7. POLLUTION MANAGEMENT PLAN

7.1 INTRODUCTION

The proposed PHD will provide cheap and clean power, direct and indirect employment opportunities, economic benefits to locals, reduction in green house emissions and tourism potential on one hand. The construction of the proposed PHD project will involve different categories of manpower like labor, technical, other officials and service providers. Most of these technical and non-technical workers will be temporary and will leave the region as soon as the construction phase of the project is over, which is estimated as 13.5 years. Some of the workers will be accompanied by their families. The total population of workers has been estimated around 5,500 persons. These people will be living in temporary and permanent colonies/settlements. The problems of loss of vegetal cover, increased soil erosion, spoil disposal, air and water pollution on the other pose some of the negative threats. Major source of pollution during construction phase is solid waste, air, water and spoil pollution which need to be managed properly. To manage pollution during construction and operation phase Pollution Management Plan came in existence. Types of Pollution Management Plan designed for PMP project are listed below:

a. Solid waste management plan,
b. Air, water and noise management plan
c. Spoil disposal plan

7.2 SOLID WASTE MANAGEMENT PLAN

Solid waste generation will be the leading problem among the negative impacts assuming that huge quantity of municipal waste that would be generated from residential colony, labor camps and office buildings when the project is constructed. Huge amount of sewage will also be generated from the similar sources during the construction and operation phase of the proposed project.

The major generation sources for sewage and municipal wastes would be as follows:

- Municipal waste from residential colony, labor camps and office buildings
- Sewage from residential colony, labor camps and office buildings
- Hazardous wastes (Bio-medical wastes) from primary health centre and hospitals

Solid waste generated from temporary and permanent colonies in construction as well as operation phase requires special management to dispose off as warranted under the Municipal Solid Wastes (Management and Handling) Rules 2000. For that, an efficient waste

management system will be required to put in place to keep the environment of the region clean and healthy. It is also expected that if proper management measures for solid waste are not adopted, it will degrade the nearby environment, create hazards for labor and staff that would be posted in the project area during construction/operation period of the project. Therefore, all the problems due to origination of solid waste require proper management facilities. The project authorities will ensure sewage treatment from the colonies of labors and workers, water supply, cleaning of the colony area and solid waste disposal. Dwellings will be provided with septic tanks and soak pits along with water supply for drinking and other daily needs for each and proper waste disposal by adopting various disposable methods.

Table 7-1: Typical composition of waste in proposed PHD project

Types of solid waste	Description	Sources
Food waste (garbage)	• Wastes from the preparation, cooking, serving of food, plastics, paper, sewage, glass, vegetables waste	Households, institutions and commercial such as hotels, stores, restaurants, markets, etc.
	• Market refuse, waste from the handling, storage and sale of produce and meats and vegetable	
Rubbish	• **Combustible** (Primary organic) • Paper, cardboard, cartons wood, boxes, plastics, rags, cloth, bedding, leather, rubber, grass, leaves, yard trimmings	
	• **Non combustible** (Primary inorganic) • Metals, tin cans, metal foils dirt, stones, bricks, ceramics, crockery, glass bottles, other mineral refuse	
Ashes and Residues	• Residue from fires used for cooking and for heating buildings, cinders, clinkers, thermal power plants.	
Bulky waste	• Large auto parts, tyre, stoves refrigerators, others large appliances, furniture, large crates, trees, branches, palm fronts, stumps, flotage	
Street waste	• Street sweepings, dirt, leaves, catch basin dirt, animal droppings, contents of litter receptacles dead animals	Streets, sidewalks, alleys, vacant lots, etc.
Dead animals	• Large animals: Horses, cows, buffaloes etc. • Small animals: Cats, dogs, poultry etc.	
Construction and demolition waste	• Lumber, roofing, and sheathing scraps, crop residues, rubble, broken concrete, plaster, conduit pipe, wire, insulation , empty cement begs, dust, debris, demolition and construction wastes, dust and ashes etc.	Construction and demolition sites, remodeling, repairing sites
Industrial waste and sludges	• Solid wastes resulting from industry processes and manufacturing operations, such as food processing wastes, boiler house cinders, wood, plastic and metal scraps and shaving, etc. Effluent treatment plant sludge of industries and sewage treatment plant sludge's, coarse screening, grit and septic tank	Factories, power plants, treatment plants, etc.
Bio-medical waste	• Syringes, cotton, bandages, glass tubes, etc.	From primary health centers
Hazardous wastes	• Hazardous wastes: pathological waste, explosives, radioactive material, toxic waste etc.	Households, hospitals, institution, stores, industry, etc.
Horticulture wastes	• Tree-trimmings, leaves, waste from parks and gardens, etc.	Parks, gardens, roadside trees, etc.

Source: Solid Waste Management in Developing Countries by Bhide & Sunderasan, INSDOC April, 1983

7.2.1 Composition of Municipal Solid Wastes

The composition of garbage in Nepal indicates lower organic matter and high ash or dust contents. It has been estimated that recyclable content in solid waste varies from 6.84 – 36.31 and compostable materials is about 10.20 – 35.64%. A typical composition of municipal solid waste is given, Table 7-2.

Table 7-2: Typical composition of solid wastes in DNP, PMP project

S N	Types of waste	Household	Institutional	Commercial
		Waste (Percentage)		
1	Organic Waste	35.64	10.20	24.04
2	Plastics	8.19	11.16	16.56
3	Paper and its products	34.17	36.31	35.36
4	Glass	2.51	7.97	1.23
5	Metals	1.41	12.71	6.84
6	Textiles	4.2	5.44	3.51
7	Rubber and leather	1.18	5	2.71
8	Others	12.70	11.21	9.75

Source: Solid Waste Management in Nepal, Current Status and Policy Recommendations, ADB, 2013

Chemical composition of solid waste is another important aspect for evaluating alternative processing and energy recovery point of view. The details of typical chemical composition of municipal solid wastes in India is given in, Table 7-3, whose composition is similar to that of Nepal.

