Endangered	2012 throughout the project area and 2013 along river(riparian grass)	Just in south-central Sri Lanka, and Asia and Africa.
Fejervarya greenii (Sri Lanka paddy field frog)	Endangered	Sept 2013 at main spoil disposal site(secondary forest in farm land)	In forest reserves in central Sri Lanka (possibly endemic).
Polypedates eques (mountain tree frog)	Endangered	Sept 2013 at project camp site (secondary forest)	Commonly found in the central hills of Sri Lanka (endemic).
Suncus zeylanicus (Sri Lanka jungle shrew)	Endangered	Sept 2013 at project camp site (secondary forest)	In other locations in central and western Sri Lanka (endemic).
Prionailurus rubiginosus (rusty spotted cat)	Endangered	2012 and 2013 all along river (riparian grass and forest)	Elsewhere in southern Sri Lanka; in other parts of Asia.
Prionailurus viverrinus (fishing cat)	Endangered	2012 and 2013 all along river(riparian grass and forest)	Elsewhere in southern Sri Lanka; in other parts of Asia.
Notocrypta curvifascia (restricted demon	Vulnerable	Sept 2013 at project camp site (secondary forest)	Throughout Sri Lanka and other parts of Asia.

Organism	National Conservation Status	Occurrence in Project Area	Wider Distribution*
butterfly)			
Papilio crino (banded peacock butterfly)	Vulnerable	2012 at northern end of project area(secondary forest)	Occurs throughout Sri Lanka; also found in India.
Eurema andersoni (one spot grass yellow butterfly)	Vulnerable	2012 at reservoir and dam site (scrub vegetation)	Occurs at other locations in southern Sri Lanka (endemic).
*Neurobasis chinensis (*oriental green wing dragonfly)	Vulnerable	2013 along river (riparian grass)	Throughout Sri Lanka and other parts of Asia.
Vestalis apicalis(black-tipped flashwing dragonfly)	Vulnerable	2013 along river (riparian grass)	Throughout Sri Lanka and India.
Libellago adami (Adam's gem dragonfly)	Vulnerable	2012 and 2013 all along the river (riparian grass)	Occurs throughout central and south Sri Lanka (endemic).
Libellago finalis (Ultima gem dragonfly)	Vulnerable	2012 and 2013 all along the river (riparian grass)	Occurs throughout central Sri Lanka (endemic).
Indolestes gracilis (mountain reedling dragonfly)	Vulnerable	2012 not specified and 2013 along river (riparian grass)	Common throughout central and south Sri Lanka; also evident in southern India.
Trithemis festiva (Indigo dropwing dragonfly)	Vulnerable	2012 at dam site and downstream (riparian grass)	Occurs throughout central and south Sri Lanka; also throughout Asia and western Pacific.
Corilla colletti (land mollusc)	Vulnerable	Sept 2013 at project camp site (secondary forest)	Occurs in forests and gardens of southwest Sri Lanka (endemic).
Lankanectes corrugates (corrugated water frog)	Vulnerable	2012 at northern end of project area (riparian grass)	Occurs throughout central and south Sri Lanka (endemic).
Boiga ceylonensis (Sri Lanka cat snake)	Vulnerable	Sept 2013 at main spoil disposal site(secondary forest in farm land)	Throughout Sri Lanka and parts of India.
Gracula ptilogenys (Sri Lanka myna bird)	Vulnerable	Sept 2013 at project camp site (secondary forest)	Common in lowlands and hills in central and south Sri Lanka (endemic).
Lutra lutra (otter)	Vulnerable	2012 and 2013 all along river (riparian grass and forest)	Occurs elsewhere in central and southern Sri Lanka; other parts of Asia.
Moschiola kathygre (Sri Lanka pygmy mouse-deer)	Vulnerable	2012 at project camp site (secondary forest)	Occurs throughout southwestern Sri Lanka (endemic).
Ratufa macroura (giant squirrel)	Vulnerable	Sept 2013 at project camp site (secondary forest)	In forests throughout Sri Lanka and southern India.

* From the IUCN Red List.

321. The most vulnerable and/or endemic faunal species noted in Table 24 and which have the most restricted distribution in Sri Lanka are just the two butterflies, *Cepora nadina* (lesser gull butterfly, which is critically endangered in Sri Lanka, observed in only a few locations, although not endemic) and *Lethe daretis* (Ceylon treebrown butterfly, which is endangered and endemic). All other fauna that were encountered and which have national conservation status

of “vulnerable”, “endangered”, or “critically endangered” have been observed at quite a few other locations in Sri Lanka (mostly in central and southern Sri Lanka) and many of these are also not endemic (occurring throughout other parts of Asia, and some beyond). For habitat enhancement, the most restricted distribution butterflies and the most vulnerable mammals would be good candidates for consideration (discussed below). Table 25 shows a list of all the other mammals that were recorded from the faunal surveys (excluding those species with national conservation status that have already been noted in Table 24 above). Only one, the Sri Lanka toque monkey, has a specific national conservation status (endemic, near threatened), but it occurs throughout Sri Lanka.

Table 25: Observations of other mammals at the project site (2012 and 2013; those species not included in Table 24).

Species	English Name	Local Name
Pteropus giganteus	Flying fox	Ma-vavula
Rhinolophus rouxii	Rufous horse-shoe bat	Borath Ashladan-vavula
Macaca sinica(endemic; near threatened)	Sri Lanka toque monkey	Sri Lanka Rilawa
Herpestes edwardsii	Grey mongoose	Alu Mugatiya
Herpestesbrachyurus	Brown mongoose	Bora Mugatiya
Canis aureus	Jackal	Nariya or Hiwala
Bos indicus	Domestic hump-backed cattle	Sinhala Elaharaka
Funambulus palmarum	Palm squirrel	Leena
Lepus nigricollis	Black-naped hare	Wal Hawa
Viverriculaindica	Ring-tailed civet	Urulewa
Muntiacus muntjak	Barking deer	OluMuwa or WeliMuwa
Susscrofa	Wild boar	WalUra
Hystrixindica	Porcupine	Ittewa
Bandicotaindica	Malabar bandicoot	Uru-miya

322. The highest faunal diversity (for higher order animals, such as birds and mammals), as expected, was associated with the dense cover secondary forest areas; most notably the proposed project camp site sampled in September 2013 and the downstream areas sampled in 2012, near the river. These areas will not have any permanent project footprint; just the temporary project camp on the right bank of the Mahaweli Ganga.

2. Pre-construction and construction phase impacts

323. The potential impacts of the Moragolla Project, related to the terrestrial environment, were defined from the overall environmental impact matrix (Table 7) and the summary of impacts associated with each project activity and environmental factor (Table 8). All possible impacts and required mitigation measures are then discussed in detail below.

324. The possible impacts of the project on terrestrial ecology during the pre-construction and construction phases focus mostly on clearing of vegetation (loss of flora, plus faunal habitats) for the various project components and possible subsequent disturbance of animal movements,

as well as the risk of poaching. Note that the possible environmental impacts are described first, followed by a discussion of the most appropriate and practical mitigation measures.

325. **Clearing of vegetation:** Clearing of vegetation will be required for the access roads, powerhouse and tailrace site, project camp, the dam site, the quarry, muck disposal sites, and in the area to be inundated. With all these project components, the only densely vegetated habitat that will need clearing will be:

- the secondary forest on the right bank of the Mahaweli Ganga (for the project camp, taking about 3-4% of the "patch" of secondary forest on the right bank, although only temporarily); and,
- the thin strip of riparian forest in the area to be inundated (equivalent to about 15-20% of the riparian forest within 6 km of the dam site, which will be replaced by a thicker replanted buffer zone around the reservoir).

326. Assuming natural revegetation of the project camp site after project construction (recruitment incursion from the adjacent forest on all sides), and eventual forest generation around the reservoir (a 100-meter strip about 5-6 times wider than the current strip; planned as an afforestation habitat enhancement measure), there should be a significant net gain in dense forest habitat (although only after 5-10 years). All other areas to be cleared have much diminished value as habitat for terrestrial fauna, and are not a concern in terms of faunal habitat. In any case, none of the areas to be cleared are critical habitat for vulnerable fauna, as they comprise degraded land or secondary forest that has grown over old farm land. All cleared areas will still have adjacent similar habitat for contiguity, to support animal movements; in other words, the vegetation clearing will not create any barriers (loss of cover or refuge) to animal movements. As a result, no net loss of terrestrial faunal diversity is expected, and animals will make adjustments by moving into adjacent habitat, which may cause a temporary "squeeze" on animals existing in those habitats, until some equilibrium is reached. All animals in the project area have already adapted to degraded habitat, patchiness of habitat, and proximity to human settlements and farming over the last 150 years; these areas are not at all pristine (such habitats are confined to the protected areas more than 25 km away; see Figure 28). Most animals will vacate project areas just before or as they are cleared in response to the disturbance. Thereafter, they are not likely to be disturbed by construction equipment or site activities (having moved into adjacent suitable habitat).

327. Slightly more than 900 trees (> 20 cm dbh; diameter at breast height) will have to be cut to allow development of the various project sites. The dominant tree species that require clearing (in accumulated counts from surveys at all project sites in 2012 and 2013) are as follows, in descending order of dominance (comprising about 72% of all the trees that need to be cleared):

- *Macaranga peltata* (kendu; 166)
- *Albizia falcataria* (albezia; 78)
- *Artocarpus heterophyllus* (jackfruit; 77)
- *Acacia mangium* (acacia; 76)
- *Swietenia macrophylla* (mahogany; 60)
- *Alstonia macrophylla* (hard milkwood; 58)
- *Gliricidia sepium* (gliricid; 34)
- *Mangifera indica* (mango; 27)

- *Swietenia mahogani* (mahogany; 27)
- *Delonix regia* (flame tree; 25)
- *Peltophorump terocarpum* (yellow flame tree; 25)

328. The main species to be removed is *Macaranga peltata* (Kendu) which has naturally colonized the abandoned forest gardens and other cultivated land in the project area. None of the tree species to be removed is critically endangered or endangered.Only one tree species, *Artocarpus nobilis* (wild breadfruit), is endemic to Sri Lanka (5 have been identified for cutting; this tree occurs throughout southwest Sri Lanka in low elevation rainforest).

329. **Poaching of wildlife:** There is a risk that construction workers will attempt to catch wildlife, if encountered, although there are no specific species of particular interest (except perhaps deer, wild boar, and hare). The risk of poaching will have to be addressed through a system of dissemination and sanctions, backed up with vigilance and community monitoring.

3. Operation phase impacts

330. For vegetation and faunal habitats, the impacts associated with the Moragolla project are confined to the pre-construction and construction phases, when the project sites will be cleared. During project operation, all the temporary project sites will be allowed to re-vegetate and the area around the reservoir will be planted with a variety of trees (these mitigation measures are discussed below). Animals will gradually spread their distribution into the newly developing habitats, which will be positive for maintaining terrestrial biodiversity and faunal population numbers (locally increased carrying capacity). Figure 29 shows the reservoir area, which will be flooded most of the time, within a range of a few meters; it is clear that this area will not suffer

Figure 29: The reservoir area for the Moragolla project.

any significant habitat loss, as there is little forest area that will be inundated, and most of the adjacent land is populated or used for agriculture. Creating a vegetated buffer around the perimeter of the reservoir will produce a degree of protection for animals that is not evident in this area at the moment.

4. Proposed mitigation measures

331. Although no unique, critical, or endangered vegetation will be impacted (it is mostly scrub and secondary forest that will be cleared), the mitigation will include replacement of lost vegetation in the reservoir buffer (in a 100-meter strip) in such a manner that will enhance habitat for selected wildlife species (although, note that no individual faunal species will be under threat because of the project; and all fauna occur elsewhere in Sri Lanka). The overall goal is to create a net increase in forest cover near the project site (to compensate for trees removed by the project, reduce inflow of sediment to the reservoir, and enhance the landscape) and also create an increase in the quality of faunal habitat adjacent to a waterbody (to protect and enhance terrestrial ecology). The proposed mitigation will also include a "find-and-move" initiative for "moveable" animal species before and during land clearing. Finally, in order to preserve and improve the quality of the surrounding land (to maintain vegetative cover and maintain water quality in the reservoir), a program of watershed management in upstream areas is proposed. These are all discussed below.

a. Pre-Construction/Construction Phase

332. Clearing of vegetation is required in the pre-construction and early construction phases, in order to allow access to work sites. Prior to clearing, all sites will be re-surveyed and tree identifications and counts confirmed (for payment of compensation). At this point, and as construction equipment is mobilized, it is recommended that all vulnerable animals be captured and moved to adjacent habitat, if possible (well away from work sites), or at least allowed to move away from the land clearing work sites. A contractor can be engaged to undertake this service as needed. All wildlife encounters will be logged, to build up the faunal database for the project area (voucher specimens may be collected, as needed, if plant and animal numbers allow this; unique specimens will be photographed and moved carefully).

333. The main mitigation measure for this phase of the project is initiation of the afforestation plan, which is intended to enhance habitat for wildlife (to compensate for those habitats which will be lost to land clearing and inundation). The main planting area will be a 100-meter buffer strip all around the reservoir, an area of about 70 hectares (twice the area that will be inundated, more than compensating for the flooded area and other permanent project "footprints"). This area will be surveyed and marked early in the construction phase, and the various steps required to undertake the planting of trees will be started as early as possible (before the reservoir is filled), so that riparian forest habitat development can start as early as possible. The combination of selected vegetation types will reflect the needs of targeted faunal species, for habitat enhancement. The concept and required steps are described below.

334. According to the ADB Safeguard Policy Statement (2009), a critical habitat includes areas with high biodiversity value, including habitats required for the survival of Critically Endangered (CR) or Endangered (EN) species, areas of special significance for endemic or restricted-range species, sites that are critical for the survival of migratory species, areas that support globally significant concentrations or numbers of individuals of congregatory species, areas with unique assemblages of species, that are associated with key evolutionary processes

or provide key ecosystem services, and areas with biodiversity of significant social, economic, or cultural importance to local communities. Critical habitats include those areas either legally protected or officially proposed for protection, such as areas that meet the criteria of the World Conservation Union classification, the Ramsar List of Wetlands of International Importance, and the United Nations Educational, Scientific, and Cultural Organization's Natural World Heritage Sites. In the case of the Moragolla project, it has been determined that there are no project areas that can be classified as "critical habitat" (see Section IV.K.1.c)[35]. On the other hand, the concept of habitat enhancement to strive towards protection of critically endangered or endangered species that may frequent the area has been assumed as a mitigation measure for this project.

335. A process was undertaken by IUCN to rank the 41 faunal species recorded in the project area that are either endemic, near threatened, vulnerable, endangered, or critically endangered (in the Sri Lanka classification), so that habitat enhancement measures can address those species that would gain the most protection potential from the effort. The key parameter that can be used to ascertain the importance of a given habitat or area for the long term survival of a critical species, is the proportion of the population of that critical species that occupies a specific habitat. However, information on the overall population sizes of the 41 critical species is not available or reliable, so, in the absence of population data, alternative proxies were used to make such an assessment which allowed ranking of species in the project area which would have the maximum protection benefit from an afforestation program. This process is described below.

