Environmental Impact Assessment (Draft)

August 2014

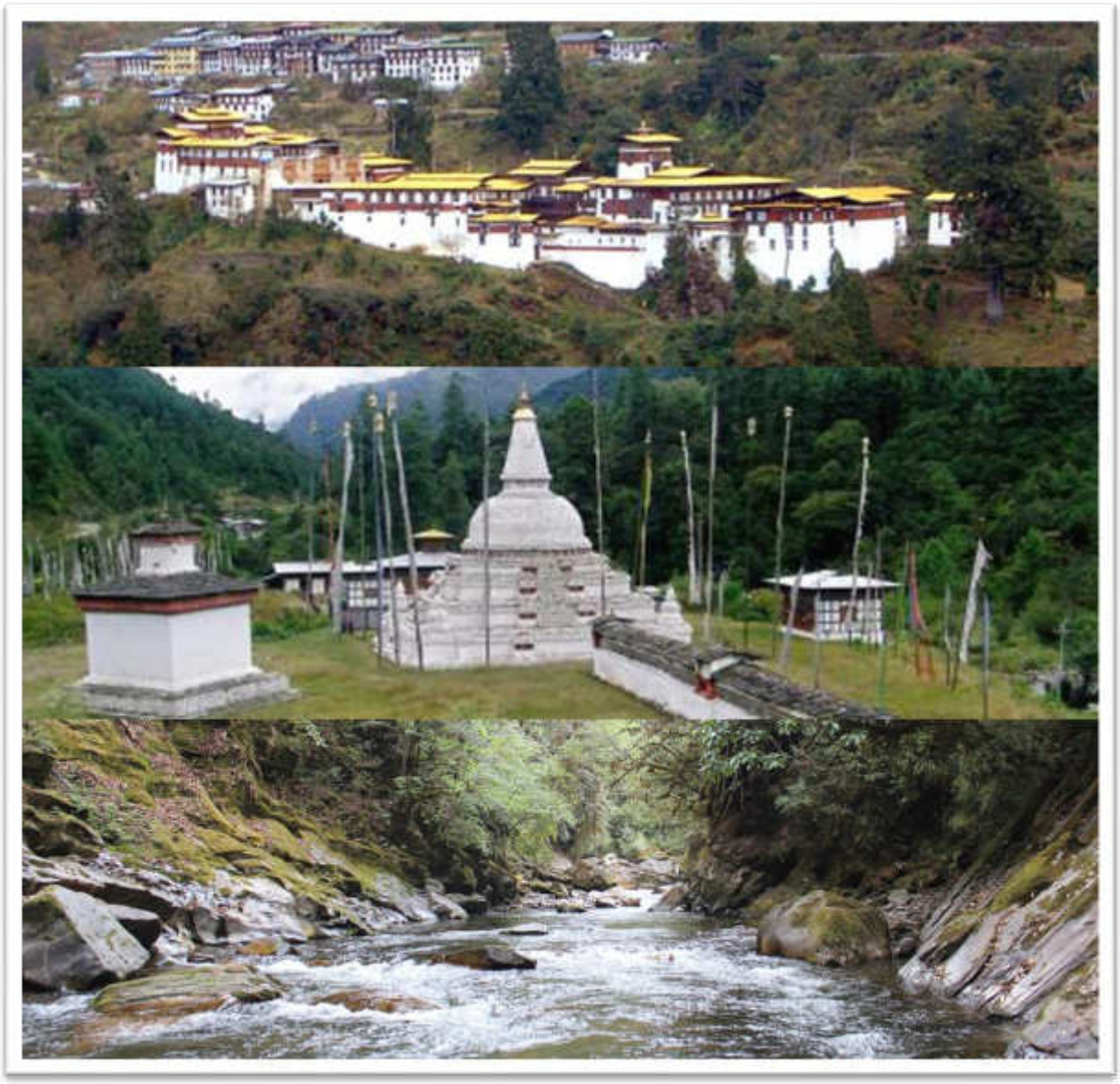
BHU: Green Power Development Project II

(Part A: Hydropower Plant Component)

Environmental Management Plan

Prepared by Druk Green Power Corporation Limited and Tangsibji Hydro Energy Limited for the Asian Development Bank

The environmental impact assessment report is a document of the borrower. The views expressed herein do not necessarily represent those of ADB's Board of Directors, Management, or staff, and may be preliminary in nature.



NIKACHHU HYDROPOWER PROJECT, BHUTAN (118 MW)

ENVIRONMENT MANAGEMENT PLAN (EMP) - 2014

VOLUME IV: PART 2

Prepared for:

Druk Green Power Corporation Limited and
Tangsibji Hydro Energy Limited (THyE)
Thori Lam, Thimphu
Bhutan

Prepared by:

Bhutan Consultants & Research (BHUCORE)
Taba, Post Box: 955, Thimphu
(revised by PWC Consultants)

Preamble

The Nikachhu Hydropower Project Environmental and Social Impact Assessment (ESIA) was originally prepared in 2012 by BHUCORE. This current version of the ESIA is a revision of the September 2012 draft, and reflects additional field surveys, site visits, consultations with stakeholders in the Trongsa area and Thimphu, and various briefing sessions with stakeholders and regulators (including an information session and initial review by the National Environmental Commission in late 2013, and NEC formal review of the ESIA and EMP in April 2014). It also reflects a detailed study of the project components and impacts at the Dagachhu hydropower project site, as there are many similarities between the two projects. It has been prepared by two PricewaterhouseCoopers (PWC India) consultants, within the overall ADB technical assistance being provided to the Druk Green Power Corporation Limited. Tangsibji Hydro Energy Limited (THyE), a 100% DGPCL owned subsidiary company has been incorporated on April 25, 2014 to implement the project.

Part 2 (this document) of the ESIA is the Environmental Management Plan (EMP), which is based on the analysis of project activity interactions with the baseline features in the project area, and the impact assessment and development of mitigation measures documented in Part 1. The EMP reflects all identified impacts and required mitigation measures, as well as monitoring programs, in conformity with the requirements of the Royal Government of Bhutan, while also being compliant with the Environmental Safeguard policies of ADB, so that this one document can meet the requirements for approvals in both Bhutan and at ADB.

Other documents in this series include Part 1, with the baseline features in the project area and the impact assessment (with mitigation measures), and Part 3 (the Resettlement Plan, which also includes the social impact assessment, public consultation details, and the grievance redress mechanism (the latter is also summarized in this EMP, to address ADB requirements).

Table of Contents

ABBREVIATIONS AND ACRONYMS

BHU	Basic Health Unit
BHUCORE	Bhutan Consultants and Research
CEO	Chief Executive Officer
CLO	Community Liaison Officer
DGPCL	Druk Green Power Corporation Limited
DOFPS	Department of Forest and Park Services
DoR	Department of Roads
ECDMD	Environment Clean Development Mechanism Division
EMP	Environmental Management Plan
EMS	Environmental Management System
ESIA	Environment and Social Impact Assessment
HRT	Head Race Tunnel
LPC	Liquid Petroleum Gas
MHEP	Mangdechhu Hydro-Electric Project
MT	Metric Ton
Nu.	Ngultrum
OHS	Occupational Health and Safety
OHSAS	Occupational Health and Safety Management System
SFD	Social Forestry Division
VIP	Ventilated Improved Pit

1 ENVIRONMENTAL MANAGEMENT PLAN

1.1 Overview of Expected Impacts and Required Mitigation Measures

This document catalogues all the expected impacts from the Nikachhu Hydropower Project and the required mitigation measures to address them. Mitigation can be achieved through three basic approaches:

- taking advantage of the natural features and qualities of the various locations for project components;
- taking advantage of specific project design features (which have evolved through experience to mitigate technical issues, and to reduce environmental and social concerns); and,
- implementing specific mitigation measures that address residual concerns not covered by the advantages of project location and project design features (many of these are considered to be standard "best practice" approaches in project construction; others are designed to address unique concerns).

These are described below, first of all as a summary of all impacts and the required mitigation measures, to frame the EMP, then an account of the specific details associated with each proposed mitigation measure, including the monitoring and institutional requirements to ensure proper implementation and accountability for mitigation performance.

Table 1.1 Summary of impacts and mitigation measures

Overview of Impacts		**Required Mitigation Measures**		
Project Activities	**Possible Impacts (on all baseline parameters)**	**Mitigation Associated with Project Location**	**Mitigation in Project Design Features**	**Residual Mitigation Measures (not addressed by location and design)**
Pre-Construction				
1. Land acquisition: temporary.	• Impacts are due to loss of access and clearing vegetation, leading to: • Reduced use of farm land (pasture) during construction period (then access again). • Reduction in visual aesthetics of current lands (going to roads, truck traffic, construction sites). • Temporary loss of habitat and associated biodiversity,	• In patches of degraded forest and pasture land. • No buildings will need to be moved. • Re-vegetated muck disposal areas and access roads may provide useful land for	• All temporary land acquisition will be restored, with facilitation from project (standard practice).	• Compensation will be paid to landowners for temporary loss of land access.

Overview of Impacts		Required Mitigation Measures		
Project Activities	**Possible Impacts (on all baseline parameters)**	**Mitigation Associated with Project Location**	**Mitigation in Project Design Features**	**Residual Mitigation Measures (not addressed by location and design)**
	due to vegetation clearing, including a small segment in the biological corridor; tree clearing (to be compensated); possible temporary disturbance of terrestrial wildlife during construction activities. • Then, all temporary land acquisition areas will revert to rehabilitated or wild state after construction.	local communities.		
2. Land acquisition: Permanent.	• As above (#1), except there will be no permanent land acquisition in the biological corridor. So, • Impacts are due to loss of access and clearing vegetation, leading to: • Permanent reduced use of farm land (pasture); compensated. • Reduction in visual aesthetics of current lands (less appealing visuals, due to 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.	• In patches of degraded forest and pasture land . • No buildings will need to be moved.	• All permanent land acquisition will be taken up with project buildings and re-vegetated grounds (standard practice).	• Compensation will be paid to landowners for permanent loss of land.
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 rivers (reduced water quality due to turbidity and possible occlusion of aquatic habitat, until sediments are flushed naturally).	• In patches of degraded forest and pasture land; therefore, no loss of unique or vulnerable habitats. • Approximately half the work sites are in a low slope gradient area, which is less challenging than some of the other work sites.	• Access road design allows for suitable slope gradients to make construction work manageable (although this increases the length of the road, which is inevitable in Bhutan).	• Trees that are cut will be replaced in an area 2x larger than the cleared areas (subject to site selection decisions from DoF). • Retaining walls will be in place to avoid slope failure associated with cuts. • Use of equipment will be managed to

Overview of Impacts		Required Mitigation Measures		
Project Activities	**Possible Impacts (on all baseline parameters)**	**Mitigation Associated with Project Location**	**Mitigation in Project Design Features**	**Residual Mitigation Measures (not addressed by location and design)**
	• Generation of dust (transient). • Associated noise (transient). • Health and safety issues associated with construction, as well as 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 eastern end of the project area, where there are more people).	• At least half the work sites are located more than 500 m from the river (reduced risk of sediment incursions to the river).		reduce frequency of soil movement (stockpiling as much as possible). • Dry sediment areas will be sprinkled with water. • New slopes will be planted with suitable vegetation (as per experience in southern Bhutan). • Public access to new project roads will be carefully managed (restricted). • Vulnerable animals that are encountered during land clearing will be rescued when practical. • Large mammal monitoring during project construction and operation will be supported by the project.
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, increased business opportunities associated with worker consumption.	• Workers will be located and housed in specific camps away from local communities and vulnerable habitats (all on the north side of the Nikachhu, in degraded forest areas).	• Worker camps will be self-contained and properly organized to handle waste issues (standard practice). • Workers will be briefed on health and safety issues and provided with PPEs (standard practice).	• Workers will be briefed on their obligations regarding proper management of work and behavior in the project area, with sanctions for inappropriate behavior or illegal activity. • The area near the National Park will be fenced off (to prevent access and poaching).
5. Construction equipment mobilized.	• Mostly a concern with noise, emissions, and dust; 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 pristine environment.	• Most work sites will be located well away from local communities (so, minimal disturbance from noise, dust, emissions). • Work in the biological	• Noise and emissions will be required to meet Bhutan standards, so will have emission and muffler controls, and specific operating	• As noted above, vulnerable animals encountered during construction will be captured and moved, if practical. • All animal sightings (larger birds and mammals) will be recorded during construction and

Overview of Impacts		Required Mitigation Measures		
Project Activities	**Possible Impacts (on all baseline parameters)**	**Mitigation Associated with Project Location**	**Mitigation in Project Design Features**	**Residual Mitigation Measures (not addressed by location and design)**
	• Equipment in the biological corridor may inhibit wildlife movements.	corridor will only preclude about 15% of its width on a sporadic basis; wildlife will continue to have contiguous habitat on either side for refuge and movements.	hours when near local communities. • Workers will be briefed on safety issues and will be issued with equipment-associated PPEs (standard practice).	less intensively during project operation. • Vehicle movements on the National Highway will be addressed in signage, and specific work sites handled by road workers, for traffic control.
6. Fuel storage.	• Risk of spill, if not properly controlled and bunded; risk of contamination of groundwater and surface water (aquatic habitat compromised; possible impact on brown trout). • Explosion risk.	• A safe location will be selected.	• Fuel storage is controlled by Bhutan regulations; standard procedures will require bunding to avoid spillage to the environment, and controlled access.	• No additional measures.
Construction				
7. Influx of more workers (worker camps).	• As in #4 above, except that numbers ramp up and risks increase accordingly.	• As above.	• As above.	• As above.
8. More construction equipment used.	• As in #5 above, except that more equipment over a longer period will be activated, so risks increase accordingly.	• As above.	• As above.	• As above.
9. More fuel storage.	• As in #6 above, except that the risk of a spill increases (higher volumes in more locations).	• As above.	• As above.	• As above.
10. Blasting.	• Generally, this can be managed with few or no impacts, but a residual concern for "knock-on" effects, such as slope instability, noise and risk of wildlife disturbance, possible fracturing of bedrock and alteration of existing aquifer dynamics (groundwater). • Associated health and safety risk.	• Most blasting will occur well away from local communities. • With the exception of the biological corridor, blasting will not occur in critical habitat.	• Blasting in Bhutan is controlled by various standards and regulations. • Blasting routine will be managed to avoid wide distribution of blast debris.	• No additional measures.
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	• Separate EIA shall be carried out for quarry as part of Final Mine Feasibility Study Accessing	• Quarry operations will meet Bhutan standards and regulations, which are	• The quarry will be fenced off (no public access). • Site drainage will be designed to avoid run-off to adjacent

Overview of Impacts		Required Mitigation Measures		
Project Activities	**Possible Impacts (on all baseline parameters)**	**Mitigation Associated with Project Location**	**Mitigation in Project Design Features**	**Residual Mitigation Measures (not addressed by location and design)**
	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.	and working the quarry from the "back" will reduce or eliminate most quarry concerns.	intended to address health, safety, and environmental concerns.	watercourses. • Quarry access to the National Highway will be managed (signage and staff) to avoid traffic congestion and accident risk issues.
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 (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.	• The crusher plant will not be located in any critical habitat or near any local communities (not very visible or audible).	• Crusher plant operation will be temporary, and the site will then be restored. • Standard worker safety measures will apply.	• The noise and dust management procedures noted above for other construction activities will apply here. • A site drainage scheme will ensure that there is no entry of loose sediments into adjacent watercourses.
13. Muck generation and disposal.	• Concern is for slope stability and proper containment (it is more significant for this activity than any of the others); disposal sites will require preparation and containment structures (retaining walls) before muck is disposed; • 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 trucks and dumping). • More difficult access to areas adjacent to muck disposal sites. • The muck disposal sites present poor visual aesthetics until such time as they are terraced and re-vegetated. • Health and safety issues (especially truck drivers and dozer operators). • Temporary occlusion of part of the biological corridor (possible disturbance of terrestrial wildlife movements).	• Muck disposal sites have been selected for practicality of operation and avoidance of critical habitat and local communities. • Disposal sites will be located at least 30 meters above the flood line of the river. • For those Muck Disposal Sites falling in along the stream, the stream shall be provided with waterways such as culverts and hume pipes.	• Some muck will be recycled (used for aggregate). • Muck disposal sites will be stabilized with retaining walls and appropriate site drainage (standard practice). • All muck disposal sites will be terraced and re-vegetated when filled (standard practice), which will add the option of pastureland available to local communities.	• The noise and dust management procedures noted above for other construction activities will apply here.
14. River	• Very temporary disturbance of	• This is a narrow	• A diversion	• Fish in the Nikachhu

Overview of Impacts		Required Mitigation Measures		
Project Activities	**Possible Impacts (on all baseline parameters)**	**Mitigation Associated with Project Location**	**Mitigation in Project Design Features**	**Residual Mitigation Measures (not addressed by location and design)**
diversion (cofferdam).	the river (during finalization of the two cofferdams). • The river will be channeled 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. • Cofferdam work adjacent to the park, although on a steep slope that does not support wildlife access to the river.	stretch of the river, where there are generally high velocity flows and quick flushing. • Although adjacent to the National Park, the very steep slope there prevents access to people (and wildlife).	tunnel will accommodate river discharge and fish (this is standard procedure in cofferdam construction; this is the main mitigation measure). • Cofferdam work will be undertaken during the lean season when discharge rates are lowest.	will be monitored regularly during construction and operation.
15. Transmission line tower installation (land clearing).	• Minimal concern for a patchwork of small "footprints" along the right-of-way, in which vegetation will be cleared (including trees to be compensated), with a risk of some very localized slope instability. • Some loss of access to farm land (pasture and dryland crops), but temporary and compensated, as access will then be allowed after installation of towers. • Loss of visual aesthetics (the transmission towers against a pristine hill/mountain setting). • Some minor loss of terrestrial habitat for wildlife; wildlife movements will likely occur again, but away from the towers, and in altered vegetative habitat.	• The "footprints" for the tower foundations will occur in degraded forest and agricultural land, avoiding any critical habitats.	• Vegetation will be allowed to grow back to about two meters height, creating adequate refuge for animals (standard practice). • Local communities will be able to access the right-of-way for farming.	• Compensation will be paid to landowners for temporary loss of land access. • Trees that are cut will be replaced in an area 2x larger than the cleared areas (subject to site selection decisions from DoF). • Tower foundation work will be managed to avoid soil loss and erosion (adjacent area to be re-vegetated).
Operation				
16. Reduced worker numbers (just permanent staff).	• Diminishing local supplier business and reduced demand for informal businesses near construction sites and the highway. • Reduced risk of friction between immigrant workers and local communities; increased social/cultural stability.	• n/a	• n/a	• Local communities need to be warned of the possible economic shock of reduced business associated with the end of the project construction phase and dwindling number of workers.

Overview of Impacts		Required Mitigation Measures		
Project Activities	**Possible Impacts (on all baseline parameters)**	**Mitigation Associated with Project Location**	**Mitigation in Project Design Features**	**Residual Mitigation Measures (not addressed by location and design)**
				• Project will support local community skill development as a "buffer".
17. Reservoir operation (flooded area).	• Permanent flooding of the margin of the National Park (right bank; steep slope vegetation) and degraded forest on the left bank (but a very small percentage of similar adjacent habitat on both sides of the river). • Alteration of upstream hydrology (from fast-floUnit to more quiescent); this is a positive opportunity for aquatic habitat diversity and introduction of other trout species (upstream); option for the National Park to provide recreation and interpretation facilities; a positive for visual aesthetics (waterbody in mountain area); risk of safety issues, with increased public access to reservoir/river area. • Upstream areas (watershed) will need to be maintained to ensure good water quality.	• Miniscule loss of habitat up the steep loss of the National Park; most flooding affects the degraded forest on the right bank of the Nikachhu. • No critical habitat is affected.	• The reservoir can be maintained and developed as a local aesthetic feature (opportunities for limited public access and habitat/wildlife interpretation).	• No specific watershed management measures are needed, as most of the upper watershed is undeveloped and heavily forested; however, a rim protection plan will be put in place to reduce erosion potential. • Public safety issues in the reservoir area will be studied (appropriate fencing, limited access areas, and a safety boat will be considered). • Water quality and fish populations in the reservoir will be monitored regularly. • There is an opportunity to stock fish (perhaps snow trout) in the reservoir to help bolster this species in areas above the dam site.
18. Water intake to headrace.	• Risk of fish (brown trout) intake, due to accelerated velocity near intake; but a sequential screen apparatus can preclude this risk.	• The Nikachhu only supports brown trout.	• It is standard procedure to install appropriate fish screens to prevent their entrainment in the intake.	• Fish populations above and below the dam site will be monitored during construction and operation.
19. Diversion dam operation.	• Localized fish movement (brown trout) will be disrupted (no upstream movement, and just downstream movement through the spillway, with minimum environmental flow); however, no long-distant migrants use this part of the river. • Reduced downstream discharge, potential alteration of downstream surface water	• The waterfalls in the downstream section of the Nikachhu prevent upstream fish migration (precluding the need for a fish pass/ladder). • Perennial tributaries below	• Minimum environmental flow (at least 10% of average lean season flow) is the standard approach to accommodate diverted water, to	• Discharge variability, aquatic habitat, and fish below the dam will be monitored regularly during project operation.

Overview of Impacts		Required Mitigation Measures		
Project Activities	**Possible Impacts (on all baseline parameters)**	**Mitigation Associated with Project Location**	**Mitigation in Project Design Features**	**Residual Mitigation Measures (not addressed by location and design)**
	quality. • The dam itself and the reduced river flow will present a negative visual aesthetic, but in fact the dam site is not very accessible and not even visible from the highway.	the proposed dam site will contribute to environmental flow. • Most of the reduced Nikachhu river width (a potential negative visual aesthetic) will not be visible, due to steep slopes and over-hanging vegetation.	maintain a rudimentary aquatic habitat downstream.	
20. Maintenance of minimum environmental flow.	• Related to the above (#19), reduced downstream discharge, especially in the lean season (December-March). • Alteration of river width for habitat (narrower); increasingly, discharge will be made up, downstream, by perennial and seasonal tributaries; monsoon flows will still be substantial; habitat for fish will still be maintained up to the diversion dam. • Possible reduced aquifer linkages between the Nikachhu and aquifers, but these will be maintained by the tributaries. • Reduced visual aesthetics of the downstream Nikachhu (smaller river), but, as above, it is not easily viewed from the highway or the inhabited areas to the east.	• This is the mitigation for #19 above. • Perennial tributaries will assist the function of environmental flow.	• This is the mitigation for #19 above.	• As above.
21. Occasional sediment purging.	• Purging of the desilting chambers may result in occasional turbidity pulses 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-	• The sediment load in the Nikachhu is not very high; the sediment burden in the desilting chambers may not be so high.	• Sediment purging or removal through silt flushing tunnel.	• Sediment purging during monsoon discharge would allow the sediments to flush quickly down the Nikachhu and into the Mangdechhu where river discharge is considerably higher.

Overview of Impacts		Required Mitigation Measures		
Project Activities	**Possible Impacts (on all baseline parameters)**	**Mitigation Associated with Project Location**	**Mitigation in Project Design Features**	**Residual Mitigation Measures (not addressed by location and design)**
	September); sediments will be flushed quickly, into the Nikachhu and then further downstream.			
22. Risk of dam burst.	• This is a very low probability event, that can be monitored, if there are signs of pending dam failure; the concern is for human safety, but in fact there are no communities within the flash flood zone downstream, due to the very steep topography adjacent to the Nikachhu for its distance to the Mangdechhu, and a high volume flood would be contained mostly in the gorge down to the confluence. • A warning system can nevertheless be installed to notify of a pending dam failure. • A 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 the Mangdechhu; recovery from a flash flood would take a few years, but it would occur.	• There are no houses located in the predicted flash flood zone.	• Standard practice requires constant monitoring of incoming river discharge and dam condition. • Operation of the spillways would reduce flood pressure on the dam.	• A flood warning system, involving installation of sirens in all communities, backed-up with a phone communication system with community wardens, will be implemented.
23. Maintaining cleared right-of-way for transmission line.	• Regular clearing of the vegetation within the right-of-way, especially near the tower foundations, will maintain stunted vegetation and reduce the quality of wildlife habitat; however, areas between the tower foundations can be allowed to grow to a height of about two meters, which will provide cover for most wildlife that need to move through the right-of-way. • Local communities will likely use most of the right-of-way for farming and pasture, as it will be more accessible and suitable than before installation of the transmission line. • Negative visual aesthetics of the transmission line will persist, with regular clearing of the right-of-way.	• No critical habitat will be affected (see #15 above).	• Vegetation up to about two meters height will be maintained, and farmed areas will be left undisturbed (standard practice).	• Wildlife sightings in the vicinity of the transmission line right-of-way will be recorded.

1.2 Required Mitigation Measures and Associated Monitoring Programs

The mitigation measures described below are listed in the sequence in which they will be implemented, which in turn reflects the various project actions during the pre-construction, construction, and operation phases of the project. This format accommodates the need for shoUnit responsiveness to all project actions (usual ADB format) and the need to show responsiveness to the Terms of Reference for the ESIA (NEC requirements). As such, all expectations of both ADB and NEC are addressed below. Three actions described below are also addressed in the Resettlement Plan (RP). These include the nature of the land acquisition (with the budget shown in the RP), community support (also with the budget shown in the RP), and the Grievance Redress Mechanism (GRM), which has been developed under the RP process, but is required to be included in this EMP, as a management measure related to possible environmental complaints (meeting ADB SPS requirements). Note that some mitigation measures implemented in the pre-construction phase will continue through the construction phase (they are therefore not repeated again in subsequent phases). For those environmental parameters which may be influenced by the project (such as water quality, air quality, downstream hydrology, and fish populations) adequate data will be collected in both the dry and wet seasons for at least one-two years prior to major construction works (depending on how much time is available before construction starts), so that subsequent monitoring results (during and post-construction) can be reliably compared to pre-project baselines.

1.2.1 Pre-Construction Phase

1.2.1.1 Land Acquisition Management Plan (Temporary and Permanent)

The total project land requirement is only about 0.27% of the land area of Tangsibji Geog. The temporary land acquisition is equivalent to 262.50 acres, including the 59.3 acres land for the Transmission Line of Construction Power, and the permanent land acquisition is equivalent to 45.66 acres. All land acquired temporarily, once finished with after project construction, will be rehabilitated and allowed to re-vegetate and become available again to the local communities and wildlife. Access roads may also revert to a wild state, although given that they will lead from the National Highway to terraced and re-vegetated muck disposal areas, they may retain their usefulness, and provide access to these new areas, which would have value for farming (either dryland cultivation, or animal grazing; a significant positive impact).

Mitigation for land acquisition is restricted to compensation for temporary and permanent land acquisition and maintenance of positive visual aesthetics on land that is acquired for the project. Compensation in Bhutan is guided by the principle that no household should be worse off compared to their existing living conditions. Land compensation is therefore guided by the "Land Compensation Rates (2009)" and the Land Act of Bhutan (2007). The compensation rates also apply for compensating structures and fruit trees. There are three classes of land under the rural category, based on distance from the municipal boundary. As the Tangsibji Gewog falls within Class C of rural land, the compensation rate per decimal (= 40.47 m^2) is Nu 2,262.54, which means one acre will cost Nu 226,254. As the land acquisition will be governed by the Land Act 2007, Chapter 7 specifically pertains to land that will be acquired by the Government for wider public interest. It states that acquisition shall entail fair compensation. The compensation can be in cash or land or a combination of both (the land owner shall have the discretion to opt for one or the other). All compensation processes will be completed before the actual start of the project on the ground. If land is provided as compensation, the certificate for new land will be made available so that the affected people do not encounter any problems in the future. No land will be occupied by the project until the compensation process is completed and the affected are fully compensated.

If affected households are not satisfied with the proposed compensation, the grievance redress mechanism, based on the existing governance structure involving the Geog Yargay Tshogchung and the Dzongkhag Yargay Tshogde can be activated (all such details are provided in the Resettlement Plan, Part 3 of the ESIA Report).

In addition to these standard measures, the project will be able to provide job opportunities (during the construction period, employment opportunities shall be provided to one member of the displaced family affected adversely and significantly as per Sustainable Hydropower Development Policy 2008, depending on their skills). The project can also rent local houses, if suitable. Furthermore, to reduce disturbance to existing infrastructure, the opportunities for alignment of project roads with existing roads have been examined, and several possibilities have been taken advantage of; for example: aligning the road to Adit 3 with the existing Tansgibji farm road to the extent possible; the road to Adit 5 with the existing quarry road; and, the road to the muck disposal site at Tsangkha with the existing power tiller track.

Permanent land acquisition could result in negative visual aesthetics, so every effort will be made to have the structures on permanent project sites fit into the local architecture and landscape (as DGPC has done with such structures at the Dagachhu project site), and all open areas and access roads will be planted with flowering shrubs and ornamental trees to

improve the visual appeal and acceptability of the permanent project sites. In any case, most of the permanent sites will not even be visible from the National Highway or inhabited areas, so the project will have very little visual presence in the landscape.

Land that is used temporarily for project construction will be replanted to all forest to re-grown back. Work sites, the muck disposal areas (fully rehabilitated as terraced vegetated fields), and the access roads can either be used by the local communities, or allowed to revegetate naturally, depending on the community wishes. Ongoing discussions with the local government and communities will define the specific fate of each of these temporary project land use areas.

Institutional Responsibilities: The Chief Administrative Officer (CAO) assisted by Environment Officer under the Environmental Unit of Tangsibji Hydro Energy Limited (THyE) will continue to manage the compensation process to ensure that the families affected by the project are fully informed regarding the process and timetable, and that compensation is paid out and certified. The Trongsa District Administration will be included in all meetings and correspondence related to project land acquisition.

Performance Indicators and Monitoring Requirements: All land acquisition, compensation, and conditions documented in certificates and plots mapped, with copies of paperwork distributed accordingly. Local communities are satisfied with the land compensation process. Later access to temporarily acquired land is allowed (after project construction). Other monitoring is not required, if all documentation is in place, except to ensure that actual project take-over of land occurs as planned. Maintaining an ongoing log of activities and issues is recommended. The proposed format of the land acquisition log is shown below.

Table 1.2 Format of land acquisition log

Parameter	Details
Date:	
Event/ Issue:	
Issue Raised by:	
Issue Logged by:	
Land Plot, Size, Ownership:	
Previous Related Activities/ Decisions:	
Degree of Urgency:	

Expected Outcome:	
Agreed Action Deadline:	
Person Responsible for Action:	
Signature of Person Who Raised the Issue:	

Scheduling and Pacing: The process and schedule for land acquisition is shown in the table below.

Table 1.3 Schedule for land acquisition

Activities	**2013**		**2014**		**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
		Pre-constn			**Construction**				**Operation**	
Finalization of compensation scheme.										
Cadastral re-survey of affected land.										
Agreements on compensation rates and affected families.										
Issue of public notification.										
Payment of settlements.										
Monitoring of land acquisition and clearing.										

Budget: The estimated costs of compensation for land acquisition are noted in the Resettlement Plan.

1.2.1.2 Management Plan for Actions Related to Land Clearing and Cuts (Access Roads and Work Sites)

There are three specific actions triggered by the land clearing and cuts made during the pre-construction phase (and continuing through construction). These include:

- preparation for the adits and access roads, which requires slope stabilization and associated works.
- animal rescue (as wildlife are encountered during clearing) and ongoing wildlife biodiversity support; and,
- replanting of trees to compensate for those that are cut, and to provide alternative habitat for wildlife.