Table 7-3: Chemical components of municipal solid wastes, India

Component	Carbon, C	Hydrogen, H	Oxygen, O	Nitrogen, N	Sulphur, S	Ashes
	Percentage					
Food wastes	48	6.4	37.6	2.6	0.4	5
Paper	43.5	8	44	0.3	0.2	6
Card board	44	5.9	44.6	0.3	0.2	5
Plastic	60	7.2	22.8	-	-	10
Textiles	55	6.6	31.2	4.6	0.15	2.5
Rubber	78	10	-	2	-	10
Leather	60	8	11.6	10	0.4	10
Garden trimming	47.8	6	38	3.4	0.3	4.5
Wood	49.5	6	42.7	0.2	0.1	1.5
Dirt, brick etc	26.3	3	2	0.5	0.2	68

Source: Central Pollution Control Board, India

7.2.2 Environmental and Health Impacts due To Improper Solid Waste Management

Improper management of solid waste causes all types of pollution: air, soil and water. Uncontrolled dumping of wastes accelerates the contamination of surface and ground water supplies. In urban areas, solid waste clogs drains, creating stagnant water for insect breeding and floods during rainy seasons. Uncontrolled burning of wastes and improper incineration contributes significantly to urban air pollution. Greenhouse gases are generated from the decomposition of organic wastes in landfills and untreated leachate pollutes surrounding soil and water bodies. These negative environmental impacts are only a result of solid waste disposal.

Unscientific method being adopted for management of solid waste is a serious health concern, particularly, during rainy season, when the run-off and high humid conditions increase the health hazards. Open dumping of garbage serves as breeding ground for disease vectors such as flies, mosquitoes, cockroaches, rats and other pests. High risks of spreading diseases like typhoid, cholera, dysentery, yellow fever, encephalitis, plague and dengue fever.

7.2.3 *Municipal Solid Waste Management*

Management of municipal solid waste is one of the important issues. There are three major steps involved in the management of garbage viz. collection, transportation and disposal. The more concentration should be on the segregation of waste. The common method for segregation and collection of municipal solid waste is by using separate dustbins. There should be different collection centers to collect the waste during the construction as well as operation phase. The transportation of waste is also an important step in the management of garbage. The garbage during transportation to the disposal site is exposed to the open conditions thus causing public nuisance. The vehicles carrying garbage should be therefore covered. Disposal of municipal solid wastes is generally done through various techniques and technology (i.e. sanitary land-filling, Pelletisation, Pyrolysis/Gasification, Incineration, Vermi-culture etc.). In the context of PHD Project, Sanitary land-filling is the suitable technique for composting the bio-degradable waste. Other wastes including non-biodegradable like plastic, glass, scrap, etc. could be sold in the market. Hazardous and Bio-medical waste from hospital can be incinerated.

The garbage from the colony area should be collected at particular places. From these places, garbage should be transported to incinerators or landfill area. One dumper and wheel barrow are proposed for the purpose along with provisions for staff of 16 – 17 persons.

7.2.3.1 Influx of Migrant Population

The estimated peak labor force for the proposed project is around 5,500. This will include technical, non-technical and service providers, it is expected 75% of the labor will be migrant of which 20% will accompany by their families. The calculation of population load in the region due to immigrant workforce is based on the following assumptions:

- It is assumed that 75% of labors force are migrants
- 20% of migrant labor forces accompany with families
- 2% of the total migratory populations as service providers
- The average household size for migrant population; 5 persons/family

Table 7-4: Total migrant population expected in the PMP project

Particulars	Population
Required number of manpower	5,500
Supervisory categories	1,100
Semi-skilled and unskilled	4,400
Average household size	5
Migrant workers and technical staff	
Migrant supervisory (75% of 1100)	825
Migrant semi-skilled and unskilled (75% of 4,400)	3,300
Migrant supervisory with families (20% of 825)	165
Migrant semi-skilled and unskilled with families (20% of 3,300)	660
Migrant supervisory without families (80% of 825)	660
Migrant semi-skilled and unskilled without families (80% of 3,300)	2,640
Population of migrant with families [(165 + 660) × 5]	4,125
Total population (TP1) of migrant (4,125 + 660 + 2,640)	7,425
Service provider	
Required service provider (2% of migrant population; 7,425)	149
Migrant service provider (75% of 149)	112
Migrant service provider with families (20% of 112)	22
Migrant service provider without families (80% of 112)	89
Population of service provider with families (22 × 5)	110
Total population (TP2) of migrant service provider (89 + 110)	199
Grand total (GT) population of migrant personnel (TP1 + TP2)	7,624

The migrant population has been calculated around 7,624 based on these assumptions, Table 7-4. This population will reside in the project area at any given time. There are chances of increase in the migrant population. Here, the population coming for establishing other small business related to project is not considered. This temporary population will keep floating for 10 years. This much huge population will generate enormous quantity of waste that needs to be disposed without polluting land, air and water of the region.

Generally in Nepal, average per capita municipal solid waste generated per day is calculated to be 425 g (dry weight). Certainly there will be huge solid waste generation by 7,624 persons. The calculated amount per year will be around 1,182.67 ton (0.425 kg × 7,624 individual × 365 days = 1,182,673 kg/year). This waste should not be allowed to be dumped near any water body or stream. The project developer should develop proper method of collection and disposal of this waste.

