ROYAL GOVERNMENT OF BHUTAN

MINISTRY OF COMMUNICATIONS

DEPARTMENT OF ROADS

ENVIRONMENTAL CODES OF PRACTICE

HIGHWAYS AND ROADS

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ACRONYMS

ADB	Asian Development Bank
DoP	Division of Power
DoR	Division of Roads
DYT	Dzongkhag Yargye Tshogchung
EA	Environmental Assessment
ECP	Environmental Codes of Practice
FSD	Forestry Services Division
GSoB	Geological Survey of Bhutan
GYT	Geog Yargye Tshogchung
IEE	Initial Environmental Examination
MoC	Ministry of Communications
MoHA	Ministry of Home Affairs
NA	Not Applicable
NEC	National Environmental Commission
PIU	Project Implementation Unit
RGoB	Royal Government of Bhutan
RoW	Right of Way
RSTA	Road Surface Transport Authority
SMEC	Snowy Mountain Engineering Company
SoB	Survey of Bhutan
ToR	Terms of Reference
WB	The World Bank

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1. INTRODUCTION

1.1 Purpose and Scope of the Environmental Codes of Practice

According to the Bhutanese Environmental Assessment Sectoral Guidelines, February 1999, all new road projects of any classification are subject to a comprehensive Environmental Assessment (EA) and its clearance by the National Environment Commission (NEC) before any project work can start. This EA forms the basis for the environmental management of the project.

In order to manage the road project on the execution level in an environmental sound way and in accordance with the recommendations of the sectoral guidelines issued by NEC, Environmental Codes of Practice (ECP) are a requirement. The ECP include all stages of a project such as planning, study, survey, design, tendering, contract documentation, project execution and supervision, operation, maintenance, and rehabilitation.

The ECP are to be used by all parties involved with road construction and maintenance activities such as government agencies concerned (Division of Roads, Forest Services Division/Forest Development Corporation, Ministry of Trade and Industry), consultants and contractors.

The ECP are to be considered as part of the standard operating practices for all DOR road construction, maintenance and rehabilitation activities and must also become part of the project tender documents and contract documents packages.

With the help of the ECP, DOR and the other proponents concerned will be able to fulfil their obligations with regard to the "Institutionalising and Strengthening of the Environmental Assessment Process in Bhutan" (Reference Document 1999) and the "Sectoral Guidelines" for Highways and Roads.

In preparing the Bhutanese ECP, Highways and Roads, reference was also made on the Nepalese and Fijian Environmental Codes of Practice.

The ECP in its present form contains only basic environmental rules, which will allow taking the first important steps towards environmental friendly road works. Later on, when their implementation has become common practice among the actors concerned, these rules may become more rigid in order to introduce further steps in that direction. Therefore, the ECP has to be considered as a "living document" which, from time to time, may need revision.

1.2 Content of Environmental Codes of Practice and its Use

The ECP consist of a simple and summarized environmental management plan for every project stage. This management plan can be used as **Environmental Manual**.

The following project stages are covered:

- Planning, studying and surveying
- Design
- Tender documents
- Construction and supervision
- Operation and maintenance

Since road rehabilitation can be treated in the same way as road construction it is not covered separately.

The individual management plans for each project stage contain a short introduction where important aspects of that project stage are mentioned like e.g. the institutional responsibility for that project stage, the basic DOR manuals to be followed, the existing laws, rules and regulations to be followed, the correct work sequence and other matters, if any.

The management plan is kept in table form and summarizes the following:

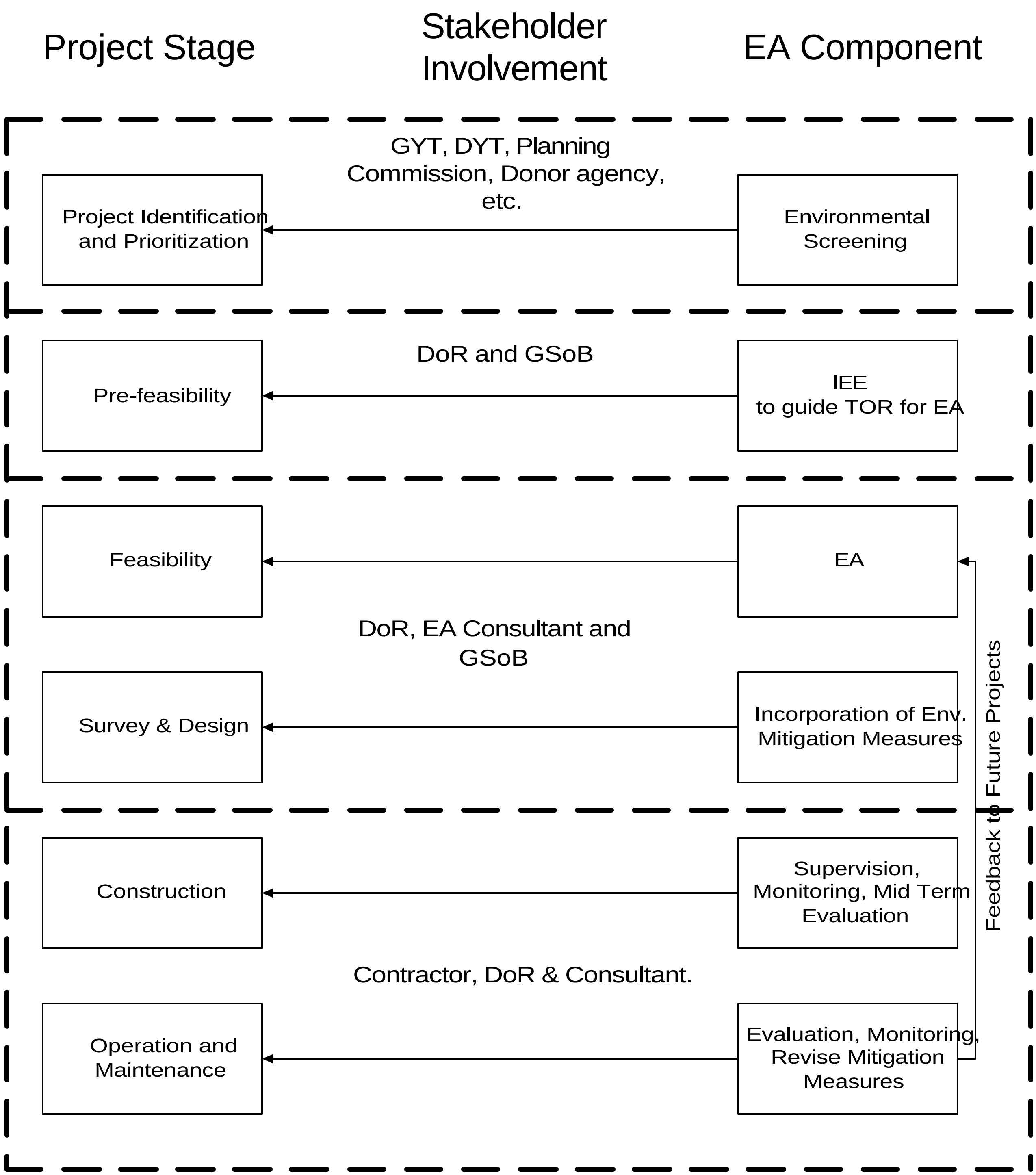
- the sequence of the project activities to be carried out

- the potential negative environmental impacts for each activity
- the proposed mitigation measures
- the need for public participation and co-ordination with other government agencies
- socio-economic and cultural considerations
- the need to budget mitigation measures
- the supervision requirements (only for construction, operation and maintenance)
- the monitoring and evaluation requirements

Very often, the time required to plan and prepare a road construction project is underestimated. Therefore, the management plans for these project stages contain an average time frame for the execution of all the required stage activities.

Since the proposed management plans are new for DOR and kept very short and to the point, it was felt necessary to explain them in more detail. Therefore, each management plan is supplemented with an annex where the required explanations and suggested instructions and/or specifications can be found.

The involvement of environmental activities at various project stages is illustrated in the following page.



Integrating EA at Various Project Stages, Highways and Roads.

2. ENVIRONMENTAL MANAGEMENT PLANS

2.1 Planning, Studying and Surveying

The planning, study and surveying stage of the project has the **greatest impact** with regard to ecology and economy of a road project. It is imperative to assign these tasks to highly experienced engineers only. Geologically weak and ecologically sensitive areas have to be avoided if ever possible and the road must be optimally integrated into the terrain.

The DOR "Survey Manual" by ADB/SMEC is the technical basis for any road survey activities. The institutional responsibility for planning, studying and surveying lie with the DOR.

The work sequence **for planning, studying and surveying follows as below:**

- Planning
  - ordering of topographical map
  - geological assessment based on aerial photos
  - input of all available data (e.g. social, cultural, environmental and geological) into topographical map

- Pre-feasibility Study
  - desk study based on topographical map
  - ground reconnaissance for all alignment options
  - proposal of best alignment

- Feasibility Study (preliminary survey)
  - select optimal road corridor and peg line fixation

- Environmental Assessment (EA and feasibility study should be conducted interactively)
  - identify all significant environmental issues
  - draw environmental management plan

- Detailed Survey
  - comprehensive mapping of road corridor

2.1.1 Time Frame

Enough time must be allowed for the initial project phase to allow for environmental friendly and economical solutions.

TIME FRAME

Activity	Time required (months)
Planning	11
topographical map	10
Geo-technical and socio-ecological assessment (screening)	1
Studying and Surveying	**10**
pre-feasibility study (desk study, ground reconnaissance & project proposal)	3
government clearance for project proposal	1
EA and feasibility study (coordinated and integrated)	3
government clearance for EA	1
detailed survey (10 km road section)	2
TOTAL	**21**

2.1.2 Environmental Management Plan applied for Planning, Studying and Surveying

The environmental management plan is shown in the following table.