These mitigation measures will be implemented as soon as practical during the late part of the pre-construction phase and will continue as needed through the construction phase. They are described individually below, with site-specific details provided, to the extent possible.

a. Construction of Adits and Access Roads

The main concern with land clearing and making cuts into mountain slopes is associated with the muck disposal sites and developing the access roads. The latter are required at eight locations, with an accumulated total length of 16.488 km (see details in the ESIA. These roads typically require a corridor of 30 m (Road Act Bhutan, 2004). While the access roads for the dam site, Adit 1, Adit 2, Adit 3, Adit 5, Surge Shaft and Power House will be developed on relatively moderate slopes (average terrain gradient of 45%, therefore with less concern for landslides), the access roads for Adit 4 will be constructed in areas with average terrain gradients of 50-60%, which is very steep by any standard, and increases the risk of slope instability and loss of surficial sediments. Luckily, where the slopes are greatest, and the risk of slope instability and soil loss is highest, the locations are further away from the Nikachhu (however, closer to the Mangdechhu), so possible occlusion of watercourses by sediments lost down-slope and resultant temporary degradation of water quality and aquatic habitat is diminished as a risk.

Concerns about construction of adits and access roads include loss of forest cover and disruption to wildlife and biodiversity, risk of slope instability, muck transportation and management of disposal sites, risk of sediment entry to local creeks, dust and noise generation, health and safety issues of truck drivers and excavator operators, and, most importantly, temporary occlusion of part of the Biological Corridor (Adit 2). These can be handled by various mitigation programs related to worker safety, and air and water quality which are described in paragraphs 1.2.2.8 and 1.2.2.9, and specific measures described below (the table below summarizes the suite of mitigation measures required for construction of adits and access roads). The details on access roads, including potential impacts and mitigation measures, are provided in the Application for Environmental Clearance (Guideline for Highways and Roads), which is an annex to the ESIA.

Table 1.4 Potential environmental and social impacts related to adits and access roads and their mitigation measures.

No.	Potential Impact	Mitigation Measure
Pre-construction Phase		
1	Loss of forest cover.	Compensatory afforestation plan. Cut only those trees marked by the Forestry staff. Ensure that the area is cleared as per directives/delineation of Forestry staff.
2	Loss of private land and livelihood.	Compensation as per Land Act. Community livelihoods support program.
3	Influx of construction workers.	Mitigation as per management of labour camps, water management, waste management, Occupational Health and Safety plan.
4	Mobilization of construction equipment.	Mitigation as per construction equipment management plan.
5	Increase in congestion due to increased traffic.	Identify and upgrade parts of the National Highway that will be used by project vehicles, so that narrow sections and blind curves (so-called "chokepoints") do not create a high accident risk.
Construction Phase		
1	Loss of Biodiversity, disturbance/accidents/injury to wildlife.	Creation of a greenbelt along access roads to compensate for the loss of habitat. Biodiversity Conservation and Wildlife Management Plan.
2	Increase in air pollution.	Follow air quality management plan.
3	Dust and noise pollution	Air quality and noise management plan, sprinkling of water to reduce dust.
4	Risk of landslides, erosion and sedimentation.	Construction of retaining walls, bioengineering works.
5	Sedimentation in streams; Impact on water quality.	The roads will be maintained at least 30 meters from watercourses. Where roads cross water courses, culverts will be built to minimize impairment of streams.
6	Health impact on workers.	Follow occupational health and safety plan.
7	Fuel spills.	Fuel storage as per storage plan.
8	Storage of construction materials.	Construction materials will be stored along wider sections of the highway (only at the take off points), and at designated sites along other access roads.
9	Muck generation and disposal.	Muck disposal management plan.
10	Traffic congestion and road accidents.	Use of signage to warn road users of impending construction work, or falling boulders. Use flag persons in narrow and accident prone areas congested with material or equipment. Designate hours for peak construction work and 'traffic hours'.
11	Damage to highway from heavy trucks and machines.	Provision for repair and maintenance of the National Highway (at the end of the construction phase).

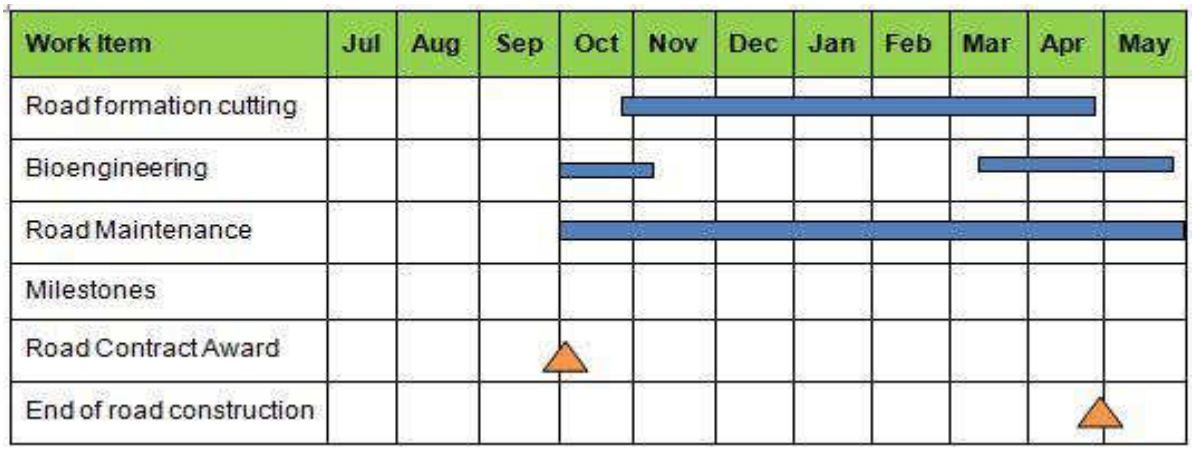
No.	Potential Impact	Mitigation Measure
Operation Phase		
1	Damage to highway from heavy trucks and machines.	Provision for repair and maintenance of the National Highway and all permanent access roads.
2	Air pollution.	Follow air quality management plan.
3	Landslides and erosion leading to sedimentation of streams.	Slope stabilization using retaining walls and planting with local species.
4	Road closure.	Follow closure plan. Remove all machines, equipment, debris from roads. Hand over road to the Forestry Division for Compensatory Afforestation program to re-vegetate and restore the area to its natural state.

Various steps are required to set up the construction of adits and access roads to minimize environmental impacts. These are described below:

- Approval from parent organization to minimize conflicts and harmonize all work with existing road work and repair: prior to beginning the construction of adits and access roads, the DGPC has received clearance from the Department of Roads (DoR). This is a pre-requisite when applying for Environmental Clearance. This Clearance process will allow DoR to anticipate the take-off of access roads from the highway, the increase in traffic and congestion along the highway, and also work with the Project for future maintenance works along the highway. There will be joint verification of road alignments by the project management and contractor, to familiarize the contractor with the exact alignment (to reduce the risk of indiscriminate clearing by the contractor).
- Identify affected people and compensate for land and crops loss: socio-economic surveys, meetings and consultations have been organized with local communities and affected people and a resettlement plan has been prepared to compensate for loss of land and livelihoods. There will be no displacement of any individual or household. Land measurement has been conducted jointly by the project, District Land officers, and households, and compensation will be as per the prevailing Land Act. This is detailed in the Resettlement Plan (a summary was provided above).
- Collaborate with Department of Forestry to minimize impact on forests: once the contractor has been awarded the work, the project must ensure that the contractor and his engineer work closely with the forestry field staff. The Contractor must ensure that only those trees that are marked are felled, and that land clearing does not exceed beyond the designated area delineated by the Forestry staff. All felled trees must also be removed carefully to avoid damaging nearby trees (then trees will be replanted under the compensatory afforestation program in the area that is cleared; described below).

- Construction equipment mobilization: The mobilization of equipment will have to be carefully staged to avoid road congestion; all equipment will follow the requirements for noise and air quality management.
- Of prime importance is planning the road formation cutting in the dry season. For the project area, September to May would be ideal for this (providing 9 months; see table below). The experience elsewhere has proved that formation cutting in the wet season has an increase of three-fold in environmental damage, compared to the dry season.
- Rescue and release of wildlife species encountered during construction works: the contractor will be required to contact the Park office in case any wildlife are encountered, or injured by accident during construction works. The rescue, treatment, and release of wildlife will be as per protocols followed by the Department of Forest and Park Services. The wildlife management plan is described below.
- Slope stabilization and bio-engineering works: At the takeoff point from the highway, it will be important to erect a retaining wall at the same time with the formation cutting to prevent damage to the highway from slumping. Retaining walls and toe walls must be constructed prior to slope disturbance. New slopes must be re-planted as soon as possible (bio-engineering) and consolidated prior to the monsoon. Cut and fill should be the standard construction method. In addition, special care will be taken to construct the access road to Adit #3, as there is a canal for a micro-hydroelectricity project located below the National Highway. This hydro project canal also serves irrigation water for paddy cultivation for the major Tangsibji Geog. Boulders from construction, if left to roll downhill, could damage the canal.

Table 1.5 Schedule for land clearing for access roads (in the first year of the project).



Monitoring

All elements related to mitigation of the adits and access roads, and their monitoring requirements, are summarized below. Note that many of these are itemized separately in sections of the EMP below.

Table 1.6 Mitigation and Monitoring Plan.

Mitigation Measure	Indicators	Period	Responsibility	Monitoring	Frequency
Compensatory afforestation (see separate section below)	Acres of land replanted, in areas designated by DoF	All phases	Project management and Social Forestry Division with local forestry staff	THyE	Quarterly
Cut off only those trees marked by the Forestry staff	Number of trees felled in excess of those marked	Pre-construction	Contractor and Project management	THyE	Quarterly
Ensure that area cleared is as per directives/delineation of Forestry staff	Land clearance as per demarcation	Pre-construction	Contractor and Project management	THyE	Quarterly
Compensation as per Land Act (see summary above)	Number of affected persons compensated	Pre-construction	Project management	THyE	Quarterly
Community livelihoods support program (summarized in the EMP below)	Number of affected persons gainfully employed or involved in new livelihoods program	Pre-construction	Project management	THyE	Quarterly
Mitigation as per 'management of labour camps, water management, waste management, Occupational Health and Safety plan' (see separate sections below)	As per management plan	Pre-construction	Project management and contractor	THyE	Quarterly
Mitigation as per "construction equipment management plan'	As per management plan	Pre-construction	Project management and contractor	THyE	Quarterly
Identify and upgrade parts of the National Highway that will be used by project vehicles, so that narrow sections and	As per plan developed in cooperation with DoR	Pre-construction	Project management and DoR	THyE	Quarterly

Mitigation Measure	Indicators	Period	Responsibility	Monitoring	Frequency
blind curves (so-called "chokepoints") do not create a high accident risk. (see separate section below)					
Creation of a greenbelt along access roads to compensate for the loss of habitat (see separate section below)	Length of greenbelt developed. Number of roads with green belt	Construction and Operation	Project management and contractor	THyE	Quarterly
Biodiversity Conservation and Wildlife Management Plan (see separate section below)	As per biodiversity plan	All phases	Project management and DoF staff	THyE	Quarterly
Air Quality and Noise management plan, sprinkling of water to reduce dust	As per air quality and noise management plan	All phases	Project management and contractor	THyE	Quarterly
Construction of retaining walls, bioengineering works	No slope instability	All phases	Project management and contractor	THyE	Quarterly
The Roads will be maintained at least 30 meters from watercourses	Alignment maintained and no sedimentation in watercourses	Preconstruction and construction	Project management and contractor	THyE	Quarterly
Where roads cross water courses, culverts will be built to minimize impairment of streams	Free flow of streams across roads	Preconstruction and construction	Project management and contractor	THyE	Quarterly
Fuel storage as per storage plan	No fuel spills	Preconstruction and construction	Project management and contractor	THyE	Quarterly
Construction materials will be stored along wider sections of the highway (only at the take off points), and at designated sites along other access roads	No obstruction of roads	Preconstruction and construction	Project management and contractor	THyE	Quarterly
Muck disposal management plan (see separate section below)	As per muck management plan	Preconstruction and construction	Project management and contractor	THyE	Quarterly
Use of signage to warn road users of impending construction work, or falling boulders	Good traffic safety record and minimal disruption of traffic	Preconstruction and construction	Project management and contractor	THyE	Quarterly
Use flag persons in narrow and accident prone areas congested with material or equipment.	Good traffic safety record and minimal disruption of	Construction	Project management and contractor	THyE	Quarterly

Mitigation Measure	Indicators	Period	Responsibility	Monitoring	Frequency
	traffic				
Designate hours for peak construction work and 'traffic hours'	Good traffic safety record and minimal disruption of traffic	Construction	Project management and contractor	THyE	Quarterly
Provision for making repairs to the National Highway (at the end of the construction phase) and permanent project access roads	Roads in good condition	Construction and Operation	Project management and contractor	THyE	Quarterly
Slope stabilization using retaining walls and planting with local species	No road slumping; slopes vegetated	All phases	Project management and contractor	THyE	Quarterly
Follow Closure plan	No debris and no unvegetated, eroding surfaces at work sites	Operation phase	Project management and contractor	THyE	Quarterly
Remove all machines, equipment, debris from roads	No road obstructions	Operation phase	Project management and contractor	THyE	Quarterly
Hand over road to the Forestry Division for Compensatory Afforestation program to re-vegetate and restore the area to its natural state	Unused access roads re-planted/ no erosion	Operation phase	Project management	THyE	Quarterly

In addition to the monitoring of the different mitigation measures listed above, there will be daily and weekly compliance monitoring of the road formation works, including the quarry site (to ensure compliance with engineering/ environmental requirements), to be undertaken by the Environmental Unit of THyE and the site engineer of the contractor. The monitoring elements will include:

- Confirmation of work within agreed alignment (visual checks and photographs);
- Adequate drainage and erosion controls in place (slope stabilization and bio-engineering started/ consolidated);
- Proper distance from watercourses and proper waterways at stream crossings;
- Adequate signage and traffic controls;
- Proper staffing of safety positions and adherence to regulated work hours;
- Proper stockpiling of work site materials;

- Proper clearing of vegetation;
- All required equipment controls for noise and dust in place;
- Workers are using PPEs; and,
- Restricted areas are properly fenced off and marked with signs.

Most mitigation components related to adits and access roads are itemized separately below and have their own budgets. The budget specific to environmental management of access roads is shown below.

Table 1.7 Costs for environmental management of access roads.

Work Item	Quantity	Unit	Rate (Nu.)	Cost (Nu.)
Transportation of cut materials	25,000	m^3	165	4,125,000
Bio-engineering	88,000	m^2	10	880,000
Road maintenance	4	Year	720,000	2,880,000
Total				**7,885,000**

b. Biodiversity Conservation and Wildlife Management Plan

The project site is important in terms of biodiversity conservation and management because of its location immediately adjacent to the Jigme Singye Wangchuck National Park (JWSNP) and also because of the Biological Corridor connecting Wangchuck Centennial Park (WCP) and JSWNP. The need for conservation, preservation and management of biological diversity arises because of threats to natural ecosystems by anthropogenic activities. Construction of the dam and other project ancillaries is likely to disturb the natural ecosystem, and thus there is a need for conservation, preservation and management of the biodiversity. The project activities that may affect the biodiversity would include road construction, blasting and excavation for tunnels, quarrying, dumping of excavated materials, and human population pressure on the resources. These activities cannot be prevented, but they can be mitigated. The main concern is the temporary activity in the biological corridor; however, only 12-15% of the width of the biological corridor will be tied up in construction activities, temporarily (about 2 years), so wildlife will have natural options to skirt around noisy construction areas, and also move at night or use the adjacent contiguous habitat on either side for refuge and movements.

The impacts of the project that will affect various habitats and biodiversity of the project area are summarized below:

Pre-construction phase:

- Land acquisition and conversion from forest to access roads, housing/office colonies etc. that will result in permanent loss of habitat and associated biodiversity, as areas are no longer accessible or attractive to terrestrial wildlife;
- Temporary loss of habitat and associated biodiversity in the biological corridor, due to vegetation clearing and disturbance of terrestrial wildlife during construction activities; equipment in the biological corridor may inhibit wildlife movements.

Construction Phase:

- Loss of habitat and disturbance of terrestrial wildlife, avifauna and other species during construction activities.

Operation phase

- Maintenance of the transmission line corridor as a right-of-way.

In view of the various disruptive activities, the Biodiversity Conservation and Management Plan for the Nikachhu project has been framed with an objective to:

i. conserve and preserve natural ecosystems around the proposed project;
ii. minimize project impacts on rare, endangered or threatened species and rehabilitate keystone species; and,
iii. develop the information database on biodiversity at the project site.

The main elements of the plan are described below.

c) Establishment of a Biodiversity Management Committee

A Biodiversity Management Committee shall be constituted for effective implementation, monitoring and evaluation of the Biodiversity Conservation and Wildlife Management Plan for the project. The committee shall constitute representatives from the project authority, and other members from Dzongkhag and Department of Forest and Park Services, Wildlife Conservation Division, Department of Agriculture, Soil Conservation, Animal Husbandry and Fisheries (for technical advice). The committee will look after the demarcated conservation areas, monitor and enforce regulatory provisions and ensure that the structure and functions of the natural ecosystems in the area are not changed or subjected to any threat. It would also propose other approaches for the biodiversity conservation plan, whenever deemed necessary.

c. Conservation Plan for Floral Species

i. Rescue of Flora

Since the project area has a rich biodiversity, the project will aim to rescue and conserve any botanical species deemed worth conserving and cultivating for scientific and educational purposes. This is especially so for shrub species, epiphytes, medicinal plants, ferns and fungi that may otherwise be damaged during brush clearance or that may be lost by the submergence at the dam site. Prior to road clearance or construction of the dam, the Project will seek technical assistance of the National Biodiversity Centre and Department of Forests and Park Services (DoFPS). After rescue, for the conservation of floral species, it will be placed in the Botanical Garden in Thimphu, or through establishment of new one after coordination with DoFPS. This activity will take place in the pre-construction phase. Specific sites, such as the submergence area, and cleared areas for infrastructure, roads, and muck disposal, will be surveyed for this purpose.

ii. Establishment of a Botanical Garden

Establishment of a botanical garden is proposed for conservation of rare, medicinal and economically important plants found in the Nikachhu Project area. Such activity is proposed as a measure for *ex situ* conservation and propagation. The garden may be developed and maintained by the Department of Forest and Park Services in consultation with the experienced plant taxonomists of the Royal University of Bhutan/UWICE (Ugyen Wangchuk Institute of Conservation and Environment) under the Department of Forest and Park Service in collaboration with National Biodiversity Center. The location for development of a Botanical Garden shall be determined in consultation with the DoFPS. Consultations to date with Zhemgang Territorial Division, DoFPS, has indicated that a Botanical Garden for rescue and conservation of rare and endangered species at Tingtibi (Zhemgang) could cater to three projects: namely, Nikachhu HPP, Mangdechhu HPP, and Chamkharchhu-I HPP. Appropriate vegetative propagation methods will be adopted. In addition, a collection of orchids may be maintained in collaboration with the National Biodiversity Center. These gardens can be used for scientific research, conservation, education and awareness programs as well. The size, location and management of the Botanical Garden will be discussed once project approval is obtained.

d. Ensure Minimal Land Clearing and Removal of Vegetation

The project will ensure that the land acquisition process for conversion to other land uses, such as colonies, roads, etc., is as per the identified acreage and that there is no rampant clearing or felling of forest in and around work sites. Only those trees identified and marked by the Department of Forest will be felled and removed from the site

e. Rehabilitate and Restore all Cleared Sites

All temporary land acquisition areas will be restored in collaboration with the Compensatory Forestry Program, with fast growing local species of trees and shrubs to allow the area to be rehabilitated to the wild state. Rarer protected plants from the Botanical Garden and orchids from NBC can be replanted in these areas.

f. Wildlife Conservation

i. Rescue and Release Program

Land clearing may result in encounters with wildlife and birds; all wildlife encounters will be logged. A program for capturing, treating/rehabilitating, and releasing wild animals found in pain or distress, particularly as a result of human interference and project activities, will be initiated with the DoFPS. The primary goal will be to treat and rehabilitate the wildlife and release them back to the habitat from which they were collected (or safe adjacent areas). This component includes allocation of a site, design and construction of animal accommodation/ enclosures, treatment facilities and equipment for the capture, treatment and release procedures, medicines, trained manpower/veterinarian, and a caretaker, as well as a data management and record keeping system.

ii. Promote Wildlife Surveys and Monitoring in the Biological Corridor as well as the Park

This activity is aimed at adding to the existing knowledge base on wildlife presence and movements in the vicinity of the Nikachhu project. This is especially recommended so that the data collected can add to the baseline information collected during the EIA preparatory phase (adding to the seasonal data). Also, as project activities will be ongoing in the Biological Corridor, the surveys will improve the understanding of wildlife presence, distribution, movements and seasonality in the vicinity of the Nikachhu project. This will also add to the

biodiversity database especially for endangered species such as tigers, bears, leopards, and red pandas. The presence of wildlife in the Biological Corridor and near the Park will be monitored by using camera traps provided by the project. This wildlife survey in the Biological Corridor, as well as in other project areas, will be conducted by the DoFPS. Significant budgets are provided to allow the DoFPS database, staff capability, and Park interpretation initiatives to grow over the 6 years of project interventions. These will perhaps facilitate the development of a full Management Plan for the Park, which can then properly address the future protection of the Park, as well as issues related to access and development on the periphery.

g. Anti-Poaching Measures

i. Awareness Raising

With the construction of the access road to the dam and a bridge across the river from the dam site, the accessibility of humans to JSWNP will increase, which may increase the risk of poaching. At other sites too, wildlife are at risk from poaching by construction workers, so awareness raising will be an important means to mitigate this risk. Awareness will be raised among workers and contractors regarding illegal poaching and copies of the Forest and Nature Conservation Act, Rules and Regulations will be made available to them. Workers must be made aware of the fines and penalties for poaching, as well as the risk of job loss, if caught in these illegal activities. This will be done during the pre-construction phase, but after the Contractor has been selected.

ii. Strengthen Patrolling

To minimize the risks of poaching, awareness programs will be combined with an increase in patrolling by local forestry staff. To support enhanced patrolling, the project will provide assistance through purchase of equipment such as GPS, binoculars cameras, and bikes. The project will also discuss possibilities for funding a community neighborhood program, through hire of ‘risups’ or village guards to alert forestry officials of any illegal activities in the worker camps or at project sites.

iii. Build up Scientific Database

The project will provide support to the field staff of DoFPS, through provision of computers and funds to develop research and survey proposals for general biodiversity surveys, or species-specific surveys, with details of fund requirements.

h. Mitigation of Human-Wildlife Conflict

One of the pressing issues in the project area is wildlife predation on crops, which has remained an unresolved problem until now. Rats, monkeys, wild boars, and porcupines seem to be the common predators on crops. Farmers also lose livestock to wildlife as elsewhere in the country. To minimize the human-wildlife conflict, the project will also provide funds for the Dzongkhag, DoFPS, or concerned villages (whichever is most relevant) to develop a proposal for mitigation of such conflicts. This plan, once approved, will be disseminated through workshops and meetings and implemented as per the proposal. The program will be tested in one village and if successful, then it may be replicated in other villages.

Institutional Responsibilities: The Biodiversity Management Committee and THyE will determine suitable partners for each component of the program. Other potential partner implementers include;

a. National Biodiversity Centre;
b. Ugyen Wangchuck Institute for Conservation and Environment (UWICE);
c. Jigme Singye Wangchuck National Park (JSWNP);
d. Zhemgang Forestry Division, DoFPS;
e. Dzongkhag Forestry, Agriculture, Land, Environment Officers;
f. Geog Administration and Gup; and,
g. Ministry of Agriculture and Forests.

The implementation and monitoring schedule for the biodiversity conservation program is shown below.

Table 1.8 Implementation and Monitoring Schedule for Biodiversity Conservation Program

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Establishment of Biodiversity Management Committee	BMC established and operational	All phases	THyE and Nikachhu Project Management	THyE	every quarter
	Reports of meetings of BMC	All phases	THyE and Nikachhu Project Management	THyE	every quarter

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Rescue of flora	Number of floral species rescued	Pre-construction	Partner Implementer	THyE	after pre-construction phase
Establishment of a Botanical Garden	Botanical garden established and operational	Construction	Partner Implementer	THyE	every quarter
Ensure minimal land clearing and removal of vegetation	% of trees felled as per marking by forestry staff	Pre-construction	Partner Implementer	THyE	every quarter
Rehabilitate and restore all cleared sites	Number of sites restored and rehabilitated; degree of restoration	Construction and Operation	Partner Implementer	THyE	every quarter
Rescue and release program	Number of wildlife species rescued, treated and released	Construction and Operation	Partner Implementer	THyE	every quarter
Promote wildlife surveys	Number of surveys conducted	Construction and Operation	Partner Implementer	THyE	every quarter
	Number and diversity of wildlife species caught on camera traps	Construction and Operation	Partner Implementer	THyE	every quarter
Awareness raising	Number of awareness raising meetings held by project	Construction and Operation	Partner Implementer	THyE	every quarter
	Date of distribution of Acts and regulations	Construction and Operation	Partner Implementer	THyE	every quarter
Strengthen patrolling	Number of patrols carried out	Construction and Operation	Partner Implementer	THyE	every quarter
	Budget for equipment purchase handed over to Park and forestry staff	Construction and Operation	Partner Implementer	THyE	every quarter
	Number of village forest guards hired	Construction and Operation	Partner Implementer	THyE	every quarter
Build up scientific database	Number of computers given to Park/ Dzongkhag/ District Forestry Office. Receipt of research proposal from Park and transfer of research fund to park.	Construction and Operation	Partner Implementer	THyE	every quarter
Mitigation of human wildlife conflict	Proposal developed for human-wildlife mitigation	Construction and Operation	Partner Implementer	THyE	every quarter
	Implementation of pilot program	Construction and Operation	Partner Implementer	THyE	every quarter

The costs associated with wildlife biodiversity protection are noted below.

Table 1.9 Costs related to wildlife removal (over two years)

Work Item	Quantity	Unit	Rate (Nu.)	Cost (Nu.)
"On-call" staff for trapping/tranquilizing wildlife and moving them, and related expenses.	Provision for 20 x 2 yrs	Encounters/ year	25,000	1,000,000
Facilities, equipment, and staff time for handling injured animals.	-	-	-	1,800,000
Contingency for unexpected conservation measures.				1,500,000
Total				4,300,000

Table 1.10 Costs related to increased knowledge and capacity of the Forestry Staff (surveys and compliance/ enforcement measures related to the project).

Work Item	Estimated Cost (Nu.)
Establishment of Botanical Garden for rescue of rare and endangered botanical species (the site has been identified by DoFPS for Mangdechhu HPP, Nikachhu HPP and Chamkharchhu HPP for common place for in-situ conservation botanical species at Tingtibi, Zhemgang).	6,700,000
Promotion of ecotourism and birding in areas opened up by the project.	2,550,000
Increased and improved patrolling by Park and forestry staff. (computers, equipment, motorbikes, extension kits, etc.)	2,050,000
Augmentation of baseline surveys and ongoing biodiversity surveys (aquatic, plants, bird and mammals) (camera traps, related costs)	1,500,000
Mitigation of human/ wildlife conflicts	3,000,000
Total	**9,770,000**

i. Compensatory Afforestation to Mitigate Effects of Habitat Loss

The Bhutan Guidelines on Compensatory Afforestation will be followed to ensure a systematic approach to rehabilitation and afforestation so that the Country's commitment to retaining a minimum of 60% forest cover for all times to come can be achieved. In order to ensure that a successful afforestation and conservation program is achieved, the Nikachhu Project Management will collaborate with the Department of Forest and Park Services.

As per the Social Forestry Norms currently being applied under the Punatshangchhu, Tala, and Mangdechhu Projects, for every hectare of land deforested by a project, compensatory afforestation of double the size of land is recommended. After detailed surveys for the Nikachhu project, it has been estimated that the total affected land due to project construction would be 312.17 acres (about 126 ha) including the right-of-way for 33kV transmission Line for Construction Power, of which only 3.577 acres (1.45 ha) belongs to private owners; the rest falls in State Reserved Forest Land. Therefore, the total area that will be afforested is 624.34 acres (252.66 ha).

Another key feature of compensatory afforestation is that it should firstly focus on deforested areas in and around the project site, but it should not be restricted to project areas if enough sites are not available; it should extend to other areas within the vicinity of project area. The program will also focus on barren areas that are located in the upper catchment, so that erosion can be minimized and the quality of water going into the reservoir maintained.

After developing a mutually agreeable project proposal between the DoFPS and the project authority, the Memorandum of Understanding (MoU) shall be drawn covering project activities for financing and execution.

Priority areas for replanting that have been identified to date include:

- areas as suggested by the Local Forest Officers and the local community, such as:
    1. Drangla Community Forest (CF, 25 ha);
    2. Nyala CF (25 ha);
    3. Tangsibji CF (45 ha);
    4. Tshangkha CF (30 ha);
    5. Kella Langbro CF (10 ha); and,
    6. Kella Cherub CF (15 ha).
- catchment areas, such as areas near Sephu, and degraded areas above Tshangkha, where there is recent forest fire damage.
- along the national highway.
- edges and slopes of access roads.
- muck disposal sites.
- around the quarry site.
- around permanent residential and office colonies.
- the green belt area near the worker colonies, and near the dam site.

- other barren areas (characterized by overgrazing, forest fire damage, or tree felling).

The choice of species shall be decided by the implementing agencies based on the climatic and edaphic conditions of the locality, ensuring composition of different species (trees and shrub) for successful growth. Species composition selection will be important in ensuring diversity of species, and habitats for wildlife and avifauna. Some of the trees species that can be reviewed for plantation are presented in the following table.

Table 1.11 Tree species that can be found growing in the project area and that can be used for plantation (seeds should be collected from locally available trees).

Species	Seed Collection*	Sowing*
Acer campbellii	*Nov-Dec*	*Mar-Apr*
Alnus nepalensis	*Dec-Mar*	*Mar-Apr*
Betula utilis	*Aug-Oct*	*Jan-Mar*
Betula alnoides	*Oct-Feb*	*Nov-Mar*
Carpinus verminea	*Jul-Oct*	*Feb-Mar*
Castanopsis hystrix	*Oct-Mar*	*Dec-Jan*
Castanopsis tribuloides	*Nov-Jan*	*Mar-Apr*
Cinnamomum camphora	*Sep-Nov*	*Feb-Mar*
Cinnamomum glaucescens	*Oct-Nov*	*Mar-Apr*
Daphnephyllum himalense	*Nov-Dec*	*Jan-Mar*
Eleacarpus sp.	*Nov-Feb*	*May-Jun*
Erythrina arborescens	*Jun-Aug*	*Apr-Jun*
Exbucklandia poplunea	*Dec-Mar*	*Mar-Apr*
Juglans regia	*Sep-Dec*	*Feb-Mar*
Michelia champaca	*Jul-Aug*	*Jul-Aug*
Michelia doltsopa	*Aug-Sep*	*Sep-Oct*
Queruc griffithii	*Nov-Feb*	*Feb-Mar*
Quercus lanata	*Nov-Dec*	*Feb-Mar*
Quercus lamellose	*Oct-Dec*	*Feb-Mar*
Quercus semicarpifolia	*Jun-Aug*	*Jul-Aug*
Rhododendron arboretum	*Aug-Mar*	*Mar-Apr*
Schima wallichii	Jan-Apr	Apr-May
Sauruaia nepalensis	Mar-Apr	Mar-Apr

**Collection and sowing information derived from the 'Norms and Standards for Nursery and Plantation (2008), Social Forestry Division, Department of Forest, Ministry of Agriculture, Bhutan.*

Currently, Zhemgang Forest Division under the Department of Forest and Park Services has established a nursery at Tingtibi to cater to seedlings for the Chamkharchhu and Mangdechhu Projects. It may be possible for the Nikachhu Project to use the same nursery. Therefore, at this point, the need to develop a nursery just for the project is not envisaged.