336. The ranking of individual species (as candidates for targeted habitat enhancement) was based on an accumulated score reflecting various species factors, as follows (higher scores reflect greater conservation needs):

Species status: This indicates the overall status of the species, as follows:

(i) Indigenous (1 point);
(ii) Endemic (3 points); and,
(iii) Possible new species (3 points).

Distribution: A species that shows a wider distribution within a country across several bio-climatic zones is less likely to be affected by a single project or catastrophic event that might result in large-scale mortality of members of that species, compared to those with more limited distribution. Distribution was scored as follows:

(i) Island wide (0 points);
(ii) Mahaweli basin and Dry Zone (1 point);
(iii) Mahaweli basin and Wet Zone (2 points);
(iv) Mahaweli basin only (3 points); and,
(v) Restricted to the project area (4 points).

Habitat impact: Some species can be affected negatively, while others may benefit, through the habitat changes that can take place as the result of a project. Habitat impact was scored as follows:

[35] IUCN (2013). Additional Studies. Expert Report on Habitat Creation and Management to Enhance Terrestrial Biodiversity.

(i) Positive impact (-2 points);
(ii) No impact (0 points); and,
(iii) Negative impact (+ 2 points).

For all the terrestrial faunal species encountered in the project area, the project is considered to have a net negative impact, mostly because the project will result in the conversion of terrestrial habitats into waterbodies (net loss of terrestrial habitat). However, this presents an opportunity to support fauna which have an association with water.

Conservation status: This indicates the long term survival potential of the species, and has been determined based on overall population trends, as well as threats that are operating on the species at a national scale. Conservation status was scored as follows:

(i) Not evaluated (2 points, as this indicates species that have been described after 2012);
(ii) Least Concern (LC) (0 points);
(iii) Near Threatened (NT) (1 point);
(iv) Data Deficient (DD) (2 points, as Data Deficient species may be extremely rare species);
(v) Vulnerable (VU) (3 points);
(vi) Endangered (EN) (4 points); and,
(vii) Critically Endangered (CR) (5 points).

337. Based on this ranking scheme, the maximum possible score is 14, reflecting species that have significant conservation needs and which could gain maximum benefit from habitat enhancement. The cut-off point was taken to be seven points (the mid-point). A species that obtained a score above the cut-off point was considered to be a suitable candidate for habitat enhancement in the project area, with a moderate to significant impact on survival of the species. Figure 30 shows the ranking for the 41 faunal species considered in this analysis (see the IUCN Habitat Creation report in Volume 4 for the detailed scores). Photo 4 shows the top five ranked species that can be targeted for the habitat enhancement program and Table 26 shows the conservation classifications and habitat needs of these species.

338. The proposed new forested buffer zone around the reservoir will provide habitat for these selected faunal species (and many others) as well as protection for the immediate catchment of the reservoir, to reduce soil erosion and potential siltation of the reservoir (some of the slopes near the inundation area approach 50^{o} and are therefore quite vulnerable to erosion). The most suitable tree and shrub species for these purposes will be planted in this area as soon as possible after the project construction starts. Figure 31 shows the proposed buffer zone around the reservoir, which will replace mostly old tea plantations, home gardens, and scrub vegetation.

Figure 30: Ranking of endemic and/or threatened faunal species in the project area for habitat enhancement targets.

Photo 14: The top five ranked faunal species in the project area targeted for habitat enhancement (left-to-right; top-to-bottom: lesser gull butterfly; one-spot grass yellow butterfly; fishing cat; rusty-spotted cat; Sri Lanka pygmy mouse-deer).

Table 26: Conservation status and habitat risks of the five selected species.

Family	Species	Status	Conservation Status		Habitat Risks *
			National	Global	
Pieridae	*Cepora nadina* Lesser gull	Indigenous	CR		Reduction of feeding and nectar plants.
	Eurema andersoni One-spot grass yellow	Endemic	VU		Reduction of feeding and nectar plants.
Felidae	*Prionailurus rubiginosus* Rusty-spotted cat	Indigenous	EN	VU	Reduction of hiding places and hunting grounds.
	Prionailurus viverrinus Fishing cat	Indigenous	EN	EN	Reduction of hiding places and hunting grounds.
Tragulidae	*Moschiola kathygre* Sri Lanka pygmy mouse-deer	Endemic	VU	LC	Reduction of hiding places and feeding grounds.

* Based on the IUCN analysis undertaken for the project in 2013.

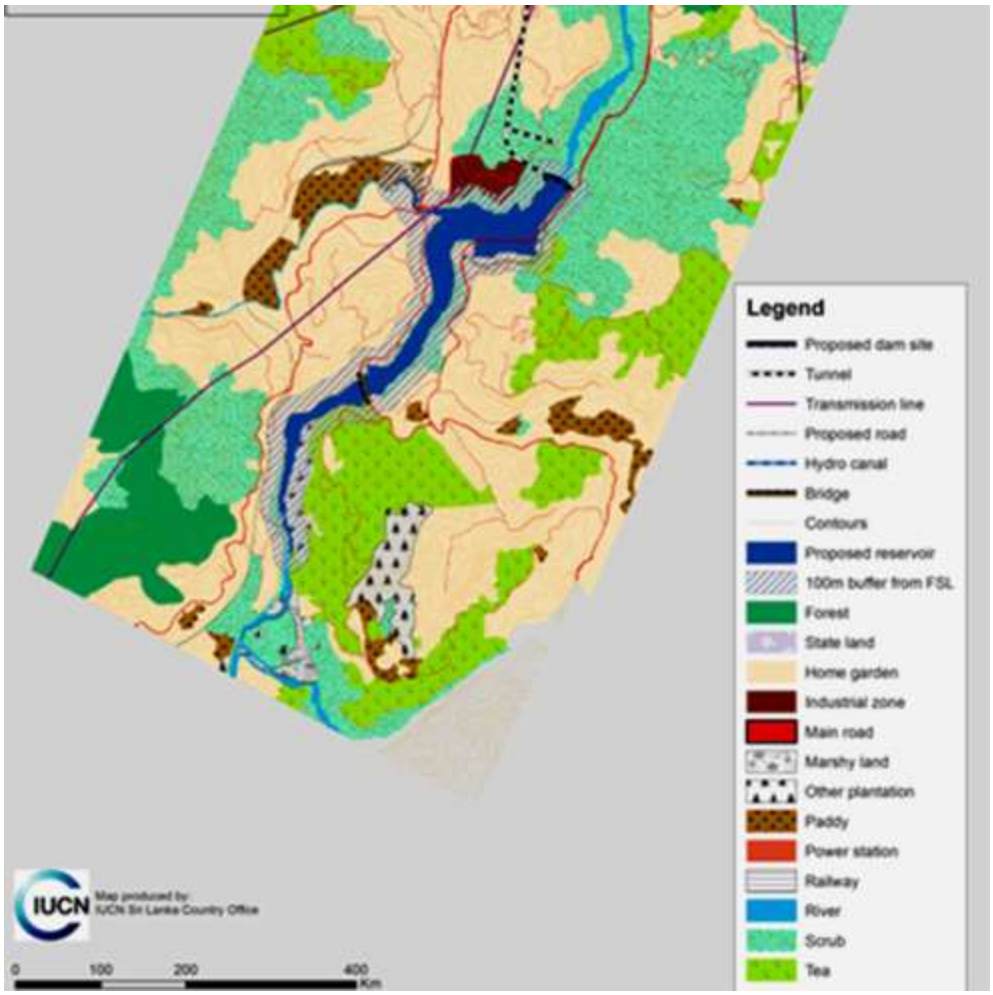

Figure 31: Proposed buffer zone around the reservoir, for faunal habitat enhancement.

339. Planting trees and shrubs in dense patches will help to create the habitats necessary for the three mammal species and two butterfly species that have been identified, as well as others occurring in the project area. Table 27 shows the range of vegetation that can suit the habitat enhancement purposes, and Photo 15 shows the intended effect of habitat enhancement (what the reservoir buffer forest should look like in 5-10 years). A mixed-species planting approach (polyculture) is recommended in order to create suitable habitat conditions.

Table 27: Proposed species for the reservoir buffer area (habitat enhancement).

Plant Species	Common Name	Beneficiary Faunal Species
Tremaorientalis	Gedumba	Insect eating birds.
Macarangapeltata	Kenda	Fruit eating birds.
Macarangaindica	Kenda	Fruit eating birds.
Mallotustetracoccus	Bu Kenda	Fruit eating birds.
Ficus sp.	Nuga	Fruit eating birds, *Moschiola kathygre* (Sri Lanka pygmy mouse-deer)and*Macaca sinica* (Toque monkey).
Ficusracemosa	Attikka	Insect eating birds and mammals (e.g. *Macaca sinica* and*Moschiola kathygre*), and butterflies for which this species is a host plant.
Acacia sp.		Insect eating birds and species for which it is a host plant.
Albizia lebbeck	Kabal mara	*Pantoporia hordonia* (Common lasker) (as a host plant).
Madhucaneriifolia	Gam Mi	Fruit eating birds and mammals (e.g. *Macaca sinica* and *Moschiola kathygre*).
Symplocoscochinchinensis	Bombu	Butterflies for which it is a feeding plant.
Artocarpusnobilis	Wal del	Fruit eating birds and mammals (e.g. *Macaca sinica*).
Chloroxylon swietenia	Satinwood	*Papilio crino* (Banded peacock) (as a host plant).
Plant species belonging to Family Lauracea (camphor, laurel, and cinnamon)	Wal enasal	*Papilio clytia* (Mime) (as a host plant); *Prionailurus rubiginosus* (Rusty-spotted cat), *Prionailurus viverrinus* (Fishing cat) and *Moschiola kathygre* (Sri Lanka pygmy mouse-deer) as a hiding place.
Erythrina subumbrans	Erabadu	Shade loving flora and fauna.
Delonix regia	Mara	Insect eating birds and species for which it is a host plant.
Mangifera indica	Amba	Fruit eating birds and mammals (e.g. *Macaca sinica*).
Artocarpus heterophyllus	Kos	Fruit eating birds and mammals (e.g. *Macaca sinica* and*Moschiola kathygre*).
Capparis sp.	Wellangiriya	Butterflies (as a host plant) and *Prionailurus rubiginosus* (Rusty-spotted cat), *Prionailurus viverrinus* (Fishing cat) and *Moschiola kathygre* (Sri Lanka pygmy mouse-deer) as a hiding place.
Spathodea campanulata	African tulip tree	Small mammals, birds and butterflies that feed on these plants.
Ochlandra sp.	Bata	Larval feeding plant for butterflies; *Prionailurus rubiginosus* (Rusty-spotted cat), *Prionailurus viverrinus* (Fishing cat) and *Moschiola kathygre* (Sri Lanka pygmy mouse-deer) as a hiding place.
Cassia sp.	Thora	Grass yellow butterfly larvae, as a feeding plant.

Photo 15: Expected habitat vegetative diversity in the reservoir buffer area (examples from the Kothmale reservoir and the Moragolla project area)**.**

340. Since the afforestation program for the reservoir buffer will involve state lands (reservations with degraded forests), private home gardens, cultivated lands, tea lands and RDA lands (road reservations), new legislation will be required to facilitate the planting of trees and shrubs and then to regulate land use activities in the buffer area. There are several options which will be explored in the pre-construction phase of the project, including declaring the buffer zone as an "Environmental Protection Area" under the National Environment Act (under the jurisdiction of the Central Environmental Authority, or reaching a local agreement between landowners and the Mahaweli Authority of Sri Lanka to encourage local people to be custodians of the reservoir buffer area. Actual planting of trees will probably fall within the responsibilities of the Forest Department, with the activity funded by CEB. There will have to be extensive dissemination of the reservoir buffer concept, so that trees, shrubs, and animals are left undisturbed (backed up with regular compliance monitoring). As well, there will have to be vigilance to ensure that invasive alien species do not proliferate in the reservoir buffer area (or other project sites); these species include *Lantana camara* (Gandapana), *Eupatorium odoratum*, *Mimosa pigra* (Yodha Nidi kumba), *Alstonia macrophylla* (Hawari Nuga), *Ludwigia peruviana*, and *Clusia rosea* (Gal Goraka).

341. The proper development of the reservoir buffer forest will require several tasks in the correct sequence. The intention is to develop the reservoir buffer forest as quickly as possible. It obviously will not be ready to receive any displaced animals from the land clearing phase, so those animals encountered will have to be moved to other suitable adjacent habitats for the time being. The afforestation steps are summarized below (more details are provided in the EMP; Volume 2):

- Demarcation (with posts) of the reservoir buffer area, to ensure no further development or farming within its area;
- Selection of specific sites and species combinations and planting densities within the reservoir buffer zone (250 to 1,100 trees per hectare, depending what is already there), determining soil type and depth, slope, soil moisture levels; home gardens may be left up to the individual land owners, but other degraded forest areas adjacent to the reservoir should be planted according to the faunal habitat needs mentioned above;
- Development of a detailed planting plan, including the specific locations, number of plants of each selected species, and expected planting time;

- Establishment of the nursery (based on the requirements identified above, to handle up to 80,000 seedlings); this will require collaboration with the Forest Department and selection of an appropriate site (near the reservoir area, with adequate water supply); the nursery will probably have to be in operation for at least 8-10 months before planting can begin;
- Planting of seedlings, then ongoing maintenance (including fire protection) and weeding for at least three years; and,
- Regular monitoring of the reservoir buffer forest, including: seedling survival counts; regular surveillance of pests and diseases; careful monitoring of invasive species; monitoring of changes in the floral and faunal composition of the area; monitoring of significant soil erosion in the afforestation sites; and, monitoring of encroachments or unauthorized activities in the afforestation area.

b. Operation Phase

342. The main concern during the operation phase of the Moragolla project is maintaining vegetative cover and stable soil conditions in the upper watershed, to maintain habitat for fauna (as much as possible) and to reduce the sediment inputs to the Moragolla reservoir. Therefore, a Watershed Management Program is proposed, which will include various technical approaches for private land (home gardens and tea land) and state land in the upper watershed (up to Nawalapatiya). This program will include provision of technical assistance and funding. Details are summarized below (see the EMP Volume 2 for additional details and implementation arrangements).

343. Table 28 shows the range of watershed management techniques that have been proposed for the Moragolla upper watershed area, along with their intended objectives and their association with various land uses in the area (additional details are provided in the EMP Volume 2, in particular installation approaches and costs).

Table 28: Summary of proposed watershed management techniques for the Moragolla upper watershed.

Technique	Description	Purpose	Applicable Land Uses
Lock and spill drains	Specific type of drains along contours that capture runoff in small stilling ponds.	Slowing down runoff, temporary storage of runoff water, promotion of infiltration and thereby groundwater recharge, and trapping of silt.	Tea cultivation areas.
Bunds and stone walls	Embankments along contours that intercept runoff and sediments, and lead runoff to exit the land.	Slowing down of runoff, trapping of sediments, and disposal of runoff water from the fields.	Cultivated lands and home gardens.
Small check dams along tributaries	Small scale embankments across creeks to create ponds.	Slowing down of storm water, prevention of flash flooding, trapping of silt, and temporary holding of water allowing groundwater recharge through the banks.	Creeks and streams.
Ground-cover crops	Crops that provide either continuous ground cover or a multi-layer canopy to intercept rainfall.	Reduction of soil detachment and transport (soil erosion), reduction of runoff velocity, possible provision of additional income depending on the type of cover crop used.	Tea cultivation areas and home gardens.