Activity	Potential Negative Environmental Impacts	Mitigation Measures	Public Participation and Coordination	Socio-Economic and Cultural Considerations	Budgeting	Supervision	Monitoring
Planning	• future temporary or permanent large scale slope failures • temporary or permanent disturbance of social, cultural and environmental sensitive sites/areas	• order topo map from SoB (scale 1:25000, 10m contour lines) • geo-technical assessment by engineering geologist on aerial photo basis • socio-ecological assessment on available data basis e.g. land use map and satellite imagery	• coordinate the production of topo map with SoB • coordinate the assignment of engineering geologist	NA	• cost of SoB topo map • cost of engineering geologist	NA	NA
Pre-feasibility Study (Reconnaissance Survey)	• future temporary or permanent large scale slope failures • temporary or permanent disturbance of social, cultural and environmental sensitive sites/areas	• desk study based on topo map and geological and socio-ecological assessments • careful ground reconnaissance • proposal of best alignment based on weighted selection criteria	• inform local population about planned road alignment options • collect important data for all alignment options from local population	• optimize road length • assess access options to all villages and infrastructure of the road area • consider existing network of mule tracks and footpaths • identify affected private land and property • consider land use along the alignments • consider cultural sites	NA	NA	NA
Feasibility Study (Preliminary Survey)	• too high road construction costs • high restoration costs every year • large scale ecological damages • soil erosion damages at surface water outlets	• identify optimal road corridor and peg line • improve alignment if it minimises environmental and social impact • identify geological features by engineering geologist • identify ecological features by environmentalist • determine adequate water management requirements	• collect data on previous slope failures • collect data on springs, flood levels of streams and rivers	NA	• cost of engineering geologist • cost of environmental specialist	NA	NA

Environmental Management Plan applied for Planning, Studying and Surveying

Activity	Potential Negative Environmental Impacts	Mitigation Measures	Public Participation and Coordination	Socio-Economic and Cultural Considerations	Budgeting	Supervision	Monitoring
EA	• future environmental problems not realized in advance	• EA team based on clear TOR • EA clearance by NEC	• assign the team for the EA • inform local population about the selected alignment • collect specific and detailed information from local population for the selected alignment option	• detailed identification of affected private land and property • detailed identification of affected infrastructure • detailed consideration of affected cultural sites	• cost of EA team	NA	NA
Detailed Survey	• inappropriate design due to missing survey data • shallow slope failures (tree felling)	• careful mapping of road corridor terrain • careful mapping of other relevant data like potential spoil locations, quarry sites, fragile slopes, seepage areas, etc. • no tree felling within road corridor for visibility, only bush clearing	• exchange of any information if required	NA	NA	NA	NA

2.2 Design

The DOR "Road Design Manual" by ADB/SMEC is the technical basis for any road design activities. All data collected during the previous project stages (pre-feasibility, feasibility and detailed survey) must be made available to the design engineer. In order to get a realistic picture of the prevailing site conditions the design engineer must visit the road alignment before he starts with the design to be able to produce a realistic and sound design.

The institutional responsibility for the design lies with the DOR.

The **work sequence** for design follows as below:

- Alignment
  - preliminary drafting of vertical alignment
  - preliminary drafting of horizontal alignment
  - optimization of vertical/horizontal alignment
  - cross sections
  - mass haul diagram
- Other design features
  - permanent structures / slope stabilization
  - water management
  - temporary facilities

2.2.1 Time Frame

Due to accessibility problems, road construction must be executed section-wise. In average, a section of 10 km is a suitable contractor workload. Hence, the design work must be staged accordingly. To cover all aspects required for a careful and sound road design the following time frame is suggested.

TIME FRAME

Activity	**Time required (months)**
Horizontal and Vertical Alignment, Cross Sections	**2.5**
input of all survey data	0.5
draft horizontal/vertical alignment	1.0
cross sections and draft mass haul diagram	0.5
final horizontal/vertical alignment and mass haul diagram	0.5
Structures	**0.5**
Plan Printing	**0.5**
TOTAL	**3.5**

2.2.2 *Environmental Management Plan applied for Design*

The environmental management plan is as provided in the following table.

Activity	Potential Negative Environmental Impacts	Mitigation Measures	Public Participation and Coordination	Socio-Economic and Cultural Considerations	Budgeting	Supervision	Monitoring
Vertical Alignment	• requirement of re-alignment for road up-grading • fast surface scouring	• fix alignment so that re-alignment is not required for upgrading • road length should not exceed 100 m for grades 8 - 10%	NA	NA	NA	NA	NA
Horizontal Alignment	• temporary or permanent slope failures • destruction of up and down slope vegetation and valuable forest by uncontrolled dumping of spoil material • wide and barren road corridors restrict the free movement of wild animals	• relax design standard, if necessary and road user safety is not compromised • keep earthwork volume minimal to limit disturbance to fragile slopes • balance cut/fill within the cross section for slopes of less than 70% • balance cut and fill over short road sections for slopes of more than 70% • minimize the transportation of spoil material • in forest areas, use log barriers • draw mass haul diagram	NA	NA	NA	NA	NA
Permanent Structures	structure failure in unstable areas (sinking)	• select flexible structures (gabions) when the site conditions require it	NA	NA	NA	NA	NA
Water management	• massive soil erosion due to increased volume of discharge water • road sinking due to seepage water below the road • up-slope failure due to seepage water	• cross-fall always to the mountain side for low standard roads • use only, but every stream crossing to discharge side drain water • specify erosion protection measures for all discharge structures locations • side drains and up-slope catch drains must be lined in areas with high water table (seepage)	NA	NA	NA	NA	NA

Environmental Management Plan applied for Design

Activity	**Potential Negative Environmental Impacts**	**Mitigation Measures**	**Public Participation and Coordination**	**Socio-Economic and Cultural Considerations**	**Budgeting**	**Supervision**	**Monitoring**
Slope Stabilization	• slope erosion and shallow slope failures	• bio-engineering measures must be tailor made for the prevailing site conditions • structures (breast and toe walls) in combination with bio-engineering measures • close co-operation with engineering geologist	NA	NA	NA	NA	NA
Temporary Facilities	• soil and air pollution • disturbance of river flow patterns	• indicate suitable sites (camps, spoil disposal, quarries, borrow pits for soil, gravel and sand) in the alignment plans	NA	NA	NA	NA	NA

2.3 Tender Documents

All work items concerning environmental issues must be included in the Tender Documents:

as quantified work items in the Bill of Quantity (BoQ) and as clauses in the Technical Specifications (TS). This forces the contractor to calculate costs and to execute them in a technically correct manner.

To facilitate an environmental friendly road construction, formation cutting and permanent works must be tendered as one package because support structures for safe spoil material deposits or retaining walls have to be built before spoil material deposition or back filling of retaining walls can start.

The institutional responsibility for the tender procedure lies with the DOR.

The **work sequence** for preparation of tender documents follows as below:

- Bill of Quantity
  - preparation of work items list
  - calculation of quantities
  - preparation of schedule of rates
- Contract clauses
  - special clauses
  - technical specifications

2.3.1 Time Frame

For the introduction of environmental friendly construction methods many new work items will be required. These items will have to be specified (Technical Specifications) and rated (Schedule of Rates) to be included in the Tender Documents. This will lengthen the present tendering procedure to at least 2.5 months.

TIME FRAME

Activity	Time required (months)
Preparation of Tender Documents	**1.0**
Revise and complement TS and BoQ and prepare schedule of rates of rates for new work items	0.5
Calculate work quantities and prepare BoQ and Cost Estimate	0.5
Tendering of Works and Contract Award	**1.5**
TOTAL	**2.5**

2.3.2 Environmental Management Plan applied for Tender Documents

The environmental management plan is as provided in the following table.

Activity	Potential Negative Environmental Impacts	Mitigation Measures	Public Participation and Coordination	Socio-Economic and Cultural Considerations	Budgeting	Supervision	Monitoring
Preparation of Tender Documents	• intended measures are not executed properly or not at all • intended measures are not priced and hence not executed • opening, running and closure of temporary facilities (contractor camps, spoil disposal areas, quarries, borrow pits for soil, gravel/sand extraction pits in rivers)	• define all mitigation work items for inclusion in the standard Bill of Quantities (include opening, running and closure of temporary facilities like contractor camps, spoil disposal sites, quarries, borrow pits for soil, gravel and sand) • prepare the schedule of rates for such work items • prepare contract clauses for work items for inclusion into the Conditions of Work and Technical Specifications (including opening, operation and closure of temporary facilities)	NA	NA	• to review environmental items	NA	• review of environmental items by EA specialist
Tendering of Works	• Insufficient awareness of environmental requirements	• include the ECP in the Tender Documents	NA	NA	NA	NA	NA

2.4 Construction and Supervision

It is in this stage of the project where **corrective** environmental mitigation measures are considerable. In identifying the best possible mitigation measures the important is to know which area of construction activity needs corrective action. The area requiring corrective measures can therefore be scoped into 11 broad headings:

1. Quarries and gravel/sand extraction from river beds
2. Spoil disposal (including temporary stockpiling of materials)
3. Slope stability
4. Drainage
5. Work camp location, operation and closure, restrictions on workers (sanitation, fuelwood collection, poaching)
6. Use of bitumen
7. Explosives and toxic waste management
8. Management of stone crushing plants
9. Water management
10. Air and noise management
11. Road use and safety operation

This document should be used along with DoR "Blasting Manual" by SMEC and "Bio-Engineering Manual in Bhutan" by John Howell, 1999.

In addition the following documents should be followed:

- Rules and Regulations for construction of temporary, semi-permanent and permanent houses on either sides of the roads, 1995
- Forest and Nature Conservation Act of Bhutan, 1995
- Road Safety and Transport Act, 1997
- Land Compensation Rate, 1996
- Institutionalizing and strengthening of the environmental assessment process in Bhutan, Volume II – Appendices, 1999
-

The **work sequence** for preparation of tender documents follows as below:

- 1st contract
  - retaining structures
  - formation cutting / embankment
  - water management (catch drains, French drains and temporar y side drains)
  - breast walls
  - bioengineering

- 2nd contract
  - stone soling
  - side drains
  - cross drainage structures
  - layer works
  - additional bioengineering

- 3rd contract
  - pavement works

2.4.1 *Environmental Management Plan applied for Construction and Supervision*

The environmental management plan is as provided in the following table.

Activity	Potential Negative Environmental Impacts	Mitigation Measures	Public Participation and Coordination	Socio-Economic and Cultural Considerations	Budgeting	Supervision	Monitoring/Evaluation
1. Quarries and gravel/sand extraction from river beds	• landscape instability • dust pollution • aesthetics • damages to vegetation	• careful siting and investigations • proper operation • rehabilitation	• GSoB • FSD • Dzongkhag Administration and locals	• consider local resource demand	• restoration cost included in the project and paid by BoQ	• project implementation unit (PIU), DOR	• DOR (as may be needed) • external agency (team) • evaluated by external agency
2. Spoil Disposal (including temporary stockpiling of material)	• disruption of local hydrology • landslides • damage to vegetation • damage to existing infrastructure	• use of excavator • balance cut and fill • deposit cut material in suitable depression • bioengineer exposed slopes	• bioengineering specialist	• consider local water supply (domestic irrigation)	• include in project	• PIU, DOR	• DOR (as may be needed) • external agency (team) • evaluated by external agency
3. Slope Stability	• slope failure • clog side drain • hinder traffic	• execute slope stability study by engineering geologist • bioengineer slopes and protect from grazing • erect retaining structures	• engineering geologist • bioengineering specialist	• consider local land use and grazing	• bioengineering cost • protection cost	• PIU, DOR	• DOR (as may be needed) • external agency (team) • evaluated by external agency
4. Drainage	• surface runoff along road • siltation of water down stream • slope failures • water seepage	• design structures to accommodate discharge • check adequacy of culverts/drains and its functions • clearing of debris & vegetation, clogging culverts • line drainage structures where required	• involve Dzongkhag administration and locals	• consider local drinking water supply and irrigation channels	• include in the project budget	• PIU, DOR	• DOR (as may be needed) • external agency (team) • evaluated by external agency