As a general rule of thumb, each afforestation hectare costs about Nu. 90,000 to develop (see the table below for a breakdown of costs). In this case, per hectare costs are slightly higher.

Table 1.12 Expected costs for replanting trees for the Nikachhu project.

Particulars	Cost/ha (Nu)
Purchase of seedlings and other materials	
Cost of seedlings (@Nu.10 per seedling)	10,000.00
Purchase of fencing post from NRDCL	10,000.00
Cost of Barbed wire	21,280.00
Cost of U nails, nails	800.00
Cost or preservatives	1,000.00
Cost of sign board	8,000.00
Labour costs	
Site survey	330.00
Site clearance	3,300.00
Alignment and staking	1,320.00
Pit digging for planting	6,600.00
Planting of seedlings	4,455.00
Dressing of post	660.00
Application of Preservatives	660.00
Pit digging for posts	1,650.00
Fixing and stretching of barbed wire	3,300.00
Transportation Costs	
Carriage of seeds to truck and loading and unloading	660.00
Mechanical transportation of seedlings	5,000.00
Manual carriage of seedlings from road head to planting sites (1km distance)	1,815.00
Mechanical transportation of barbed wire, nails	2,000.00
Mechanical transportation of fencing posts	4,000.00
Manual carriage of fencing posts from road head to site (1km)	1,650.00
Maintenance cost	
Monitoring and maintenance of replanted areas	20,000.00

Particulars	Cost/ha (Nu)
Total cost per Ha	**108,480.00**
Grand Total Cost (240 ha)	**26,035,200.00**

The estimated cost for Compensatory Afforestation for the project per ha is Nu. 108,480. Since the total area to be reforested is 624.34 acres (252.66 ha), the total cost of compensatory afforestation is Nu. 26,035,200.

Implementation

The Territorial Divisions, Parks, Dzongkhag Forestry Sector and the Project Authority shall be responsible for planning and implementation of afforestation activities, based on the MOU drawn between DoFPS and the Social Forest Division, in particular. The Social Forestry and Extension Division will be the focal agency for all the technical matters, including need-based monitoring and evaluation from the headquarters and reporting of these to the Nikachhu Project Management

Monitoring

Monitoring will be very important for assessing the success of plantation and rehabilitation works. There will be three tiers of monitoring: (i) regular monitoring by the implementer; (ii) ad hoc monitoring by the department; and, (iii) joint monitoring by three agencies (implementer, department, and the project authority). The monitoring protocols will be outlined in the MOU.

The Social Forestry Division will submit a report to the THyE every six months regarding the progress of the Compensatory Afforestation Program, as well as an annual report. At the end of each year, the two Agencies will jointly review the progress of the program and propose any new mitigative or additional measures that may be required to improve the program. These details are summarized below.

Table 1.13 Nikachhu afforestation activities.

Activities	Period	Responsibility for Implementation	Monitoring
Preparation of MOU and discussion	Pre-construction	THyE, SFD	THyE, SFD
Signing of MOU	Pre-construction	THyE, SFD	THyE, SFD
Delegation of responsibilities	Pre-construction	THyE, SFD	THyE, SFD
Site selection	Pre-construction	THyE, SFD	THyE, SFD
Preparation of work program as per sites selected	Pre-construction	SFD,TD,PM, DFO	THyE, SFD

Activities	Period	Responsibility for Implementation	Monitoring
Selection of nurseries/nursery development	Pre-construction	SFD,TD,PM, DFO	THyE, SFD
Purchase of materials and seedlings	Pre-construction	SFD,TD,PM, DFO	THyE, SFD
Afforestation	Construction	SFD,TD,PM, DFO	THyE, SFD
Monitoring	Construction and Operation	THyE, SFD	THyE, SFD
Evaluation and review of program	Construction and Operation	THyE, SFD	THyE, SFD

Preparation of tree seedlings/ saplings for re-vegetating exposed slopes requires some "upfront' work to prepare the nursery. The schedule for this activity is shown below. Year 1 should be considered to be the first full year of pre-construction, so that planting can proceed in the second year of construction (Year 3 in the table below). Year 1 is 2015.

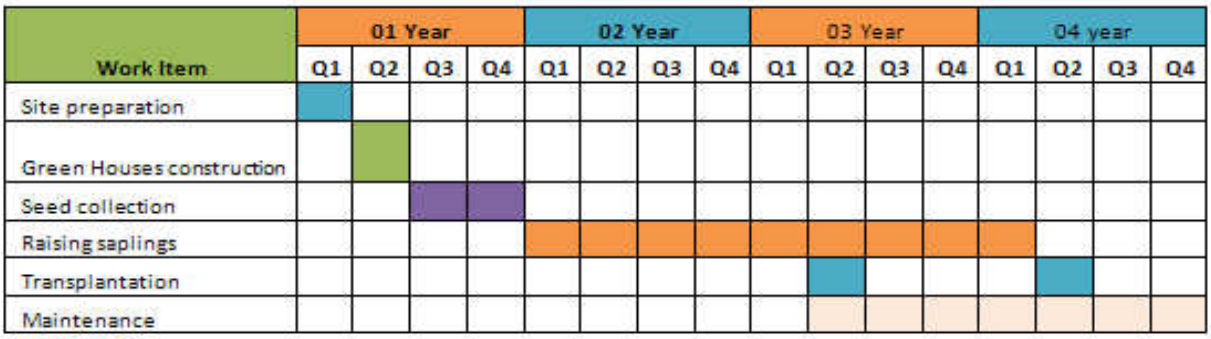


Table 1.14 Schedule for preparing nursery

The engagement of the Park and Forestry staff in the conservation activities related to land clearing and follow-on activities is shown in the schedule below:

Table 1.14 Land clearing activities

Action	Year
Rescue of rare and endangered botanical species	
Collaboration with partners (NBC/DoFPS) and develop plan of action	Year 1, Pre-construction period
Survey of selected sites	Year 1, Pre-construction period
Collection of species and replanting at NBC or selected site in Trongsa	Year 1, Pre-construction period
Promotion of eco-tourism activities	Year 2
Consultation with DoFPS on activities and locations to implement the budget	Year 2

Action	Year
Requisition and implementation schedule to be finalized	
Release of budget and implementation of activities such as development of birding and hiking trails, signage, campsites, education and awareness programs	Year 2-3
Capture, Treat/Rehabilitate, and Release program for any wildlife	Year 1
Consultation with DoFPS on how to implement this activity	
Proposal submitted by DoFPS to NHPP, review, discussion and consensus on approach	
Construction of infrastructure to keep the wildlife	
Purchase of equipment, medicine	
Training of manpower	
Implementation of program	
Maintenance of program for at least 5 years	
Enhance their Biodiversity database	
Develop research and survey proposal for general biodiversity survey, or species specific survey with details of fund requirement	
Purchase of equipment such as camera traps, binoculars, gps and other survey equipment	Year 1 and Year 2
Conduct surveys each year so that trends in biodiversity can be monitored	Every year
Capacity building and training for forestry staff in biodiversity survey methodologies, conservation, rehabilitation, human wildlife conflict resolution, afforestation	
Augment baseline surveys by conducting seasonal surveys	Year 1
Increased and improved patrolling by Park and forestry staff	Year 1,2 & 3
Provide equipment and funds for improved patrolling	
Provide funds to develop a community neighborhood watch program	
Implement program	
Mitigation of human/ wildlife conflict	Year 1,2 & 3 DoFPS and concerned Gewogs
Develop a proposal to mitigate human/ wildlife conflict	
Conduct workshops and meetings	
Implement the proposal as a case study for replication in other geogs if successful	
Land management campaigns	Year 1,2,3 until the end of project period
Identify sites for implementation of land management campaigns by DoFPS	
Procurement of materials	
Conduct meetings, workshops, awareness programs	
Implement the campaign and pay for labour	

Action	Year
Yearly maintenance and monitoring of sites	
Compensatory afforestation	Until the end of project period
Revegetation of the slopes on sides of the reservoir with fast growingt local species	

1.2.1.3 Environmental Plan for Labour Camps

All concerns associated with a worker influx and development of the worker camps need to be addressed with good planning and suitable mitigation measures; this has been done for other infrastructure development projects in Bhutan and appropriate experience and procedures are now in place, which helps with the process for the Nikachhu project. Various elements related to the worker camps are described below.

During the construction phase of the Nikachhu project, it is envisaged that about 2,000 labourers from outside the project site and about 80 technical staff will be accommodated on and near the project site. Labourer (worker) camps will therefore be required to be set up during the latter part of the pre-construction phase. These will have to be designed to accommodate residential and office units, drinking water, electricity, fuel storage, and waste management, most of this on a temporary basis. The environmental plan for the labourer camps therefore includes:

1. House for workers
2. Provision for facilities for drinking water and electricity
3. Sanitation and sewage treatment
4. Closure and restoration of the camp sites

a. Housing for Workers

Temporary colonies will be built for the workers, rather than relying on commercial enterprises in Trongsa District providing these facilities. However, in the initial pre-construction and contruction stage of the project, some houses available within the project locality may be hired to provide office and transit camp facilities for the project.

The worker camps will be located away from the local communities; this relative isolation of the worker camps quite far away from local communities will help to minimize an overloading of worker-local community interactions, which should help reduce social and cultural conflicts, as well as the risk of spread of communicable diseases.

Project housing will be segregated into permanent and temporary types. Prior to beginning the construction works, the general layout of the labour camps at each construction site will be designed and approved by the Project Management. This will allow planning for location of important structures such as drinking water storage tanks or taps, the location of communal kitchens, and the location of community toilets (as far away from watercourses as possible). Labourer accommodation will be provided with electricity and proper ventilation.

b. Provision of Facilities for Drinking Water and Electricity

As noted previously, it is estimated that about 2,000 workers will be deployed at various locations during the peak construction period. According to the World Health Organization (WHO), 50 to 100 liters of water per person per day is needed to ensure that the most basic needs are met and few health concerns arise. Accordingly, the water requirement at each location for drinking and washing is given in the table below, followed by the source of water for each project location. Water will be supplied through GI water pipes of diameter 40 mm, 50 mm and 65 mm.

Table 1.15 Location of project water requirements.

Location	Number of Workers	Water Requirement (litres/sec)
Dam area including Coffer Dam and Diversion Tunnel	200	0.116
Intake	50	0.029
Desilting Chamber	150	0.087
Adit 1 and HRT	200	0.116
Adit 2 and HRT	200	0.116
Adit 3 and HRT	200	0.116

Adit 4 and HRT	200	0.116
Adit 5 and HRT	200	0.116
Surge Shaft	150	0.087
Pressure Shaft	150	0.087
Power House, TRT	300	0.174
Total	**2,000**	**1.157**

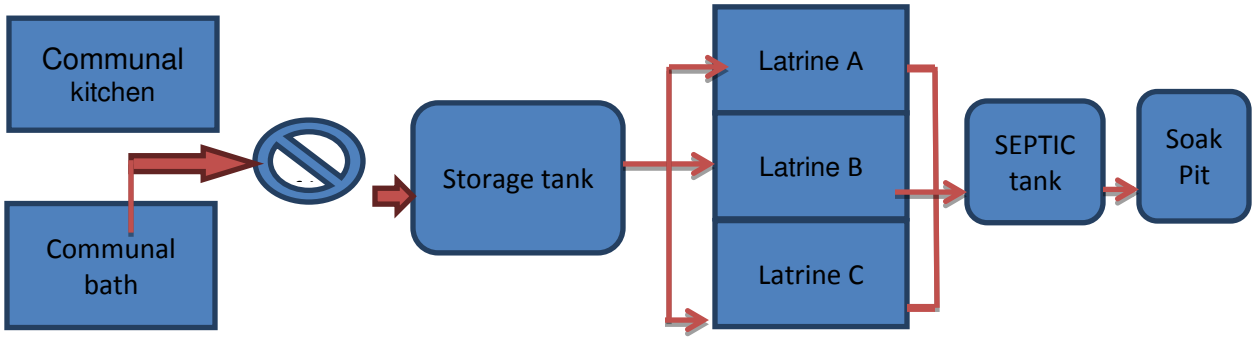
Table 1.16 Source of project water.

Worker Camp	Source of Water
Labour Camp at Dam and Adit 1	Nyalalumchhu
Adit 2 labour camp	Banglachupa
Adit 3 labour camp	Zalamchhu
Adit 4 labour camp	Gongkhorchhu / Shau Chhu
Labour Camps for Adit 5,Surge Shaft, and Power House	Gongkhorchhu

All worker camps will be electrified by trained electricians, drawing power from the source required for the overall project

c. Sanitation and Sewage Treatment

The use of communal kitchens and communal toilets will help to reduce both the demand for fuel and water, and minimize pollution (by allowing centralized wastewater treatment). Grey water from the kitchens and bathrooms may be passed through a pipe to a storage tank. Before it is taken to the storage tank the grey water will be filtered to remove large particles such as food and hair, so that the pipes are not blocked.



From the storage tanks, the water will be passed onto the latrines to be used for flushing the toilets. This allows for re-using the water twice, as well as ensuring that the wastewater is directed towards a central septic tank rather than allowed to overflow into the neighbourhood. The filters will need to be cleaned regularly. Also, the sludge that forms at the base of the storage tank will be removed at regular intervals (such as every three or six months depending on the accumulation). Re-using the water twice will also reduce the burden on freshwater required for the toilets. Also, community latrines will ensure that all the sewage can be treated in nearby septic tanks with a soak pit.

The construction of a central Sewerage Treatment Plant is not feasible, since eventually the number of workers during the Operation and Maintenance stage of the project will be only 67, versus about 2,000 plus and 80 technical staff during the peak construction phase.

d. Closure and Restoration of Camp Sites.

Once the project construction is over, all temporary camp sites must be restored as close as possible to their natural state. To do this, all structures must be dismantled/ demolished and construction materials and all debris removed from the site. All septic tanks and soak pits will be covered with an adequate amount of soil. Cleared land will be re-vegetated with fast growing local species of trees and shrubs. This will allow regeneration and prevent animals from grazing on the saplings. This must be the responsibility of the Contractor. The other option is to hand over the site to be restored under the Compensatory Afforestation program (if these sites are suitable and have higher value as habitat than alternative sites).

Institutional Responsibilities: Environmental Unit of THyE will manage the contractors and sub-contractors, who will in turn develop the worker camps, and who will be responsible for their own workforces. All workers will, in turn, through their own contract covenants, be responsible for their own behavior and committed to meeting behavioural expectations, subject to the conditions of their contracts. The design and management of the camps and work sites will be fundamentally important to proper management of possible social and environmental issues associated with a worker influx.

Monitoring will include visual inspections of the camps and work sites by THyE staff (Environmental Unit), backed up with water quality monitoring in the Nikachhu. Any issues between workers and local communities will be logged and tracked for resolution/follow-up by

THyE staff, copied to the respective contractors. Monitoring costs will be absorbed within the operational budgets of THyE and contractors.

Monitoring Plan.

Table 1.17 Monitoring Plan

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Housing for workers	Appropriate design and location of worker housing	Pre-construction and Construction	Contractor and Project Management	THyE	Twice a year
Provision of facilities like drinking water and electricity	Good, stable availability of drinking water and electricity	Pre-construction and Construction	Contractor and Project Management	THyE	Every quarter
Sanitation and sewage treatment	Availability of sanitation and sewerage facility	Pre-construction and Construction	Contractor and Project Management	THyE	Every quarter
Restoration of worker camps to their natural state	Worker camps restored	Operation phase	Contractor and Project Management	THyE	Every quarter

Scheduling and Pacing: Temporary and permanent worker camps will be built in the first year of the project, as soon as access roads are in place.

Budget: all costs for worker and worker camp budgets will fall within the project construction budget. Restoration of worker camps must be included under the Contractor's cost, or included in the green belt development or compensatory afforestation (see other sections). Enhancement of the permanent staff colony conditions, to reduce risk of erosion (maintaining trees and planting greenbelts), and to beautify the site for proper integration into the surrounding landscape, has an additional cost, noted below.

Table 1.18 Costs related to site enhancement at the permanent staff colony.

Work Item	Quantity	Unit	Rate (Nu.)	Amount (Nu.)
Transportation of excavated materials	61,717	m^3	40	2,468,680
Landscaping and beautification	148,120	m^2	25	3,703,000
Tree plantations	1,234	tree	150	185,100

Work Item	Quantity	Unit	Rate (Nu.)	Amount (Nu.)
Tree guards	2,962	tree	100	296,200
Maintenance	30	month	30000	900,000
Total				7,552,980

1.2.1.4 Solid Waste Management at Offices, Colonies and Worker Camps

About 2,000 workers will be deployed during the peak construction of the Nikachhu project, which may double the solid waste volumes currently produced. The source of the waste will be from the temporary colonies of labourers, site offices, and construction sites. The wastes will be mostly PET bottles, paper, plastics, glass, organics, metal, etc. Improper segregation and dumping of waste will result in negative impacts, such as visual aesthetics, as well as increasing health risks for all staff and workers.

As per the Waste Prevention and Management Act 2009, all implementing agencies will ensure that the reduction, reuse, recycling, and disposal of non-hazardous waste are addressed in an environmentally sound manner.

The project will aim for the following in waste management

a. **Waste Reduction**: this will be done through use of electricity instead of firewood, provision of drinking water instead of promoting use of water bottles (in offices and residences).
b. **Waste Reuse**: The project will promote the reuse of large plastic containers, jars and bags wherever possible in worker campsites. Tires can be used to make large flower pots and offices can reuse office paper.
c. **Waste Recycling**: Organic waste will be recycled to make compost. Each worker camp and office colony will have a composting bin, or a compost site shall be identified and suitably located at all worker sites. This will be developed in collaboration with Dzongkhag Administration, Trongsa and Department of Agriculture (Ministry of Agriculture and Forests). The costs for operation of the compost site and its maintenance will be covered by the Project until the operation period (after which the huge reduction in workers will decrease organic waste production significantly), but maintenance and operation will be done by locals, who can benefit from the compost produced.
d. **Waste segregation for recycling**. Each site (including offices, colonies, and worker camps) will be provided with 3 separate bins for: a) plastics and bottles; b) paper; and c)

organic waste. At the end of each week/fortnight, recyclable materials like plastics, bottles, paper, and metals, and e-waste, can be sent via the project vehicle to recycling facilities, where they can be further processed and recycled.

e. **Waste disposal**.

f. Only waste which cannot be reused or recycled will be disposed. Currently MHEP is in the process of developing a Landfill in collaboration with the Dzongkhag Administration. The same Landfill could be used by Nikachhu Hydropower Project for the disposal of solid waste only. A waste collection protocol will be established for each site so that waste does not pile up, causing problems to the environment or workers.

.

g. **Awareness**. The biggest cause of improper waste management is lack of awareness of waste and waste management. The project will conduct awareness meetings and campaigns through posters to make workers aware of the "3Rs" (Reduce, Reuse and Recycle). Public awareness and education on waste management will also be initiated with the Geog Tsogdue and interested locals shall be encouraged to collect paper, bottles, PET bottles, plastics and metal which can be sold to recycling agencies or to scrap dealers.

h. **Promotion of Druk Green's Being Green Initiative**. DGPC has started off with the Being Green Initiative; an advocacy program to protect river catchment areas and improve waste management. One of the programs under this initiative is the Race against Waste program, in which schools participate in waste collection and they are awarded with cash prizes, both from Druk Green and Greener Way, depending on the amount of waste collected. Such initiatives can be replicated in the project area to spread awareness among local school children and their parents to reduce waste (especially in Tangsibji village which is nearby).

i. **Site inspections**. Monitoring of waste management at all sites will include visual inspections of the camps and work sites. This will be conducted by THyE.

j. **Collection and compilation of data on waste generation and management**. The Environment Unit of THyE will compile all reports from site inspections and surveys to generate data on waste generation and management.

As noted above, the organic wastes shall be dumped in a composite yard and yard shall be selected based on following criteria: avoiding dense forests, environmentally sensitive areas, and geologically sensitive areas near faults, landslides, or wetland areas. The chosen area will

be acceptable to the nearby community and also accessible enough to keep transportation costs to a minimum. Generally, the following distances will be maintained:

- between 15 m and 50 m from any property boundary, of which the 15 m closest to the boundary must be reserved for natural screening;

- minimum of 300 m from residences, water supply sources, water intakes, hotels, restaurants, food processing facilities, schools, monasteries, or public parks;

- minimum 100 m from the nearest surface water; and,

- minimum 100 m away from an unstable area.

The design of the new Trongsa landfill must ensure minimal environmental impacts and risks in itself, and ensure compliance with any criteria issued by NEC. This design must also be approved by the Dzongkhag Environmental Committee/NEC and must be located at least 1.2 m above the seasonal high water table, must include details of intermediary cover, final cover, leachate management, gas venting or recovery requirement, access road, fencing, signboard, waste compaction and covering, operation and maintenance plan, and a final closure plan. THyE will assist this process by accurately estimating its solid waste volumes for different categories of waste over the project period.

Budget

The budget for project waste management is noted below.

Table 1.19 Budget for Waste Management

Work Item	Quantity	Unit	Rate (Nu.)	Amount (Nu.)
Provision of waste bins at all worker sites for waste segregation	100	Number	2,000	200,000
Transporation of waste to landfill	300	Trip	1,000	300,000
Creation and operation of composting site	4	Number	100,000	400,000
Set-up and cleaning of septic systems				500,000
Awareness programs regarding waste	8	Number	50,000	400,000
Druk Green's Being Green Initiative in schools	4	Number	20,000	80,000
Landfill study in collaboration with MHEP, Dzongkhag and contribution to solid waste management	-	-	-	2,600,000
Total				**4,480,000**

Monitoring Plan

The monitoring plan for project waste management is noted below.

Table 1.20 Monitoring Plan for Waste Management

Activity	Indicators	Period	Responsibility	Monitoring	Frequency
Waste reduction	Amount of plastic containers, jars, tires being reused	All phases	Project Management	THyE	Establishment of each site
Recycling	Amount (kg) of material being recycled each month	All phases	Site supervisor	THyE	Establishment of each site
Waste segregation	Number of bins distributed at each site. Use of bins for different types of waste.	All phases	Site supervisor	THyE	Establishment of each site
Awareness programs for workers	Number of posters printed and distributed. Number of awareness meetings	All phases	Project management	THyE	Every quarter
Druk Green's Being Green Intiative	Results of school participation	All phases	Project management	THyE	Twice a year
Site inspections	Number of site inspections and reports	All phases	THyE	THyE	Every quarter
Maintain database	Availability of information on waste at project sites	All phases	THyE	THyE	Every quarter

1.2.1.5 Project Water Supply System

The various project components are located in an area stretching from the diversion inlet to the TRT outlet. A residential area is also planned at the dam site. During the construction stage, apart from the permanent quarters, temporary colonies will be constructed at the dam area, powerhouse, and surge shaft to accommodate the manpower required for the construction. For the quarters and office space required for the powerhouse during project operation, it is planned that the project will use the Mangdechhu project dam area infrastructural facilities. Apart from the colonies and office facilities for the client, labour camps and site offices are planned to be established at various locations to support the contractors' manpower. Arrangements for clean potable water are to be made for all these places, including the construction sites. For the purpose of providing clean and potable water, several streams have been identified as the main possible sources (see below).

Table 1.21 Water Supply Sources

Name of Stream	Project Components Using the Water Supply Source
Nyalalumchhu and Khangkhangme Chhu	Water requirement for dam site colony & Adit 1 to HRT can be met from this stream. However, if there is a shortage, the water from Khangkhangme can address the deficiency.
Banglachhupa	Water requirement for contractor's colony at Adit 2 to HRT can be met from Banglachhupa.
Tsheringma Drupchhu and Zalamchhu	Water requirement for contractor's colony at Adit 3 to HRT can be met from the Zalamchhu alone. However, Tsheringma Drupchhu can also be a good source of drinking water for the colony.
Shauchhu/Gongkhorchhu	The water requirement for contractor's colony at Adit 4 to HRT can be met from this stream. Similarly, the water requirement for Contractor's Colony as well as temporary Project Colony at Adit 5 to HRT, Surge Shaft and Powerhouse can be met from this stream.

a. Water Supply System

During the construction of the project, water will be required for the following main purposes:

i. Drinking and washing by the laborers;
ii. Sprinkling on the roads to suppress dust;
iii. During construction, involving drilling, grouting, shotcreting, concreting, and curing.

i. Water utilization for drinking and washing

It is estimated that about 2,000 workers will be deployed at various locations during the peak construction period. According to the World Health Organization (WHO), 50 to 100 liters of water per person per day are needed to ensure that most basic needs are met and few health concerns arise. Accordingly, the water requirement at each location for drinking and washing is given in the table below.

Table 1.22 Estimated water requirement at each location.

Location	Number of Workers	Water Requirement (litres/sec)
Dam area including Coffer Dam and Diversion Tunnel	200	0.116
Intake	50	0.029
Desilting Chamber	150	0.087
Adit 1 and HRT	200	0.116
Adit 2 and HRT	200	0.116

Location	Number of Workers	Water Requirement (litres/sec)
Adit 3 and HRT	200	0.116
Adit 4 and HRT	200	0.116
Adit 5 and HRT	200	0.116
Surge Shaft	150	0.087
Pressure Shaft	150	0.087
Power House, TRT	300	0.174
Total	**2,000**	**1.157**

ii. Water utilization for sprinkling on roads to suppress dust

It is proposed to use the water tanker of 10,000 litres capacity at various project sites to reduce dust. The estimated water requirement at each location is given below.

Table 1.23 Water requirements for sprinkling on roads.

Locations	Length of Road (km)	Number of Times per Day	Number of Tankers	Water Requirement (litres/sec)
Dam Complex	2.1	2	1	0.231
Adit 1 and HRT	2.278	2		0.231
Adit 2 and HRT	1.973	2	1	0.231
Adit 3 and HRT	1.943	2		0.231
Adit 4 and HRT	0.577	1		0.116
Adit 5 and HRT	0.417	1	1	0.116
Surge Shaft	1.5	2		0.231
Powerhouse complex	5.9	2		0.231

iii. Water utilization during construction involving drilling, grouting, shotcreting, concreting and curing

During the construction stage, water will be required for various activities like drilling, grouting, shotcreting, concreting, curing, etc. However, most of the above activities are carried out in sequence, which means the water requirement is not utilized at the same time by all the activities. For example, in the tunnel, the activities like drilling, grouting, shotcreting, concreting and curing are carried out in series during different periods of time. The water utilization by each of the activities in the tunnel has been estimated below.

Table 1.24 Water requirements for various activities in the tunnel.

Details	Unit	Values
Boomer M2D for drilling		
Pump capacity	litres/min	250
Water consumption as per specification of the Boomer	litres/s	1.1
water consumption in two faces	litres/s	2.2
Grouting		
Pump capacity asper tech. specs	litres/min	150
% of water in cum grout mix	%	85%
Water consumption in two faces	litres/s	4.25
Shotcreting		
Capacity of Shotcrete machine as per tech. specs	m^3/hr	16
water utilisation for mix	m^3	0.18
water utilisation for 2 faces	litres/s	1.6
Concreting		
Progress per month as per DPR	m	143
Progress per day	m	24.00
Diameter of tunnel	m	4.50
Thickness of concrete	mm	300.00
Quantity of Concrete per m length	m^3	19.09
Quantity poured per day	m^3	458.04
W/C ratio		45%
Cement in one cum of concrete (1:1:2)	m^3	0.25
water in 1 cum of Concrete	m^3	0.11
Water required	litres/s	0.5964
Curing (in 100% of concreting)	litres/s	0.5964

From the data above, it is seen that the maximum water will be required during grouting compared to other activities and therefore for the purpose of estimation, the water required for grouting will be taken into account.

Similarly, during the construction of the dam, the maximum water will be required during the concreting and curing as given below.

Table 1.25 Water requirement for concreting and curing of dam.

Details	Unit	Values
Concreting of Dam		
Capacity of batching machine	m^3/hr	60

Details	Unit	Values
Cement in one cum of concrete	m^3	0.25
W/C ratio (45%)	m^3	0.1125
Water required per m^3 of concrete	litres	112.50
Volume of water required	m^3/s	0.001875
Curing (100% of concreting)	m^3/s	0.001875

b. Source of water and maximum water utilization

The source of water supply for the dam area, Adit 1, Adit 2 and Adit 3 has been identified from the tributaries of the Nikachhu. For Adit 4, Adit 5 and Surge Shaft, Pressure Shaft and Powerhhouse Complex, the water supply source has been identified from Gongkharchhu, which is a tributary of Mangdechhu. The details of source of supply, pipe length and total water requirement from each source is given below.

Table 1.26 Details of water source and % water utilized.

Components	Source of Supply	Approx. Pipe Length for Water Supply (km)	Water require-ment in litres/sec	Minimum water available at source in litres/sec	% of Water Utilised
Dam & Adit 1	Nyalalumchhu	2.23	5.06	73.46	6.89%
Adit 2	Banglachupa	0.25	4.60	66.45	6.92%
Adit 3	Zalamchhu	0.41	4.60	121.09	3.80%
Adit 4	Gongkhorchhu / Shau Chhu	0.35	4.48	**84.10**	**21.73%**
Adit 5	Gongkhorchhu	2.78	4.48		
SS and BVC	Gongkhorchhu	1.56	4.57		
PS, PH and TRT Area	Gongkhorchhu	1.20	4.74		
Adit 4, 5, SS and BVC, PS,PH, and TRT			**18.27**		

For Nyalalumchhu and Banglachhu, presently, the water is not used upstream or downstream. The water source for Adit 3 is Zalamchhu. The water from Zalamchhu is presently being used for drinking water for Tansibji village and 30 kW Micro-hydel. For both purposes, water is tapped upstream of the proposed source for Adit 3. The elevation at the Intake of Tangsibji Micro-hydel is 2,284.8 m, while the invert level of Adit 3 is at 2,230 m, which is downstream of the intake location of micro-hydel. Similarly, there are no downstream users for Gongkhorchhu.

The water requirement calculated above is the maximum water required. It is pertinent to mention here that about 50% to 60% of the estimated water requirement for the project will be discharged back to the stream as wastage.

Institutional Responsibilities: THyE and selected contractors will be responsible for sourcing water for drinking and various construction work.