Technique	Description	Purpose	Applicable Land Uses
Mulching	Covering the ground with organic matter (grass, leaf litter).	Reduction of soil detachment and transport (soil erosion), reduction of runoff velocity, provision of natural fertilizers to crops and thereby increasing yields and income, and increasing of the water holding capacity of the soil.	Tea cultivation areas.
Grass strips	Establishing vegetative barriers along the contour lines at a relatively low cost, with little labour and maintenance.	Slowing down runoff, intercepting and settling sediments, provision of a good quality and quantity of runoff to streams and reservoirs.	Tea cultivation areas, stream reservations, home gardens and abandoned lands.
Reforestation	Replanting blocks of lands with suitable tree species, particularly those that are consistent with the natural vegetation of the area.	Provision of canopy cover to intercept rainfall, provision of litter layer on the ground further reducing the runoff velocity and allowing infiltration, improvement of soil texture, support of cover crops, interception of dew and thereby provision of additional precipitation, and creation of micro- and macro-habitats.	Stream banks, degraded forest areas and other reservations owned by the state.
Home garden improvement	To establish a suitable vegetative cover (see details in the EMP) in private home gardens to provide effective protection against soil erosion.	Minimization of soil erosion.	Home gardens.
Establishment of wetlands	To establish and maintain areas which are inundated seasonally and feature aquatic and semi-aquatic vegetation.	Trapping of silt, allowing groundwater recharge, purification of water by removal of certain pollutants and creation of habitats.	Suitable places within the stream reservation.
Awareness raising	To carry out public awareness programmes in order to raise the awareness of local communities regarding the importance of protecting the watershed.	Encouragement of the local community - particularly the private land owners - to adopt environmentally friendly land use options.	Tea cultivation areas, cultivated lands, and home gardens.

344. A detailed survey will be undertaken in the area between Nawalapatiya and the reservoir, to identify candidate sites for implementation of the watershed management techniques. A mechanism to disseminate the various technical approaches for watershed management and a fair system to disburse grants for their installation and maintenance will be established, so that these techniques can be applied throughout the target area. Photo 16 shows an example of a checkdam and the expected effect of such watershed management techniques.

Photo 16: Example of a checkdam near the project area.

L. Recommendations of Local EIA study: Human Environment

345. The Local EIA report describes existing conditions in the human environment under eight main headings. These are: demographic and socio-economic status of the communities; river users; income generation sources and patterns; existing environmental considerations, problems or issues; cultural and archaeological aspects/considerations; existing infrastructure facilities, transportation, communications, power supply, etc.; social/cultural and archaeological sensitive places; and socio-economic environment in the 1 km radius of each location. Potential project impacts and mitigation were then discussed under a variety of different headings. This analysis is consolidated and summarised in Table 29 below, which shows existing conditions, potential impacts and proposed mitigation in the human environment of the immediate project area, as assessed by the Local EIA study.

Additional Table 29(a) for Addendum: Human Environment

Description	Local EIA (2012)	Environmental Addendum (2013)
1- Baseline data	• Sect. 3.3 Social environment • Sect. 3.2 Biological environment	• Collection of updated information by a new socio-economic survey to inform the resettlement plan (updated information will be discussed further in the standalone document Vol.3 Resettlement Plan)
2,3- Impacts	• Sect 4.6 Resettlement impact	• Resettlement impact will be discussed further in the

		standalone document Vol.3 Resettlement Plan
4- Mitigation	• Sect 5.6 Mitigation measures to address impact on the social environment.	• Resetlement planing will be discussed further in the standalone document Vol.3 Resettlement Plan

346. Table 29 shows that the main negative impacts on the human environment anticipated by the Local EIA study during the construction period are:

- 26 families living on land designated for project facilities will be relocated and their land will be acquired;
- If the project reduces downstream water supply, the livelihoods of 210 families depending on farming land irrigated by Dunhinda canal may be disrupted, sand miners and people employed in the Crysbro Plant could lose employment and livelihoods, and local people could lose sites currently used for washing and bathing in the river.

Table 29: Summary of existing conditions, potential impacts and mitigation in the human environment, as presented in the 2012 Local EIA study

Existing Conditions in the project area (approximately 1 km radius)	Potential Impacts	Proposed Mitigation
Population Demographics: In 2009 there were 13,116 people in 3,209 families living within 1 km of the project sites, all located around the reservoir, tunnel and powerhouse. In demarcated project areas there were 157 Affected Persons in 32 families (20 in the reservoir area, 2 at the powerhouse, 6 at the residential area and 4 in a proposed labour camp on the left bank). 24 of these families are Sinhalese, 5 Tamil and 3 Muslim; and 68 people in 14 families are of the "blacksmith" caste, who were moved to Kandy due to construction of Kotmale Power Plant in 1984, and were then relocated to this site because of landslides. The other APs are low-income, from the Govigama caste.	The 26 families living in land designated for project facilities will be evacuated and their land will be acquired.	Prepare a Resettlement Plan. Resettle families; provide compensation according to the National Involuntary Resettlement Policy. Prioritise affected people for employment in project implementation.
River Users: a) Dunhinda Irrigation Canal extracts 0.28 m^3/s via an intake on the left bank upstream of the tailrace, to irrigate 54 ha of land in the Gampolawela Minor Irrigation Scheme (2 season, paddy and vegetables). This supports 210 families, mostly tenant farmers, who earn about SLR 75,000 gross per season from 0.5 ha. b) Crysbro Broiler Processing Industry pays MASL SLR 15,000 a month to extract 220,000 litres a day from the left bank upstream of Dunhinda Canal. Effluent is discharged 200 m downstream and should be treated to industrial wastewater standards. Current discharges are 600,000 litres per day. 700 employees process 25,000 birds per day, and the plant supports around 1200 poultry suppliers and 4000 farmers growing maize. c) Three locations are used for daily bathing and washing: right bank at Kotmale Oya confluence (50 families); left bank near Ulapane Bridge (15 families); left bank opposite Atabage Oya (20 families). d) In 2012, 19 parties obtained permits from GS&MB for sand mining in the project area. Two operate upstream of the dam site and the rest are downstream around/beyond Atabage Oya. Each hire 2-5 divers on a daily basis to collect sand using buckets. Divers earn SLR 800 - 2,000 per day and permit holders 2,000 - 3,000. There is also unlicensed mining, done in the same way.	If the downstream water supply is disrupted: a) Livelihoods of 210 farmer families dependent on Dunhinda Irrigation Canal could be disturbed. b) People employed at Crysbro and in the supply-chain could lose jobs and livelihoods. c) People could lose bathing and washing sites. d) Sand miners could lose livelihoods.	Proposed Environmental Flow of 1.5m^3/s includes 0.29 m^3/s to cover the needs of the two major river users: Gampowela irrigation scheme and Crysbro Broiler Industry. Provide a pool with steps near new Ulapane Bridge as alternative place for bathing and washing. Provide affected sand miners compensation or employment in project construction & operation.
Employment and Income: People in the project area are employed as: self-employed (38%); private sector (27%); government (18%); agriculture (13%); overseas (4%). Families at project sites are employed: private sector (14), labouring (8); agriculture (5); government (3); business (2). Most families are moderate income (SLR 5,000-15,000 a month)	The project will provide employment opportunities for people living in the area.	Give local people priority in employment during project construction and operation.
Infrastructure: a) Water: The project area is supplied with piped water from Ulapane Oya, and 48% of people have access. This does not include any of the families living on project sites, who use common wells (50%), protected wells (36%) or unprotected wells (14%). b) Transport: The area is well connected to the rest of the country by road (to Gampola and Nawalapitiya) and rail (Ulapane station is on the Colombo to Badulla line). c) Electricity: All communities in the area are provided with electricity from the national grid. d) Telephone: Mobile and land-line services are available in the area.	Infrastructure improved by the project will improve access facilities	The project should improve existing roads and build new roads in the affected area

Existing Conditions in the project area (approximately 1 km radius)	Potential Impacts	Proposed Mitigation
<u>Physical Cultural Resources:</u> The Bureau of Earth Reconnaissance conducted an Archaeological Impact Assessment Survey and found no archaeologically sensitive places within 1 km radius of any of the project sites. There were four locations in a wider 5 km buffer zone, as follows: a) Niyamgampaya Raja Maha Viharaya: 2 km NNW of powerhouse. Protected archaeological monument. Buddhist monastery from 14th century. Image house and related components with sculptures and paintings. b) Valvasagoda Raja Maha Viharaya: 2.4 km NW of powerhouse. Buddhist Vihara (monastery) built by King Buvanekabahu IV (1470-1478 CE). Renovated several times. Only remaining features are devala and stupa. c) Purana Gal Viharaya in Mawatura. 1.75 km south of dam. Unfinished stone building of similar architectural style to buildings of the Gampola period (1341-1415 CE). d) Pattini Devala in Savandarapitiya. 2.5 km SW of dam. Tampita Vihara style building probably built in the 18th century. The original structures and plan of the building have been changed several times. Observations and field walking in the project area, including the reservoir site showed a lack of archaeological scatter on the ground. The area was re-examined as prehistoric implements were found from Ethgala hillock but no such artefacts were found, due to the high degree of landscape modification that has occurred in this area.	There are no ground monuments of archaeological importance within a radius of 1 km from the project site and a careful ground search revealed no artefacts. There are unlikely to be any direct archaeological impacts from any construction activity; and propagation of vibration from tunnelling will not be a key factor because of the distance from any important monuments.	No mitigation proposed
<u>Existing Projects in the Area:</u> a) Ulapane Industrial Area: left bank close to dam site. 10 ha with approval for 11 investors to set up industries. 5 in operation (expected employment in brackets) for manufacture or processing of: shoes (200); polythene (53); flexible conduits (168); spices (33); cement products (54). 6 others established: agricultural equipment (21); steel and MDF furniture (86); hotel matchboxes (80); food & drinks (60); PVC pipes (45); flat screen TV (234). 4 more in future: polythene; timber picture frames; MDF, timber and steel furniture; fruit drinks. b) Kotmale Dam on Kotmale Oya upstream of proposed dam site; power house underground on right bank. c) Raja Ela Irrigation Scheme: 13 km long; draws water from a point well upstream on Ulapane Oya. d) Dunhinda Ela Irrigation Scheme draws water from Mahaweli Ganga between proposed dam and tailrace. e) Towns South of Kandy Water Supply Scheme (NWS&DB). Under construction. 8,000 m^3 treatment plant at Ulapane and one of the intakes upstream on Ulapane Oya. f) Ulapane Bridge on Mahaweli Ganga near upper limit of the proposed reservoir is under construction by RDA	The MHPP will provide a reliable source of water for the farming community that is sustained by the Gampolawela Irrigation Scheme	Ensure the minimum environmental flow release downstream of the dam and improve the existing irrigation diversion facilities
<u>Planned Projects in the Area:</u> a) Ethgala New Town: being implemented by UDA with Ganga Ihala Korale Pradheshiya Sabha funds b) Ulapane Industrial Area: 4 more industries planned (see above); 2 new water tanks being built. c) Raja Ela Irrigation Scheme: Rehabilitation works to be done on irrigation canal and structures. d) Ulapane Mahawilawatte Land and Housing Project: Lands have been distributed and 100 houses built.	The MHPP will not affect implementation of these projects	No mitigation necessary

347. Mitigation proposed in the Local EIA report to address these impacts is as follows:

- Prepare a Resettlement Plan and provide compensation for the socio-economic losses according to the National Involuntary Resettlement Policy (2001);
- Prioritise the directly affected families to be offered employment in project implementation;
- The proposed Environmental Flow of 1.5 m^3/s includes an allowance of 0.29 m^3/s to cover the requirements of Dunhinda irrigation canal and the Crysbro Broiler Industry;
- Provide a pool with steps near the new Ulapane Bridge as an alternative place for local people to wash and bathe;
- Provide affected sand miners with financial compensation for any livelihood losses, or provide them with employment in project construction and operation.

348. The Local EIA also identified certain positive impacts of the project on the human environment (in addition to the major benefits of helping the country to meet its energy needs in a sustainable manner). These are:

- The project will provide employment opportunities for people living in the area;
- Some local infrastructure will be improved so that it is suitable for use by the project;
- The proposed Environmental Flow will provide a reliable flow of water for the farming community that is sustained by the Gampolawela irrigation scheme.

349. To ensure and enhance these benefits the Local EIA proposed that:

- Local people should be given priority for employment in project construction and operation;
- The project should build new roads and improve existing roads in the project area.

350. The socio-economic impacts of the project were re-examined as part of the FS Review and Detailed Design Study in 2013; and the manner in which they will be mitigated is set out in the project Resettlement Plan, prepared according to the requirements of the National Involuntary Resettlement Policy (2001) and the ADB Safeguard Policy Statement (2009). This includes the mitigation and enhancement measures proposed in the Local EIA study, and many others.

351. There are certain other ways in which a project can affect people, which do not necessarily produce socio-economic impacts. Such impacts include reductions in air quality, increases in noise and dust, changes in land use and landscape, and reductions in the quality and availability of water supplies. These impacts and their potential effects on people and their environs in relation to this project have all been described in detail in the individual sections above. This examination and the analysis presented in the Resettlement Plan cover almost all of the potential impacts of the MHPP on the human environment.

352. There are two remaining issues, which have been mentioned in this document, but for which suitable mitigation has not yet been proposed. These relate to physical cultural resources and dam safety and disaster preparedness. These are discussed in the final two sections of this chapter below.

M. Physical Cultural Resources

1. Existing Conditions

353. The Physical Cultural Resources of the study area, and the potential impacts of the project, were described in some detail in the Local EIA report, on the basis of an Archaeological Impact Assessment Survey conducted by the Bureau of Earth Reconnaissance in 2010. The report and a letter of approval from the Department of Archaeology are contained in Appendix B of the Local EIA report (Volume 5). The archaeological survey and its main results are summarised in Table 29 above. Data collection and analysis were done according to the legally-prescribed procedure[36] and involved expert field walking and observation, and examination of records pertaining to known protected and unprotected archaeological monuments and sites in the vicinity.

Additional Table 29(b) for Addendum: Physical Cultural Resources

Description	Local EIA (2012)	Environmental Addendum (2013)
1- Baseline data	• Sect. 3.3.5 Cultural and Archiological aspects/consideration • Sect. 3.3.7 Social/Cultural and Archiological sensitive places.	• No change
2,3- Impacts	• No impact	• No change
4- Mitigation	• No Mitigation measures required.	• No change If such site found by chance Sect VI.M.4 Proposed mitigation measures

354. The four known existing sites were visited and examined and brief descriptions were provided in the report (summarised in Table 29). These are all ancient and not well-preserved Buddhist buildings dating from the 14th, 15th and 18th centuries, some of which have been modified and renovated in the past. Two are located 2 and 2.4 km north-west of the powerhouse site and the other two are 1.75 and 2.5 km south and south-west of the dam. The most important is the Niyamgampaya Raja Maha Viharaya, a Buddhist monastery from the 14th century, 2 km NNW of the powerhouse, which has been designated as a protected archaeological monument.