Environmental Management Plan applied for Construction and Supervision

Activity	Potential Negative Environmental Impacts	Mitigation Measures	Public Participation and Coordination	Socio-Economic and Cultural Considerations	Budgeting	Supervision	Monitoring/Evaluation
5. Work Camp Location, Operation & Closure, restrictions on workers (sanitation, fuelwood collection, poaching)	• conflict with locals • garbage, oil & grease pollution • damage to vegetation and wildlife	• proper siting • provide sanitary facilities • restoration • provide fuel	• Dzongkhag administration and local people • FSD • awareness of labors	• consider local culture, land expropriation and compensation including temporary sites	• providing sanitation & restoration of camps (provision of camps should be included) • compensation • fuel for labors	• PIU, DOR	• DOR (as may be needed) • external agency (team) • evaluated by external agency
6. Use of Bitumen	• deforestation • soil and water pollution • air pollution	• use bitumen emulsion wherever feasible • use bitumen heaters • discourage or prohibit fuelwood use (depending on site)	• FSD	• consider local fuelwood demand • drinking water	• provide budget for waste clean up after the activity	• PIU, DOR	• DOR (as may be needed) • external agency (team) • evaluated by external agency
7. Explosives & Toxic Waste Management	• fire & explosion hazard • ground & surface water pollution	• do not store near surface waters • use plastic sheeting under hazardous material • collect wastes properly and dispose off safely	• contact Ministry of Home Affairs in case of hazard, or needing material annihilation.	• consider local drinking water sources	• hazard compensation and other safety measures included in the project	• PIU, DOR • sometimes by Home of Ministry Affairs	• DOR (as may be needed) • external agency (team) • evaluated by external agency
8. Management of Stone Crushing Plants	• damage to local crops and surface waters from dust • excessive noise	• locate away from population centers and ecologically sensitive areas • operate during day only • refer section 4.10	• locals, & Dzongkhag administration • involve FSD and GSoB	• consider local crops and damages to the cultural monuments	• rehabilitation cost of site to be included in the project	• PIU, DOR	• DOR (as may be needed) • external agency (team) • evaluated by external agency
9. Water Management	• sedimentation of surface waters • slope failures • creation of new gullies • water seepage	• build check dams • tape excess water by catch drains and dispose off natural gully	• involve locals when deciding about discharge location • Dzongkhag administration	• irrigation channel and drinking water supplies need consideration	• additional water management structures	• PIU, DOR	• DOR (as may be needed) • external agency (team) • evaluated by external agency

Environmental Management Plan applied for Construction and Supervision

Activity	Potential Negative Environmental Impacts	Mitigation Measures	Public Participation and Coordination	Socio-Economic and Cultural Considerations	Budgeting	Supervision	Monitoring/Evaluation
10. Air and Noise Management	• emission of toxic pollutants • high concentration of airborne dust • excessive noise disrupting livestock and wildlife	• conduct blasting during day hours • conduct controlled blasting • gravel road through populated areas is suggested to be black topped • provide safety gadgets for labors • use bitumen emulsion where feasible	• coordinate with locals • Ministry of Home Affairs	• health of local people • damage to local crops • livestock	• contingency budget should be kept in the project for compensation of health & livestock loss	• PIU, DOR	• DOR (as may be needed) • external agency (team) • evaluated by external agency
11. Road Use and Safety Operation	• loss of human life • loss of property	• the sign be distinct and visible • all danger sites should have signs indicating the type of problem	• Road Safety Transport Authority (RSTA)	NA	• signs and paints	• PIU, DOR	• DOR (as may be needed) • external agency (team) • evaluated by external agency

2.5 Operation and Maintenance

It is often a tendency to emphasize the importance of providing roads and overlooking the continuous maintenance required for road. These high recurrent costs can have a big (negative) impact on the sustainability of a project. Potential environmental impacts during operations are: wearing road surface, development of potholes, landslides, pollution of waters near work campsites, and often health hazards due to accidents. To eliminate the above problems areas requiring usually the most mitigation are listed below:

1. Quarries and gravel/sand extraction from river beds
2. Spoil disposal (including temporary stockpiling of materials)
3. Slope stability
4. Drainage
5. Work camp operation
6. Use of bitumen
7. Explosive and toxic waste management
8. Management of stone crushing plants
9. Water management
10. Air and noise management
11. Road use and safety operation
12. Road surface

Although some of the mitigation measures reflected here are similar to the construction phase because operation and maintenance are an independent work phases they need to be mentioned here. Theses code of practices may be more useful if used along with DOR's "Field Manual of Road Maintenance" prepared by SMEC and "Bioengineering Manual in Bhutan" by John Howell, 1999.

2.5.1 Environmental Management Plan applied for Operation and Maintenance

The environmental management plan is as provided in the following table.

Activity	Potential Negative Environmental Impacts	Mitigation Measures	Public Participation and Coordination	Socio-Economic and Cultural Considerations	Budgeting	Supervision	Monitoring
1. Quarries and gravel/sand extraction from river beds	• landscape instability • dust pollution • aesthetics • damages to vegetation	• careful siting and investigations • proper operation • rehabilitation	• GSoB • FSD • Dzongkhag Administration and locals	• consider local resource demand	• restoration cost include in the project and paid by BoQ	• specific site engineer • DoR	• specific site engineer • DoR • external agency (requested by Dzongkhag or other)
2. Spoil Disposal (including temporary stockpiling of material)	• disruption of local hydrology • landslide • damage to vegetation • damage to existing infrastructure	• use of excavator • balance cut and fill • deposit cut material in suitable depression • bioengineer exposed slopes	• bioengineering specialist	• consider local water supply (domestic irrigation)	• include in project	• specific site engineer • DoR	• specific site engineer • DoR • external agency (requested by Dzongkhag or other)
3. Slope Stability	• slope failure • clog side drain • hinder traffic	• execute slope stability study by engineering geologist • bioengineer slopes and protect from grazing • erect retaining structures	• engineering geologist • bioengineering specialist	• consider local land use and grazing	• bioengineering cost • protection cost	• specific site engineer • DoR	• specific site engineer • DoR • external agency (requested by Dzongkhag or other)
4. Drainage	• surface runoff along road • siltation of water down stream • slope failures • water seepage	• design structures to accommodate discharge • check adequacy of culverts/drains and its functions • clearing of debris & vegetation, clogging culverts • line drainage structures where required	• involve Dzongkhag administration and locals	• consider local drinking water supply and irrigation channels	• include in the project budget	• specific site engineer • DoR	• specific site engineer • DoR • external agency (requested by Dzongkhag or other)

Environmental Management Plan applied for Operation and Maintenance

Activity	Potential Negative Environmental Impacts	Mitigation Measures	Public Participation and Coordination	Socio-Economic and Cultural Considerations	Budgeting	Supervision	Monitoring
5. Work Camp Location, Operation & Closure, restrictions on workers (sanitation, fuelwood collection, poaching)	• conflict with locals • garbage, oil & grease pollution • damage to vegetation and wildlife	• proper siting • provide sanitary facilities • restoration • provide fuel	• Dzongkhag administration and local people • FSD • awareness of labors	• consider local culture, land expropriation and compensation including temporary sites	• providing sanitation & restoration of camps • compensation • fuel for labors	• specific site engineer • DoR	• specific site engineer • DoR • external agency (requested by Dzongkhag or other)
6. Use of Bitumen	• deforestation • soil and water pollution • air pollution	• use bitumen emulsion wherever feasible • use bitumen heaters • discourage or prohibit fuelwood use (depending on site)	• FSD	• consider local fuelwood demand • drinking water	• provide budget for waste clean up after the activity	• specific site engineer • DoR	• specific site engineer • DoR • external agency (requested by Dzongkhag or other)
7. Explosives & Toxic Waste Management	• fire & explosion hazard • ground & surface water pollution	• do not store near surface waters • use plastic sheeting under hazardous material • collect wastes properly and dispose off safely	• contact Ministry of Home Affairs in case of hazard, or needing material annihilation.	• consider local drinking water sources	• hazard compensation and other safety measures included in the project	• specific site engineer • DoR	• specific site engineer • DoR • external agency (requested by Dzongkhag or other)
8. Management of Stone Crushing Plants	• damage to local crops and surface waters from dust • excessive noise	• locate away from population centers and ecologically sensitive areas • operate during day only • refer section 4.10	• locals, & Dzongkhag administration • involve FSD and GSoB	• consider local crops and damages to the cultural monuments	• rehabilitation cost of site to be included in the project	• specific site engineer • DoR	• specific site engineer • DoR • external agency (requested by Dzongkhag or other)
9. Water Management	• sedimentation of surface waters • slope failures • creation of new gullies • water seepage	• build check dams • tape excess water by catch drains and dispose off natural gully	• involve locals when deciding about discharge location • Dzongkhag administration	• irrigation channel and drinking water supplies need consideration	• additional water management structures	• specific site engineer • DoR	• specific site engineer • DoR • external agency (requested by Dzongkhag or other)

Environmental Management Plan applied for Operation and Maintenance

Activity	Potential Negative Environmental Impacts	Mitigation Measures	Public Participation and Coordination	Socio-Economic and Cultural Considerations	Budgeting	Supervision	Monitoring
10. Air and Noise Management	• emission of toxic pollutants • high concentration of airborne dust • excessive noise disrupting livestock and wildlife	• conduct blasting during day hours • conduct controlled blasting • gravel road through populated areas is suggested to be black topped • provide safety gadgets for labors • use bitumen emulsion where feasible	• coordinate with locals • Ministry of Home Affairs	• health of local people • damage to local crops • livestock	• contingency budget should be kept in the project for compensation of health & livestock loss	• specific site engineer • DoR	• specific site engineer • DoR • external agency (requested by Dzongkhag or other)
11. Road Use and Safety Operation	• loss of human life • loss of property	• the sign be distinct and visible • all danger sites should have signs indicating the type of problem	• Road Safety Transport Authority (RSTA)	NA	• signs and paints	• specific site engineer • DoR	• specific site engineer • DoR • external agency (requested by Dzongkhag or other)
12. Road Surface	• shoulder erosion • potholes • traffic skidding • settlement of structures	• monitor potholes and patch it (NEVER fill with soil) • enforce Rules & Regulations for erection of structures on sides of roads issued by Ministry of Home Affairs, 1995	• involve Dzongkhag administration	• consider compensating people already settled along the road side if needs relocation	• compensation cost	• specific site engineer • DoR	• specific site engineer • DoR • external agency (requested by Dzongkhag or other)

ANNEXES

1 PLANNING, STUDYING AND SURVEYING

The planning, studying and surveying phase is the most important phase of all the project stages. It is in this phase where all the fundamental decisions are made to achieve an alignment, which can be constructed and maintained with least cost, minimum instability and a tolerable environmental impact.

Therefore, only a highly experienced and multi-disciplinary team of specialists can adequately handle these tasks.

1.1 PLANNING

1.1.1. Potential Negative Environmental Impacts

Often, **large slope failures** of temporary or even permanent nature occur after construction. In many cases, these failures require comprehensive stabilization measures such as costly support structures or other recurrent restoration measures after every monsoon. Sometimes, such failures are so deep rooted that there is no chance of stabilization and re-alignment over several kilometers is the only solution.

But slope stability is not the only factor. Also the **social, cultural and ecological environment** can be negatively affected or even destroyed during or after road construction.

1.1.2. Mitigation Measures

With the existing aerial photographs of 1:35,000 scale covering most of the country, SoB can produce **topographical maps** of 1:25,000 scale and, depending on the ruggedness of the area, 10m or 20m contour lines. These maps are a solid basis for designing of optimal alignments at an early project stage.