Performance Indicators and Monitoring Requirements: The main indicator of effective water supply management is provision of adequate water for all purposes, through sourcing, while maintaining supply and conservation of the streams and tributaries

Scheduling and Pacing: Water sourcing will begin at the pre-construction phase, continue throughout the first three years of the project construction phase and reduce drastically as major construction activities are completed. Water supply and maintenance will then only remain for those colonies used during the operation phase.

Budget: Water supply and sourcing will be included in the overall project budget. The budget for routine monitoring of streams and incidences of illegal activities will be included within the overall Environmental Monitoring Program.

Table 1.27 Water Supply Management and Monitoring.

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Sourcing of water	Number of tributaries/streams sourced Number of incidences of water shortage	Pre-construction	Contractor and project management	THyE	At the start of the project
Maintenance of water supply system	Number of repairs and maintenance of water supply	Pre-construction and construction	Contractor and project management	THyE	Every quarter
Conservation of water sources	Number of incidences of illegal use of streams such as washing of cars	All phases	Project management	THyE	Every quarter

1.2.1.6 Construction Equipment Mobilization Plan

Mitigation Measures: Most construction equipment and trucks (with the exception of those working the quarry run) will be located on the access roads and at the work sites (and most of these will be mobilized in the construction phase). Up to 150 trucks may be required, when in full construction mode. The actual location of construction equipment, most of the time "off road", is an important mitigating factor, in terms of reducing risk of accidents, limiting the exposure of local communities to noise and dust, and reducing the negative visual impact of construction equipment in such a pristine environment. To help reduce traffic snarls and risk of accidents, signs will posted at frequent intervals along the National Highway, and flag persons can be used for areas that may be congested with project construction equipment (working from 8 a.m. to 6 p.m., at the beginning and end of each narrow section, equipped with radio communication to control the traffic; this will allow smooth passage of traffic).

There will also be a concerted effort at the beginning of the project to upgrade parts of the National Highway that will be used by project vehicles, so that narrow sections and blind curves (so-called "chokepoints") do not create a high accident risk. Vertical height from the road bed will have to be at least 6.2 meters. All of this can be well-planned, with suitable analysis of the existing highway and proper sequencing of tasks, to be undertaken by THyE and Department of Roads. There will also be provision for making repairs to the National Highway (at the end of the construction phase) that may be required as a result of damage caused by project vehicles and equipment.

With regard to mitigation of dust, vehicle emissions, and noise, standard procedures are already in place in Bhutan, including the topical water spraying by trucks every two hours (without over-watering and creating muddy areas). Workers will be required to wear face masks in particularly dusty areas, where construction equipment is working (and will wear ear plugs at noisy locations). Vehicle emissions and noise from equipment can be mitigated to some extent by the use of mufflers and emission control devices, which would be required to meet vehicle standards in Bhutan, in any case. Luckily, as noted before, most construction equipment will be working well away from local communities, which will therefore not be frequently exposed to these nuisances. Waste oil from project vehicles will be collected at vehicle work stations and sent for recycling (as is done now with waste oil from Trongsa).

Construction equipment will be required to make the access road and prepare the muck disposal area in the biological corridor. These activities cannot be prevented. However, as noted before, only 12-15% of the width of the corridor will be tied up in construction activities, temporarily (about 2 years), so wildlife will have natural options to skirt around noisy construction areas, and also move at night, which would reduce concern for interactions between construction equipment and wildlife within the corridor. Any animals that are encountered near construction equipment will be captured and moved, if practical, or at least given a chance to make an escape from the work area. All encounters with wildlife and larger birds will be logged.

The objective of managing construction equipment is to minimize the environmental as well as health impacts associated with mobilization of construction equipment. Specific points in the construction equipment mobilization plan include the following:

a. Works shall be located well away from local communities (so, minimal disturbance from noise, dust, emissions). This will be identified by the Project Engineer and the Contractors who will be responsible for the operation of their vehicles and their movement on public roads. Machinery will be moved from one place to the other during off peak traffic hours (either early morning or late evenings);

b. Project Engineers will check all machinery prior to operation to ensure that these meet the regulations and standards for noise and vehicle emissions. If machines are too old and emit higher than allowable noise and air emission standards, the contractor will be required to change these;

c. Contractors will ensure that Occupational Health and Safety regulations are followed (mentioned elsewhere);

d. Machinery to be operated near local communities will be used only during the period 7 a.m. to 7 p.m., to avoid disturbing wildlife and humans;

e. Noise and air quality will be monitored (this will be focused on nearest sensitive receptors, which include three houses about 100 meters from muck disposal sites; if noise standards are exceeded, or there are complaints, noise barriers can be installed);

f. All encounters with wildlife and large birds will be logged, to build up a database of wildlife-habitat associations in the project area.

Institutional Responsibilities: The individual sub-contractors (under THyE) will be responsible for the operation of their vehicles. They must all meet the Bhutanese regulations and standards for noise and vehicle emissions, as well as appropriate operating times when near local communities. All workers will also be required to wear PPE at appropriate times and locations (this is their responsibility, as well as that of their employer). Vehicle movements on public roads will be under the control of contractor road safety staff. THyE staff will be responsible for monitoring the emission levels as well as for dust and noise control.

Performance Indicators and Monitoring Requirements: Vehicle emissions and noise will meet Bhutan standards (noise and air quality will be monitored accordingly). Local communities do not complain of noise, emissions, or dust and do not suffer long delays on public roads. Workers all use their safety equipment (in particular masks and ear plugs) to preclude health issues related to construction equipment. There are no losses of vulnerable wildlife or birds due to encounters with construction equipment.

Table 1.28 The Proposed Monitoring Program.

Mitigation Action	Indicator	Location	Responsibility	Monitoring	Frequency	Phase
Location of machinery	Distance of machinery from highways and local communities	All sites	Contractor	THyE	Upon commencement of use of machinery	Pre-construction and Construction
Check all machinery prior to operation	dust, noise and emission levels of machines	All sites	Contractor	THyE	Upon commencement of use of Machinery.	Pre-construction and Construction
Ensure occupational safety standards	Use of PPE by operators. Placement of emergency operating procedures	All sites	Contractor	THyE	Every quarter	Pre-construction and Construction
Control operation hours	Operating hours of machines	All sites	Contractor	THyE	Ever quarter	Pre-construction and Construction

Scheduling and Pacing: Management of construction equipment will be a constant task through the pre-construction and construction phases. There is no particular schedule or pacing related to this.

Budget: Costs of management of construction equipment and work sites will be internalized to the project construction costs. Contractors will quote accordingly. Provision is made for National Highway improvements and management required to handle project vehicles, and to allow for repairs that may be needed when construction is finished. These are shown in the table below.

Table 1.29 Budgets

Work Item	Quantity	Unit	Rate (Nu.)	Total Cost (Nu.)
Survey & preparations	1	LS	200,000	200,000
Earth works	8,100	m^3	275	2,227,500
Rock cutting	1,500	m^3	715	1,072,500
Subgrade	32,000	m^2	55	1,760,000
Sub-base	5,600	m^3	275	1,540,000
Base-course	4,200	m^3	825	3,465,000
Bitumen 5 cm	28,000	m^2	605	16,940,000
Stone masonry walling	2,250	m^3	2500	5,625,000
Line drain	4,000	m	600	2,400,000
Salary of Flagmen	4	Person	360000	1,440,000
Provision for repairs at end of construction phase	-	-	-	10,000,000
Total				**46,470,000**

1.2.1.7 Fuel Storage Management Plan

Where sites are close to Trongsa, fuel storage may not be necessary, as trucks can replenish their fuel as and when required from current fueling facilities. However, there is a risk of a spill if fuel is not stored well; this creates a risk of contamination of groundwater and surface water (aquatic habitat compromised; possible impact on brown trout).

Mitigation Measures: Proper fuel storage will preclude any risk of negative environmental impacts and risk of accidents (concern for human safety). Standard practice requires storage of

fuel at a flat, properly drained, isolated, fenced, and bunded area, where any slow or fast leaks of fuel will be contained, so that an explosion risk is minimized, and fuel cannot enter any adjacent watercourses. The fuels and greases shall be stored in labeled containers with cushion below to absorb the substances, if leaked. The standard practice in the country is to store fuel in barrels, so drainage may not be necessary. The exact location for project fuel storage will be determined by Project Management at an optimal location to reduce travel time between the fuel depot and work areas.

Both the project management (if the project requires a fuel storage depot) and the contractor will ensure the following:

- Maintain a minimum distance of 50 m from water supply sources/rivers and streams to avoid contamination of water sources in case of leakage;
- Maintain a minimum distance of 30 m from labour camps to avoid risks of explosions;
- Store fuel in 200 litre barrels, that are leak proof, covered at all times in sheds, as protection from direct sunlight and rainfall; and,
- Keep at least six sand buckets and fire extinguishers at the same storage shed as precautionary emergency measures.

Institutional Responsibilities: THyE and contractor staff will determine the most appropriate locations for fuel storage and will develop technical specifications for securing the site and eliminating the risk of explosions.

Performance Indicators and Monitoring Requirements: Fuel storage depot(s) is fully compliant with Bhutan standards and safety requirements specific to the project. There is no spillage or contamination of adjacent soil and watercourses. Explosion risk is minimized (there are no explosions). Project management will check to see that all fuel is well stored, protected from leakage and exposure to fire hazards, and isolated. Environmental Unit of THyE will undertake compliance check every quarter (but unannounced) basis.

Table 1.30 Proposed Monitoring Program.

Mitigation Action	Indicator	Responsibility	Monitoring	Frequency	Phase
Proper storage facilities	Location of fuel storage sites in shed	THyE and Contractor	THyE	after award of tender to contractor	Pre-construction and Construction

Mitigation Action	Indicator	Responsibility	Monitoring	Frequency	Phase
	Fuel is stored in 200 litre leak proof barrels on flat ground and in a protected shed	Contractor	THyE	on commencement of work	Pre-construction and Construction
Complete avoidance of fuel spills into water sources	Distance of fuel storage site from the nearest streams/rivers	Contractor	THyE	every quarter	Pre-construction and Construction
Secure the site from risk of explosion	Distance of fuel storage site from camps/offices, or fire risk areas	Contractor	THyE	every quarter	Pre-construction and Construction
	Number of sand buckets and fire extinguishers and condition of fire extinguishers	Contractor	THyE	every quarter	Pre-construction and Construction

Scheduling and Pacing: Fuel storage requirements and site development will be undertaken in the first six months of the project.

Budget: Proper fuel storage will be included in the overall project budget.

1.2.2 Construction Phase

The construction phase of the Nikachhu project will involve a continuation of activities from the pre-construction phase (cleared site management, worker camps, construction vehicles, and fuel storage), as well as a scaling up or acceleration of other elements, such as occupational health and safety measures, blasting, muck disposal, air quality management, and water quality management (these will be consistent with Bhutan standards, as well as World Bank EHS guidelines on environment, construction, and health and safety). These are discussed below.

1.2.2.1 Occupational Health and Safety

Occupational Health and Safety covers all personnel working under the project and will be in line with the General Rules and Regulations on Occupational Health and Safety (OHS) in Construction, Manufacturing and Mining and Service Industries, 2006 (RGOB). Chapter IX of the Labor and Employment Act of Bhutan (2007) clarifies details on the Occupational Health and Safety of workers, which are mandatory in the Construction Industry. They will also be consistent with World Bank EHS guidelines on health and safety.

The Occupational Health and Safety program will aim to ensure that the workplace is safe and healthy by: addressing the hazards and risks at the workplace; outlining the procedures and responsibilities for preventing, eliminating and minimizing the effects of those hazards and risks; identifying the emergency management plans for the workplace or workplaces; and, specifying how consultation, training and information are to be provided to employees at various workplaces.

Some of the risks/hazards associated with workplaces are due to working close to or at blasting sites associated with the various project construction activities. Other risks associated with the project construction phase include risk of increase of vector borne and other different diseases. The following sections will be implemented during the construction phase to address and ensure workers' health and safety.

a. Screening and regular unannounced checking of workers.

As per the procedure for hiring foreign workers, all contractors and labour agencies are required to make all prospective workers undergo medical tests to screen for diseases and sicknesses, prior to selection and employment of any foreign worker. The contractor is also responsible for ensuring that no foreign worker who has a criminal record is employed at the project site. It will be ensured that all workers undergo medical tests to screen diseases at source and at sites in consultation with the Trongsa Dzongkhag Health Officer.

In addition to this, the Project Management will also undertake sudden, unannounced checks on workers to look for diseases such as HIV, STDs, and hepatitis. This is being suggested because surprise checks in projects like Mangdechhu have resulted in workers being detected as positive for HIV. If such cases are detected, the contractor will be required to immediately release the worker from the site (as this indicates that proper screening was not conducted).

b. Minimizing hazards and risks at the workplace.

To ensure safety at all work sites, the following will be carried out:

i. Installation of signboards and symbols in risky and hazardous areas, to inform workers to be careful.
ii. Construction of barricades around construction sites and deep excavated pits, to cordon off and deter entry of unauthorized personnel and workers into these areas.
iii. Providing a safe storage site/area for large equipment such as power tools and chains, to prevent misuse and loss.
iv. Proper Housekeeping: Ensuring that materials are all stacked, racked, blocked, interlocked, or otherwise secured to prevent sliding, falling, or collapse. Brick stacks will not be more than 7 feet in height and for concrete blocks they will not be more than 6 feet high.
v. Removing all scrap timber, waste material and rubbish from the immediate work area as the work progresses.
vi. Where scaffolds are required, ensuring that each scaffold or its components shall be capable of supporting its own weight and at least 4 times the maximum intended load applied or transmitted to it. The platform/scaffold plank shall be at least 15 inches wide and 1.5 inches thick. The rope should be capable of supporting at least 6 times the maximum intended load applied or transmitted to that rope. Pole scaffolds over 60 feet in height shall be designed by a registered professional engineer and shall be constructed and loaded in accordance with that design. Where scaffolds are not provided, safety belts/safety nets shall be provided;
vii. Ensure that all ramps or walkways are at least 6 feet wide, having slip resistance threads and not inclined more than a slope of 1 vertical and 3 horizontal.
viii. Stacking away all excavated earth at least 2 feet from the pit to avoid material such as loose rocks from falling back into the excavated area and injuring those working inside excavated sites.
ix. Constructing support systems, such as bracing to adjoining structures that may be endangered by excavation works nearby.
x. Only a trained electrician to construct, install and repair all electrical equipment to prevent risks of electrical shocks and electrocution.

xi. Install fire extinguishers and/or other fire-fighting equipment at every work site to prepare for any accidental fire hazards.

c. Provision of Personal Protective Equipment

Risks to the health and safety of workers can be prevented by provision of Personal Protective Equipment (PPEs) to all workers. This will be included in the construction cost for each Contractor. Depending on the nature of work and the risks involved, contractors must provide without any cost to the workers, the following protective equipment:

i. Helmet shall be provided to all workers, or visitors visiting the site, for protection of the head against impact or penetration of falling or flying objects.
ii. Safety belt shall be provided to workers working at heights (more than 20 ft) such as roofing, painting, and plastering.
iii. Safety boots shall be provided to all workers for protection of feet from impact or penetration of falling objects on feet.
iv. Ear protecting devices shall be provided to all workers and will be used during the occurrence of extensive noise.
v. Eye and face protection equipment shall be provided to all welders to protect against sparks.
vi. Respiratory protection devices shall be provided to all workers during occurrence of fumes, dusts, or toxic gas/vapor.
vii. Safety nets shall be provided when workplaces are more than 25 feet (7.5 m) above the ground or other surfaces where the use of ladders, scaffolds, catch platforms, temporary floors or safety belts is impractical.

The specific PPE requirements for each type of work are summarized below.

Table 1.31 PPE Requirement List

Type of Work	PPE
Elevated work	Safety helmet, safety belt (height greater than 20 ft), footwear for elevated work.
Handling work safety	Helmet, leather safety shoes, work gloves.
Welding and cutting work	Eye protectors, shield and helmet, protective gloves.
Grinding work	Dust respirator, earplugs, eye protectors.
Work involving handling of chemical substances	Dust respirator, gas mask, chemical-proof gloves. Chemical-proof clothing, air-lined mask, eye protectors.
Wood working	Hard hat, eye protectors, hearing protection, safety footwear, leather gloves and dust respirator.
Blasting	Hard hat, eye and hearing protection.
Concrete and masonry work	Hard hat, eye protectors, hearing protection, safety footwear, leather gloves and dust respirator.
Excavation, heavy equipment, motor	Hard hat, safety boots, gloves, hearing protection.

graders, and bulldozer operation	
Quarries	Hard hat, eye protectors, hearing protection, safety footwear, leather gloves and dust respirator.

d. Procedures to Deal with Emergencies such as Accidents, Sudden Illness and Death of Workers

First aid kits will be made available at all times throughout the entire construction period by the respective contractors. This is very important, because all work sites are quite far from the nearest Basic Health Unit. In addition to the first aid kits, the following measures should be in place:

i. Provision of dispensaries by the individual EPC contractor.
ii. A vehicle shall be on standby from the Project Office so that emergency transportation can be arranged to take severely injured/sick workers to the nearest BHU or Trongsa Hospital for immediate medical attention.
iii. A designated Health Officer/worker for the Project will be identified as a focal person to attend to all health and safety related issues. This employee's contact number will be posted at all work sites for speedy delivery of emergency services. The focal person shall be well versed with the medical system and facilities available at the Trongsa Hospital and the BHU.
iv. Communication arrangements, such a provision of radios or mobile communication for all work sites, for efficient handling of emergencies, will be made.

e. Record Maintenance and Remedial action

The Project Management will maintain a record of all accidents and injuries that occur at the work site. This work will be delegated by the contractor to the site supervisor and regularly reviewed every quarter by project management. Reports prepared by the contractor shall include information on the place, date and time of the incident, name of persons involved, cause of incident, witnesses present and their statements. Based on such reports, the management can jointly identify any unsafe conditions, acts or procedures and recommend for the contractor to undertake certain mitigative actions to change any unsafe or harmful conditions.

f. Compensation for Injuries and Death

Any casualty or injury resulting from occupational activities should be compensated as per the Labor and Employment Act of Bhutan (2007). Where compensation is sought by the injured party, proper procedures for documentation of the case will be followed, including a detailed report on the accident, written reports from witnesses, report of the examining doctor and

his/her recommendation for treatment. Each individual contractor will be responsible for ensuring compensation for the respective workers.

g. Awareness Programs

The Project management will undertake awareness programs through posters, talks, and meetings with the contractors to undertake the following activities:

i. Dissemination sessions will clarify the rights and responsibilities of the workers regarding interactions with local people (including communicable disease risks, such as HIV/AIDS), work site health and safety, waste management (waste separation, recycling, and composting), and the illegality of poaching.
ii. Make workers aware of procedures to be followed in case of emergencies such as informing the focal health person who in turn will arrange the necessary emergency transportation or treatment.

h. Nomination of a Health and Safety Focal Person

Within each site (especially if different sites are being implemented by different contractors), a Health and Safety Focal Person will be appointed. The Terms of Reference for the focal person will mainly be as follows:

i. Function as the focal person/representative for all health and safety matters at the workplace;
ii. Responsible for maintaining records of all accidents and all health and safety issues at each site, the number of accidents and its cause, actions taken and remedial measures undertaken in case of safety issues;
iii. Be the link between the contractor and all workers and submit grievances of the workers to the contractor and instructions/directives on proper health care and safety from the contractors back to the workers;
iv. Ensure that all workers are adequately informed on the requirement to use Personal Protective Equipment and its correct use;
v. Also responsible for the first aid kit and making sure that the basic immediate medicines are readily available.

i. Code of Conduct

The Contractor will be required to instruct the site supervisor on the code of conduct and ethics for foreign workers. As per the Regulations on working conditions of the Department of Labour, 2012, all foreign workers are required to respect the values, traditions, culture and law of the country and respect all regulations and rules. No worker will be allowed to enter areas restricted for foreigners without specific permits.

Institutional Responsibilities: THyE will manage the contractors and sub-contractors, who will in turn be responsible for their own workforces. All workers will, in turn, through their own contract covenants, be responsible for their own behavior and committed to meeting behavioral expectations, subject to the conditions of their contracts. The focal person will be responsible for ensuring that OHS Protocols are followed at each site

Monitoring. Monitoring will include visual inspections of the camps and work sites by THyE staff (Environment Unit), with the assistance (if required) from the district health worker. Any issues between workers and contractors will be logged and tracked for resolution/follow-up by THyE with respective contractors. All contractors will be required to log specific incidents and worker accidents and report these to THyE. Monitoring costs will be absorbed within the operational budgets of THyE and contractors.

Table 1.32 Implementation and Monitoring Program

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Screening and regular unannounced checking of workers.	Number of unannounced checks conducted	pre construction and construction	Contractor	THyE	every quarter
Minimizing hazards at the workplace.	Number, type and location of signboards	pre construction and construction	Contractor	THyE	every quarter
	Presence of barricades around construction	pre construction and construction	Contractor	THyE	every quarter
	Storage site/area for large equipment	pre construction and construction	Contractor	THyE	every quarter
	Inspection of material storage	pre construction and construction	Contractor	THyE	every quarter
	Presence of scrap timber, waste material and rubbish	pre construction and construction	Contractor	THyE	every quarter
	Scaffold installation and design	pre construction and construction	Contractor	THyE	every quarter
	Width and safety of ramps	pre construction and construction	Contractor	THyE	every quarter

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
	Storage of excavated earth from pits	pre construction and construction	Contractor	THyE	every quarter
	Presence of support systems such as bracing	pre construction and construction	Contractor	THyE	every quarter
	Qualification/ experience of electricians	pre construction and construction	Contractor	THyE	every quarter
	Number of fire-fighting equipment present at site	pre construction and construction	Contractor	THyE	every quarter
Provision of personal protective equipment.	Use of PPE by workers	pre construction and construction	Contractor	THyE	every quarter
Procedures to deal with emergencies.	Number of first aid kits at work site	pre construction and construction	Contractor	THyE	every quarter
	Presence of emergency standby vehicle	pre construction and construction	Contractor	THyE	every quarter
	Name of designated Health Officer/worker	pre construction and construction	project management	THyE	every quarter
	Number of radios or mobile communication	pre construction and construction	Contractor	THyE	every quarter
Record maintenance and remedial action.	Number of accidents and injuries logged at each site	pre construction and construction	Contractor	THyE	every quarter
Compensation for injuries and death.	Details of Compensation paid for injuries/death	pre construction and construction	Contractor	THyE	every quarter
Awareness programs.	Number of dissemination sessions/ meetings	pre construction and construction	Contractor	THyE	every quarter
	Number of workers aware of emergency protocols	pre construction and construction	Contractor	THyE	every quarter
	Number of workers aware of code of conduct	pre construction and construction	Contractor	THyE	every quarter
Nomination of a Health and Safety Focal Person.	Health Focal person nominated from among workers	pre construction and construction	Contractor	THyE	every quarter

Budget: Costs associated with worker health and safety will be absorbed by the specific contractors, or by the operational budget for THyE (this includes radios and vehicles, as well as first aid kits and PPEs, which will need to be quoted in the contractor bids).

1.2.2.2 Management of Blasting

Blasting is a necessary part of making road cuts in some areas where bedrock occurs right at or near the surface, and may be required in some other locations as well (starting the adits, for example). Also, excavation of the HRT will require blasting among many other activities such as drilling, charging, de-fuming, scaling, mucking, cleaning, concreting, etc.

Most blasting activities will occur well away from local communities, so the effects of blasting on the health of local communities and structures will be negligible. However, impacts from blasting are difficult to predict and there are concerns related to "knock-on" effects. Specific measures are proposed to ensure that impacts from blasting are mitigated.

The objectives of the blasting management plan are to minimize the impacts of blasting, such as slope instability, impacts on existing infrastructure, noise, and risk of wildlife disturbance, and the risk of localized fractures in geology that might change the aquifer dynamics.

a. Management Actions

i. Use of Controlled Blasting

Blasting will be undertaken in a manner that avoids wide dispersal of flying rocks and the creation of landslide risk. DGPC now has considerable experience in controlled blasting techniques, which have been used effectively to avoid associated impacts at the Dagachhu and Tsibjalumchhu (Diversion Schemne at Tala Hydropower Plant) project sites. Special care will be taken to construct the access road to Adit 3 as there is the canal for the micro-hydroelectricity project located below the National Highway (this also serves as irrigation water for paddy cultivation for Tangsibji Geog).

Blasting method: Simultaneous blasting using codex and detonating cord will be adopted. This

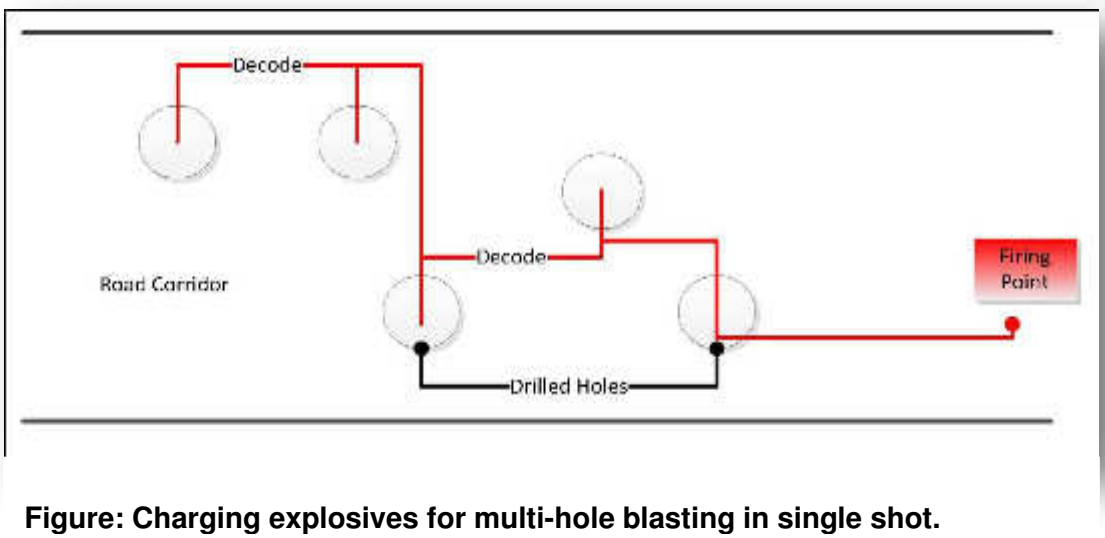


Figure: Charging explosives for multi-hole blasting in single shot.

will prevent flying rocks, thus keeping broken rocks in one place through the phenomenon called "pushing against one another" (simultaneous blasting using codex and detonating cord will be adopted; this causes the percussive force of simultaneous blasts to counter against each other, reducing rock dispersal). The figure below illustrates the layout and charging of explosives.

ii. Observe Blasting Times for Human Safety and Minimal Wildlife Disturbance

A schedule for blasting will be observed (daytime) and blasting must be avoided in the early hours and at night when visibility is poor and it is impossible to visually observe blasting impacts. Also, blasting at night will disturb most wildlife that may be moving around.

iii. Observe Blasting Protocols

To minimize the impacts of blasting along the highway and effects on traffic, a blasting protocol will be managed to minimize any safety concerns (this involves posting the blasting schedule and locations, clearing the area and checking, and using a warning signal). Also, all explosives will be stored in a secure, locked location.

iv. Prepare Baseline and Monitoring of Nearby Existing Infrastructure

Since the main concern from blasting is damage to adjacent structures, a data collection and mapping program for structures and buildings near the prospective blast zones will be undertaken, including photographs of structures and buildings before and after blasting. If there are any concerns or claims, these photographs can be consulted to objectively determine any possible effects from project blasting.

v. Maintain a Database on any Injuries, Accidents, Damage Caused by Blasting

Each contractor will be required to report any accidents or damage to wildlife and other complaints/reports received due to blasting. This must be submitted to project management to further enable management of risks due to blasting.

The monitoring of blasting operations is summarized below.

Table 1.33 Blasting Monitoring Plan.

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Use of controlled blasting	Type of blasting method use	Pre-construction and Construction	THyE	THyE	Once prior to blasting
Observe blasting times for human safety and minimal	Observation report on blasting hours	Pre-construction and	Contractor	THyE	Once every quarter

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
wildlife disturbance		Construction			
Observe blasting protocols	Blasting protocols being implemented	Pre-construction and Construction	Contractor	THyE	Once every quarter
Prepare baseline and monitoring of nearby existing infrastructure	Baseline photos documented	Pre-construction	Project management	THyE	Once every quarter
Maintain a database on any injuries, accidents, damage caused by blasting	Database on injuries, wildlife accidents, or complaints	Pre-construction and Construction	Contractor and Project management	THyE	Once every quarter
	Actions taken to mitigate blasting concerns	Pre-construction and Construction	Contractor and Project management	THyE	Once every quarter

Institutional Responsibilities: THyE and contractor staff will be responsible for safety measures associated with blasting.

Scheduling and Pacing: Management of the blasting operations will be continuous throughout the pre-construction and construction phases.

Budget: Management of blasting operations will be included in the project construction budget.

1.2.2.3 Quarry Operation

Mitigation Measures: All efforts should be made to route the access road to the "back" of the quarry, and work the selected mountain or hill from a location that cannot be seen from the road. This will also eliminate noise and dust problems along the public road or highway that will connect the quarry to the project sites. This would leave truck traffic on public roads as the main issue. This can be addressed by having quarry trucks moving along public roads during low traffic hours (this would be early morning, and at night). The quarry will need to be fenced off, to avoid public safety issues, and also to keep larger wildlife from entering this work zone. The quarry site will need to be carefully designed and managed to ensure proper site drainage and keeping mobilized sediments on site with checkdams and sedimentation ponds. These are all standard quarry operating procedures, and would need to be documented as such. Presumably, the selected quarry would have an economic life beyond just the Nikachhu project; however, when it is depleted, it would need to be rehabilitated as much as possible, so that it can assume a natural state.

For the quarry workers themselves, airborne particulates pose a potential health risk; these can lead to respiratory, dermal, and ocular irritation or damage. The particular concern in some stone quarries is inhalation of dust containing silica, which can lead to silicosis (a serious lung

disease). Therefore, the quarry staff will have to follow best occupational health and safety guidelines including: ensuring that all saws and drilling machines have adequate dust catchment or air filtration systems, particularly when the machines are situated in a confined or enclosed area where air flow is limited; using water misting to remove airborne particulates; cover rock and gravel stock piles and carrier trucks with tarpaulins; lay gravel on the quarry access roads; and, avoiding drilling and sawing when the cloud ceiling is low or the wind is high so that dust plumes are not created in the vicinity.

Institutional Responsibilities: THyE will assume responsibility for the management of quarry operations, which will be worked by various contractors.

The detailed EIA and Mining Plan for the Quarry shall be carried out separately during the Final Mine Feasibility Study which is perquisite as per the Regulation of Mines and Mineral Management.*Performance Indicators and Monitoring Requirements:* The main performance indicators are adequate air quality and noise limits at the periphery of the quarry (these will be monitored, as part of the routine monitoring program). A worksite safety record will be maintained at the premises (HSE briefings will be required for all quarry workers). THyE staff will undertake routine inspections to check for compliance. Any sightings of wildlife and large birds at or near the quarry will be recorded (with information submitted to THyE staff, to be passed on to DoFPS staff to build up the database for biological corridors). Truck movements will be monitored, and times of movements can be adjusted to suit the prevailing traffic patterns on the National Highway, to avoid undue congestion.