7.2.4 Sanitation Facilities

As mentioned earlier about 7,624 workers and staff are likely to work during project construction phase. Water consumption per capita in rural area has been estimated to be 45 liters per day in Nepal which shall include for washing, bathing, cooking and drinking purposes. The estimated quantity of water consumption for workers is about 343,080 liters per day. Of which nearly (80%) 274,464 liters per day would be changed into sewerage. It is therefore proposed to treat the sewage generated from labor colonies and residential areas before disposal. Normally, during project construction, the labor population is concentrated at 3 – 4 locations. Thus, the sewage would flow into Mahakali River at these 3 – 4 locations. The sewage is proposed to be treated before disposal to avoid the deterioration of water quality of the receiving water body. It is proposed to commission adequate number of septic tanks for treatment of sewage. It has been observed during the construction phase of many projects, that contractor makes a block of two large rooms in which about 30 – 40 workers stay. It is proposed that one community latrine can be provided per 20 persons. The sewage from the community latrines can be treated in septic tanks. For each 500 persons, one septic tank should be provided. To ensure that the sewage from the labor camps do not pollute the river water.

Septic Tanks

Solid waste from the toilets should be collected in the tanks or vats of 25 cubic meter size. Soak pits or septic tanks should be near to each toilet set or building having toilets.

Bathrooms and Washing Facilities

Workers and laborers will require bathing facilities. Provisions are made for providing these facilities in the permanent as well as in temporary colonies.

Sewage Treatment Plant

The quantity of waste generated from the colony area shall be treated using appropriate treatment methods. A sewage plant is proposed in the management plan for treating the waste water. This waste water after proper treatment shall be either reused for irrigation or horticultural purposes or should be released to the streams or rivers.

Community toilets

In order to avoid the open defecation, there is a provision of establishment of community toilets at temporary colonies and working sites.

7.2.5 Management of Solid Waste

The project authority shall, within the territorial area of the project complex/colony, be responsible for the implementation of the provision of Solid Wastes Management. Any solid waste generated in the project complex/ project colony/ labor colony, shall be managed and handled as described below.

7.2.5.1 Collection of Solid Wastes

The project authorities shall prohibit littering of solid wastes in the area under their control by resorting to following:

- Initiate organizing house to house collection of solid waste on regular pre-informed timing and scheduling through any of the methods, like community bin collection (Central bin) and make them adopt this practice.
- Collected waste from residential areas shall be transferred to community bin by hand-driven containerized carts or other small vehicle
- Devising collection of wastes from office complexes and commercial areas
- Avoiding mixing of Bio-medical wastes with municipal solid wastes
- Horticulture and construction/ demolition wastes or debris shall be separately collected and disposed off
- Wastes like dry leaves shall not be burnt
- Collection of wastes from vegetable and fruit shops and meat shops and also dry leaves collected from avenues/parks, which are biodegradable in nature to be finally disposed off through aerobic composting in composting units of size 8 m × 2.5 m build from bricks. The compost thus obtained shall be used for development of flower beds and avenue plantation around colonies and office areas and also in biological measures to be adopted in respect of soil tips developed at muck disposal sites.

7.2.5.2 Segregation of Solid Wastes

The project authority shall organize awareness programme to ensure community participation in waste segregation.

7.2.5.3 Storage of Solid Wastes

The project authority shall establish and maintain storage facilities in such a manner as they do not create unhygienic and insanitary conditions around it. Following criteria shall be taken into account while establishing and maintaining storage facilities.

- Storage facilities of bins shall have 'easy to operate' design for handling, transfer and transportation of waste. Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be painted white and those for storage of other wastes shall be painted black.
- Manual handling of waste shall be prohibited. If unavoidable due to constraints, manual handling shall be carried out under proper precaution with due care for safety of workers.

7.2.5.4 Transportation of Municipal Solid Wastes

- Vehicles used for transportation of wastes shall be covered. Wastes should not be visible to public nor exposed to open environment preventing their scattering.
- Transportation vehicles shall be so designed that multiple handling of waste, prior to final disposal, is avoided.

7.2.5.5 Processing of Solid Wastes

The project authorities shall adopt suitable technology or combination of such technologies in coordination with local authorities to make use of wastes so as to minimize burden on landfill.

Following criteria shall be adopted:

- The biodegradable wastes shall be processed by composting, vermiform composting or anaerobic digestion for stabilization of wastes.
- Mixed waste containing recoverable resources shall follow the route to recycling.
- Incineration canal so be used for processing wastes.

7.2.5.6 Bio-medical Wastes

All kinds of hospital waste are considered as hazardous waste. Hospital waste is generated during the diagnosis, treatment or immunization of human beings. It may include waste like scrap, anatomical waste, culture media, discarded medicines, chemical waste, syringes, swabs, bandages, body fluids, human excreta, etc. This waste is highly infectious and can be serious threat to human health if not managed in a scientific and discriminate manner. It is expected that in Integrated PMP project. Project, generation of such hazardous waste will be very less. For the purpose of management, special type of collection container and incinerator should be placed near the hospital for proper collection and disposal of hospital waste. All kind of hospital waste should be incinerated or buried at isolated, identified sites. Any kind of hospital waste should not be either recycled or reused. Incinerator is also a legal requirement for hospital waste management as such the non-biodegradable waste generated from colony as well as hospital can be scientifically disposed. One incinerator must be installed at suitable site in colony for reduction of total volume of non-biodegradable solid waste including bio-medical waste.

7.2.6 Management of Wastes From Construction Activities

Apart from the municipal solid waste in the project area, a lot of waste is expected to be generated on account of construction activities. This would mainly consist of cement bags, iron scrap, packing material, dust etc. It is expected that most of the iron scrap and packing material would be recycled since it has reuse value apart from monetary values and hence, it is proposed that stipulations should be imposed on suppliers and contractors to take away the scrap and packing materials. Apart from above, about 13.3 lakh MT of cement will be required for remaining construction works. Since cement is supplied in gunny bags with capacity of each bag as 50 kg only. As a result large number of gunny bags would require proper disposal arrangement. For this purpose, it is proposed that for slope stabilization works, use of these gunny bags should be made to the extent possible by filling them with debris and 2% cement for strengthening. These bags can be placed along the contours to reduce the flow length and velocity. The remaining quantity of cement bags should be collected and disposed properly.