Aerial photographs also allow a preliminary assessment of the **geo-technical situation** of the project area. An interpretation of the photographs enables an experienced engineering geologist to indicate potential geological weak spots on the topographical map.

The assessment of all known **socio-ecological data,** viz. taken from land use maps, property maps and satellite imageries, such as existing infrastructures, location of prime agricultural land, sensitive ecosystems and important cultural and religious sites, and its position on the topographical map further allow engineers to avoid sensitive sites or areas when selecting suitable road alignment options at the pre-feasibility study stage.

1.1.3. Public Participation and Coordination

The planning stage requires co-ordination between DoR and other government bodies such as the SoB.

The production of an accurate **topographical map** is time consuming and must therefore be ordered from SoB well in advance to have it available when the pre-feasibility project phase starts.

The same timely (early) assignment of an **engineering geologist** is required for the assessment of the geo-technical situation of the project area.

1.1.4. Budgeting

For the planning phase the costs for the production of the **topographical map** and for the assignment of the **engineering geologist** must be duly budgeted.

1.2 PRE-FEASIBILITY STUDY

1.2.1. Potential Negative Environmental Impacts

What has been said under para 1.1.1 is equally valid for pre-feasibility study phase. In addition to this, **protected areas** and **species habitats** can also be negatively affected or even destroyed during or after road construction.

1.2.2. Mitigation Measures

The **desk study** must be based on all available data known. This includes the topographical map, the geo-technical and socio-ecological assessments. Wherever possible, the proposed alignment options must avoid geo-technical weak spots, not affect socio-ecological sensitive areas and cultural sites and be practical and direct as possible.

The **ground reconnaissance** must include a complete walkover of all the selected alignment options to determine the topographical and geological feasibility and to collect as much data as possible to gain a sound basis for the physical, environmental, economic and social comparison of the alignment options.

Based on the ground reconnaissance, out of the available alignment options, the best alignment must be chosen by **weighing** the given **set of selection criteria**.

1.2.3. Public Participation and Coordination

Public participation is an important and necessary component for road projects. Public involvement is likely to result in a more sustainable project when people feel a sense of local ownership, acceptability and a commitment for maintaining the road. It involves a **two-way flow of information**. Firstly, the study team has a duty to inform the local population in the road area of all aspects of the project for all the project stages (adverse impacts and benefits). Secondly, the public should be knowledgeable about local conditions and issues that are crucial for a good project design, the project management and the road operation. During the execution of the pre-feasibility study, the local population must be informed about options for providing motorable access to their area. The better they are informed about advantages and disadvantages of alignment options the easier will be the dialogue later on when they are confronted with the disadvantages of the new road during construction, operation and maintenance.

At this project stage, all available data concerning **physical, socio-economical, cultural and ecological factors** must be collected from locals to receive a broad and valid information basis for all the proposed alignment options.

1.2.4. Socio-Economic and Cultural Considerations

A very crucial factor is the **road length**. The shorter the road, the lower the construction, operation and maintenance costs and the less environmental damage. But from a purely social point of view, all people of the project area should profit by a direct access to the new road. However, this can lead to a high increase of road length, and increased costs.

In addition, the existing network of mule tracks and footpaths should be taken into account to arrive at the optimal access.

A careful weighing of all factors involved will lead to an optimal solution and show which village or infrastructure can be accessed directly or only indirectly by the planned road.

A careful identification of **affected private land and property** for each individual alignment option is essential because it is an important criterion with regard to the selection of the best alignment.

Likewise, the **land use** and the location of **cultural sites** along different alignment options are of high economical, cultural and ecological significance for the selection of the best alignment

1.3 FEASIBILITY STUDY

1.3.1. Potential Negative Environmental Impacts

The less accurate the information on the future road is, the greater the potential that unexpected factors crop up during the construction which may result in a considerable cost increases. This is not only valid for the **construction costs** but also for recurrent costs for operation and maintenance.

Inaccurate or missing information on the ecological factors of a road area also may lead to large-scale damage or even to a substantial destruction of the **ecological environment.**

Negligence or inaccurate information on the discharge volume of surface water can trigger large-scale **soil erosion** especially at outlets.

1.3.2. Mitigation Measures

The road corridor and the peg line must carefully consider the topographical, geo-technical (slope stability, rock strata, quarries and material disposal sites) and hydrological factors (wet zones) to come up with an **optimal road corridor and peg line**.

If there are possibilities to minimize negative environmental and social consequences, then the alignment should be adapted accordingly.

An engineering geologist can only effectively assess the geological features.

The same is valid for the **ecological features**. An experienced environmentalist is needed for this task.

At this stage already, hydrological features need close attention to develop adequate and suitable water management measures.

In addition, suitable sites for temporary facilities such as contractor camps, spoil disposal areas, potential quarries (aggregate extraction) and borrow pits (soil, gravel and sand extraction) have to be identified. This will help with early identifications of resource bottlenecks requiring the additional resources far from the planned alignment, and the feasibility of access.

1.3.3. Public Participation and Coordination

Frequently the local populations can offer essential and valid information about the **stability of slopes**. They know where and how previous slope failures had occurred and where soil erosion is likely to occur.

They also know about the location of **water sources** and water table levels (danger of seepage) at various places. For suitable dimensioning of water crossings (bridges, culverts, and causeways), the local population must be consulted about the **flood level** of streams and rivers.

1.3.4. Budgeting

The works of all the other specialists, other than DoR engineers, who contribute to this project stage must be budgeted. This involves the **engineering geologist** and the **environmental specialist**.

1.4 ENVIRONMENTAL ASSESSMENT (EA)

1.4.1. Potential Negative Environmental Impacts

The negligence or inadequate recording of all the prevailing environmental factors may lead to significant and costly **environmental problems** later on.

1.4.2. Mitigation Measures

The most important factor to optimally guide the EA is a clear **ToR** for the EA Team. Development of ToR must be given to experienced specialists in the fields concerned. The team must propose mitigation measures wherever required and come up with improvements when necessary to protect the environment to the extent possible. The team must assess whether the project is environmentally feasible or not.

The potential stakeholders such as involved government agencies, NGOs and private people have to be approached for their input with regard to potential environmental problems caused by the road project.

Environmental clearance by the NEC is required before development can proceed.

1.4.3. Public Participation and Coordination

For this project stage, the **assignment of EA Team** requires adequate preparation and co-ordination. The team can be assigned by DoR only when NEC has developed or approved the ToR for the EA.

The EA Team must **inform local populations** which alignment option has been selected for execution and for what reasons. Complete information on the process of alignment selection again helps to secure the full co-operation of the local population for the further project stages.

More **specific and detailed information** on important project issues can now be collected from the local population for the selected alignment option.

1.4.4. Socio-Economic and Cultural Considerations

The EA Team now must identify in detail all **affected private land and property** with regard to size, value and owner.

Furthermore, the team must identify **affected infrastructure** and **cultural sites** with regard to the potential damages and suggest means of mitigation and protection.

1.4.5. Budgeting

DoR must include a budget for the cost of the EA Team.

1.5 DETAILED SURVEY

1.5.1. Potential Negative Environmental Impacts

Missing or incomplete survey data results in faulty or inadequate design and may lead to higher construction, operation and maintenance costs.

Unnecessary tree cutting for better visibility during the survey weakens the stability of the surface soil layers and can result in **shallow slope failures**. The wide corridor opening also results in loss of wildlife habitat, particularly birdlife.

1.5.2. Mitigation Measures

The **road corridor** needs careful and complete mapping of all important terrain features and must be wide enough at places where spoil deposits are feasible. Other relevant data like land use, infrastructure, cultural sites, fragile slopes, seepage areas, etc. must also be mapped.

In addition, campsites, spoil locations, quarry and borrow pit sites must be located too.

The **felling of trees** for visibility during the detailed survey weakens surface soil layers and may trigger shallow slopes failures. To the extent possible tree felling should be avoided at this project stage.

1.5.3. Public Participation and Coordination

Whenever and wherever required, the further mutual **exchange of information** between project staff and locals should be encouraged and supported.

2 DESIGN

2.1 VERTICAL ALIGNMENT

2.1.1. Potential Negative Environmental Impacts

Requirement of **re-alignment** at the time of road upgrading and rehabilitation due to inadequate and too steep grades.

Fast **road scouring** due to vehicle pressure and surface runoff.

2.1.2. Mitigation Measures

Compared to the horizontal alignment the **vertical alignment** must satisfy also the requirements of the next higher road class because once it needs upgrading, this should be possible without requiring a re-alignments with corresponding high costs.

For the gradient of 8 – 10% the road stretch should not exceed 100m.

2.2 HORIZONTAL ALIGNMENT

2.2.1. Potential Negative Environmental Impacts

Large-scale **slope failures** of temporary or even permanent nature may occur after construction completion. In many cases, these failures require comprehensive stabilization measures such as costly support structures or other recurrent restoration measures after every monsoon. Sometimes, such failures are so deep rooted that there is no chance of stabilization and re-alignment over several kilometers is the only solution.

The **destruction of up- and down-slope vegetation** and of valuable forest over wide areas due to uncontrolled dumping of spoil material.

Wide **road corridors, bare of any vegetation**, restrict the free movement of wild animals considerably.

2.2.2. Mitigation Measures

For the construction of feeder roads, the general rule must be to keep the amount of **earthwork minimal**. In steep mountainous terrain, this can only be achieved if the horizontal alignment follows as closely as possible the contour lines. The advantages of minimal earthwork are low construction costs and most importantly, it reduces negative impacts on up- and down-slopes such as up-slope failures, damage to vegetation, valuable forest and agricultural land, and uncontrolled deposition of large volumes of spoil materials.

In areas with less than 70% slope grade, a **balanced cut and fill** within the cross section should be applied. In areas with over 70% slope grade, the balance should be achieved over short road sections. This requires a certain amount of support structures such as toe walls, retaining walls and breast walls.

Full cut can be applied when the risk of slope failure is minimal and safe locations for deposition of spoil material exist.

Full fill is recommended when the prevailing rock has persistent joints, bedding or foliation planes dipping parallel to the slope, when scree or similar deposits are at a critical stability angle, when eroding or highly erodible soils have to be crossed and when, for pavement drainage purposes, terraces have to be crossed.

In steep forest areas, spoil material can be deposited below the road in a controlled way by the application of **log barriers**.

A valuable tool concerning the arrangement of spoil material deposition is the **mass haul diagram** which indicates where and how much spoil material exists and where it can be safely deposited.

2.3 PERMANENT STRUCTURES

2.3.1. Potential Negative Environmental Impacts

Structure failures often occur in **unstable areas** (sinking) or when the structure cannot be founded on solid rock.

2.3.2. Mitigation Measures

In unstable areas or when the structure is not founded on bedrock, **flexible gabion structures** should be chosen to withstand unfavorable site conditions. Suitable support structures for spoil material deposits are toe walls and log barriers.

2.4 WATER MANAGEMENT

2.4.1. Potential Negative Environmental Impacts

Uncontrolled surface water discharge over the road edge creating **large-scale erosion** on the down-slopes.

The **sinking** of road sections and **up-slope failures** due to down- and up-slope seepage.