355. Expert observations and field walking in the project area (including the reservoir site), and a subsequent re-examination, revealed no archaeological material, and it was concluded that this was a result of the high degree of landscape modification (mainly land clearance for agriculture) that has occurred in the project area.

356. The Local EIA study did not mention physical cultural resources of a more local interest, of which there are some in areas that could be affected by the project. For example Photo 17

[36] Project Procedure Orders No 1 of 2000. Section 47 read with Section 43(b) of the Antiquities (Amendment) Act No 24 (1998) published in the Government Gazette No 1152/14 dated 2 October 2000

shows a small Buddhist shrine located beside the Gampola road at the entrance to the site designated for use by the Contractors (see Fig 19).

2. Pre-construction and construction phase impacts

357. The Archaeological Assessment and the Local EIA study concluded that there were unlikely to be any direct archaeological impacts from the construction activities, because there are no ground monuments or sites of any archaeological importance within a radius of 1 km from the project site and no artefacts were found in the immediate project area after a careful and repeated ground search. These conclusions were reached after a thorough and expert examination, so it can be assumed they remain valid and that no special precautions are therefore needed to avoid or mitigate impacts on archaeological resources.

358. The smaller sites (such as the shrine pictured above) that are of local interest are often located beside roads, where they could be damaged directly by the passing works traffic, or indirectly from dust or vibration produced by the traffic, especially trucks carrying spoil. There is also a risk that people visiting the shrines could be injured, possibly seriously, from the increased traffic in the vicinity, so precautions will be needed to maintain safety.

Photo 17: Buddhist Shrine alongside Gampola Road

3. Operation phase impacts

359. The only potential source of vibration during operation of the project is from the force of water cascading through the headrace tunnel and out through the tailrace outfall. Any resulting ground vibration will be much less than that caused during blasting and tunnel excavation, which the archaeological assessment concluded would not cause any archaeological damage because of the distance to the nearest monument (2 km). It is safe to assume therefore that the operating project will also not cause any archaeological damage.

360. There will also be no risk to the roadside shrines or any other physical resources of cultural importance locally, primarily because an operating hydropower station does not require regular deliveries of fuel or other materials via large vehicles. The only increase in vehicular traffic as a result of the MHPP will be from cars or small mini-buses carrying staff, and these provide no more risk than the traffic already present on the local roads.

4. Proposed mitigation measures

361. **Pre-construction and construction phases:** No mitigation is needed to protect existing archaeological resources during the pre-construction stages as the expert assessment concluded that the only significant sites and monuments are sufficiently far from the project area for there to be no risk of damage. The absence of any archaeological scatter in the project area also suggests that this is an area of low archaeological potential, in which there is little risk that significant material would be discovered during ground excavation. However this is not certain, so a precautionary approach should be adopted, whereby safeguards are established that would allow any archaeological material to be recognised and protected, if it were to be found. This will require:

- Establishing a 'chance finds' procedure, which defines action to be taken if any archaeological material is discovered (including as a minimum, cessation of excavation in the affected area and on-site assessment by a qualified archaeologist);
- Training excavator operators and site supervisors in the recognition of archaeological material during ground excavation and the action to be taken when necessary.

362. The small roadside shrines and any other objects or areas of local cultural importance should be protected by a series of relatively simple actions as follows:

- Contacting local communities in the project area to determine the location and nature of all sites of local cultural importance (shrines, meeting places, sacred sites, etc);
- Visiting each site to determine the nature and seriousness of the risk and any necessary mitigation;
- Discussing proposed mitigation with the affected community, and arranging the action once agreed.

363. The survey work, consultation and design of mitigation should be done by appropriate experts, and the mitigation may include such measures as:

- Imposing strict speed limits on all construction traffic in the vicinity of sensitive locations;
- Training truck drivers in the risks to culturally sensitive sites and pedestrians nearby and training and enforcement of safe driving techniques both off-site and on-site;
- Relocation of any sites/material that are at particular risk, if approved by the community;

- Payment of compensation to the community if any damage is sustained.

364. **Operation phase:** No mitigation is needed in the operation stage because, as explained above, the operating project poses no risk to archaeological sites and monuments, or any locally-important cultural resources.

N. River Users and Dam Safety

365. The Local EIA study surveyed and described the human uses and users of the river between the tailrace outfall site and the upper limit of the proposed reservoir. These data are summarised in Table 29. The Local EIA also assessed the potential impacts of the operating project on these activities (mainly resulting from changes in river flow, sediment supply, and access to the reservoir area). **Additional Table 29(c) for Addendum: River Users and Dam Safety**

Description	Local EIA(2012)	Environmental Addendum(2013)
Baseline data	• Sect. 2.2.12 Detailed required to check the adequacy of the proposed dam and associated structures considering probable failure condition. • Sect. 2.2.13 Proposal for emergency action plan along with arrangements for early warning systems and details required to ensure the dam safety aspects. • Sect. 3.3.2 River users	• Volume 4; Collection of updated information by a new river downstream survey. • CEB conducted Inundation mapping
Safety	• Sect. 4.6.1 Impact on existing water users. • Endanger downstream property and human life • Sect. 5.6.1 Mitigation of impacts on existing water users upstream and downstream. • Sect. 5.4.9 Disaster management plan.	• No change • No change • No change • No change Enhanced mitigatory measures are specified in Sect VI.N.2 clause 375 and 376.

366. The Local EIA report considered the likelihood of the dam failing, leading to large-scale downstream flooding, and described the elements of an Emergency Action Plan and Disaster Management Plan. It did not however quantify the risk in terms of the area that could be affected; and it did not consider whether there were any risks to river users from the short term fluctuations in river flow that will result from normal power generation operations. These factors are therefore discussed below.

1. Existing Conditions

367. The Local EIA report described the human uses of the river in the immediate project area in 2009, and provided information on the numbers of people involved. Sand mining licences are valid for one year only, so data on this activity were updated in 2012. This information is summarised in Table 29, which shows that between the upper limit of the proposed reservoir and the tailrace outfall site there are four main river uses. These are:

- Dunhinda Irrigation Canal (Photo 18) extracts 0.28 m^3/s from the left bank upstream of the tailrace site (Fig 19) to irrigate 54 ha of farmland in Gampolawela Irrigation Scheme;
- Crysbro Broiler Processing Industry extracts around 600,000 litres/day from upstream of the Dunhinda intake and returns inadequately treated effluent 200m farther downstream;
- Three locations are used by 85 families for washing and bathing: two in the reservoir area and one downstream opposite Atabage Oya (Fig 19);
- In 2012, 19 parties obtained sand mining licences and employed 2-5 divers each at two locations upstream of the dam and the rest downstream around/beyond Atabage Oya.

368. The updated land-use survey in 2013 found an increased number of bathing places in the reservoir area (4 in total, Figure 19), and a decrease downstream as the Atabage Oya site is no longer used. It also found that the two upstream sand mining locations are now abandoned so there is only one site currently in use, downstream of Atabage Oya (Figure 19). Clearly the number of people using the river and the locations vary from year to year and during the year, but these four activities remain the only human uses of the river in the immediate project area.

369. To properly consider the issue of safety for river users during the normal power generation cycle and in the (unlikely) event of a dam failure, information was collected in September 2013 over an extended area downstream, to Peradeniya Bridge 17 km away (Figure 32). The key details for each activity are that in the area between the proposed Moragolla outfall and Peradeniya Bridge:

- Sand mining is currently practiced in 21 locations by 19 parties (11 licensed), employing 63 people an average of three days per week (Photos 19 and 20);
- Bathing and washing is performed at 34 locations by an estimated 367 families in the wet season and 753 families in the dry season (Photo 21);
- There is no commercial fishing and only very small-scale subsistence fishing using rods;
- There are no offtakes in this part of the river for irrigation or industrial use; but there are two offtakes for domestic use: Kandy South Water Supply Scheme and the University of Peradeniya, both implemented by the National Water Supply and Drainage Board.

2. Normal safety for downstream river users

370. In the construction period the natural downstream river flow will be maintained by means of the diversion tunnel described in Section VI.C.2 above. There will therefore be no changes in flow and no additional risks to the safety of downstream users, beyond those that are inherent in these activities in normal circumstances.

371. When the completed scheme is operating, downstream river flow will vary as described in Section VI.C.2. The main characteristics of the new flow regime are as follows:

Photo 18: Dunhinda Irrigation Canal

Photo 19: Sand Mining at Atuwewatta (S1 on Fig 22)

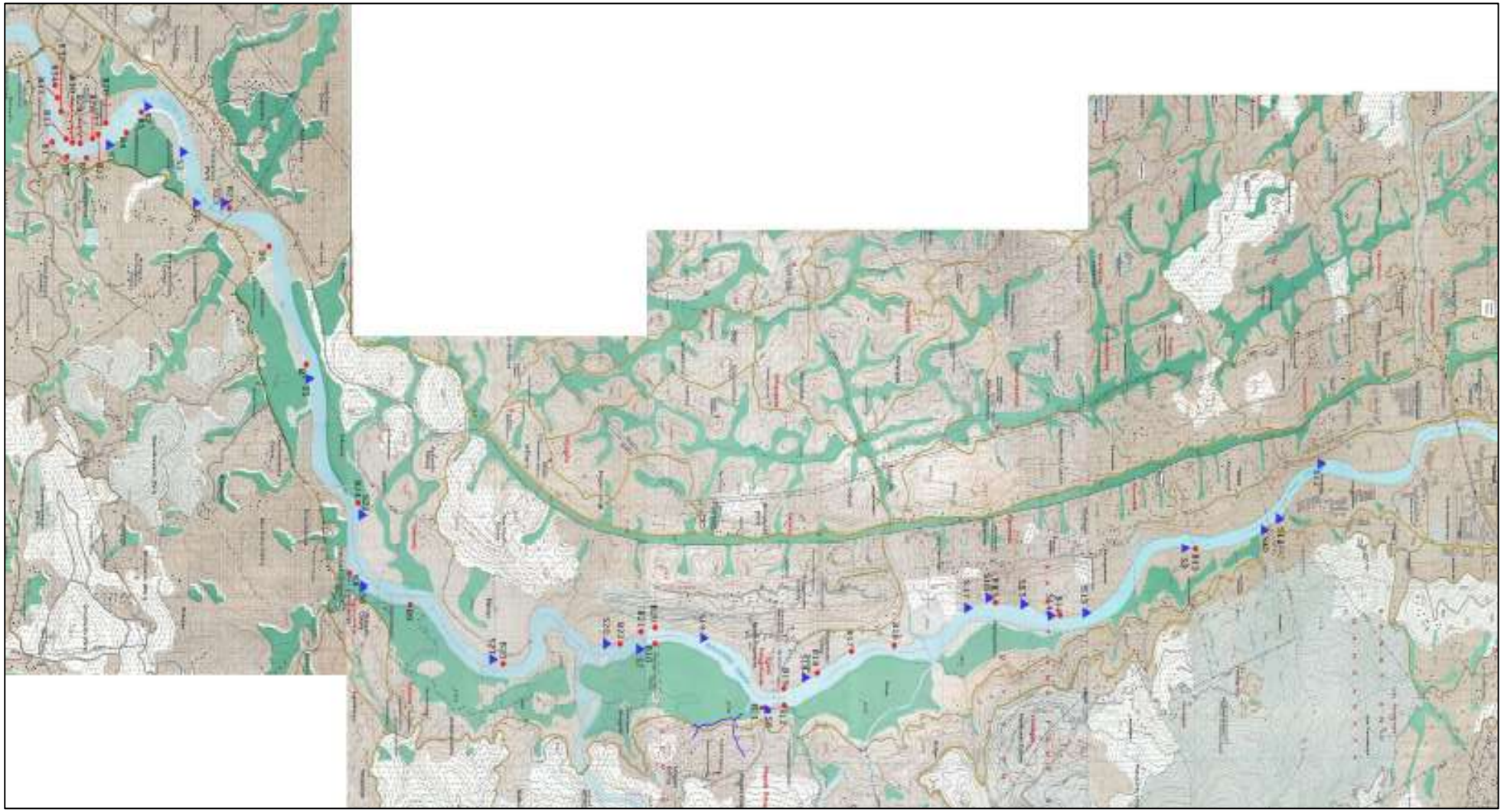

Figure 32: Locations of human uses in the river between Gampola and Peradeniya Bridges

Photo 20: Sand mining at Ihalawela (S2 on Fig 22)

Photo 21: Bathing at Iskolawatta (B7 on Fig 22)

Dam to tailrace outfall	- All seasons: reduced flow as 50 m^3/s of water is diverted through the tunnel when power is generated and returned 2.7 km downstream; - Dry season: no overspill from the dam so river flow will comprise the E-flow of 1.5 m^3/s (41% of annual minimum natural flow) plus an input from a small local stream (Gal Kotuwa Ela, Fig 2); - Monsoon: E-flow will be augmented by overspill from the reservoir and increased flow in Gal Kotuwa Ela, so flow will be higher, but still less than the normal flow;
Downstream of tailrace outfall	- Monsoon: Similar flow to normal as water will be discharged from the Moragolla and Kotmale tailraces for 15-19 hours a day and there will also be flood-season inputs from Atabage Oya and other tributaries; - Dry season: reduced flows in the upper region as Moragolla and Kotmale tailraces will only discharge for 4-6 hours per day so for 18-20 hours river flow will comprise Moragolla E-flow, plus dry-season inputs from tributaries, of which there are only three in the first 8 km (Fig 33).

372. This shows that the main differences in flow will occur in the area between the dam and the tailrace outfall, where flows will be reduced in all seasons and especially in the dry season (December to April), when discharges via E-flow and the one local stream will comprise around 50% of the natural minimum flow. This should however have no significant impact on the river users in this area because:

- The E-flow has been designed to ensure that there is sufficient water for the needs of the Dunhinda canal and the Crysbro intake and CEB will refurbish and adjust the intake structures if necessary to ensure this flow is captured at all times;
- There are currently no other river uses in this area.

373. This analysis also shows that downstream of the tailrace outfall, river flows will be similar to normal in the monsoon, but reduced in the dry season, at least in the upper part of this area. This is because at this time there will be no discharge from the Moragolla and Kotmale tailraces for 18-20 hours each day, and there will be little augmentation of the Moragolla E-flow by inputs from tributaries as there are only three in the first 8 km (Angammana Oya, Pallewela Ela and Kaudupitiya Ela). Figure 33 shows that beyond Kaudupitiya Ela there are 14 more tributaries in the next 10 km to Peradeniya Bridge, so augmentation by natural inflow should return the river to its normal flow regime in this area.

374. The offtakes for the two water supply schemes are both located in the downstream end of this river reach, where there should be no change in river flow, so there will be no impact on these schemes. There should also be no major impact on the sand mining or washing/bathing activities, because even in the area where there could be reductions in flow, there will still be sufficient water available for these purposes. Furthermore, if flow and water volume are reduced, it might make sand mining slightly less strenuous for the divers if the river bed is easier to reach.