7.2.7 Management of Hazardous Wastes From Hospitals

It is expected that in PMP project, generation of hazardous waste will be very less and would be mostly from of hospital waste. Hospital waste is generated during the diagnosis, treatment or immunization of human beings. Biomedical waste includes like anatomical waste, culture media, discarded medicines, chemical waste, syringes, bandages, body fluids, human excreta, etc. This waste is highly infectious and can be serious threat to human health if not managed in a scientific manner. It is estimated that out of 15 kg of hospital waste, 1 kg would be infected. For this purpose, special type of collection container and incinerator should be placed in hospital for proper collection and disposal of hospital waste.

7.2.8 Other Measures

The following other measures are also proposed for management of solid waste under the PMP Project.

- A proper sewerage and drainage plan for each complex such as colonies and office complexes should be formulated and implemented at the initial stages when these structures are started by the project proponent
- There should be a separate drainage channel, which should be either connected to a sewerage channel or should have its own treatment plant before this waste is released in Mahakali River or other aquatic body. In no case the untreated water from the lanes and drains should be discharged in riverine or reservoir system

- There should be a sewage treatment plant in each colony. Where it is not feasible or the population is small, it is proposed that proper sewage septic tanks should be installed. However provision for these community latrines and septic tanks is being made by the project proponents in the project cost, hence no budgetary estimate for these are made.
- The solid waste like the kitchen waste, packing material, plastic bags, pet bottles, office garbage etc. should not be littered all around. It is proposed that proper litter collectors in sufficient numbers, separate for plastic goods and other solid materials, should be installed at regular intervals within a locality, or colony or office by the project authorities.
- It is also proposed that an incinerator must be installed near the site colony for the proper disposal of the bio-medical waste from project health care center and hospitals.

For the proper disposal of the plastic items, which is non-biodegradable in nature, it is proposed that these can be collected and sold or sent for recycling, wherever such facilities are available, otherwise these would create lots of health and environmental problems.

7.3 AIR, WATER AND NOISE ENVIRONMENT MANAGEMENT PLAN

7.3.1 Impacts on Physical Environment

Hydroelectric projects are generally considered cleaner source of energy as the environmental impacts are considerably lower during the project operation phase. However, the construction phases of such project, in ecologically rich areas, pose serious threats to surrounding environment. Therefore, it is important to identify and quantify such impacts and formulate mitigation measures in order to have minimum damage to project surrounding areas during construction period.

During construction phase, the activities like site preparation, approach roads, excavation, drilling, blasting, foundation, tunneling, deployment of machinery, erection, transportation, dumping will be taken up. Tunneling and foundation works will involve land excavation, affecting environment by noise and dust pollution. Structural work, deployment of machinery, approach roads construction and erection work will also result in dust, noise pollution and vehicular traffic. Material handling and transportation would also lead to significant increase in air and noise pollution. Muck generation, its transportation and disposal may pollute surface water due to the generation of large quantities of suspended particulate matter. Waste water from labor camps and colonies may also pollute water bodies in the area.

The likely impacts on the physical environment during the construction phase are listed in Table 7-5. In addition, another important aspect to be taken care of during the construction phase of the project is that of "Safety". Deployment of large number of labor during the 13.5 years construction phase in difficult terrains, underground works, use of machinery and equipment, use of explosives for blasting, etc. may lead to serious accidents, if adequate safety measures are not adopted.

Table 7-5: Impacts during construction and operational phase

Construction and operational phase	Activity	Potential Environmental Impact
Site work/ other facilities	Cleaning and grading	Dust emission
	Temporary facilities, such as sheds, approach roads, sanitary facilities	Dust emission, water pollution and solid waste generation
	Earth work comprising of excavation and trenches	Soil erosion, run off, increase in traffic, dust emission
	Foundation work, piling and construction of check barrages	Dust, visual and noise pollution, waste water generation
	Construction of permanent structures like roads, colony, etc.	Dust and noise pollution and waste water generation
	Mechanical erection and utility systems	Dust, noise and visual impact
Construction of approach roads tunneling works and foundations	Excavation	Dust, soil erosion, waste water generation and noise
	Drilling & Blasting	Dust, noise and health hazards
	Dumping	Dust, noise and river pollution
	Transportation	Dust, noise and visual
Accident	In all construction activities	Major or minor health impact

7.3.2 Air Environment

As observed during various field visits to the study area, the air quality in the area is pristine. In the absence of industries, the only source of air pollution in the area at present is vehicular traffic and few other anthropogenic activities like burning of fuel wood, garbage, etc. or occasional use of DG sets in the area. However, quantity of such emissions is relatively small and sources are scattered, therefore, ambient air quality is generally good for the entire area.

Construction and operation of the PMP project will definitely impact the air quality of the area. 13.5 years construction period will involve exploration activities, construction of dam, tunnel sand approach roads, operation of batch mixing plants, aggregate processing plants, crushers, dumpers, cranes and other construction equipments, operation of DG sets for construction power, quarrying operations, muck generation and disposal, repair and maintenance workshops, penstock fabrication, transportation of men and material, etc. All these activities will contribute to air pollution in the area. The nature and extent of impact on air environment will vary from time to time, location to location and through different stages of development of the project. As all these activities contribute to fugitive emissions in various forms, quantification of air pollution at this stage is not possible.

7.3.2.1 Impacts on Ambient Air Quality

Considerable amount of air pollution will take place during different stages of construction. Suspended Particulate Matter (SPM) is the main pollutant during construction phase, released in the form of fugitive dust from various operations and activities. Additionally, SO_2 and hydrocarbons will also be released as product of fuel burning during operation of equipments.

The pollutants released during the construction activities may cause immediate effect on the construction workers who are directly exposed to them. However, the pollutant will not travel to longer distances as the project site is located in between hills. Disadvantage of such locations is that pollution generated in the valley do not get dispersed easily, hence even smaller quantities have serious impacts.