2.4.2. Mitigation Measures

The limited width and the design speed of feeder roads allows for a constant **cross-fall** towards the mountainside. This prevents an uncontrolled surface water discharge over the road edge.

Side drain water must be discharged at every available **stream crossing** so that the amount of discharge water can be kept minimal and no erosion is caused at the water outlets. Only natural stream crossings must be used for water discharge.

Where an increased discharge of surface water endangers the stability of the water outlet, **erosion protection measures** must be applied (bioengineering measures, ripraps, check dams, etc.).

In areas with high water table (seepage), **side drains and up-slope catch drains** must always been **lined** so that no surface water can penetrate into the subsoil. This avoids building up of pore water pressure, which increases the risk of slope failure.

2.5 SLOPE STABILISATION

2.5.1. Potential Negative Environmental Impacts

After construction, bare **slopes** tend to **erode and fail** under difficult site conditions (geological weak areas, erodible soils).

2.5.2. Mitigation Measures

Bare slopes must always be covered with vegetation (grass, shrub and trees) as soon as the works on the slopes are completed to avoid erosion and shallow slope failures. These **bioengineering measures** are cheap and perfectly suitable in most of the cases. But they must be tailor made for each individual site responding to the prevailing site conditions.

For unfavorable site conditions (deep-rooted instability) **support structures** such as breast, toe and retaining walls are required. But very often, such permanent structures can be kept smaller and cheaper when applied in **combination with bioengineering measures**.

To find suitable and long-lasting solutions slope stabilization measures must always be designed in close co-operation with **engineering geologists**.

2.6 TEMPORARY FACILITIES

2.6.1. Potential Negative Environmental Impacts

Temporary facilities such as road camps, borrows pits, spoil disposal sites, quarries and stone crushing plants can produce **soil and air pollution**.

Spoil disposal activities may **disturb river flow** patterns.

2.6.2. Mitigation Measures

These temporary facilities must be incorporated in the design to guide the project properly.

3 TENDER DOCUMENTS

3.1 PREPARATION OF TENDER DOCUMENTS

3.1.1. Potential Negative Environmental Impacts

Intended measures aiming at environmentally sound construction are not executed properly or not at all because they are not described in the Contract Clauses and not priced as work items in the Bill of Quantities.

Temporary facilities such as contractor camps, spoil disposal areas, quarry sites and borrow pit areas can have serious negative effects on the environment if they are not managed carefully.

3.1.2. Mitigation Measures

The intended mitigation measures must also be included as work items in the **Bill of Quantities** with the estimated amount of work volume so that the contractor can calculate the item price and the total cost for their execution.

Likewise, all mitigation measures must be individually defined and described in detail in the **Contract Clauses** of the Tender Documents so that the contractor knows how to perform them properly.

With regard to the cost estimate of the work contract, DoR must prepare a **schedule of rates** for all the intended mitigation measures.

DoR must also include special clauses in the **Conditions of Contract** with regard to the environmental project management such as:

- the contractor must **comply** with the environmental mitigation measures as per ECP
- besides the work program, the contractor has also to submit an **environmental management plan**, specific to the works, that conforms with the requirements stated in the ECP. This plan, prepared by the contractor, shall include specific methods to be employed for: location of work and labor camps, drawings indicating how storage areas and adjacent surface waters will be protected against contamination, methods of spoil disposal, quarry and borrow area site operation, protection and restoration procedures.
- the Engineer has the authority to immediately **stop the works** in areas of concern when environmental supervision activities reveals a serious existing or imminent environmental hazard.
- the Engineer has the authority to **extend the contract duration** and **increase the cost** of the contract for the implementation of remedial actions, provided the environmental problem was not caused due to negligence or non-compliance to the ECP by the contractor.
- **final acceptance** of the completed works will not occur until the environmental clauses have been satisfactorily implemented.
- operation, restoration and renovation of all **quarry sites and borrow areas** must be in accordance with the environmental mitigation measures as per ECP.

- **disposal of spoil** and excess material as per ECP.

3.1.3. Budgeting

Review of tender documents regarding environemnt requirements by an EA specialist must be budgeted.

3.1.4. Monitoring

It is suggested that the **tender documents** are **reviewed** by an EA specialist before tendering to assure that all measures are taken to prevent unnecessary environmental hazards to the project area.

3.2 TENDERING OF WORKS

3.2.1. Potential Negative Environmental Impacts

Insufficient awareness of the environmental requirements may lead to inadequate description of environmental meas ures and thus to unsatisfactory implementation of necessary works.

3.2.2. Mitigation Measures

Therefore, the **ECP** must explicitly become an **integral part of the Tender Documents**.

4 CONSTRUCTION AND SUPERVISION

4.1 QUARRY

4.1.1. Potential Negative Environmental Impacts

Impacts resulting from quarry activities are: slope instability, as breaks in natural contours often causes slope failures, dust pollution, surface water disruption, health hazards, and aesthetical impacts.

4.1.2. Mitigation Measures

In addition to the indicated quarry sites (by EA report) the responsible authority should physically identify and thoroughly investigate the sites by involving engineering geologist. Locations should be away from population centers, cultural sensitive sites, drinking water intake points, potential croplands, and protected biological areas.

When opening the site, care should be taken to keep vegetation clearing at a minimum. Blasting operations should be conducted in a controlled manner, not overcharging the holes and proper warnings/signals relayed to surrounding people in the danger zone. Bench blasting is always recommended (series of holes blasted at a time and the next series following few seconds later and so on..). For stone quarrying, the operation should begin from the crown of the slope and then move gradually downward. Shot hole blasting is NOT RECOMMENDED. In case of dry weather the contractor should wet the site by spraying water to minimize the dust.

Sand quarrying along the riverbed should not be concentrated at one spot to avoid natural flow disruption. Quarrying near bridges or river training structures should not take place.

Quarries should be restored through proper site trimming and bioengineering measures.

4.1.3. Public Participation and Coordination

To enhance environmental mitigation measures it is important that DoR initiates consultation and coordination with relevant government agencies and local people. GSoB and FSD should be involved in identifying and locating quarries. GSoB can ensure that the site is technically feasible. As both of these agencies issue quarrying permits conflicts arising later due to duplication of permit for the same site can be resolved by involving both agencies at the same time. Bioengineering specialist can help to restore the sites by suggesting and identifying suitable vegetation species.

Equally important is the involvement of the Dzongkhag administration and local people in designating the sites, and its distinct boundaries. This can avoid road damages resulting from random quarrying.

4.1.4. Socio-Economic and Cultural Considerations

When considering a quarry it should also incorporate local concerns. The commercial quarries should not deprive the resources of local people. Their agriculture-based livelihood should be respected.

4.1.5. Budgeting

It is a traditional practice that quarries are not restored after the operation, as this has not been budgeted for. Budgeting provisions have to be covered by the project under site restoration and slope stabilization head. The contractor shall be paid as per actual work performed and to the satisfaction of the DoR engineer (BoQ).

4.1.6. Supervision

The success of environmental mitigation measures largely depends on quality supervision. The supervisor should know the measures to be implemented at each site. He should be equipped with all relevant documents such as project and contract documents, road construction manual, blasting manual and bioengineering manuals.

It is assumed that the daily supervision is executed by the contractor's engineer. However, the periodic supervision should be conducted by the project implementation unit (PIU), DoR. All the supervision activities planned and executed must be well documented.

4.1.7. Monitoring / Evaluation

The monitoring can be segregated into two: daily monitoring and periodic monitoring. Again it is assumed that the daily monitoring will be carried out by the contractor's engineer. While periodic monitoring should be carried out by DoR on need basis and biannually by an external team. All findings and instructions imparted must be well documented.

The evaluations carried out at project midterm or at its completion can also be called a monitoring in the sense that findings can alter the ongoing as well as future project implementation modalities.

The indicators are: sites look relatively level and vegetation growing, completed engineer's report of site closure and executed restorations.

Remarks: all rehabilitation/restoration works should be completed before the DoR issues the completion certificate. This applies to all the following construction activities.

4.2 SPOIL DISPOSAL

4.2.1. Potential impact

A series of adverse impacts can result from improper spoil disposal including: disruption of local hydrology, manmade landslides, loss of vegetation cover, pastureland and aesthetically unpleasing sites.

4.2.2. Mitigation Measures

To keep the damage to a minimum, excavators must be used for construction. The excavated material such as topsoil and stones should be stacked at safe places for reuse at a later stage of construction.

For slope gradients of less than 70%, a concept of balancing cut and fill should be applied. Minimizing the cut material can eliminate/reduce environmental damages (refer design mitigation measures). The recommended spoil disposal sites are small natural depressions, abandoned quarries and degraded areas. Spoil material should be filled in benches to prevent slope overloading. The spoil deposits should be trimmed well and bioengineering measures applied.

4.2.3. Public Participation and Coordination

To ensure that spoil is deposited at the right places prior consultation of the local people is required. This can prevent spoil from depositing in cultural and other sensitive areas (local beliefs). For bioengineering measures, bioengineering specialist should be consulted with regard to suitable vegetation species.

4.2.4. Socio-Economic and Cultural Considerations

The experiences elsewhere in the country and in the region have revealed that casual spoil disposal has deprived local drinking and irrigation water facilities and at the same time has damaged agricultural land. Road construction activities should attempt to avoid such damages. In addition complaints from locals can hinder project progress.

4.2.5. Budgeting

Spoil haulage must be budgeted for the distances required.

4.2.6. Supervision

The responsible agencies and the frequency of monitoring are as discussed in section or para 4.1.6.

4.2.7. Monitoring / Evaluation

The responsible agencies and the frequency of monitoring are as discussed in section or para 4.1.7.

The parameters to be monitored are: spoil disposal sites, bioengineering applications and success rates, conflicts with the locals.

The success indicators are: fewer landslides, vegetated construction sites, no local conflicts, and completed engineers report.

4.3 SLOPE STABILITY

4.3.1. Potential Negative Environmental Impacts

Unstable up and downhill road slopes can result in: soil erosion, clogging of side drains, runoff spillover on the road surface and down the slope causing landslides, and hindering the traffic movement.

4.3.2. Mitigation Measures

Maintain the batters' gradient as specified in the Road Design Manual, developed by DOR. The existing vegetation on the slopes outside the immediate construction corridor should remain undisturbed during road construction and/or upgrading. Bioengineer barren slopes to stop soil erosion and protect them from grazing. Erect support structures where slope failures are anticipated or have occurred. Monitor slope failures and initiate remedial actions at the earliest possible stage.

4.3.3. Public Participation and Coordination

To carry out slope stability investigations, DOR should consult and coordinate with engineering geologist for professional inputs. In addition the DOR should suggest or recommend suitable vegetation species to FSD staff when applying bioengineering measures.

4.3.4. Socio-Economic and Cultural Considerations

When applying mitigation measures consideration should be given to the local land use and grazing habits.

4.3.5. Budgeting

The cost for engineering geologist advice, bioengineering measures and grazing protection cost should be included in the overall budget of the project.

4.3.6. Supervision

As discussed in section 4.1.6.

4.3.7. Monitoring/Evaluation

As discussed in the section 4.1.7.

The success indicators are: no landslides; and bioengineering measures visible.