Scheduling and Pacing: Quarry operations will be required throughout the pre-construction and construction phases of the project. Standard operating procedures and required monitoring will be in force the whole time.

Budget: The budget for quarry operation will include standard operating procedures which are intended to address environmental and worker safety issues.

1.2.2.4 Crusher Plant Operation

Mitigation Measures: The same mitigation measures (dust and noise management; worker safety controls) that were described for construction equipment and quarry operation (Sections 1.2.1.4 and 1.2.2.5) apply for the crusher plant operation, since this activity involves handling of aggregate, rock, and muck; however, in a location that is away from the river and public areas (it will not be visible or audible). Proper site drainage will be required to keep sediments from entering adjacent watercourses. The site of the crusher plant will be rehabilitated (replanted with trees) when the construction phase is completed.

Institutional Responsibilities: THyE and selected contractors will be responsible for proper crusher plant operations and site management that will ensure all environmental and safety risks are minimized.

Performance Indicators and Monitoring Requirements: The main performance indicators are adequate air quality and noise limits at the periphery of the crusher plant (these will be monitored, as part of the routine monitoring program). A worksite safety record will be maintained at the premises (HSE briefings will be required for all crusher plant workers). THyE staff will undertake routine inspections to check for compliance. Any sightings of wildlife and large birds at or near the crusher plant will be recorded (with information submitted to THyE staff). Water quality monitoring in the Nikachhu will be undertaken to ensure that sediments are not entering the river (proper operation of site drainage, check dams, and sedimentation pond).

Scheduling and Pacing: Crusher plant operations will continue through the construction phase. The site will be rehabilitated when the crusher plant is dismantled and moved away. Full compliance with environmental management and safety procedures is expected for the duration of operations over 3-4 years.

Budget: Proper operation of the crusher plant is expected to be included in the project budget. Routine monitoring (noise, air and water quality) will be included in the Environmental Unit of THyE budget for project monitoring.

1.2.2.5 Muck Disposal Management Plan

As part of the DPR survey and investigation, ten muck disposal sites located within the project area have been identified. As can be seen from the following table, large quantities of muck will be generated as a result of various activities such as tunneling operations, construction of roads, and excavation of the site office, residential, non-residential, and contractors' facilities at the powerhouse area. Disposal planning and management is very important, to mitigate the possible environmental impacts of improper disposal resulting in increased sedimentation of streams and damaging the visual aesthetics of the area. Proper muck disposal management will ensure that muck that is not reused for construction work is well disposed, and these disposal areas are restored to the natural state by afforestation or by developing areas such as recreation parks or camping grounds/football grounds as desired by the Dzongkhag and local communities.

Muck disposal management involves several steps, beginning with site identification and preparation, for care and maintenance, and handing over of the sites to the district authorities for long-term management. The following sections provide details on the management process for generation and disposal of muck.

STEP 1. Identification of Location of Muck Disposal Sites

A total of eleven muck disposal sites have been identified during the DPR, however, when the actual ground survey was carried out by Dzongkhag, the common Muck Disposal Site was identified as Royal *Tsamdro* and the Project Authority had to drop the area, thereby reducing the muck disposal sites to ten(these are depicted in the ESIA and in the related Annex). The ten Muck Disposal Sites and their area are as listed below in the Table. These disposal sites were identified based on proximity to the muck generation sites, for instance an adit or access road, the practicality of operation, and avoidance of critical habitats and local communities. The risk of sediment entry to local creeks and the river have been avoided by ensuring that disposal sites are located at least 30 meters away from rivers and streams.

Table 1.34 Identified Muck Disposal Sites.

Muck Disposal Area	Locations	Area m^2
Disposal site- I	Upstream of dam	44,605.00
Disposal site- II	Downstream of dam	23,373.00
Disposal site- III	Near Silt Flushing Tunnel	46,990.00
Disposal site-IV	Adit -1	55,958.00
Disposal site- V	Adit -2	72,996.00
Disposal site- VI	Adit – 3	83,055.00
Disposal site- VII	Aidt – 4	29,303.00
Disposal site- VIII	Common disposal site at Tsangkha	73,116.00
Disposal site- IX	Adit- 5	51,631.00
Disposal site- X	Surge Shaft area	41,198.00
Disposal site- XI	Pressure Shaft area	16,593.00
Disposal site- XII	Power House area	71,000.00
	Total	***609,818.00***

Table 1.35 Total volume of muck associated with specific project components.

Sl. No.	Description	Volume of Muck from each work site (m^3)	Identified Muck Disposal Sites	Volume of Muck (m^3)	Available Capacity of Disposal Sites (m^3)
1	Diversion Tunnel	6,357.90	Disposal site - I and II	197,273.03	339,890.00
2	Dam	156,815.43			
3	Inlet Tunnel	9,124.90			
4	GOC	24,974.80			
5	Desilting Chamber	68,796.00	Disposal site – III	87,191.23	197,358.00
6	SFT	6,714.73			
7	ADIT to Desilting	11,680.50			
8	ADIT-1	19,048.18	Disposal site IV	87,919.18	167,874.00
9	In HRT from Adit-1	68,871.00			
10	ADIT-2	27,965.50	Disposal site – V	94,007.50	182, 490.00
11	In HRT from Adit-2	66,042.00			
12	ADIT-3	21,692.70	Disposal site – VI	92,484.70	199,332.00
13	In HRT from Adit-3	70,792.00			
14	ADIT-4	25,041.98	Disposal site - VII & VIII	102,127.98	204,838.00
15	In HRT from Adit-4	77,086.00			
16	Adit-5	27,777.80	Disposal site – ix	76,904.80	154,893.00
17	In HRT from Adit-5	49,127.00			
18	ADIT to Surgeshaft Top	14,809.43	Disposal site- X	42,221.52	123,594.00
19	ADIT to BVC	12,682.02			
20	Surge shaft	9,685.78			
21	Butterfly valve chamber	5,044.29			
22	ADIT to Pressure Shaft	18,481.66	Disposal site – XI	27,309.07	53,097.00

Sl. No.	Description	Volume of Muck from each work site (m^3)	Identified Muck Disposal Sites	Volume of Muck (m^3)	Available Capacity of Disposal Sites (m^3)
23	Pressure shaft	8,827.41			
24	Power house cavern	60,353.95	Disposal site – XII	184,105.10	213,000.00
25	Main access tunnel	22,806.22			
26	Tail race tunnel	14,766.11			
27	ADIT to TRT	9,972.82			
28	ADIT to Control Room cum Ventilation Tunnel	44,874.08			
29	Transformer cavern	24,307.05			
30	Ventilation tunnel, cat	7,024.87			
31	Site office, residential , non - residential and contractors facilities at Dam area	45,060.74	Disposal site - I and II	45,060.74	142,616.97
32	Contractors facilities at Adit -1	364.22	Disposal site – IV	364.22	79,954.82
33	Contractors facilities at Adit -2	1,011.72	Disposal site- V	1,011.72	88,482.50
34	Contractors facilities at Adit -3	2,630.46	Disposal site- VI	2,630.46	106,847.30
35	Contractors facilities at Adit -4	991.48	Disposal site- VII & VIII	991.48	102,710.02
36	Contractors facilities at Adit -5	404.69	Disposal site- IX	404.69	77,988.20
37	Non - Residential And Contractors Facilities at Dam area	5,365.07	Disposal site – X	5,365.07	81,372.48
38	Site office, residential, non - residential and contractors facilities at Power House area	54,445.40	Disposal site- X,XI & XII	54,445.40	179,849.82
39	Road to Dam	76,257.80	Disposal site I &	76,257.80	

Sl. No.	Description	Volume of Muck from each work site (m^3)	Identified Muck Disposal Sites	Volume of Muck (m^3)	Available Capacity of Disposal Sites (m^3)
	Complex		II		97,556.23
40	Road to Adit 1	64,994.90	Disposal site IV	64,994.90	79,590.60
41	Road to Adit 2	41,296.40	Disposal site V	41,296.40	87,470.79
42	Road to Adit 3	48,809.10	Disposal site VI	48,809.10	104,216,84
43	Road to Adit 4	10,269.00	Disposal site VII	10,269.00	101,718.51
44	Road to Adit 5	8,487.52	Disposal site IX	8,487.52	77,583.51
45	Road to BVC and Surge Shaft top	35,568.66	Disposal site X	35,568.66	76,007.41
46	Road to Power House Complex	127,378.22	Disposal site XI & XII	127,378.22	128,115.99
Total estimated muck		**1,514,879.48**			

STEP 2. Land Acquisition for Muck Disposal Sites

This will be undertaken as part of the land acquisition program/land lease from the Dzongkhag Administration and National Land Commission, along with all other land acquisition procedures for the Project office, non-office, contractor camps, roads, and overall project activity (described previously under pre-construction; this must be done during the pre-construction phase to allow ample time for planning and preparation of muck disposal sites before construction work can actually commence).

STEP 3. Clearing of Muck Disposal Site and Site Preparation

Trees, if any, will be marked by the Department of Forest and Park Services and cut and other undergrowth such as shrubs cut as well. To avoid damaging large areas, care will be taken to ensure that the least possible area required is demarcated and cleared off. The top soil from the land will be removed and stored at a designated site close by to be reused at a later stage.

STEP 4. Terracing and Construction of Retaining Walls and Drainage

Terraces will be created and developed by constructing suitable retaining walls (gabion masonry) to support dumping of mud on steep slopes and for optimum space utilization. In between the terraces, catch water drains will be constructed to provide drainage. The retaining walls will be built before muck dumping, and each dumping will be followed by compaction, so

that it does not enter adjacent watercourses or cause compounding slope failures. The type and height of the retaining wall will be determined by the THyE and will vary from one site to the other, depending on the slope and terrain of each site.

At the Muck Disposal Site with an area of 8.9 acres (3.56 ha) located upstream of the dam site, where two streams run through, hume pipes will be laid along the streams before the disposal of muck in the area. The same measure will be replicated at the Muck Disposal Site of Adit 3, through which Tsheringma Drupchhu passes, and the Muck Disposal site of the Surge Shaft and at the Adit IV Muck Disposal Site, through which a stream passes (however, the stream which passes through the proposed Muck Disposal Site of Adit 4 is the stormwater generated at the Tsangkha Middle Secondary School, located north of Adit 4).

STEP 5. Dumping of Muck

Some muck will be re-used as construction material for various project appurtenances. The balance will be disposed at the designated Disposal Sites noted previously. Muck generated from the adits or the construction of roads will then be dumped into the pre-prepared site. Dumping of muck will be undertaken in contours (following the local topography), with each layer arranged in benches. Dumping will be avoided during the high speed winds, so that suspended particulate matter (SPM) levels are not excessive. To minimize the creation of dust, the soil will be compacted using an excavator (see figure below).

STEP 6. Rehabilitation of Disposal Sites under Compensatory Afforestation

Muck generally lacks nutrients and therefore can be difficult to re-vegetate. Therefore, the top soil that was previously removed will be added back on the top of the compacted muck. If the soil does not contain adequate nutrients, then natural fertilizers will be used or compost from the proposed composting site will be used to add nutrients to the soil to promote growth of vegetation. As per the agreement for future use of the disposal site, if the area is to be naturally restored, then this site will be included under the Compensatory Afforestation program and will be handed over for plantation so that vegetation cover can then control the mechanical and hydrological effects on the slopes and would give permanent stability to the muck. To stabilize the muck and restore the disposal sites, fast growing plant species are suggested. The grasses are suited to bind loose soil, and shrubs and trees hold soil up to deeper levels. The selection of local plant species will be done, taking the climate, soil, and drainage conditions of the sites into account (see figure below).

STEP 7. Handing over of Rehabilitated Dumping sites

If there is mutual agreement with the district and the local community that a specific disposal site will be used for other purposes such as camping grounds, recreation purposes, football ground for schools etc., then the area will be handed over to the respective authorities for future management.

Figure: Example of muck benching and re-vegetation.

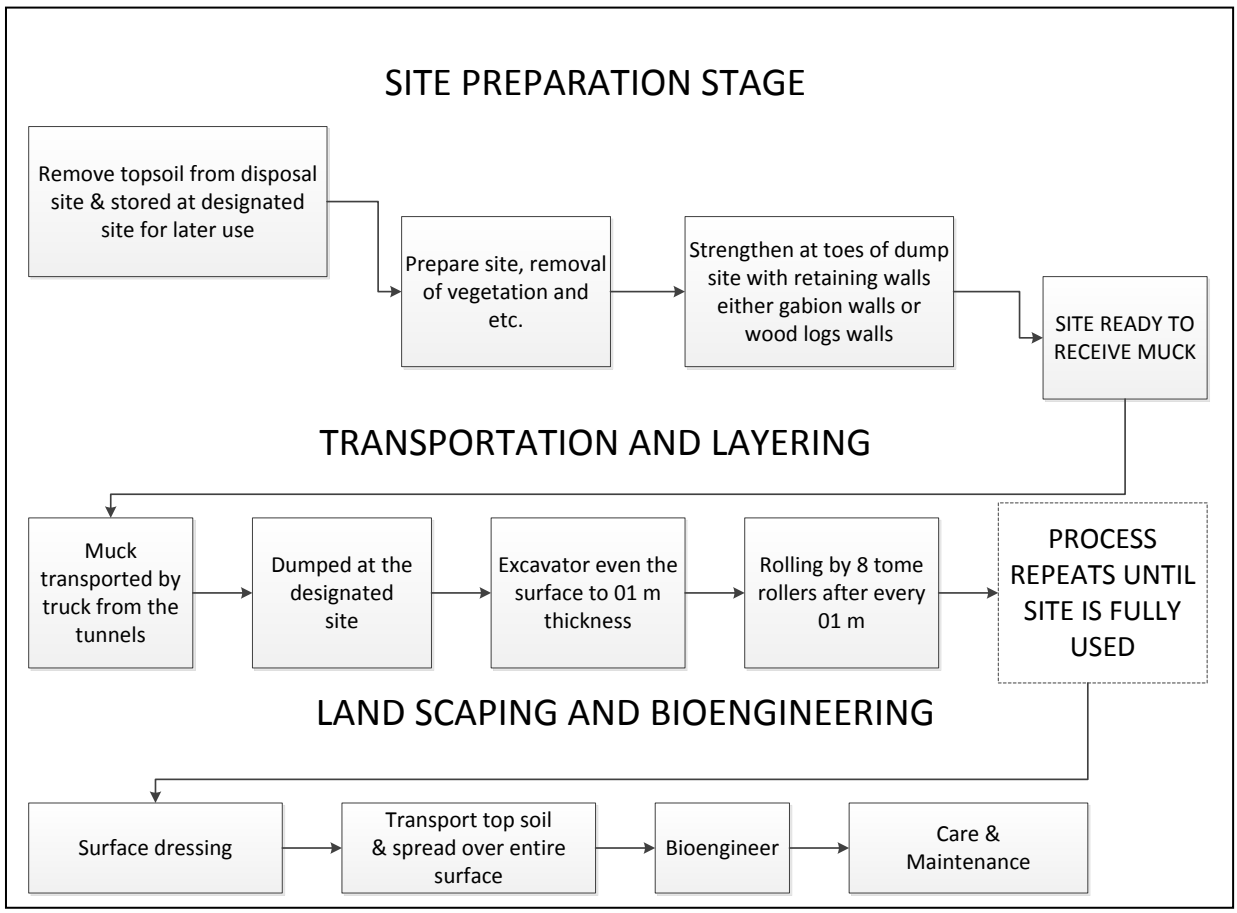


Figure: Muck Disposal Sequence

Institutional Responsibilities: THyE and selected contractors will be responsible for proper siting and development of muck disposal sites, as well as ongoing management of the muck disposal

and rehabilitation of the sites when they are full. The THyE will be duly responsible to ensure that muck is disposed at designated sites and mandatory management activities are implemented in close coordination with the contractors.

Performance Indicators and Monitoring Requirements: The main indicator of effective muck disposal site management will be containment of all disposed muck within the defined perimeters of the disposal sites (no entry to adjacent forests or watercourses). Site conditions will therefore be monitored frequently (by THyE staff), and corrective action taken when necessary. Any sightings of wildlife and large birds at or near muck disposal sites will be recorded (with information submitted to THyE staff). Routine noise, air quality, and water quality monitoring will be undertaken to ensure that muck and dust is contained and that there is no damage to adjacent forests and water courses.

Table 1.36 Muck Disposal Monitoring.

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Identification and location of disposal sites	Number and distance of identified sites from nearest water source	Carried out during DPR Preparation	Project management	THyE	at the start of the project
Land acquisition for muck dumping site	Number of sites handed over to project and contractor, site demarcation completed	Pre-construction	Project management	THyE	at the start of the project
Clearing of muck dumping site and site preparation	Top soil removed and stock piled near the site	Pre-construction	Contractor	THyE	As and when required
Terracing and construction of retaining walls and drainage	Number of terraces and quality of retaining walls and drains constructed	Pre-construction	Contractor	THyE	As and when work commences
Dumping of muck	Number of truckloads of muck dumped	Construction	Contractor	THyE	as and when work starts
Rehabilitation with Compensatory Afforestation	Date of handing over of site for compensatory afforestation, size of afforested area	Construction	Social Forestry Division	THyE	after completion of muck dumping
Handing over of rehabilitated dumping sites	Final handing over of dump site to Dzongkhag	Post – construction	Project management	THyE	post construction

Scheduling and Pacing: Muck disposal will occur throughout the first three years of the project construction phase (during the tunneling process). Rehabilitation of individual terraces at the disposal sites will occur as needed (when terraces are full and properly secured).

Budget: Proper muck disposal at selected sites will be included in the overall project budget. Routine visual, noise, air quality, and water quality monitoring is budgeted separately.

1.2.2.6 River Diversion (Cofferdam)

Mitigation Measures: During the period of dam construction, the river will be channeled to the diversion tunnel. This will maintain downstream discharge and accommodate regular seasonal variations, so that the river does not breach the work area (for the main diversion dam). The diversion tunnel will fully accommodate movements of fish, as it is known from observations of the Dagachhu diversion tunnel that fish of various species could move above and below, and through the diversion tunnel.

Institutional Responsibilities: The cofferdam and diversion tunnel concept is part of the project design and therefore under the responsibility of THyE.

Performance Indicators and Monitoring Requirements: The main indicators of successful operation of the cofferdam and the diversion tunnel will be continued presence of fish (brown trout, at least) in the river above and below the work site, and maintenance of good water quality. Fish and water quality will be monitored regularly before (to establish a baseline) and throughout the construction period and occasionally during the initial years of project operation (a fish specialist can be hired to undertake the fish monitoring for this requirement and other project activities that may affect fish habitat and populations). THyE staff will undertake regular visual inspections at the cofferdam site to ensure that sediments are contained, that the cofferdam is stable, and that the diversion tunnel is working properly.

Scheduling and Pacing: River diversion will be required during the last 3-4 years of the construction phase, after which the water in the Nikachhu will be diverted to the headrace intake and dam spillway.

Budget: The construction of the cofferdam and the diversion tunnel is included in the overall project budget. Provision for the fish specialist is made below (see Appendix 1 for terms of reference).

Table 1.37 Cost of Fish specialist

Work Item	Quantity	Unit	Rate (Nu.)	Cost (Nu.)
Various fish monitoring tasks (trap, identify, measure, count), as required at various sites and over the construction and operation phases.	Provision for 2 surveys/yr x 6 yrs	/survey	150,000	1,800,000

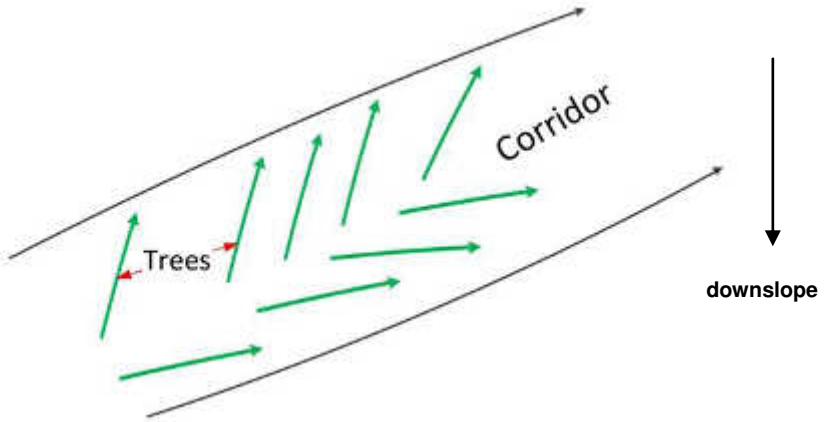
1.2.2.7 Transmission Line Tower Installation (Land Clearing)

Mitigation Measures: A separate IEE was prepared for the transmission line (details were summarized in the project ESIA). Mitigation measures from the IEE and from the ESIA summary are provided here (note that the transmission line EMP has a separate budget of Nu. 7.6 million which is not recorded in this document). Compensation will paid, where needed, for temporary and permanent loss of access to land (about 14 acres; 5.6 ha). Regarding the risk of disturbance of local communities and wildlife, the work crews for each foundation area will be small and not on-site for long, so any disturbance will be transient. As with the other project component sites, land clearing, cutting of trees, and site preparation for the tower footings can be managed to minimize negative environmental impacts. All efforts will be made to fell trees so that they do not slide downhill and knock out other vegetation (Forestry staff should be involved in the selection and marking of trees in the right-of-way, as well as monitoring tree cuts during the alignment work). Previous practice suggests that this can be undertaken in a herring bone pattern (see below). These trees will be categorized and pulled from the site at access points that will not damage the forest or watercourses (these trees will most likely be used for fuelwood). As much as possible, large trees on the edge of the right-of-way should not be disturbed or damaged, as these are favoured habitat of the rufous-necked hornbill (which is protected). As with other project areas where trees will be cut, the potential loss of bird and wildlife habitats can be countered by planting suitable trees at other locations which are currently degraded (habitat enhancement in those areas). For example, for rufous-necked hornbills, which are largely frugivorous (feeding mainly on berries, drupes of Lauraceae, Meliaceae, Myristicaceae, Annonaceae and Moraceae - figs), this would involve replanting of fig species and well as species like *Ficus roxburghii*, *Ficus hookeri*, and *Ficus altissima*, to compensate for the loss of felled species.

Larger trees that are cut for the transmission line will be replaced at a ratio slightly more than 2:1 (planted in sites selected in consultation with Department of Forests). Tower footings will be located at stable locations, and site preparation will ensure that sediments are not mobilized. Once the tower footing foundations are poured, muck will be placed back against the footing, and the site re-vegetated (low elevation species), to reduce the erosion risk. Much of the alignment will be allowed to grow back to at least 2 meters height (which will provide refuge for any wildlife that attempt to cross the alignment), or will be left available for dryland cultivation.

In addition to the points noted above, prior to the land clearing required for the transmission line, sites of local historical and cultural significance will be identified in consultation with the local communities, to ensure that there will be no intrusion, damage or development of towers that may affect important sites (location of towers can be adjusted accordingly within the general

alignment). Contractors will be instructed to leave a covering of grass and other low vegetation in the RoW, to provide cover and habitat for moving animals. Some of the cut material should be allowed to rot *in situ*, to create micro-habitat for small animals. There should be no burning of vegetation within the ROW.



a. Proposed felling method for trees along the transmission line corridor.

Since the transmission line area falls outside the jurisdiction of the Park, the forestry officials from the District should be encouraged to conduct bird surveys to determine the current distribution and abundance, as well as to evaluate population trends and rates of range contraction. In particular, it would be beneficial to monitor trends in selected key populations of rufous-necked hornbills.

Institutional Responsibilities: THyE and the selected contractors will be responsible for clearing the transmission line alignment and ensuring that all exposed slopes are stabilized when foundation work is completed.

Performance Indicators and Monitoring Requirements: There are no land slips along the transmission line alignment. Trees are extracted from the alignment without damage to adjacent habitats. Local people are able to access and use the alignment soon after the tower foundations are constructed. Wildlife movements in the area are not disturbed.

THyE staff will undertake occasional visual checks of work along the alignment. All encounters with wildlife and large birds will be recorded and reported to THyE staff. Compensatory tree planting will be monitored by THyE staff.

Scheduling and Pacing: Clearing for the transmission line will occur during the latter phase of the project construction period.

Budget: The budget for proper management of work activities along the transmission line alignment will be included in the overall project budget. This budget is expected to include the proper extraction and disposal of trees cut along the alignment and slope protection measures. Compensation for land acquired for the alignment is addressed in the budget in the RP, and the budget for tree replacement is already included in the budget noted in Compensatory Afforestation.

1.2.2.8 Air Quality and Noise Management Plan

Noise generation and impacts on air quality will come from various construction activities such as tunnel construction, rock blasting, work at quarry sites, foundation excavation, cement mixing, and adit and road construction at all work sites. This noise will be due to the use of heavy construction machinery such as crusher machines, batching plants, excavators, chain saws for tree felling, or use of diesel generators. Fugitive emissions and increased dust levels will include airborne dust as well as NOx, SOx and particulate matter. Other impacts on air quality are from increased vehicular emissions and emissions from fires in the new worker camps. Air quality over time could improve, if there is less burning of fuelwood and hydrocarbons for heat and cooking (replaced by electricity).

It is expected that all air quality impacts will be localized and transient during pre-construction and construction and will not impact local communities severely as these are not located adjacent to work sites.

National ambient air quality standards establish upper limits for the concentration of air pollutants in outdoor air, for the protection of human health, agriculture, natural vegetation and ecosystems, and the environment in general and are shown below. Noise standards are also shown.

Table 1.38 Ambient air quality standards (maximum permissible limits in µg/m^3), NECS Bhutan (2010).

Parameter	Industrial Area	Mixed Area*	Sensitive Area**
Total Suspended Particulate Matter 24 Hour Average Yearly Average	 500 360	 200 140	 100 70
Respirable Particulate Matter (PM 10) 24 Hour Average Yearly Average	200 (World Bank/WHO = 150) 120 (World Bank/WHO = 70)	 100 60	 75 50

Parameter	Industrial Area	Mixed Area*	Sensitive Area**
Sulfur Dioxide 24 Hour Average Yearly Average	 120*** 80	 80 60	 30 15
Nitrogen Oxides 24 Hour Average Yearly Average	120 80 (World Bank/WHO = 40)	 80 60	 30 15
Carbon Monoxide 8 Hour Average 1 hour Average	 5,000 10,000	 2,000 4,000	 1,000 2,000

* ***Mixed Area*** *means an area where residential, commercial, or both activities take place.*

** ***Sensitive Area*** *means an area where sensitive targets are in place, like hospitals, schools, sensitive ecosystems.*

*** *Exceeds (better than) WHO/World Bank guidelines.*

Table 1.39 Motor vehicle emission standards.

Fuel Type	Vehicle registered prior to Jan 1, 2005	Vehicle registered after Jan 1, 2005	Type Approval
Petrol (%CO)	4.5	4	Euro-II
Diesel (%HSC)	75	70	

Table 1.40 Environmental standards for noise.

Land Use Category	Maximum Level	
	Day	Night
Industrial Area	75 db	65 db
Mixed Area	65 db	55 db
Sensitive Area	55 db	45 db

Noise standard as per land use Category 2. World Bank noise guidelines are 70 db day and night for industrial areas, and the same as Bhutan guidelines for sensitive areas.

a. Air pollution control measures

Most air pollution risks will be associated with vehicle movements, especially transportation of construction material. The following measures will be implemented:

- Covering of trucks/dumpers to avoid spillage; compacted roads, speed control on vehicles and provision for mobile water sprinklers on roads.
- The crushers should be fitted with bag filters and have covered unloading points so as to minimize dust emissions.
- The chimney height as well as the emission from DG set should meet the national standards.

- Regular water spraying around the crushing sites, haul road, quarry as well as the dumping sites should be ensured.
- As a safety measure, all workers must be provided with Personal Protective Equipment (see the section dealing with Worker Health and Safety). Masks should be provided to the workers and staff.
- Development of a green belt of suitable width on both sides of road, which acts as a wind break and traps fugitive dust.

Measures for control of noise pollution that could be caused by the project include:

- Ear protection aids such as ear plugs, earmuffs, noise helmets, etc., must be provided to the workers.
- Noise producing machines (such as crushers, aggregate processing plants, etc.) must be provided with noise barriers where required.
- Proper and regular maintenance /lubrication of machines should be done.
- Afforestation in the form of green belts around the project area, residential colonies and office complexes should be done effectively, which will also help in reducing the noise pollution to a great extent.

Monitoring

An Ambient Air Monitoring Program to monitor air quality and noise levels will be implemented as part of the overall EMP by THyE. The purpose of the monitoring program will be to observe air pollution levels and detect sources of air pollution so that remedial measures can be undertaken. Monitoring will be conducted at each work site. This may be done on a rotational basis, with THyE staff moving from one site to the other. The parameters to be measured are TSS, PM 10, Sulphur dioxide, Nitrogen Oxides, Carbon monoxide, and Noise levels in dBA. The data collected will be compiled every month and, accordingly, if the air quality and noise levels exceed acceptable standards, this could potentially have health impacts, and require further management and planning controls. In such cases, remedial action will be proposed by the THyE, which the contractor will be required to undertake.

Table 1.41 Air quality and noise monitoring requirements.

Feature	Parameter	Location	Respons-Ibility	Time/ Frequency
Air Quality	PM 10, Sulphur dioxide, Nitrogen Oxides and Carbon monoxide	All active work sites and worker camps.	THyE	Should cover all work sites at least once a monthduring construction.

Feature	Parameter	Location	Respons-Ibility	Time/ Frequency
Noise	Noise pressure level in dBA.	All active work sites and worker camps.	THyE	Should cover all work sites at least once a month during construction.

Budget

Most of the cost of environmental quality monitoring will be associated with staff level of effort, which is already budgeted for in THyE operations. It is assumed that there will be additional costs associated with sampling equipment and laboratory analysis. This may come to about 600,000 Nu/year.

1.2.2.9 Water Quality Management Plan

The Nikachhu catchment area upstream of the proposed dam site is about 373 km^2. There are no glacier-fed lakes in the catchment. The average lean flow of the Nikachhu at the proposed dam site is 4.8 m^3/sec (recorded between December and March). There are 26 tributaries between the proposed dam site and the confluence of the Nikachhu and the Mangdechhu; 11 of these are perennial. These tributaries contribute another 0.45 m^3/s flow in the leanest months. Most of the rain falls during the monsoon (June-September).

The Nikachhu reflects a very healthy river system, with no evidence of contamination from human sources. In addition, despite water sampling at the beginning of the monsoon, turbidity is actually very low, reflecting very little sediment mobilization (from erosion) in the upper watershed of the Nikachhu (which in turn reflects very high vegetative cover).

Concerns about impacts on the quality of surface water in the project area include:

Pre-construction Phase

1. Increase in water demand from the influx of new workers for the project;
2. Seepage of sewage into tributaries/streams from worker camps;
3. Cutting into the land to create road bases and level areas for construction (mobilizing sediments and creating the risk of slope instability, potential occlusion of creeks and rivers, and temporary decrease in water quality).

Construction Phase

1. Excavation work along all work sites (dam site, powerhouse site, access roads, muck disposal sites, etc.) leading to sediments entering creeks and rivers;
2. Risk of contamination of surface water by organic and hazardous materials such as fuel and oil.