Pollution due to Fuel Combustion in Equipments

Major fuel consumption i.e. that of diesel will be in DG sets for meeting construction power requirement, which is estimated as 9 MVA. As this power requirement will be at different construction sites, it will be met through a number of DG sets installed at different construction sites, colonies and workshops. Operation of DG sets and other construction equipments requires combustion of diesel. The major pollutant which gets emitted as a result of combustion of diesel is SO_2. The SPM emissions are generally not significant; however, amount depends upon quality of fuel used.

Emissions from Construction Equipment

Following major construction and repair facilities will be generated for the project which will lead to air pollution in the surrounding areas:

Aggregate processing plants

Several aggregate processing plants of required capacities to be set up at dam site.

Concrete Batching and Mixing Plants:

Required number of batching and mixing plant will be installed of required capacities to full fill the requirement of dam construction.

Repair and maintenance workshops

Several base workshops have been proposed for earth moving equipment, for concreting and drilling equipments near the dam and the powerhouse areas. Additionally, to provide

for day to day maintenance and running repairs, small shops would be set up outside each portal of the various adits.

These plants and workshops will generate fugitive emissions comprising mainly the suspended particulate matter during loading/unloading of material and repair and maintenance activities. Major impact will be on the immediate vicinity i.e. affecting the workers involved in these operations. Provision of appropriate dust masks and other required Personal Protective Equipment at all the locations and enforcing their use by workers will help reducing emission's impact at work place environment.

Depending on wind direction and other meteorological factor these emissions may also disperse in atmosphere and will affect the surrounding area. The impacts will remain limited to immediate surrounding and vary with wind direction. Best mitigation method is to keep the emissions under check so that they do not spread to outside the battery limits of these plants.

Fugitive emissions from various sources

Construction activities such as tunneling, excavation, road cuttings, etc. are associated with large amount dust generation. Additionally, quarrying operations, muck transport and dumping, transportation and storage of construction material like sand, fine aggregate, etc. generate large amount of dust. Continuous exposure to fugitive dust has serious health effects on workers and residents of nearby areas. Impacts are local and temporary, and their significance can be reduced by adopting various mitigation measures such as controlling emissions at source, water sprinkling and use of PPEs.

Emission due to vehicular traffic

The project construction will involve transportation of large quantities of construction material to the project site and all the transportation in the project area will be done by road. This would lead to substantial increase in heavy vehicular traffic in the area. Emissions from vehicular traffic, due to diesel burning, will lead to air pollution in the area. The impact cannot be eliminated; however, it can be reduced by enforcing on transporters that the vehicles used should have valid PUC certificate.

7.3.2.2 Mitigation Measures for Air Emissions

The best way of impact mitigation is to prevent the event occurring. All efforts should be made to locate the developmental activities in an area free of agricultural lands, ecologically sensitive, erosion, forests, flooding, human settlements, landslides, natural scenic beauty, water logging. However, practically, this is not possible as project design criteria govern the location of various activities. Therefore, the next step is to look at the raw materials/ technologies/ processes alternatives which produce least impact i.e. adopting or using processes or technologies which are efficient and produce recyclable wastes/minimum waste/wastes that can be easily disposed, without seriously affecting the environment. However, if the developmental activities produce the adverse impact action has to be taken to mitigate the same. Following are some of the recommendations on mitigation measures.

a. Use of DG sets to be kept at minimum and only for captive power generation, if possible
b. Location of DG sets and other emission generating equipment should be decided keeping in view the predominant wind direction so that emissions do not effect nearby residential areas.
c. Stack height of DG sets to be kept in accordance with CPCB norms, which prescribes the minimum height of stack to be provided with each generator set to be calculated using the following formula:

$$H = h + 0.2 \times \sqrt{KVA}$$

Where,

H = Total height of stack in meter

h = Height of the building in meters where the generator set is installed

KVA = Total generator capacity of the set in KVA

d. Proper maintenance for efficient functioning of DG sets and other construction equipment is essential to minimize exhaust
e. Construction equipment and vehicles will be turned off when not used for extended periods of time. Unnecessary idling of construction vehicles to be prohibited.
f. The entire contractor's vehicle should have valid PUC certificate and same condition may be enforced on transporters bringing in material for construction.
g. Effective traffic management to be undertaken to avoid significant delays in and around the project area.
h. Road damage caused by sub – project activities will be promptly attended to with proper road repair and maintenance work.
i. Wherever practical, excavated spoils to be removed as the contractor proceeds along the length of the activity.
j. When necessary, stockpiling of excavated material will be covered or staged off site location with muck being delivered as needed during the course of construction.
k. Excessive soil on paved areas will be sprayed (wet) and/or swept and unpaved areas will be sprayed and/or mulched. The use of petroleum products or similar products for such activities will be strictly prohibited.
l. Contractors will be required to cover stock piled soils and trucks hauling soil, sand, and other loose materials (or require trucks to maintain at least two feet of freeboard).
m. Dust sweeping – the construction area and vicinity (access roads, and working areas) shall be swept with water sweepers on a daily basis or as necessary to ensure there is no visible dust.
n. All the construction workers and other staff, who get directly exposed to dust, should necessarily be provided with dust masks.
o. The project authorities will work closely with representatives from the community living in the vicinity of project area to identify areas of concern and to mitigate dust - related impacts effectively (e.g., through direct meetings, utilization of construction management and inspection program and/or through the complaint response program).

7.3.3 Noise Levels

The sound will be generated during almost all the construction activities such as tunneling, blasting, movement of vehicles, operation of construction machines and equipments, repair and maintenance work, operation of DG sets, etc. Continuous exposure of workers to high sound levels may result in annoyance, fatigue and may cause temporary shift of threshold limit of hearing and even permanent loss of hearing. As is evident from the baseline data, in the absence of vehicular traffic, sound levels in the area are generally low. There are no industries or any other source of noise in the area.