4.4 DRAINAGE

4.4.1. Potential Negative Environmental Impacts

Excess surface runoff along the road due to inadequate drainage structures, siltation of water courses down stream due to erosion from unlined drains, slope failures or landslides and water seepage.

4.4.2. Mitigation Measures

The adequacy of culverts, channels, bridge waterways and other drainage structures and their ability to discharge the runoff should be considered. All permanent drainage channels through high water table areas should be lined. Maintain drains open at all times.

4.4.3. Public Participation and Coordination

Dzongkhag administration and locals should be consulted when locating drainage structures.

4.4.4. Socio-Economic and Cultural Considerations

When deciding on local drainage installations, the drinking water and irrigation water supply should be considered. Considering this at an early stage can avoid conflict with the locals, which can affect project progress.

4.4.5. Budgeting

Adequate budget provision should be kept for additional drainage structures, as drainage is considered to be the most important factor for hill roads.

4.4.6. Supervision

As discussed in section 4.1.6.

4.4.7. Monitoring/Evaluation

As discussed in section 4.1.7.

Success indicators are: controlled surface runoff, no landslides, no complaints from the locals.

4.5 WORK /LABOR CAMP LOCATION, OPERATION AND CLOSURE

4.5.1. Potential Negative Environmental Impacts

Air and noise pollution from the construction machines, water pollution from oil and grease and unsanitary waste disposal practices, social conflict, deforestation and wildlife disturbance.

4.5.2. Mitigation Measures

Camps should be located away from settlements or drinking water supply intakes, landslides or flood prone areas. The trees should be protected as far as possible when setting up camps. No tree cuttings shall be allowed except dead and fallen trees.

Labors should be provided with reasonable shelters, preferably made of bamboo and tin sheet roofing. The camps must be equipped with water and pit latrine facilities. Solid wastes should be collected (pit holes) and disposed off to safe places. Oil and grease from machines should be collected and removed from the site for recycling or annihilation.

When closing the camps all wreckage, rubbish and items no longer used must be collected and disposed off or burned. The site must be restored applying bioengineering measures.

The workforce should be provided with fuel in areas of fuelwood shortage.

4.5.3. Public Participation and Coordination

To ensure that a suitable site is located it should be mandatory to consult the local people through the respective Dzongkhag administration. Involving the locals will allow to identify sites acceptable to all the parties and will avoid sites sensitive to local beliefs, close to monuments and water supply intakes.

To create awareness among the labors on the preservation of vegetation and wildlife FSD should be consulted.

4.5.4. Socio-Economic and Cultural Considerations

If private land is involved expropriation of land should be according to the Land Act of Bhutan, 1979 (amended in 1998) and compensated as per the Land Compensation Rate, 1996. It is recommended that priority should be given for **land for land'** in the same locality. Temporary land expropriation should be compensated as per the annual yield of the land.

The cultural sites should be identified and protected, e.g. *chortens* should be protected.

4.5.5. Budgeting

The budget for sites restoration, provision of reasonable shelters for labors, solid and liquid wastes disposal and sanitary provisions, property compensation, and fuel for labors should be included in the project cost.

4.5.6. Supervision

As discussed in section 4.1.6.

4.5.7. Monitoring / Evaluation

As discussed in the section 4.1.7.

Parameters to be monitored are: provision for water & sanitation, waste collection facilities and disposal sites, proper site closure.

Success indicators are: no disruption of local water supplies, effective wastes disposal, site appearance restored, DoR's site engineer report.

4.6 USE OF BITUMEN

4.6.1. Potential Negative Environmental Impacts

Deforestation as a result of fuelwood extraction for bitumen heating. Outbreak of forest fires. Free dumping of bitumen wastes and pollution of air and surface waters.

4.6.2. Mitigation Measures

Bitumen emulsion should be used wherever feasible. Encourage contractors to heat with kerosene, diesel or gas to gradually substitute fuelwood. Fuelwood usage for heating should be limited to only unsound log i.e. dead and fallen trees.

Bitumen should not be applied during strong winds (danger of forest fire). Bitumen emulsion should not be used in rains. No bitumen must be allowed to flow into the side drain. The bitumen drums should be stored in a designated place and not be scattered along the roadside.

Rubbish, debris and bitumen wastes remaining after blacktop works should be cleaned and disposed off to a safe place.

4.6.3. Public Participation and Coordination

FSD should be consulted for collection of dead and fallen trees.

4.6.4. Socio-Economic and Cultural Considerations

The fuelwood requirement for blacktop works should not deprive the demand of the locals. The local drinking water supply should not be polluted.

4.6.5. Budgeting

The waste clean up after the bitumen activity should be budgeted in the project cost.

4.6.6. Supervision

Same as in section 4.1.6.

4.6.7. Monitoring / Evaluation

As discussed in the section 4.1.7.

The parameters to be monitored are: compliance with requirements.

The success indicators are: no use of fuelwood except where use is sustainable, site cleanup and waste disposal.

4.7 EXPLOSIVES AND TOXIC WASTE MANAGEMENT

4.7.1. Potential Negative Environmental Impacts

Damage to property, livestock, human health hazard, flora and fauna of the area as a result of explosives' mishandling. Ground and surface water pollution from improper handling of oil and grease.

4.7.2. Mitigation Measures

Explosives should be stored in a standard magazine (approved by the Ministry of Home Affairs). The hazardous material must not be stored near surface waters and should be stored over plastic sheeting to prevent leaks and spills.

Waste oil and grease should be collected in a container and dispose of. Contaminated runoff from storage should be captured in ditches or ponds with an oil trap at the outlet. Contaminated plastic sheeting should be packed and disposed of.

Explosives should be handled as per MoHA guidelines/regulations.

4.7.3. Public Participation and Coordination

MoHA should be contacted in case of hazard and explosives needing annihilation.

4.7.4. Socio-Economic and Cultural Considerations

Considerations should be given to the local drinking water supplies when handling hazardous material.

4.7.5. Budgeting

Budgeting should be provided for the compensation of injury and loss of life and annihilation of explosives.

4.7.6. Supervision

Same as in section 4.1.6.

4.7.7. Monitoring / Evaluation

As discussed in section 4.1.7.

The parameters to be monitored are: compliance with requirements.

The success indicators are: no conflict with the locals, no contamination of water and soil.

4.8 MANAGEMENT OF STONE CRUSHING PLANTS

4.8.1. Potential Negative Environmental Impacts

Damage to local crops and surrounding vegetation as a result of dust pollution. Surface water pollution and dust causing respiratory diseases to the humans. Excessive noise from the plant.

4.8.2. Mitigation Measures

Locate stone crushing plants away from population centers, ecologically sensitive areas, cultivated lands, drinking water intakes, religious monuments; and culturally sensitive sites.

The equipment should be operated according to manufacturer's specifications. The labors should be provided with the safety gadgets such as ear protectors, masks, helmets, goggles and gloves.

The plant should be operated during daytime.

4.8.3. Public Participation and Coordination

When locating a suitable stone crushing plant locals and concerned Dzongkhag, as well as FSD and GSoB should be consulted. This can, not only avoid interest conflicts but locals can help identify the best possible site for the setup.

4.8.4. Socio-Economic and Cultural Considerations

Discussed under mitigation measures.

4.8.5. Budgeting

The rehabilitation/restoration cost of such sites must be included in the project cost.

4.8.6. Supervision

As discussed in section .1.6.

4.8.7. Monitoring / Evaluation

As discussed in section 4.1.7.

The parameters to be monitored are: noise level and compliance with air pollution requirements.

Success indicators are: no complaints from local residents, dust controlled equipment is utilized.

4.9 WATER MANAGEMENT

4.9.1. Potential Negative Environmental Impacts

Uncontrolled water runoff can disrupt and increase the sedimentation load of surface waters, and can cause landslides damaging vegetation cover and property. This can also lead to formation of new gullies. Water seepage can also trigger landslides and reduce the roads bearing capacity.

4.9.2. Mitigation Measures

Identify the sources of excess water entering into the problem areas and tap it through surface and sub-surface catch drains. Drain the catched water into nearby natural gullies. Build check dams, steps, energy dissipaters as far down the gully as required to prevent erosion and slope failures.

Roads intersecting irrigation channels must be provided with suitable water conveyance arrangements.

4.9.3. Public Participation and Coordination

Since most of the roads run through or near agricultural lands, irrigation water often be experienced as a major huddle in the existing road network in Bhutan. Major landslides have occurred simultaneously damaging huge chunk of agricultural land. Dzongkhag administration and locals should be consulted particularly when installing cross drains. This can prevent people from using the road for drawing water for irrigating.

4.9.4. Socio-Economic and Cultural Considerations

The construction should ensure that existing local irrigation and drinking water facilities are not disrupted.

4.9.5. Budgeting

Additional water management structures should be included in the project cost.

4.9.6. Supervision

As discussed in section 4.1.6

4.9.7. Monitoring / Evaluation

As discussed in section 4.1.7.

The parameters to be monitored are: effectiveness of water management measures and proper coordination with affected people wherever necessary.

Success indicators are: no presence of fresh surface erosion, slope failures, and new gullies. No visual increase of turbidity of surface waters. No evidence of fresh losses of agricultural or forest lands. No complaints from the locals.

4.10 AIR AND NOISE MANAGEMENT

4.10.1. Potential Negative Environmental Impacts

Emission of air toxic pollutants such as hydrocarbons, nitrogen oxides, carbon monoxides, and sulfur dioxide resulting in human health hazard and destruction to vegetation. High concentration of airborne dusts can damage surrounding vegetation, agricultural crops, and surface water resources. Excessive noise can result in the disruption of livestock and wildlife's natural existence, and can also cause annoyance and a potential health hazard to human population.

4.10.2. Mitigation Measures

The blasting operation should adopt controlled methods (i.e. no overcharging) and be conducted during daylight hours. Single shot hole blasting should be discouraged.

Stockpiled sand and gravel should be slightly wetted before loading especially during windy conditions. Dirt or gravel roads passing through population centers should be black topped and water sprayed during construction.

Vegetative buffer zones should be used to protect potential water resources from road activities. The buffer zones should be planted with trees using local species.

The labors should be equipped with safety gadgets viz. ear protector, masks and goggles.

Where feasible use bitumen emulsion to avoid air pollution.

4.10.3. Public Participation and Coordination

Coordination should be maintained with the locals particularly to arrange herding cattle during blasting operations.

In case of health hazards resulting from blasting operations and concerning safety aspects, the MoHA should be consulted and actions coordinated.

4.10.4. Socio-Economic and Cultural Considerations

Due consideration should be adhered to the health of the local populace, potential damage to the agricultural crops and livestock of the area.

4.10.5. Budgeting

Health and property loss compensation should be included in the project cost.

4.10.6. Supervision

As discussed in section 4.1.6.

4.10.7. Monitoring / Evaluation

As discussed in section 4.1.7.

The parameters to be monitored are: compliance with the requirements and maintaining vegetative buffer zones.

The success indicators are: air pollution control devices installed on the equipment and operating at all times, no excess dust deposition on crops and vegetation; no complaint from the locals; and survival rate of plants.

4.11 ROAD USE AND SAFETY OPERATION

4.11.1. Potential Negative Environmental Impacts

Loss of human life and property are two major impacts foreseen from improper safety standards.