375. During normal operations of hydropower plants, the safety of downstream river users is generally only an issue with respect to the sudden increases in flow and volume that occur when the plant begins operations after a period of shut-down, when people who are in the river may be caught unawares. This is less of an issue for stations that are operated on a peaking basis, as these changes occur on a daily basis, so river users are far more attuned to their

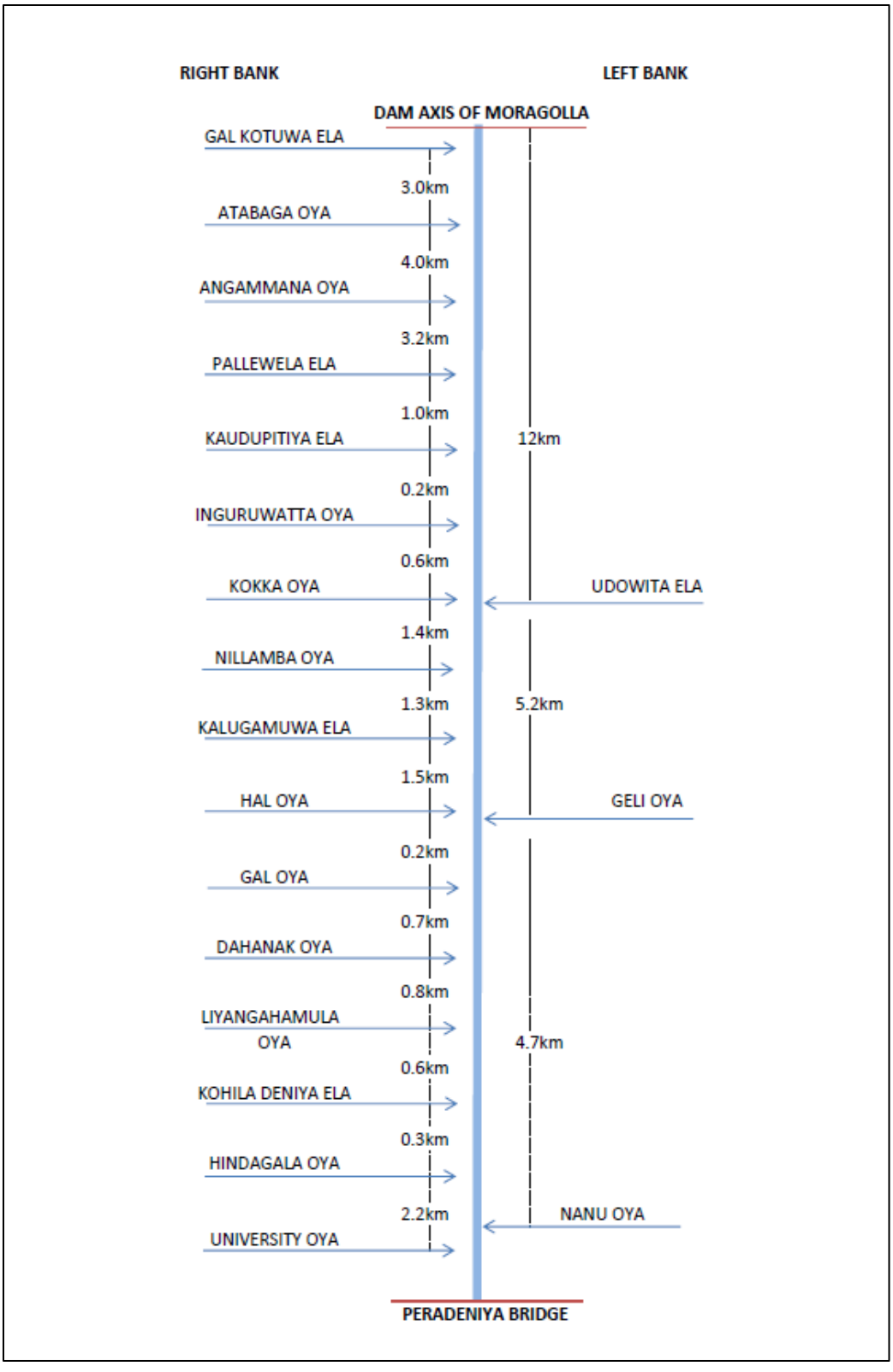

Figure 33: Confluences of the Mahaweli Ganga from Moragolla Dam site to Peradeniya Bridge

occurrence, even without the warning systems that have become a feature of modern schemes. CEB already has plans to ensure the safety of river users in the downstream area, which are mentioned in the Additional Study Report on this issue. These comprise:

- Information programmes via mass media to raise public awareness of the potential changes in water level and when they are likely to occur; and
- Establishment of a system of sirens to warn local people when the combined discharge from the Moragolla and Kotmale tailraces will exceed 110 m^3/s.

376. The only revisions to this, which are proposed on the basis of the analysis above, are to:

- Establish the system of warning sirens between the Moragolla Dam and the Kaudupitiya Ela 11.2 km downstream, to ensure that the area in which there could be significant changes in flow rate and water level is fully protected; and
- Consider modifying the operation of the sirens to provide a warning each time that flow from the tailraces is about to resume (on a daily basis) after a period of no flow.

3. Safety under extreme conditions

377. The issue of dam safety and the likelihood of the dam failing were examined in both the Feasibility Study in 2009 and the FS Review and Detailed Design Study in 2013 and the results were discussed in Section IV.G.2 above. These were independent analyses conducted by different experts and they both came to the same conclusion: that there is no possibility of the Moragolla Dam failing. The re-examination in 2013 (see the expert report in Volume 4) pointed out that the very few failures of concrete gravity dams occurred in the early part of the last century, and that since 1930 a total of 2,500 such dams have been built worldwide, in a wide variety of different situations and circumstances, and none has failed.

378. Nevertheless the consequences of dam failure were examined, and as explained in Section IV.G.2 above, this considered the worst case scenario of a 1-in-10,000 year flood and a complete dam failure, allowing a sudden flow of an estimated 13,300 m^3/s downstream. The hydrological predictions of this event suggest that it would raise water levels by around 20 m in Gampola (to 488 masl) and 22 m at Peradeniya (to 482 masl). These flood levels and the areas inundated are shown in Figure 20 above.

379. This indicates that a great deal of land and property would be flooded by such large increases in water level, and there is a risk that quite large numbers of people could be killed. The force of the cascading water would scour river valleys, carrying rocks and boulders downstream, causing further destruction from physical contact with the material and when it comes to rest. Houses, businesses, schools, hospitals, and their occupants and contents would be at risk, along with crops, infrastructure, food and water supplies, wildlife, etc. Figure 20 shows just two areas to illustrate the scale of the event, and this would be repeated in other parts of the flood zone, between these locations and downstream. The flood would gradually dissipate with distance downstream as the water is absorbed by the many river valleys, floodplains and reservoirs in the upper Mahaweli watershed. The downstream reaches contain some heavily populated areas, in particular around Kandy (30 km from Moragolla) and if floodwater reached this area it could increase the death toll and economic costs significantly.

380. This is however a hypothetical scenario, which will not happen. Firstly the strongly held expert view is that the dam will not fail; and secondly a concrete dam would not fail suddenly and completely in the manner assumed above. There would be prior indications, such as seepage, or indications from the dam structure that would be detected in the multitude of tests and inspections that are carried out routinely in relation to an operating dam. Even this is extremely unlikely to happen, but if it did, there would be ample opportunity for CEB to take emergency action, such as informing communities in at-risk areas that they should move to higher ground; and organising full opening of the spillway gates of the five dams downstream to allow as much of the flood to discharge in existing river channels as possible.

381. Precautions that are put in place to deal with dam failure, normally involve the following:

- Emergency response procedures, in the form of a Disaster Preparedness Plan (DPP) or similar manual, containing detailed instructions of activities and responsibilities, all designed to produce timely appropriate action that will minimise the loss of life, damage to property and other consequences outlined above;
- An emergency warning system to rapidly convey messages to all responsible persons and to the general public in key at-risk areas so that they can take actions ascribed to them in the DPP to protect themselves and their families and communities;
- Regular training of all parties regarding their actions and responsibilities; and regular review and updating of the plan by appropriate experts.

382. CEB should therefore engage consultants to establish these and any other necessary elements of an appropriate emergency response procedure. This should however be appropriate to the level of risk involved, which is very small. There should therefore not be frequent practice sessions involving the general public, which would spread unnecessary and unwarranted alarm. Rather, regular training should be given to key individuals who would be responsible for organising appropriate action in their communities as and when needed. Extensive training should also be given to the CEB management team who would be responsible for coordinating the response.

VII. INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION

Additional Table 30(a) for Addendum: Information Disclosure, Consultation and participation

Description	Local EIA (2012)	Environmental Addendum (2013)
A – Consultation & disclosure during Local EIA Study	• Volume 5 Appendix A; Metings and awareness programs.	-
B – Consultation & Disclosure during Environmental addendum Study	-	Minutes of the consultation meetings are in Vol.4 Report 6

A. Consultation and disclosure during Local EIA study

1. Meetings and awareness programmes

383. Public consultation meetings and awareness programmes were conducted by the Feasibility Study (FS) consultant (CECB)[37] and the Ceylon Electricity Board during Local EIA preparation in 2009 -2012. The main objectives of the consultation were to disseminate the information about the project and the potential environmental impacts to a border spectrum of the stakeholders. The results are shown in Table 30 below:

Table 30: Stakeholder consultation by CEB and the Local EIA consultant

Forms of Contact and Participants	Summary of Discussions
1. Consultation meetings and awareness programmes	
• Awareness programme for stakeholder government agencies held in June 04, 2009 at Kotmale Holiday Resort. 30 government officers participated. • Awareness programme for the Farmer Organisations of "Dunhinda Ela" irrigation scheme held on May 08, 2012 at Maligapurana Temple, Gampola. 27 representatives of three farmer organisations participated. • Awareness programme organised for the members of Community-Based Organisations (CBO) held on October 18, 2012 at Auditorium of Ganga IhalaKorale Divisional Secretariat Office. 26 members of various CBO were participated • Consultative meeting with the Management of Farm's Pride (Pvt) Ltd; Crysbro Processing Plant held on August 21, 2012 at the Factory premises. (No of participants: 5) • Consultative meeting with the Management of Farm's Pride (Pvt) Ltd.,Crysbro Processing Plant held on	• The issues relevant to "Dunhinda Ela" irrigation scheme; potential reduction of water for the cultivation of paddy land during construction period and operation period of the project, and the water quality impacts due to effluent discharge from the poultry processing farm were the main points discussed at the above meetings. • It is also pointed out that the lands cultivated under the irrigation scheme belong to the "Dalada Maligawa" - Temple of Tooth, Kandy. The farmers inherited the lands, which they have cultivated for generations; and they pay tax bi-annually to the Temple of Tooth for their hereditary land. Even if they are unable to cultivate, taxes need to be paid to Dalada Maligawa"and it is requested that CEB inform the Tax Officer about the project and possible problems the farmers will face during construction and find an amicable solution. • During the discussions the CEB ensured an un-interrupted supply of water for the irrigation scheme,

[37]Central Engineering Consultancy Bureau – consultant who carried out the feasibility studies including EIA during 2009-20012.

September 21, 2012: at the Office of Farm's Pride (Pvt) Ltd. at Jayamalapura (No of participants : 6)	while taking appropriate action to rehabilitate the intake structure and the canal section traversing through CEB premises, which is now in dilapidated condition. • Mitigation measures proposed for the effluent discharged by Crysbro Processing Plant is to relocate the discharge point to downstream of the tail race outlet so that required dilution could be achieved.
2. Meetings with representatives of key stakeholder agencies during socio-economic survey	
Divisional Secretary of Udapalatha and Grama Niladaries of the area.	Most of the lands required to be acquired for the project are only having annual permits issued by the MASL. Such land shall also receive fair compensation.
Divisional Secretary of Ganga Ihala Korale.	The proposed project may not create serious negative impacts on the settlements in the division because the proposed tunnel is an underground construction and also other project interventions will be carried out in non-residential lands. However, project development activities should be implemented in accordance with the recommendations in the Local EIA Report.
National Water Supply & Drainage Board; Officer in charge and the Technical Assistant of the water treatment plant	There are no domestic water supply projects located downstream of the proposed dam which will have impacts due to the proposed project.
Road Development Authority; Executive Engineer of Pilimathalawa office	The road section which will be inundated in the right side of Mahaweli River shall properly be relocated without causing any nuisance to the road uses.
Department of Agrarian Services; Divisional Officer of Ganga Ihala Korele office	Agriculture in Gampola-Raja Ela irrigation scheme is also equally important as the power generation. Therefore, the Dunhinda Ela irrigation canal which is located downstream of proposed dam should be provided with adequate water to deliver to the Gampola-Raja Ela Irrigation scheme.
3. Group discussions with affected communities during socio-economic surveys	
Sand miners in the project area	It is mentioned that they have been involved in sand mining in the river at different locations for a long period of time. The labourers working in sand mining sites are from local communities. It is requested that the labourers who will lose their jobs be given employment in the project.
Affected Persons living in the reservoir area	• Most of the affected people are the same people who were once evacuated from Kotmale area due to Kotmale power project. Once again they will face the same fate. However, are ready to be relocated if they are given suitable alternative places and other assistance to re-establish their settlements. • Proper compensation shall be paid to the land and affected property.. • All potentially vulnerable houses must be evacuated from the area upstream of the reservoir although the houses will not be inundated. • It is agreed that a proper and fair compensation mechanism will be provided through the resettlement planning process.
Community members affected due to access roads (Ethgala to Powerhouse and other access roads)	• Expansion of roads will be a benefit to the community from the project. However, there will be some negative impacts due to acquisition of land and demolition of structures such as boundary walls, fences, gates etc. • There will be disturbances to the local road users during the construction phase of the roads. • It is expected that the CEB will properly control the

	Construction Contractors and manage the construction sites in such a way so as to minimize the possible disturbances to the local communities.
Business people from Ulapane Industrial Estate	• Industrial Estate is not yet fully occupied. Major portion of the land allocated for industries have not yet been established. • Water scarcity is a significant problem in the area since the ground water table is very deep. There are also no surface water sources to tap easily. The only negative impact perceived is potential disturbance to the limited ground water due to construction activities during underground tunnelling works of the project.
People who use the river for washing and bathing	• Water in the river is good for bathing and washing. Only three locations upstream and one location downstream of the proposed dam are used for bathing. The locations are the only places that can be reached with no serious access difficulties. Most of other locations of the river within the project area cannot be reached due to its steep river bed posing serious access difficulties. It is requested to establish alternative locations for bathing and washing and construct concrete steps to create safer access to these bathing spots. • It is agreed that alternative locations for bathing be established by the project.

2. Correspondence with government stakeholders

384. The correspondence made with government organisations during Local EIA preparation period by CEB and CECB are summarised below.