Construction phase will generate noise at various locations in the project area and is likely to affect residents and construction workers. The simultaneous operation of some equipment may increase the noise manifolds, however, resultant increase in noise levels will depend upon location of such equipment with respect to habitation, availability of the silencers/ mufflers, condition of the equipment, losses during transmission, etc. Increase in vehicular traffic in the area will also contribute to high sound levels in the area. Construction activities such as tunneling, blasting, etc. also lead to high noise generation.

Sound attenuates with the distance and even if all the attenuation factors are removed, direct sound levels reduce by 6 dBA with every doubling of distance. Further, the sound level

reduces substantially when the wave passes through a barrier. Therefore, if location of construction equipment is planned keeping in view the safe distance from habitation, impact can be greatly reduced on large section of population. Workers who are directly exposed need to use Personal Protective Equipments (PPEs) to reduce the impact.

7.3.3.1 Mitigation Measures for Noise Impact

Impacts due to high noise levels can be greatly reduced by adopting mitigation measures, as discussed below:

- Location of the construction equipment to be decided keeping in view the safe distance from habitation.
- Contractors will be required to maintain properly functioning equipment and comply with occupational safety and health standards.
- All the construction equipment will be required to use available noise suppression devices and properly maintained mufflers.
- Staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be avoided whenever possible.
- Minimize the use of noise producing equipment during night hours to avoid the disturbance to locals and wild animals of surrounding area.
- Use of temporary sound fences or barriers to be evaluated.
- Notification will be given to residents within 300 feet of major noise generating activities. The notification will describe the noise abatement measures that will be implemented.
- Monitoring of noise levels will be conducted during the construction phase of the project. In case of exceeding of pre-determined acceptable noise levels by the machinery will require the contractor(s) to stop work and remedy the situation prior to continuing construction.
- Vehicles to be equipped with mufflers recommended by the vehicle manufacturer.

The following Noise Standards for DG sets (15 – 500 KVA) are recommended for the running of DG sets during the construction.

- The total sound power level, L_w, of a DG set should be less than, 94 + 10 $\log_{10}$ (KVA), dBA.
- Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically.
- The Acoustic Enclosure should be made of CRCA sheets of appropriate thickness and structural/ sheet metal base. The walls of the enclosure should be insulated with fire retardant foam so as to comply with the 75 dBA at 1 m sound levels specified by CPCB, Ministry of Environment & Forests.
- The acoustic enclosure/ acoustic treatment of the room should be designed for minimum 25 dBA Insertion Loss or for meeting the ambient noise standards, whichever is on the higher side.
- The DG set should also be provided with proper exhaust muffler with insertion loss of minimum 25 dBA.
- Proper efforts to be made to bring down the noise levels due to the DG set, outside its premises, within the ambient noise requirements by proper sitting and control measures.
- A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

7.3.4 Water Environment

Construction work require large quantities of water to be used in various processing plants for material preparation; curing purposes, cooling water in equipments, domestic usages in

colonies, etc. waste water will be generated in various forms processing plants, workshops and residential areas. Additionally, during the construction work, muck transportation and transportation of materials; large quantities of suspended particulate matter will be generated to end up in the water body. As the construction period is long such impacts can permanently deteriorate the water quality in the area, if adequate mitigation measures are not adopted.

The following mitigation measures are suggested to be followed during the construction of the project:

- Minimize flow variation from the mean flow. Adequate river water will be secured to meet the requirements of riparian people, livestock, and wild animals and to sustain the aquatic ecosystem.
- Segregation of different types of wastes at source and avoid their mixing up in the river.
- Accumulation of oil wastes in depressions should be minimized in order to avoid possible contamination of the ground water system.
- Surface run off from oil handling areas/ devices (workshops and DG operation areas) should be treated for oil separation before discharge into the environment. If oil wastes are combined with sanitary sewage, oil separation will be necessary at the waste water treatment facility.
- All effluents containing acid/ alkali/ organic/ toxic wastes should be processed by treatment methods. The treatment methods may include biological or chemical processes.
- The impact due to suspended solids may be minimized by controlling discharge of wastes that contain suspended solids; this includes sanitary sewage and other wastes. Also, all activity that increases erosion or contributes nutrients to water (thus stimulating algal growth) should be minimized.
- For wastes containing high TDS treatment methods include removal of liquid and disposal of residue by controlled land filling to avoid any possible leaching of the fills. All surface run offs around quarries and excavation areas should be properly channelized and taken care of.
- The growth of aquatic weeds is to be monitored in the reservoir and excess weeds will be removed.
- Fish production in the reservoir will be monitored for any possible decrease. If any unexpected negative impact occurs, fish will be restocked. Technical support will be provided to the fish farming activities in the reservoir.
- Adequacy of the fish population will also be monitored and adequate stock of fingerlings to be maintained in the hatchery.

7.4 SPOIL DISPOSAL PLAN

The spoil generated from various project activities during the construction of a PMP project may adversely affect the environment if not properly managed. The generated muck volume, if not properly disposed, can

i) destroy the landscape
ii) increase the atmospheric particulate levels and
iii) Increase the sediment load in river channels

The proposed PMP project is likely to generate large volume of muck, of which some quantity will be utilizable and the remaining muck volume needs to be rehabilitated at appropriate dumping sites in a technically and ecologically sound manner.

7.4.1 Spoil Source and Volume

During the construction phase, a total 13 million M^3 of muck will be generated from excavation for dam with an average swelling factor 1.2, the volume to be disposed comes 15.6 million m^3.

7.4.2 Selection of Dumping Sites

The dumping sites were selected after careful examination of following points:

- The dumping sites should be selected nearby the adits and near the dam sites to avoid long-distance transport of muck.
- The sites must be free from active landslides or creeps and care should be taken that the sites do not have a possibility of toe-erosion related slope failure.
- The base level of the sites must be at higher elevation than the maximum flood level.
- The sites must not be on the concave side of a meander belt.
- There should not be any channel of small streams flowing through the dumping sites.
- These sites should not be pristine habitats containing endangered and rare species.