4.11.2. Mitigation Measures

The road signs/indications should be painted with approved paints ensuring distinct and easy visibility. All danger sites should have clear signs indicating the type of problem. During blasting operations, approaching traffic should be stopped.

Safety support structures should be erected wherever necessary.

4.11.3. Public Participation and Coordination

To have standard signs and knowledge of approved paints, RSTA should be consulted.

4.11.4. Budgeting

Provide budget for signs and paints.

4.11.5. Supervision

As discussed in section 4.1.6.

4.11.6. Monitoring

As discussed in section 4.1.7.

The parameters to be monitored are: erection of signs/structures at all required sites.

Indicators: distinct and visible signs, no or fewer accidents.

5 OPERATION AND MAINTENANCE

Most of the environmental problems related in this phase are similar to the ones mentioned in the construction phase. However, there may be additional concerns depending upon the nature of the problems in the maintenance phase.

5.1 QUARRY

5.1.1. Potential Negative Environmental Impacts

The impacts resulting from quarry activities include: slope instability as a break in natural contours often causes slope failures, dust pollution, surface water disruption, health hazards, and are aesthetically unpleasing.

5.1.2. Mitigation Measures

In addition to the indicated quarry sites (by EA report) the responsible authority should physically identify and investigate it involving engineering geologist. The location should be away from population centers, culturally sensitive sites, drinking water intake points, potential croplands, and protected biological areas.

When opening the site, care should be taken to keep vegetation clearing to a minimum. Blasting operations should be conducted in a controlled manner, not overcharging the holes and proper warnings/signals relayed to the surrounding people. It is recommended to execute blasting operations in benches (series of holes blasted at a time and the next series following few seconds later and so on..). For stone quarrying, the operation should begin from the crown of the slope and then move gradually downward. Shot hole blasting is NOT RECOMMENDED. In case of dry weather it may be necessary to wet the site by spraying water to keep down dust pollution.

Sand quarrying along the riverbed should not be concentrated at one spot to avoid natural flow disruption. Quarrying near bridges or river training structures should not take place.

Quarries should be restored through proper site trimming and bioengineering measures.

5.1.3. Public Participation and Coordination

To enhance environmental mitigation measures it is important that DoR initiates consultation and coordination with relevant government agencies and local people. GSoB and FSD should be involved in identifying and locating quarries. GSoB can ensure that the site is technically feasible. As both of these agencies issue quarrying permits conflict arising later due to duplication of permit for the same site can be resolved by involving both parties concurrently. Bioengineering specialist can help to restore sites by suggesting and identifying suitable vegetation species.

Equally important is the involvement of the Dzongkhag administration and local people in designating sites, and its distinct boundaries. This can avoid road damages resulting out of random quarrying.

5.1.4. Socio-Economic and Cultural Considerations

When considering a quarry it should also incorporate the local interest. The commercial quarries should not deprive the resources of local people. Their agriculture-based livelihood should be respected.

5.1.5. Budgeting

It is a traditional practice that the quarries are not restored after the operation, as this has not been budgeted. Budgeting provision has to be covered under the annual maintenance budget.

5.1.6. Supervision

Close supervision is necessary during spoil spreading, as it is advisable to lay in benches. The daily supervision should be the responsibility of site engineer. Periodic supervision can be carried out DoR.

5.1.7. Monitoring

The road maintenance site engineer should carry out the daily monitoring, while a periodic monitoring should be done by DoR.

An external team (possibly initiated by Dzongkhag) can also conduct periodic monitoring on an as need basis.

The parameters to be monitored are: spoil disposal sites, bioengineering applications and success rates, conflicts with the locals.

5.2 SPOIL DISPOSAL

5.2.1. Potential impact

Adverse impacts can result from improper spoil disposal like: disruption of local hydrology, manmade landslides, loss of vegetation cover, pastureland and aesthetic impacts.

5.2.2. Mitigation Measures

To minimize damage use excavators for construction. The excavated material such as topsoil and stones should be stacked at safe places for reuse at a later stage of construction.

For slope gradients of less than 70%, a concept of balancing cut and fill should be applied. Minimizing the cut material can eliminate/reduce the environmental damages (refer design mitigation measures). Recommended spoil disposal sites are small natural depressions, abandoned quarries and degraded areas. Spoil material should be filled in benches to prevent slope overloading. The spoil deposits should be trimmed well and bioengineering measures applied.

5.2.3. Public Participation and Coordination

To ensure that spoil depositing occurs at the right places, prior consultation of the local people is required. This can prevent spoil depositing in the culturally and other sensitive areas (local beliefs). For bioengineering measures, bioengineering specialist should be consulted with regard to suitable vegetation species.

5.2.4. Socio-Economic and Cultural Considerations

The experiences elsewhere in the country and in the region have shown that casual spoil disposal can degrade local drinking and irrigation water facilities, as well as damage agricultural land. Care should be taken to minimize damages so that project progress is not hindered due to upset locals.

5.2.5. Budgeting

Spoil haulage must be budgeted for the distances required.

5.2.6. Supervision

The responsible agencies and the frequency of monitoring are as discussed in section or para 5.1.6.

5.2.7. Monitoring

The responsible agencies and the frequency of monitoring are as discussed in section or para 5.1.7.

The parameters to be monitored are: spoil disposal sites, bioengineering applications and success rates, conflic ts with the locals.

The success indicators are: fewer landslides, vegetated construction sites, no local conflict, and the engineers completion report.

5.3 SLOPE STABILITY

5.3.1. Potential Negative Environmental Impacts

Unstable up and downhill road slopes along road can result in: soil erosion, clogging of side drains, runoff spillover on the road surface and down the slope causing landslides, and hindering the traffic movement.

5.3.2. Mitigation Measures

Maintain the batters' gradient as specified in the Road Design Manual, developed by DOR. The existing vegetation on the slopes outside the immediate construction corridor should remain undisturbed during road construction and/or upgrading. Bioengineer barren slopes to stop soil erosion and prevent them from grazing. Erect support structures where slope failures are anticipated or have occurred. Monitor slope failures and initiate remedial actions as early as possible.

5.3.3. Public Participation and Coordination

To carry out slope stability investigations, DOR should consult and coordinate with engineering geologist for professional inputs. In addition the DOR should also consult with the bioengineering specialist to suggest suitable vegetation species when applying bioengineering measures.

5.3.4. Socio-Economic and Cultural Considerations

When applying mitigation measures consideration should be given to the local land use and grazing habits.

5.3.5. Budgeting

The cost for a geological advice, bioengineering measures and grazing protection cost should be included in the overall budget for maintenance.

5.3.6. Supervision

As discussed in section 5.1.6.

5.3.7. Monitoring

As discussed in the section 5.1.7.

The success indicators are: no landslides; and bioengineering measures visible.

5.4 DRAINAGE

5.4.1. Potential Negative Environmental Impacts

Excess surface runoff along the road due to inadequate drainage structures, siltation of water courses down stream due to erosion from unlined drains, slope failures or landslides and water seepage.

5.4.2. Mitigation Measures

The adequacy of culverts, channels, bridge waterways, and other drainage structures and their ability of structures to discharge the runoff should be considered. All permanent drainage channels through high water table areas should be lined. Maintain drains open at all times.

5.4.3. Public Participation and Coordination

Dzongkhag administration and locals should be consulted when locating drainage structures.

5.4.4. Socio-Economic and Cultural Considerations

When deciding on local drainage installations, the drinking water and irrigation water supply should be considered. Considering this at an early stage can avoid conflicts with the locals, which can affect project progress.

5.4.5. Budgeting

Adequate budget provision should be kept for additional drainage structures, as drainage is considered to be very important factor for hill roads.

5.4.6. Supervision

As discussed in section 5.1.6.

5.4.7. Monitoring

As discussed in section 5.1.7.

Success indicators are: controlled surface runoff, no landslides, no complaints from the locals.

5.5 WORK /LABOR CAMP LOCATION, OPERATION AND CLOSURE

5.5.1. Potential Negative Environmental Impacts

Air and noise pollution from construction machines, water pollution from oil and grease and unsanitary waste disposal practices, social conflicts, deforestation and wildlife disturbance.

5.5.2. Mitigation Measures

Camps should be located away from settlements or drinking water supply intakes, landslides or flood prone areas. Trees should be protected as much as possible when setting up camps. No tree cuttings shall be allowed except dead and fallen trees.

Labors should be provided with reasonable shelters, preferably made of bamboo and tin sheet roofing. The camps must be equipped with water and pit latrine facilities. Solid wastes should be collected (pit holes) and disposed of to safe places. Oil and grease from machines should be collected and removed from the site for recycling or disposal.

When closing the camps all wreckage, rubbish and items no longer used must be collected and disposed of or burned. The site must be restored applying bioengineering measures.

The workforce should have access to other energy means in areas of fuelwood shortage.

5.5.3. Public Participation and Coordination

To ensure that a suitable site is found it should be consulted the local people through the respective Dzongkhag administration. Involving locals will allow to identify sites acceptable to all the parties and will avoid sites sensitive to local beliefs, close to monuments and water supply intakes.

To create awareness among the labors on the preservation of vegetation and wildlife FSD should be consulted.

5.5.4. Socio-Economic and Cultural Considerations

If private land is involved the expropriation of land should be according to the Land Act of Bhutan, 1979 (amended in 1998) and compensated as per the Land Compensation Rate, 1996. It is recommended that priority should be given for **land for land'** in the same locality. Temporary land expropriation should be compensated as per the annual yield of the land.

The cultural sites should be identified and protected with mitigation measures e.g. *chorten* should be prevented from damage and restored after construction with paintings.

5.5.5. Budgeting

The budget for sites restoration, provision of reasonable shelters for labors, solid and liquid wastes disposal and sanitary provisions, and property compensation should be included in the overall maintenance cost.

5.5.6. Supervision

As discussed in section 5.1.6.

5.5.7. Monitoring

As discussed in the section 5.1.7.

Parameters to be monitored are: provision for water & sanitation, waste collection facilities and disposal sites, proper site closure.

Success indicators are: no disruption of local water supplies, effective wastes disposal, site appearance restored, DoR's site engineer report.

5.6 USE OF BITUMEN

5.6.1. Potential Negative Environmental Impacts

Deforestation as a result of fuelwood extraction for bitumen heating. Out break of forest fire. Free dumping of bitumen wastes and pollution of air and surface waters.

5.6.2. Mitigation Measures

Bitumen emulsion should be used wherever feasible. Encourage contractors to heat with kerosene, diesel or gas to gradually substitute fuelwood. Fuelwood usage for heating should be limited to unsound log i.e. dead and fallen trees.

Bitumen should not be applied during strong winds (danger of forest fire). Bitumen emulsion should not be used in rains. No bitumen must be allowed to flow into the side drain. The bitumen drums should be stored in a designated place and not be scattered along the roadside.

Rubbish, debris and bitumen wastes remaining after blacktop works should be cleaned and disposed of in a safe place.

5.6.3. Public Participation and Coordination

FSD should be consulted for collection of dead and fallen trees.

5.6.4. Socio-Economic and Cultural Considerations

The fuelwood requirement for bitumen sealing works should not deprive the demand of the locals. The local drinking water supply should not be polluted.