Table 31: Correspondence by CEB and the Local EIA consultant with government stakeholders

Organisation	Summary of Discussions
National water Supply and Drainage Board	Approval for MHPP is granted subject to the conditions of the Memorandum of Understanding signed between NWS&DB and CEB
Engineer in Charge, Kothmale, MASL	The existing quarry has only a IML-C category licence, and hence only a very small quantity of rubble can be extracted. If CEB intend to adopt large scale blasting, an Local EIA is essential. Transport of material across the existing Kotmale dam is not allowed.
Road Development Authority, RDA	Grant consent for MHPP subject to several conditions.
Irrigation Department (ID)	Conditions of consent : 1. No impact shall be caused to the command area of “Raja Ela” irrigation scheme. High Flood Level (HFL) of the reservoir shall be below the anicut and the irrigation scheme. 2. The water requirement for Dunhinda anicut ,which is located below the proposed reservoir, shall not be reduced. The power generation intake shall be designed in order to allow release of a minimum of 10 cusecs to the irrigation canal. A Memorandum of Understanding shall be signed between ID and CEB .If CEB decide to transfer the hydropower scheme to a third party, the ownership of the plant and the reservoir shall be transferred to CEB. 3. If water shortage is experienced during the dry season, priority shall be given to providing sufficient water for the Dunhinda irrigation scheme. 4. Water for the environmental requirements shall also be released in addition to the water needed for irrigation purposes.
Forest Department	No forest reserve or forest plantations are involved in the proposed MHPP and hence no objection regarding the implementation of MHPP.

Geological Surveys and Mines Bureau	The proposed quarry site has been operated to supply rock material to construct the Kotmale dam. If quarrying activities at the same site are commenced it would adversely affect the surrounding area because soil creeping and earth subsidence have been reported since impoundment of Kotmale reservoir. It is therefore suggested to identify a suitable alternative quarry site to obtain rock material for Moragolla Hydropower Project.
Divisional Secretary, Ganga Ihala Korale	Current development programmes in Ulapane area are as follows: 1. Raja Ela Development 2. Mahawelawatta Land and Housing Project 3. Ethgala New Town Development 4. Ulapane Industrial Zone 5. Kandy South Water Supply Scheme As the tunnel of the proposed project traverses beneath the Ulapane Industrial Zone, it is proposed by the DS to have a discussion with the industrialists of the zone regarding their concerns and come to an amicable solution. The following mitigatory measures to minimise the potential environmental impacts are proposed: • Proper compensation shall be paid for the loss of land and property. • Any damage caused to Dunhinda Ela irrigation scheme shall be rehabilitated • Any impact on Ulapane Industrial zone shall be rectified.
Divisional Secretary, Udapalatha,	There are no development programmes in the project area. Consent for MHPP is grant subject to the following conditions: • Proper resettlement of affected persons • Develop and implement a forestry programme. • Minimise the public nuisance caused due to dust, noise and vibration • Minimise soil erosion, water pollution and air pollution Proposed the following mitigation measures: - Provide alternative lands for the people who are living in the proposed reservoir area as the lands are either privately owned or colony lands. - Provide alternative lands for the people impacted due to the construction of proposed alternative roads. - Alternative roads shall be constructed without causing any environmental problems. - Sufficient water to sustain the river system shall be released to the river stretch between the dam and the power house.
Urban Development Authority (UDA)	The proposed project site does not fall within the area declared under the Urban Development Authority Act.
Board of Investment (BOI) of Sri Lanka	The BOI has granted an approval for M/S Farm's Pride (Pvt) Ltd to establish a Broiler Processing Plant at Davidson Estate Ethgala, Gampola.
Regional Director, Regional Industry Service Centre – Central Province	1. Proposed industries to be established with the industrial zone are as follows: • Diva Plastic Ltd – Polythene and Plastic • Fermtech Co. – Wooden frames • Jayalanka Furniture – MDF and steel furniture • Tharindu Products – Fruit drinks 2. No waste water discharge from the industrial zone. Solid waste is collected and disposed of through Ganga IhalaPradeshiya Sabah. 3. The only rain water is discharged into storm water drainage system. 4. An IEE report for Ulapane Industrial Zone is being prepared. It is authorised by MASL to discharge industrial wastewater which conforms to MASL norms within 60m from river bank
Chairman, Farm's Pride (Pvt.) Ltd	400,000 litres of water is required per day at present and we may need max of 1,000,000 litres per day for expansion of production in the future. The water used for the production facility is discharged to the river after treatment as per CEA specification.
Chief Engineer, Kotmale Power Project	The identified lands in four blocks (total area ~5ha) can be used for the disposal of spoil material.
Resident Project Manager, Victoria /Kotmale Project,	Request CEB to prepare a survey plan of the proposed land for spoil disposal in order to obtain the consent of the physical planning committee of MASL and submit the same for the approval of Director General of MASL
Chairman, Ganga IhalaKorale Pradeshiya Sabha (PS) – Kurunduwatte Bazaar	Grant the approval of PS

3. Public disclosure

385. The Local EIA report prepared by the EIA consultants (Central Engineering Consultancy Bureau and Al-Habshi Consultants Office, Kuwait) based on the Terms of Reference (ToR) issued by the Project Approving Agency (PAA), Mahaweli Authority of Sri Lanka, was opened for public comments on April 01, 2013 for a period of 30 working days, as required by the NEA. The Local EIA report was made available in the following locations in Sinhala, Tamil and English languages for the inspection by the public:

- Divisional Secretariat Office, Udapalatha
- Divisional Secretariat Office, Ganga IhalaKorale
- Engineer-In-Charge Office, Head Works Administration, Operation and Maintenance Division, MASL, Riverside, Mawathura
- Library, Central Environmental Authority, 104, DenzilKobbekaduwaMawatha, Battaramulla
- PradeshiyaSabha Office, Udapalatha
- PradeshiyaSabha Office, Ganga IhalaKorale
- Central Environmental Authority, Regional Office, Dam Site, Polgolla
- Library, 6th Floor, MASL, 500, T B Jaya Mawatha, Colombo 10

386. Newspaper advertisements were published by the PAA, in Dinamina (Sinhala),Thinakaran (Tamil) and Daily News (English) on April 01, 2013 inviting the general public to submit their comments (if any) in writing on the project to the Director General of MASL. The thirty day public commenting period ended on May 15, 2013. No comments were received from the affected parties, the general public, or any stakeholder agencies.

B. Consultation and disclosure during Environmental Addendum study

1. 1st multi-stakeholder meeting

387. A formal consultation meeting was held at the Sri Gangarama Temple at Weliganga to create awareness about the Moragolla Hydropower Project and to stimulate discussion on the environmental impacts of the project among the local people and other relevant stakeholders. A total of 117 stakeholders attended the meeting. The Project Manager (PM) of the Moragolla Hydropower Project gave a comprehensive account on the project using a PowerPoint presentation. He specially mentioned that the project has been planned in such a manner that it will not pose any threat to the environment. He also stated that the Project will bring about enormous benefits to the nation. Speaking on the entitlements of the affected people, the PM said that every effort will be made to safeguard these. In preparation of the Resettlement Plan (RP), the views and observations of the affected people and other stakeholders will be entertained as appropriate, he added.

388. During the subsequent discussion session the stakeholders raised several questions to obtain clarifications from the project team. Their opinion on the anticipated impacts and possible mitigation measures were also discussed. Questions and issues raised by the participants and the clarifications made are shown in Table 32.

Table 32: Summary of discussions at stakeholder consultation meeting - 24 January 2013

Question/Comment	CEB Response
Would there be a 100 metre security zone on either side of the river coming within the proposed reservoir	The river reservation of the Mahaweli River differs from place to place depending on certain factors
It is learnt that the location of the proposed dam has now been changed and it would be located 50 metres downstream. With this change will the height of the Dam be raised	There is a possibility of moving the Dam by nearly 100 metres further downstream. Therefore height of the Dam may be changed by a few feet. However full supply level (FSL) will not be changed and hence there will be no significant change in the inundation area.
What is the method of resettlement of affected households and payment of compensation in respect of acquired properties?	Provision of alternative buildings in lieu of affected houses and business establishments is being considered. Payment of compensation in respect of land and other structures will be made to bona fide claimants. An entitlement package will be introduced shortly.
At present I am running a business. If that is affected what action would be taken to restore the loss.	After a census survey and establishment of the ownership, either an alternative place will be provided or compensation will be paid depending on the circumstances.
If the Project is going to take some action against discharge of harmful effluents to the river by the Crysbro poultry farm	This issue is not directly relevant to the Project. However, the Project will discuss this matter with the management of the poultry farm and suitable action will be initiated.
In allocating alternative houses in lieu of those are to be affected, are there any arrangements to provide alternative lands in similar extents in lieu of those to be acquired along with the houses	There is no firm decision as yet whether to provide alternative lands in lieu of those are to be affected. However, action will be initiated to secure the rights of the affected people to the maximum. Development of an Entitlement Policy is underway.
Whether the same type of alternative houses will be provided to all affected households, in lieu of those affected.	Basis for the provision of alternative houses will be the floor areas of the affected houses. Therefore sizes of the alternative houses will depend on the floor areas of the existing houses.
Whether the alternative lands will be provided in lieu of the tea lands to be affected.	Development of an Entitlement Policy is underway. In developing the Entitlement Policy this request will also be taken into consideration.
Due to the construction work of the Moragolla Project I will stand to lose my land. What action would be taken by the Project to restore the loss.	All affected assets other than those that will be replaced by the Project, will be adequately and suitably compensated.
Whether future meetings of this nature could be held on week end days.	Some of the stakeholders such as public officers may not be willing to attend meetings on week end days due to different reasons. However, in future, attempts will be made to hold the meetings on week end days.
Due to the implementation of the Moragolla Hydropower Project the sand miners along the Mahaweli River, within the project area, will stand to lose their livelihood. What action will be taken by the Project to restore their livelihood?	Project has already collected information on the sand miners to be affected within the project area. The Project will implement an income restoration/enhancement programme covering all genuine sand mining people.

2. 2nd multi-stakeholder meeting

389. The second stakeholder consultation meeting was held on November 18, 2013 at the Sri Gangarama Temple at Weliganga to appraise the affected people and other concern parties about the additional studies carried out on natural environment during the Feasibility Study Review and Detail Design Preparation (FSR &DD) stage of the Moragolla Hydropower Project (MHPP) and to introduce the Entitlement Matrix to the affected people. A total of 128 stakeholders attended the meeting. The meeting was commenced with religious observance performed by Ven. Kotikawatte Vipassi Thera.

390. After the welcome address, by the CEB engineers, the Project Manager (PM) of the Moragolla Hydropower Project presented the design changes incorporated into the MHPP during FSR process. Subsequently, the National Environmental Specialist of the FSR and DD team gave a comprehensive account on potential Environment Impacts of the project, proposed measures to mitigate of minimise such impacts and the Environmental Impact Assessment procedure followed by the Ceylon Electricity Board during 2009-2012. He further mentioned that the Local EIA report of the project was opened for public comments in April 2013 for a period of one month and approval obtained from the Project Approving Agency (ie., Mahaweli Authority of Sri Lanka – MASL). Since CEB intend to obtain financial assistance from Asian Development Bank (ADB) for the implementation of the project, a gap analysis based on the environmental safeguard requirements of ADB followed by the following additional studies were carried out during December 2012 – May 2013 to bridge the gaps.

391. During the subsequent discussion session the stakeholders raised several questions to obtain clarifications from the project team. Their opinion on the anticipated impacts and possible mitigation measures were also discussed. Questions raised and suggestions given by the participants and the clarifications made by the project team are as follows

Table 33: Summary of discussions at stakeholder meeting on 18 November 2013

Question / Suggestion	Response Given
Can the Dunhinda Ela be rehabilitated by the project as it is in a dilapidated condition?	Yes, it is taken a decision to rehabilitate 400m of the canal from the intake point.
All employment opportunities shall be provided to the people of the area.	Priority will be given to the affected people and the people of the area depending on their qualifications and capabilities.
The land which will be given to affected people shall be equal or better quality and the land shall be properly developed before handing over to the recipients.	Once the financial arrangements of the project are finalised, the resettlement land will be purchased and handover to the APs.
Who will be affected in Weliganga area?	The 10 households identified in the Weliganga area to be relocated are as follows: M A N Sarath Kumara, L R M karunawathi, M A Aberatne, M G Pushpa Gunatunga, P G R R Parakramage, M G gnnaappu, P G K P Parakramage A N M Naazik, Y G Thilakaratne and N G Prematunga
Have the lands which will be inundated are gazetted	Not yet, it will be done after the project finances are finalised
Can we opt for compensation in cash.	Yes, it is possible. But, it will be more beneficial to the affected people accept the land and the house instead of cash compensation as it can take longer period to finalise the legal procedures under land acquisition laws of the country and it is necessary to prove proper ownership to obtain proper compensation. However, the legal ownership will not be considered according to the compensation payment policy of the project.
Who will be affected in Ulapane area?	The 5 households identified in the Ulapane area to be relocated are as follows: S Krishnamoorthi, T L Ranjith Liyanage, M L Danials, W M Indika weerasinghe and R M Sumanadasa
Who will be affected in Ehgala area?	Two households identified in the Ethgala area to be relocated are as follows: H M Fransis and K N S Chandakanthi,

3. 3rd multi-stakeholder meeting

392. A multi-stakeholder meeting will be held immediately after the Environmental Addendum and Environmental Management Plan are prepared, on 27 December 2013. The reports in Sinhala, Tamil and English languages will be disclosed to the participants. The salient features of the environmental mitigation and management plans along with monitoring mechanisms will be explained to the local people and other relevant stakeholders and a discussion on the environmental impacts and proposed mitigation measures will be simulated.

4. Public disclosure

393. Environmental Addendum and the Environmental Management Plan will be posted on websites of ADB and CEB. They will be made available in Sinhala, Tamil and English languages for the inspection by the public at the same locations where the Local EIA report was made available for public inspection in April 2013 (see Section VI.A.3 above).

394. Newspaper advertisements will be published, in *Dinamina* (Sinhala),*Thinakaran* (Tamil) and Daily News (English) papers inviting the general public to submit their comments (if any) in writing on the Environmental Addendum and the EMP to the Project Manager of MHPP of CEB.

C. Future consultation and disclosure

395. CEB will continue to consult with relevant stakeholders throughout the life cycle of the Project i.e. pre-construction (from now until construction contract is offered), construction and operation phases of the Project. It will also report ongoing consultations as part of its regular reporting requirements to ADB. In addition, monthly environmental monitoring reports will be posted on the websites of ADB and CEB for the information of wider stakeholders.

396. Consultation during construction will be more focussed on information on safety, community development programs, environmental monitoring, employment issues, and health awareness which will include:

- Maintain regular communications with all stakeholders, including the media
- Provide local residents with regular information on the progress of work and related implications
- Provide local residents with information on employment and training opportunities
- Maintain awareness of health and safety issues specially through the local work force
- Maintain constructive relationships between local residents and project representatives by continuing regular information meetings and informal interactions
- Identify and respond to new stakeholder issues and concerns by reviewing the complaints file and listening to stakeholders
- Ensure complaints are addressed according to the established process, and that project affected persons are educated on appropriate grievance redress procedures
- Monitor implementation and effectiveness of community development initiatives, and other investment programs
- Ensure gender sensitive and culturally appropriate processes are used in communication and interactions

GRIEVANCE REDRESS MECHANISM

A. Rationale

397. Construction activities of hydropower projects, especially where Involuntary Resettlement is involved, might give rise to grievances among Affected Persons (APs), however much the potential sources of conflict have been addressed in Environmental Management Plans and Resettlement Plans and Policies. Grievances may be related to social issues such as eligibility criteria and entitlements, location of resettlement sites, quality of services at those sites, allocation of houses, livelihoods and social and cultural issues, etc. Grievances may also be related to environmental issues such as dust generated due to clearing and grubbing works, vibration and damages to structures, noise, traffic congestion, decrease in water level and water pollution in private and public wells due to blasting and tunnelling, damage to tea plantations and agricultural lands, etc.