Operation Phase

1. Reduced discharges in the lean season (with minimum environmental flow) could create a higher risk of reduced water quality in downstream areas;
2. Occasional sediment purging from the desilting chambers could cause some turbidity plumes downstream;
3. Risk of dam burst and flash flood would cause scouring along the river banks and a huge turbidity plume, damaging the existing downstream aquatic habitat, although it is a very low probability event given the size of the Nikachhu reservoir size and low dam height.

a. During Pre-construction Activities

Drinking water sources have been identified by the project (see above). There is adequate water to provide for all additional workers. This demand for water will continue during the construction phase, but will decrease substantially during the operation phase as all construction work winds up and workers leave the project site.

To reduce impacts on streams/rivers from seepage from worker camps, all septic tanks, soak pits will be located at a parallel minimum distance of 50 meters from the nearest stream, and if practical at the furthest location away from watercourses (depending on how site drainage works).

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). Still, some measures to reduce the amount of sediments from construction work, and measures recommended for reducing the risk of landslides and slope instability, which could affect water quality, are outlined below (under 'construction phase').

b. During Construction Activities

Luckily, where the slopes are greatest, and the risk of slope instability and soil loss is highest, the locations are further away from the Nikachhu river, so possible occlusion of watercourses by sediments lost down-slope and resultant temporary degradation of water quality and aquatic habitat is diminished as a risk. Nevertheless, the following measures will be implemented:

- To reduce ground movement of surficial sediments, excavators, rather than bulldozers, will be used.

- At the takeoff point for roads, retaining walls must be erected at the same time that formation cutting is going on, to prevent damage to the highway and roads from local slides.
- Other steep exposed slopes should be protected with retaining walls, before significant sediment excavation and certainly before the onset of the monsoon.
- Simultaneous blasting using codex and detonating cord could be adopted to prevent flying rocks, thus keeping broken rocks in one place, and not going downslope.
- Loose slopes can also be stabilized with the plantation of various local species (bioengineering approach).
- For all project work sites, site drainage will be carefully studied and managed, to prevent erosion of exposed sediments into adjacent watercourses.
- Piles of sediments will also be covered to prevent their erosion.
- The use of small checkdams and sediment retention ponds adjacent to cleared work sites will also be studied and implemented where necessary.
- Proper fuel storage standard practices will be implemented, requiring storage of fuel at a flat, properly drained, isolated, fenced, and bunded area, where any slow or fast leaks of fuel will be contained and fuel cannot enter any adjacent watercourses.
- As per existing rules, no washing of project vehicles will be allowed near streams and rivers, to minimize pollution of the natural water system.

c. During Operation Phase

Monitoring for any signs of pending dam failure or flood conditions will be conducted as part of the overall monitoring program of the Project. The dam burst monitoring system includes a warning system installed at regular points plus emergency communication system. Recovery from a flash flood would take a few years, but it would occur in time

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. To mitigate this, upper watershed management (see catchment plan described below) will be encouraged, along with the compensatory afforestation.

d. Monitoring of water quality

Water quality monitoring will be conducted at key streams and in the Nikachhu river at least twice a year, starting as soon as possible to build up the pre-project baseline. These samples will be compared with the existing baseline, such as the Tsheringma drupchu, as well as against standard parameters approved by the NEC. The sampling points for water quality monitoring along the Nikachhu river include;

1. Above the dam;
2. Immediately below the dam;

Table 1.42 Water quality at Tsheringma Drupchhu (July 2012); reference point for future water quality monitoring results.

Parameter	Unit	Tsheringma Dupchu
Turbidity	TU	8
pH		6.8
Temperature	Centigrade	13.8
Conductivity	µS/cm	29.7
Dissolved Oxygen	mg/L	7.69
Chlorine	mg/L	0
Arsenic (50 ml)	Ppb	0
Arsenic (9.6 ml)	Ppb	0
Coliform	cfu/ml	71

ECDMD staff will maintain visual checks of the reservoir and will undertake routine monitoring of water quality and fish populations in the reservoir and below the dam (during the first two years), as well as routine monitoring of discharge from the spillway. Parameters for water quality testing and associated features (hydrology and fish) are included in the following table.

Table 1.43 Parameters for water quality testing and associated features

Feature / Issue	Parameter	Location	Responsibility	Time/ Frequency
Water Quality	Ambient Temperature (^oC), pH, Conductivity (µmhos / cm), Total Suspended Solids (mg/l), Total Phosphorus (mg/l), Total Kjeldahl Nitrogen (mg/l), Ammoniacal Nitrogen, (NH_3 – N) (mg/l), Nitrate Nitrogen (NO_3 – N) (mg/l), Nitrite Nitrogen, (NO_2 – N) (mg/l) Dissolved Oxygen (mg/l), Biological Oxygen Demand (BOD5 @ 20^oC) (mg/l), Chemical Oxygen Demand (CODCr) (mg/l), Total Sulphate (mg/l), Fecal Coliform Count (MPN Index / 100ml).	Nikachhu above dam and Nikachhu immediately below dam.	THyE	Quarterly, starting as soon as possible, and during construction and semi-annually during first two years of project operation.
Hydrology	Discharge rate (m^3/s).	Above dam, below dam, at confluence of Nikachhu with Mangdechhu.	THyE	Monthly during construction and first two years of operation.

Feature / Issue	Parameter	Location	Responsibility	Time/ Frequency
Aquatic Habitats	Overall quality (visual observations of riverbed, weeds, sediments).	In reservoir, immediately below dam, and in Nikachhu at confluence with Mangdechhu.	THyE	Twice annually, starting as soon as possible (in lean season and immediately after monsoon), and then during construction and first two years of operation.
Fish	Frequency of occurrence (numbers and size) and species diversity.	In reservoir, immediately downstream of dam, and in Nikachhu at confluence with Mangdechhu.	THyE and DoFPS staff	Twice annually, starting as soon as possible (in lean season and immediately after monsoon), and then during construction and first two years of operation.

1.2.2.10 Reservoir Management and Rim Treatment Plan

The submergence due to reservoir development behind the diversion dam will be a total of about 12.29 acres (4.9 ha), forming a water body about 810 meters long (about 60 m wide near the dam, then tapering to the west). Given the cross-section of the gorge at the dam site, most of the flooded area (about 70%) will be on the left bank of the river in degraded forest (between the Nikachhu and the national highway), rather than on the National Park side of the river (the right bank). Only 6 acres (2.4 ha) of the park area (within the buffer zone) will be permanently flooded. Along one side of the reservoir is the steep right bank border of the Park, which is quite inaccessible to people, from the dam site down to the confluence with the Mangdechhu. Because of the very steep slopes, it is not expected to be commonly used by wildlife for access to the river. As such, the reservoir impingement on the edge of the park will likely have no practical effect on the park operations.

Although the Nikachhu project will have a relatively small reservoir, nevertheless a “rim” treatment plan has been formulated to mitigate the geo-environmental hazards in the reservoir area. The aim of the plan is to reduce sedimentation into the reservoir, and therefore to mitigate the effects of debris flows on extreme slopes and extreme events such as landslides, as follows:

- to prevent land degradation/soil erosion;
- to enhance the quality of reservoir by reducing siltation; and,
- to stabilize soil to prevent landslides and landslip zones around the reservoir.

Treatment measures will include various approaches, described below.

a. Slope stabilization

After the construction of the dam, slope stabilization works on both banks of the river (at least where there is soil, rather than bare rock) will be required to stabilize the soil and prevent landslides or debris falling into the reservoir. This will entail the construction of retaining walls, gabion toe walls, wire crates, or breast walls. Proper drainage along the slopes is required to reduce risk of landslides and erosion.

b. Use of geotextiles

Coir geotextiles can be used on the stabilized slopes for erosion control. As coir geotextiles last for approximately 3 – 5 years (depending on the weight), by the time the product degrades, it converts itself into humus enriching the soil.

c. Plantation with local fast growing species

The slopes can also be stabilized by planting fast growing local species that can colonize loose soil. The type of vegetation cover is the most important factor to minimize the magnitude of potential landslides, so selection of species can be done in tandem with the Compensatory Afforestation program. The vegetation will form the green belt around the reservoir while at the same time providing important habitat for wildlife species that might inhabit the area.

d. Fencing off the National Park area

The National Park side of the reservoir will be fenced, to prevent any public access in that area. This will ensure minimal disturbance to the Park. In any case, as noted previously, it is almost impossible for people to access the park, given the very steep slopes on the right bank of the Nikachhu.

e. Promotion of eco-tourism and bird watching

There is also potential to open the left bank side to public access and interpretation for National Park features, since the access road will be in place and the reservoir will be a significant visual enhancement in this area (this needs more discussion and study, especially to address potential safety issues if there is public access to the left bank). If there is interest in promotion of eco-tourism activities and bird watching in this area, then facilities will be required at the dam site, which in turn will require some funds for infrastructure development, creation of birding trails, educational boards, and signposts. There is also the possibility of stocking the reservoir with local fish (snow trout would be preferred; subject to studies on the feasibility of this).

Institutional Responsibilities: THyE will be responsible for management of the reservoir above the diversion dam. DoFPS staff can be responsible for undertaking the study of public access to the reservoir, options for interpretation facilities, and stocking the reservoir with fish (possibly snow trout). THyE staff will be responsible for routine monitoring of water quality and fish populations in the reservoir (as well as below the diversion dam); addressed elsewhere.

Performance Indicators and Monitoring Requirements: The reservoir is maintained in a good state, with suitable water quality, a diversifying fish population (more than just brown trout), and (if the study indicates the merits) controlled public access and interpretation facilities on the left bank of the Nikachhu, above the dam. The banks of the reservoir will be allowed to re-vegetate, which will reduce sediment inputs.

THyE staff will maintain visual checks of the reservoir and will undertake routine monitoring of water quality and fish populations in the reservoir and below the dam (during the first two years), as well as routine monitoring of discharge from the spillway (addressed elsewhere). The use of the area by wildlife will also be logged (incidental sightings will be recorded).

Scheduling and Pacing: The reservoir will be properly maintained throughout the operational phase of the Nikachhu project.

Table 1.44 Reservoir management and rim treatment.

Item	Quantity	Unit	Rate (Nu.)	Amount (Nu.)
Land stabilization and bioengineering	**-**	**-**	**-**	**2,500,000**
Safety equipment (boat, radio, life saving equipment, signage) and fencing at reservoir	Various	-	825,000	825,000
Promotion of eco-tourism and bird watching	1	One six month study	800,000	800,000
Operational expenses (related to above)	3 years	/year	150,000	450,000
Total				**4,575,000**

Table 1.45 Monitoring plan.

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Slope stabilization	Size of area/slope stabilized	Construction	Contractor	THyE	Every quarter
Use of geotextiles	Area covered with geotextiles	Construction	Contractor	THyE	Every quarter
Creation of greenbelt and plantation	Size of area under green belt plantation. Number of trees/shrubs planted.	Construction	Contractor	THyE	Every quarter

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Fencing along Park bank	Length of right bank fenced	Construction	Contractor	THyE	Every quarter
Promotion of eco-tourism and bird watching	Educational boards for birding	Operation	Park Management /Forestry Division	THyE	Every quarter
	Creation of birding trails	Operation	Park Management /Forestry Division	THyE	Every quarter
	Number of signposts	Operation	Park Management /Forestry Division	THyE	Every quarter

1.2.2.11 Greenbelt Development and Land Management Plan

Several developmental activities at project sites are expected to cause environmental degradation in terms of air pollution, dust emissions, soil erosion, and risk of sedimentation of surface waters. Another impact is the aesthetic impact of clearing forests, to be replaced by other land uses such as office and housing colonies, roads, etc. Therefore, extensive greenbelt development will be carried out along the boundaries of most project features, to mitigate the loss of forest cover, provide habitat and mitigate the loss of biodiversity, and reduce the risks of air and water pollution and environmental degradation.

The objectives of the greenbelt development and land management plan are to:

- mitigate environmental degradation due to developmental activities;
- enhance forest habitat, as well as improve the aesthetic value of the project area; and,
- prevent land degradation, soil erosion and landslides around the reservoir, roads and other construction sites.

The plan aims to achieve the above objectives through the following activities:

1. Identification and selection of areas for land rehabilitation and management;
2. Development of a greenbelt wherever possible adjacent to colonies, the dam complex, powerhouse site, campsites, approach roads to all adits, all of which can attenuate dust emission and noise during construction.

a. Management Steps

i. Survey of all potential areas to be included for greenbelt development

A joint survey by the Forestry staff and Project Management will be conducted to determine all areas that are appropriate for green belt development. This will be done only after areas for

colonies, dam site, approach roads have been delineated in the field and it is clear where the boundaries of these development centers are. Surveys will include assessment of the following:

1. Areas under landslide or prone to landslides.
2. Size of area, length of road and availability of space at colonies to be developed.
3. Slope and soil assessments, along with major vegetation types.

ii. Prioritization and scheduling for each site

Based on the project development process, those areas where construction has begun will be prioritized for greenbelt development. A schedule for greenbelt development will be formulated to allow proper planning for each successive site. Water requirements, type of species to plant, and planting method and season, will all be included in the schedule.

iii. Slope stabilization and drainage

Where required, slopes must be stabilized. All engineering measures such as construction of retaining walls, crate walls, stream bank treatments, etc. to stabilize landslips around the reservoir, access roads, and colonies will be carried out simultaneously or immediately after the construction of the primary structure.

iv. Site development and plantation with local species of trees and shrubs

Avenue plantation on both sides of access roads and plantations along the periphery of the reservoir and colonies will be protected with bamboo fencing, to keep out grazing animals and prevent disturbance. These areas will be demarcated and handed over to be replanted under the ompensatory afforestation program (the total area to be reforested under the program is 600 acres; 240 ha). Therefore, rather than look for new areas to reforest, inclusion of the greenbelt will also ensure that land management and reforestation programs across the project site are coordinated and well planned.

v. Monitoring of plantation success

Once work on each greenbelt has begun, the progress and success of the regeneration will be assessed so that remedial measures, if required, can be undertaken immediately.

Table 1.46 Monitoring Plan

Activities	Indicators	Period	Responsibility	Monitoring	Frequency

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Prioritization and scheduling for greenbelt development	List of priority areas for greenbelt development along with workplan and scheduling	Construction and Operation	Project Management	THyE	Towards the completion of each development work
Slope stabilization and land management	Size of area/slopes stabilized with proper drainage	Construction and Operation	Project management and contractor	THyE	Every quarter after each site has been developed
Site development and reforestation	Size of area handed over under compensatory afforestation for greenbelt development	Construction and Operation	Project management and Social Forestry Division, Local Forestry staff	THyE	Every quarter
Monitoring of greenbelt development	Number of greenbelt areas developed	Construction and Operation	Project Management	THyE	Every quarter

Institutional Responsibilities: THyE will manage the contractors and sub-contractors, who will in turn develop the greenbelt sites. Once the area has been handed over, the Department of Social Forestry and local Forestry officials will be responsible for implementing the plan.

Scheduling and Pacing: Greenbelt development is expected to happen only after the construction of access roads, colonies and reservoir is completed. A workplan will determine the schedule for each site.

Budget: The budget for slope stabilization and drainage works will be included in the overall construction budget for that particular development activity (road, dam construction etc.) while the cost of developing the greenbelt will be included under the compensatory afforestation program. Monitoring will be included as part of the overall monitoring of the THyE.

1.2.2.12 Energy Conservation Plan

During the socioeconomic survey, it was determined that only 23.6% of households use electricity for cooking, while 21.8% use LPG, and 54.2% of the households use fuelwood for both heating and cooking. Less than 1% uses kerosene.

The project itself and the influx of workers will add stress to the availability of essential fuel items (liquid petroleum gas (LPG), diesel, petrol, and kerosene). This was observed during the first phase of the Mangdechhu project construction, and the Government quota for the Trongsa area had to be raised (apparently shortages were still experienced). On the other hand, the

increased availability of electricity over the longer-term (from both Mangdechhu and Nikachhu) will potentially reduce some pressure on fuel (for heating and cooking).

The objectives of the Energy Conservation Plan are:

- to ensure that the increase in workers (2,000+) does not add to the existing local pressure on essential fuel;
- to ensure proper fuel arrangements for all workers while also ensuring that no illegal felling of trees for firewood occurs.

Various mitigation measures are proposed.

a. Request for additional quotas for subsidized fuel to meet increased demand

With the already existing demand for fuel (LPG, diesel, petrol and kerosene) from existing projects like Mangdechu, the Project will therefore start the process for an increase in supply for fuel for an additional 2,000 workers.

b. Arrange to supply felled trees as fuelwood for local use as well as project use

Since 54.2% of the households use fuelwood for both heating and cooking, the project could make arrangements with the Local Forest Office to allow local communities to use the felled trees. There may also be some benefit in the use of the cut trees (fuelwood quality) to help take pressure off LPG and kerosene. As the Mangdechhu project winds down, and consumption of subsidized fuels decreases somewhat, this will make room for the fuel demand associated with the Nikachhu project and the worker camp needs.

c. Use communal kitchens in worker camps

The use of communal kitchens in worker camps will require less LPG and fuelwood, compared to individual kitchens. Also, contractors can then make arrangements for the entire site rather than each individual.

d. Centralized Fuel Depot

Where fuel like diesel or petrol is required in large quantities for machines or trucks located far away from Trongsa town, contractors can make arrangements for a centralized fuel storage site (see fuel storage management plan). In this way, fuel and transportation costs can be saved.

e. Electrification of worker camps

All work sites and camps will be electrified. This will reduce the use of fuelwood for lighting and heating purposes, especially in winter when the weather is quite cold.

f. Awareness of penalties for illegal felling of trees

All workers will be made aware that it is illegal to fell trees for any purpose without a permit from the concerned forest office. This must be done by the Contractor and Project Management and can be incorporated in the general awareness program for all workers when they arrive at the project site.

Institutional Responsibilities: THyE and contractor staff will be responsible for all energy conservation measures.

Monitoring: The THyE will undertake compliance checks every quarter (but unannounced).

Budget: Energy conservation measures will be included in the overall project budget.

Table 1.47 Implementation and monitoring schedule.

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Request for additional quotas for subsidized fuel to meet increased demand	Increase in quota of fuel supply for Trongsa	Pre-construction	DGPC	THyE	after pre-construction phase
Arrange to supply felled trees as fuelwood for local use, as well as project use	Number of fuelwood permits issued	Pre-construction and construction	Project management	THyE	every quarter
Communal kitchens	Number of communal kitchens operational	Pre-construction and construction	Contractor	THyE	every quarter
Centralized fuel depot	Number of fuel depots	Pre-construction and construction	Contractor	THyE	every quarter
Electrification of worker camps	Number of worker camps/ colonies electrified	Pre-construction and construction	Contractor	THyE	every quarter
Awareness campaigns	Number of awareness meetings held	Pre-construction and construction	Contractor and project management	THyE	every quarter

1.2.2.13 Closure Plan for Construction Works

The purpose of the closure plan is to ensure that project components not pose a future threat to human health and to allow the natural environment to recover and flourish again

All elements of closure for each of the pre-construction and construction project activities have already been identified and budgeted within the individual mitigation measures and environmental management plans. The closure details are summarized below, and can serve as a checklist for completion of all pre-construction and construction activities.

a. Temporary Land Use:

- Areas that have been used and rehabilitated will be identified and transferred back to land owners and the Government, as relevant, with summary statements about the use and rehabilitation of the temporary land use areas.

b. Adits and Access Roads and All Other Temporary Work Sites:

- Those roads and adits that do not remain functional for project operations will be cleaned of all equipment, debris, rubble, and sodded and re-vegetated as specified in the individual activity plans, the greenbelt plan, or the compensatory afforestation plan, depending on specific fate noted for each site.
- Those parts of the National Highway which may have suffered damage due to project equipment will be repaired in consultation/ coordination with the District and DoR.

c. Labour Camps:

- All buildings and service infrastructure will be de-constructed and recycled, or disposed as solid waste.
- All equipment, debris, residual waste, etc. will be cleared from the site and disposed according to the project solid waste management plan.
- Septic tanks will be cleaned and filled and covered.
- The remaining area, once cleared as described above, will be graded and prepared for re-vegetation (a target for compensatory afforestation).
- All camp sites will then be inspected, documented, and photographed as evidence of full camp closure.

d. Project Fuel Depots:

- All fuel containers will either be moved or emptied, so that no fuel containers are left on site.
- All surficial sediments in and around the vicinity of the temporary fuel depot will be scraped down to clean soil layers, and disposed in a designated hazardous materials disposal location.
- All fuel service equipment/ infrastructure will be removed from the site.

- The soil will be tested for hydrocarbons, and if the site is deemed clean, will be re-vegetated.

e. Quarry:

- The remaining working life of the quarry will be evaluated; if it has economic value, it can remain open and continue to serve local needs for aggregate or the quarry can be closed according to all the closure procedures identified about for other project work sites.

f. Muck Disposal Sites:

- There is a detailed procedure for preparation and re-vegetation of all muck disposal sites. They will be terraced, compacted, and prepared for re-sodding or replantation of trees (depending on ultimate fate; whether being kept as a public playing field, or allowed to revert to wild state).

1.2.3 Operation Phase

1.2.3.1 Reduced Worker Numbers

Mitigation Measures: This negative "turn" needs to be broadly disseminated from the beginning of the project, since local people are already experiencing the positives of the Mangdechhu project and will feel secure in the future, as the Nikachhu comes along to replace the economic activity. The Nikachhu project proposes to create a buffer against the possible negative economic shock, by implementing a Community Support Enhancement Program, which will involve setting aside a fund to provide grants for such activities as the following:

a) mitigating wildlife-human conflicts, by providing electric fencing to protect crops (some additional studies and community workshops will be supported, to come up with viable solutions to the problem);
b) supporting roadside produce vending (stalls and shades near the roads); and,

c) training communities in vocational skills.

The implementation of the fund will require setting clear criteria and an objective selection process, so that all local communities have fair access. The expenditures and results from community investments will then be monitored and reported publicly.

Institutional Responsibilities: The use of community support grants will be proposed by the Chief Administrative Officer (CAO) of THyE assisted by Environment Officer based upon community needs assessment and proposals submitted to the project authority. The community

projects could be implemented by the community themselves, so that money can be retained with them, or can be outsourced to a contractor, if skills to implement it are not within the communities.

Performance Indicators and Monitoring Requirements: As business opportunities wane (as the project construction nears completion, and workers leave), the local community will have established some new enterprises that can be sustained into the future. These will increase local income, or reduce costs, depending on the type of venture supported by the Community Support Program. The CAO of THyE will monitor implementation of the grants (for administrative and financial propriety) and will also evaluate the grant outcomes for the beneficiaries.

Scheduling and Pacing: The proposed grant program will likely get engaged in the last 2-3 years of the construction phase, and the results of the grants should persist in the years following that.

Budget: The proposed budget for the Community Support Program is noted in the Resettlement Plan.

1.2.3.2 Diversion Dam and Reservoir Operation (Flooded Area); Fisheries Development Plan

Mitigation Measures: As noted previously, the reservoir has some potential as a more quiescent aquatic habitat, in which other fish (other than brown trout) could be stocked, and which waterfowl might be able to use as a roosting and feeding area. There is also potential to open the left bank side to public access and interpretation for National Park features, since the access road will be in place and the reservoir will be a significant visual enhancement in this area (this needs more discussion and study, especially to address potential safety issues if there is public access to the left bank; addressed previously). As noted previously, if there is interest in promotion of eco-tourism activities and bird watching in this area, then facilities will be required at the dam site, which in turn will require some funds for infrastructure development, creation of birding trails, educational boards, and signposts (budgeted previously). The National Park side of the reservoir would be completely fenced, to prevent any public access in that area. Fencing might be required on the left bank as well, to keep cattle and people out of the reservoir (but not necessarily away from the banks of the reservoir). The rim treatment plan described previously will ensure that all slopes (other than bare rock) are properly vegetated and secured, so there is slope failure and entry of sediments into the reservoir.

A series of screens will be required to keep fish from the immediate intake area, and will be designed to allow fish to approach the screens but not be impinged on them, so that fish can

move to the spillway and continue downstream. Screens can be made of various materials, such as perforated plates, metal bars, wedgewire, plastic, or metal mesh. The objective is to create uniform velocities and eddy-free currents upstream of the screens to effectively guide fish towards the bypass or spillway (see below).

Figure: Example of fish screens at hydropower intakes.

Institutional Responsibilities: THyE will be responsible for management of the reservoir above the diversion dam, including installation and cleaning of the fish screens at the intake. As noted previously, DoFPS staff can be responsible for undertaking the study of public access to the reservoir, options for interpretation facilities, and stocking the reservoir with fish (possibly snow trout). THyE staff will be responsible for routine monitoring of water quality and fish populations in the reservoir (as well as below the diversion dam).

Performance Indicators and Monitoring Requirements: The reservoir is maintained in a good state, with suitable water quality, a diversifying fish population (more than just brown trout), and (if the study indicates the merits) controlled public access and interpretation facilities on the left bank of the Nikachhu, above the dam. The banks of the reservoir will be allowed to re-vegetate.

THyE staff will maintain visual checks of the reservoir and will undertake routine monitoring of water quality and fish populations in the reservoir and below the dam (during the first two years), as well as routine monitoring of discharge from the spillway. The use of the area by wildlife will also be logged (incidental sightings will be recorded).

Scheduling and Pacing: The reservoir will be properly maintained throughout the operational phase of the Nikachhu project.

Budget: The design and installation of fish screens will be included in the overall project budget. Engagement of a fish specialist has already been budgeted above (required for monitoring fish, associated with the cofferdam operation). Fish stocking costs are noted below.

Table 1.48 Fisheries Development Associated with Reservoir Management

Item	Quantity	Unit	Rate (Nu.)	Amount (Nu.)
Fish stocking (3,000 fingerlings/year)	**3 years**	**/year**	**165,000**	**495,000**

1.2.3.3 Maintenance of Minimum Environmental Flow

Mitigation Measures: Spillway operations will ensure that at least 10% of average lean season flow in the Nikachhu will be released downstream. In the monsoon, released amounts will be larger than this. Just prior to the confluence of the Nikachhu with the Mangdechhu, the accumulated discharge of the Nikachhu (in the lean season) is expected to be about 1 m^3/s, which is about 18.5% of the average lean season discharge in the Nikachhu (10% is considered to be a globally acceptable standard for environmental release). For the first 5 km below the dam, the minimum environmental flow may be below 15%, then for the rest of the Nikachhu to the confluence with the Mangdechhu, the minimum environmental flow will exceed 15% of the average lean season discharge. Maintenance of minimum environmental flow is considered a primary mitigation measures (required because of the diversion dam).

Institutional Responsibilities: THyE will be managing the operation of the dam and the spillway.

Performance Indicators and Monitoring Requirements: Aquatic habitat below the diversion dam is maintained, at least in a rudimentary state, which allows fish to stay in all stretches of the river down to the confluence with the Mangdechhu in all seasons.

The state of aquatic habitats, discharge rates, water quality, and fish populations below the diversion dam will be monitored at least twice per year during the first two years of operation of the Nikachhu project. Also, incidental sightings of wildlife will be logged and reported to THyE staff (as part of the overall wildlife sightings recording for the project area).

Scheduling and Pacing: Minimum environmental flow will be maintained at all times.

Budget: Project operations are included in the overall project budget. Provision for a fish specialist has already been made above. Monitoring costs are noted separately in Section 5 below.

1.2.3.4 Occasional Sediment Purging

Mitigation Measures: Any turbidity issues in the Nikachhu can be mitigated by undertaking sediment purging during the monsoon, when turbidity in the river is at a maximum, in any case.

Institutional Responsibilities: THyE will be responsible for cleaning of the desilting chambers when and as required.

Performance Indicators and Monitoring Requirements: Sediment purging does not cause a prolonged measurable increase in suspended sediment load in the downstream section of the Nikachhu. Occasional water quality monitoring in the Nikachhu will confirm this.

Scheduling and Pacing: The frequency of sediment purging will depend on the accumulation in the desilting chambers, during the operation phase.

Budget: Operation of the desilting chambers is included in the overall project operation budget.

1.2.3.5 Risk of Dam Burst and Disaster Management Plan

The gross reservoir capacity of the project is only 0.537 million m^3, with 0.046 km^2 of reservoir surface area at full reservoir level created by a 33 m high dam. The reservoir backflow stretches only about 800 m. This reservoir volume, compared with mean annual flow volume of the Nikachhu (505 million m^3) is only about 0.10%, which is very small. For the Sankosh reservoir hydropower project, the reservoir volume (3,920 million m^3) as compared with mean annual flow volume (15,220 million m^3) is about 26%, with reservoir fetch of 45 km and reservoir surface area of 46.26 km^2. Presently, there are three hydropower reservoirs under operation in Bhutan, namely: Chukha Hydropower Plant since 1986 (3.1 million m^3), Kurichhu Hydropower Plant since 2001 (15.7 million m^3), and Tala Hydropower Plant since 2006 (9.8 million m^3). The geological formation in the reservoir area of Nikachhu is competent to take the weight from the small reservoir volume. Based on the experience of existing hydropower plants and given the small size of the Nikachhu reservoir, it is not expected that a reservoir-induced seismic event is likely.

The Nikachhu dam will be a concrete gravity dam. The dam will be designed based on site-specific seismic parameters which have been studied and determined by the Indian Institute of Technology, Roorkee, India as per the guidelines prescribed by the National Committee on Seismic Design Parameters (NCSDP), India. The institute is one of the two national institutes in India approved for such specialized studies. The site-specific seismic parameters consider the seismic zonation of the project area, geo-tectonic features, and large seismic events in the vicinity of project area.

To address the unlikely event of a dam failure, a hazard zonation map downstream of the dam until its confluence with the Mangdechhu has been delineated. During the operational phase of the project, as is being practiced in existing power plants, an emergency preparedness and mitigation plan will be in place to address risks to the safety of downstream settlements. However, there are no communities within the flash flood zone downstream, along the Nikachhu, due to the very steep topography adjacent to the Nikachhu for its distance to the

Mangdechhu (it is very inaccessible, for both people and livestock). A high volume flood would mostly be contained in the gorge down to the confluence with the Mangdechhu and then in the Mangdechhu itself, after a lag period. The modeling data indicate that there are no buildings in the flooded zone until the lower reaches of the Mangdechhu (below the confluence with the Nikachhu; about 20 km from the dam site); some cultivated land would be flooded (also along the lower reaches of the Mangdechhu).

While this is a very low probability event, mitigation measures are necessary to prepare for such disasters. The objective of the Disaster Management Plan is to:

- promote a planned approach to dealing with disasters to ensure appropriate and timely response strategies;
- build a disaster management mechanism at the Dzongkhag and Geog levels.