5.6.5. Budgeting

The waste clean up after the bitumen activity should be budgeted in the maintenance cost.

5.6.6. Supervision

Same as in section 5.1.6.

5.6.7. Monitoring

As discussed in the section 5.1.7.

The parameters to be monitored are: compliance with requirements.

The success indicators are: no use of fuelwood except where use is sustainable, site cleanup and waste disposal.

5.7 EXPLOSIVES AND TOXIC WASTE MANAGEMENT

5.7.1. Potential Negative Environmental Impacts

Damage to property, livestock, human health hazard, flora and fauna of the area as a result of mishandling explosives. Ground and surface water pollution from improper handling of oil and grease.

5.7.2. Mitigation Measures

The explosive should be stored in a standard magazine (approved by the Ministry of Home Affairs). Hazardous materials must not be stored near surface waters and should be stored over plastic sheeting to prevent leaks and spills.

Waste oil and grease should be collected in a container and disposed of. Contaminated runoff from storage should be captured in ditches or ponds with an oil trap at the outlet. Contaminated plastic sheeting should be packed and disposed off site.

Explosives should be handled as per MoHA guidelines/regulations.

5.7.3. Public Participation and Coordination

MoHA should be contacted in case of hazard and explosives needing annihilation.

5.7.4. Socio-Economic and Cultural Considerations

Considerations should be given to the local drinking water supplies when handling hazardous material.

5.7.5. Budgeting

Budget should be provided for the compensation of injury and loss of life and annihilation of explosives.

5.7.6. Supervision

Same as in section 5.1.6.

5.7.7. Monitoring

As discussed in section 5.1.7.

The parameters to be monitored are: compliance with requirements.

The success indicators are: no conflict with the locals, no contamination of water and soil.

5.8 MANAGEMENT OF STONE CRUSHING PLANTS

5.8.1. Potential Negative Environmental Impacts

Damage to local crops and surrounding vegetation as a result of dust pollution. Surface water pollution and dust causing respiratory diseases to humans. Excessive noise from the plant.

5.8.2. Mitigation Measures

Locate stone crushing plants away from population centers, ecologically sensitive areas, cultivated lands, drinking water intakes, religious monuments; and culturally sensitive sites.

Stone crushing plants should be operated according to manufacturer's specifications. The workforce should be provided with safety gadgets such as ear protectors, masks, helmets, goggles and gloves.

The plant should be operated during the daytime.

5.8.3. Public Participation and Coordination

When locating a suitable stone crushing plant locals and concerned Dzongkhag officials, as well as FSD and GSoB should be consulted. This can, not only avoid interest conflicts but locals can help identify the best possible site for the setup.

5.8.4. Socio-Economic and Cultural Considerations

Discussed under mitigation measures.

5.8.5. Budgeting

The rehabilitation/restoration cost of such sites must be included in the maintenance cost.

5.8.6. Supervision

As discussed in section 5.1.6.

5.8.7. Monitoring

As discussed in section 5.1.7.

The parameters to be monitored are: noise levels and compliance with air pollution requirements.

Success indicators are: complaint from local residents, dust controlled equipment is utilized.

5.9 WATER MANAGEMENT

5.9.1. Potential Negative Environmental Impacts

Uncontrolled water runoff can disrupt and increase the sedimentation load of surface waters, and can cause landslides damaging vegetation cover and property. This can also lead to formation of new gullies. Water seepage can also trigger landslides and reduce the roads bearing capacity.

5.9.2. Mitigation Measures

Identify the sources of excess water entering into the problem areas and tap it through surface and sub-surface catch drains. Drain the catched water into nearby natural gullies. Build check dams, steps, energy dissipaters as far down the gully as required to prevent erosion and slope failures.

Roads intersecting irrigation channels must be provided with suitable water conveyance arrangements.

5.9.3. Public Participation and Coordination

Since most of the roads run through or near agricultural lands, irrigation water often be experienced as a major hurdle for maintenance of existing road network in Bhutan. Major landslides can damage huge chunks of agricultural land. Dzongkhag administration officials and locals should be consulted particularly when installing cross drains. This can prevent people from not using the road for drawing water for irrigating.

5.9.4. Socio-Economic and Cultural Considerations

The construction should ensure that existing local irrigation and drinking water facilities are not disrupted.

5.9.5. Budgeting

Additional water management structures should be included in the maintenance cost.

5.9.6. Supervision

As discussed in section 5.1.6

5.9.7. Monitoring

As discussed in section 5.1.7.

The parameters to be monitored are: effectiveness of water management measures and proper coordination with affected people wherever necessary.

Success indicators are: no presence of fresh surface erosion, slope failures, and new gullies. No visual increase of turbidity of surface waters. No evidence of fresh losses of agricultural or forest lands. No complaints from the locals.

5.10 AIR AND NOISE MANAGEMENT

5.10.1. Potential Negative Environmental Impacts

Emission of air toxic pollutants such as hydrocarbons, nitrogen oxides, carbon monoxides, and sulfur dioxide resulting in human health hazard and destruction to vegetation. High concentration of airborne dusts can damage surrounding vegetation, agricultural crops, and surface water resources. Excessive noise can result in the disruption of livestock and wildlife's natural existence, and can also cause annoyance and potential health hazard to human population.

5.10.2. Mitigation Measures

The blasting operation should adopt controlled methods (i.e. no overcharging) and be conducted during daylight hours. Single shot hole blasting should be discouraged.

Stockpiled sand and gravel should be slightly wetted before loading especially during windy conditions. Dirt or gravel roads passing through population centers should be black topped and water sprayed during construction.

Vegetative buffer zones should be used to protect potential water resources from road activities. The buffer zones should be planted with trees using local species.

The labors should be equipped with safety gadgets viz. ear protector, masks and goggles.

Where feasible use bitumen emulsion to avoid air pollution.

5.10.3. Public Participation and Coordination

A good coordination should be maintained with the locals particularly with the arrangements of herding their cattle during blasting operation.

In case of health hazard resulting out of blasting operation and concerning safety aspects the MoHA should be consulted and actions coordinated.

5.10.4. Socio-Economic and Cultural Considerations

Due consideration should be adhered to the health of the local populace, potential damage to the agricultural crops and livestock of the area.

5.10.5. Budgeting

Health and property loss compensation should be included in the maintenance cost.

5.10.6. Supervision

As discussed in section 5.1.6.

5.10.7. Monitoring

As discussed in section 5.1.7.

The parameters to be monitored are: compliance with the requirements and maintaining of vegetative buffer zones.

The success indicators are: air pollution control devices installed on the equipment and operating at all times, no excess dust deposition on crops and vegetation; no complaint from the locals; and survival rate of plants.

5.11 ROAD USE AND SAFETY OPERATION

5.11.1. Potential Negative Environmental Impacts

Loss of human life and property are two major impacts foreseen from improper safety standards.

5.11.2. Mitigation Measures

For road signs/indications standard approved paints should be used ensuring distinct and easy visibility. All danger sites should have clear signs indicating the type of problem. During blasting operations a person should convey the warning to the approaching traffic.

Safety support structures should be erected wherever necessary in danger sites.

5.11.3. Public Participation and Coordination

To have standard signs and knowledge on approved paints RSTA should be consulted.

5.11.4. Budgeting

Provide budget for signs and paints.

5.11.5. Supervision

As discussed in section 5.1.6.

5.11.6. Monitoring

As discussed in section 5.1.7.

The parameters to be monitored are: erection of signs/structures at all required sites.

Indicators: distinct and visible signs, no or less accidents.

5.12 ROAD SURFACE

5.12.1. Potential Negative Environmental Impacts

The impacts related to poor road surface maintenance are: road shoulder erosion, development of potholes, traffic skidding and development of settlement structures.

5.12.2. Mitigation Measures

Monitor potholes and fill them with suitable aggregates and patch up with bitumen incase of blacked topped road. Never ever fill potholes with soil (particularly with high clay content) as this makes roads slippery. Ensure that proper road shoulders are maintained and cleaned of debris and other objects.

Enforce Rules and Regulations for construction of temporary, semi-permanent and permanent houses on either sides of roads, 1995 issued by Ministry of Home Affairs (MOHA).

5.12.3. Public Participation and Coordination

DOR should consult and coordinate with concerned dzongkhag administration officials and enforce the rules and regulations, issued by MOHA.

5.12.4. Socio-Economic and Cultural Considerationss

If existing structures within the road right of way (ROW) need to be relocated for safety reasons, compensation should be arranged as per Land Compensation Rate, 1996.

5.12.5. Budgeting

Compensation for the relocation of existing structures within road ROW should be included in the annual maintenance budget.

5.12.6. Supervision

As discussed in section 5.1.6.

5.12.7. Monitoring

As discussed in section 5.1.7.

The indicators are: no potholes, no accidents, no cowsheds and other structures are seen along the road.

6 MONITORING / EVALUATION

Monitoring is an important tool to ensure that the proposed mitigation measures are implemented and to evaluate the effectiveness of the mitigation measures. This also indicates if there is a need to revise mitigation arrangements for the potential adverse impacts. Monitoring activities are:

1. **Baseline Monitoring,** is a collection or measurement of environmental parameters prior to project starts.

2. **Effects Monitoring**, is a collection or measurements of environmental parameters during project implementation that can be attributed to the project.

3. **Compliance Monitoring**, is a periodic sampling or measurement to ensure that the regulatory requirements are observed and the standards are met.

For the monitoring to be effective it is crucial to have well established baseline data. Monitoring of impacts should be linked to the predictions of impacts so that there is information on:

- the nature of impacts;
- the magnitude of impacts;
- the geographical extent of impacts;
- the time-scale of impacts;
- the probability of impacts occurring;
- the significance of impacts; and
- the level of confidence in the prediction of impacts.

Environmental monitoring for roads is required at two stages:

1. Construction phase monitoring; and
2. Operation phase monitoring.

6.1 CONSTRUCTION PHASE MONITORING

In this phase of the project, three levels of monitoring are pertinent i.e. routine monitoring, periodic monitoring and evaluations.

6.1.1. Routine Monitoring

This should be the responsibility of the construction agency, and happens on a routine basis as the project advances. Records should be maintained for whatever is monitored.

6.1.2. Periodic Monitoring

An external team (team recommended in the EA for that particular project) has to be formed as appropriate to carry out this monitoring. The cost of monitoring should be included in the budget for project. If possible bia nnual monitoring should be carried out, once during monsoon and once during the dry season.

6.1.3. Evaluation

Projects may be subjected to evaluations e.g. midterm and final evaluations to meet economical ecological requirements. The findings of the mission should be used to better manage the project to mitigate some of the adverse impacts.

6.2 OPERATION PHASE MONITORING

Unlike the construction phase monitoring there are two levels of monitoring, i.e. routine monitoring and periodic monitoring.

6.2.1. Routine Monitoring

The site engineer should carry out this monitoring on a routine basis. He should inform the in-charge of the Road Maintenance Cell responsible for that road for timely action.

6.2.2. Periodic Monitoring

An externally formed team should carry out this monitoring if possible on biannual basis. The team can be proposed by the EA team commissioned for the particular project. The budget for this monitoring should be included in the maintenance cost.