398. Social grievances occur mostly at the time of implementation of the Resettlement Action Plan; and complaints on environmental issues and public nuisances generally occur during the construction period. Both types of grievances are different in nature. However, it is imperative to have a mechanism in place to examine each and find solutions in a transparent manner, to demonstrate to the people that their grievances are examined carefully. A Grievance Redress Mechanism (GRM) is essential for smooth implementation of the project. The main objective of establishing a GRM is to resolve problems in an efficient, timely and cost-effective manner in a cordial environment with the participation of all stakeholders including affected parties.

399. It is preferable to resolve the grievances and disputes at the community level and as and when they occur. Donor agencies are inevitably highly concerned about the grievance redress and dispute resolution mechanisms in the implementation of development projects. The GRM should be able to provide benefits to both the project and affected parties by setting up the following objectives:

- Provide a forum for redressing grievance and disputes at the lowest feasible level;
- To create effective communication between the project and affected parties;
- To build up productive relationships among the stakeholders including affected parties;
- Provide access to allow affected parties to negotiate and influence the decisions and policies of the project which might adversely affect them;
- Mitigate or prevent adverse impacts of the project on the environment and produce appropriate corrective or preventive action;
- To harmonize both project and affected parties' activities.

B. Complaints Management

400. All complaints regarding environmental issues are usually received either orally or in writing by the Project Proponent (PP) or the Construction Contractor (CC). A key part of the GRM is the requirement for the PP /CC to maintain a registry of complaints received at the respective project site offices. A sample complains registry is provided in the EMP (Volume 2).

401. All complainants shall be treated respectfully, politely and with sensitivity. Every possible effort should be made by the PP or the CC to resolve the issues referred to in the complaint within their purview. However, there may be certain problems that are more complex and cannot

be solved through project-level mechanisms. Such grievances will be referred to the Grievance Redress Committee (GRC, see below).

402. The proposed complaint handling and Grievance Redress Mechanism for the Moragolla project is illustrated in Figure 34.

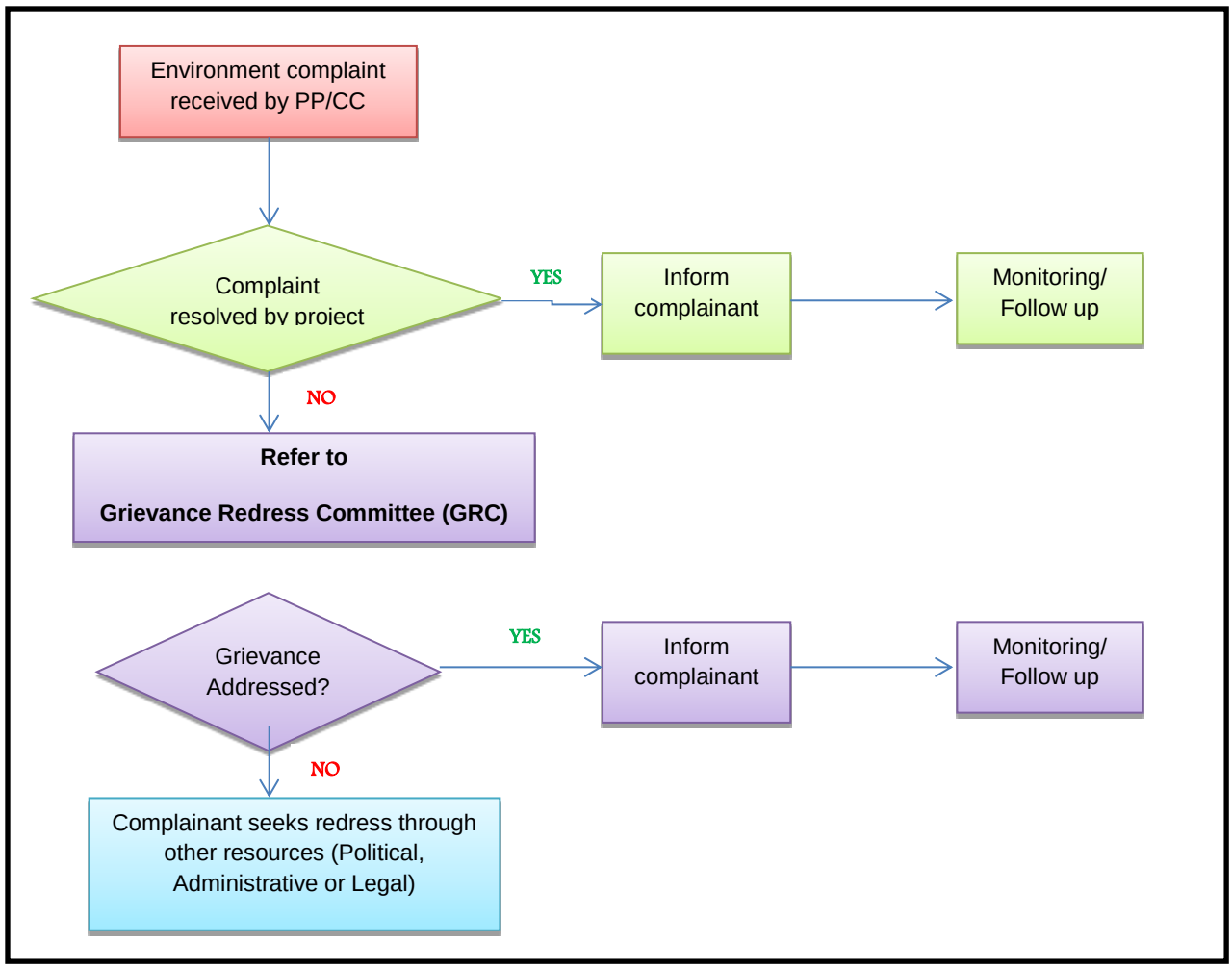

Fig. 34: Complaint handling and Grievance Redress Mechanism (PP= Project Proponent (Ceylon Electricity Board); CC= Construction Contractor)

C. Grievance Redress Committee (GRC)

403. The Moragolla Hydropower Project, in keeping with the ADB and national safeguard policies, will set up a Grievance Redress Committee (GRC), which will function as an independent body to find solutions to grievances and disputes among the affected and concerned parties.

404. The appointment of the GRC will be notified to the general public by publication of a notice in national newspapers in three languages ie., Sinhala, Tamil and English. The local

community will also be informed about the grievance handling procedures of the project through Grama Niladharis[38]of the area and displaying notices at important public places within the Divisional Secretariat Divisions of Udapalatha and Ganga Ihala Korale.

D. Institutional Arrangements for GRM

405. The Additional District Secretary of the Kandy District will function as the Chairperson of the GRC. Members to represent the Affected Persons (AP) at the GRC will be appointed from among respected persons[39]in the area on the recommendations of the Divisional Secretaries of Udapalatha and Ganga Ihal Korale. Other members of the GRC shall be the Project Director (PD) of the PMO, a senior representative of the Design and Supervision Consultant and representative(s) of the Contractor(s). An officer nominated by the Project Director of the MHPP will serve as the Secretary to the GRC. An honorarium will be paid to the members of the GRC; the required funds for operation of the GRC will be borne by CEB.

406. A suitable place and other facilities to conduct the meetings of the GRC will be provided by MHPP. However, GRC meetings can also be held at any other suitable location for the convenience of the affected parties (eg. in case of ill health or any other valid reasons).

407. The GRC is expected to meet at least once a month, although more meetings may be held depending on the number of complaints received. The GRC may make field visits where necessary and these will be facilitated by MHPP.

[38]GramaNiladhari (Village leader) is a Sri Lankan public official appointed by the central government to carryout administrative duties in a GramaNiladhari division, which is a subunit of a divisional secretariat. The duties of a GramaNiladhari include the reporting of issuing of permits, gathering statistics, maintaining the voter registry and keeping the peace by settlement of personal disputes. They are responsible for keeping track of any criminal activity in their area and issuing character certificates on behalf of residents when requested.

[39]Such as Senior Citizens; Priest of the Temple, Church or Kovil; Headmaster of school etc.,

APPENDICES

Appendix 1: Gap Analysis - Compliance of the Moragolla HPP Local EIA (2012) with ADB Safeguard Policy Statement (2009)

ADB REQUIREMENT (SPS 2009, Appendix 1 Annex)	EXTENT OF COMPLIANCE	CONCLUSION AND REMEDIAL ACTION
Preamble This outline is part of the Safeguard Requirements1. An environmental assessment report is required for all environment category A and B projects. Its level of detail and comprehensiveness is commensurate with the significance of potential environmental impacts and risks. A typical EIA report contains the following major elements, and an IEE may have a narrower scope depending on the nature of the project. The substantive aspects of this outline will guide the preparation of environmental impact assessment reports, although not necessarily in the order shown.	The Local EIA study was conducted by consultants between February and May 2009 and CEB submitted the draft final report to the Project Approving Agency (PAA), the Mahaweli Authority of Sri Lanka (MASL) in September 2010. The document was then subject to a series of revisions by the Local EIA consultant over the next two years, to address comments from the PAA. Final revisions are currently being completed, after which CEB expects the document to be approved by the PAA for public inspection in late 2012, after which it should be finalised in early 2013. The Local EIA report comprises 230 pages of text, 59 pages of additional Tables, 40 Figures and over 100 pages of additional information in Appendices. It complies with the layout and content prescribed by the Terms of Reference (ToR) for the study (provided by the PAA); and the independent review by this project indicates that the level of detail and content of the report are similar to those of other Category A projects involving Hydropower schemes in Sri Lanka (eg Broadlands Hydropower Project[40]) and in other countries (eg Tanahu (Upper Seti) Hydropower Project in Nepal[41]).	CEB anticipates that the finalised Local EIA report should be approved by the PAA in the near future as complying with the requirements of the Sri Lankan EIA law. It should therefore not require extensive revision to comply with ADB policy. This is confirmed by the Gap Analysis presented below.
A. Executive Summary This section describes concisely the critical facts, significant findings and recommendations.	The Executive Summary follows the same general format as the overall report and summarises the main findings of each section well. It also provides a useful table summarising the main environmental impacts of the project (positive and negative) as described in the report, and the proposed mitigation and enhancement. It also summarises the salient technical features of the project (hydrology and project infrastructure).	The Executive Summary adequately presents the main findings of the Local EIA report in a succinct manner and provides a useful summary table. If any amendments are made to the report during the present study (FS review and DD), or new sections are added, these changes should be reflected in the Executive Summary.
B. Policy, Legal and Administrative Framework This section discusses the national and local	Sections 1.3.2, 1.6, 1.7 and 1.8 of the Local EIA report provide a good picture of the national and local framework for environmental regulation for hydropower projects and the institutions involved. Section 1.3.2 describes the Local EIA	The policy, legal and administrative framework in which the project has been developed and the Local EIA conducted is adequately described. No changes are expected during the timescale of this project, so no amendments or additions should be necessary to

[40] Ceylon Electricity Board/Japan International Cooperation Agency: Study of Hydropower Optimization in Sri Lanka; Final Report; Vol III Appendix II: EIA Report for The Broadlands Hydropower Project (2004)

[41] Nepal Electricity Authority/Tanahu Hydropower Limited/Asian Development Bank: Tanahu (Upper Seti) Hydropower Project: EIA (2009); IEE of Transmission Line (2010); Environmental Management Plan (2012)

ADB REQUIREMENT (SPS 2009, Appendix 1 Annex)	EXTENT OF COMPLIANCE	CONCLUSION AND REMEDIAL ACTION
legal and institutional framework within which the environmental assessment is carried out. It also identifies project-relevant international agreements to which the country is a party.	process in Sri Lanka. Section 1.7 includes a useful update on the status of each of the individual approvals/consents that are required from the state agencies; and Section 1.8 describes conditions imposed by each agency in granting approval, or in their comments on the project. This is supported by copies of all key correspondence in the report Appendices. Sections 1.1 and 1.2 describe the national policy framework within which the decisions to proceed with additional hydropower generation and at this location were taken. Section 1.2 mentions some relevant international agreements, specifically the Clean Development Mechanism (CDM) and the UN Convention on Climate Change.	this part of the report.
C. Description of the Project This section describes the proposed project; its major components; and its geographic, ecological, social and temporal context, including any associated facility required by and for the project (for example access roads, power plants, water supply, quarries and borrow pits, and spoil disposal). It normally includes drawings and maps showing the project's layout and components, the project site, and the project's area of influence.	Section 2.2 contains the description of the project. This begins with a description of the site context (location, land ownership, access routes), followed by a list of the main technical features of each project component (dam and intake; spillway; reservoir; headrace tunnel; surge shaft; penstock and tunnel; powerhouse and tailrace channel; turbines; generators; transformers; power generation; and transmission line). The reservoir inundation area is then described, along with the associated project facilities, including alternative quarry sites and spoil disposal areas, access roads, labour camps, contractor's and engineer's site offices, permanent residential camps, etc. Clear technical drawings are provided of all key components, along with coloured maps of the project site, layout and other features. Site preparation activities, construction methods and the likely workforce are described; and operational/safety factors are considered including: discharge of probable maximum flood; dam safety and the likelihood of failure; and the requirements of an Emergency Action Plan.	The project description covers all of the features specified in the ADB SPS and provides useful additional material, such as descriptions of site preparation activities and the main construction methods. Clear and comprehensive drawings, maps and other illustrations are also provided. If there are no significant changes in the project, no changes in the description will be necessary, apart from checking the accuracy of the information quoted (especially technical details) and correcting if necessary. If however significant changes are introduced during the present study, these will need to be described and appropriate new illustrations provided.
D. Description of the Environment (Baseline Data) This section describes relevant physical, biological and socioeconomic conditions within the study area. It also looks at current and proposed development activities within the project's area of influence, including those not directly connected to the project. It indicates the accuracy, reliability and sources of the data.	Chapter 3 contains the Description of the Existing Environment, which comprises descriptive text, supported by tables in the text and in Annexures 1-6, plus illustrations in an Annex, and reports of specialist surveys conducted by subcontractors (Appendices C and D). The description covers physical and biological environments, and includes the following topics: 1. Physical: topography; geology; land use; hydrology/drainage; hazards and disaster management; water quality; air quality; noise; vibration. 2. Biological: vegetation/habitats; fauna and flora; rare, threatened and endemic species; animal migration;	The description of the existing environment covers most topics that are normally studied in an EIA of a hydropower project. Most descriptions are relevant, understandable and based on data that was current at the time of the Local EIA study and was collected in an appropriate manner. Descriptions are illustrated by generally relevant tables of data, plus maps and other illustrations. Overall the chapter provides an adequate description of existing environmental conditions in the area likely to be affected by the project, and should therefore be a suitable basis on which to evaluate environmental impacts and develop mitigation. Several deficiencies noted by this review do not affect the