The required management actions are described below.

a. Collaboration with the Department of Disaster Management and National Emergency Operations Centre (NEOC)

The project will develop operational linkages with the Department of Disaster Management and the National Emergency Operations Centre (NEOC), that is supposed to maintain continuous disaster surveillance, tracking and ensure real-time warning dissemination to the Dzongkhags, Dungkhags and Geogs likely to be impacted by an impending disaster. At the operational level, the project will also collaborate with the Dzongkhag Disaster Management Committee (DDMC) constituted under the Chairmanship of the Dzongda. This will ensure speedy delivery of emergency operations in case of a disaster.

b. Develop a forecasting and early warning system

i. Using meteorological information from MoEA

The forecast system will entail using meteorological and rainfall data that is collected by the Department of Hydro Met of the Ministry of Economic Affairs, which also provides daily forecasts and early warnings and alarms regarding extreme events such as floods. This will allow the project to prepare for such events. The project shall also install its own flood detection system in which the water levels are monitored on a daily basis.

ii. Monitoring of the dam condition

As part of the operational work, the Dam Safety Committee of DGPC shall conduct routine monitoring of the dam conditions. The reports will be logged and a copy submitted to the THyE

for their monitoring purposes. Any damage to the dam will be immediately reported to the THyE for immediate restorative action

iii. Installation of a warning system

A warning system (sirens) will be installed at regular points along the highway to notify people who may be near the river in the event of the risk of dam failure. This system will be backed up with an emergency communication system (a cascading system of phone calls that passes the warning message to all inhabitants near the river).

c. Disaster Preparedness Plan

The objective of this plan is to minimize the adverse effects of a disaster through adequate preparedness and response planning to ensure timely and coordinated action at the Dzongkhag, project, and community levels to cope with any disaster.

Some actions to be undertaken under the disaster preparedness plan include:

a. Installation of signs along the National Highway and any roads that lead down to the Nikachhu and Mangdechhu;
b. Developing protocols in dealing with a disaster/flood, including institutional arrangements and mobilization of resources during emergencies including conducting mock-drills;
c. Regular checking of warning systems;
d. Assigning of specific project personnel as disaster focal persons who can design the disaster preparedness plan in collaboration with the Dzongkhag;
e. Provide training for disaster management and preparedness and awareness on the plan and protocols to be followed such as evacuation
f. Retain a specific budget for disaster management, emergencies, and compensation, if required.

Institutional Responsibilities: THyE will take the lead in developing collaborative disaster management strategies. The Project will collaborate with the District and local authorities in designing, setting up, disseminating, and testing the flood warning procedures (in the event of a pending dam burst). Provision has been made for a technical consultant to assist with this (see terms of reference in Appendix).

Budget: The proposed budget below includes the siren system, signage, dissemination, related technical assistance (see Terms of Reference in Appendix 1), and testing in the last year of construction and the first year of operation of the Nikachhu project.

Table 1.49 Cost of siren system, signage, dissemination, and related technical assistance.

Item	Quantity	Unit	Rate (Nu.)	Amount (Nu.)
National Collaboration	Included in project operational cost (staff time)			
Dzongkhag level collaboration	Included in project operational cost (staff time)			
Develop forecasting and early warning system				
a. Siren system (up to ten along the highway to Trongsa)	10	/siren	50,000	500,000
b. Associated wiring and linkage to master control	1	/system	275,000	275,000
c. Setting up mobile phone contact system	1	/set-up	200,000	200,000
d. Testing system	2	/test	50,000	100,000
e. Technical specialist for design and testing	3	Month	375,000	1,125,000
Monitoring of dam conditions	Included in operational cost			
Disaster preparedness plan				
a. Dissemination sessions with communities and district authority	2	/session	100,000	200,000
b. Signage	10	/sign	10,000	100,000
Develop disaster preparedness protocols				600,000
Provide training				400,000
Emergency budget/relief fund	Included in contingency cost			
Total				**3,500,000**

Performance Indicators and Monitoring Requirements: The system is fully operational, and all communities near the Nikachhu and Mangdechhu are aware of how it operates. If a dam burst were ever to actually occur there should be no loss of human life.

Table 1.50 Monitoring Plan.

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
National Collaboration	Formal operational linkages developed	Construction	THyE	Project management	At the beginning of the project
Dzongkhag level collaboration	Formal operational linkages developed	Construction	Project management	Project management	At the beginning of the project
Develop forecasting and early warning system	Develop linkages with Hydro Met	Construction	THyE	Project management	At the beginning of the project
Monitoring of dam conditions	Dam assessment report	Operation	THyE	THyE	Every month
Installation of early warning system	Number of warning systems installed	Operation	Project	THyE	Every quarter

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Disaster preparedness plan	Signs installed	Operation	Project	THyE	Every quarter
	Disaster protocols in plan with institutional linkages	Operation	Project	THyE	Every quarter
	Warning systems tested	Operation	Project	THyE	Every quarter
	Nomination of focal disaster management officer	Operation	Project	THyE	Every quarter
	Training on disaster management conducted	Operation	Project	THyE	Every quarter
	Awareness meetings with nearby downstream villages conducted	Operation	Project	THyE	Every quarter
	Separate emergency budget for disaster and emergencies	Operation	Project	THyE	Every quarter

1.2.3.6 Catchment Management Plan (CMP)

A catchment is defined as the land area from which water drains to a given point. The Catchment Management Plan (CMP) aims to improve productivity of land through land management, to ensure good quantity and quality of water draining from that land, to rehabilitate any degraded parts of the watershed, and in the process to assist with conservation of overall biodiversity.

Bhutan consist of a mosaic of watersheds draining into 7 major basins, namely Amochhu, Wangchhu (Haa chhu, Paro chhu, Thimp chhu), Punatsangchhu (Mo chhu, Pho chhu, Dagachhu), Mangdechhu (Nikachhu, Mangdechhu), Kuri chhu, Drangmechhu (Gamri, Kholongchhu, Tawangchhu), and Nyera Ama chhu (from Guidelines for Watershed Classification, DoFPS).

The river Mangdechhu rises in Wangdue Phodrang near Gangkar phuensum and flows through central Bhutan traversing roughly north-south before merging into the Manas. The Nikachhu is a sub-watershed to Mangdechhu watershed. It has a catchment area of 373 km^2 (from the dam site of Nikachhu Hydropower Project). It originates at an elevation of 3,918 m. Its catchment is spread over parts of Wangdue Phodrang in the north and Trongsa in the south. Within the catchment, the river flows through steep narrow valleys, with an average catchment slope of around 43.7%, which is about 23.5 degrees. The major river network is sub-parallel in nature, indicating presence of structural control near the central portion of the catchment. Watershed Management Division, DoFPS has assessed and classified watersheds into critical, normal and pristine watersheds using 22 criteria. A critical watershed requires immediate action, normal requires periodic monitoring and pristine requires no action (see Guidelines for Watershed Classification, DoFPS). Currently, classification of the Punatsangchhu Basin and Wangchhu basin have been completed; classification of the Mangdechhu Basin has not yet been done.

The Nikachhhu catchment is sub-divided into seven major “micro” watersheds, namely; Bushipa chhu, Longtechhu, Khabarchhu, Dzongtegala chhu, Nobsang chhu, Nakha chhu and Gulela micro watershed, with an average slope of 43.7%. The land use type in the catchment is mainly open shrubs and forest and only a few settlements are present in the catchment, with most concentrated in the Longtoe micro-watershed as shown in the figure below.

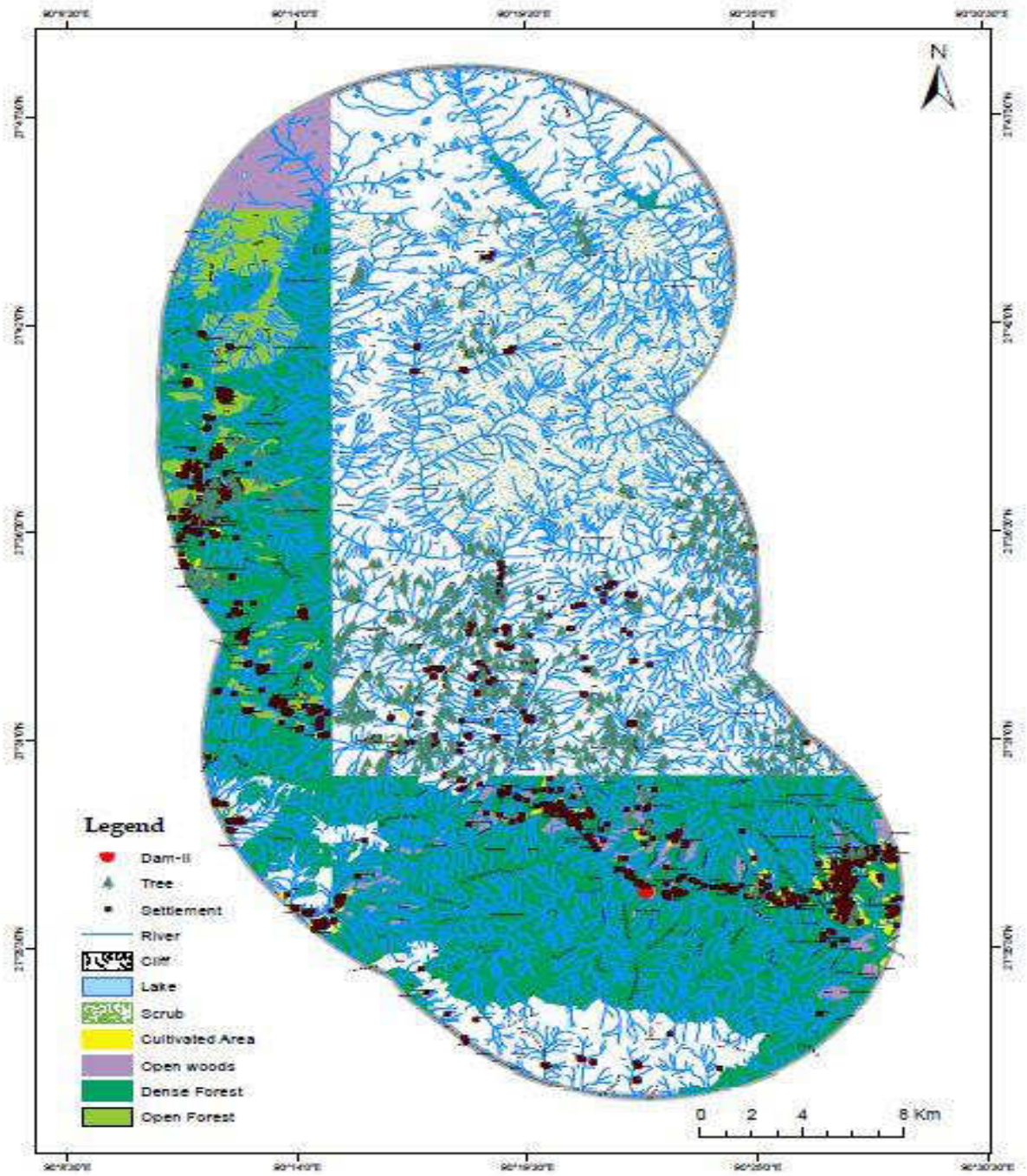


Figure: Land Use Map of the Nikachhu Catchment.

There are no glacial lakes in the catchment and therefore the project area is free from the risk of Glacial Lake Outburst Flood (GLOF). The catchment is supplied with snow-melt water and rainfall, most of which is channeled through many smaller tributaries that join the Nikachhu, and most of which discharge in the monsoon (June-September, as noted previously). The average lean flow of the Nikachhu at the proposed dam site is 4.8 m^3/sec (recorded between December and March). There are 26 tributaries between the proposed dam site and the confluence of the

Nikachhu and the Mangdechhu; 11 of these are perennial. These tributaries contribute another 2.88 m^3/s flow in a year.

No agriculture is practiced in the catchment except in some places like Rukubji, Chendibji, and Tanchuji. Therefore, the catchment does not seem to be critical. However, a CMP (Catchment Management Plan) has been proposed for Nikachhu to maintain good ecosystem health and to maintain/ enhance forest cover for increasing soil holding capacity and arresting total sediment flow into the Nikachhu reservoir, to prolong the storage capacity of the reservoir.

The purpose of the Catchment Management Plan is to encourage coordinated planning and management by all concerned stakeholders so as to balance hydropower development with sustainable water use and protection and conservation of the catchment area.

Proposed management actions are described below.

a. Identification of degraded and deforested areas in Upper Catchment area

The first step will be to identify degraded and deforested areas (due to grazing, forest fire, indiscriminate tree felling) in the upper catchment of the Nikachhu, so that erosion can be minimized and the quality of water going into reservoir maintained. Field investigations must identify areas prone/vulnerable to erosion and the causes responsible for this. Once these areas are identified and delineated, the area will be put under the Compensatory Afforestation program. The ESIA study and discussions with the local forest officers have already identified the catchment areas near Sephu, and degraded areas above Tshangkha, where there was recent forest fire damage along the national highway.

Further, in collaboration with the Watershed Management Division of DoFPS, the rapid classification of watersheds along the Nikachhu catchment shall be initiated to identify critical micro-watersheds, if any. Remedial measures, as recommended by the Watershed Management Division including engineering measures, if required, can then be implemented to improve the condition of the watershed. Critical watersheds, if any, shall be assessed in detail for management measures to be carried out.

b. Organize a catchment management committee

Since the catchment includes a large area with various stakeholders and users, a catchment management committee comprising Local District Officers such as Land Record, Forestry Officer, Agriculture Officer, Park staff, Territorial Forestry staff and Geog representative/Gup and members of the local community will be organized. This will allow each agency to make good use of existing resources, technical knowledge and expertise within each sector for the benefit of the entire catchment. This will also allow multiple issues to be discussed and resolved in a coordinated manner, including water use and sharing, conservation priorities and avoiding duplication during implementation of strategies.

c. Conduct consultative meetings and awareness workshops to prepare a Catchment Management Plan

To generate a wider ownership and enable successful catchment management planning, collaborative consultation and planning by all stakeholders will be encouraged through a formal consultative process such as a workshop. The main objective of the workshop will be to identify priority issues related to water use, conservation, and their impacts, and formalize these actions through a Catchment Management Plan that reflects local views and specific conservation needs specific to the watershed. Areas falling under severe erosion must be treated with high priority and management measures must include both biological and engineering measures.

Year wise targets for implementation of the CAT will be outlined for instance, surveys and field investigations, prioritization of degraded areas for plantation and afforestation of these in year 1, followed by engineering measures like contour bunding, erection of gabion structures, retaining walls and selection of secondary priority areas for years 2 and 3. Monitoring of the Catchment area will be included from year 2-4 and evaluation in year 4.

d. Develop Catchment Area Monitoring Program

This monitoring program will focus on the Nikachhu and its major tributaries, to assess and monitor the status of all water bodies and their quality including aquatic life and water volume. This will be undertaken by THyE and will work in close conjunction with the Catchment Committee to incorporate other monitoring requirements as required. This will also ensure long-term data collection, monitoring, and subsequent management.

Table 1.51 Monitoring Plan

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Identification of degraded areas/	Number and size of areas identified for	Pre-construction	Project management	THyE	Every quarter

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
classification of watershed	reforestation				
Catchment management committee created	Number of agencies and members in committee	Pre-construction	Project management	THyE	Every quarter
Preparation of catchment management plan	Workshops and meetings conducted and the outputs	All phases	Project management	THyE	Every quarter
Implementation of catchment conservation measures	No. of measures implmeneted	All phases	Catchment management committee	THyE	Twice a year
Catchment area monitoring program	Monitoring program initiated	Construction	Project management	THyE	Every quarter

Institutional Responsibilities: THyE and project management will take the lead in this, but once the Catchment Committee is created then this committee will take over as principal implementers. Monitoring will be undertaken as part of the THyE project monitoring defined elsewhere (addressing water quality and afforestation success.

Scheduling and Pacing: Catchment management planning is expected to begin from the pre-construction phase, but due to the number of stakeholders that may be involved, activities will continue into the Construction and Operation phases (beyond the project period).

Budget: Monitoring of the effectiveness of catchment actions will be addressed in regular THyE monitoring (budgeted elsewhere). Costs related to establishment of the CMP are addressed below, as estimated lumpsums that will create momentum for long-term effectiveness of the CMP.

Table 1.52 Budget for Catchment Area Management Plans

Description	Cost (Nu)
Rapid classification of micro-watersheds and reporting	1,000,000
Assessment of critical micro-watersheds and planning remedial measures	1,500,000
Implementation of remedial measures (separate from compensatory afforestation, already budgeted)	7,000,000
Total	**9,500,000**

1.2.3.7 Maintaining Cleared Right-of-Way for Transmission Line

Mitigation Measures: Areas between the tower foundations can be allowed to grow to a height of about two meters, which will provide cover for most wildlife that need to move through the right-of-way. Local communities will likely use most of the right-of-way for farming and pasture, as it will be more accessible and suitable than before installation of the transmission line (this is a positive indirect side-effect). Otherwise. vegetation that is growing too high will be cleared from time-to-time.

Institutional Responsibilities: BPC will be responsible for maintaining the transmission line right-of-way, once it is handed over by the project.

Performance Indicators and Monitoring Requirements: There are no serious disturbances of wildlife along the right-of-way. Local communities are able to maintain dryland cultivation and pastureland along the right-of-way.

Wildlife sightings along the transmission line will be recorded opportunistically (as noted by local communities). This information will then be retrieved by BPC and THyE, and put into the overall wildlife log to be maintained for the project area.

Scheduling and Pacing: It is difficult to predict the frequency at which clearing of the transmission line right-of-way will be required (perhaps every 3-4 years).

Budget: Transmission line right-of-way maintenance will be covered by the project operational budget.

1.2.3.8 Grievance Redress Mechanism

A Grievance Redress Mechanism (GRM) will be established to handle all public complaints about environmental issues (and others) which may crop up during all phases of the Nikachhu Hydropower project. A GRM leads to a clear transparent process through which complaints and grievances from people who feel they are exposed to environmental effects from the project can be addressed. The project will establish a grievance redress process in two ways. In the first instance, immediately after the project has initiated activities, local communities will have the opportunity to submit their grievances in written form to the THyE whenever they feel inclined. Then, within the existing mechanism of local committees (Geog Tshogde, Dzongkhag Tshogde) and the Dzongkhag, details will be received and the process started to facilitate solutions to environmental issues. If the issue is not resolved, the individual or group may approach THyE directly. In any case, THyE should be copied on all written environmental complaints, so that

there is full accountability for the GRM process (receiving, assessing, and solving environmental complaints).

In order to ensure that all people who may have environmental complaints have avenues for redressing their grievances, detailed procedures for the redress of grievances need to be established for the Project. The Project proposes the following procedures for grievance redress:

If any person perceives environmental issues caused by the project, he/she can lodge a written grievance with the Grievance Redress Committee (GRC) comprising officials from the THyE and Dzongkhag Administration at any time that such issues are observed. The committee's officials must respond within 15 days.

If the person making the complaint is not satisfied with the decision or he/she receives no response within 15 days of registering the grievance, or receives the response and is still unsatisfied, he/she can approach the THyE, and ultimately to appropriate authorities of the Royal Government of Bhutan (RGoB).

Over the project implementation phase, complaints registers will be maintained by the project managers and the contractors where pending or further grievances can be registered. This will be an additional grievance redress mechanism.

An additional facility that the THyE can use with other collaborating agencies (such as the local government) is a Complaint Register. Such a register will be maintained by the Tshogpa (Village Head person) in the village. People can at any time write down their complaints in the Register if they are not satisfied with the implementation of the project, with regard to environmental issues, as well as any other issue regarding the project construction. This Register will be examined and monitored by the implementing agency, namely the Geog Tshogde and THyE for appropriate response measures.

2 ORGANIZATION AND REPORTING

The Environment Unit of THyE has been established under the Chief Administration Officer of THyE, for activities during the Nikachhu construction phase and the operation phase. Note that this Division has been in operation for the construction of the Dagachhu hydropower project as well, so the individuals involved have the necessary experience and skills to continue the EMP functions in the Nikachhu project. This Division will assume the powers and responsibilities for overall environmental management, monitoring, and reporting to the RGoB and ADB (quarterly environmental management and monitoring reports will be disclosed on the ADB website). This will include management of the few outside consultants who are identified for specific EMP tasks (see Appendix 1), as well as Government agencies, such as DoFPS, who will have specific functions related to their forestry and park services. Environmental Unit will monitor all the other stakeholders as per the EMP tasks recommended above. In the construction phase, the Environmental Unit will be headed by Chief Administrative Officer assisted by an Environmental Officer.

The Environmental Unit, on behalf of the project authority, will function as an environmental management unit shall assist the contractor in implementation of environmental management tasks. The Environmental Unit will have the following capacities and capabilities.

- the necessary capability to supervise the implementation of the environmental measures proposed in the EMP;
- the capacity to include environmental mitigation measures into civil engineering works; and,
- the capacity for making decisions regarding the applicability of enhancement design options and any modifications, if needed.

The Contractors will be the major implementers of the EMP. The roles and responsibilities of these contractors will include:

- incorporating the EMP into the overall workplan for construction plan and submit it to the Environmental Unit for approval;
- ensuring proper construction and maintenance of the facilities at the worker camps; and,
- ensuring that proper environmental safeguards are being maintained at all times, within their responsibility areas, as well as completing the documentation for all this (this will require monthly environmental performance/compliance reports to be submitted to the Environmental Unit for their review).

The organizational charts for EMP implementation during all phases of the project are shown below.

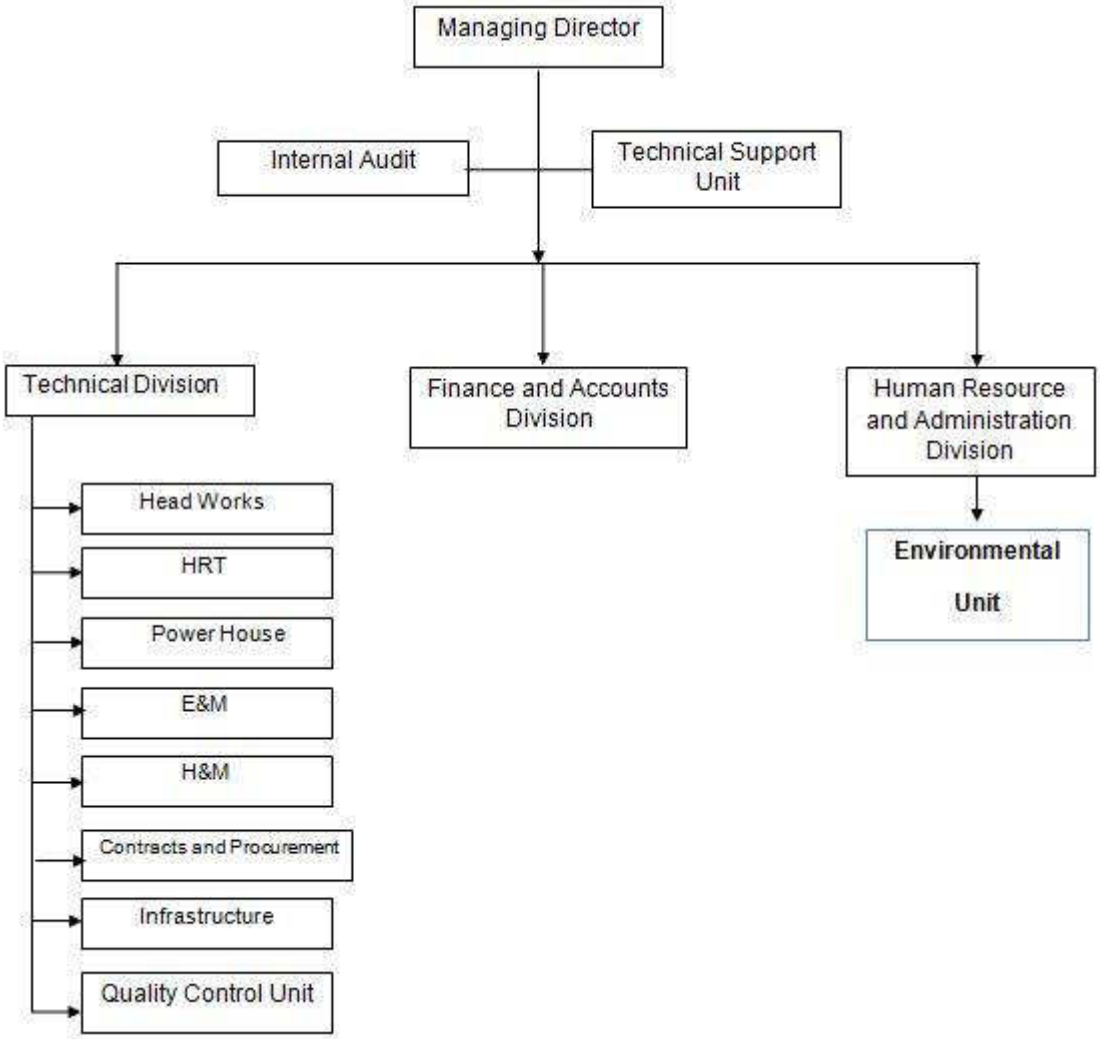


Figure 2.1 Organization for implementation of the Environmental Management Plan during the pre-construction and construction phases.

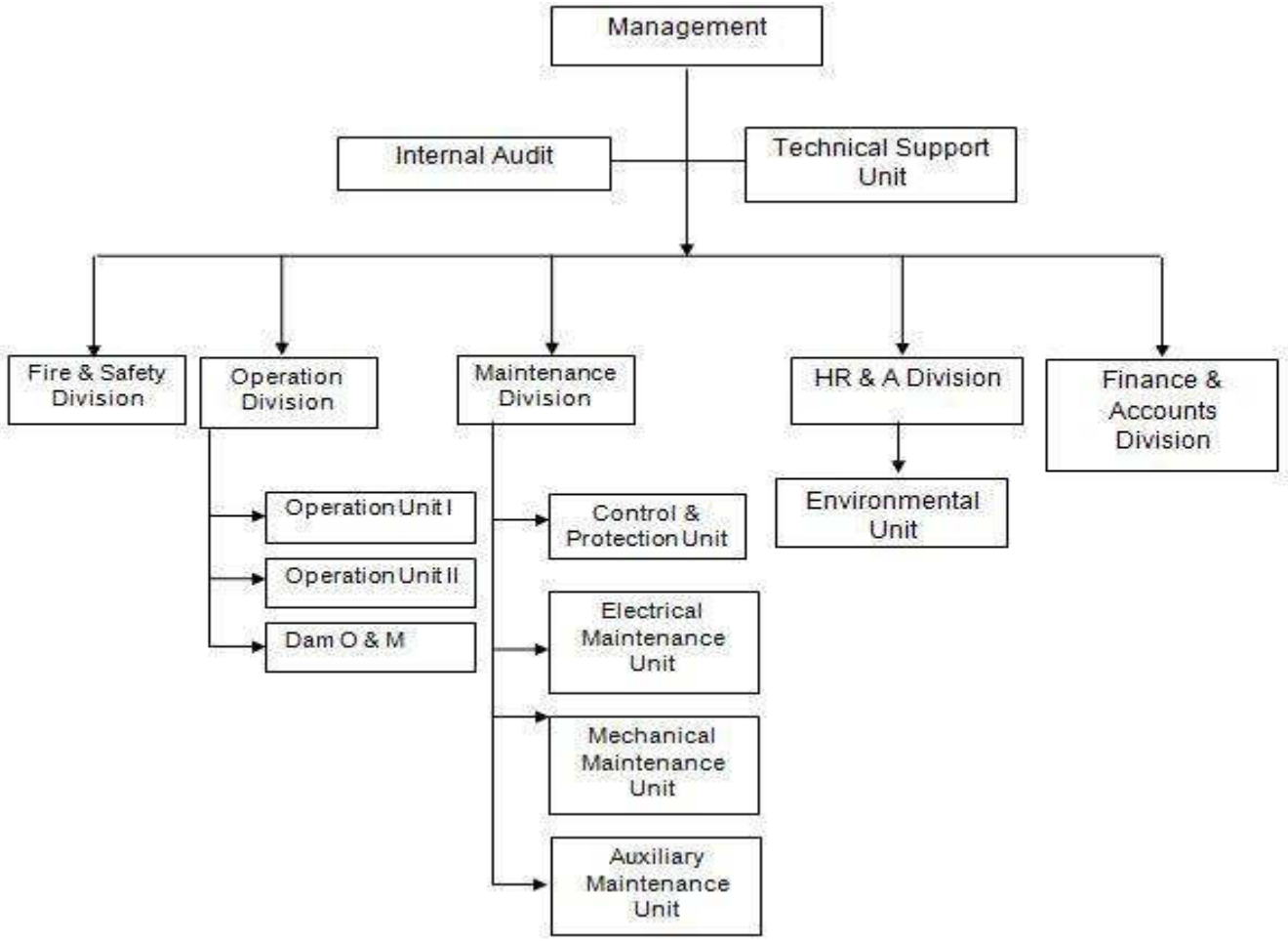


Figure 2.2 Organization for implementation of the Environmental Management Plan during the operation phase.

Costs: The costs noted below are for managing the Environment Unit through the pre-construction and construction phases.

Table 2.1 Environment Unit management costs (pre-construction and construction phases).

Description	Quantity	Unit	Rate (Nu.)	Amount (Nu.)
Pick up (Toyota Hilux)	1	No	1,500,000	1,500,000
Computers	4	No	100,000	400,000
Printers	2	No	25,000	50,000
Office set up	1	LS	200,000	200,000
Salary Unit Head	48	Month	35,000	1,680,000
3 Staff	144	Month	25,000	3,600,000
Driver salary	48	Month	12,000	576,000
Stationeries	4	Year	50,000	200,000
Maintenance	4	Year	25,000	100,000
Contingency	1	LS	300,000	300,000
Total				**8,606,000**

Table 2.2 DGPC environmental management staff costs (operation phase; for 2 years).

Description	Quantity	Unit	Rate (Nu.)	Amount (Nu.)
Salary Environment Officer	24	Month	25,000	600,000
Driver salary	24	Month	12,000	288,000
Stationeries	2	Year	50,000	100,000
Maintenance	2	Year	25,000	50,000
Contingency	1	LS	300,000	300,000
Total				1,338,000

Reporting: Based upon the EMP, the Environment Unit will prepare yearly rolling plans and budgets. Environment Unit will then prepare quarterly reports indicating progress on environmental management tasks, any residual issues, and the overall environmental performance of the project, to be submitted to the Chief Administrative Officer; these will be passed on to ADB for safeguards accountability and reporting. Review of the quarterly environmental safeguards report (by both RGoB and ADB) will provide opportunities for identifying and implementing required "fixes" (corrective actions). Subsequent quarterly reports will report on the degree of implementation and effectiveness of corrective actions. Environmental management reporting will form part of the overall project progress report. Environment Unit will also prepare annual reports, summing up environmental performance and making adjustments in the EMP as necessary.

3 AUDITING

THyE proposes to undertake at least one environmental audit in the middle of the construction phase of the project, to clarify the environmental performance of THyE in implementing the EMP, and one in the first year of project operation, to determine the effectiveness of site rehabilitation and community acceptance of the project. The environmental audits will be informed by the quarterly progress and annual reports up to that point, and a detailed field inspection. In general terms, the environmental audits will gather information on the following topics:

- the condition of natural/social/economic resources prior to project implementation and after project construction is completed;
- whether or not the impacts forecast by the ESIA occurred and, if so, the extent of these impacts;
- whether or not the mitigation measures implemented were effective in controlling adverse impacts or enhance beneficial impacts;
- whether or not all landscapes degraded due to project construction have been restored to their original (or better) conditions;
- what are the impacts of the possible “boom-bust” scenario among the workforce involved in project construction and the local economy; and,
- the overall effect on the local economy of project construction.