Based on these criteria, confluence of Saryu and Mahakali River in Parakoti settlement area of Pancheshwar VDC is chosen as muck disposal site. This area will further submerged in the reservoir.

7.4.3 Process of Dumping

The main objectives of process of muck dumping and restoration of these muck disposal sites are:

- Protect and control soil erosion
- Create greenery in the muck disposal areas
- Improve and develop the sites into recreational sites
- Ensure maximum utilization of muck for the construction purpose
- Develop the muck disposal sites/ dumping yards to blend with the surrounding landscape
- Minimize damages due to the spoilage of muck in the project area.

Suitable retaining walls shall be constructed prior to dumping of muck and terraces would be developed so as to support the muck on vertical slope and for optimum space utilization. Loose muck would be compacted layer-wise. The muck disposal area will be developed in a series of terraces of retention walls. In between the terraces, catch water drains will also be provided. The terraces of the muck disposal area will be ultimately covered with fertile soil and suitable plants will be planted adopting suitable bio-technological measures.

The project authorities would ensure that the dumping yards blend with the natural landscape by developing the sites with gentle slopes, bunds, terraced and water ponds, patches of greenery in and around them. These sites can also be developed later as recreational parks and tourist spots with sufficient greenery by planting ornamental plants. The re-vegetation of dumping yards through 'Integrated Biotechnological Approach' would be undertaken. It may be necessary to inoculate the spoil dumps for development of landscape as the soils would be poor in nutrients. This can be developed through culture of microorganism or vermiculture practices at the nurseries developed for this purpose.

All the spoil areas will be developed as per the latest technology of dumping, the impact of rain, the time and angle of soil setting. In addition sprinkling of water may also be resorted to, if required to avoid or minimize dust pollution. Proper drainage system also has to be provided to ensure unobstructed flow of runoff. Planting with suitable species of trees, shrubs and other biomass will also be initiated.

7.4.4 Spoil Rehabilitation Plan

The spoil rehabilitation plan involves both engineering and biological measures that depend on the terrain and eco-climatic conditions. Stability of the loosely held muck requires appropriate method of consolidation and biological measures so that the muck is not easily eroded leading to subsequent ecological problems. The measures suggested for the proposed dumping sites in the PMP Project are discussed below.

7.4.4.1 Engineering Measures

Retaining walls filled with plum concrete are proposed to hold the disposed spoil. These retaining walls (5 m high) shall be of stone masonry filled with plum concrete for both the dumping sites. The retaining walls shall be provided in stone masonry of grade M15 (1:2:4). The foundation of retaining wall structure shall be of cement concrete of grade M10 (1:3:6). A stone filled layer shall be placed at the side facing the dumped materials. The retention walls should carry weep holes for the discharge of subsurface water during rainy season. The weep holes should also carry filters at the side facing the dumped materials.

7.4.4.2 Biological Measures

In order to stabilize the stacked dumped material vegetation cover would be provided which will hold the dumped material over a period of time. Following steps are envisaged.

- Plantation of suitable tree species and soil binding using bio-fertilizer technology.
- Turfing of the exposed area and improvement of environment with ornamental species.
- Protection with mechanical support
- Social fencing through the mass public awareness.

The work plan formulated for re-vegetation of the dumping sites through 'Integrated Biotechnological Approach' is based on following parameters:

- Evaluation of dumped material for their physical and chemical properties to assess the nutrient status to support vegetation.
- Formulation of appropriate blends of organic waste and soil to enhance the nutrient status of rhizosphere.
- Isolation and screening of specialized strains of mycorrhizal fungi, rhizobium, azotobacter and phosphate solubilizers (biofertilizers inoculum) suitabile for the dumped material.
- Mass culture of plant specific biofertilizer and mycorrhizal fungi.
- Plantation of dumping sites/areas using identified blend and biofertilizer inoculum.

The afforestation with suitable plant species of high ecological and economic value which can adapt to local habitat will be undertaken with 400 - 600 plants per hectare depending upon the canopy cover required. Major tree species which would be planted are *Acer caesium, Betula alnoides, Cedrus deodara, Populus ciliata*, *Pinus wallichiana*, *Alnus nepalensis, Quercus semecarpifolia* and *Salix denticulata*. The shrubs are planted in between the trees are *Cotoneaster microphyllus*, *Desmodium elegans, Indigofera heterantha, Euphorbia royleana, Agave americana, Sorbaria tomentosa* and *Wikstroemia canescens*. The herbaceous layer is also helpful for the soil binding it reduces soil erosion due to rain. Herbs and grasses suggested for plantation is *Mentha arvensis, Peristrophe speciosa, Amaranthus hybridus, Lotus corniculatus, Eriophorum comosum, Carex alpine, Trigonella corniculata, Salvia moorcrotianna, Cynodon* sp., *Digitaria cruciata, Arundo donax*, etc.

Planting of Trees

The selected species will be planted after their nurseries have been developed. The saplings will be transplanted when these are 1 – 2 year old. The plantation can be carried out in lines across the slope, usually following the contour to prevent the development of rill and trap material moving down the slope. Brush layers, fascines and palisades can be used because their use controls erosion, catches debris and provides strong, fibrous root reinforcement. Different plant species when used together will provide increased stability. Grasses planted

in a line across a slope will provide a continuous chain of support in retaining debris, reinforcing soil and increasing the infiltration capacity of the area.

Plant saplings may be raised on biodegradable pots and transplanted as such. The plantation should be done during monsoon season. Pits of 0.45 m × 0.45 m × 0.45 m will be dug and filled with some soil rich in nutrients. Compost from the local organic waste can be used. An integrated biotechnological approach will be very useful for sustenance and growth of plants. This approach involves the following steps:

- Assessment of the nutrient status of the soil and evaluation of the physical and chemical properties of the dumped material.
- Formulation of the appropriate blend of organic waste and soil to enhance the nutrient status of the rhizo sphere.
- Isolation and screening of specialized strains of mycorrhizal fungi, rhizobium, azobacter and phosphate solubilizers (biofertilizer inoculum) which can be best suited for the dumped material.
- Mass culture of plant specific biofertilizer and mycorrhizal fungi.
- Plantation of dumping sites/areas using identified blend and bio-fertilizer inoculums.