ADB REQUIREMENT (SPS 2009, Appendix 1 Annex)	EXTENT OF COMPLIANCE	CONCLUSION AND REMEDIAL ACTION
	environmental issues. 3. Social: population and demographics; river users; income and employment; environmental issues; archaeology and cultural resources; infrastructure; socio-economics; existing and planned projects. Most topics are discussed on the basis of site-specific data collected by new surveys, conducted for the Local EIA study or for the engineering aspects of the project (geology, hydrology). Most descriptions are supported by relevant data and illustrations. A small number of deficiencies were identified by this review, as follows: • Survey methods are not well described (eg ecology). • Some topics are described in technical language, which is difficult for a non-specialist to understand (eg bank full discharge; vegetation and habitats; flora and fauna). • Locations of planned projects in the area are not shown on a map. • There is no clear description of ecology in the river downstream of the proposed dam site, which will be subject to reduced river flow • There is no information on the quality and distribution of groundwater, which will be affected by tunnel construction; and data on the quality of river water should be updated to clarify the extent of faecal pollution from the Crysbro Broiler Plant. • Socio-economic data is mainly based on surveys conducted in 2009 and local government data from 2008 and some features will have changed. There are also discrepancies in some of the data quoted in different sections (eg numbers of sand miners).	assessment of project impacts and mitigation and therefore do not need to be corrected. Those deficiencies that could affect the assessment of impacts will be corrected, by the following action: • Collection of data and preparation of descriptions of existing conditions in: aquatic ecology; groundwater; and river water quality. • Preparation of an updated map of detailed land use (to replace Figure 3.7). • Collection of updated information by a new socio-economic survey (including inventories of houses, land ownership, river users, income and employment, and infrastructure locations) - if feasible this will be combined with a similar data collection exercise related to Resettlement planning. Other baseline data does not need to be updated as features will not have changed significantly in the intervening period and impacts have already been adequately identified and mitigation proposed (see Section E). If the FS review and DD study recommends changes in the locations of any elements of the project (eg spoil disposal or resettlement sites) additional surveys to assess the physical, biological features of the new sites will be conducted.
E. Anticipated Environmental Impacts and Mitigation Measures This section predicts and assesses the project's likely positive and negative direct and indirect impacts to physical, biological, socioeconomic (including occupational health and safety, community health and safety, vulnerable groups and gender issues, and impacts on livelihoods through environmental	Chapter 4 of the Local EIA report discusses the Anticipated Environmental Impacts of the Project and Chapter 5 discusses the Proposed Mitigation Measures. Both accounts cover physical, biological issues and include positive, negative, direct, indirect, temporary and permanent impacts. The main issues discussed are: Physical: soil erosion and siltation; water quality; river discharge capacity; bedrock stability.	The Local EIA report follows the layout and format specified in the ToR, but there are a number of deficiencies in this approach. The main issues are: 1. The impacts of construction and operation are not treated separately, and are instead discussed together in each individual section of the report. This affects the coherence of the account because the impacts of these processes are quite different and occur at different times. 2. Mitigation is then discussed in a separate chapter, which causes

ADB REQUIREMENT (SPS 2009, Appendix 1 Annex)	EXTENT OF COMPLIANCE	CONCLUSION AND REMEDIAL ACTION
media), and physical cultural resources in the project's area of influence, in quantitative terms to the extent possible; identifies mitigation measures and any residual negative impacts that cannot be mitigated; explores opportunities for enhancement; identifies and estimates the extent and quality of available data, key data gaps, and uncertainties associated with predictions and specifies topics that do not require further attention; and examines global, trans-boundary and cumulative impacts as appropriate.	Biological: terrestrial fauna and flora; aquatic fauna and flora including fish migration and environmental flow. Social: water users; land use; commercial activities; noise, vibration and dust; water abstraction (drinking water, irrigation); resettlement. Impacts are quantified to the extent possible and certain enhancements are proposed, eg afforestation of hill-slopes and landscaping spoil disposal areas.	a lot of unnecessary repetition, as impacts are re-described in the mitigation chapter (often using the same text as in the impacts chapter) before mitigation is proposed. 3. Issues are discussed under different headings in the two chapters, and often in a quite different order, which leads to further confusion. Because of these and other deficiencies, the account of the impacts and mitigation in the Local EIA is unclear, incoherent and difficult to understand. A somewhat better understanding can be gained by reading about each issue separately, first in Chapter 4 (impacts) and then in Chapter 5 (mitigation), and referring also to the impacts table in the Executive Summary. This reveals some of the logic of the assessment of impacts and the derivation of mitigation, and suggests that, despite the issues of presentation, the consultant has correctly identified most potential impacts of both construction and operation of the project and proposed generally appropriate mitigation. At this stage the only significant issues that appear to have been omitted or inadequately treated are: • Impacts of tunnel construction on the availability of groundwater and impacts of tunnel dewatering on water quality in the river. • Water quality in the reservoir and downstream during initial impoundment and later scheme operation, and impacts on aquatic ecology; and adequacy of the proposed environmental flow. • Impacts of access roads on privately owned structures and local cultural sites, and the potential for amending routes to avoid impacts ADB policy does not specify a particular approach to the discussion of impacts and mitigation and does not advocate dealing with construction and operation separately or discussing impacts and mitigation together. This review by the present study indicates that the Local EIA reaches appropriate conclusions and recommends suitable mitigation, so an extensive revision is not necessary. The work will be reviewed again to produce a comprehensive table of impacts and mitigation, which is the starting point for development of an Environmental Management Plan (see Item I below). This will incorporate and explain any changes in the impacts or mitigation that may result from the

ADB REQUIREMENT (SPS 2009, Appendix 1 Annex)	EXTENT OF COMPLIANCE	CONCLUSION AND REMEDIAL ACTION
		further review and re-assessment, or from any major changes in the project proposed by the FS Review and DD study.
F. Analysis of Alternatives This section examines alternatives to the proposed project site, technology, design and operation - including the no project alternative - in terms of their potential environmental impacts; the feasibility of mitigating these impacts; their capital and recurrent costs; their suitability under local conditions; and their institutional, training and monitoring requirements. It also states the basis for selecting the particular project design proposed and justifies recommended emission levels and approaches to pollution prevention and abatement.	Section 1.1 of the Local EIA report describes the process through which the Moragolla site was identified as suitable for hydropower generation, and the subsequent studies through which the project was developed over several decades. The Feasibility Study investigated three alternative locations for the dam, which also involved different dam heights, lengths of headrace tunnel, and other scheme variations. Section 2.1 describes the features of each alternative and the no project option, and discusses their main environmental impacts, ease of mitigation and other aspects, including capital costs. Table 2.1 compares the two most likely alternatives, which shows a clear preference for the chosen alternative (Alternative 2) on grounds of capital cost and environmental impacts. Section 2.1.4 summarises the rationale for selecting the preferred option. Section 2.1.3 “Mitigation through Planning and Design” gives a good account of how certain features of the preferred option were adjusted to minimise impacts further, including lowering the reservoir Full Supply Level to reduce inundation area and mitigation costs, realigning the headrace tunnel to allay fears of blasting effects in the Ulapane Industrial Estate, and selecting the outlet portal location to preserve the function of the Dunhida Irrigation Canal.	No amendment to the Analysis of Alternatives is necessary, unless new alternatives are introduced during the FS review and DD study, or if the review suggests that a different alternative is now preferred. If this is the case the environmental implications of the alternatives will need to be re-examined and the results will be input into the re-selection process.
G. Information Disclosure, Consultation and Participation This section: (i) describes the process undertaken during project design and preparation for engaging stakeholders, including information disclosure and consultation with affected people and other stakeholders; (ii) summarizes comments and concerns received from affected people and other stakeholders and how these comments have been addressed in project design and mitigation measures, with special attention paid to the needs and concerns of vulnerable groups, including women, the poor and	The text of the Local EIA report does not contain a section describing information disclosure, consultation and participation, and provides no evidence of an organised process of stakeholder involvement in the project. Such a process was conducted however, as is evident from discussions with CEB and information provided in the annexes and appendices to the Local EIA report. This involved: <u>1. Contacts made by the EIA team in the course of socio-economic survey work:</u> a) Focus group discussions with representatives of key stakeholder organisations (summarised in Local EIA report Annexure 1 Item (i)). b) Group discussions with communities likely to be affected by the project (summarised in Annexure 1 Items (ii), (iii), (iv), (v) and (vi)).	A process of information disclosure, consultation and stakeholder participation has been conducted, involving contact with institutional and local stakeholder organisations and individuals by the project proponent (CEB) and their consultants. This, plus further consultation and disclosure required by the ToR for the FS Review and DD Study should satisfy ADB requirements. However the process needs to be better documented, in a more easily accessible form than provided in the present Local EIA. The FS and DD consultant will therefore prepare an account of the information disclosure, consultation and participation process. This will summarise previous and currently planned activities, and those that will be conducted during future project implementation, using information in the Local EIA, supplemented by additional material from CEB where available. Wherever possible the new account will describe each activity, summarise the comments and concerns raised by stakeholders and explain how they have been (or will be)

ADB REQUIREMENT (SPS 2009, Appendix 1 Annex)	EXTENT OF COMPLIANCE	CONCLUSION AND REMEDIAL ACTION
Indigenous Peoples; and (iii) describes the planned information disclosure measures (including the type of information to be disseminated and the method of dissemination) and the process for carrying out consultation with affected people and facilitating their participation during project implementation.	c) Interviews with likely Project Affected Persons (no summary given) 2. Contacts made by CEB: a) Awareness programme for stakeholder government agencies (list of participants and comments made in Appendix A). b) Letters subsequently received from stakeholder government agencies (Appendix F). c) Providing the draft final Local EIA report for review and comment by the public (expected in the next 2-3 months).	addressed in project design and mitigation measures. This will include a separate account of the views of vulnerable groups (if information is available), explaining how they have been consulted and involved, and the resulting project action.
H. Grievance Redress Mechanism This section describes the grievance redress framework (both informal and formal channels), setting out the time frame and mechanisms for resolving complaints about environmental performance.	There is no mention of a Grievance Redress Mechanism (GRM) in the Local EIA report (main text, annexures or appendices)	The FS Review and DD Study consultant will plan a GRM that is appropriate to this project, in view of the likely project organisation, the expected volume of complaints, and the support for the project amongst likely affected communities. This will be coordinated with the resettlement studies (which also require a GRM) in order to develop a single mechanism to deal with all issues if possible. Proposals will be discussed with CEB and once agreed a description of the GRM, its rationale and mode of operation will be prepared for incorporation into the project Environmental Management Plan (see below).
I. Environmental Management Plan This section deals with the set of mitigation and management measures to be taken during project implementation to avoid, reduce, mitigate or compensate for adverse environmental impacts (in that order of priority). It may include multiple management plans and actions. It includes the following key components (with the level of detail commensurate with the project's impacts & risks): (i) Mitigation: (a) identifies and summarizes likely significant adverse environmental impacts and risks; (b) describes each mitigation measure with technical details, including the type of impact to which it relates and the conditions under which it is required (for instance continuously or in the event of contingencies), together with	The Local EIA report does not contain an Environmental Management Plan (EMP). Chapter 6 of the report provides an outline Environmental Monitoring Programme, which includes: 1. Pre-Construction Monitoring of existing (baseline) conditions; 2. Construction Compliance Monitoring to confirm effective implementation of mitigation measures; and 3. Impact Confirmation Monitoring to check the effectiveness of mitigation and validate the assumptions made in the EIA process. The Programme includes monitoring of the physical, biological environments and describes the monitoring objectives, location, parameters, frequency and responsibility (Table 6.2). It explains the required institutional framework for impact mitigation and monitoring (Section 6.3); and provides broad-scale estimates of monitoring costs (although with little explanation or justification). It discusses monitoring of the Resettlement process in some detail and suggests performance indicators for monitoring the physical and financial progress of the Resettlement Plan (RP).	The Monitoring Programme in the Local EIA report deals only with monitoring and does not relate the proposed activities to specific impacts and mitigation measures, or describe how the mitigation will be achieved. It is also broad in scale and includes few technical details of the methods proposed, and provides no information on reporting. It therefore does not fulfil ADB requirements as an Environmental Management Plan or an Environmental Monitoring Plan. The FS Review and DD consultant will prepare a new Environmental Management Plan (EMP), following ADB requirements as shown in Column 1. The EMP will re-assess the project impacts (as proposed above) and incorporate any modifications necessary to address any impacts unforeseen by the previous study or that may result from any significant changes in the project introduced during the design stage. It will include an Environmental Management Plan (EMP) describing the action needed to provide each mitigation measure and responsibility for each action. It will also include an Environmental Monitoring Plan (EMoP) describing (a) supervision to be conducted to ensure mitigation is provided as described in the EMP and (b) monitoring

ADB REQUIREMENT (SPS 2009, Appendix 1 Annex)	EXTENT OF COMPLIANCE	CONCLUSION AND REMEDIAL ACTION
designs, equipment descriptions, and operating procedures, as appropriate; and (c) provides links to any other mitigation plans (for example, for involuntary resettlement, Indigenous Peoples, or emergency response) required for the project. (ii) Monitoring: (a) describes monitoring measures with technical details, including parameters to be measured, methods to be used, sampling locations, frequency of measurements, detection limits and definition of thresholds that will signal the need for corrective actions; and (b) describes monitoring & reporting procedures to ensure early detection of conditions that necessitate particular mitigation measures and document the progress and results of mitigation. (iii) Implementation arrangements: (a) specifies the implementation schedule showing phasing and coordination with overall project implementation; (b) describes institutional or organizational arrangements, namely, who is responsible for carrying out the mitigation and monitoring measures, which may include one or more of the following additional topics to strengthen environmental management capability: technical assistance programs, training programs, procurement of equipment and supplies related to environmental management and monitoring, and organizational changes; and (c) estimates capital and recurrent costs and describes sources of funds for implementing the environmental management plan. (iv) Performance indicators: describes the desired outcomes as measurable events to		to ensure that the mitigation protects the environment as intended. It will also describe the institutional arrangements for implementing the EMP and EMoP, and will include an analysis of the environmental capacity of all involved institutions, and estimates of the cost of implementing both plans.

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the extent possible, such as performance indicators, targets, or acceptable criteria that can be tracked over defined time periods.		
J. Conclusion and Recommendation This section provides the conclusions drawn from the assessment and provides recommendations.	Chapter 7 of the Local EIA presents the Conclusions and Recommendations of the study. This includes a summary of the approach to the work conducted and a summary of the main environmental impacts of the project (negative and positive), the reasons why they may occur and the mitigation proposed to address negative impacts. It provides a final conclusion, which is that if the recommended mitigation is implemented as described in the report there should be no major adverse environmental impacts of construction or operation of the Moragolla Hydropower Project.	The Conclusion and Recommendation chapter of the Local EIA report accurately summarises the main impacts of the project as predicted by the Local EIA study and the proposed mitigation, and draws a conclusion that is clearly evident from the work presented in the report. If there are major changes in the project, and if this or the re-assessment of impacts proposed above, result in significant changes in the impacts predicted and/or mitigation proposed, the Conclusions may need to be amended to incorporate these changes. If there are no major changes, Chapter 7 should satisfy ADB requirements unaltered.