More specifically, the following questions will be addressed:

- How have the environmental conditions changed from the baseline conditions?
- Are there any problems relating to slope stability in the project area?
- Have slope stability and erosion control measures adopted by the project been effective in minimizing slope instability, erosion and landslides?
- What is the flow and quality of water in the river and its tributaries? Did it change significantly from the baseline condition?
- Are there any bare or degraded areas around the project? What is the condition of the quarry site, borrow areas, and the spoil disposal areas?

- What is the condition of the local forests?
- How has the local community adapted to the loss of jobs following the end of construction activities?
- What is the attitude of the local people towards the project?
- What has been the impact of the project on the local and national economy?

The environmental audits should be carried out by an independent group of experts so that the findings are unbiased and recommendations are prescribed for practical implementation. Provision is made for the costs environmental audits estimated at Nu. 2,000,000.

4 ENVIRONMENTAL MONITORING

The monitoring requirements associated with the implementation of the EMP were identified previously for each specific management plan (these included visual compliance checks, as well as scientific environmental effects monitoring; as mentioned previously, the latter will require sampling as soon as possible to build up the pre-project baseline database, against which project related effects can be compared). Many of the monitoring tasks can be assumed within the daily and weekly tasks of the Environment Unit staff (visual compliance checks) and many of the actual environmental quality monitoring tasks can be rolled into an overall program that addresses the locations and periodicity of the various project activities that are of concern, to be undertaken by Environment Unit and consultants. The monitoring requirements associated with each project activity are summarized below, followed by a summary of the environmental quality monitoring program that addresses all the aspects of effects monitoring for air quality, water quality, aquatic habitat/fish monitoring, and wildlife. The overall budget for environmental monitoring is then noted.

Land acquisition/compensation: Maintaining an ongoing log of activities and issues related to land acquisition.

Land clearing and road cuts: Regular photographs of the "before-and-after" situation at each work site, with a specific focus on the quality of adjacent watercourses; water quality monitoring in the Nikachhu; maintaining a log of all trees cut and stock-piled for fuelwood; photographic tracking of tree planting and survival rates; maintaining a log of encounters with wildlife and large birds; and compliance monitoring by Environment Unit to ensure proper work site practices.

Worker influx: Visual inspections of the camps and work sites by THyE staff (Environment Unit), backed up with water quality monitoring in the Nikachhu; any issues between workers and local communities will be logged and tracked for resolution/follow-up by THyE staff, copied to the respective contractors; all contractors will be required to log specific incidents and worker accidents and report these to THyE.

Construction equipment: Noise and air quality will be monitored; all encounters with wildlife and large birds will be logged, to build up a database of wildlife-habitat associations in the project area.

Fuel storage: THyE staff will undertake compliance checks on a regular (but unannounced) basis.

Blasting: Any incidents related to blasting will be logged and reported to THyE and the authorities.

Quarry operations: Air quality and noise limits at the periphery of the quarry will be monitored, as part of the routine monitoring program; THyE staff will undertake routine inspections to check for compliance; any sightings of wildlife and large birds at or near the quarry will be recorded (with information submitted to Environment Unit staff); truck movements will be monitored, and times of movements can be adjusted to suit the prevailing traffic patterns on the National Highway, to avoid undue congestion.

Crusher plant: Air quality and noise limits at the periphery of the crusher plant will be monitored, as part of the routine monitoring program; a worksite safety record will be maintained at the premises; THyE staff will undertake routine inspections to check for compliance; any sightings of wildlife and large birds at or near the crusher plant will be recorded (with information submitted to *Environment Unit*); water quality monitoring in the Nikachhu will be undertaken to ensure that sediments are not entering the river (proper operation of site drainage, check dams, and sedimentation pond).

Muck disposal: Site conditions will be monitored frequently (by *Environment Unit*), and corrective action taken when necessary; any sightings of wildlife and large birds at or near muck disposal sites will be recorded (with information submitted to *Environment Unit*); routine noise, air quality, and water quality monitoring will be undertaken to ensure that muck and dust is contained and that there is no damage to adjacent forests and water courses.

Cofferdam: Fish and water quality will be monitored regularly throughout the construction period and occasionally during the initial years of project operation; THyE staff will undertake regular visual inspections at the cofferdam site to ensure that sediments are contained, that the cofferdam is stable, and that the diversion tunnel is working properly.

Transmission line clearing: *Environment Unit* will undertake occasional visual checks of work along the alignment; all encounters with wildlife and large birds will be recorded and reported to *Environment Unit*; compensatory tree planting will be monitored by *Environment Unit*.

Community support: The CAO of THyE will monitor implementation of the grants (for administrative and financial propriety) and will also evaluate the grant outcomes for the beneficiaries.

Reservoir: *Environment Unit* will maintain visual checks of the reservoir and will undertake routine monitoring of water quality and fish populations in the reservoir and below the dam

(during the first two years), as well as routine monitoring of discharge from the spillway; the use of the area by wildlife will also be logged (incidental sightings will be recorded).

Minimum environmental flow: The state of aquatic habitats, discharge rates, water quality, and fish populations below the diversion dam will be monitored at least twice per year during the first two years of operation of the Nikachhu project; also, incidental sightings of wildlife will be logged and reported to *Environment Unit* (as part of the overall wildlife sightings recording for the project area).

Sediment purging: Occasional water quality monitoring in the Nikachhu.

Dam burst system: Routine testing of the system.

Transmission line alignment maintenance: Wildlife sightings along the transmission line will be recorded opportunistically (as noted by local communities); this information will then be retrieved by BPC and THyE, and put into the overall wildlife log to be maintained for the project area.

The following Tables provides the detailed monitoring activities with performance indicators against each activity with frequency and institution responsible for implementation of the mitigation and management activities.

Table 4.1 Compensatory Afforestration

Activities	Indicators	Period	Responsibility for Implementation	Monitoring	Frequency
Preparation of MOU and discussion	MOU prepared and signed	PC	THyE, SFD	THyE, SFD	every quarter
Delegation of responsibilities	Official letter delegating responsibilities	PC	THyE, SFD	THyE, SFD	every quarter
Site selection	No. sites selected	PC	THyE, SFD	THyE, SFD	every quarter
Preparation of work program as per sites selected	Work plan submission	PC	SFD,TD,PM, CFO	THyE, SFD	every quarter
Selection of nurseries/nursery development	No. of nurseries developed	PC	SFD,TD,PM, CFO	THyE, SFD	every quarter
Purchase of materials and seedlings	Budget spent on purchase	PC	SFD,TD,PM, CFO	THyE, SFD	every quarter
Afforestation	Size of land replanted	Construction	SFD,TD,PM, CFO	THyE, SFD	every quarter

Activities	Indicators	Period	Responsibility for Implementation	Monitoring	Frequency
Monitoring	No. of monitoring visits carried out	Construction and O	THyE, SFD	THyE, SFD	every quarter
Evaluation and review of program	Evaluation reports and Final Review of program	Construction and O	THyE, SFD	THyE, SFD	every quarter

Note: PM: Project Management, C: Contractor, SFD: Social Forestry, Park M: Park Management, PC: Pre-construction, O: Operation, THyE*:Tangsibji Hydro Energy.*

Table 4.2 Management of Labour

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Screening and regular unannounced checking of workers.	Number of unannounced checks conducted	PC and Construction	C	THyE	every quarter
Minimizing hazards at the workplace.	Number, type and location of signboards	PC and Construction	C	THyE	every quarter
	Presence of barricades aroundC	PC and Construction	C	THyE	every quarter
	Storage site/area for large equipment	PC and Construction	C	THyE	every quarter
	Inspection of material storage	PC and Construction	C	THyE	every quarter
	Presence of scrap timber, waste material and rubbish	PC and Construction	C	THyE	every quarter
	Scaffold installation and design	PC and Construction	C	THyE	every quarter
	Width and safety of ramps	PC and Construction	C	THyE	every quarter
	Storage of excavated earth from pits	PC and Construction	C	THyE	every quarter
	Presence of support systems such as bracing	PC and Construction	C	THyE	every quarter

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
	Qualification/ experience of electricians	PC and Construction	C	THyE	every quarter
	Number of fire-fighting equipment present at site	PC and Construction	C	THyE	every quarter
Provision of personal protective equipment.	Use of PPE by workers	PC and Construction	C	THyE	every quarter
Procedures to deal with emergencies.	Number of first aid kits at work site	PC and Construction	C	THyE	every quarter
	Presence of emergency standby vehicle	PC and Construction	C	THyE	every quarter
	Name of designated Health Officer/worker	PC and Construction	PM	THyE	every quarter
	Number of radios or mobile communication	PC and Construction	C	THyE	every quarter
Record maintenance and remedial action.	Number of accidents and injuries logged at each site	PC and Construction	C	THyE	every quarter
Compensation for injuries and death.	Details of Compensation paid for injuries/death	PC and Construction	C	THyE	every quarter
Awareness programs.	Number of dissemination sessions/ meetings	PC and Construction	C	THyE	every quarter
	Number of workers aware of emergency protocols	PC and Construction	C	THyE	every quarter
	Number of workers aware of code of conduct	PC and C	C	THyE	every quarter
Nomination of a Health and Safety Focal Person.	Health Focal person nominated from among workers	PC and Ccontruction	C	THyE	every quarter

Table 4.3 Management of Machinery

Mitigation Action	Indicator	Period	Responsibility	Monitoring	Frequency
Location of machinery	Distance of machinery from highways and local communities	PC and Construction	C	THyE	Upon commencement of use of machinery
Check all machinery prior to Operation	dust, noise and emission levels of machines	PC and Construction	C	THyE	Upon commencement of use of Machinery.
Ensure occupational safety standards	Use of PPE by operators.	PC and Construction	C	THyE	Every quarter
	Placement of emergency operating procedures				
Control Opeartion hours	Operating hours of machines	PC and Construction	C	THyE	Ever quarter

Table 4.4 Highway Maintenance

Mitigation Action	Indicator	Period	Responsibility	Monitoring	Frequency
Identify and upgrade parts of highway	No. of repairs made along highway	PC	PM	THyE	Quarterly

Table 4.5 Biodiversity Conservation and Management Plan

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Establishment of Biodiversity Management Committee	BMC established and Oal	All phases	DGPC & PM	THyE	every quarter
	Reports of meetings of BMC	All phases	THyE & PM	THyE	every quarter
Rescue of flora	Number of floral species rescued	PC	NBC, PARK	THyE	after PC phase
Establishment of a Botanical Garden	Botanical garden established and Oal	Construction	NBC, PARK	THyE	every quarter
Ensure minimal land clearing and removal of vegetation	% of trees felled as per marking by forestry staff	PC	PM	THyE	every quarter

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Rehabilitate and restore all cleared sites	Number of sites restored and rehabilitated; degree of restoration	Construction and O	PM	THyE	every quarter
Rescue and release program	Number of wildlife species rescued, treated and released	Construction and O	PARK/DOFPS	THyE	every quarter
Promote wildlife surveys	Number of surveys conducted	Construction and O	PARK/DOFPS	THyE	every quarter
	Number and diversity of wildlife species caught on camera traps	Construction and O	PARK/DOFPS	THyE	every quarter
Awareness raising	Number of awareness raising meetings held by project	Construction and O	PARK/DOFPS	THyE	every quarter
	Date of distribution of Acts and regulations	Construction and O	PM	THyE	every quarter
Strengthen patrolling	Number of patrols carried out	Construction and O	PARK/DOFPS	THyE	every quarter
	Budget for equipment purchase handed over to Park and forestry staff	Construction and O	PARK/DOFPS	THyE	every quarter
	Number of village forest guards hired	Construction and O	PARK/DOFPS	THyE	every quarter
Build up scientific database	Number of computers given to Park/ Dzongkhag/ District Forestry Office.	Construction and O	PARK/DOFPS	THyE	every quarter
	Receipt of research proposal from Park and transfer of research fund to park.				

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Mitigation of human wildlife conflict	Proposal developed for human-wildlife mitigation	Construction and O	PARK/DOFPS	THyE	every quarter
	Implementation of pilot program	Construction and O	PARK/DOFPS	THyE	every quarter

Table 4.6 Greenbelt Management Plan

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Prioritization and scheduling for greenbelt development	List of priority areas for greenbelt development along with workplan and scheduling	Construction and O	PM	THyE	Towards the completion of each development work
Slope stabilization and land management	Size of area/slopes stabilized with proper drainage	Construction and O	PM	THyE	Every quarter after each site has been developed
Site development and reforestation	Size of area handed over under compensatory afforestation for greenbelt development	Construction and O	PM	THyE	Every quarter
Monitoring of greenbelt development	Number of greenbelt areas developed	Construction and O	PM	THyE	Every quarter

Table 4.7 Reservoir and RIM Treatment

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Slope stabilization	Size of area/slope stabilized	Construction	C	THyE	Every quarter
Use of geotextiles	Area covered with geotextiles	Construction	C	THyE	Every quarter
Creation of greenbelt and plantation	Size of area under green belt plantation.	Construction	C	THyE	Every quarter
	Number of trees/shrubs planted.				
Fencing along Park bank	Length of right bank fenced	Construction	C	THyE	Every quarter
Promotion of eco-	Educational	O	Park M		Every

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
tourism and bird watching	boards for birding		/Forestry Division		quarter
	Creation of birding trails	O	Park M SFD	THyE	Every quarter
	Number of signposts	O	Park M SFD	THyE	Every quarter

Table 4.8 Fuel Storage and Management

Activities	Indicator	Phase	Responsibility	Monitoring	Frequency
Proper storage facilities	Location of fuel storage sites in shed	PC and C	C	THyE	after award of tender to contractor
	Fuel is stored in 200 litre leak proof barrels on flat ground and in a protected shed	PC and C	C	THyE	on commencement of work
Complete avoidance of fuel spills into water sources	Distance of fuel storage site from the nearest streams/rivers	PC and C	C	THyE	every quarter
Secure the site from risk of explosion	Distance of fuel storage site from camps/offices, or fire risk areas	PC and C	C	THyE	every quarter
	Number of sand buckets and fire extinguishers and condition of fire extinguishers	PC and C	C	THyE	every quarter

Table 4.9 Muck Management Plan

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Identification and location of disposal sites	Number and distance of identified sites from nearest water source	Carried out during DPR Preparation	PM	THyE	at the start of the project
Land acquisition for muck dumping site	Number of sites handed over to project and contractor, site demarcation completed	PC	PM	THyE	at the start of the project
Clearing of muck dumping site and site preparation	Top soil removed and stock piled near the site	PC	C	THyE	As and when required

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Terracing andC of retaining walls and drainage	Number of terraces and quality of retaining walls and drains constructed	PC	C	THyE	As and when work commences
Dumping of muck	Number of truckloads of muck dumped	Construction	C	THyE	as and when work starts
Rehabilitation with Compensatory Afforestation	Date of handing over of site for compensatory afforestation, size of afforested area	Construction	SFD	THyE	after completion of muck dumping
Handing over of rehabilitated dumping sites	Final handing over of dump site to Dzongkhag	Post – construction	PM	THyE	Post Construction

Table 4.10 Blasting Management Plan

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Use of controlled blasting	Type of blasting method use	PC and C	ECDMD	THyE	Once prior to blasting
Observe blasting times for human safety and minimal wildlife disturbance	Observation report on blasting hours	PC and C	C	THyE	Once every quarter
Observe blasting protocols	Blasting protocols being implemented	PC and C	C	THyE	Once every quarter
Prepare baseline and monitoring of nearby existing infrastructure	Baseline photos documented	PC	PM	THyE	Once every quarter
Maintain a database on any injuries, accidents, damage caused by blasting	Database on injuries, wildlife accidents, or complaints	PC and C	C	THyE	Once every quarter
	Actions taken to mitigate blasting concerns	PC and C	C	THyE	Once every quarter

Table 4.11 Machinery Management

Mitigation Action	Indicator	Period	Responsibility	Monitoring	Frequency

Mitigation Action	Indicator	Period	Responsibility	Monitoring	Frequency
Location of machinery	Distance of machinery from highways and local communities	PC and C	C	THyE	Upon commencement of use of machinery
Check all machinery prior to O	dust, noise and emission levels of machines	PC and C	C	THyE	Upon commencement of use of Machinery.
Ensure occupational safety standards	Use of PPE by operators.	PC and C	C	THyE	Every quarter
	Placement of emergency operating procedures				
Control O hours	Operating hours of machines	PC and C	C	THyE	Ever quarter

Table 4.12 Water Conservation and Management

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Sourcing of water	Number of tributaries/streams sourced	PC	C & PM	THyE	At the start of the project
	Number of incidences of water shortage				
Maintenance of water supply system	Number of repairs and maintenance of water supply	PC and C	C & PM	THyE	Every quarter
Conservation of water sources	Number of incidences of illegal use of streams such as washing of cars	All phases	PM	THyE	Every quarter

Table 4.13 Catchment Area Monitoring Program

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Identification of degraded areas/ classification of watershed	Number and size of areas identified for reforestation	PC	PM	THyE	Every quarter
Catchment management committee created	Number of agencies and members in committee	PC	PM	THyE	Every quarter

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Preparation of catchment management plan	Workshops and meetings conducted and the outputs	All phases	PM	THyE	Every quarter
Catchment area monitoring program	Monitoring program initiated	Construction	PM	THyE	Every quarter

Table 4.14 Management of Worker Camps

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Housing for workers	Appropriate design and location of worker housing	PC and C	C & PM	THyE	Twice a year
Provision of facilities like drinking water and electricity	Good, stable availability of drinking water and electricity	PC and C	C & PM	THyE	Every quarter
Sanitation and sewage treatment	Availability of sanitation and sewerage facility	PC and C	C & PM	THyE	Every quarter
Restoration of worker camps to their natural state	Worker camps restored	O phase	C & PM	THyE	Every quarter

Table 4.15 Waste Management and Segregation

Activity	Indicators	Period	Responsibility	Monitoring	Frequency
Waste reduction	Amount of plastic containers, jars, tires being reused	All phases	PM	THyE	Establishment of each site
Recycling	Amount (kg) of material being recycled each week/month	All phases	C	THyE	Establishment of each site
Waste segregation	Number of bins distributed at each site.	All phases	C	THyE	Establishment of each site
	Use of bins for different types of waste.				
Awareness programs for workers	Number of posters printed and distributed.	All phases	PM	THyE	Every quarter
	Number of awareness meetings				

Activity	Indicators	Period	Responsibility	Monitoring	Frequency
Druk Green intiative	Results of school participation	All phases	PM	THyE	Twice a year
Site inspections	Number of site inspections and reports	All phases	THyE	THyE	Every quarter
Maintain database	Availability of information on waste at project sites	All phases	THyE	THyE	Every quarter

Table 4.16 Energy Conservation

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Request for additional quotas for subsidized fuel to meet increased demand	Increase in quota of fuel supply for Trongsa	PC	THyE	THyE	after PC phase
Arrange to supply felled trees as fuelwood for local use, as well as project use	Number of fuelwood permits issued	PC andC	PM	THyE	every quarter
Communal kitchens	Number of communal kitchens Oal	PC andC	C	THyE	every quarter
Centralized fuel depot	Number of fuel depots	PC andC	C	THyE	every quarter
Electrification of worker camps	Number of worker camps/ colonies electrified	PC andC	C	THyE	every quarter
Awareness campaigns	Number of awareness meetings held	PC andC	C & PM	THyE	every quarter

Table 4.17 Disaster Preparedness Plan

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
National Collaboration	Formal linkages developed	Construction	THyE	Project management	At the beginning of the project
Dzongkhag level collaboration	Formal linkages developed	Construction	PM	Project management	At the beginning of the project

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Develop forecasting and early warning system	Develop linkages with Hydro Met	Construction	THyE	Project management	At the beginning of the project
Monitoring of dam conditions	Dam assessment report	O	PM	THyE	Every month
Installation of early warning system	Number of warning systems installed	O	PM	THyE	Every quarter
Disaster preparedness plan	Signs installed	O	PM	THyE	Every quarter
	Disaster protocols in plan with institutional linkages	O	PM	THyE	Every quarter
	Warning systems tested	O	PM	THyE	Every quarter
	Nomination of focal disaster management officer	O	PM	THyE	Every quarter
	Training on disaster management conducted	O	PM	THyE	Every quarter
	Awareness meetings with nearby downstream villages conducted	O	PM	THyE	Every quarter
	Separate emergency budget for disaster and emergencies	O	PM	THyE	Every quarter

Table 4.18 Fisheries Development Plan

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Stocking of the reservoir (possibly snow trout)	Healthy, more diversified fish population in the reservoir (numbers and size)	O	Park M	Park M; THyE	2x/ year
Cleaning of fish screens	No trash or debris on screens	O	PM	THyE	As needed

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Maintaining good water quality in reservoir (through catchment plan, rim treatment plan)	Good water quality	O	PM	THyE	2x/ year

Table 4.19 Closure Plan

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Temporary project use areas rehabilitated and transferred back to land owners and the Government, as relevant, with summary statements about the use and rehabilitation of the temporary land use areas.	Temporary land use areas transferred back in good condition	end-construction	PM	THyE	Once, on transfer
Roads and adits that do not remain functional for project operations cleaned of all equipment, debris, rubble, and sodded and re-vegetated as specified in the individual activity plans, the greenbelt plan, or the compensatory afforestation plan, depending on specific fate noted for each site.	All temporary work sites are completely clean and re-vegetation underway	end-construction	PM	THyE	Once, when closure completed
National Highway repaired in consultation/ coordination with the District and DoR.	National Highway is fully repaired (as good or better than at start of project)	end-construction	PM	THyE/DoR	Once, when repairs completed
Labourer Camps: All buildings and service infrastructure de-constructed and recycled, or disposed as solid waste.	No buildings or service infrastructure on project camp sites	end-construction	PM	THyE	Once, when camps cleared

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
Labourer Camps: All equipment, debris, residual waste, etc. will be cleared from the site and disposed according to the project solid waste management plan.	No waste or debris left on site	end-construction	PM	THyE	Once, when camps cleared
Labourer Camps: Septic tanks cleaned, filled, and covered.	Septic tanks completely filled and covered	end-construction	PM	THyE	Once, when camps cleared
Labourer Camps: The remaining area, once cleared as described above, will be graded and prepared for re-vegetation (a target for compensatory afforestation).	Camp sites graded and re-vegetation started	end-construction	PM/SFD	THyE/SFD	ongoing, through operation phase
Labourer Camps: All camp sites inspected, documented, and photographed as evidence of full camp closure.	All photographs indicate cleaned and prepared sites (reverting to natural state)	end-construction	PM	THyE	once, when site closure completed
All fuel containers moved or emptied; no fuel containers are left on site	No fuel containers on site	end-construction	PM	THyE	Once, when fuel depots cleared
All surficial sediments in and around the vicinity of the temporary fuel depot scraped down to clean soil layers, and disposed in a designated hazardous materials disposal location	Clean soil at temporary fuel depots	end-construction	PM	THyE	Once, when fuel depots cleared
All fuel service equipment/ infrastructure will be removed from the site	Nothing left on site	end-construction	PM	THyE	Once, when depots cleared
Soil tested for hydrocarbonsl; if the site is deemed clean, then re-vegetated	Clean site; revegetation started	end-construction	PM	THyE	Once, when depots cleared

Activities	Indicators	Period	Responsibility	Monitoring	Frequency
The remaining working life of the quarry to be evaluated; if it has economic value, it can remain open and continue to serve local needs for aggregate	Quarry may continue to operate; with best practices	end-construction	PM, District	THyE	assessment at end project
If the risk of ongoing disturbance to wildlife movements is deemed to be too great, the quarry can be closed according to all the closure procedures identified for other project work sites	Full closure, with clean-up of equipment and revegetation started	end-construction	PM	THyE	Once, when quarry closed and cleaned
Muck disposal sites terraced, compacted, and prepared for re-sodding or replantation of trees (depending on ultimate fate; whether being kept as a public playing field, or allowed to revert to wild state)	Terraced muck disposal sites have started to revegetated	end-construction	PM	THyE	Once, when muck disposal sites have been closed, prepared, and revegetation started (then trees monitored occasionally during operation)

As noted above, environmental quality monitoring (noise, air quality, water quality, hydrology, aquatic habitats, fish populations, and incidence of wildlife) will be required to measure the effects of specific project activities at specific locations during the construction phase and the first few years of the operation phase of the Nikachhu project. These requirements are summarized in the table below. Note that compliance monitoring for implementation of specific EMP actions has been identified for each EMP program, described previously; most of these require visual checks and photo-documentation, to be undertaken by THyE (Environmental Unit).

Table 4.20 Environmental quality (effects) monitoring requirements (Nikachhu construction and operation phases)

Feature / Issue	Parameter	Location	Responsibility	Time/ Frequency
Air Quality	PM 10 and PM 2.5, NO_x (using volume samples and filters). Work stoppage and corrective action will be required when	All active work sites and worker camps. "Nearest neighbor" sensitive receptors.	THyE	Quarterly during construction (compared to baseline data to be

Feature / Issue	Parameter	Location	Responsibility	Time/ Frequency
	Bhutan standard is exceeded in replicated samples.			collected at the very beginning of the project).
Noise	Noise pressure level in dBA (using decibel meters). Work stoppage and corrective action will be required when Bhutan standard is exceeded in replicated samples.	All active work sites and worker camps. "Nearest neighbor" sensitive receptors.	THyE	Quarterly during construction (compared to baseline data to be collected at the very beginning of the project).
Water Quality	Ambient Temperature (^oC), pH, Conductivity (µmhos / cm), Total Suspended Solids (mg/l), Total Phosphorus (mg/l), Total Kjeldahl Nitrogen (mg/l), Ammoniacal Nitrogen, (NH_3 – N) (mg/l), Nitrate Nitrogen (NO_3 – N) (mg/l), Nitrite Nitrogen, (NO_2 – N) (mg/l) Dissolved Oxygen (mg/l), Biological Oxygen Demand (BOD5 @ 20^oC) (mg/l), Chemical Oxygen Demand (CODCr) (mg/l), Total Sulphate (mg/l), Fecal Coliform Count (MPN Index / 100ml). *In situ* water sampling methods (e.g., Hach kit) will be used as much as possible; samples for BOD, COD, and coliform will be analyzed in the laboratory.	Nikachhu above dam, Nikachhu immediately below dam, Nikachhu at confluence with Mangdechhu, Mangdechhu below confluence with Nikachhu	THyE	Quarterly during construction and semi-annually during first two years of project operation (compared to baseline data to be collected at the very beginning of the project).
Hydrology	Discharge rate (m^3/s).	Above dam, below dam, at confluence of Nikachhu with Mangdechhu. E-flow at the dam will be monitored constantly (*in situ* gauge)	THyE	Monthly during construction and first two years of operation.
Aquatic Habitats	Overall quality (visual observations of riverbed, weeds, sediments).	In reservoir, immediately below dam, and in Nikachhu at confluence with Mangdechhu.	THyE	Twice annually (in lean season and immediately after monsoon), during construction and first two years of operation.
Fish	Frequency of occurrence (numbers and size) and species diversity.	In reservoir, immediately downstream of dam, and in Nikachhu at	THyE (consultant) and DoFPS staff	Tthrice annually (in lean season and immediately after monsoon), and

Feature / Issue	Parameter	Location	Responsibility	Time/ Frequency
		confluence with Mangdechhu.		winter months during construction and first two years of operation.
Wildlife	Baseline surveys (camera traps) at very beginning of project and during pre-construction; thereafter, all incidental sightings logged.	At all work sites and at the reservoir and along transmission line alignment.	THyE and DoFPS staff	Baseline survey to be implemented before any site work, then wildlife recorded as observed, up until end of second year of operation.

Most of the cost of environmental quality monitoring will be associated with staff level of effort, which is already budgeted for in Environmental Unit of THyE operations above. It is assumed that there will be additional costs associated with sampling equipment and laboratory analysis. This may come to about 600,000 Nu/year (based on the experiences at Dagachhu, which is a similar size project). The total incremental cost of environmental quality monitoring could therefore be about 3,600,000 Nu, over four years of construction and two years of operation.

5 SUMMARY OF EMP COSTS

The environmental management costs are summarized below. The total costs are estimated at approximately Nu. 141.9 million. These include the specific measures associated with individual project activities, as well as the operation of the Environment Unit of THyE, through the pre-construction, construction, and operation phases (the latter for two years), as well as the proposed audits and environmental monitoring.

Table 4.1 Summary of EMP costs.

Description	Amount (Nu.)
Environmental management access roads	7,885,000
Wildlife removal	4,300,000
Forestry staff involvement and biodiversity surveys	9,770,000
Compensatory afforestation	26,035,200
Site enhancements permanent staff colony	7,552,980
Project solid waste management	4,480,000
Required National Highway improvements and repairs; traffic management	46,470,000
Specific fish monitoring tasks	1,800,000
Reservoir management and rim treatment	4,575,000
Fisheries Development Plan	495,000
Dam burst safety system	3,500,000
Catchment management plan	9,500,000
Environmental Unit (THyE) operations: pre-construction and construction phases	8,606,000
Environmental Unit (THyE) operations: operation phase (2 years)	1,338,000
Audits	2,000,000
Environmental monitoring (6 years)	3,600,000
Total	**141,907,180**

6 APPENDIX

6.1 Consultant Terms of Reference

The following consultants will be required to assist with implementation of the Environmental Management Plan for the Nikachhu Project:

- Technical Supervisor for Tree Planting (national);
- Wildlife Capture and Removal Specialists (team; national);
- Fish Specialist (national); and,
- Dam Public Safety Specialist (national);

Individual terms of reference, levels of effort, schedules, and budgets are noted below.

Technical Supervisor for Tree Planting (national):

- 10 months effort (total 2,000,000 Nu) spread over the pre-construction and construction phases;
- Assistance with selection of appropriate tree species (indigenous species) for site planting and rehabilitation; and,
- Provision of technical oversight related to raising seedlings, planting, maintenance, and subsequent vegetation management (including planting locations, methods, schedule, and monitoring plan).

Wildlife Capture and Removal Specialists (team; national):

- Provision for 40 animal captures (small and large mammals) over two years of land clearing (pre-construction and early construction phase; total of 1,000,000 Nu);
- To operate as “on-call” staff for trapping/tranquilizing wildlife (as they are encountered by construction crews) and moving them safely to appropriate adjacent undisturbed sites; and,
- Photographic and narrative documentation of all wildlife encounters, noting developing spatial and temporal trends.

Fish Specialist (national):

- Provision for two surveys per year over the construction and operation phases of the project (total six years; 1,800,000 Nu);
- Various fish monitoring tasks (trap, identify, measure, count), as required at various sites (in the reservoir area, immediately downstream of dam, and in the Nikachhu at the

confluence with the Mangdechhu), in the lean season and immediately after the monsoon;

- Full documentation of results, noting developing spatial and temporal trends, and the possible influence of the Nikachhu project; and,
- Provision of technical assistance in assessing the practicality of seeding the reservoir with snow trout.

Dam Public Safety Specialist (national):

- Provision for three months effort at the end of the construction phase and beginning of the operation phase (total 1,125,000 Nu);
- Provision of technical assistance in assessing the safety needs and designing the warning system for a possible dam failure in the Nikachhu project, including the required technical specifications and spacing of sirens, and use of the mobile phone network to set up a phone cascade warning system; and,
- Full testing of the system, with documentation of results, development of an operational manual, and training for project staff and municipal officials.