The rich soil and farmyard manure requirement for nearly 100 pits will be about 1 cubic meter with approximate weight of 200 kg. The saplings will be planted at 3 m intervals along the contour and 5 m across it. Wherever terracing shall be prescribed, the same will be done on terraces at 3m intervals leaving one-meter space from the edge of the terrace. About 600 – 900 seedlings shall be planted per ha depending on the space available at the site. Shrubs and herbs will be planted in the interspaces. The local Forest Officials should be informed of the requirement of species well in advance and the seedlings will be procured on the prevalent cost basis. About 80,000 plant saplings will be planted at different dumping sites.

7.5 ENVIRONMENTAL MONITORING PROGRAMME

Environmental Monitoring is an essential tool in relation to environmental management as it provides the basis for rational management decisions regarding impact control. Monitoring shall be performed during all stages of the project (namely: construction, commissioning, and operation) to ensure that the impacts are no greater than predicted, and to verify the impact predictions. The monitoring program will indicate where changes to procedures or operations are required, in order to reduce impacts on the environment or local population. The monitoring program for the PMP Project will be undertaken to meet the following objectives:

- To monitor the environmental conditions of the Mahakali River and the reservoir as impacted by the PMP Project;
- To check on whether mitigation and benefit enhancement measures have actually been adopted, and are proving effective in practice;
- To provide information on the actual nature and extent of key impacts and the effectiveness of mitigation and benefit enhancement measures which, through a feedback mechanism, can improve the planning and execution of future, similar projects.

7.5.1 Areas of Concern

From the monitoring point of view, the important parameters are water quality, air quality, noise and muck & spoil disposal. An attempt is made to establish early warning of indicators of stress on the environment. Suggested monitoring details are outlined in the following sections.

7.5.1.1 Water Quality

Construction Phase

It is proposed to monitor the effluent before and after treatment from sewage treatment plant. The frequency of monitoring could be once per month. The sampling sites shall be Colony area, Power house site, Dam site; 3 km downstream of dam site, Confluence Point of Mahakali River. A total of 60 samples need to be analyzed every year. The parameters to be monitored include pH, Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS) and Total Dissolved Solids (TDS). The monitoring is proposed to be done over a period of 13.5 years.

Operation phase

The surface water quality of the proposed reservoir and river Mahakali can be monitored thrice a year (summer, pre and post-monsoon seasons). The proposed parameters to be monitored include; pH, temperature, electrical conductivity, turbidity, total dissolved solids, calcium, magnesium, total hardness, chlorides, Sulphates, Nitrates, DO, COD, BOD, Iron, Zinc and Manganese.

7.5.1.2 Air Quality

Construction Phase

The ambient air quality monitoring during construction phase will be carried out by the self established an environmental lab or as per requirement by the external agency, approved by State Pollution Control Board. Every year monitoring is to be done for the following three seasons:

- Winter
- Summer
- Post-monsoon

The frequency of monitoring could be twice a week for four consecutive weeks at each station for each season. The parameters to be monitored are Respirable Particulate Matter (RPM) and Suspended Particulate Matter (SPM), Sulphur dioxide (SO_2) and Nitrogen Oxides (NO_x).

7.5.1.3 Noise

Construction Phase

Noise emissions from vehicular movement, operation of various construction equipments may be monitored during construction phase at major construction sites. The frequency of monitoring could be once every three months.

Operation Phase

Noise monitoring will continue during operation phase also for first three years.

7.5.1.4 Muck and spoil disposal

Construction Phase

In addition to the air quality, water quality and noise quality during the construction phase, management of construction debris and muck arising out of the earth work involved in the hydro projects is also a major environmental issue. Adopting appropriate and well designed engineering structures for retaining the construction debris and muck is very crucial and this needs to be monitored regularly both for stability of the dump sites and their vulnerability to stress failures due to various factors such as erodability, strong water currents and earth pressures.

7.5.1.5 Minimum environmental flow

Operation Phase

Similarly during operation phase of the project, most crucial environmental aspect is the monitoring of flow released from the hydro project to ensure that minimum flow is maintained at all times especially during lean season. Therefore, monitoring mechanism will be established as per the requirement of HPPCB to monitor river flow immediately downstream of the diversion structure.

Table 7-6: Matrix of environmental monitoring plan

S N	Aspect	Source of impact	Monitoring methods & parameters
	Construction phase		
1	Water quality	Excavation, disposal, sewage disposal, land clearing activities and other chemical parameters	• Surveys & sample collection and field measurements: Turbidity, pH, TDS, DO, Total Coliform and E. coli
2	Air quality	Operation of DG sets, transportation of muck, road construction, mobilization of material, running of crushers	• Survey & observation Levels of SPM, SO_x and NO_x
3	Restoration of muck disposal sites, construction areas	Muck generation, transportation and dumping	• Status of protection measures at the dumping sites. Whether dumping is done so as to avoid spillage of muck into the river, especially during rains • Leveling and slope stabilization works at dumping sites • Status of afforestation/ turfing works on the dumping sites
	Operation phase		
2	Water quality and quantity (for irrigation & domestic use)	Reservoir water regulation , diversion of water for power generation	• Surveys, sample collection & field measurement water discharge d/s of dam water quality (Turbidity, coliform bacteria and others)
3	Air quality	Increased activities in the area including movement of vehicles, air pollution from colony, etc.	• Survey and observation levels of SPM, SO_x and NO_x
4	Noise levels	Noise due to operational activities including that from housing colony	• Sound levels using sound level meter
5	Disaster	Heavy rainfall, flash flood situation	• Surveillance and disaster management exercises • Regular information to people